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

Northern Pikeminnow Management Program

Annual Report
1999

DOE/BP-00004477-2

August 2003

This Document should be cited as follows:

Young, Franklin, Lyle Fox, Jennifer Amren, Bryce Glaser, Mark Wachtel, Eric Winther, Russell Porter, Roy Beaty, Mark Zimmerman, Thomas Friesen, David Ward, Howard Takata, "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; Northern Pikeminnow Management Program", 1999 Annual Report, Project No. 199007700, 108 electronic pages, (BPA Report DOE/BP-00004477-2)

Bonneville Power Administration
P.O. Box 3621
Portland, OR 97208

This report was funded by the Bonneville Power Administration (BPA), U.S. Department of Energy, as part of BPA's program to protect, mitigate, and enhance fish and wildlife affected by the development and operation of hydroelectric facilities on the Columbia River and its tributaries. The views in this report are the author's and do not necessarily represent the views of BPA.

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

Northern Pikeminnow Management Program

ANNUAL REPORT

1999

Submitted by
Franklin Young
Columbia Basin Fish and Wildlife Authority

CONTENTS

REPORT A
Implementation of the Northern Pikeminnow Sport-Reward Fishery in the Columbia and Snake Rivers

Prepared by:

Lyle G. Fox
Jennifer Amren
Bryce G. Glaser
Mark L.Wachtel
Eric C. Winther

Washington Department of Fish and Wildlife
600 Capitol Way N., Olympia, WA 98501-1091

ACKNOWLEDGMENTS

This project was funded by the Bonneville Power Administration, William Maslen and John Skidmore, Project Managers (Contract DE-BI719-94BI24514). We thank Frank Young and his staff at Columbia Basin Fish and Wildlife Authority; Mark Zimmerman and his staff at Oregon Department of Fish and Wildlife; Roy Beaty and his staff at Columbia River Inter-Tribal Fish Commission; Russell Porter and his staff at Pacific States Marine Fisheries Commission, and Carlene Stenehjem at Bonneville Power Administration - Public Affairs, for their cooperation and coordination.

We are grateful to the U. S. Forest Service for the use of Bonneville Trailhead; the U.S. Army Corps of Engineers for the use of Giles French, and Greenbelt Boat Ramps; the Washington State Parks and Recreation Commission for the use of Maryhill State Park and Lyons Ferry State Park; the Washington Department of Transportation for the use of the Vernita Rest Area; Weyerhauser for allowing us to use the Weyerhauser Boat Ramp; the Port of Klickitat County for the use of Bingen Marina; the Port of Camas/Washougal for the use of Camas/Washougal Boat Ramp; the Port of Cascade Locks for the use of Cascade Locks Marina; the Port of Cathlamet for the use of Cathlamet Marina; the Port of The Dalles for the use of The Dalles Boat Basin; the Port of Hood River for the use of Hood River Marina; the Portland Metro Regional Parks Department for the use of M.J. Gleason Boat Ramp and Chinook Landing; the City of Rainier for the use of the Rainier Boat Ramp; the City of Richland for the use of Columbia Point Park, the City of Vancouver for the use of Marine Park; Cowlitz County Parks and Recreation Department for the use of Willow Grove Park; the Port of Umatilla for the use of the Umatilla Boat Ramp; and Sheila Cannon and Ken Beer for the use of The Fishery at Covert's Landing.

We appreciate the efforts of Andrew Albrecht, Jaime Arwood, Jennie Boyd, Joe Burcar, Kathleen Byrd, Steve Cross, Denise Cummings, Suzan Deaver, Paul Dunlap, Josh Hede, Josua Holowatz, Kevin Hooker, Maria Holmes, Kurt Hubbard, Kathy Mai, Derrick Meaghers, Eric Meyer, Linda Moore, Kim Motyka-Klundt, Kathleen Moyer, Christine Oatney, David Orr, Carolyn Pearson, Jonathan Rerecich, Janet Roark, Bill Rogers, Lindie Schmidt, Troy Schumacher, Tricia Shoblom, Joe Steele Sr., Mark Thompson, Kelly Tkachenko,and Nick Yaksic operating the sport-reward fishery registration stations. We also recognize Diana Murillo and Michael Heins for their excellent work in computer data entry and verification of volumes of documents and Fella Tanaka for her numerous phone survey interviews.

We are thankful to Wilbert Morrison and Jennifer Amren for their special assistance in keeping things running smoothly throughout the year.

ABSTRACT

We are reporting on the progress of the Northern Pikeminnow Sport-Reward Fishery (NPSRF) in the lower Columbia and Snake rivers for May 3 through October 10, 1999. The objectives of this project were to (1) implement a recreational fishery that rewards anglers who harvest northern pikeminnow (*Ptychocheilus oregonensis)* $\geq$ 279 mm (11 inches) total length, (2) obtain catch data on fish species caught by fishery participants while targeting northern pikeminnow, (3) collect biological data on the above mentioned species that are returned to registration stations, and (4) collect, monitor and report data on angler participation and catch per angler day during the season.

A total of 114,687 northern pikeminnow $\geq$ 279 mm were harvested during the 1999 season and 25,906 angler days were spent harvesting these fish. Harvest was below the eight-year average of 145,606 and angler effort was well below the eight-year average of 49,948 angler days. Although harvest and angler effort were below eight year averages, the exploitation rate was 12.5%, which met the Northern Pikeminnow Management Program goal of 10-20%. Catch per angler day for all anglers during the season was 4.43 and exceeded the eight-year average of 4.15 northern pikeminnow per angler day.

Peamouth *Mylocheilus caurinus,* and white sturgeon *Acipenser transmontanus,* were the other species most often harvested by returning NPSRF anglers targeting northern pikeminnow.

INTRODUCTION

Northern pikeminnow *Ptychocheilus oregonensis* are the primary predator of juvenile salmonids *Onchorhynchus spp.* in the Lower Columbia and Snake River systems (Rieman et al. 1988). Rieman and Beamesderfer (1990) estimated that predation on juvenile salmonids could be reduced by up to 50% with a sustained exploitation rate of 10-20% on northern pikeminnow $\geq$275 mm fork length. The Northern Pikeminnow Management Program (NPMP) was created in 1990 with the goal of maintaining a 10-20% annual exploitation rate on northern pikeminnow within the program area.

One component of the Northern Pikeminnow Management Program is the Northern Pikeminnow Sport-Reward Fishery (NPSRF). The NPSRF offered monetary rewards to recreational anglers for harvesting northern pikeminnow $\geq$ 279 mm total length from within program boundaries on the Columbia and Snake rivers. In order to participate, anglers were required to register, and later exchange eligible northern pikeminnow for payment vouchers (at the end of the day). No reward was paid for northern pikeminnow less than 279 mm. All returning anglers and a sub-sample of non-returning anglers were interviewed to collect catch data needed to monitor the effect of the program on fish species other than northern pikeminnow.

The objectives of this project were to (1) implement a recreational fishery that rewards anglers who harvest northern pikeminnow $\geq$ 279 mm (11 inches) total length, (2) obtain catch data on fish species caught by fishery participants while targeting northern pikeminnow, (3) collect biological data on the above mentioned species that are returned to registration stations, and (4) collect, monitor and report data on angler harvest, participation, and catch per angler day during the season.

METHODS OF OPERATION

Boundaries and Season

The NPSRF was conducted on the Columbia River from the mouth to the boat restricted zone below Priest Rapids Dam, and on the Snake River from the mouth to the boat restricted zone below Hells Canyon Dam (Figure 1). In addition, northern pikeminnow harvested from backwaters, sloughs, and 400 feet up the mouths of tributaries within this area were also eligible for reward payment. Rules and regulations for participation in the NPSRF are listed in Appendix A. The 1999 NPSRF was fully implemented from May 3 (week 18) through September 26 (week 38).

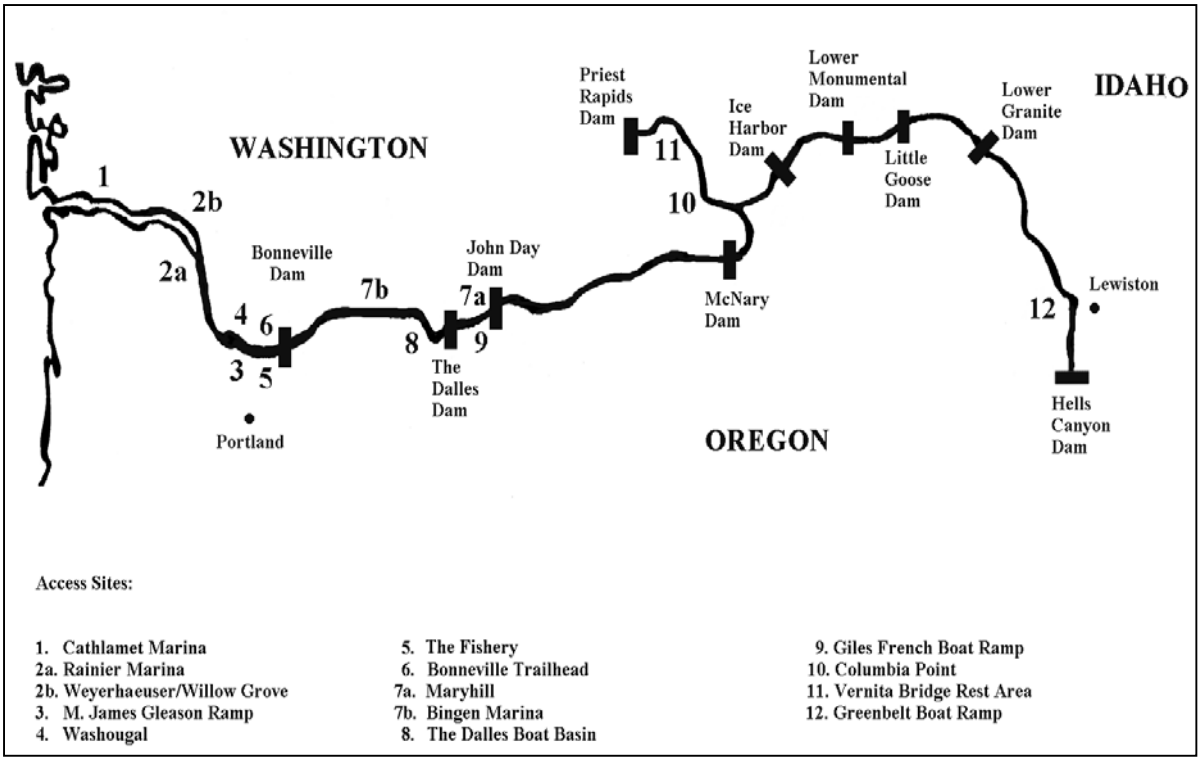


Figure 1 - 1999 Northern Pikeminnow Sport-Reward Program Registration Stations.

During the final weeks of the 1999 season, the weekly harvest, effort and CPUE reports for each registration station were examined to determine if and where season extensions should occur. Based on an identifiable upward trend in harvest and CPUE, and favorable river conditions, it was decided that registration stations located at Vernita Rest Area and Greenbelt Boat Ramp should be extended through October 10, 1999 (Week 40).

