Rocky Reach Project Resident Fish Study

Completion Report
Contractor Number 11-1914
Contract # 12-059

Submitted by:

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Table of Contents

List of Tables

List of Figures

Introduction

Construction of the Rocky Reach Hydroelectric Project (Project), Federal Energy Regulatory Commission (FERC) Project No. 2145, which is owned by Public Utility District No.1 of Chelan County (Chelan PUD), was started in 1956 and completed in 1961. In 1969, additional generating units were added and the Project reached its present generating capability and configuration in 1971. The Rocky Reach Dam (RM 76.7) created a 68-km long reservoir referred to as Lake Entiat. To meet natural resource requirements for the Project's FERC relicensing, a Natural Resources Working Group developed a Comprehensive Resident Fish Management Plan (RFMP) for the Project. An outline of the Resident Fish Study Plan was recently released and it has three clear goals to implement within the Project boundary. They are to: 1) protect and enhance resident fish; 2) protect resident fish habitat; and 3) enhance recreational fishing opportunities. In addition, Chelan PUD agreed to implement several resident fish Protection, Mitigation, and Enhancement measures (PMEs). One PME was to conduct "resident fish monitoring to measure relative abundance and species composition in the Reservoir" (Section 4.2 of the RFMP). A second PME is to "evaluate the creation of an additional recreational fishing opportunity in the Reservoir that is compatible with existing fish resources," (Section 4.1.3 of the RFMP).

In 2010 the Chelan PUD contacted the Washington Department of Fish and Wildlife (WDFW) Large Lakes Research Team (LLRT) to develop a study plan to catalogue the resident fishes within the Project. The Chelan PUD funded Rocky Reach Resident Fish Study was designed in a manner that will allow comparisons to portions other regional projects regarding resident fish assemblages.

Study Goal

The primary goal of this study was to conduct a scientifically sound resident fish survey within the Rocky Reach Project. This study was designed to be repeatable and used for future index sampling throughout the duration of the current FERC license to detect potential changes within the fish assemblage of the Project. There are three primary objectives associated with the Rocky Reach Project Resident Fish Survey.

1. To support monitor the relevant trends and abundance within the resident fish community.

2. Evaluate fish habitat in areas of heavy aquatic vegetation growth, including water quality, vegetation types in these areas (emphasizing native vs. non-native), and the relative abundance of resident predators such as northern pikeminnow (*Ptychocheilus oregonensis*), smallmouth bass (*Micropterus dolomieu*), largemouth bass (*M. salmoides*), walleye (*Sander vitreus*), and channel catfish (*Ictalurus punctatus*).

3. To evaluate potential resident fishing opportunities within the Rocky Reach Project.

Study Area

The Rocky Reach Project extends from the tailrace of the Rocky Reach Dam approximately 69 km upstream to the Wells Dam tailrace (Chelan PUD 1999) and is often referred to as Lake Entiat. The dam itself is located in north Central Washington approximately 11 km from the city of Wenatchee (Figure 1). Lake Entiat has a mean depth of 13 m and a maximum depth of approximately 37 m (Parametix et al. 2001). Three large hydroelectric dams above Rocky Reach and the subsequent impoundments supply Lake Entiat with water. Grand Coulee Dam's Lake Roosevelt is the largest of the three upstream Reservoirs and can influence biotic and abiotic factors of systems located downstream (Beckman et al. 1985). However, unlike the substantial retention time of one month within Lake Roosevelt (Parametrix et al. 2001), the water retention time within Lake Entiat can be as little as one day (S. Hemstrom, Personal communication).

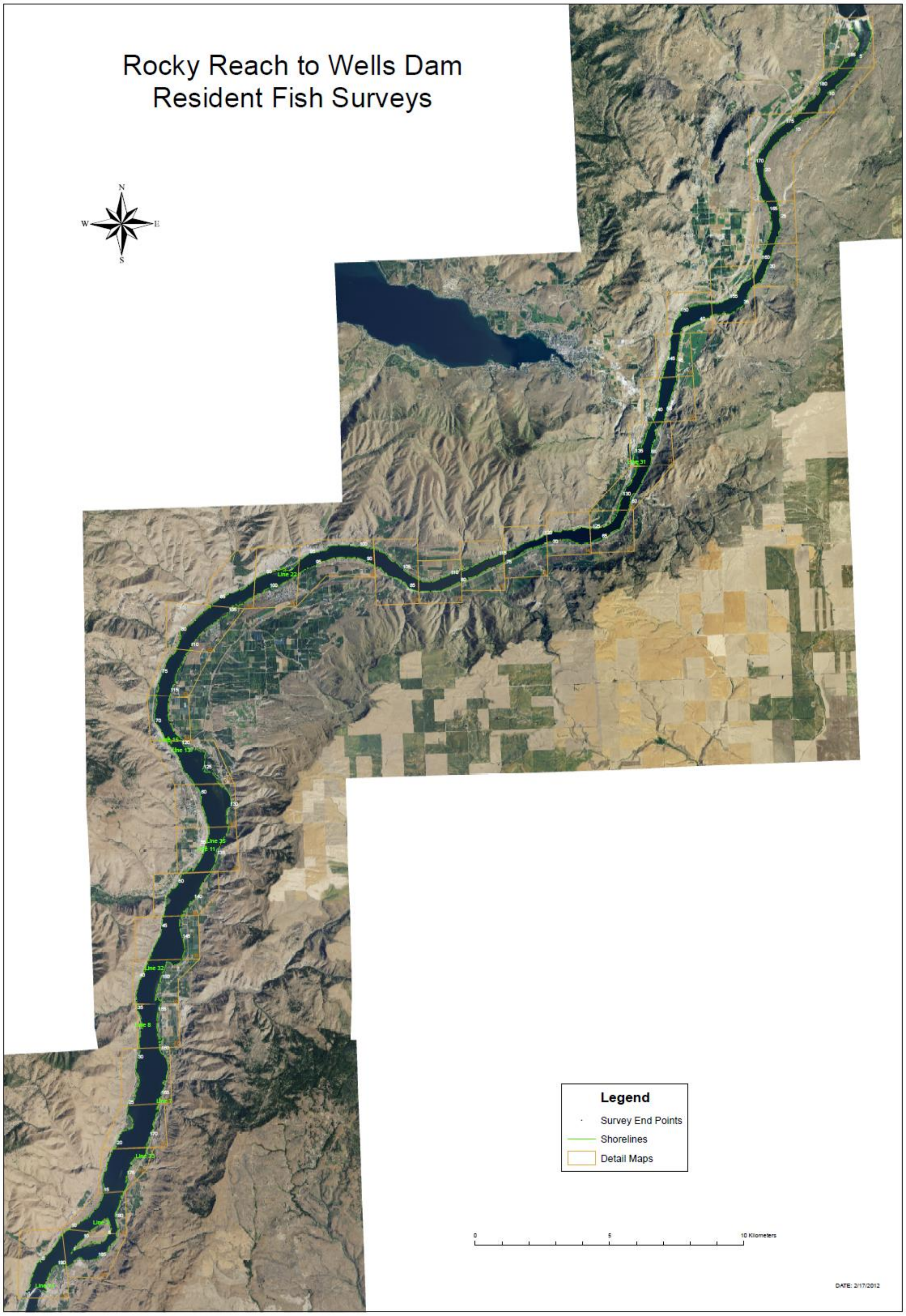

Figure 1. GIS representation of Rocky Reach Project from Rocky Reach Dam upstream to Wells Dam with individual sections throughout the Project.

Methods

Due to the large spatial scope of the sampling area the Project was divided into 3 areas, upper, middle and lower which contained 37 sections that contained multiple sites (Figure 2). Along with the visual description of individual sites, coordinates in Universal Transverse Mercator (UTM) were used to navigate during sampling efforts. Sites were selected in a stratified random fashion where the 3 areas representing the strata. Within each strata sites were randomly selected proportional to the number of sites that were available to be sampled. Sites that were either too deep (>3m) or the water was too fast to ensure safe and efficient sampling were not sampled. Due to variability in the environmental conditions of Lake Entiat the decision to sample or not sample a randomly selected site was made in real time. If a site was deemed unsuitable for sampling with respect to depth and water velocity another randomly selected sites was used. The goal was to sample 10% of the 414-600 m sites available with either electrofishing boats or fyke nets.

Pop netting sites were randomly selected from areas where substantial macrophyte growth had been previously identified by the Chelan PUD. Sites that met the criteria of macrophyte growth and appropriate depth (0.6 m – 1.8 m) were randomly selected to be pop netted. Due to the relatively small size of the pop nets and the large area of each 400 m site, sites could be selected multiple times but popnets could not be set within 50 m of one another.

Figure 2. One of the 37 sections and associated sites including the Rocky Reach Hydroelectric Project.

In order to reduce sampling bias three methods were used to collect fish during the Rocky Reach Resident Fish Survey during the summer and fall of 2012. Although gillnets are ideal for warmwater fish sampling, gillnets were not used due to the potential to encounter listed species within the Project. Like gillnetting, pop netting and fyke netting are passive capture techniques, while electrofishing is an active technique. Although both methods can be used to estimate fish abundance, estimates may be slightly biased using passive capture gears because they rely on fish behavior (movement into a stationary device) (Hayes et al. 1996). Pop netting allows sampling within areas of thick macrophytes, while fyke netting must be completed in areas free of macrophyte growth. Pop netting favors fish that inhabit weed beds. For example, threespine stickleback are known to prefer habitat with abundant vegetation (Clavero et al.), and were the dominant fish species captured in pop nets (70.5%).

Electrofishing as an active capture technique may allow for larger sample sizes, which can increase statistical precision of fish abundance estimates (Hayes et al. 1996). However, electrofishing can also introduce size bias, as larger fish of a species tend to be selected, both because larger fish receive a greater “shock” than smaller fish; and because they are more visible, and may tend to be selected by netters over smaller fish (Reynolds 1996).

Boat Electrofishing

Boat electrofishing was conducted along the shoreline at the preselected random sites using two, 5.5 m Smith Root 5.0 Generator Powered Pulsator (GPP) electrofishing boats (Figure 3). Individual electrofishing boats operated downstream and parallel to the shoreline at a rate of 1–1.4 m/hour, maintained a distance from shore that allowed the inshore boom to fish entirely in the water, and avoided areas that exceeded 3m in depth. To initiate galvanotaxis the GPP unit was operated at approximately 1–2 amperes (amps) using a low power setting (50–500 volts) with a frequency between 30–120 Hz DC. Each crew consisted of one boat operator and two dip netters stationed at the front of the vessel. A standardized electrofishing sample consists of electrofishing for 600 seconds within a 400 m site but varied on occasion due to environmental factors and in–river hazards that resulted in aborting the remainder of the site.

Boat electrofishing began thirty minutes after official sunset. However, boats were launched earlier each night in order to enter all site coordinates and test electrofishing units before transiting to designated sites in the dark. Once at a designated site, boat crews recorded the following information: water temperature, specific conductance, time when sampling began, coordinates in UTM, initials of crew, assigned coordinates, date, and site designation. Upon completion of site data collections, the boat operator verified the crew’s readiness, started the onboard generator, oriented the boat downstream, and began electrofishing. Two crew members located at the bow of the boat used 2.4m long dipnets to capture stunned fish that were immediately placed into one of the two onboard livewells equipped with a pump that continually added fresh water into the tank. It was also the job of the netters to make the boat operator aware of approaching hazards while electrofishing at which point maneuvers could be initiated to prevent injury to staff or damage to equipment. After 600 seconds of electrofishing, the ending UTM’s were recorded to identify end of the electrofishing site. This information was then recorded on the data sheet along with the power settings used to electrofish. Following site data collection, the boat crew secured all items and traveled to the next selected sample site where the methods were repeated. After the completion of two–600 second electrofishing sites, the boat operator moored the electrofishing boat and biological data was collected from all captured fish. Fish processing consisted of identifying all fish, recording their lengths and weights and releasing them back into the river. In the event transit time between sites was extended as a result of distance or environmental conditions, crews collected the pertinent data from the captured fish immediately after the completion of the first site.

Figure 3. LLRT electrofishing boat preparing to commence shocking run at a prescribed site during the 2012 survey. Whisker-like booms in the foreground are lowered into the water prior to starting the on board generator.

Fyke Netting

Unlike boat electrofishing, which is an active form of sampling, fyke nets are passive and used to intercept fishes moving parallel to the littoral zone during the night. Fyke nets were set with the lead line perpendicular to shore, and the first hoop closest to shore just under the water with the wings in a 45-degree angle towards the shore (Figure 4). The lead line on the shore was either held in place with a large weight or tied to a stationary object on shore. The cod end which was located furthest from shore was held in place with a large pancake weight to assure the fyke net remained open and did not collapse while fishing. After approximately 12 hours of soak time, a boat crew picked up the fyke net from the cod end side and placed fish immediately in the live well. Data including length, weight and species identification were recorded from captured fish. In addition total fishing time and exact location were recorded.

Figure 4. LLRT staff deploying a fyke net within the Rocky Reach Reservoir during the 2012 summer survey.

Pop Netting

In areas of thick macrophytes and appropriate depths, resident fish were sampled using pop nets Morgan et al (1988). Areas of concern were identified by PUD staff and then confirmed for heavy vegetation growth by LLRT staff. A pop net consists of a 3.05 x 3.05 m frame of polyvinyl chloride (PVC) filled with float material and a frame of equal dimensions filled with weights. Each pop net sampled a 9.29m^2 area per net set (Figure 5). The frames are connected by a 1.83m net with 6.35 mm knotless mesh. Upper and lower frames were pinned together and the nets set flush with the substrate. Contact between the substrate and the bottom frame was accomplished by placing sandbags over the bottom frame and a net skirt to ensure that fish cannot escape the sample area. To trigger the pop net, 30 m cords were attached to each pin so they could be pulled without approaching the net and skewing results. The cords that were attached to the pins ran parallel to shore and held in place far away from the trap with a small weight and buoy.

