2017 PUBLIC UTILITY DISTRICT NO. 1 OF DOUGLAS COUNTY NORTHERN PIKEMINNOW REMOVAL AND RESEARCH PROGRAM

WELLS HYDROELECTRIC PROJECT

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1.0 INTRODUCTION

Throughout the Columbia River hydro system, numerous measures have been implemented to improve the survival of salmonids (*Oncorhynchus* spp.), which pass up to nine hydroelectric projects on their migrations to and from the ocean. As one of those measures, Public Utility District No. 1 of Douglas County (Douglas PUD) is required by the Federal Energy Regulatory Commission (FERC) via the Wells Hydroelectric Project Anadromous Fish Agreement and Habitat Conservation Plan (HCP, Section 4.3.3) to implement measures for the control of predacious Northern Pikeminnow (*Ptychocheilus oregonensis*) at the Wells Hydroelectric Project (Project). Thus, in an effort to understand and control predators of juvenile salmonids within the Project, Douglas PUD has funded research on, and removal of, Northern Pikeminnow since 1993.

Pikeminnow research and removal, initiated on the lower Columbia River during the summer of 1990, has been recognized as an important part of restoring salmonid stocks within the Columbia River system (Vigg et al. 1990; Matthews et al. 1991). Initial test fisheries utilizing hook-and-line removal methodology in the lower Columbia River captured 17,334 pikeminnow (Vigg et al. 1990). In 1991, 39,817 fish were removed from eight U.S. Army Corps of Engineers hydroelectric projects on the lower main stems of the Columbia and Snake Rivers (Beaty et al. 1991). Shortly thereafter, mid-Columbia Public Utility Districts (PUDs) began to investigate the possibilities of initiating similar pikeminnow research and removal activities.

In 1993, Douglas, Chelan, and Grant PUDs jointly funded a study of predation on juvenile salmonids in the mid-Columbia region (Burley and Poe 1994), to identify areas of Northern Pikeminnow abundance and areas of high predation on out-migrating juvenile salmonids. Density-index values of pikeminnow in the mid-Columbia reservoirs were as high as many reservoirs of the lower-Columbia. The immediate tailrace of Wells Dam and the outfall of Wells Hatchery were identified as sites where large concentrations of pikeminnow could be found relative to other locations within the Wells Project.

Douglas PUD initiated a Northern Pikeminnow test fishery in 1995, with the goals of assessing the effectiveness of several gear types for removing pikeminnow, estimating the population size of pikeminnow, and removing pikeminnow from the tailrace of Wells Dam (Bickford and Klinge 1996). During the summer of 1995, crews captured 1,198 pikeminnow, with the majority captured via conventional hook-and-line gear. A similar removal program in 1996 was intended to increase effort and remove as many pikeminnow as possible from the Wells tailrace (Bickford 1997). Unfortunately, removal efforts were hampered by difficult fishing conditions related to high river flows and velocity, and only 313 Northern Pikeminnow were captured, most on sport-fishing gear. Commercial setline gear was also utilized in 1996, and although the lines did not capture many pikeminnow, catch-per-unit-effort (CPUE) was high relative to other methods tested. Prompted by low catch rates in 1996, biologists at Douglas PUD initiated a behavioral study in 1997, radio-tagging Northern Pikeminnow throughout the Wells Reservoir and tailrace. Migration patterns, spawning locations, and preferred habitats of Northern Pikeminnow were identified throughout Wells Reservoir and from the Wells tailrace to eleven miles downstream at Chelan Falls (Bickford and Skillingstad 2000).

In an effort to increase catch levels and conduct studies on Northern Pikeminnow, Douglas PUD contracted with Columbia Research in 1998. Columbia Research's removal strategy focused on an incentive-based fishery with a crew of experienced anglers paid on a per-fish basis (anglers hired directly by Douglas PUD in 1995 and 1996 were paid by the hour). Anglers in 1998 captured 7,347 pikeminnow, a significant increase over the numbers of fish captured during previous years. Catch numbers increased during each subsequent year, with 10,382 pikeminnow captured in 1999 and 12,338 in 2000. Catch numbers totaled 14,935; 20,201; and 20,065[1] pikeminnow, in 2002, 2003, and 2004, respectively. From 2005 to 2011 catch per year ranged from approximately 16,000 to 20,000 fish annually. In 2012 and 2013 total pikeminnow catch decreased to 13,218, and 11,888 fish respectively. High flows during these years hampered the crew's ability to adequately work the gear. Lower flows allowed crews to more effectively run the setline gear in 2014 and 2015 and catch increased to 16,590 and 16,488 respectively. Pikeminnow catch decreased in 2016 to 13,362 fish, probably due to environmental factors that effected setline crews ability to work the gear. During the 2017 fishery, crews captured a total of 16,571 pikeminnow.

Although CPUE levels have decreased in recent years Total catch has remained high throughout the yearly pikeminnow capture projects. However, CPUE rated have demonstrated a decreasing trend. Relatively low CPUE levels over the previous 4 years may be a result of the annual fishery impacting the existing pikeminnow population and environmental factors related to flow in the Columbia River.

To date, pikeminnow removal programs sponsored by Douglas PUD have resulted in the capture and removal of approximately 315,000 pikeminnow. It is accepted in the scientific community that these programs have decreased predation on outbound juvenile salmonids within Wells Reservoir and in the immediate Wells tailrace. The success of these annual efforts demonstrates the efficacy of the setline capture technique and the capacity of the program to annually harvest significant numbers of Northern Pikeminnow from the Project. This report outlines the results of Douglas PUD's 2017 pikeminnow removal project conducted by Columbia Research, and compares data collected from 2002 to 2017.

2.0 MATERIALS AND METHODS

One vessel crew consisting of 3 crew members participated in the project. Setline efforts were initiated on April 10, 2017 and were completed on November 6, 2017. Setline crews filled out daily data sheets specifying locations fished, number of fish caught per location, setline set times, and incidental catch.

The annual pikeminnow removal efforts were conducted throughout the Project from below the BRZ (boat restricted zone) tailrace of Chief Joseph Dam downstream to the 2 mile tailrace area of Wells Dam. A scientific collection permit was obtained from the Washington Department of Fish and Wildlife allowing crews to place setlines throughout the study area including the lower 1-mile section of the Methow River, the mouth of the Wells Hatchery outfall channel and the

[1] Includes 503 fish captured in 2004 that were not enumerated until 2005, and were not included in the totals reported in the 2004 report.

BRZ of Wells Dam. Captured Northern Pikeminnow were categorized by one of four primary catch locations: Pikeminnow captured downstream from Wells Dam were designated "Wells Tailrace." Fish captured in the reservoir between Wells Dam and the Methow River confluence were designated "Lower Wells Reservoir." Fish captured from the Methow River confluence to the tailrace of Chief Joseph Dam were designated "Upper Wells Reservoir." Fish captured within the Methow River were designated "Methow River." CPUE rates were calculated for each location.