Registration Stations and Satellites

Fourteen registration locations on the Columbia and Snake rivers allowed anglers to participate in the NPSRF (Figure 1). Registration stations were open from 1 p.m. to 9 p.m. daily. Anglers were required to complete a registration form to participate in the NPSRF. Anglers could self register during unstaffed hours using registration boxes. Stations 2a and 2b (Rainier/Weyerhaeuser) and 7a and 7b (Maryhill/Bingen) were hybird stations where a technician split the 1 p.m. to 9 p.m. shift between locations. When registered anglers returned to registration stations, technicians conducted an exit interview and issued pay vouchers for eligible northern pikeminnow. In addition to the 14 registration locations used during the 1999 season, there were seven satellites (Figure 2), which performed functions similar to full-time stations. Satellites operated 1-2 hours per day and were affiliated with a parent registration station as a way to increase their efficiency. Satellites were monitored during the season, and operating schedules were modified or discontinued to reduce operating costs.

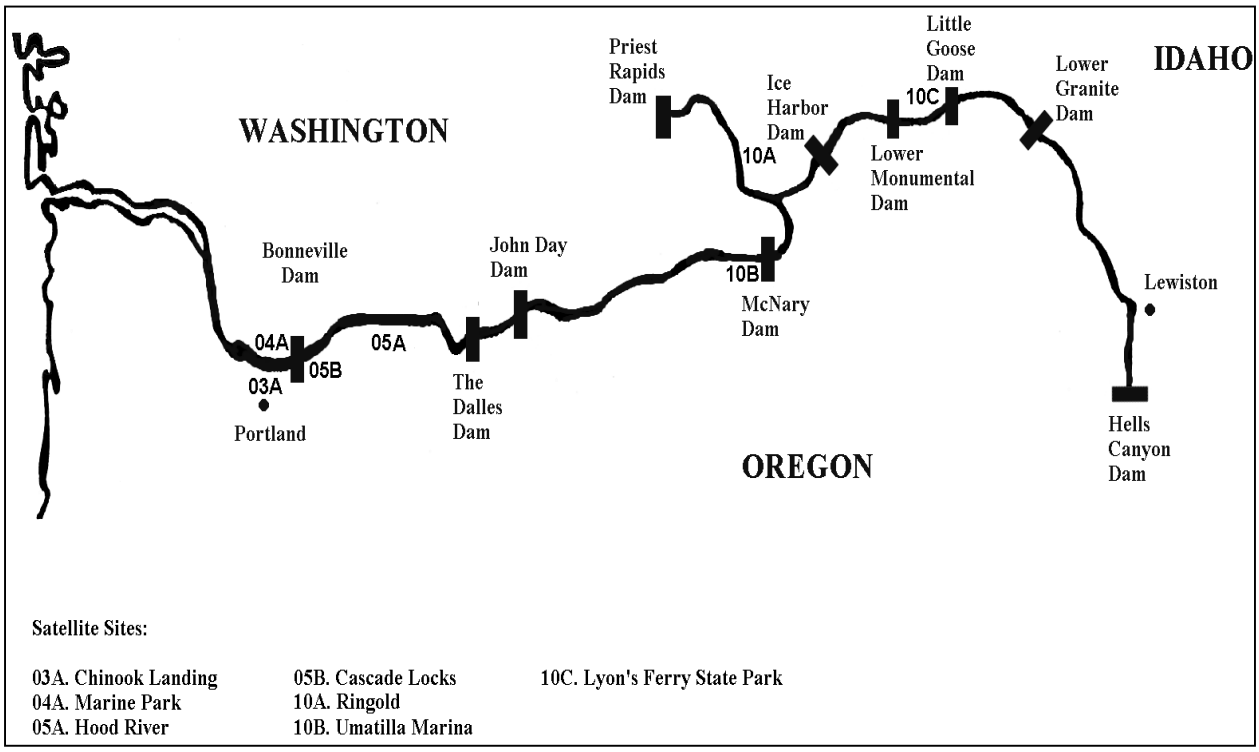


Figure 2 - Northern Pikeminnow Sport-Reward Program Satellites for 1999.

Reward System

The 1999 NPSRF continued the tiered reward system begun in 1995 (Hisata et al. 1995). However, the rewards were increased to $4 each for the first 100 northern pikeminnow returned in the season, $5 each for 101-400, and $6 each over 400. NPMP tagged northern pikeminnow continued to be worth $50 (Smith et al. 1994).

To receive payment, anglers were issued vouchers for qualifying northern pikeminnow (Appendix A) that they brought to the registration stations. Vouchers were mailed to Pacific States Marine Fisheries Commission (PSMFC) for redemption.

Returning Angler Sampling

Technicians conducted exit interviews with all returning anglers at each registration station. Interviews were made to determine location fished (Figure 3), species of fish, and number of fish caught and/or harvested while anglers targeted northern pikeminnow. Anglers were asked if they specifically fished for northern pikeminnow at any time during their fishing trip. A "No" response ended the exit interview. With a "Yes" response, anglers were asked how many of each species of fish were caught and released while they specifically targeted northern pikeminnow. A fish was considered "caught" when the angler touched, released or landed the fish, "released"

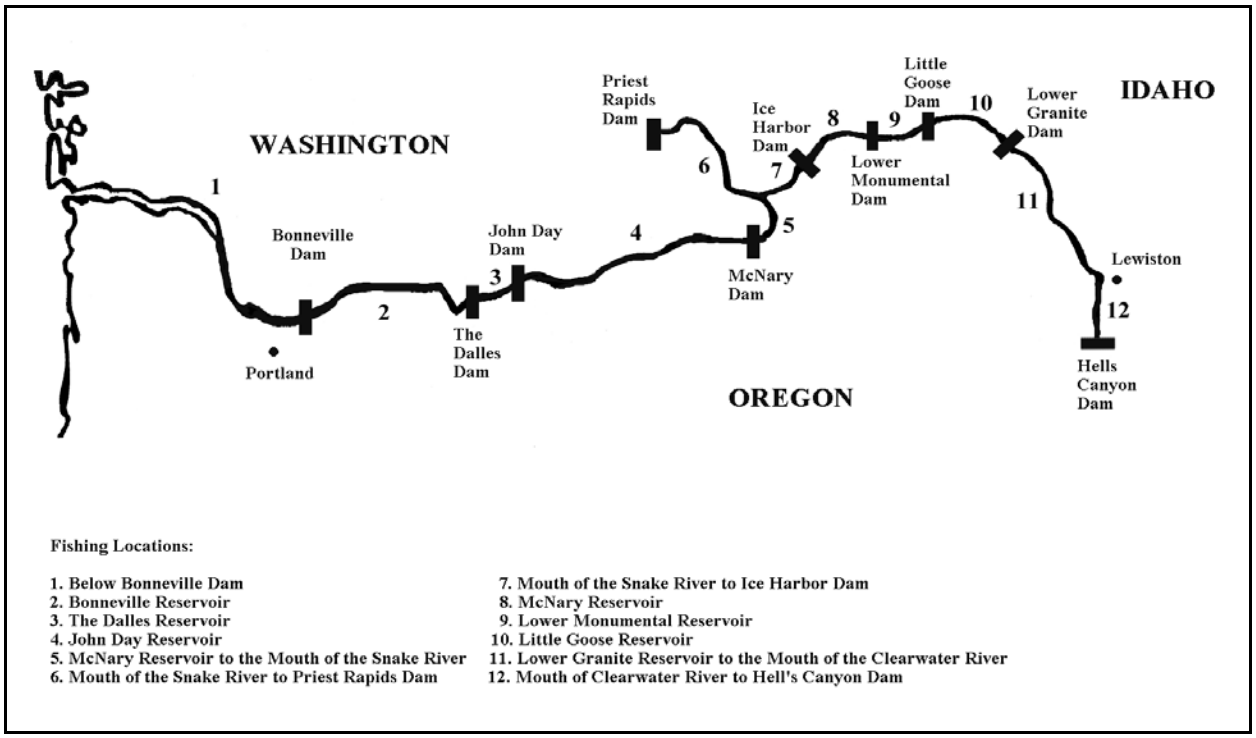


Figure 3 - 1999 Northern Pikeminnow Sport-Reward Fishing Locations

was defined as those fish returned to the water alive. Harvest was defined as those fish retained by the angler or not returned to the water alive.

Non-Returning Angler Sampling

A goal of surveying 20% of each week's non-returning anglers by telephone was set to obtain non-returning catch data from anglers targeting northern pikeminnow. Non-Returning anglers were defined as those anglers that did not return to the registration station and thus, did not participate in the exit interview as defined above. To attain our 20% goal, 50% of non-returning angler registration forms were randomly selected from all registration stations each week. A technician called anglers from each random sample until they attained the 20% goal (if the 20% goal was not reached during the first pass through the registration forms, technicians continued to re-call anglers that weren't reached during the first attempt until the goal was met). Anglers were asked: "Did you specifically fish for northern pikeminnow at any time during your fishing trip?" With a "Yes" response, anglers were asked how many and which species of adult or juvenile salmonids were caught and released while they specifically targeted northern pikeminnow (angler catch and harvest data were not collected from anglers who did not target northern pikeminnow on their fishing trip). Starting in 1999 anglers with a “Yes” response to the first question were also asked whether any northern pikeminnow (11” or longer) were caught.

Non-Returning Angler Catch Estimates

Non-Returning anglers were sampled according to the method described above. The samples were found to either have a binomial distribution or to be non-normally distributed. For non-normally distributed samples a mean catch per angler of each occurring species of salmonids and northern pikeminnow was established (x/n = 0). This mean was then applied to the known population by multiplying it by the population size (N0). The resulting number is the estimated catch of salmonids and northern pikeminnow for non-returning anglers. For salmonid samples that fit the binomial distribution (0 and 1 catches only in sample) the proportion of occurrences of 1 was estimated using the formula $\hat{p} = X / n$ (where X = the number of occurrences of 1 in the sample) and total catch by the formula $\hat{Y} = \hat{p}N$ (Zar 1984).

In order to set confidence limits around these estimates two methods were used. Using a relationship between the *F* distribution and the binomial distribution a confidence interval may be computed for the binomial parameter *p* (Bliss 1967; Zar 1984). The following formulas were used to obtain the upper and lower confidence limits around the estimated proportion:

Lower Confidence Limit

$$L_1 = \frac{X}{X + (n - X + 1)F_{\propto (2)\nu 1,\, \nu 2}}$$

$$\nu_1 = 2(n - X + 1)$$
$$\nu_2 = 2X$$

Upper Confidence Limit

$$L_2 = \frac{(X + 1)F_{\propto (2)\nu'1,\, \nu'2}}{X + (n - X + 1)F_{\propto (2)\nu'1,\, \nu'2}}$$

$$\nu'_1 = \nu_2 + 2$$
$$\nu'_2 = \nu_1 - 2$$

When *n* is appreciably large relative to N a finite population correction may be used when estimating confidence limits (Zar 1984). Given the large size of our sample (19.2%) the following correction formulas were used:

Lower Confidence Limit

$$(L_1)c = \frac{X - 0.5}{n} - \left(\frac{X - 0.5}{n} - L_1\right)\sqrt{1 - \frac{n}{N}}$$

Upper Confidence Limit

$$(L_2)c = \frac{X'}{n} + \left(L_2 - \frac{X'}{n}\right)\sqrt{1 - \frac{n}{N}}$$

$$X' = X + \frac{X}{n}$$

The corrected L_1 and L_2 were then multiplied by the known population size (N) to transform the proportions into lower and upper confidence limits around the catch estimate. All formulas are from Zar (1984). In order to obtain a lower confidence limit that did not equal 0; the confidence was lowered to the 80% level on all binomial distributed samples.