Approximately 24 hours after setting a net LLRT staff approached a pop net and simultaneously pulled the pins causing the top frame to rapidly float to the surface and enclose the fish within the area of the net. Once a pop net was deployed, a specialized seine was pulled through the pop net enclosure to capture all the fish following a depletion method (Everhart and Youngs 1981). No less than three seine passes were made. Seining continued until less than half the number of fish was collected from the previous pass. As with electrofishing and fyke netting lengths, weights, species identification and specific location were recorded. Using a YSI 6600 V2

Multiparameter Water Quality Sonde (YSI sonde) water quality param were collected in the area pop nets were set.

Figure 5. A typical pop net deployment by LLRT personnel within the littoral zone.

Analysis

Several basic indices were calculated for fish captured during electrofishing, fyke netting, and pop netting efforts. Species composition was calculated based on the proportion of the number of individuals of a species relative to the total number of fish captured. Species composition by weight biomass) was calculated using the following formula:

$$\text{Species composition by weight} = (\sum spp_{wt} / \sum T_{wt})*100$$

Where spp_{wt} is the weight of an individual species and T_{wt} is the total weight of all the species collected.

Catch per unit effort for electrofishing and fyke netting will be calculated separately using the following formulas:

$$CPUE = N / T$$

Where CPUE is catch per unit effort, N is the number of individuals, and T is time (seconds for electrofishing and net-night for fyke netting. Mean length and a 95% CI were calculated for all species captured via electrofishing and fyke netting. Whereas, mean length and the minimum and maximum length was calculated for individual species of fish captured in summer pop nets.

From each individual pop net, an expanded population estimate was calculated by linear regression for each species (Dr. David Bennett, personal communication). For each pass of the seine, the variables x and y were calculated, where *x* was the sum of catch from the previous passes (always zero for the first pass) and y was the catch for the pass. For example, in one pop net, threespine stickleback were removed from the pop net via 3 passes of the seine. In the first pass, 32 fish were captured, therefore x=0 and y=32. In the second pass, 25 fish were captured, therefore, x=32 (x+y from the first pass), and y=25. In the third pass, 4 fish were captured, therefore, x=57 (x+y from the second pass) and y=4. A total of 61 threespine stickleback were removed and the expanded population species estimate was then calculated using the formula:

$$N = \frac{a}{b}$$

Where N is the expanded number of individuals of each species in each pop net haul, a is the intercept of the straight-line equation, and b is the slope of the straight-line equation.

The IBI as defined by Karr and Dudley (1981) as “the ability to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of the natural habitat of the region.” The IBI is a sound approach to bioassessment because (1) it is qualitative and provides criteria to determine what is excellent or poor; (2) it uses several attributes to reflect conditions; (3) there is no loss of information in calculating the index value–the metric values are available to pinpoint the ecological attributes that have been altered; and (4) professional judgment is incorporated in a systematic and ecologically sound manner (Miller et al. 1988).

The IBI is designed to assess biotic integrity directly through 12 attributes of fish communities in streams (Fausch et al. 1984). These attributes, called community metrics, fall into several categories, including species richness and composition, trophic composition, fish abundance, and condition (Fausch et al. 1984). Each community metric received a score of 1, 3, or 5 depending on the criteria (Table 1). The scores for all twelve metrics were then totaled and that number was used to evaluate the fish community and compare data from 2012 in both the Rocky Reach Project and the Priest Rapids Project. Karr (1981) assigned total scores to classes according to the following scale: excellent (57–60); excellent–good (53–56); good (48–52); good–fair (45–47); fair (39–44); fair–poor (36–38); poor (28–35); poor–very poor (24–27); and very poor (≤23). The specific metrics calculated were those used by Hughes and Gammon (1987) (Table 1) for the Willamette River, Oregon, which were modified from Karr et al. (1986). The metrics from Hughes and Gammon (1987) were chosen due to the similarities between the Willamette and Columbia River systems (Reimers and Bond 1967; Wydoski and Whitney 2003). The relative tolerance to organic pollution, warm water, and sediment for each fish species sampled was assigned to each species (Table 2). This assignment was based on fish species observed in the Willamette River by Hughes and Gammon (1987), as well as Wydoski and Whitney (2003) for species that were not found in the Willamette River.

Table 1. Community metrics used in assessment of the Rocky Reach Project fish community (adopted from Hughes and Gammon 1987 and Chelan PUD 2009).

	Scoring Criteria		
	1 (worst)	3	5 (best)
Species richness and composition			
Total number of native species	0–4	5–9	10+
Number of cottid species	0–1	2	3+
Number of native cyprinid species	0–2	3–5	6+
Number of catostomid species	0	1	2
Number of intolerant species	0	1–2	3+
% of individuals as common carp	10+	1–9	0–1
Trophic composition			
% of individuals as omnivores	50+	25–49	0–24
% of individuals as insectivores	0–19	20–39	40+
% of individuals as catchable salmonids[1]	0–1	1–9	10+
Fish abundance and condition			
Number of individuals	0–49	50–99	100+
% of individuals introduced (exotic)	10+	2–9	0–1
% of individuals with anomalies[2]	6+	2–5	0–1

[1]Salmonids (excluding whitefish) > 200mm.
[2]i.e. disease, tumors, fin damage.

Table 2. List of grouped fish based on tolerance, trophic standing and geographic origin of fish potentially present in the Rocky Recah Project. [adopted from Chelan PUD (2009) from Pfeifer et al. (2001)].

Family, Species	Relative tolerance of organic pollution, warm water, and sediment	Trophic group of adults	Origin
Acipenseridae			
White Sturgeon *Acipenser transmontanus*	Intermediate	Piscivore	Native
Catostomidae			
Bridgelip Sucker *Catostomus columbianus*	Tolerant	Omnivore	Native
Largescale Sucker *Catostomus macrocheilus*	Tolerant	Omnivore	Native
Longnose Sucker *Catostomus catostomus*	Tolerant	Omnivore	Native
Centrarchidae			
Black Crappie *Pomoxis nigromaculatus*	Tolerant	Omnivore	Introduced
Bluegill *Lepomis macrochirus*	Tolerant	Insectivore	Introduced
Largemouth Bass *Micropterus salmoides*	Tolerant	Piscivore	Introduced
Pumpkinseed *Lepomis gibbosus*	Tolerant	Insectivore	Introduced
Smallmouth Bass *Micropterus dolomieu*	Intolerant	Piscivore	Introduced
White Crappie *Pomoxis annularis*	Tolerant	Insectivore	Introduced
Clupeidae			
American Shad *Alosa sapidissima*	Tolerant	Insectivore	Introduced
Cottidae			
Prickly Sculpin *Cottus asper*	Intermediate	Insectivore	Native
Torrent Sculpin *Cottus rhotheus*	Intolerant	Insectivore	Native
Cyprinidae			
Chiselmouth *Acrocheilus alutaceus*	Intermediate	Herbivore	Native
Common Carp *Cyprinus carpio*	Tolerant	Omnivore	Introduced
Leopard Dace *Rhinichthys falcatus*	Intermediate	Insectivore	Native
Longnose Dace *Rhinichthys cataractae*	Intermediate	Insectivore	Native
Northern Pikeminnow *Ptychocheilus oregonensis*	Tolerant	Piscivore	Native
Peamouth *Mylocheilus caurinus*	Intermediate	Insectivore	Native
Redside Shiner *Richardsonius balteatus*	Intermediate	Insectivore	Native
Speckled Dace *Rhinichthys osculus*	Intermediate	Insectivore	Native
Tench *Tinca tinca*	Tolerant	Omnivore	Introduced
Gadidae			
Burbot *Lota lota*	Intolerant	Piscivore	Native
Gasterosteidae			
Threespine Stickleback *Gasterosteus aculeatus*	Intermediate	Insectivore	Native
Ictaluridae			
Black Bullhead *Ameiurus melas*	Tolerant	Insectivore	Introduced
Channel Catfish *Ictalurus punctatus*	Tolerant	Insectivore	Introduced
Percidae			
Walleye *Sander vitreus*	Intermediate	Piscivore	Introduced
Yellow Perch *Perca flavescens*	Intermediate	Insectivore	Introduced
Percopsidae			
Sand Roller *Percopsis transmontana*	Intermediate	Insectivore	Native
Petromyzontidae			
Pacific Lamprey *Entosphenus tridentatus*	Intolerant	Parasite	Native
Salmonidae			
Brown Trout *Salmo trutta*	Intolerant	Omnivore	Introduced
Bull Trout *Salvelinus confluentus*	Intolerant	Piscivore	Native
Chinook Salmon *Oncorhynchus tshawytscha*	Intolerant	Piscivore	Native
Coho Salmon *Oncorhynchus kisutch*	Intolerant	Piscivore	Native
Cutthroat Trout *Oncorhynchus clarkii*	Intolerant	Insectivore	Native
Lake Whitefish *Coregonus clupeaformis*	Intolerant	Insectivore	Native
Mountain Whitefish *Prosopium williamsoni*	Intolerant	Insectivore	Native
Rainbow Trout/Steelhead *Oncorhynchus mykiss*	Intolerant	Insectivore	Native
Sockeye Salmon *Oncorhynchus nerka*	Intolerant	Insectivore	Native

[1]For fish captured not listed within this table, community metrics of similar species were used as follows (species captured by LLRT = species captured by Pfeifer et al. 2000): 1. bullhead spp. = other Ictalurids; 2. dace spp. = other species of the genus *Rhinichthys*; 3. grass carp = common carp; 4. green sunfish = bluegill; 5. sculpin = torrent sculpin; 6. sucker spp. = other species of the genus *Catostomus*; 7. whitefish spp. = other whitefish; and 8. minnow spp. = peamouth (since unidentified minnows in the field are generally believed to be peamouth/northern pikeminnow hybrids.)

Sampling Limitations
The WDFW has developed a lake and pond sampling protocol that utilized boat electrofishing, fyke netting and gillnetting to evaluate resident fisheries (Bonar at al. 2000). However, due to gear restrictions gillnetting was not permitted and habitat suitable for fyke netting was limited. However, electrofishing was conducted following the WDFW protocol.

Prior to the 2012 sampling season, the WDFW requested a permit renewal from NOAA in 2011. On June 11, 2012 NOAA issued a Scientific Research Permit 16433 to the WDFW for sampling within the Columbia Basin. Because the WDFW was operating in a system that could potentially contain several Endangered Species Act (ESA) listed species, LLRT staff maintained a high level of safety and operational standards and treated every salmonid as a listed species. In addition, salmonids were not purposely netted so as not to exceed the take. Capturing and handling salmonids can be a significant stressor to sensitive species and this can be further exacerbated during the summer months when water temperatures are at their highest. NOAA recognized the potential impacts from handling salmonids during this period and has a stipulation with our permit 16433 stating the following:

> *Each researcher must stop capturing and handling listed fish if the water temperature exceeds 70 degrees Fahrenheit at the capture site. Under these conditions, listed fish may only be identified and counted. Additionally, electrofishing is not permitted if the water temperatures exceed 64 degrees Fahrenheit.*

Consequently, the water temperature was used as an indicator when sampling within the Rocky Reach Project could be conducted.

Results

During the course of the contract, over 100 sites were sampled using all sample methods (Figure 6). The summer standardized sampling period was the week of July 27, 2012 with two electrofishing boats shocking 35 sites and setting fyke nets at seven sites. Pop netting was conducted from August 27, 2012 and was completed September 6, 2012. The fall sampling period was conducted from October 1, 2013 and concluded October 9, 2012.

Summer Sampling

Species composition and biomass was dominated by *Cyprinidae* (minnows) and *Catostomidae* (suckers) during the summer boat electrofishing and fyke netting efforts (Tables 3&4). A greater diversity and size of fish were captured during electrofishing compared to fyke netting (Table 5). A greater number of fish were also captured using electrofishing compared to fykenetting (Table 6). Members of the *Cyprinidae* and *Catostmidae* familes were the most abundant species captured. Interestingly, the species composition of fish captured in our pop nets was dominated by the family *Gasterosteidae*, specifically the three-spine stickleback (Table 7). Fish captured in the pop nets were smaller in length and were most likely comprised of young-of-the-year and one year old fish (Table 8). Poor water quality param were not detected at the popnet sites (Table 9).