From 2012 to 2017 anglers conducted hook-and-line efforts in addition to setline activities. All of the hook and line activities took place in the Wells tailrace. Hook-and-line anglers focused on the rip-rap sections below the outflow of the east and west Wells fish ladders. It was not feasible to utilize setlines in these areas due to the large rocks that entangled gear as well as the turbulent flows experienced in these areas. It was observed in these areas that larger pikeminnow were actively feeding. In an attempt to target these pikeminnow, anglers utilized hook-and-line gear to focus on the narrow rocky channel areas. A variety of baits were fished on the bottom including worms, maggots, shrimp and crickets.

From 12 to 18 setlines were typically retrieved, baited and set each day by a crew of three individuals. Each line contained approximately 120 hooks. Setline gear was fished on the bottom. Each setline consisted of a main line with a buoy and a weight attached to each end. Hooks were spaced evenly along the main line between the end weights. The hooks were then attached via leaders of 6-pound-test monofilament approximately 0.6 meters in length. Setline gear was checked once daily, allowing crews to release all non-target fish back into the river unharmed. CPUE was calculated by summing hours spent to retrieve, check, and reset lines as well as travel and preparation time (tying hooks, assembling lines, etc.). Hook-time fished was calculated as the number of hooks fished each day multiplied by total days fished multiplied by 24 hours. Effort calculations methods are consistent from 2002 to 2017 of the pikeminnow program, allowing for easy comparison within and among years.

Biological data were collected randomly from 5.1% of the weekly catch. Biological data consisted of fork length, weight, sex, digestive-tract contents, and gonad maturity. Fork lengths were measured to the nearest millimeter. An Ohaus 5000 electronic scale was used to weigh fish to the nearest 2 grams. Pikeminnow were categorized as male, female, or unidentified, and gonad maturity was identified on a scale of 0 to 4, corresponding to the criteria listed in Table 1. Digestive-tract contents were visually identified. These methods are consistent with previous years of biological data analysis.

Table 1. Gonad maturity codes.

0	Unidentified	Gonads could not be distinguished between male and female.
1	Immature	Gonads thin and streamlined, sex may be difficult to determine.
2	Developing	Eggs and milt do not flow easily with pressure, but sex is easily determined. Eggs are small and gray in color.
3	Ripe	Females contain orange-colored eggs. Eggs or milt flow freely with gentle pressure.
4	Spent	Gonad size reduced. Some eggs or sperm may still be present.

3.0 RESULTS

Crews captured 16,571 Northern Pikeminnow over 5,822 hours of effort, equating to an overall CPUE of 2.8 fish per angling hour. Over the fishing season, setline efforts translated into 9,100,000 hook hours for an overall CPUE of 0.0018 fish per hook hour. Greater than 92% of the captured fish (15,358) were equal to or greater than 229 mm in total length, The balance, 1213 (~8%), of captured pikeminnow were less than 229 mm. The 229 mm cut-off length was established by BPA as the length at which pikeminnow become predatory on juvenile salmonids (Beaty et al. 1991; Porter 2000) and has been used by Douglas PUD for grouping fish as adult or juvenile for the pikeminnow removal program. Within the lower Wells Reservoir from the Methow River confluence area to the forebay of Wells Dam, 9635 fish were captured during 3,041 hours of effort translating into a CPUE of 3.2. Set-line efforts in the lower 1-mile section of the Methow River captured 692 fish during 232 hours of effort (CPUE = 3.0). Within Wells Reservoir from the mouth of the Methow River to Chief Joseph Dam, 4,104 pikeminnow were captured during 1,704 hours of effort, a CPUE of 2.4. The remaining fish were captured in the Wells Tailrace (2,143 pikeminnow) during 845 hours (CPUE =2.5), and of these, 1,617 fish were captured on setlines and 526 fish were captured on hook-and–line gear. Figure 1 shows the 2014 Northern Pikeminnow catch numbers, and percentage of total catch number, by fishing location.

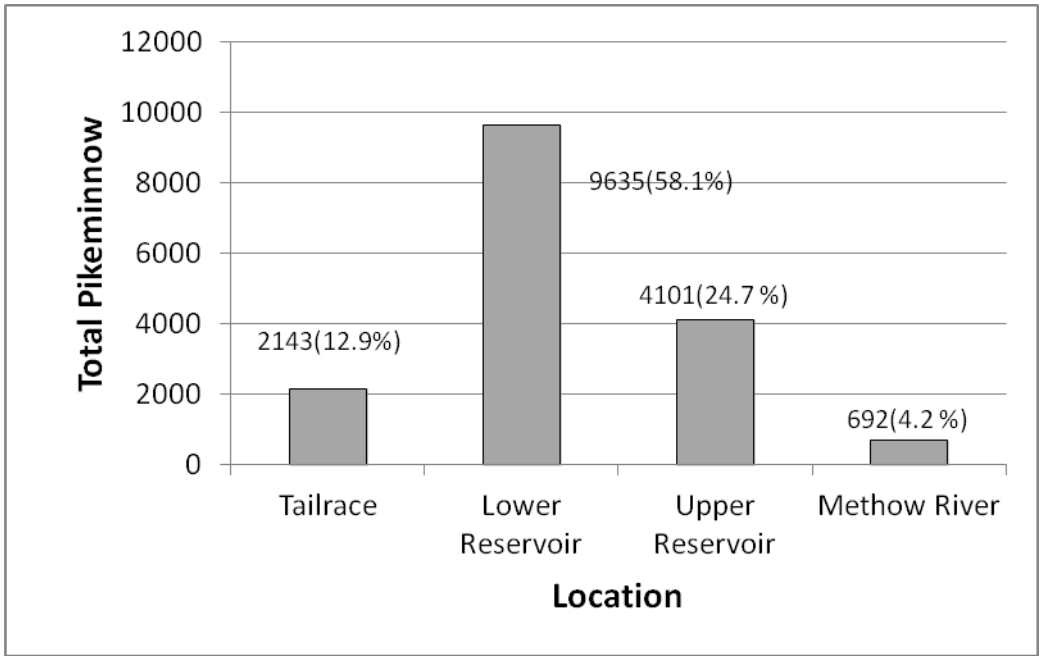

Figure 1. Catch (percentage of total catch) of Northern Pikeminnow by location.

Effort in the beginning of the annual removal program was focused in Wells Reservoir. Initial efforts in April and May were focused within the lower reservoir area from the mouth of the Methow River to Wells forebay. During June, anglers fished in the upper Wells Reservoir. CPUE rates dropped within Wells Reservoir around the middle of June at which time crews focused effort within the Wells tailrace area. Setline crews and hook and line angling crews

focused effort within the tailrace area during July. In October the crews returned to the reservoir area and experienced high CPUE rates for the remainder of the project.