The bootstrap method was used on samples that did not fit the binomial distribution and were not normally distributed. The bootstrap method may be used to obtain reliable confidence intervals around a point estimate when more traditional methods are found to be inappropriate (Annette Hoffman, biometrician, Wash. Dept. of Fish and Wildlife, personal communication). A random sample was drawn (with replacement) from the original data to create a bootstrap replicate sample. This was repeated 1000 times and the whole procedure repeated for each species of fish in question. The resulting 1000 sample catches were then sorted in ascending order and assigned a number 1 to 1000. The lower and upper confidence limits were then established by 1000(%) and 1000(1-%) respectively (Efron and Tibshirani 1993). For example, to obtain the lower confidence limit at a 95% confidence level: (1000)(.05)= 25. Thus the 25^{th} highest bootstrap replicate sample is the lower confidence limit. Accordingly, the value (1000)(1-.05)= 950 was the upper limit. In order to obtain a lower confidence limit that did not equal 0; the confidence was lowered to a point below the 95% level on some species of fish. The lower and upper confidence level figures were then expressed as a mean catch per angler from the sample and multiplied by the known population size (N) to give the final confidence limits around the estimated catch.

Biological Sampling

Northern pikeminnow returned to registration stations were sampled for biological data when time permitted. Sampling consisted of measuring fork length and determining sex (by evisceration). All tagged northern pikeminnow returned were sampled for biodata, and pertinent tag information was recorded. Tags were returned to anglers for submission with a separate tag voucher. Northern pikeminnow not eviscerated were caudal-clipped to indicate processing by NPSRF technicians. Northern pikeminnow collected were delivered to rendering facilities for disposal. When possible, other fish species brought in by registered anglers were identified and sampled for fork length.

RESULTS AND DISCUSSION

Northern Pikeminnow Harvest

The 1999 NPSRF harvested 114,687 northern pikeminnow $\geq$ 279 mm total length. Returning anglers also harvested 7,097 northern pikeminnow less than 279mm. Harvest in 1999 increased 5.3% from the 1998 season (Wachtel et al. 1998), but was 21.2% lower than the eight year average of 145,606.

Figure 4 shows the weekly harvest for 1999 compared to the means for each week from the 1991-98 seasons. Mean weekly harvest in 1999 was 4,986 with peak harvest occurring during week 26 (June 28 through July 4). Peak harvest (12,439) occurred during the same week as the mean peak harvest for 1991-98 (12,833) (Figure 4). The lowest weekly harvest for the regular season was 2,512, which was the first week of the season.

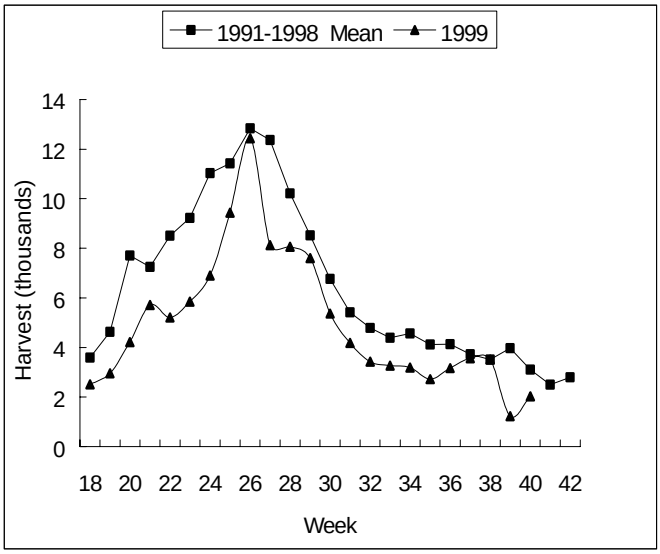
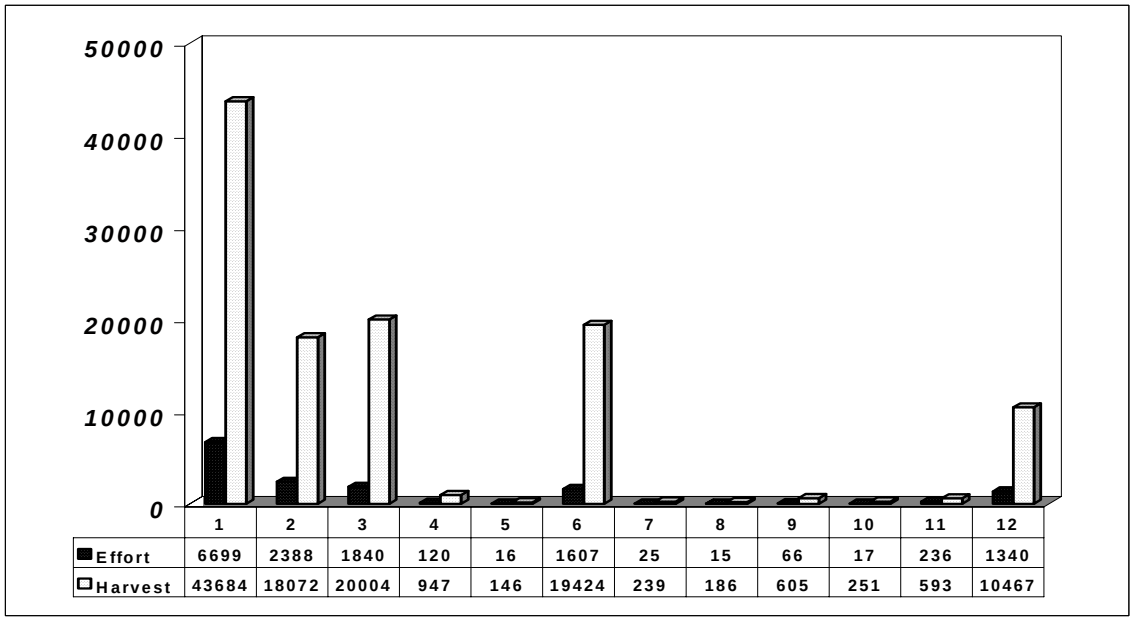


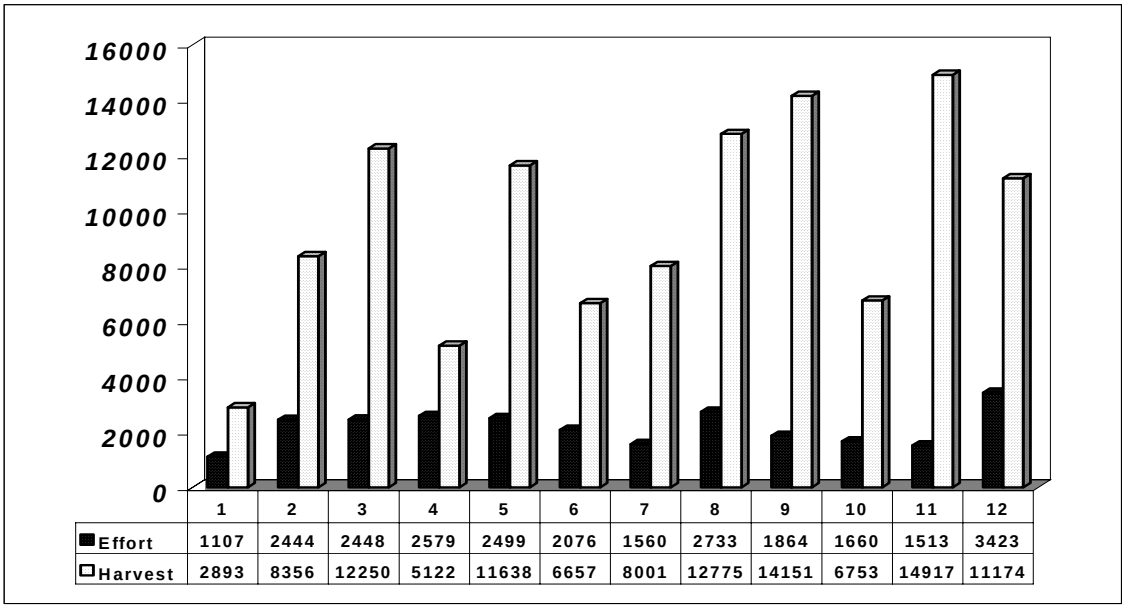
Figure 4 – 1999 northern pikeminnow harvest and mean harvest for 1991-1998 by week.

Harvest by registration station ranged from 14,917 at Vernita to 2,893 at Cathlamet (Figure 5). Harvest by fishing location ranged from 43,660 below Bonneville Dam to 146 for the area from McNary Dam to the mouth of the Snake River (Figure 6). The greatest change in harvest between 1998 and 1999 was from the mouth of the Snake River to Priest Rapids Dam, where the total 1999 harvest was 4,198 fish more than the previous year. Fishing locations 1, 2, and 3, which include everything below John Day Dam, produced 81,736 northern pikeminnow or 71.3% of the total harvest. This high proportion is typical of past years. This may be attributable to large populations of northern pikeminnow in these locations (Zimmerman et al., 1997) and their proximity to major population centers.



	1	2	3	4	5	6	7	8	9	10	11	12
Effort	6699	2388	1840	120	16	1607	25	15	66	17	236	1340
Harvest	43684	18072	20004	947	146	19424	239	186	605	251	593	10467

Figure 5-1999 northern pikeminnow harvest and total effort by registration station. 1-Cathlamet, 2-Rainier/Weyerhaeuser, 3-Gleason, 4-Washougal, 5-The Fishery, 6-Bonneville Trailhead, 7-Maryhill/Bingen, 8-The Dalles, 9-Giles French, 10-Columbia Point, 11-Vernita, 12-Greenbelt.



	1	2	3	4	5	6	7	8	9	10	11	12
Effort	1107	2444	2448	2579	2499	2076	1560	2733	1864	1660	1513	3423
Harvest	2893	8356	12250	5122	11638	6657	8001	12775	14151	6753	14917	11174

Figure 6-1999 northern pikeminnow harvest and returning angler effort by fishing location. 1-Below Bonneville Dam, 2-Bonneville Res., 3-The Dalles Res., 4-John Day Res., 5-McNary Dam to Mouth of Snake, 6-Mouth of Snake to Priest Rapids Dam, 7-Mouth of Snake to Ice Harbor Dam, 8-Ice Harbor Res., 9-Lower Monumental Res., 10-Little Goose Res., 11-Lower Granite Dam to Clarkston, 12-Clarkston to Hells Canyon Dam.

Returning Angler Harvest

Northern pikeminnow targeted and harvested by returning anglers were recorded separately from those harvested by anglers not targeting northern pikeminnow. Of the overall total harvest, 98.7% of northern pikeminnow $\geq$ 279mm were targeted. Other species harvested incidentally included 68 white sturgeon *Acipenser transmontanus,* 2 chinook jacks *Oncorhynchus tshawytscha* and 12 adult hatchery steelhead *Oncorhynchus mykiss.* Refer to Appendix B for the list of all species caught and harvested by returning anglers.

Non-Returning Angler Catch of Salmonids and Northern Pikeminnow

A total of 2,216 non-returning anglers were sampled. This was near our goal of 20% (19.21%). Juvenile steelhead (wild origin) were the salmonid species most frequently caught by non-returning anglers targeting northern pikeminnow, with an estimated 218 caught (95% confidence interval = 98-348) (Table 1). This was an increase of 151 over 1998 (Wachtel 1998). This increase and the subsequent decrease in juvenile steelhead adipose absent, 82 in 1998 and 57 (90% CI= 15-109) in 1999, is most likely in part due to a change implemented in the telephone interview process. All juvenile steelhead caught were categorized as adipose present (wild) unless the adipose was specifically noticed by the angler as being absent (hatchery). The only salmonid species reported harvested by non-returning anglers targeting northern pikeminnow was one adult steelhead (hatchery). It was estimated that 406 northern pikeminnow > 279 (95% CI= 286-557) were caught by non-returning anglers, but were not turned in for the reward.