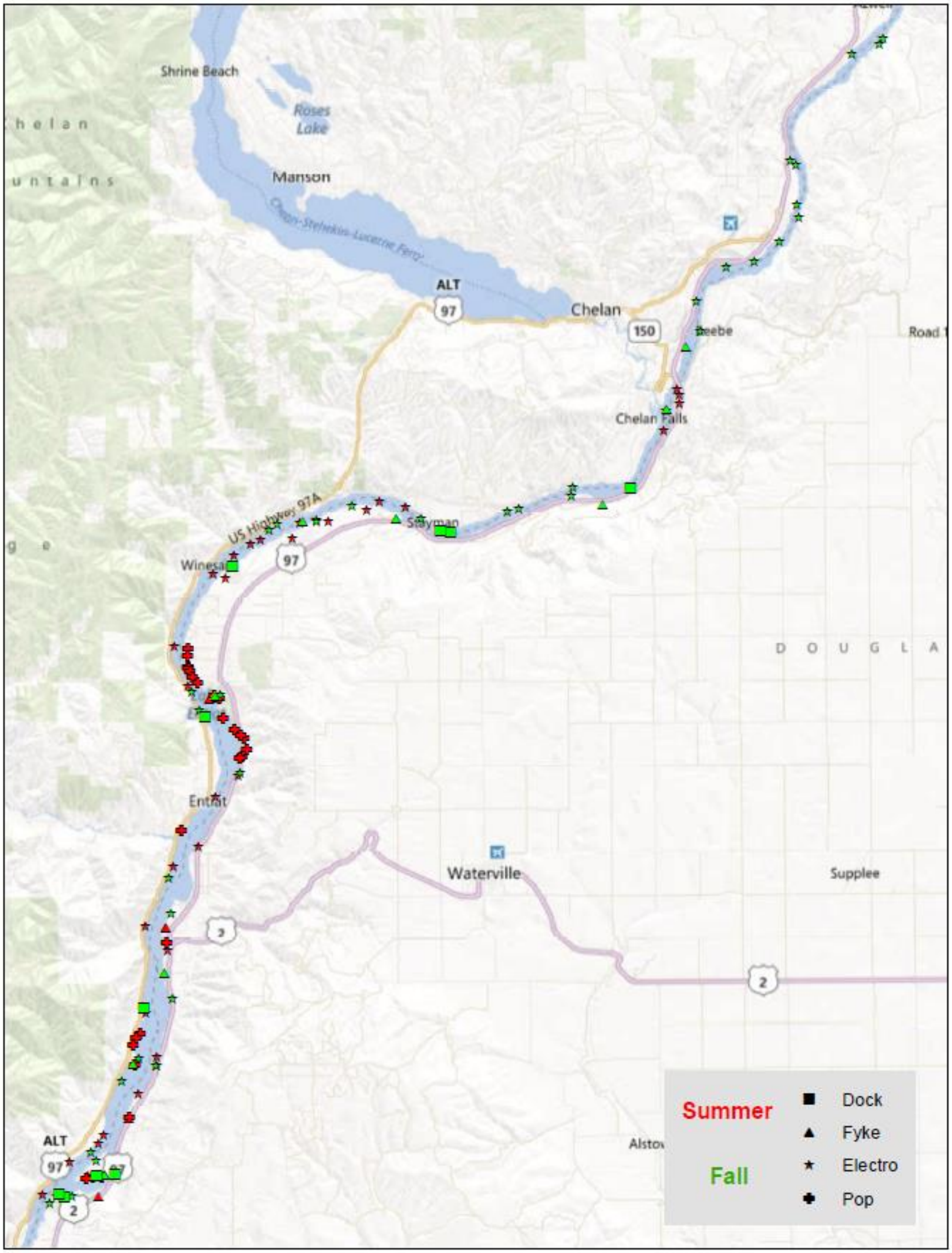

Figure 6. GIS visual of temporal and spatial distribution of all sampling techniques utilized throughout the Rocky Reach Resident Fish Survey.

Table 3. Species composition by number during summer 2012 Rocky Reach survey. (35 - 400m electrofishing sites, 7-fyke net sites).

Species	EB %	EB #	FN %	FN #
Bluegill	0.21	5	0.00	
Bridgelip Sucker	0.46	11	0.00	
Carp	0.33	8	0.00	
Chinook Salmon	0.04	1	0.71	1
Chiselmouth	8.52	205	5.71	8
Largescale Sucker	22.10	532	9.29	13
Longnose Sucker	0.25	6	0.00	
Minnow spp.	0.42	10	0.00	
Northern Pikeminnow	30.83	742	60.00	84
Peamouth	3.32	80	0.71	1
Pumpkinseed	0.04	1	0.00	
Redside Shiner	22.35	538	0.71	1
Sculpin spp.	6.94	167	2.14	3
Smallmouth Bass	0.50	12	0.00	
Sucker spp.	2.29	55	0.00	
Tench	0.46	11	2.86	4
Threespine Stickleback	0.37	9	17.86	25
Walleye	0.04	1	0.00	
Whitefish spp.	0.46	11	0.00	
Yellow Perch	0.08	2	0.00	

Table 4. Biomass of individual species for both electrofishing (EB) and fyke net (FN) sampling during 2012 summer survey.

Species	EB %	EB Wt. (g)	FN %	FN Wt. (g)
Bluegill	0.07	155	0.00	
Bridgelip Sucker	0.43	956	0.00	
Carp	5.89	12,986	0.00	
Chinook Salmon	0.01	13	0.02	2
Chiselmouth	3.38	7,460	0.72	79
Largescale Sucker	54.07	119,199	11.91	1,304
Longnose Sucker	0.61	1,337	0.00	
Minnow spp.	0.00		0.00	
Northern Pikeminnow	17.50	38,580	34.68	3,799
Peamouth	2.76	6,080	1.27	139
Pumpkinseed	0.02	45	0.00	
Redside Shiner	2.62	5,778	0.05	5
Sculpin spp.	2.81	6,196	0.98	107
Smallmouth Bass	0.70	1,553	0.00	
Sucker spp.	2.57	5,655	0.00	
Tench	6.30	13,883	50.05	5,482
Threespine Stickleback	0.00	7	0.33	36
Walleye	0.02	45	0.00	
Whitefish spp.	0.07	158	0.00	
Yellow Perch	0.16	361	0.00	

Table 5. Mean length total length (mm) and 95% confidence interval (CI) of fish captured via boat electrofishing (EB) and fyke netting (FN) during the fall 2012 Rocky Reach Resident fish survey.

Species	EB Length (95% CI)	FN Length (95% CI)
Bluegill	114.8 (31.0)	
Bridgelip Sucker	196.9 (75.1)	
Carp	699.8 (201.1)	
Chinook Salmon	112.0 (N/A)	64.0 (N/A)
Chiselmouth	152.3 (72.4)	105.8 (28.3)
Largescale Sucker	244.2 (205.1)	211.8 (88.3)
Longnose Sucker	259.3 (156.6)	
Minnow spp.	43.8 (10.2)	
Northern Pikeminnow	164.0 (121.5)	142.3 (144.6)
Peamouth	201.3 (131.1)	263.0 (N/A)
Pumpkinseed	124.0 (N/A)	
Redside Shiner	101.5 (48.8)	79.0 (N/A)
Sculpin spp.	130.0 (92.0)	143.3 (36.7)
Smallmouth Bass	200.2 (145.3)	
Sucker spp.	184.3 (163.0)	
Tench	407.7 (277.4)	464.5 (58.8)
Threespine Stickleback	48.9 (7.2)	49.8 (8.5)
Walleye	189.0 (N/A)	
Whitefish spp.	107.8 (67.7)	
Yellow Perch	233.0 (82.0)	

Table 6. Catch per unit effort (CPUE) for 35 boat electrofishing (EB) and 7 fyke netting (FN) during the 2012 summer Rocky Reach survey.

Species	EB CPUE (fish/h)	FN CPUE (fish/net night)
Bluegill	0.86	0.00
Bridgelip Sucker	1.89	0.00
Carp	1.37	0.00
Chinook Salmon	0.17	0.14
Chiselmouth	35.14	1.14
Largescale Sucker	91.20	1.86
Longnose Sucker	1.03	0.00
Minnow spp.	1.71	0.00
Northern Pikeminnow	127.20	12.00
Peamouth	13.71	0.14
Pumpkinseed	0.17	0.00
Redside Shiner	92.23	0.14
Sculpin spp.	28.63	0.43
Smallmouth Bass	2.06	0.00
Sucker spp.	9.43	0.00
Tench	1.89	0.57
Threespine Stickleback	1.54	3.57
Walleye	0.17	0.00
Whitefish spp.	1.89	0.00
Yellow Perch	0.34	0.00

Table 7. Number of fish captured (*n*), the expanded population estimate (*N*), and species composition (%) using expanded population estimates of fish captured in summer pop nets within dense macrophyte mats at specific locations of the Rocky Reach Pool.

Species	*n*	*N*	%	Species	*n*	*N*	%
Chiselmouth	7	7	0.9	Sculpin spp.	21	22	2.7
Minnow spp.	1	1	0.1	Smallmouth Bass	1	1	0.1
Northern Pikeminnow	74	99	12.3	Sucker spp.	47	60	7.4
Peamouth	9	9	1.1	Threespine Stickleback	435	568	70.5
Redside Shiner	37	37	4.6	Unknown	2	2	0.2

Table 8. Range in total length (mm) of fish captured in 27 pop nets located within areas of high macrophyte densities within the Rocky Reach Project.

Species	Min. Total Length (mm)	Mean Total Length (mm)	Max. Total Length (mm)
Chiselmouth	31	70	110
Northern Pikeminnow	12	31	98
Peamouth	13	19	23
Redside Shiner	19	63	82
Sculpin spp.	24	33	44
Smallmouth Bass	81	81	81
Sucker spp.	14	29	53
Threespine Stickleback	16	30	59
Unidentified Fish	10	10	10

Table 9. Mean standard water quality param collected from locations where pop nets were deployed during August of 2012 Rocky Reach Resident Fish Survey. Water quality profiles were taken at 1 meter intervals from the surface to the substrate.

Location	Temperature	Specific Conductance	Dissolved Oxygen	pH	Turbidity	Secchi Depth
	C	us/cm	mg/L	pH	NTU	meters
24-2	17.84	152.00	10.14	8.13	0.05	0.20
24-3	17.94	150.50	11.53	8.58	0.78	0.70
24-4	18.00	150.75	11.32	8.53	0.35	0.55
24-5	17.89	151.00	10.43	8.27	-0.55	1.00
25-2	17.87	152.00	10.86	8.30	0.70	0.40
25-3	18.03	152.00	10.76	8.17	2.80	0.30
25-6	17.95	152.00	10.29	8.11	0.73	1.50
25-7	17.81	151.00	10.13	8.03	3.25	0.50
26-1	17.97	156.00	10.54	8.38	0.90	1.00
26-2	17.83	152.00	10.71	8.41	-0.10	2.00
26-3	17.70	152.00	10.71	8.41	2.45	0.70
26-4	17.61	150.50	10.53	8.25	0.25	0.80
26-5	17.09	153.00	10.79	8.26	0.65	1.00
28-9	17.71	151.00	10.86	8.31	0.35	0.50
30-8	17.40	150.67	10.88	8.27	-0.63	1.20
32-13	17.46	150.50	10.61	8.35	-1.00	0.90
32-14	17.46	150.00	10.95	8.45	-0.60	1.30
33-6	17.90	151.00	10.17	8.08	-0.80	0.80
33-8	17.66	150.00	11.00	8.48	-1.05	1.00
34-5	17.38	151.00	10.35	8.13	-0.90	0.70
36-13	17.99	151.00	10.61	8.12	-0.45	0.70
36-14	17.47	151.00	10.30	8.06	2.67	1.20
36-15	16.60	151.50	11.00	8.37	5.55	0.94

Fall Sampling

During the fall sampling period, *Cyprinids* commonly referred to as minnows (redside shiners, chiselmouth and northern pikeminnow) dominated the species composition of fish captured in our boat electrofishing and fyke netting efforts (Table 10). Although not as abundant relative to other species sampled, largescale sucker still represented 56% of the biomass captured during our efforts (Table 11). Fyke nets captured 12 different species during the fall sampling including bluegill and a tagged adult steelhead that were not captured with boat electrofishing. Boat electrofishing yielded 18 different species, the majority of which had a mean length longer than the same species captured in the fyke nets (Table 12). The CPUE data indicated the most abundant families of fish collected were minnows and suckers with as many as 198 redside shiners collected in a typical hour of electrofishing. Three-spine sticklebacks were caught at a rate of 43 per night in the fyke nets deployed during the fall sampling period (Table 13). During the summer and fall surveys, 20 species of fish of which seven were introduced and not native to Washington State were collected (Table 14).

Table 10. Species composition by number of fish captured by electrofishing boats (EB) or with fyke nets (FN) during the fall sampling period.

Species	EB %	EB #	FN %	FN #
Bluegill	0.0		0.4	2
Bridgelip Sucker	0.5	14	0.0	
Carp	0.1	2	0.0	
Chiselmouth	16.8	452	5.6	31
Largemouth Bass	0.2	6	0.0	
Largescale Sucker	11.1	299	1.6	9
Longnose Sucker	0.3	9	0.4	2
Minnow spp.	0.2	5	0.0	
Northern Pikeminnow	15.5	417	8.7	48
Peamouth	5.0	135	1.1	6
Redside Shiner	43.0	1,158	10.3	57
Sculpin spp.	4.2	112	0.0	
Smallmouth Bass	0.1	4	0.4	2
Steelhead	0.0		0.2	1
Sucker spp.	0.7	20	0.7	4
Tench	0.0	1	0.0	
Threespine Stickleback	1.2	33	70.4	388
Walleye	0.1	3	0.0	
Whitefish spp.	0.8	22	0.0	
Yellow Perch	0.1	4	0.2	1

Table 11. Biomass of individual species for both electrofishing (EB) and fyke net (FN) sampling during 2012 fall survey.

Species	EB %	EB Wt.(g)	FN %	FN Wt. (g)
Bluegill	0.00		2.57	170
Bridgelip Sucker	1.07	2,357	0.00	
Carp	0.79	1,749	0.00	
Chiselmouth	9.86	21,702	7.06	467
Largemouth Bass	0.03	61	0.00	
Largescale Sucker	56.92	125,247	51.70	3,422
Longnose Sucker	2.04	4,482	14.16	937
Minnow spp.	0.08	172	0.00	
Northern Pikeminnow	13.90	30,594	9.84	651
Peamouth	7.11	15,642	10.70	708
Redside Shiner	4.36	9,605	3.14	208
Sculpin spp.	1.18	2,602	0.00	
Smallmouth Bass	0.08	182	0.15	10
Steelhead	0.00		0.00	
Sucker spp.	0.01	22	0.12	8
Tench	0.67	1,474	0.00	
Threespine Stickleback	0.01	15	0.54	36
Walleye	0.60	1,323	0.00	
Whitefish spp.	1.19	2,614	0.00	
Yellow Perch	0.09	207	0.03	2

Table 12. Mean length total length (mm) and 95% confidence interval (CI) of fish captured via boat electrofishing (EB) and fyke netting (FN) during the fall 2012 Rocky Reach Resident fish survey.