Analysis of digestive tracts was performed on a sample (5.1%) of the captured pikeminnow to assess their dietary preferences and predation rates on juvenile salmonids. This random sample was collected throughout the entire annual effort and on all size classes (pikeminnow over and under 229 mm). Of the 842 pikeminnow digestive tracts sampled, 52% were empty, 16% contained crayfish, 6% unidentified fish, 6% salmonids, 14% unidentified plant matter, 5% unidentified insect, and 1% sculpins (Figure 2). "Unidentified fish" may include salmonids that were unrecognizable in their digested state, and/or would require laboratory techniques to provide a positive identification. The presence of salmonids in sampled digestive tracts was recorded from the onset of fishing efforts in May through the end of September.

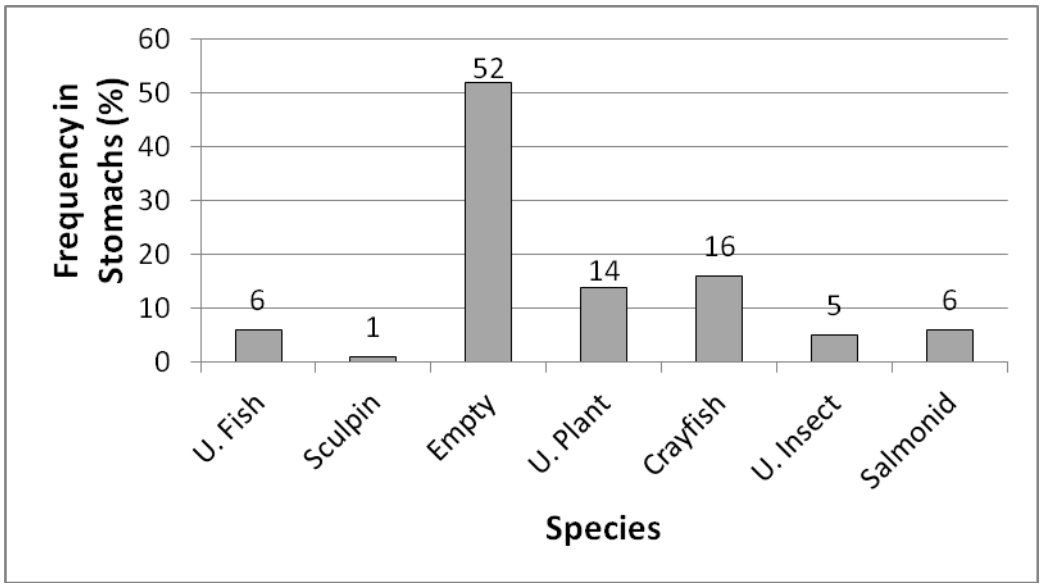

Figure 2. **Digestive-tract contents, as determined from analysis of 842 pikeminnow digestive tracts. The abbreviation "U." indicates "unidentified" items within the respective categories. In the case of "U. Fish," this category encompasses any fish other than identified lampreys, sculpins, or salmonids; "U. Plant" comprises all plant matter and "U. Insect" all arthropods other than crayfish.**

Gonad analysis indicated that the 2017 peak spawn period for Northern Pikeminnow occurred from July 10 to July 17, at which time 51% of the sampled fish were classified as ripe.

A total of 2,206 non-target fish were captured and released representing 11.7% of the overall catch. Incidental encounters consisted of nine taxa: 937 Peamouth (*Mylocheilus caurinus*), 611 Chiselmouth (*Acrocheilus alutaceus*), 317 Burbot (*Lota lota*), 218 suckers spp. (*Catostomus* spp.), 65 sculpin (*Cottus* spp.), 39 Redside Shiner (*Richardsonius balteatus*), 11 Northern Pikeminnow / Chiselmouth hybrids , 5 Brown Bullhead catfish (*Ameiurus nebulosus*), and 3 hatchery-origin White Sturgeon (*Acipenser transmontanus*). All non-target fish were released alive. No salmonids were encountered during the project (Figure 3).

In regards to incidental encounters using hook-and-line angling techniques, the following non-target species were encountered (these fish are reflected in the totals outlined above): Peamouth, 152 fish; Burbot, 14 fish; sucker spp., 29 fish; Northern Pikeminnow / Chiselmouth hybrids, 21 fish.

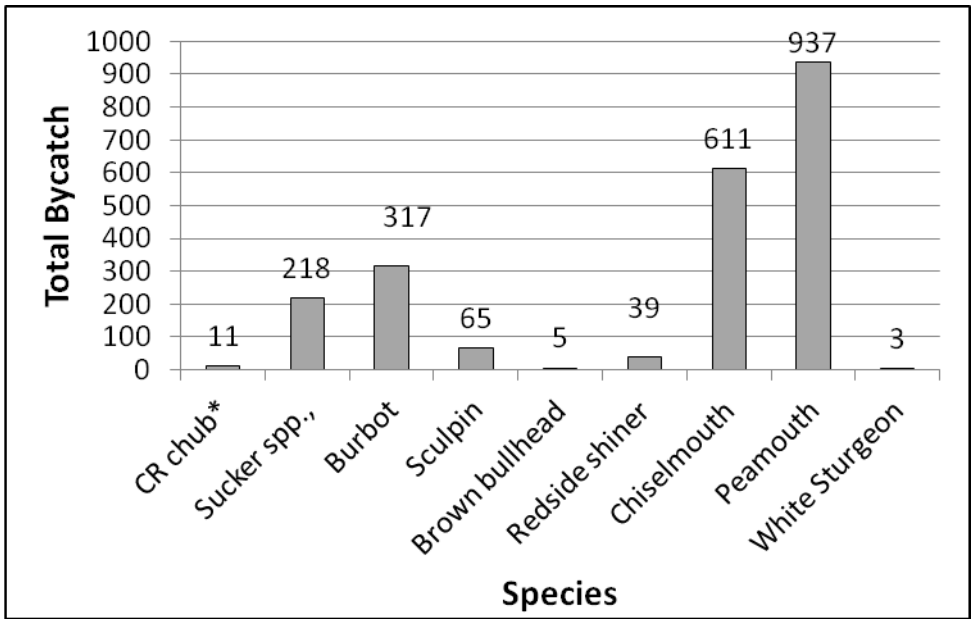

Figure 3. Numbers of non-target (incidental) fish by taxa.

4.0 DISCUSSION

In 2017 both Catch and CPUE increased to levels similar to those observed in 2014 and 2015. Water conditions were favorable to set line deployment and retrieval throughout most of the year (Figure 4).