Table 1. Estimated catch of salmonids and northern pikeminnow caught by non-returning anglers targeting northern pikeminnow in 1999.

Species	Method	Confidence Level	Estimated Catch	Range
Chinook (Adult)	Binomial	80%	10	(3 to 26)
Chinook (Jack)	Bootstrap	75%	15	(5 to 26)
Chinook (Juv.)	Bootstrap	95%	130	(57 to 223)
Steelhead (Hatchery)	Binomial	80%	20	(10 to 39)
Steelhead (Wild)	Bootstrap	80%	20	(5 to 36)
Steelhead Juv. (Hatchery)	Bootstrap	90%	57	(15 to 109)
Steelhead Juv. (Wild)	Bootstrap	95%	218	(98 to 348)
Rainbow Trout	Bootstrap	75%	15	(5 to 26)
Coho (Adult)	Binomial	80%	5	(1 to 19)
Northern Pikeminnow > 279mm	Bootstrap	95%	406	(286 to 557)

N=11537 n=2216

Angler Effort

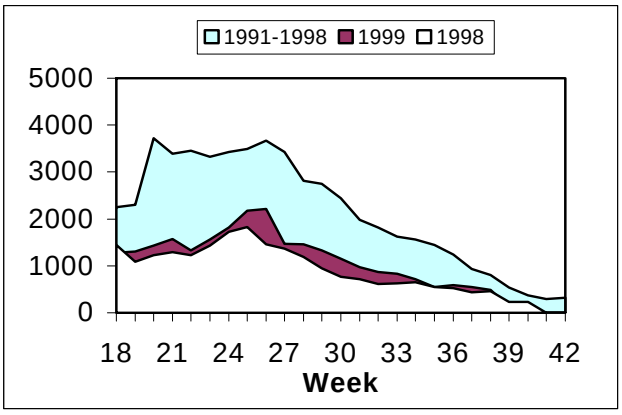


Figure 7- Total angler effort by week for 1991-1998 (mean) 1999 and 1998.

Total effort (number of registered angler days) for 1999 was 25,906 days. This was an 18% increase (3,947 days) over 1998 (Wachtel et. al. 1998), but it was 48% lower than the eight year average of 49,948. Peak angler effort occurred during week 26 (June 28 to July 4) (Figure 7); the same weeks as peak harvest (Figure 4). Returning angler effort (13,368 angler days) was 52% of total angler effort. Effort by fishing location for 1999 (returning anglers only) ranged from 6,692 below Bonneville Dam to 15 in Ice Harbor Reservoir (Figure 6). All locations experienced an increase in effort compared to the 1998 season, except for the mouth of the Snake River to Ice Harbor Dam. The location with the greatest increase in returning angler effort was below Bonneville Dam, which increased 17.7% (1,006 days) from the 1998 season. The Greenbelt registration station had the highest total effort for the 1999 NPSRF, which was 3,423 days. The second highest station was The Dalles with 2,733 days. (Figure 5).

The rise in angler effort, from the 1998 to the 1999 season, is most likely attributable to the monetary increase in the tiered-reward payment incentive. The 1999 season marked the third time in the NPSRF's history that the reward for northern pikeminnow has been increased. Each change has shown a subsequent rise in angler effort. The first was a jump from $1 to $3 during the 1990 John Day Reservoir test fishery, which produced a "sharp" increase in angler effort (Vigg et al. 1990). The second was in 1995 when the tiered-reward payment system ($3, $4, and $5) was introduced, producing a 53.8% increase in angler effort from the previous year (Hisata et al., 1995). The move to $4, $5, and $6 in 1999 was followed by the first year to year increase in angler effort since 1995 (Hisata et al. 1995, Winther et al. 1996, Petersen et al. 1997, and Wachtel et al. 1998). This trend, of a rise in angler effort following a reward increase, reinforces that angler participation in the NPSRF is heavily influenced by monetary incentives.

Catch Per Angler Day

Overall (returning + non-returning anglers) catch per angler day (CPUE) for nothern pikeminnow $\geq$ 279 mm in 1999 was 4.43 fish/angler day. The 1999 NPSRF's weekly CPUE remained above mean weekly CPUE for 1991-98 (Figure 8A) and overall CPUE exceeded the mean 1991-98 CPUE of 4.15 fish/angler day. In general, while CPUE for the 1999 NPSRF was lower than in 1998 (4.96), it continues to conform to the upward trend in CPUE seen from 1991 to 1998 (Figure 8B).

When we exclude non-returning anglers, CPUE was 8.6 fish/returning angler day which was virtually unchanged from 1998 (8.7). Returning angler CPUE by fishing location ranged from 14.76 (Little Goose Reservoir) to 2.51 in the area from Lower Granite Dam to Clarkston (Figure 9). The registration station with the highest angler CPUE was Vernita with 9.86 fish/returning angler day whereas Washougal had the lowest with 1.99 (Figure 10).
The reduction in overall CPUE from last season is most likely accounted for by the fact that the

increase in effort (angler days) was primarily from non-returning anglers who have a much lower CPUE than returning anglers (Hisata et. al. 1995). Given this information, and since returning angler CPUE did not appreciably change from 1998 it is unlikely that the decrease in overall CPUE was a result of any other factors such as fewer fish being available.

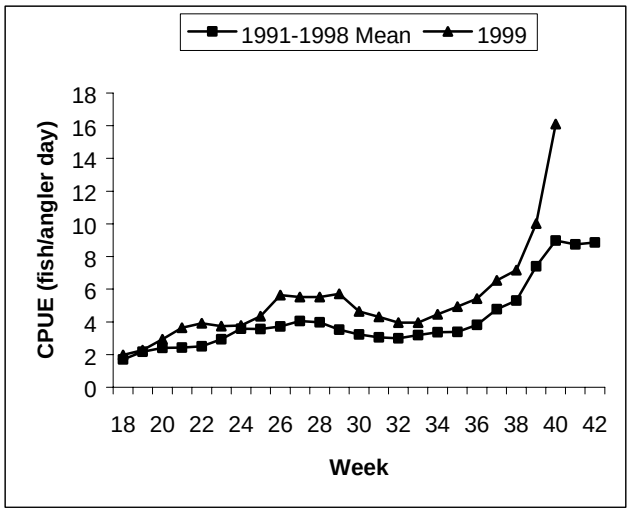


Figure 8A- CPUE (catch/angler day) by week for 1991-1998 (mean) and 1999.

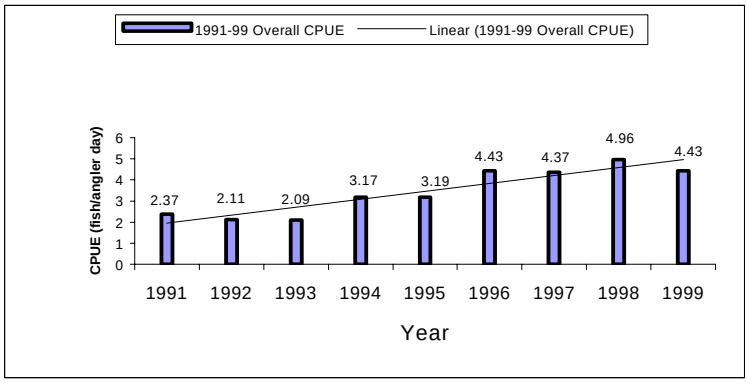


Figure 8B- CPUE (catch/angler day) by year for 1991-1999.

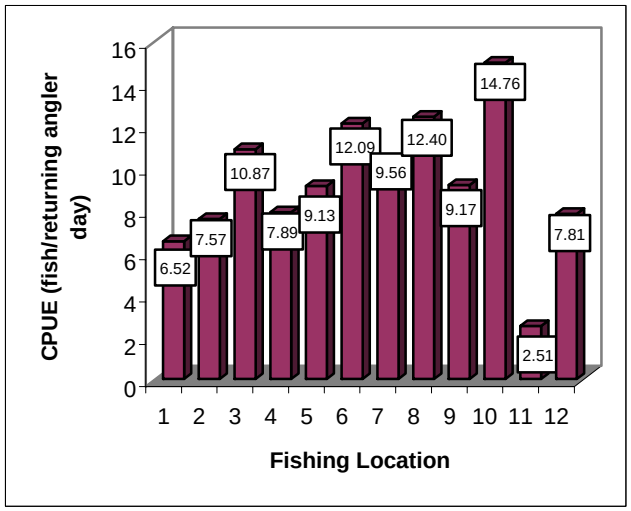


Figure 9- CPUE of returning anglers by fishing location in 1999. 1- Below Bonneville Dam, 2– Bonneville Res., 3-The Dalles, 4- John Day Res., 5- McNary Dam to Mouth of Snake River, 6- Mouth of Snake River to Priest Rapids Dam, 7- Mouth of Snake River to Ice Harbor Dam, 8- Ice Harbor Res., 9- Lower Monumental, 10- Little Goose Res., 11-Lower Granite Dam to Clarkston, 12- Clarkston to Hells Canyon Dam.

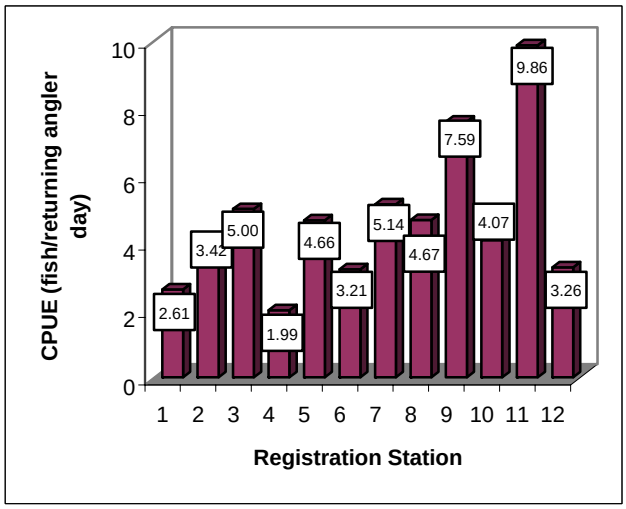


Figure 10- CPUE of returning anglers by registration station in 1999. 1- Cathlamet, 2- Rainier/Weyerhauser, 3-Gleason, 4- Washougal, 5- The Fishery, 6-Bonneville Trailhead, 7- Maryhill/Bingen, 8- The Dalles, 9- Giles French, 10- Columbia Point, 11-Vernita, 12-Greenbelt.

Exploitation Rate

The Northern Pikeminnow Management Program goal is to maintain an exploitation rate of 10-20% for the entire program, which includes the NPSRF, dam angling, and gill netting. Oregon Department of Fish and Wildlife (ODFW) has estimated the 1999 exploitation rate for the NPSRF to be 12.5% (Zimmerman and Friesen, Draft 1999 Annual Report) the second highest in the program's history. This is an indication that the decline in harvest and effort, as compared to 1991-98 annual means (Figure 11), has not had a negative effect on the program.