Species	EB Length (95% CI)	FN Length (95% CI)
Bluegill		146.5 (41.0)
Bridgelip Sucker	245.9 (90.0)	
Carp	584.5 (340.8)	
Chiselmouth	169.7 (89.1)	95.5 (92.5)
Largemouth Bass	88.0 (36.3)	
Largescale Sucker	303.3 (274.3)	216.9 (387.7)
Longnose Sucker	361.7 (145.1)	362.5 (137.2)
Minnow spp.	109.0 (206.7)	
Northern Pikeminnow	178.6 (146.8)	108.4 (81.0)
Peamouth	216.3 (169.7)	243.3 (111.3)
Redside Shiner	97.1 (54.7)	77.9 (42.3)
Sculpin spp.	114.7 (53.5)	
Smallmouth Bass	109.0 (171.5)	69.5 (41.0)
Steelhead		561.0 (N/A)
Sucker spp.	53.3 (22.6)	61.8 (8.5)
Tench	531.0 (N/A)	
Threespine Stickleback	38.3 (22.6)	47.0 (13.8)
Walleye	244.0 (455.9)	
Whitefish spp.	218.5 (115.2)	
Yellow Perch	117.5 (165.7)	56.0 (N/A)

Table 13. Catch per unit effort (CPUE) for 35 boat electrofishing (EB) and 9 fyke netting (FN) during the 2012 fall Rocky Reach survey.

Species	EB CPUE (fish/h)	FN CPUE (fish/net night)
Bluegill	0.00	0.22
Bridgelip Sucker	2.40	0.00
Carp	0.34	0.00
Chiselmouth	77.49	3.44
Largemouth Bass	1.03	0.00
Largescale Sucker	51.26	1.00
Longnose Sucker	1.54	0.22
Minnow spp.	0.86	0.00
Northern Pikeminnow	71.49	5.33
Peamouth	23.14	0.67
Redside Shiner	198.53	6.33
Sculpin spp.	19.20	0.00
Smallmouth Bass	0.69	0.22
Steelhead	0.00	0.11
Sucker spp.	3.43	0.44
Tench	0.17	0.00
Threespine Stickleback	5.66	43.11
Walleye	0.51	0.00
Whitefish spp.	3.77	0.00
Yellow Perch	0.69	0.11

Table 14. Origin and current status of fish collected during the 2012 Rocky Reach Resident Fish Survey.

Species	Origin	Predator	Current Game Fish[1]
Bluegill	Introduced		X
Bridgelip Sucker	Native		X
Carp	Introduced		
Chinook Salmon[2]	Native		X
Chiselmouth	Native		
Largescale Sucker	Native		X
Longnose Sucker	Native		X
Minnow spp.	Native[3]		
Northern Pikeminnow	Native	X	X
Peamouth	Native		X
Pumpkinseed	Introduced		X
Redside Shiner	Native		
Sculpin spp.	Native		
Smallmouth Bass	Introduced	X	X
Sucker spp.	Native		X
Tench	Introduced		
Threespine Stickleback	Native		
Walleye	Introduced	X	X
Whitefish spp.	Native		X
Yellow Perch	Introduced		X

[1]Game fish are defined by the WDFW in the 2012-2013 Fishing in Washington Rules Pamphlet. http://wdfw.wa.gov/fishing/regulations/
[2]Defined by the WDFW as a food fish.
[3]Although carp and tench are minnows, all minnows unidentified to species were of native origin.

Index of biotic integrity scores were similar for both the Rocky Reach and Priest Rapids projects (Table 15). The IBI score was lower in the Rocky Reach Project by two points, which is classified as "Good–Fair" compared to "Good" in the Priest Rapids Project. This was due to the higher percent of individuals as omnivores, lower percent of individuals as insectivores, and lower percent of introduced species. The higher percent of omnivores may be a result of the higher number of suckers captured in the Rocky Reach Project (604) compared to the Priest Rapids Project (410). Fewer introduced species were captured in the Rocky Reach Project compared to the Priest Rapids Project, particularly bass. Smallmouth bass were captured at a rate of six and two fish per hour in Priest Rapids and Rocky Reach, Respectively. No largemouth bass were caught in the Rocky Reach project whereas they were caught at a rate of two per hour in the Priest Rapids Project.

Table 15. Community metrics scores and total index of biotic integrity (IBI) scores calculated for data collected in 2012. Fish were collected via boat electrofishing in the Rocky Reach Project and the Priest Rapids Project (WDFW 2012 unpublished data).

	Score and (Value)	
	Rocky Reach Project	Priest Rapids Project
Species richness and composition		
Total number of native species	5 (13)	5 (15)
Number of cottid species	1 (1)	1 (1)
Number of native cyprinid species	3 (5)	3 (5)
Number of catostomid species	5 (4)	5 (4)
Number of intolerant species	5 (4)	5 (5)
% of individuals as common carp	5 (<1)	5 (<1)
Trophic composition		
% of individuals as omnivores	3 (25.9)	5 (20.6)
% of individuals as insectivores	3 (34.2)	5 (45.5)
% of individuals as catchable salmonids[1]	1 (<1)	1 (<1)
Fish abundance and condition		
Number of individuals	5 (2,407)	5 (2,000)
% of individuals introduced (exotic)	5 (1.7)	3 (4.4)
% of individuals with anomalies[2]	5 (<1)	5 (<1)
Total IBI Score	46	48
Class	Good–Fair	Good

[1]Salmonids (excluding whitefish) > 200mm.
[2]i.e. disease, tumors, fin damage.

Discussion

As expected for the species of fish that were sampled in high numbers, cohort mean lengths increased between the summer and fall sampling periods. In addition, CPUE data indicates that the distribution of fish throughout the Project also varies between summer and fall sample periods. Variations in distribution between seasons are often attributed to life history traits such as temporal spawning movements, seasonal changes in prey distribution, water temperatures, or both. Due to seasonal variability, it is not appropriate to directly compare catch data between the summer and fall periods. The sampling design employed in 2012 and related data will be used for comparison with future resident fish population surveys to detect potential changes in species composition.

Similar to other pools in the Mid-Columbia a large number of minnows and suckers were sampled. However, the Rocky Reach Pool lacks comparative numbers of non-native predators such as smallmouth bass to other areas within the Mid-Columbia River. The lack of non-native predators captured during the surveys could be related to sampling error and gear bias or the lack of suitable habitat within the Rocky Reach Project. The former of the two possibilities is not likely as multiple gears types were used throughout Lake Entiat during multiple times of the year. Furthermore, boat electrofishing and fyke netting are two sampling methods commonly used by WDFW staff to a evaluate warmwater fish populations within Washington State (Bonar et al 2000). The lack on non-native predators was further corroborated during an unrelated contract that was to determine the relative abundance of predators around docks within the Rocky Reach Project. During this sampling effort, no smallmouth bass were collected and only one walleye and four largemouth bass were collected (WDFW unpublished data 2012).

The Chelan County PUD Fish Management Plan suggests the lack on non-native predators within the Rocky Reach Project can be attributed to the lack of quality available habitat (Chelan PUD, 2006). Water temperatures within the Rocky Reach pool is most likely factor limiting warmwater fish production. Smallmouth bass for example spawn between 15.6-18.3 ^{o}C (Becker 1983) and have an optimal temperature range of 21.1-26.7 ^{o}C (Wydoski and Whitney 2003). During 2012, water from Wells Dam was within the range for smallmouth to spawn (Columbia Basin Research 2012). However, temperatures never exceeded 19 ^{o}C and until the end of August. Such cold temperatures would negatively impact incubation times. In addition, it is thought that should a spring spawn be successful that this would coincide with annual high flow events, which would cause male bass to abandon their nests (Wydoski and Whitney 2003). Although slightly more tolerant with respect to temperature requirements, largemouth bass prefer shallow weedy lakes and backwaters (Wydoski and Whitney 2003) which are limited within the Rocky Reach Project.

Walleye are another non-native fish found within the Columbia River and can be found in waters from 0-32.2 ^{o}C (Wydoski and Whitney). Walleye broadcast spawn in rivers below structures such as waterfalls and dams (Colby et al 1979). Considerably more fecund than the bass species, walleye exhibit no parental care post spawning. Consequently, walleye eggs and fry are highly susceptible to predation and experience high mortality rates. Temperatures within the Rocky Reach Project are within the range acceptable for walleye to spawn. However, the retention time within the Project is on average 1.8 days (Chelan PUD 2001). Walleye prefer relatively low velocities (Jones et al. 1974) which are not present within the Project waters. The likelihood of the bass species or walleye remaining in the Rocky Reach Reservoir is very unlikely due to the high probability of larval fish entrainment under current conditions (Winchell et al. 1997).

The CPUE of both bass species and walleye were caught at a rate less than one percent of the northern pikeminnow CPUE. Therefore, the impact of the three non-native predators is most likely negligible. A well-designed food habits study would further corroborate this assumption. The impacts of northern pikeminnow have been well documented and have resulted in the development of removal programs throughout the Columbia Basin. Between 1994 and 2012 the Chelan PUD has removed over 600,000 northern pikeminnow from project waters (Chelan PUD 2006; Chelan PUD http://www.chelanpud.org/documents/39456_ComparisonCatch.pdf). In addition, the Chelan PUD also currently sponsors an annual northern pikeminnow tournament in conjunction with the East Wenatchee Rotary Club. This effort not only removes excess predators during the event but could also spark an interest in anglers learning to more efficiently target northern pikeminnow during non-tournament times.

One of the concerns the Chelan PUD has with the Rocky Reach pool are the large number of macrophyte mats and what their impacts may be on water quality in the vicinity of the mats. There have been recorded instances in other systems of submerged vegetation impacting dissolved oxygen and pH param (Clayton and Edwards 2006; Frodge et al. 1990). However in a system such as the Rocky Reach pool where there is a constant flow of water and a mean hydraulic retention time of as little as one day (Chelan PUD 2001; S. Hemstrom, personal communication), the likelihood of sustained poor water quality standards persisting is minimal. That being said, fish in the egg stage could be impacted by low D.O. and poor pH conditions in localized areas with dense macrophyte growth. Such conditions would be a concern if no young of year fish were detected, but that was not the case. In addition, macrophyte mats do not become established until spawning and incubation for most fish within the project in completed. The abundance of young-of-the-year fish suggests dense macrophytes aggregations are not impacting water quality on a scale that affects fish production and habitat utilization.

Prior the commencement of the Rocky Reach resident fish survey, we expected to encounter a higher abundance of game fish like smallmouth bass and walleye as in other nearby reservoirs If congregations of such fish had been identified locations could have been published and an angler friendly GIS product used to target said populations. Not only would this strategy have been desirable to many anglers but could potentially relieve deleterious interactions between native and non-native fishes within the system had they existed. However, our sampling methods during both seasons yielded very few desirable game fish.

Some of the original ideas for creating stronger resident fisheries within the Rocky Reach pool were to supplement the reservoir with such species as kokanee or rainbow. However, a program would not be beneficial to the sensitive and listed species that utilize and pass through the project. Kokanee for example, have been used extensively throughout the Northwest with some degrees of success in various lake and reservoir systems. However, several researchers have found that kokanee can be susceptible to entrainment and the likelihood of kokanee remaining in a reservoir system like Rocky Reach with its strongly riverine flow conditions is minimal

(Maiolie et al. 1992; Stober et al. 1983). In addition, the potential for kokanee to negatively interact with returning sockeye salmon would exist.

Hatchery and pen reared rainbow trout are the most stocked resident species in the Pacific Northwest. In Washington State, the annual trout opener attracts upwards of 300,000 anglers opening day weekend. This type of fishery, supported by stocking, is appropriate in closed lake systems where immigration and emigration is not possible. However, in open systems with listed salmonids the hatchery supplementation of rainbow trout is not recommended for several reasons. The primary concern with rainbow of hatchery origin within the Rocky Reach Project is the potential to hybridize with native wild stocks and dilute the genetic composition of the listed native populations. In addition, negative interactions between wild fish and hatchery fish have been well documented (McMichael et al. 1999; Nickelson 2003; Weber and Fausch 2003). Interactions can be qualified as competition for resources or direct predation. During the net pen rearing program on Moses Lake it was determined that rainbow trout were one top end predators of other fish species in the lake as indicated by stable isotope analysis (Burgess et al. 2003). Consequently, the supplementation of any fish species that could potentially impact native protected stocks is not recommended.

The question still remains regarding the creation of a resident fishery that is appropriate with the current species assemblage flow characteristics within the Rocky Reach pool. One possible option would be to utilize the resident fisheries within Lake Entiat. For example, carp were introduced to the Great Lake Region in the late 1800s but has only recently been targeted as a formidable game fish primarily by specialized anglers (Baldwin et al. 1962; Bogue 2000). The carp angling trend has also been picking up in the northwest and guided trips are now being offered on Banks Lake (http://www.bennett-watt.com/Fly-Fishing-Adventure-Washingtons-Carp/productinfo/DVDFFAWAC/). In an ever changing and unpredictable fishing environment, anglers are generally resourceful and are willing to change focus and tactics to target other potential fisheries. The fish assemblage within the Rocky Reach Pool is dominated by endemic minnows and suckers. The former of the two groups are sought after in other parts of the world such as Europe. However, suckers are commonly targeted and consumed in the mid-west. Sucker species represented over 20% of the fish captured during the survey and were available at all sites sampled. Therefore, based on their distribution and size, suckers could potentially comprise an alternate resident fishery. Although the idea of eating a sucker may not be appealing to Washington anglers, in other regions of North America suckers are not only targeted for sport but also consumption (Associated Press 2013; Manitoba Conservation Fisheries 2013; Philips 2013).