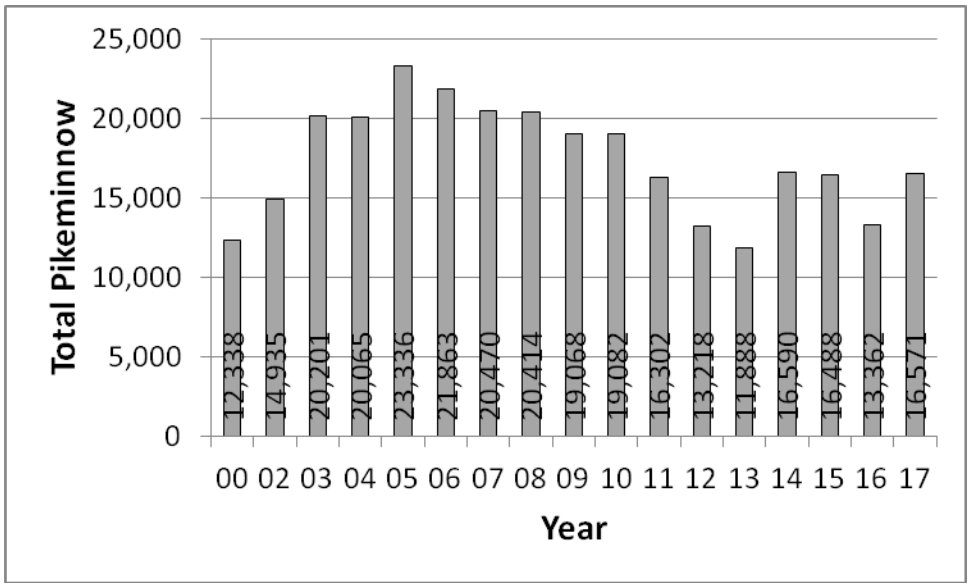

Figure 4. Douglas County PUD total Northern Pikeminnow catch by year.

4.1 Pikeminnow Diet

The timing of the peak migration of salmonid smolts from the Methow and Okanogan rivers (May and June) corresponds with an increase in smolts in pikeminnow diets as identified during stomach analysis (data on the timing of smolt migration from Columbia River DART http://www.cbr.washington.edu/). In August from 2014 to 2016 (Jerald 2017) a high incidence of salmonids were identified in pikeminnow gut analysis in the wells tailrace. This occurrence was once again recorded in 2017. During this time pikeminnow were seen actively feeding on juvenile salmonids and aggressively attacked lures presented by hook and line angling crews.

4.2 Incidental Catch

During the development stage of the setline removal approach, concerns were raised regarding high incidental catch and mortality. In contrast to those concerns, setline methods have proven to be highly selective for Northern Pikeminnow, with extremely low rates of encounter with non-target sensitive and game species, including no encounters with salmonids (Jerald 1998; Jerald 1999; Jerald 2000; Magnotti and Jerald 2001; Jerald 2005). Setlines have allowed for the selective removal of northern pikeminnow from all depths and substrates, in most currents, and in all seasons, with minimal by catch of non-target species, and to date, no bycatch of salmonids other than whitefish. Previous annual reports (Jerald 2005, Jerald 2006) discuss possible explanations for the selectivity of the setline techniques.

White Sturgeon were only encountered as bycatch within the Wells tailrace (upper end of Rocky Reach Reservoir). These encounters are attributed to the release of juvenile sturgeon by Chelan PUD within Rocky Reach Reservoir as part of their White Sturgeon supplementation program. All incidentally captured White Sturgeon were determined to be from these releases by PIT tag and scute mark identification.

From 2012 to 2016, an atypically high number of Burbot were encountered within Wells Reservoir. An increasing trend in burbot encounters has been documented over the last 4 years. Total burbot catch in 2010 was 146 fish, 579 fish in 2011, 3,203 fish in 2012, 2,416 fish in 2013, 1,838 fish in 2014, 1,216 in 2015, 982 fish in 2016, and 317 fish in 2017. Previous to 2012, much of the burbot catch was restricted to the deep China Ditch section of the reservoir below the Methow River confluence. From 2012 to 2016 burbot were encountered in large numbers throughout the reservoir area. It is interesting to note that 2011 appears to be a peak year of burbot abundance in the reservoir. Thereafter incidental catch of burbot has decreased each year. It is possible that there was an influx of burbot from the upper Columbia River reservoirs into Wells Reservoir in 2011 (Bickford pers. com).

4.3 Yearly Comparisons

Catch information has been compiled from the annual Douglas PUD removal programs to provide comparative analysis of the yearly data from multiple years catch data of intensive setline efforts. The 2002 to 2017 data represents pikeminnow that have been captured on similar sampling gear within the Wells Project Area (excluding 622 fish that were caught on hook and line gear in 2012, 1,666 fish in 2013, 1,764 fish in 2014, 2,445 fish in 2015, 2,417 fish in 2016, and 526 fish in 2017). It should be noted that there has been a dramatic shift in catch distribution within the project area from 2002 to 2017 (Figure 5). A large portion of the catch from 2002 to 2007 was captured in the Wells tailrace. From 2008 to 2010 catch was almost evenly distributed between Wells reservoir and wells tailrace. From 2011 to 2017 a higher portion of pikeminnow were captured in the Wells pool. The current year 2017 marks the highest number of pikeminnow captured in the Wells Pool. This trend of increased catch in the Wells pool may be a factor of the crew's compounded yearly experience fishing within the vast pool area. It could also be an indication of an increased pikeminnow population within Wells Reservoir

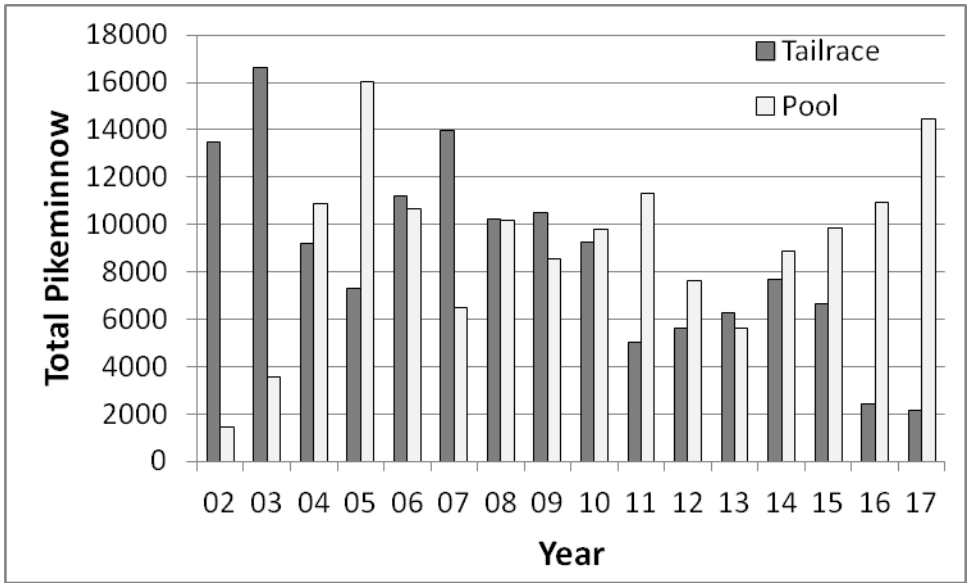

Figure 5. Catch distribution from 2002 to 2016 within Wells Tailrace and Wells Reservoir .