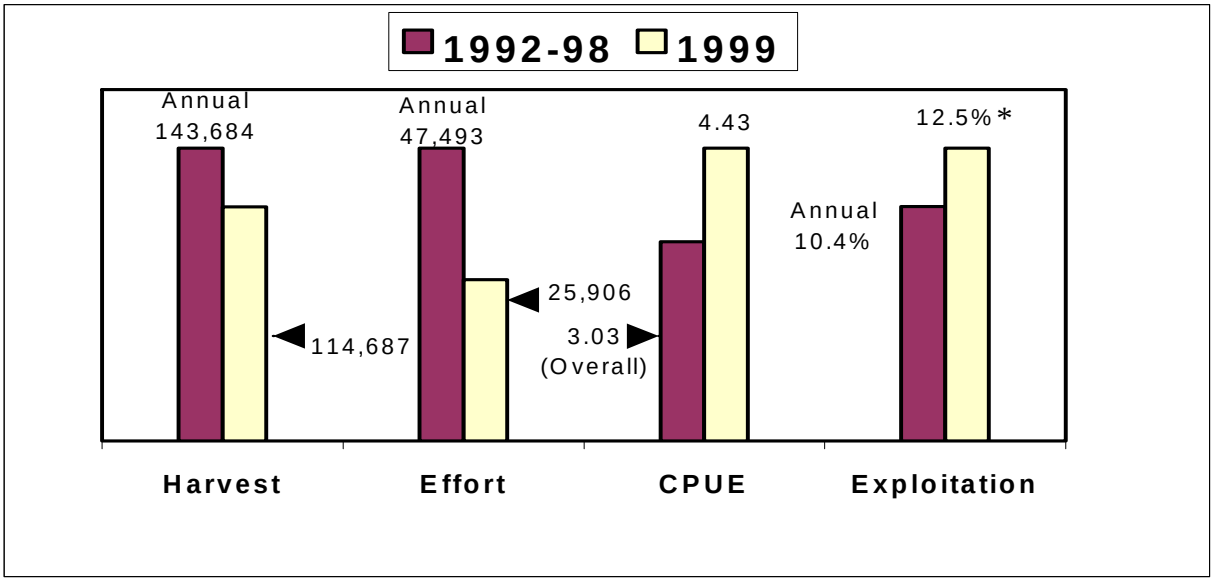


Figure 11 - Comparison of 1992-1998 Annual Means and 1999 Harvest, Effort, CPUE, and Exploitation. Note: The 1992-1998 period is used for comparison rather than 1991-1998 because exploitation information is only available back to 1992. * Zimmerman, M.P.and T.A. Friesen, 1999

Season Extension

The two week extension produced an additional harvest of 3,268 northern pikeminnow ≥279mm; 1,782 from Vernita and 1,486 from Greenbelt (Table 2). Mean weekly harvest at Vernita during the extension was 891 northern pikeminnow, up from the regular season mean of 625 (Table 2). Greenbelt's mean weekly harvest also increased; from 461 northern pikeminnow during the regular season to 743 during the extension (Table 2). CPUE for the extension was 19.8 at Vernita and 9.53 at Greenbelt. (Table 2). Figure 12 shows the 1999 weekly CPUE values for Vernita and Greenbelt, indicating both stations recorded their highest CPUE values during the last week of the extension (week 40).

Table 2: 1999 northern pikeminnow harvest, angler effort, and CPUE totals for Vernita and Greenbelt registration stations.

	Harvest	Effort	CPUE
Vernita			
Regular Season Total	13,134	1,424	9.22
Weekly Mean	625	68	
Season Extension Total	1,782	90	19.8
Weekly Mean	891	45	
Greenbelt			
Regular Season Total	9,680	3,267	2.96
Weekly Mean	461	156	
Season Extension Total	1,486	156	9.53
Weekly Mean	743	78	
Vernita/Greenbelt Combined			
Season Extension Total	3,268	246	13.3
Weekly Mean	1,634	123	

During the extension, the increased mean weekly harvest and high CPUE values for these stations, as compared to regular season values (Table 2), suggest that, per angler, the extension was the most productive period of the season for these two sites. At the end of the extension, CPUE values at Vernita and Greenbelt were on an upward trend (Figure 12). Assuming effort levels could have been maintained, it may have been possible to further extend the season, and achieve the same or higher levels of harvest for an undetermined amount of time. Examples of high angler productivity at season's end are not limited to this instance. Each year since 1994, the system-wide CPUE has trended upward late in the season, peaking during the last 2-3 weeks (Smith et al. 1994, Hisata et al. 1995, Winther et al. 1996, Petersen et al. 1997, Wachtel et al. 1998). Extensions during these years (when less productive sites are closed) probably account for some of the rise in overall CPUE seen during the last two weeks. In fact, extensions are intended to exploit high CPUE and harvest levels at selected registration stations, late in the season (Smith et al. 1994). Favorable fishing conditions (lower, warmer, and less turbid water) likely contribute to the rise in angler productivity seen during these times. It may be beneficial to focus more attention on individual registration stations and identify periods of peak productivity and favorable fishing conditions for each. The traditional NPSRF start or ending dates could be modified to better accommodate these periods. Season extensions have proven to be an effective means for exploiting year to year variability in late season fishing conditions; these extensions could be lengthened when appropriate. Also, a similar format could be developed to exploit areas of high productivity at the beginning of the NPSRF season. Essentially a shorter "core" season could be established with more site-specific flexibility added onto each end.

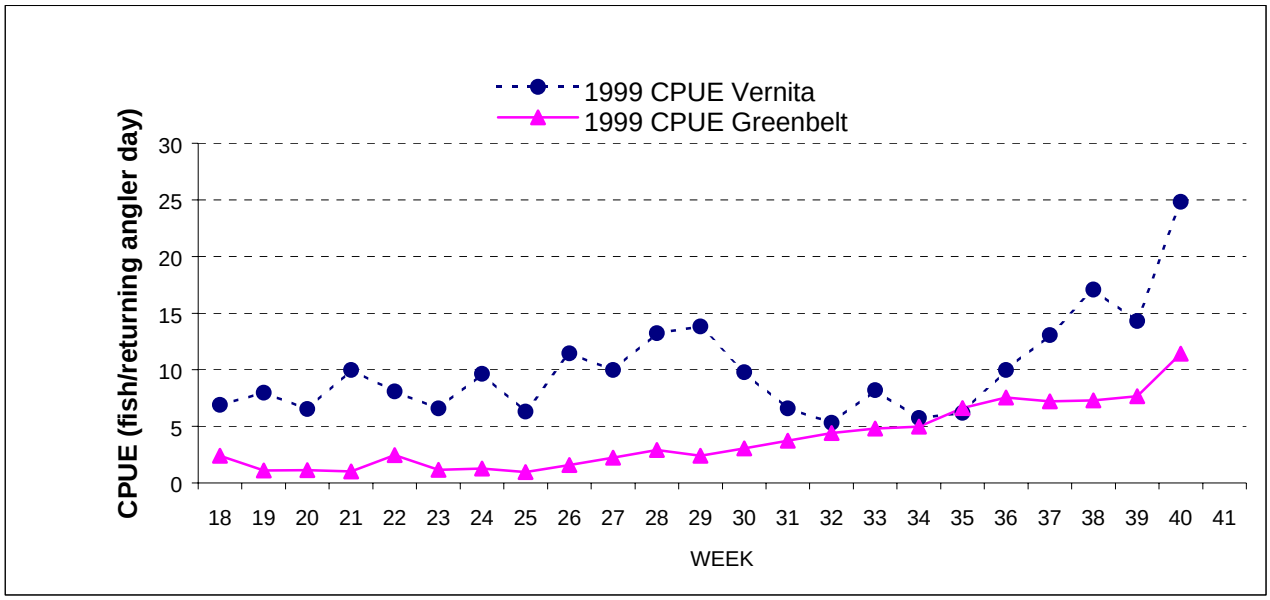


Figure 12 – 1999 weekly CPUE values for Vernita andGreenbelt registration stations.

Fork Length Data

A total of 79,084 northern pikeminnow were sampled for fork length in 1999. Of these, 78,324 fish (99%) had a fork length greater than or equal to 250mm. The mean fork length for northern pikeminnow ≥ 250mm was 326mm (SD 58.7) Mean fork lengths for each reservoir ranged from 303mm (S.D. 53.0) in the Lower Granite Reservoir to 353mm (S.D. 53.5) in The Dalles Reservoir (Table 3). Fork lengths occurred with the highest frequency (40.65%) between 250 and 299mm (Figure 13).

Table 3: 1999 mean fork length values by reservoir for northern pikeminnow ≥ 250mm.

Reservoir /Area	n	Mean fork Length (mm)	S.D.
Below Bonneville Dam	33,227	316	56.8
Bonneville	13,365	339	59.4
The Dalles	13,337	353	53.5
John Day	536	346	62.6
McNary	7,551	331	57.6
Ice Harbor	148	318	50.0
Lower Monumental	234	309	40.5
Little Goose	202	310	64.4
Lower Granite	9,708	303	53.0
Other*	15	310	41.1
Combined Total	**78,323**	**326**	**58.7**

*Fork lengths that were not assigned to a specific fishing location.

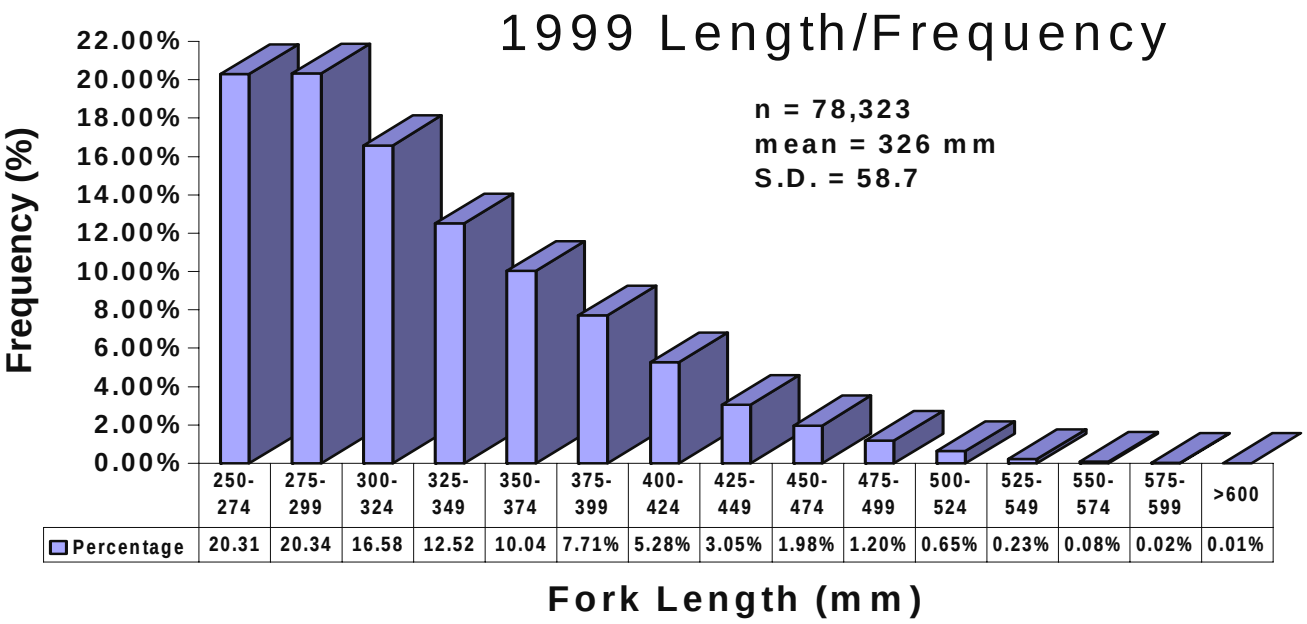


Figure 13: 1999 length / frequency distribution for northern pikeminnow $\geq$ 250mm fork length.