Conclusion

In its current state the Rocky Reach Pool does not support a viable resident native or non-native fishery. Any option to develop a resident fishery via hatchery supplementation would not be desirable considering the presence of listed and sensitive salmonids that migrate through the Rocky Reach Pool. The lack of non-native predators that can negatively impact native species can be attributed to current environmental conditions associated with the shoreline shape, current flow characteristics, and water temperature regime. However, as with any system changes in environmental conditions could alter the current resident fish assemblage. Environmental conditions could change as a result of regional climate or modification of current water operations. In addition to changes in environmental conditions altering the resident fishery, fish may also be introduced to the Rocky Reach Pool via entrainment and anglers. Recently, a LLRT creel clerk contacted an angler that captured a 66 cm northern pike that was caught at North Port, Washington and another one caught at the confluence of the Colville River and that was over 76 cm long (Figure 7). Salmonids are also susceptible to entrainment from reservoirs within the Columbia Basin. Rainbow trout from FDR and the Pend Oreille have been caught in Banks Lake during LLRT surveys (WDFW unpublished data). As well as the potential for fish to be entrained into the Project, fish can also be relocated by anglers. In 2008 a Moses Lake, tagged walleye was captured just below Wells Dam and it is believed this fish was moved by an angler (WDFW unpublished data).

In closing Rocky Reach Pool does not support a viable recreational fishery and deleterious non-native species were not abundant during our sampling efforts. If performed identically to the methods used during this survey future data collections can be used to detect changes in the resident fish assemblage.

Figure 7. Angler with northern pike caught at the confluence of the Colville River on the FDR Reservoir on July 13, 2013.

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Appendix 1. Comments from Art Viola regarding the direction of the study submitted to the Chelan PUD.

One of the goals of the Resident Fish Study is:

Goal: Recommend future actions needed to increase angling opportunity for resident fish in the Rocky Reach Reservoir.

Objective 1. Identify current resident fish species composition and relative abundance to one another.

Tasks: These need to be filled in, but are basically the field sampling already detailed in the draft study.

Objective 2. Describe the present habitats preferred by each resident fish species and if these are different or change with age class, time of year, water temperatures, and water flows, D.O. levels, etc.

Task 1. A literature search.

Task 2. Compare and describe preferred habitats of resident fish sampled in the field with literature derived information.

Objective 3. Describe current forage resources and resource abundance in the reservoir including, phytoplankton, zooplankton, macro-invertebrates.

Tasks: These need to be filled in, but are basically the field sampling already detailed in the draft study.

Task. Compared and describe preferred forage of resident fish sampled in the field with literature derived information.

Objective 4. Describe competition in time and location for forage among current resident fish species, potential future resident fish (stocked) and anadromous species.

Task 1. Compare and describe preferred forage of resident fish sampled in the field with literature derived information.

Objective 5. Describe predation in time and location among present resident fish species, potential future resident (stocked) and anadromous species.

Task 1. A comparison of field survey results with literature derived information.

Objective 6. Based on data collected in the field and literature derive information evaluate if an ecological niche exits capable of supporting the addition (by stocking) of a new resident fish species e.g. (cutthroat, kokanee or some other species) and whether this niche can be occupied without adding excessive competition for forage or predation to the present day assemblage of resident and anadromous fishes.

Task 1. A comparison of field survey results with literature derived information.

Objective 7. Provide a summary of your recommendations of future actions needed to increase angling opportunity for resident fish in the Rocky Reach Reservoir.

Appendix 2. Standard Operating Procedures for Boat/Towing Operations, Safety, and Gear Types Used for Fish Collections.

Boat Operations and Towing

All permanent LLRT personnel are required to complete both the U.S. Department of the Interior's Motorboat Operators Certification Course (MOCC) as well as the Smith-Root, Inc. Principles of Electrofishing class. Operators and crew are required to wear U.S. Coast Guard approved PFD's (type I, II, III, IV) at all times. All LLRT vessels are equipped with mapping GPS; however, operators should not rely on these systems during operations and always be on the lookout for hazards. While operating a vessel with the LLRT it is important that you adhere to the MOCC student manual as well as the Washington State Parks Adventures in Boating Washington Handbook. Prior to trailering a boat, it is the responsibility of the crew to conduct a thorough safety check of both the tow vehicle and trailer.

Safety checklist

Tow Vehicle

- Tire pressure
- Oil
- Coolant
- Lights and indicators

Trailer and Boat

- Safety chain properly secured
- Lights hooked up and operational
- Everything inside vessel is secured
- Boat is secured to trailer
- Tire pressure
- Greased bearing buddies
- Motor up and locked
- Batteries turned off
- Plug is out during trailering

Towing

- Maintain longer distances between yourself and car in front
- Frequently check mirrors and status of boat

Launching Boat

- Do not unstrap and unchain boat until down the ramp
- Make sure plug is in
- Batteries turned on
- Motor lifted and unlocked
- Trailer lights unplugged
- When stopped on ramp leave truck in gear or park and engage parking brake

- When making final launching approach take off seatbelt and open windows for communications between yourself and crew members outside of vehicle

<u>Gear Types used for Fish Collections</u>
GPS coordinates (UTM) for all sampling gears are collected at each location

Adapted from Bonar et al. (2000)

Fyke Nets
4' high, 3/8" diameter aluminum or stainless steel circular hoops with two 25' wings and up to a 100' lead. Mesh size is 0.25".

- Fyke nets should be set perpendicular to shore.
- Nets should be set in the evening/late afternoon before electrofishing starts and retrieved the next morning.
- Record set time and pick up time.
- Try to set the net so the top of the first hoop is no more than about 1 foot under the water's surface.

Electrofishing
18 ft Smith Root 5.0 Generator Powered Pulsator (GPP) electrofishing boat.

- Electrofishing should be conducted with pulsed DC, high range 100-1000 volts, 120 cycles per second.
- Standardize power output of the electrofishing unit based on the specific conductivity of each lake.
- Electrofish starting at each randomly chosen sampling point for 600 seconds as measured by the timer on the electrofishing unit12. Always record on data sheets the actual number of seconds electrofished (e.g., 578 sec, 600 sec, 605 sec, etc.).
- Electrofish in the same direction from the sampling point for all samples.
- Electrofish pedal operations (continuous or intermittent) are at the discretion of the operator, and should be designed to capture the highest number of fish. Use intermittent electrofishing when approaching structure such as beaver lodges, downed trees, docks, and weed patches.
- Stay off the pedal until close to structure, and then hit the pedal.
- A minimum of two dippers and one driver should be in each electrofishing boat.
- Dippers should attempt to net everything, even young-of-year (YOY).
- We have found that catch rates go down if you electrofish the same section over again.
- Make sure that when fish are worked up, they are released back at the start of the section, and not near the end where they can stray into the next section to be electrofished again. Electrofish at night to have the highest catch rates.

LLRT Amendment to Boat Electrofishing Operations

- Low power, 100-500 volts, and 42-48% range at 30 Hz DC. We have found that fishes respond better to and exhibit galvanotaxis more frequently at lower power settings. In addition, the probability of injury is lessened when fish exhibit taxis compared to tetany.

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Appendix 3. Standard Operating Procedures for Boat Electrofishing (specific methods used for Chelan PUD funded Rocky Reach Project Study).

Purpose
To provide guidelines for physical capture of predatory fish using an electrofishing boat.

Area of Applicability
For USGS and WDFW LLRT personnel collecting fish using an electrofishing boat for the investigation of predator-prey interactions within the Mid-Columbia River.

Materials Needed

- Electrofishing boat with live wells and depth finder
- GPS receiver
- Fiberglass handled nets, rubber gloves, rubber boots, and PFDs
- Data sheets, pens, field notebook
- Timepiece
- Specific conductivity meter
- Back-up headlamps
- Marine radio and or cell phone

Procedures

1. Prior to electrofishing boat deployment, alert KitCom and Chelan Co. dispatch and inform them WDFW LLRT / USGS boats will be conducting research on the Columbia River.
2. Make sure all personnel onboard the electrofishing boat wear rubber boots and PFDs. In addition, netters should wear rubber gloves and use fiberglass handled nets to capture fish.
3. Navigate to selected transect using a GPS receiver and a laptop equipped with GIS software or a paper map with a list of transect coordinates.
    a. Verify that the GPS start point is within the correct reservoir, site strata (i.e. forebay, tailrace, tailrace Boat restriction zones [BRZ], etc.) and depth strata (less than 3 m depth).
    b. If sample point is not in correct reservoir or site strata, randomly select a different site from the provided list of alternate sample points.
    c. If GPS point is onshore or too shallow for electrofishing, move outwards from the GPS start point perpendicular to shore until a depth is reached that can be sampled.
    d. If GPS point is too deep for electrofishing, from GPS start point move perpendicular towards shore until a depth is reached that can be sampled.
    e. Estimate whether the entire electrofishing transect will be within the specified depth strata (less than 3 m). If the entire transect will likely not fit within the specified depth strata, randomly select a different site from the provided list of alternate sample points, such that the entire transect will be within the less than 3 m depth strata. Repeat steps 2a-2d if necessary.

    f. If a GPS site is located such that the crew determines the site is not safe to sample, then the safety issue will be recorded, and a different site from the provided list of alternate sample points will be chosen randomly. Repeat as necessary.

4. Record the following information on the data sheet before electrofishing begins: Outing Start Date (MM/DD/YYYY), Reach & Location (e.g. WM1; Character (C) 1 is reach/Project (R=Rock Island, W=Wanapum or P=Priest Rapids), C2 is location within reach (F=forebay, M=mid, T=tailrace), C3 is 0=BRZ or 1=non-BRZ)), Net #, Start Date/Time (HH:MM in military time), Assigned UTM coordinates, Assigned Depth Strata, Boat Operator, Netters, Temperature (°C [°C]), and Specific conductivity (in microsiemens per cm).
5. At the start of sampling, using the GPS receiver, record the Actual UTM Start (in UTM zone 10N WGS84) on the data sheet.
6. Moving in an upstream direction in waters between 0.5-3 m, perform low-power electrofishing using 50-500 volts and 42-48% range at 30 Hz DC, to produce 1-2 amps. Standardize power output of the electrofishing unit based on the specific conductivity of the water. If fish display severe tetanus, adjust settings to induce taxis and minimize tetanus.
7. Electrofish pedal operations (continuous or intermittent) are at the discretion of the operator, and should be designed to capture the highest number of fish. Use intermittent electrofishing when approaching structures such as beaver lodges, downed trees, docks, and weed patches. Stay off the pedal until close to structure, and then hit the pedal.
8. Never cover the same section that you have electrofished over again, as catch rates decrease.
9. Electrofishing is discontinued in any transect where excessive numbers of salmonid juveniles or adults are incidentally shocked. When adult salmon are encountered, temporarily turn off the electric power allowing the adult to swim free and escape. Non-target species should be counted but not netted.
10. Place netted fish in circulating live wells until they can be processed.
11. At the end of the transect (600 electrofishing seconds) record Actual UTM End, End Date/Time, Effort (the actual number of seconds electrofished - from the boat’s counter), Power (high or low, Hz and % Range), Minimum (Min) Actual Depth (in m), and Maximum (Max) Actual Depth (in m).
12. Make sure that after fish are worked up, they are released back at the start of the section, and not near the end where they can stray into the next section to be electrofished again.

Appendix 4. Standard Operating Procedures for Water Quality Data Collection.

Purpose
To provide guidelines for conducting water quality surveys.

Area of Applicability
For WDFW LLRT personnel conducting water quality surveys.

Materials needed

- YSI 6600 V2 Multiparameter Water Quality Sonde, handheld YSI computer and cord
- Secchi disk and line
- Anchor and line
- Bucket
- Static sites
- Data sheets and pencils

Procedures

1. Arrive at specific site using GPS coordinates. Throw anchor and make sure the boat is not moving. Fill bucket 2/3 full of water from the body of water to be sampled. Use the YSI sonde to measure the water quality param.
2. Before sampling begins, hold the YSI sonde just below the surface of the water for 40 seconds prior to recording any data to acclimate the YSI sonde and allow it to clean the optic ports. The first reading can then be taken at the surface and then at each meter until the bottom is reached (try not to touch the bottom).
3. Param are logged on the handheld YSI computer and recorded on the water quality data sheets (Figure 1). The param include depth (m), temperature (°C), specific conductivity (s/cm), dissolved oxygen (mg/L), pH, turbidity (NTU) and chlorophyll (μg/L). Also, record the barometric pressure at the first site.
4. After the last reading is recorded at the bottom of the water column, slowly pull the YSI sonde up and out of the water. Place the YSI sonde in the bucket of water that was previously filled. The bucket should be dumped and refilled periodically throughout the day.
5. Secchi depths are taken at each site. Sunglasses and hats should be removed when taking readings. The Secchi disk is lowered into the water on the shaded side of the boat. Once the disk disappears, pull it back up until it reappears again. Raise the disk up and down until the exact vanishing point is found and record the depth (m) on the data sheet.
6. After all data is recorded and equipment is secured, pull anchor and proceed to the next site.

W.Q. Data Sheet
Page: ____________ Project: ________

Date: ________ B.P. ________ Initials: ____________

Field data check ________
Office data check ________
Bio data check

Location	Depth (m)	Temp.	SpC	D.O. mg/L	pH	Turbidity NTU	Chl (µg/L)	Secchi (m)	Zoop. Pull Depth (m)

Calibration date:	
Comments	

Appendix 5. Calibration Instructions for the YSI 6600 V2 Multiparameter Water Quality Sonde.