Decreasing CPUE rates were identified from 2009 to 2013 (Figure 6). A slight increase in CPUE was observed during 2014 and 2015. A significant shift in CPUE is demonstrated in figure 6 when comparing average CPUE from 2004 to 2010 vs 2011to 2017. The average CPUE for 2004-2010 is 5.17; the average CPUE for 2011 to 2017 is 2.8. Therefore the data indicates a large decrease in CPUE over the last 6 years of the project. Recent year fishery CPUE levels have not returned to levels experienced from 2004 to 2010. Yearly CPUE levels have remained relatively consistent from 2011 to present.

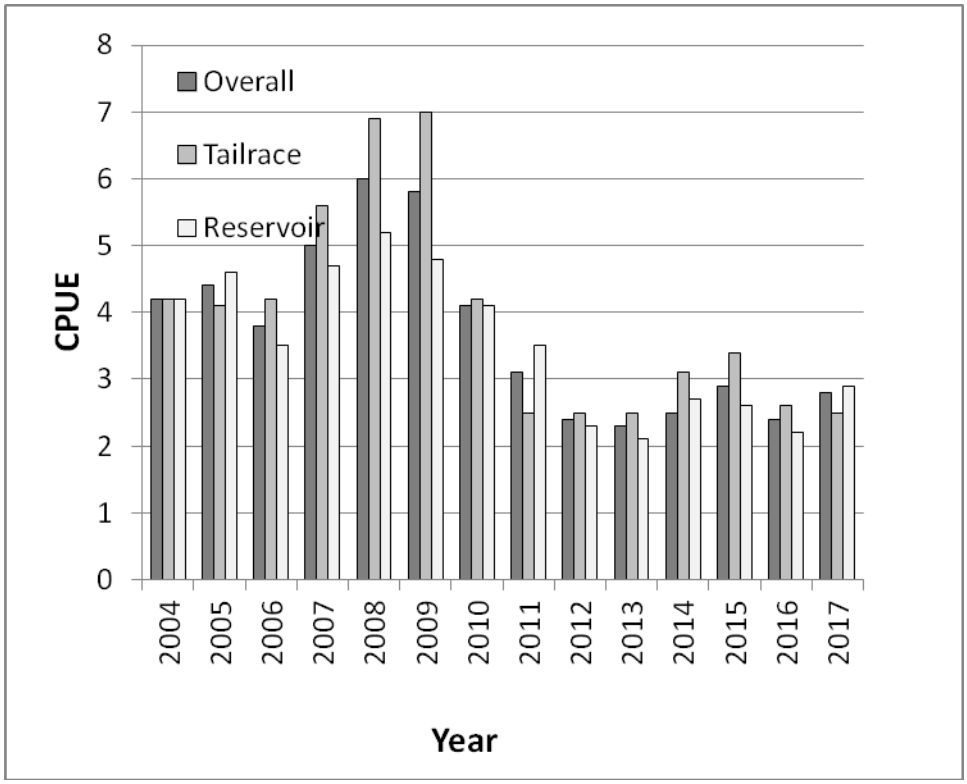

Figure 6. CPUE values by location for Wells Project pikeminnow removal program, 2004 to 2016.

Approximately 315,000 pikeminnow have been captured within the Wells Reservoir and tailrace through Douglas PUD sponsored removal efforts. These programs may have effectively reduced the population of pikeminnow in the study area. Additionally, Chelan PUD conducts an extensive pikeminnow removal program in the lower Rocky Reach Pool. Bickford and Skillingstad (2000) documented the migration of pikeminnow from middle and lower Rocky Reach Reservoir into the Wells tailrace for spawning and/or predation activities. A substantial reduction in the pikeminnow population within Rocky Reach Reservoir could result in decreased CPUE rates within the Wells tailrace.

Another factor in overall lower total catch / CPUE values is the documented occurrence of Burbot predation in Wells Reservoir. Burbot depredation may have significantly decreased setline crew's ability to retrieve pikeminnow trapped on the setline gear during recent years.

Additionally, an annual salmon fishery is conducted below Wells Dam on July 1 of each year. In recent year an increase in participation has been observed. During recent years, recreational anglers have frequently become entangled in setline gear and tampered with that gear, resulting in substantial setline gear loss and decreased CPUE levels in the Wells tailrace.

A decreasing trend in average lengths is observed from 2002 to 2009 (Figure 7). The lowest average pikeminnow length and weight was recorded during 2009 at 273 mm in length and 243 grams in weight. From 2004 to 2009 (similar fisheries with similar effort within reservoir and tailrace areas) the average pikeminnow length decreased by 29 mm and weight by 53 grams[2].

During 2010 and 2011 a slight increase was recorded in average length and average weight, but both weights and lengths dropped in 2012 to more closely match the 2009 data. From 2010 to 2017 average fish lengths have only varied no more than 11 mm. This may be an indication that yearly pikeminnow removal efforts have reduced the population to an equilibrium level where fishing effort has offset recruitment.