SUMMARY

- The 1999 NPSRF harvested 114,687 northern pikeminnow $\geq$ 279mm total length. Peak harvest occurred in week 26 as it typically has, and the full season closely resembled that of previous years.

- A total of 41 salmonids from seven different species were reported harvested by anglers targeting northern pikeminnow during the 1999 season. This incidental harvest was small when compared to the 114,687 northern pikeminnow removed from the system.

- The increase in reward payment rate put into effect in 1999 is considered to be the major reason for angler effort increasing by 18% over the previous year.

- Overall CPUE for the 1999 NPSRF was down from 1998 but above 1991-98 mean CPUE. The reduction in CPUE was due to an influx of new, inexperienced anglers since returning angler CPUE remained the same.

- The 1999 NPSRF exploitation rate was 12.5%. Although 1999 harvest and effort were lower than the 8 year averages, the NPSRF exploitation rate fell within the 10-20% range set as a goal by the NPMP.

- The two-week season extension at the Vernita and Greenbelt registration stations was a highly productive period for these sites. Each site showed an increase in mean weekly harvest and CPUE. The season extension "format" could be expanded or modified to further exploit these (and similar) periods of high productivity.

Recommendations for the 2000 Season

1. In response to the recommendations made in the 1996 Annual Report, expand the non-returning angler survey to include all incidental species to verify that trends in harvest have not changed.

2. Develop criteria for determining season extensions on a site-specific basis.

3. Develop strategies that will allow managing sites based on fishery conditions.

4. Begin the 2000 season on May 1 (week 18) and continue through September 24, last Sunday in September (week 38), which would be a 19-week "core" season.

5. Conduct a statistical analysis of fork length data to determine if significant changes have occurred in recent years.

REFERENCES

Bliss, C.I. 1967. Statistics in Biology, Vol. 1. McGraw-Hill, New York.

Efron, B., and R. J. Tibshirani. 1993. An introduction to the bootstrap. Chapman and Hall, New York.

Hisata, J.S., M.R. Petersen, D.R. Gilliland, E.C. Winther, S.S. Smith, and J. Suarez-Pena. 1995. Implementation of the northern squawfish sport-reward fishery in the Columbia and Snake Rivers. Report A *in* Development of a system-wide predator control program: stepwise implementation of a predator index, predator control fisheries, and evaluation plan in the Columbia River Basin (Northern Squawfish Management Program).1995 Annual Report, project number 90-077. Contract DE-B179-90BP07084, Bonneville Power Administration, Portland, Oregon.

Petersen, M.R., J.S. Hisata, E.C. Winther, R.C. Welling and M.L. Wachtel. 1997. Implementation of the northern pikeminnow sport-reward fishery in the Columbia and Snake Rivers. *In* Development of a system-wide predator control program: stepwise implementation of a predator index, predator control fisheries, and evaluation plan in the Columbia River Basin (Northern Pikeminnow Management Program). 1997 Annual Report, project number 90-077. Contract DE-B179-90BP07084, Bonneville Power Administration, Portland, Oregon.

Rieman, B.E., R.C. Beamesderfer, S. Vigg, and T.P. Poe. 1988. Predation by resident fish on juvenile salmonids in a mainstem Columbia reservoir: Part IV. Estimated total loss and mortality of juvenile salmonids to northern squawfish, walleye, and smallmouth bass. T. P. Poe and B. E. Rieman, editors. Resident fish predation on juvenile salmonids in John Day Reservoir, 1983-1986. Final Report (Contracts DE-AI79-82BP34796 and DE-AI79-82BP35097) to Bonneville Power Administration, Portland, Oregon.

Rieman, B.E., and R.C. Beamesderfer. 1990. Dynamics of a northern squawfish population and the potential to reduce predation on juvenile salmonids in a Columbia River reservoir. North American Journal of Fisheries Management 10:228-241.

Smith, S.E., D.R. Gilliland, E.C. Winther, M.R. Petersen, E.N. Mattson, S.L. Kelsey, J. Suarez-Pena, and J. Hisata. 1994. (Implementation of the northern squawfish sport-reward fishery in the Columbia and Snake Rivers. In Development of a system-wide predator control program: Evaluation of the northern squawfish sport-reward fishery in the Columbia and Snake Rivers. Washington Department of Fish and Wildlife, Contract Number DE-BI79-90BP07084. 1994 Annual Report to Bonneville Power Administration, Portland, Oregon.)

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. Oregon Department of Fish and Wildlife, Contract number DE-B179-90BP07084 1990 Annual Report to Bonneville Power Administration, Portland, Oregon.

Wachtel, M.L., MR. Peterson, J.S. Hisata, E.C. Winther, and R.C. Welling. 1998 (Implementation of the northern squawfish sport-reward fishery in the Columbia and Snake Rivers. In Development of a system-wide predator control program: Evaluation of the northern squawfish sport-reward fishery in the Columbia and Snake Rivers. Washington Department of Fish and Wildlife, Contract Number DE-BI79-90BP07084. 1998 Annual Report to Bonneville Power Administration, Portland, Oregon.)

Winther, E.C., J.S. Hisata, M.R. Petersen, M.A. Hagen and R.C. Welling. 1996. Implementation of the northern squawfish sport-reward fishery in the Columbia and Snake Rivers. *In* Development of a system-wide predator control program: stepwise implementation of a predator index, predator control fisheries, and evaluation plan in the Columbia River Basin (Northern Squawfish Management Program). 1996 Annual Report, project number 90-077. Contract DE-B179-90BP07084, Bonneville Power Administration, Portland, Oregon.

Zar, J. H. 1984. Biostatistical Analysis. Prentice-Hall Inc., Englewood Cliffs, New Jersey.

Zimmerman, M.P., D.L. Ward, 1997 (Index of Predation on juvenile salmonids by Northern Squawfish in the Lower Columbia River Basin from 1994-1996.) Paper No. 2 In Evaluation of the Northern Squawfish Management Program, Final Report of Research 1990-96. Project number 90-077. Bonneville Power Administration, Portland, Oregon.

Zimmerman, M.P. and T.A. Friesen, 1999 (Development of a system-wide predator control program: indexing and fisheries evaluation. In Development of a system-wide predator control program: stepwise implementation of a predator index, predator control fisheries, and evaluation plan in the Columbia River Basin (Northern Squawfish Management Program). 1999 Draft Annual Report, project number 90-077. Bonneville Power Administration, Portland, Oregon.)

Appendix A
Northern Pikeminnow Sport-Reward Fishery Rules and Regulations

1. Each angler must:

a) Obtain an appropriate fishing license. (Contact your local state fishery agency for information regarding fishing regulations and license requirements.)

b) Adhere to state fishing regulations for the area in which they fish.

c) Register in person at one of the registration stations or authorized satellite stations each day prior to fishing. Anglers may self-register at any time when registration stations are closed. Self-registration facilities are provided at all registration stations.

d) Mail in all reward vouchers within 30 days from the end of the season.

2. Northern pikeminnow submitted for reward payment must satisfy all of the following criteria:

a) Must have been caught in the mainstem Columbia River from the mouth up to the boat restricted zone below Priest Rapids Dam, or in the Snake River from the mouth up to Hells Canyon Dam. Also open are backwaters and sloughs, as well as up to 400 feet into any tributaries within the area described above.

b) Fish must be live, or in fresh condition. Fish that are or have been frozen will not be accepted for payment. The technicians have authority to determine whether or not northern pikeminnow meet these standards.

c) Fish must be 11 inches or longer. There is no reward for fish shorter than 279 mm (11 inches).

d) Fish must be returned the same day an angler registers (within 24 hours), to the same registration station where the angler registered, in order to receive a reward payment.

Violation of any of the above rules may result in disqualification from the Northern Pikeminnow Sport-Reward Program.

Appendix B
Returning Anglers
All Species Caught

Species (Non-Salmonid)	Catch	Harvest	Percent Harvested
Northern Pikeminnow ≥ 279 mm	113,246	113,080	99.85%
Northern Pikeminnow ≤ 279 mm	28,541	7,097	24.87%
Peamouth *Mylocheilus cauriuus*	12,064	2,871	23.80%
White Sturgeon *Acipenser transmontanus*	3,048	68	2.23%
Smallmouth Bass *Micropterus dolomieui*	4,354	690	15.85%
Channel Catfish *Ictalurus punctatus*	1,039	375	36.09%
Walleye *Stizostedion vitreum*	431	233	54.06%
American Shad *Alosa sapidissima*	376	192	51.06%
Brown Bullhead *Ictalurus nebulosus*	64	0	0%
Black Crappie *Pomoxis nigromaculatus*	6	1	16.67%
Blue Catfish *Ictalurus punctatus*	6	0	0%
Bluegill *Lepomis macrochirus*	13	3	23.00%
Bullhead (Unknown)*Ictalurus spp.*	305	40	13.11%
Black Bullhead *Ictalurus melas*	2	0	0%
Bridgelip Sucker *Catostomus columbianus*	34	7	20.59%
Crappie (Unknown)*Pomoxis spp.*	46	13	28.26%
Chiselmouth *Acrochilus alutaceus*	325	110	33.85%
Sculpin *Cottus spp.*	781	185	23.69%
Carp *Cyprinus carpio*	409	42	10.27%
Flathead Catfish *Pylodictis olivaris*	11	3	27.27%
Largemouth Bass *Micropterus salmonids*	19	5	26.32%
Longnose Sucker *Catostomus catostomus*	12	1	8.33%
Largescale Sucker *Catostomus macrocheilus*	25	6	24.00%
Redside Shiner *Richarsonius balteatus*	1	1	100%
Sunfish *Lepomis cyanellus*	13	0	0%
Starry Flounder *Platichthys stellatus*	242	34	14.05%
White Crappie *Promoxis annularis*	9	9	100%
Mountain Whitefish *Prosopium williamsoni*	35	2	5.71%
Yellow Bullhead *Ictalurus natalis*	45	10	22.22%
Yellow Perch *Pevca flaescen*	218	75	34.40%

Appendix B Continued

Species (Salmonid)	Catch	Harvest	Percent Harvested
Chinook (Adult) *Oncorhynchus tshawytscha*	20	0	0.00%
Chinook (Jack)	14	2	14.29%
Chinook (Juvenile)	46	1	2.17%
Steelhead (Hatchery) *Oncorhynchus mykiss*	25	12	48.00%
Steelhead (Wild)	16	0	0.00%
Steelhead Juv. (Hatchery)	56	0	0.00%
Steelhead Juv. (Wild)	24	3	12.50%
Rainbow Trout	43	12	27.91%
Coho (Juvenile) *Oncorhynchus kisutch*	6	0	0.00%
Chum (Adult) *Oncorhyncus keta*	5	0	0.00%
Resident Cutthroat *Oncorhyncus clarki*	25	9	36.00%
Searun Cutthroat *Oncorhyncus clarki*	12	1	8.33%
Dolly Varden/Bull Trout Unk. *Salvelinus spp.*	1	0	0.00%

REPORT B
Northern Pikeminnow Sport Reward Payments – 1999

Prepared by
Russell G. Porter

Pacific States Marine Fisheries Commission
45 S.E. 82nd Drive, Suite 100
Gladstone, OR 97027

February, 2000

INTRODUCTION

The **Northern Pikeminnow Predator Control Program** was administered by PSMFC in 1999. The program is a joint effort between the fishery agencies of the states of Washington and Oregon, the Columbia River treaty tribes, the Columbia River Intertribal Fish Commission (CRITFC), the Columbia Basin Fish and Wildlife Authority (CBFWA) and the Pacific States Marine Fisheries Commission (PSMFC). Washington ran the sport-reward registration/creel check stations throughout the river and handled all fish checked in to the program. Oregon provided fish tagging services, population studies, food habit and reproductive studies, as well as exploitation rate estimates. PSMFC contracted with the CBFWA for technical administration of the program. PSMFC provided fiscal and contractual oversight for all segments of the Program and processed all reward vouchers for the sport-reward anglers. CRITFC and the treaty tribes conducted angling at the dams and site specific removals by means of gillnets at tributary mouths to aid salmonid downstream migrant survival.