Purpose
To provide guidelines for calibration methods to ensure the YSI 6600 V2 Multiparameter Water Quality Sonde is accurate for specific bodies of water.

Area of Applicability
For WDFW LLRT personnel calibrating the YSI 6600 V2 Multiparameter Water Quality Sonde.

Materials needed
- YSI 6600 V2 Multiparameter Water Quality Sonde, YSI computer and cord
- Distilled water
- Known turbidity standard (<0.1, 10, 20, and 40 NTU)
- 4, 7, and 10 pH standards
- Known conductivity solution
- KimWipes®
- Paper towels
- Calibration data sheet

Procedures
1. Fill out a calibration data sheet for the specific body of water to be sampled and gather the proper standards for the calibration.
2. Connect the YSI sonde to the handheld YSI computer with its field cord. Turn on the handheld YSI computer and bring up the calibration menu. Remove the black cap from the calibration cup on the YSI sonde and fill 1/3 of the calibration cup with distilled water. Replace the cap and swish gently to rinse. Empty the distilled water and repeat the rinse step. For the calibration of conductivity and pH, the calibration cup will be attached to the YSI sonde and the probes are pointing up when standards are poured. For the calibrations turbidity, chlorophyll, and dissolved oxygen, the calibration cup is removed from the YSI sonde and inserted so that the probes are now pointing down.
3. On the calibration menu, scroll to the conductivity option and press enter. Choose the SpCond option for specific conductivity and press enter. Enter the value of standard used in this calibration (for most of our water quality surveys we calibrate at 0.5 µm/s). Fill the calibration cup to cover the sensor. Pay close attention that air bubbles are removed from the sensor for an accurate reading. On the handheld YSI computer, press enter to start the calibration and allow some time for the sensor to give an accurate reading. Record this reading in the in the "actual" box on the calibration data sheet and then press the enter key again to calibrate the sensor. A new number should read on the screen. Record this number in the "after calibration" box. The standard should then be transferred into a clean, labeled bottle for benchmarking after the survey is completed. Rinse the calibration cup and sensors with distilled water for the next calibration.
4. Select pH from the calibration menu on the handheld YSI computer. Choose the 3-point calibration option from the menu. Start with the pH 7 standard (press 7 on the numeral keypad). Pour a small amount of the pH 7 standard over the sensor and then swish to rinse out any existing distilled water and empty. Fill the calibration cup with pH 7

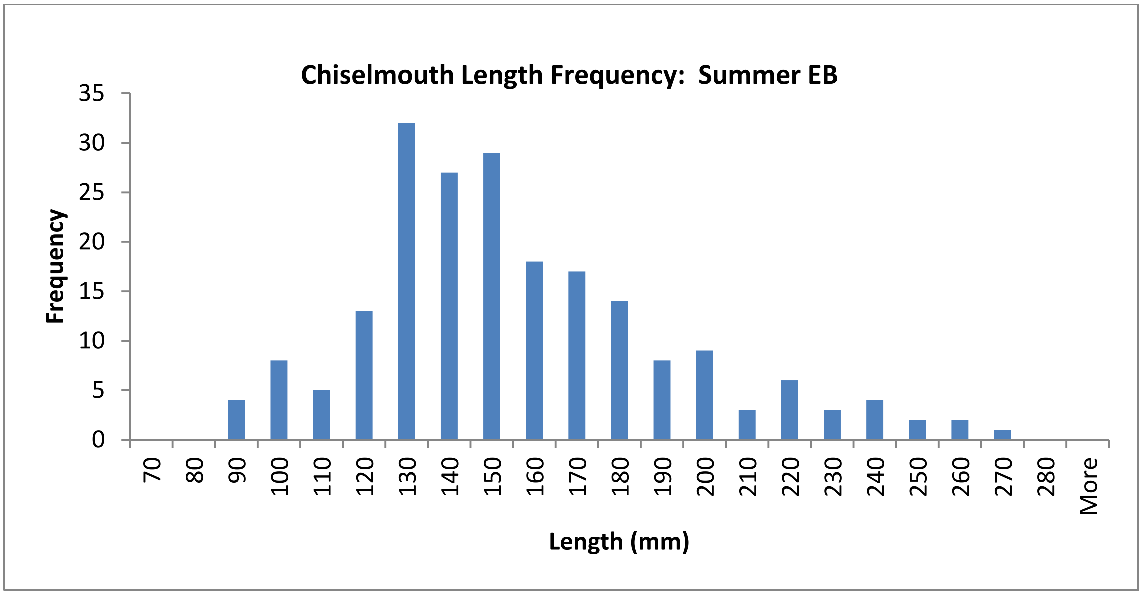
standard to cover the sensor. On the handheld YSI computer, press the enter key and allow some time for the sensor to give an accurate reading. Record the actual reading along with pH MV Buffer reading on the data sheet in the appropriate boxes. Press enter to accept calibration, and record the next readings in the "after calibration" boxes. Once calibration is successful, pour the pH 7 standard into a clean, labeled bottle for benchmarking after the survey is completed. Rinse out the calibration cup with distilled water for the next standard. Repeat step 4 for using pH standards 4 and 10.

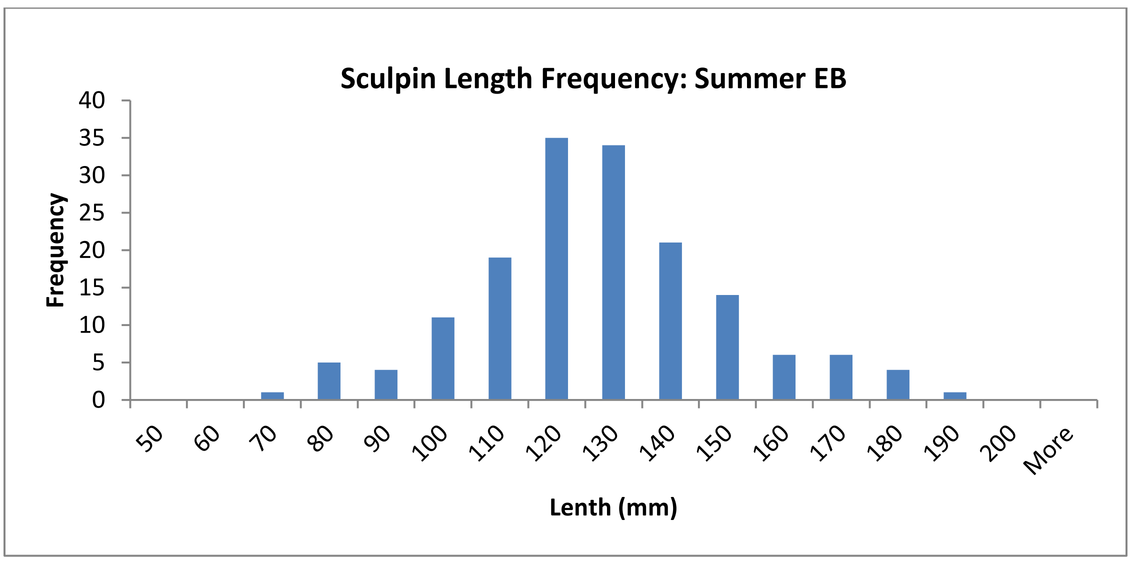
5. Next, choose turbidity 3-point calibration on the handheld YSI computer. The calibration will start with a 0 value. To begin, rinse the sensors and calibration cup with distilled water and dry with KimWipes®. Pay close attention to dry between the sensors. The calibration cup should be removed and completely disassembled to dry all parts. Reassemble the calibration cup and pour in a small amount of the <0.1 NTU standard to rinse the calibration cup and the YSI sonde sensors. The calibration cup and instruments must be dried again. Reassemble the calibration cup with the black lid attached to the bottom. Pour <0.1 NTU standard into the calibration cup until it is about 1/3 full. Immerse the sensors carefully into the standard (make sure no bubbles are on the sensor); if the standard does not completely cover the bottom of the sensor add a small amount of <0.1 NTU standard to the calibration cup. Press the enter key to give the actual reading. There will be an option to clean optics; select this for the best calibration results. Once the cleaning is through, record the reading in the in the "actual" box on the calibration data sheet, accept the calibration, and record the reading again in the "after calibration" box on the calibration data sheet. Repeat this process for the next two turbidity calibrations.
6. Rinse the calibration cup and the YSI sonde sensors with distilled water. Choose the chlorophyll option from the calibration menu and then the 1-point calibration from the next menu. Fill the calibration cup 1/3 full with distilled water and immerse the YSI sonde into the calibration cup. Run the optic cleaner to remove any bubbles or debris. Record the actual reading and accept the calibration. Record the next reading also. Empty the distilled water from the calibration cup.
7. Return to the calibration menu and select dissolved oxygen and then %Saturated. Fill the calibration cup 1/3 full with distilled water and set the sensors into the calibration cup. Make sure no water droplets are on the dissolved oxygen membrane and the water level is not touching the membrane. Enter the barometric pressure on the handheld YSI computer located at the bottom of the screen and select enter. Let the meter sit up to ten minutes and then record the actual and calibrated values.
8. Empty the water, replace the wet sponge in the calibration cup, and screw it back onto the YSI sonde. Pack all the components back into the travel bag.
9. Upon return from the water quality sample period, benchmark each standard. Test each standard with the YSI sonde to document the values after the survey. Use distilled water to rinse between each standard. The turbidity samples must be benchmarked with the same procedures as in step 5. The calibration cup and the YSI sonde must be cleaned and dried before each turbidity standard. Each benchmark value should be recoded in the proper space on the calibration data sheet.

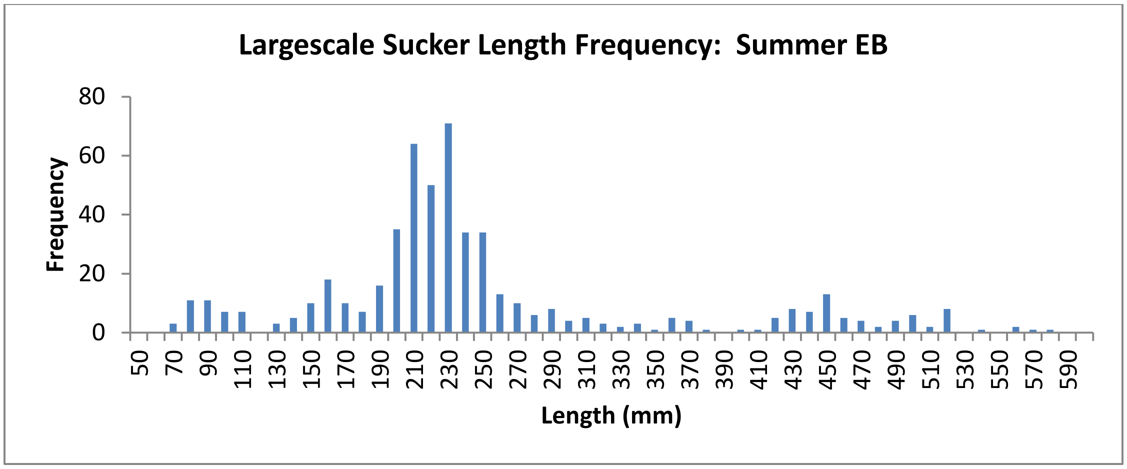
Appendix 6. Number of individuals of each species captured at each site during August 2012 pop netting efforts. Chiselmouth (CMO), sculpin spp. (COT), minnow spp. (CYP), northern pikeminnow (NPM), peamouth (PMO), redside shiner (RS), smallmouth bass (SMB), sucker spp. (SK), threespine stickleback (TSS), unknown (UNK).