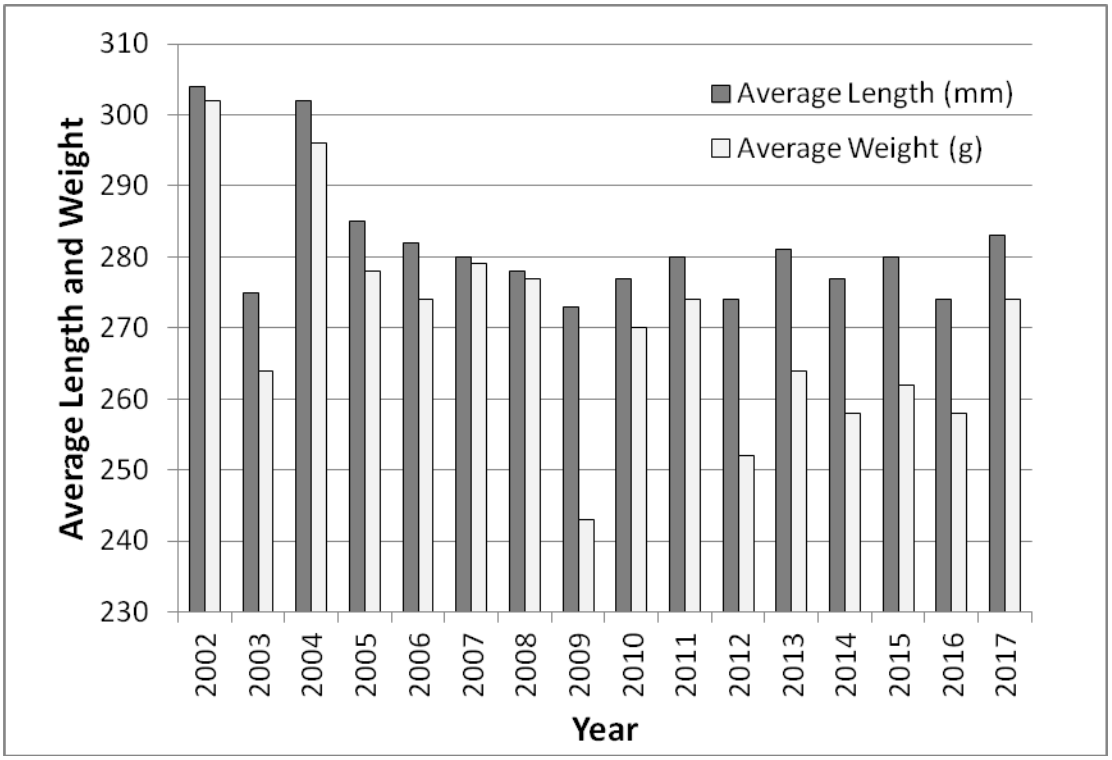

Figure 7. Average pikeminnow length (mm) and weight (g) from sampled pikeminnow in Wells Tailrace and Wells Reservoir.

[2] The apparent 27-mm increase in average length from 2003 to 2004 is likely because most pikeminnow were captured in the Wells tailrace in 2003, but in 2004 (and each subsequent year), substantially more pikeminnow were captured in Wells Reservoir than during 2003. Fish captured in Wells Reservoir during 2004 were noticeably larger than those captured in the tailrace.

Average fish weight is an unreliable indicator of trends in average fish size in the pikeminnow population over time, as the observed weight per length of pikeminnow varies seasonally (data not shown). Factors affecting fish weight during the fishery likely include fish condition going into the previous winter, winter water temperatures, and the rate of increase in spring water temperature. Additional factors may include the influence of environmental variables on the availability of prey, such as the timing of salmonid fry emergence and smolt migrations or the recruitment rate of larval resident fish from the previous year class. Timing of the commencement of the annual fishery also influences fish weight per length. For example, fishing began much later in 2007 (May 6), 2008 (April 22), 2011 (April 7) and 2012 (April 12) than in 2004, 2005, 2006, 2009, and 2010 (March 8, 3, 21, 19, and 16, respectively), and we observed apparently anomalous average pikeminnow weights in 2007 and 2008, despite the annual decline in average length and overall decrease in average weights over the 2004-2009 period. Fish of all lengths captured in April and May would have experienced several additional weeks of foraging before the commencement of fishing relative to the fish subjected to those fisheries that began in March. Thus, fish captured late in the fishery would have exhibited an overall improvement in condition factor relative to those fish of equal length captured early in those fisheries that began in March. In 2009 body masses were approximately 10% lower than in previous years and are likely attributed to overwinter conditions rather than timing of capture (see Figure 7). Fluctuations in the duration of the annual pikeminnow removal program may also affect the displayed catch data, with the longer fishing periods in 2010 to 2016 inevitably effecting catch data when comparing on an annual basis.

Average fish length can be a more reliable factor when comparing catch amongst years, as length is not as heavily influenced by environmental variables as weight. From the catch data it can be observed that the highest yearly average lengths were recorded in 2002 and 2004. This period marks the beginning of the intense fishery and it is likely that the un-exploited population contained a large number of older individuals and therefore resulted in a high average pikeminnow length. Pikeminnow lengths remained fairly consistent from 2005 to present, an indicator that the pikeminnow population may be in a state of equilibrium between exploitation and recruitment.

No trends have emerged in the percentages of fish in the total annual catch that are either less than 229 mm or greater than or equal to 229 mm in length (Figure 8). Therefore, the observed decline in average fish size from 2002 to 2009 cannot be explained by a disproportionate reduction in the numbers of fish greater than or equal to 229 mm, but rather by a reduction in the average size of fish in that category.

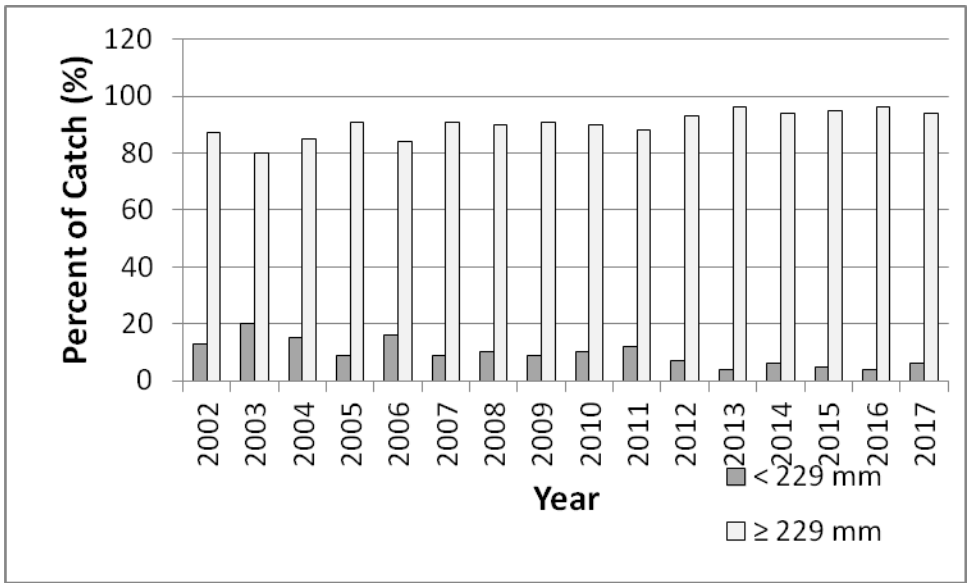

Figure 8. Catch composition by size category reported as the percentage of fish captured annually that were either <229 mm or ≥229 mm.

The size distribution of large pikeminnow over 350 mm was analyzed in an attempt to quantify any increase or decrease of very large predatory pikeminnow within the population over time. In the 2002 fishery, fish greater than 350 mm comprised 23% of the total catch (Figure 9). The occurrence of these larger fish decreased systematically from 2002 to 2009. In 2009, 2014, and 2016 the lowest occurrence of sampled fish greater than 350 mm was observed, comprising only 14% of the total catch. From 2006 to 2017 catch composition of these larger fish only varied from 14% to 17% of total catch, a further indication that the fishery may have reached an equilibrium point with recruitment. While the numbers of very large fish (>350 mm) have declined since 2002, smaller fish within the greater than or equal to 229 mm category either remain numerous or have increased in numbers to the extent that a corresponding decrease has not occurred in the total numbers of fish within that length category (see Figures 8 and 9).