CATCH AND PAYMENTS

In 1999 a total of 114,687 fish were harvested in the sport-reward fishery. Vouchers for 113,395 fish were submitted for payment totaling rewards of $565,277. Rewards were paid at $4 for the first 100 fish caught during the season, $5 for fish in the 101-400 range, and $6 for all fish caught by an angler above 400 fish. PSMFC maintained an accounting system during the season to determine the appropriate reward amount due each angler for particular fish. Coupons good for one free $4 reward were issued again in 1999 as an incentive to stimulate angler participation. A total of 1,648 coupons were returned for payments of $6,592. Anglers were able to use a coupon on a voucher when they caught one or more pikeminnows for the extra $4 reward. A total of 2,086 anglers who registered were successful in catching one or more fish in 1999. The 1999 season ran from May 3, 1998 through October 10, 1999.

TAGGED FISH PAYMENTS

A total of 159 tagged fish were caught. Anglers were issued a special tagged fish voucher for all tagged fish brought to the registration station. The tag voucher was then sent in with the tag for verification and payment of the special $50 tagged fish reward. This resulted in tag reward payments of $7,950.

TOURNAMENTS

A number of radio stations participated with the Pikeminnow Program in sponsoring tournaments in the five sections of the river for a 9-day period. Daily prizes were provided by the radio station sponsors. The Pikeminnow Program provided cash prizes at the end of the tournament for the largest three fish turned in at each Program registration station during the various tournaments. Prize money for the five tournaments totaled $10,200.

ACCOUNTING

Total payments for the season of regular vouchers, tagged fish, coupons and tournaments totaled $590,019. All IRS Form 1099 Mis. Statements were sent to the qualifying anglers for tax purposes in the third week of January, 2000. Appropriate reports and copies were provided to the IRS by the end of February, 2000.

A summary of the catch and rewards paid is provided in Table 1. For further information contact Russell Porter, PSMFC, Field Programs Administrator at (503) 650-5400 or email at: *russell_porter@psmfc.org*

TABLE 1. 1999 SPORT REWARD PAYMENTS SUMMARY

The following is a summary of the vouchers received and paid as of November 22, 1999.

TOTAL REWARD DOLLARS PAID: **$590,019**

		$ Amount
Number of fish paid @ Tier 1 ($4.00):	38,808	$155,232
Number of fish paid @ Tier 2 ($5.00):	36,523	$182,615
Number of fish paid @ Tier 3 ($6.00):	37,905	$227,430
Total fish paid at "tier" level:	**113,236**	**$565,277**
Tags returned:	**159**	**$7,950**
Coupons returned:	1,648	$6,592
Total fish "caught":	114,687	
Total fish "paid":	**113,395**	
Remaining total "not" paid (vouchers not returned):	1,292	

Tournament winnings (including all drawings): **$10,200**

Number of anglers @ Tier 1	**1,876**	Number of anglers with 10 fish or less:	**1,447**
Number of anglers @ Tier 2	**135**	Number of anglers with 2 fish or less:	**840**
Number of anglers @ Tier 3	**75**	Number of Predacards	
Number of separate anglers	**2,086**	ordered and/or Issued:	**710**

	Top Ten Anglers *	**TIER 1**	**TIER 2**	**TIER 3**	**COUPON**	**TAGS**	**TOTAL FISH** (not including coupon)	**TOURN.**	**BALANCE**
1	HOLSCHER,ERIC G	99	300	2,394	1	1	2,794	$0	$16,314
2	DOUGLAS, THOMAS J SR	99	300	2,305	1	0	2,704	$0	$15,730
3	WORTHEN, AARON J	100	300	1,419	0	0	1,819	$0	$10,414
4	MILLER, EARL D	99	300	1,411	1	0	1,810	$0	$10,366
5	PAPST,THOMAS H	99	300	1,369	1	3	1,771	$0	$10,264
6	MUCK,JAMES E	99	300	1,392	1	0	1,791	$0	$10,252
7	BROWN, JOHN G	99	299	1,294	1	3	1,695	$250	$10,059
8	SMITH, DEAN M	99	300	1,096	1	0	1,495	$0	$8,476
9	CALDWELL,TIMOTHY E	99	300	1,070	1	3	1,472	$0	$8,470
10	LEITCH, GARY L	99	300	1,092	1	0	1,491	$0	$8,452
	** (by dollar amount paid)*	**991**	**2,999**	**14,842**	**9**	**10**	**18,842**	**$250**	**$108,797**
1	HOLSCHER,ERIC G	99	300	2,394	1	1	2,794	$0	$16,314
2	DOUGLAS, THOMAS J SR	99	300	2,305	1	0	2,704	$0	$15,730
3	WORTHEN, AARON J	100	300	1,419	0	0	1,819	$0	$10,414
4	MILLER, EARL D	99	300	1,411	1	0	1,810	$0	$10,366
5	MUCK,JAMES E	99	300	1,392	1	0	1,791	$0	$10,252
6	PAPST,THOMAS H	99	300	1,369	1	3	1,771	$0	$10,264
7	BROWN, JOHN G	99	299	1,294	1	3	1,695	$250	$10,059
8	SMITH, DEAN M	99	300	1,096	1	0	1,495	$0	$8,476
9	LEITCH, GARY L	99	300	1,092	1	0	1,491	$0	$8,452
10	CALDWELL,TIMOTHY E	99	300	1,070	1	3	1,472	$0	$8,470
	** (by total fish caught)*	**991**	**2,999**	**14,842**	**9**	**10**	**18,842**	**$250**	**$108,797**

REPORT C
Controlled Angling for Northern Pikeminnow at the Four Lower Columbia River Dams in 1999

Prepared by

Roy E. Beaty

Columbia River Inter-Tribal Fish Commission
729 NE Oregon, Suite 200
Portland, OR 97232

1999 Annual Report

ACKNOWLEDGMENTS

Thanks to David Wolf (Confederated Tribes of the Umatilla Indian Reservation), George Lee (Confederated Tribes and Bands of the Yakama Indian Nation), Colleen Fagan (formerly, Confederated Tribes of the Warm Springs Reservation of Oregon) and the tribal crews for implementing the field work and for collecting the data summarized in this report. I appreciate their cooperation.

Personnel from the U.S. Army Corps of Engineers assisted in providing access for the crews to work at Corps dams: Jennifer Sturgill and Erich Geadeke (Bonneville Dam); Bob Cordie (The Dalles and John Day dams); and Brad Eby (McNary Dam).

Funding for this work was provided by the Bonneville Power Administration (John Skidmore, COTR) through the Pacific States Marine Fisheries Commission (Russell Porter, Program Manager) with coordination from the Columbia Basin Fish and Wildlife Authority (Frank Young, Program Manager).

ABSTRACT

Controlled angling for northern pikeminnow *Ptychocheilus oregonensis* (NPm) was conducted at Bonneville, The Dalles, John Day, and McNary dams on the lower Columbia River during the months of June through October 1999. Methods were the same as used in previous years: crews were encouraged to innovate and to fish the hours, sites, and baits that were most effective. Boat angling was tried only at McNary Dam. A total of 3,737 predator-sized NPm were caught in 3,206 hours of angling at all four dams, producing a catch-per-angler-hour (CPAH) of 1.2. Although results overall were comparable to those in 1998, catch at Bonneville Dam increased 2.3-fold (CPAH was unchanged at 1.5), where 1,926 NPm (51.5% of the total) were caught. Success rates (CPAH) ranged from 1.5 at Bonneville down to 0.7 at McNary. Boat angling was less successful than angling from the dam itself at McNary. Incidental species composed 3.5% of the total catch at all dams and 12.9% of the catch at The Dalles, where bass *Micropterus* sp. were relatively abundant. Only two salmonids – one adult and one juvenile – were caught, both at Bonneville.

INTRODUCTION

The eight hydroelectric dams and their reservoirs on the lower Columbia and Snake rivers provide predatory fishes with favorable conditions for feeding on juvenile salmonids (Raymond 1979; Rieman et al. 1991), many populations of which are now protected by Endangered Species Act listings. A principal predator – northern pikeminnow (NPm) *Ptychocheilus oregonensis* – is being controlled in the lower Columbia and Snake rivers by fisheries implemented through the Northern Pikeminnow Management Program.

Angling at mainstem dams by crews of technicians has been employed as one of the control methods since the Program's inception in 1990 (Vigg et al. 1990; Beaty et al. 1993; Parker et al. 1993; CRITFC 1994, 1995; Collis et al. 1997). Other existing fisheries include an extensive sport reward fishery, conducted by the Washington Department of Fish and Wildlife, and a small gillnet fishery implemented by the Columbia Basin treaty tribes at selected sites, primarily in Bonneville reservoir. The continuing mission of the dam angling fishery is to efficiently remove NPm from areas near dams using hook and line angling, while keeping the catch of incidental species, particularly salmonids, at a minimum.

METHODS

As in 1998, dam angling was conducted only at the four U.S. Army Corps of Engineer dams on the lower Columbia River (Figure C-1). Our angling was confined to the boat-restricted zones (BRZ) at these dams, with most effort focused in the tailraces.

The overall angling season was from June through October with differences among dams in dates fished. The Confederated Tribes of the Umatilla Indian Reservation (CTUIR) crew began work at McNary Dam on June 4, whereas the other crews began fishing at Bonneville, The Dalles, and John Day dams in late June, when their site-specific gillnet fisheries ceased (Fig. C-1, Table C-1). Although the CTUIR crew fished exclusively at McNary, the crews from The Confederated Tribes of Warm Springs Reservation of Oregon and from The Yakama Nation moved about among the three lower dams to identify and to exploit productive fishing sites. Fishing continued well into October at The Dalles and John Day dams to exploit the high late-season catches noted during the 1998 fishery (Beaty 1999).

The CTUIR crew occasionally angled from a boat in the tailrace Boat Restricted Zone of McNary Dam during June and July.

Field procedures were essentially the same as in years past: anglers fished the most favorable daytime and/or nighttime hours, explored and exploited fishing sites as conditions (e.g., spill) changed and success varied, and used their choice of baits/lures and angling techniques. Anglers were encouraged to experiment and to innovate.