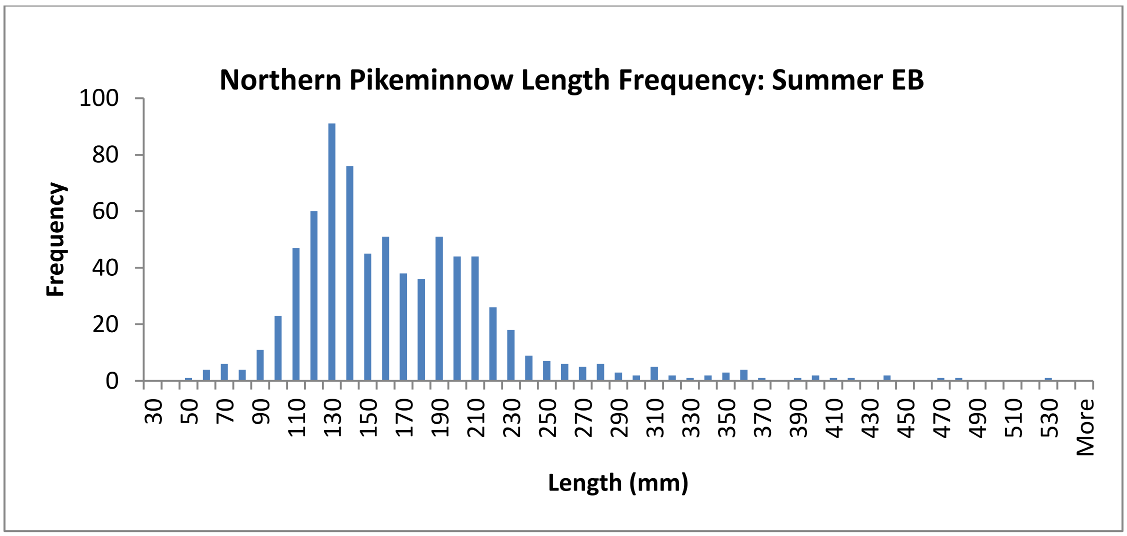
Site	CMO	COT spp.	CYP spp.	NPM	PMO	RS	SMB	SK spp.	TSS	UNK
24-2		1		37	2			2	116	1
24-3		1		6				1	72	
24-3A.2	1			12		36		6	18	1
24-3B		1			2			1		
24-4A					1	1		1	11	
24-4B		2							5	
24-5		1						8	20	
25-2				12					1	
25-3				1			1			
25-6		4							1	
25-7		2							1	
26-1A	4			10					16	
26-1B	1	4		1				6	1	
26-2				4				1	54	
26-3				1				10	1	
26-4									1	
26-5										
28-9				2				4	67	
30-8		3		2				1	3	
32-13				1	2				52	
32-14			1					2	1	
33-6		2						7		
33-8		1		4	2			1	4	
34-5				1					45	
36-13								2	77	
36-14	1			5					1	
36-15								7		
#per site	7	22	1	99	9	37	1	60	568	2
%N	0.9	2.7	0.1	12.3	1.1	4.6	0.1	7.4	70.5	0.2

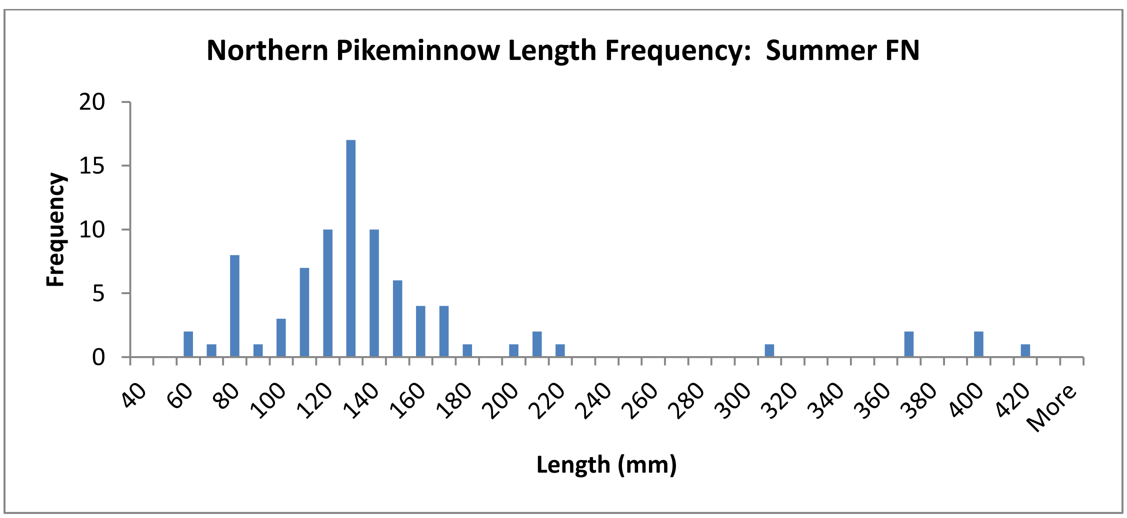
Appendix 7. Length frequency histograms of species captured during the summer and fall 2012 boat electrofishing (EB) and fyke netting efforts (FN). Histograms developed for species with more than 30 individuals collected.

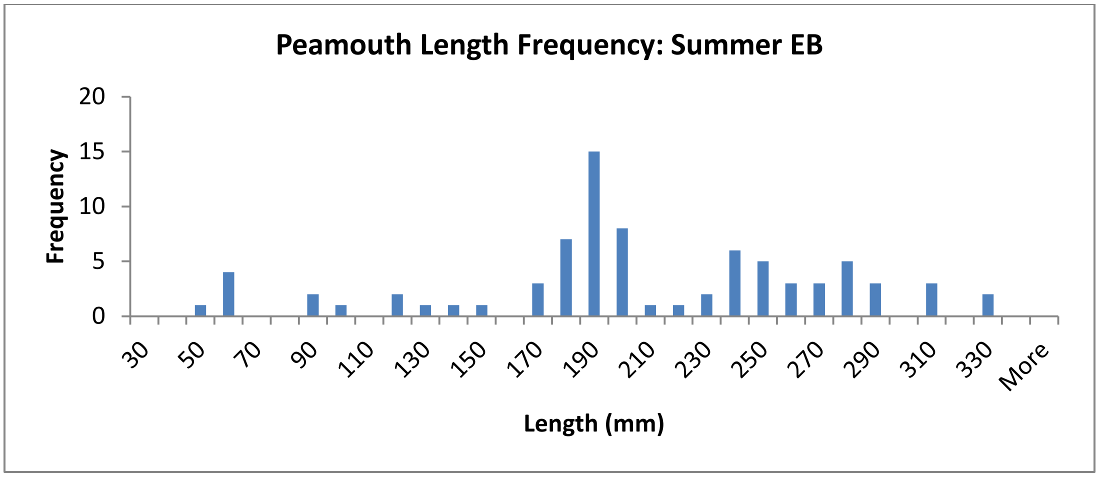


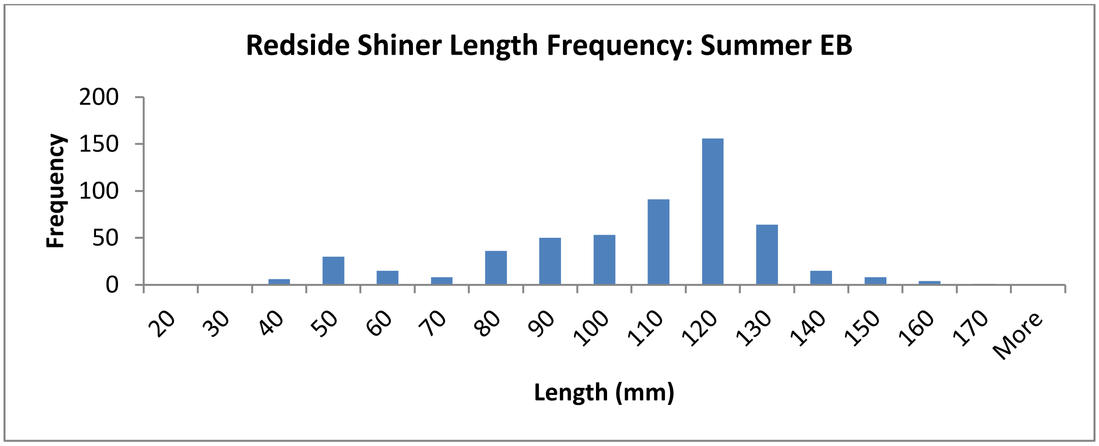


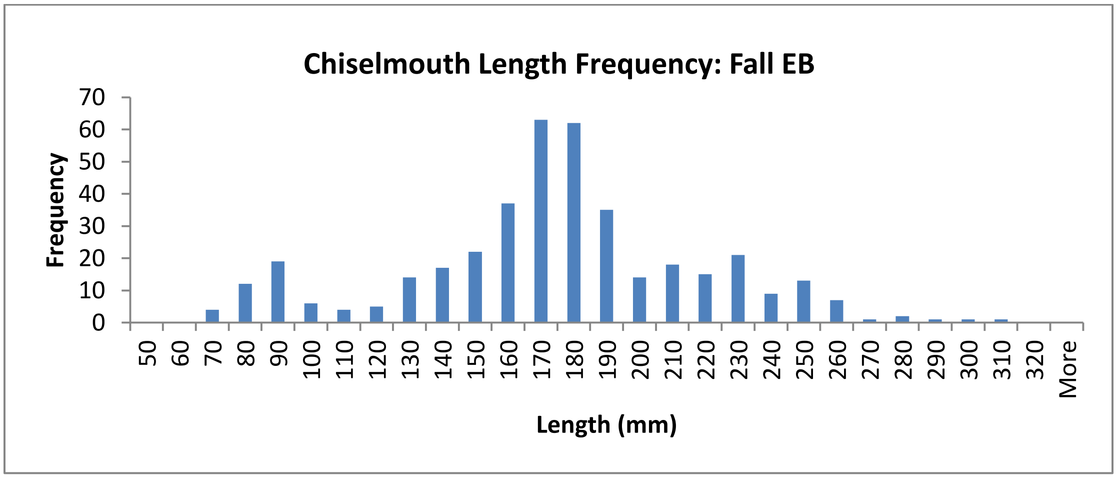

Largescale Sucker Length Frequency: Summer EB
Frequency
80
60
40
20
0
50
70
90
110
130
150
170
190
210
230
250
270
290
310
330
350
370
390
410
430
450
470
490
510
530
550
570
590
Length (mm)

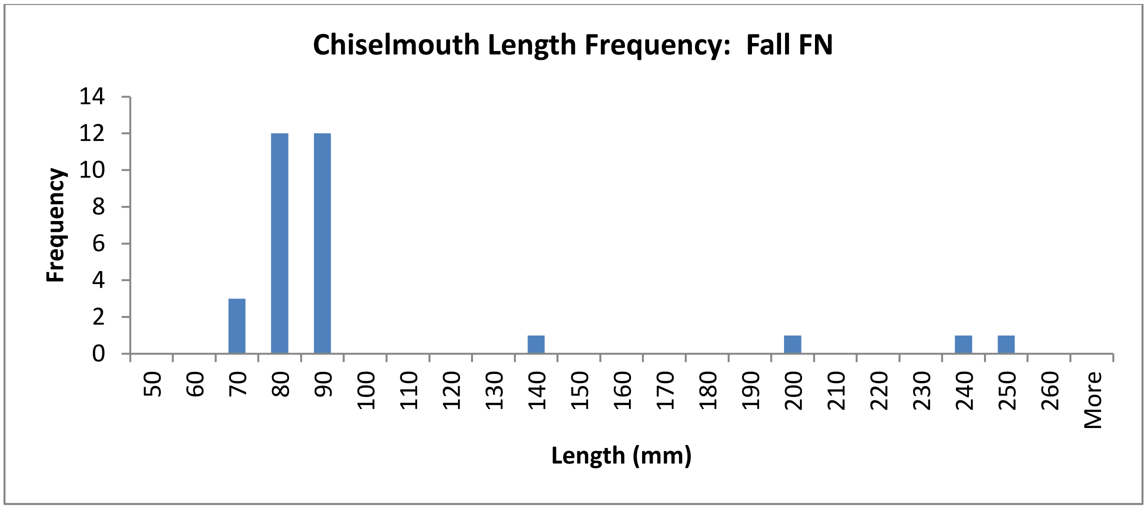

Northern Pikeminnow Length Frequency: Summer EB
Frequency
100
80
60
40
20
0
30
50
70
90
110
130
150
170
190
210
230
250
270
290
310
330
350
370
390
410
430
450
470
490
510
530
More
Length (mm)

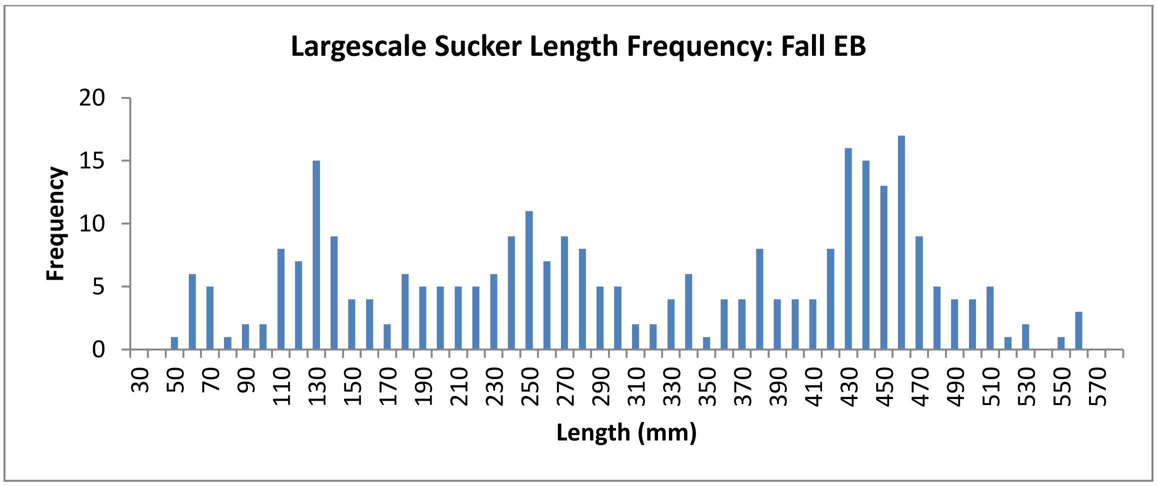

Northern Pikeminnow Length Frequency: Summer FN
Frequency
20
15
10
5
0
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
More
Length (mm)

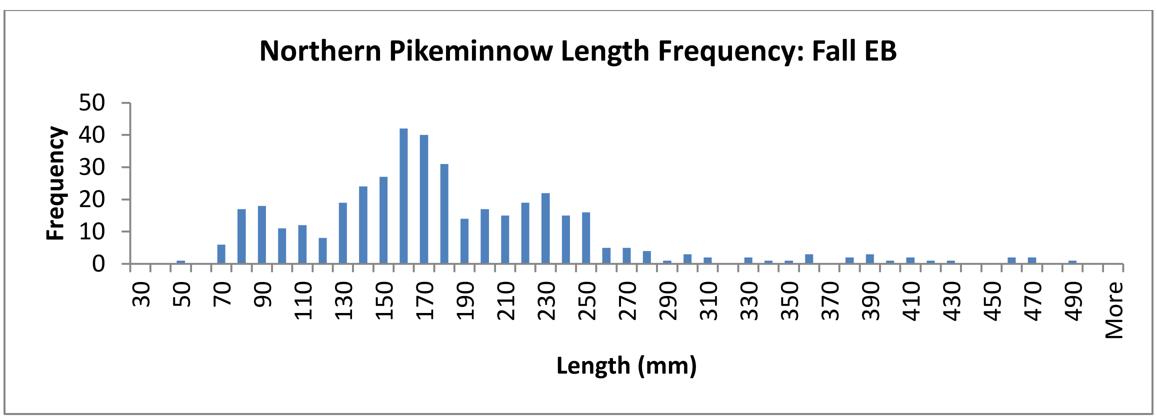

Peamouth Length Frequency: Summer EB
Frequency
20
15
10
5
0
30
50
70
90
110
130
150
170
190
210
230
250
270
290
310
330
More
Length (mm)