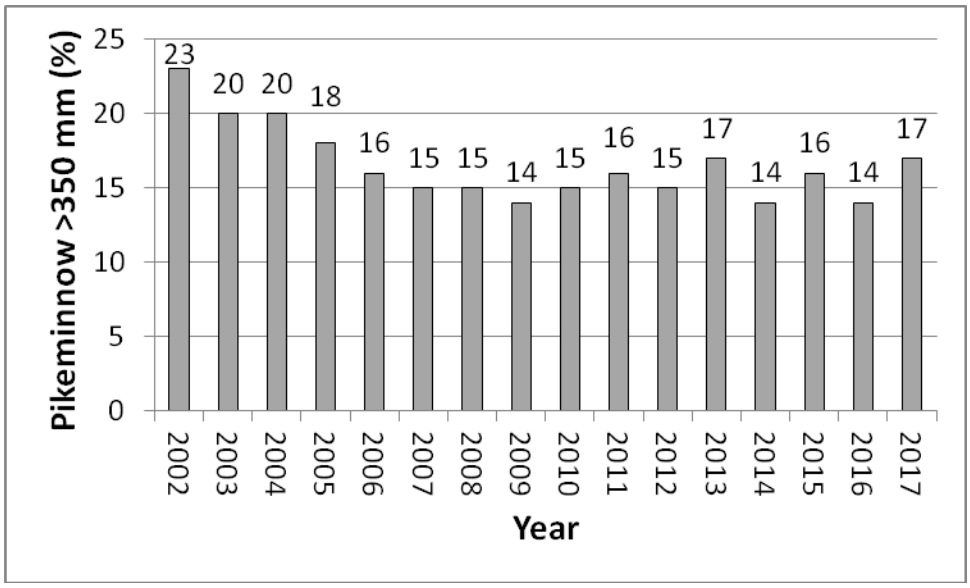

Figure 9. Catch composition as the percentage of fish sampled annually that were >350 mm.

There was no discernible trend in salmonid consumption by Northern Pikeminnow in the yearly data (Table 2). The highest occurrences of salmonid consumption were observed in 2004, 2008, and 2015, and the lowest incidences were documented in 2006, 2007 and 2012. High turbidity levels during those 3 years (documented high flow periods) may have decreased predator efficiency resulting in a low observance of salmonids during analysis of digestive tracts. The relatively late onset of fishing in 2007 (May 1; see discussion above) would have missed the majority of hatchery spring Chinook smolts that migrated in April, possibly explaining the low incidence of smolts in pikeminnow digestive tracts in 2007. Lamprey were first recorded during analysis of digestive tracts in 2009, which likely resulted from training technicians in lamprey identification prior to the onset of the fishing season, and the initiation of fishing effort in the Lower Methow area during the peak of the lamprey emigration. However, no lamprey were observed in the stomachs of the sampled pikeminnow from 2010 to 2017.

Table 2 Yearly digestive-tract contents (%) for pikeminnow captured in Wells Project (approximately 5% of the catch sampled each year).

Year	Empty	Smolt	Crayfish	Unidentified Fish	Unidentified Plant	Unidentified Insect	Sculpin	Lamprey
2002	69	7	6	7	7	1		
2003	60	8	9	8	7	6		
2004	66	10	4	7	9	3		
2005	61	7	14	6	9	2		
2006	74	5	6	4	6	4		
2007	76	4	4	6	5	4		
2008	64	10	7	8	7	2		
2009	42	7	10	7	21	11		2
2010	55	6	11	6	14	7	1	
2011	46	6	22	3	15	7	1	
2012	43	5	20	8	16	7	1	
2013	45	6	18	9	15	6	1	
2014	51	8	16	9	11	4	1	
2015	45	10	20	10	8	7	1	
2016	49	8	17	12	8	5	1	
2017	52	6	16	6	14	5	1	
Mean	56.1	7.1	12.5	7.3	10.8	5.1	0.5	0.1

5.0 CONCLUSIONS

The Northern Pikeminnow removal program has removed large numbers of pikeminnow from the Wells Project from 2002 to 2017, with catches ranging from 11,888 pikeminnow in 2013 to 23,336 pikeminnow in 2005. From 2003 through 2010, yearly catches of pikeminnow exceeded 19,000 fish and CPUE levels were relatively high. In 2011 a significant decrease in CPUE and total catch was recorded, and the decreases continued through 2012 and 2013. The 2013 CPUE rates were the lowest recorded to date for any of the annual setline fisheries and the 2016 CPUE rates were similar. In 2013 and other low catch years environmental factors, specifically high flow conditions , hampered the crew's ability to effectively work setline gear. Interference by recreational anglers below Wells Dam, and Burbot consumption of pikeminnow on the setline gear in Wells reservoir likely contributed to recent years reduced catch and CPUE levels. Additionally, we cannot ignore the potential that the intensive DPUD- and CPUD-sponsored pikeminnow removal programs have appreciably reduced pikeminnow abundance in the study area, as crews have found it increasingly difficult to capture pikeminnow in recent years.

Since 2002, the percentages of pikeminnow that are greater than or equal to 229 mm in the annual catches have remained relatively steady, while the percentage of large (>350 mm) pikeminnow (which are likely to be females due to sexual dimorphism) have declined from 23% in 2002, to consistently within the 14- to 16-percent range, reaching a low of 14 percent in 2009 and 2014. The pikeminnow removal program has reduced the average size of piscivorous and reproductive-sized pikeminnow greater than 350 mm while not discernibly reducing the

proportions of fish captured from the greater than or equal to 229 mm and less than 229 mm categories.

During 2009 and 2010, CPUE rates in March were the lowest recorded, and CPUE rates did not increase to over 4.0 until mid-April. From 2012 to 2016, crews did not initiate fishing efforts until April, at which time relatively high CPUE levels were recorded when compared to monthly CPUE values during each specific year. It is suggested that in 2016, crews once again initiate fishing efforts in April, to avoid low CPUE levels that have previously been recorded in March.

In previous annual reports it has been suggested that the pikeminnow population within the study area has reached an equilibrium stage between the fishery and recruitment (Jerald 2013, Jerald 2014). The decreasing trend of captured pikeminnow from 2011 to 2013 (16,302, 13,218, and 11,888 fish, respectively) is a potential indicator of decreasing pikeminnow abundance in the study area during those years. However, during project years 2014 and 2015 total catch and CPUE increased from the 2012 and 2013 levels. The 2014 and 2015 water flows were moderate in comparison to 2011 to 2013. It is documented (Jerald 2012, Jerald 2013) that high spring flows prevent crews from effectively capturing pikeminnow and result in decreased CPUE rates within the study area. Conversely, moderate water flows (those witnessed in 2014 and 2015) provide crews with the opportunity to effectively present gear and result in increased CPUE. Flows in 2017 were considered moderate and crews experienced few problems running gear. As a result catch and CPUE levels increased from 2016 levels.

Two factors may strongly influence future annual CPUE rates. A long term trend in decreased pikeminnow abundance should result in relatively low annual CPUE rates as have been documented from 2011 to 2017. However, short term environmental conditions related to flows will also have an influence on annual CPUE. Analysis of future yearly catch data will provide further indication of the state of the pikeminnow population and the effects of environmental conditions. An equilibrium state of the fishery would be indicated by consistent CPUE levels analyzed on a multi-year rolling-average. Environmental factors that affect the fishery could be determined by analyzing long term patterns of CPUE in relation to water flows in the Columbia River.

Consistent catch and CPUE levels from 2011 to 2017 indicate an equilibrium state for the current annual fishery (Figure 4, Figure 6,). Total catch over the last 7 years has remained consistent from 11,888 pikeminnow to 16,571 pikeminnow. CPUE fluctuated little during this period from 2.2 to 3.1. Yearly graphs from 2011 to 2017 show small fluctuations in catch and CPUE (when compared to data from 2001 to 2010).

Evidence that the fishery is keeping the annual average pikeminnow length below that of an unexploited population can be seen in the length data. Annual average lengths varied by only 11mm from 2011 to 2017 (Figure 7). During early years of the fishery average fish lengths were much higher and contained a greater degree of variance (e.g. 2002 average length was 303mm, and 2003 average length was 274 mm). The recent trend from 2011 to 2017 shows similar average lengths much lower than the initial years of the fishery. This is an indicator that the current fishery is providing significant levels of exploitation of the natural population.

Ultimately these continued efforts will keep the pikeminnow population at a lower average length than what would otherwise be observed in a natural unexploited population.

6.0 REFERENCES

Beaty, R.E., B.L. Parker, K.C. Collis, and K. McRae. 1991. The use of controlled angling to manage northern squawfish populations at selected dams on the Columbia and Snake Rivers. Report C in 1994 BPA Annual Report: Development of a system-wide predator control program: Stepwise implementation of a predation index, predator control fisheries, evaluation plan in the Columbia River Basin.

Bickford, S., and R. Klinge. 1996. Wells Dam northern squawfish removal efforts 1995. Douglas County Public Utility District No. 1, 1151 Valley Mall Parkway, East Wenatchee, WA. 98802.

Bickford, S. 1997. Removal and Census of Northern Squawfish in the tailrace of Wells Dam, 1996. Douglas County Public Utility District No. 1, 1151 Valley Mall Parkway, East Wenatchee, WA. 98802.

Bickford, S., and T. Skillingstad. 2000. Movements of Northern Squawfish in the reservoir, forebay, and tailrace of the Wells Hydroelectric Project, Mid-Columbia River, Washington. Douglas County Public Utility District No. 1, 1151 Valley Mall Parkway, East Wenatchee, WA. 98802

Burley, C.C., and T. Poe. 1994. Significance of predation in the Columbia River from Priest Rapids Dam to Chief Joseph Dam. Washington Department of Fish and Wildlife and National Biological Survey. Prepared for Chelan County Public Utility District, Douglas County Public Utility District, and Grant County Public Utility District. Contract 430-486.

Jerald, T. 1998. 1998 Public Utility District No. 1 of Douglas County Northern Pikeminnow Removal and Research Program. Prepared by Columbia Research for Public Utility District No. 1 of Douglas County, 1151 Valley Mall Parkway, East Wenatchee, WA 98802-4497

Jerald, T. 1999. 1999 Chelan PUD Northern Pikeminnow Research and Removal within Rock Island and Rocky Reach Reservoirs. Columbia Research. 426 E. Woodin Ave. Chelan, WA 98816. Prepared for Chelan County Public Utility District, 327 N. Wenatchee Ave., Wenatchee, WA 98801.

Jerald, T. 2000. 2000 Public Utility District No. 1 of Douglas County Northern Pikeminnow Removal and Research Program. Prepared by Columbia Research for Public Utility District No. 1 of Douglas County, 1151 Valley Mall Parkway, East Wenatchee, WA 98802-4497.

Jerald, T. 2005. 2004 Public Utility District No. 1 of Douglas County Northern Pikeminnow Removal and Research Program. Prepared by Columbia Research for Public Utility District No. 1 of Douglas County, 1151 Valley Mall Parkway, East Wenatchee, WA 98802-4497.

Jerald, T. 2006. 2005 Public Utility District No. 1 of Douglas County Northern Pikeminnow Removal and Research Program. Prepared by Columbia Research for Public Utility District No. 1 of Douglas County, 1151 Valley Mall Parkway, East Wenatchee, WA 98802-4497.

Jerald, T. 2012. 2011 Public Utility District No. 1 of Douglas County Northern Pikeminnow Removal and Research Program. Prepared by Columbia Research for Public Utility District No. 1 of Douglas County, 1151 Valley Mall Parkway, East Wenatchee, WA 98802-4497.

Jerald, T. 2013. 2012 Public Utility District No. 1 of Douglas County Northern Pikeminnow Removal and Research Program. Prepared by Columbia Research for Public Utility District No. 1 of Douglas County, 1151 Valley Mall Parkway, East Wenatchee, WA 98802-4497.

Jerald, T. 2014. 2013 Public Utility District No. 1 of Douglas County Northern Pikeminnow Removal and Research Program. Prepared by Columbia Research for Public Utility District No. 1 of Douglas County, 1151 Valley Mall Parkway, East Wenatchee, WA 98802-4497.

Jerald, T. 2017. 2016 Public Utility District No. 1 of Douglas County Northern Pikeminnow Removal and Research Program. Prepared by Columbia Research for Public Utility District No. 1 of Douglas County, 1151 Valley Mall Parkway, East Wenatchee, WA 98802-4497.

Magnotti, M., and T. Jerald. 2001. Northern Pikeminnow Removal Program Report for 2000. Prepared by Columbia Research for Grant County Public Utility District No. 2. P.O. Box 878 Ephrata, WA.

Matthews, S.B., T.K Iverson, J.M. Lynch, B.D. Mahoney, and R.W. Tyler. 1991. Evaluation of harvest technology for squawfish in Columbia River Reservoirs. Report D in 1991 BPA Annual Report: Development of a system-wide predator control program: Stepwise implementation of a predation index, predator control fisheries, evaluation plan in the Columbia River Basin.

Porter, R. 2000. Development of a system-wide predator control program: Stepwise implementation of a predation index, predator control fisheries, and evaluation plan in the Columbia River Basin. 2000 Annual Report. Project Number 90-077.

Vigg, S., C.C. Burley, D.L. Ward, C. Mallette, S. Smith, and M. Zimmerman. 1990. Development of a system-wide predator control program: Stepwise implementation of a predation index, predator control fisheries, and evaluation plan in the Columbia River Basin. BPA Annual Report. Project No. 90-077.