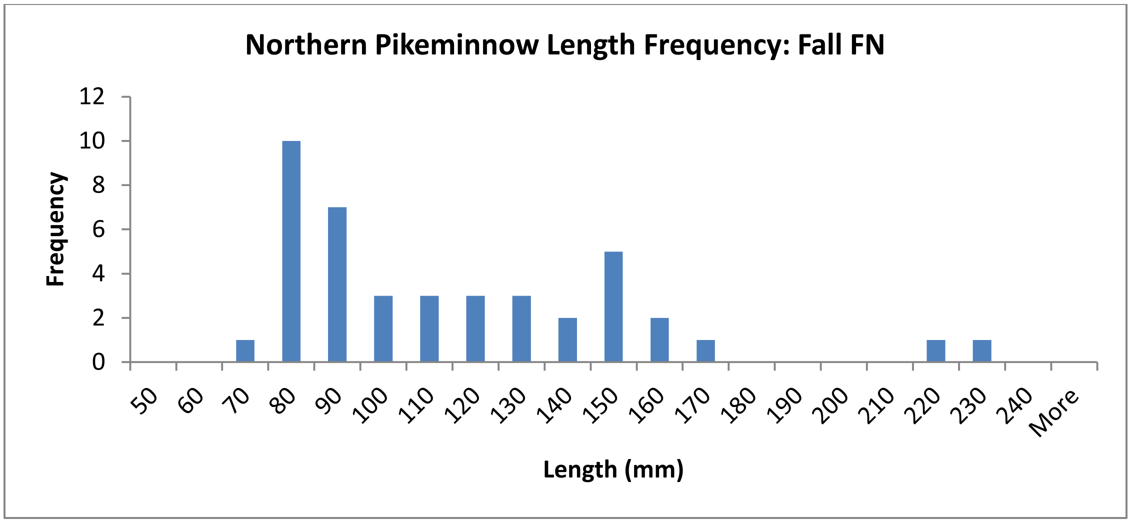

Redside Shiner Length Frequency: Summer EB
Frequency
200
150
100
50
0
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
More
Length (mm)

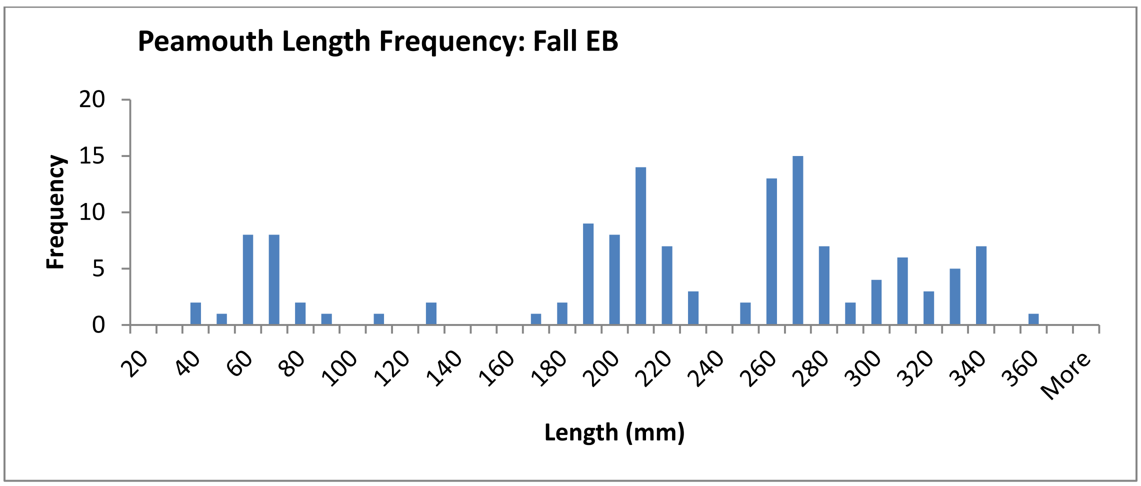

Chiselmouth Length Frequency: Fall EB
Frequency
70
60
50
40
30
20
10
0
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250
260
270
280
290
300
310
320
More
Length (mm)

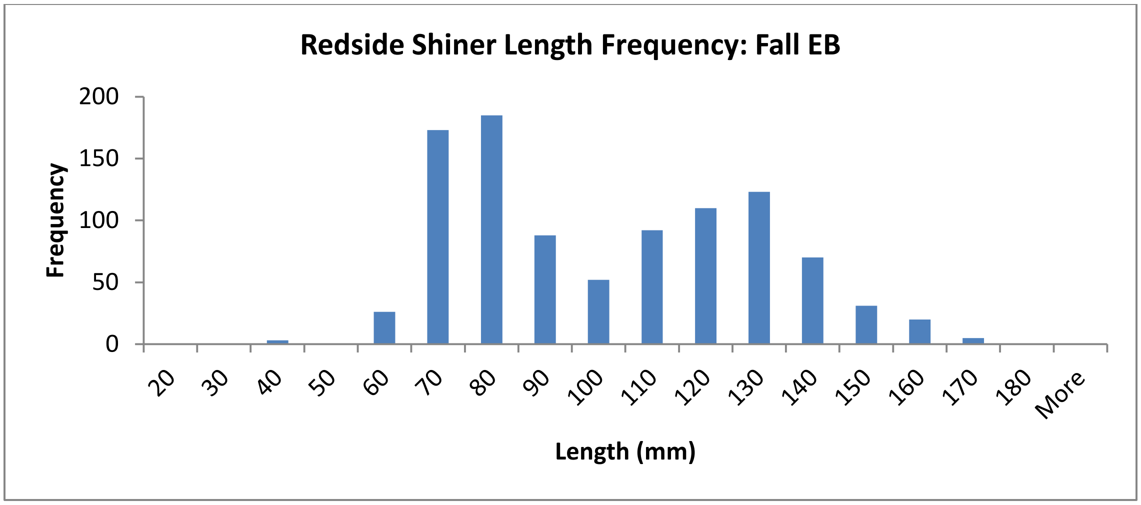

Chiselmouth Length Frequency: Fall FN
Frequency
0
2
4
6
8
10
12
14
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250
260
More
Length (mm)

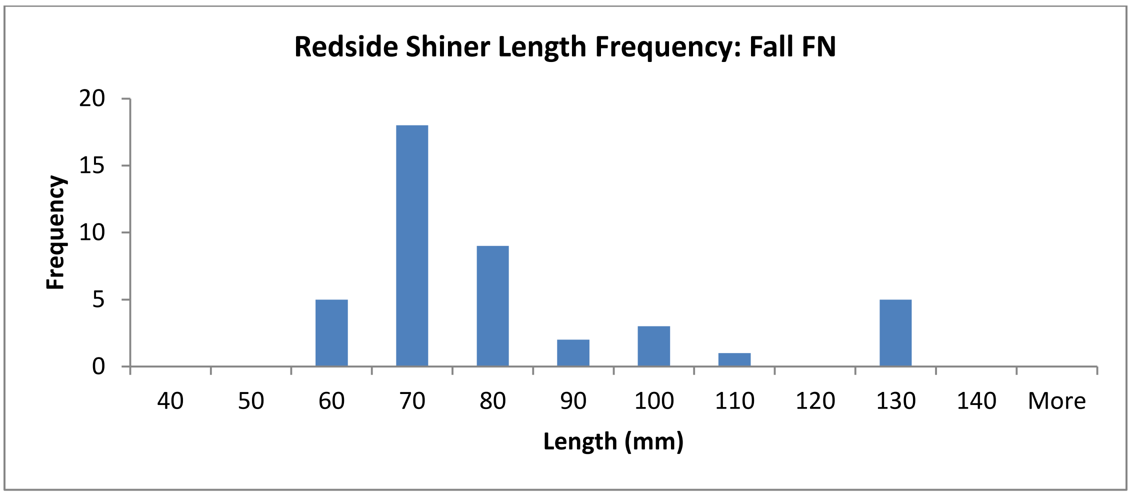

Largescale Sucker Length Frequency: Fall EB
Frequency
0
5
10
15
20
30
50
70
90
110
130
150
170
190
210
230
250
270
290
310
330
350
370
390
410
430
450
470
490
510
530
550
570
Length (mm)

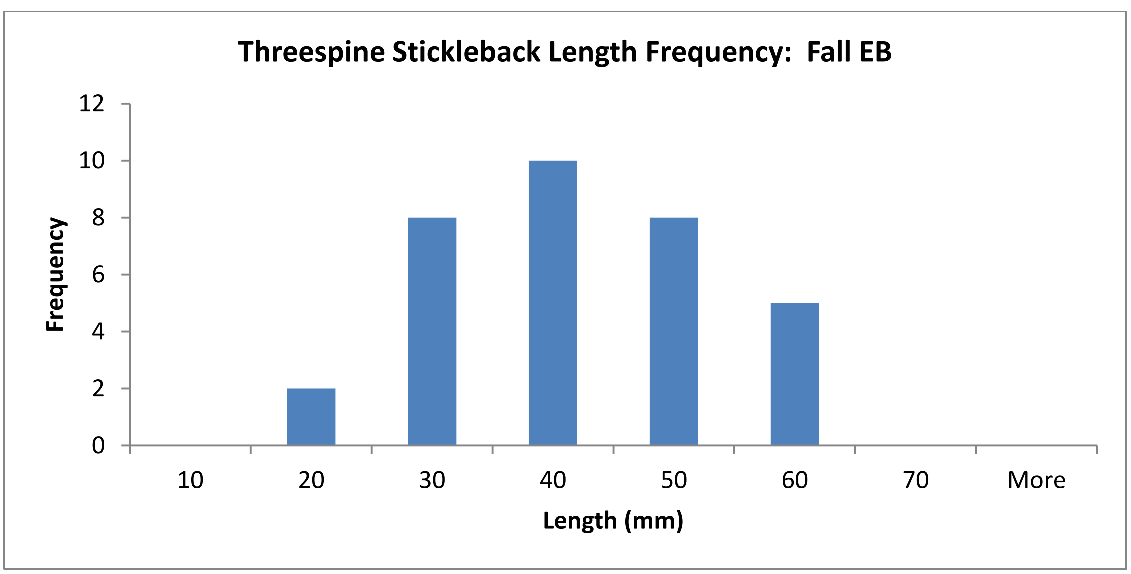

Northern Pikeminnow Length Frequency: Fall EB
Frequency
0
10
20
30
40
50
30
50
70
90
110
130
150
170
190
210
230
250
270
290
310
330
350
370
390
410
430
450
470
490
More
Length (mm)

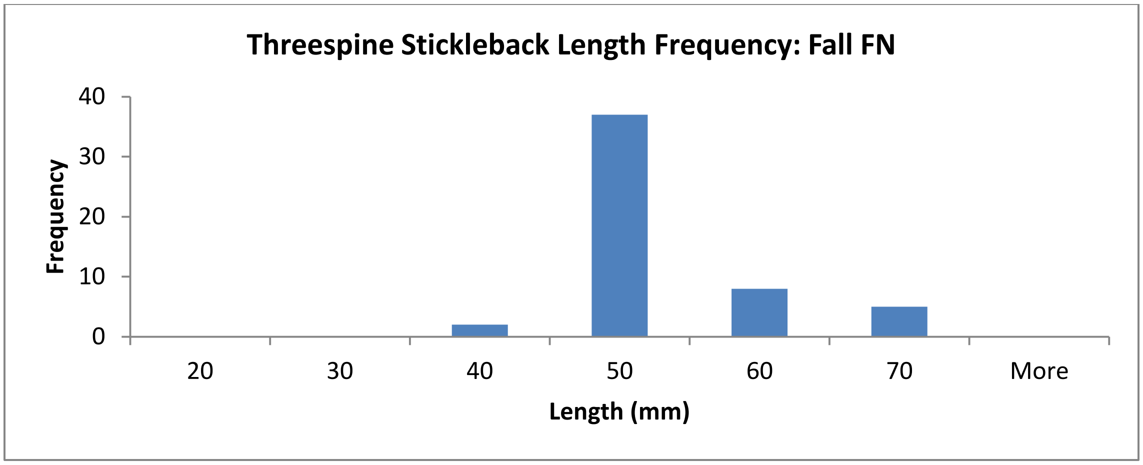

Northern Pikeminnow Length Frequency: Fall FN
Frequency
0
2
4
6
8
10
12
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
More
Length (mm)


Peamouth Length Frequency: Fall EB
Frequency
0
5
10
15
20
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
More
Length (mm)


Redside Shiner Length Frequency: Fall EB
200
150
100
50
0
Frequency
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
More
Length (mm)


Redside Shiner Length Frequency: Fall FN
20
15
10
5
0
Frequency
40
50
60
70
80
90
100
110
120
130
140
More
Length (mm)


Threespine Stickleback Length Frequency: Fall EB
12
10
8
6
4
2
0
Frequency
10
20
30
40
50
60
70
More
Length (mm)


Threespine Stickleback Length Frequency: Fall FN
Frequency
40
30
20
10
0
20
30
40
50
60
70
More
Length (mm)