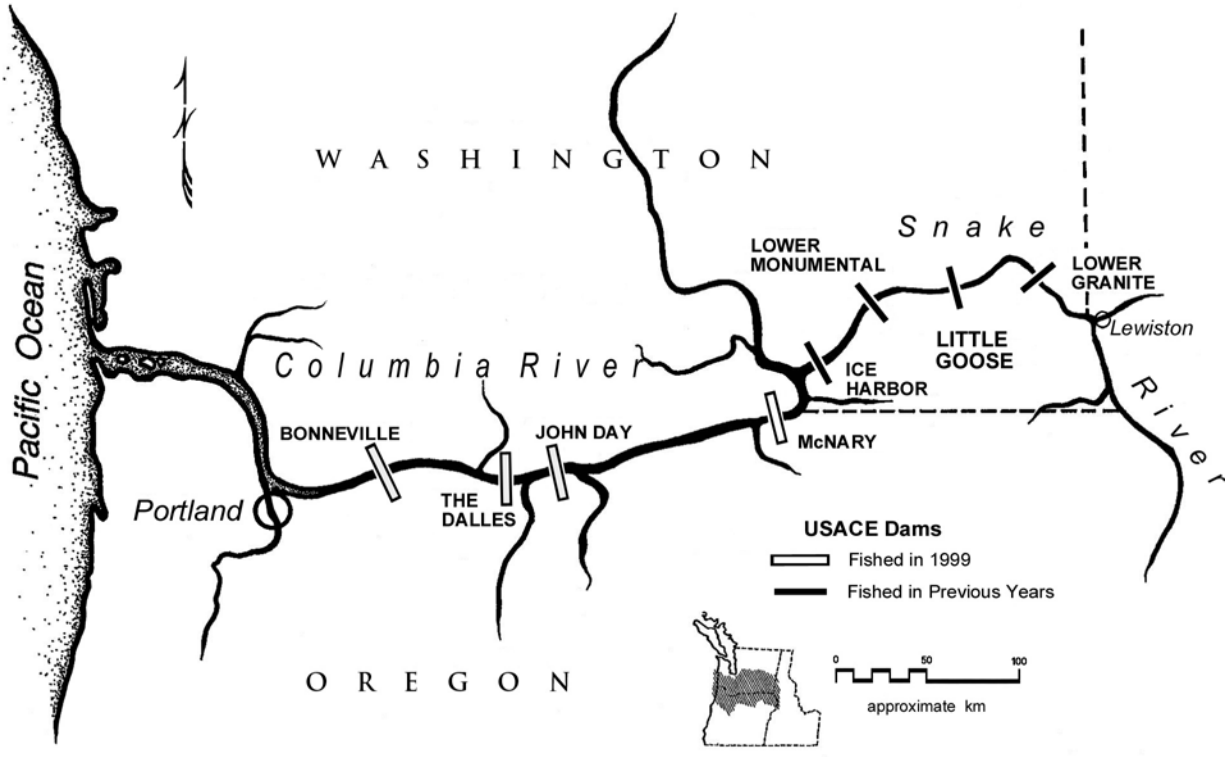


Figure C-1. Dams at which controlled angling for NPm has been conducted between 1991 and 1999.

Data were recorded on paper forms and transmitted to us via fax. We then entered the data into a computer database (Microsoft Access) and summarized them for weekly reports. Some data, probably about 2% of the total, were not received and included in the database.

RESULTS AND DISCUSSION

In 1999 angling crews caught 3,737 predator-size northern pikeminnow in 3,206 hours of fishing, for a seasonal catch per angler hour (CPAH) of 1.2 (Table C-1). Total catch increased slightly (1.5%) relative to 1998, despite nearly a 10% reduction in effort. The 1999 results continued the generally flat or declining trends in both catch and CPAH of recent years (Fig. C-2), with catch at Bonneville Dam showing the only noteworthy increase (2.3-fold) from 1998.

Table C-1. Northern pikeminnow (NPm) catch, effort (angler hours), and catch per angler hour (CPAH) for dam-based and boat angling (combined), by statistical week at Columbia River dams in 1999. First and last fishing days are shown in parentheses beside dam names. Rounding may cause some apparent discrepancies.

Statistical Week		Bonneville (7/1-10/19)			The Dalles (6/30-10/27)			John Day (6/23-10/27)			McNary (6/4-8/30)		
No.	Dates	NPm	Effort	CPAH	NPm	Effort	CPAH	NPm	Effort	CPAH	NPm	Effort	CPAH
22	5/31/99 – 6/6/99	–	0	–	–	0	–	–	0	–	0	2	0.0
23	6/7/99 – 6/13/99	–	0	–	–	0	–	–	0	–	2	26	0.1
24	6/14/99 – 6/20/99	–	0	–	–	0	–	–	0	–	11	32	0.3
25	6/21/99 – 6/27/99	–	0	–	–	0	–	28	48	0.6	11	53	0.2
26	6/28/99 – 7/4/99	132	42	3.2	54	24	2.2	0	10	0.0	15	39	0.4
27	7/5/99 – 7/11/99	106	54	2.0	90	60	1.5	17	41	0.4	28	61	0.5
28	7/12/99 – 7/18/99	329	131	2.5	51	27	1.9	–	0	–	70	57	1.2
29	7/19/99 – 7/25/99	169	66	2.6	89	62	1.4	55	44	1.2	43	57	0.8
30	7/26/99 – 8/1/99	390	190	2.1	53	36	1.5	–	0	–	101	99	1.0
31	8/2/99 – 8/8/99	199	138	1.4	–	0	–	36	51	0.7	54	81	0.7
32	8/9/99 – 8/15/99	128	143	0.9	6	6	0.9	12	30	0.4	78	93	0.8
33	8/16/99 – 8/22/99	29	74	0.4	18	43	0.4	130	95	1.4	30	46	0.6
34	8/23/99 – 8/29/99	76	111	0.7	36	70	0.5	20	47	0.4	6	37	0.2
35	8/30/99 – 9/5/99	103	129	0.8	15	29	0.5	10	25	0.4	3	9	0.3
36	9/6/99 – 9/12/99	–	0	–	21	57	0.4	136	56	2.4	–	0	–
37	9/13/99 – 9/19/99	49	36	1.4	23	61	0.4	134	100	1.3	–	0	–
38	9/20/99 – 9/26/99	63	42	1.5	22	35	0.6	7	24	0.3	–	0	–
39	9/27/99 – 10/3/99	49	52	0.9	11	19	0.6	96	64	1.5	–	0	–
40	10/4/99 – 10/10/99	92	30	3.1	–	0	–	57	30	1.9	–	0	–
41	10/11/99 – 10/17/99	–	0	–	–	0	–	32	18	1.8	–	0	–
42	10/18/99 – 10/24/99	12	13	0.9	–	0	–	60	38	1.6	–	0	–
43	10/25/99 – 10/31/99	–	0	–	17	10	1.6	23	7	3.3	–	0	–
	Total:	**1926**	**1249**	**1.5**	**506**	**540**	**0.9**	**853**	**726**	**1.2**	**452**	**691**	**0.7**

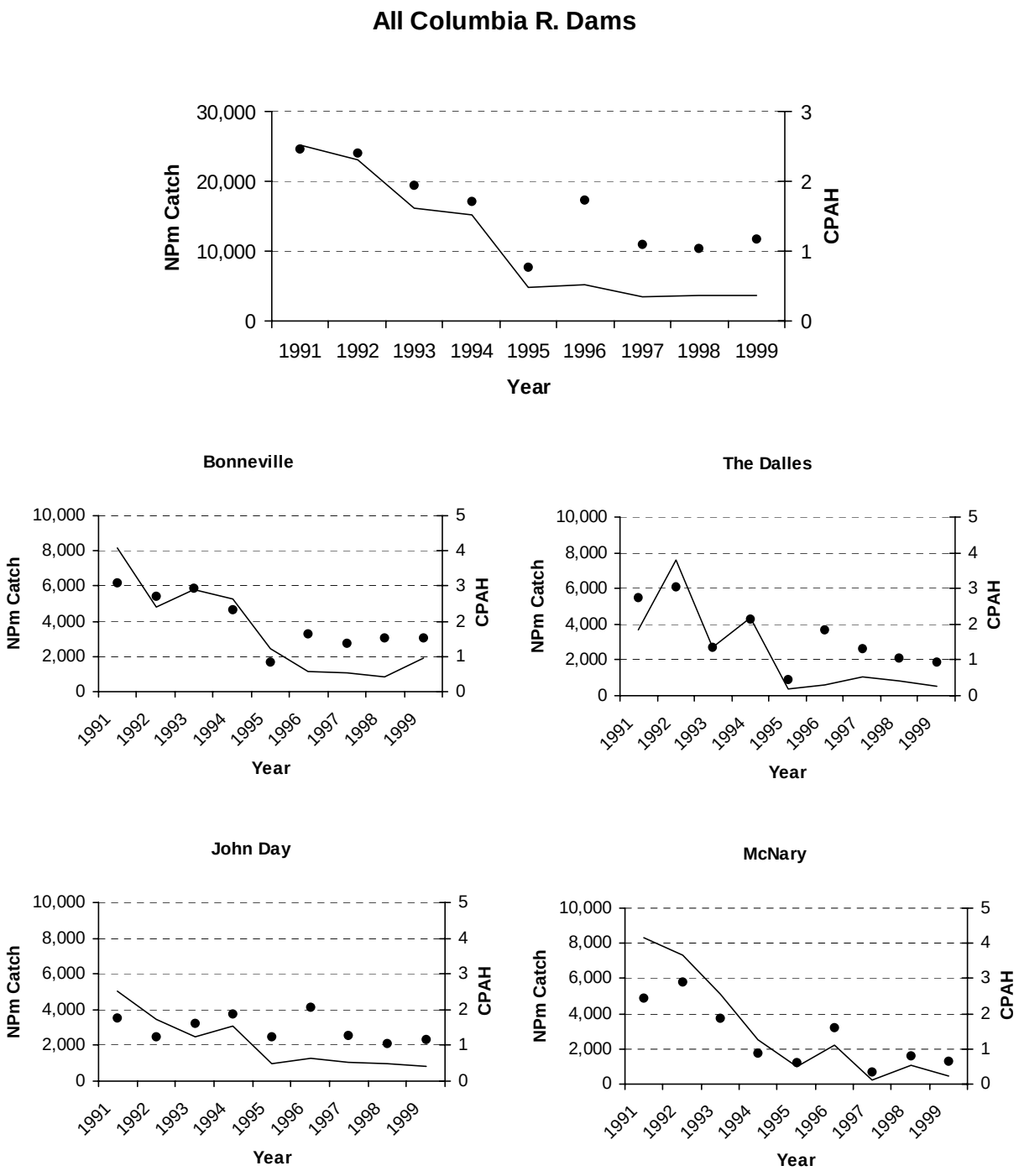


Figure C-2. Trends in annual NPm catch (lines) and CPAH (•) for Columbia R. dams, 1991-99.

Over half (51.5%) of the total catch was taken at Bonneville Dam; Bonneville tailrace alone accounted for 1,784 fish, or 47.7% of the total (Table C-2). Catches and catch rates were highest early in the season (July; Table C-3) and diminished through the summer, as in 1998 (Beaty 1999). The increase in catch at Bonneville in 1999 was proportional to the increase in effort there; angler success (CPAH = 1.5) did not change from 1998 (Table C-2).

Angler success at Bonneville Dam appears to me to depend considerably on experienced technicians who have learned how to fish under the diverse conditions there. For example, during daytime spill, anglers can be very successful in the swift and turbulent waters along the south shore of the spill basin. A successful technique at this site is to use extra weights and to drift the lure close to the bottom without getting hung up in the rock armoring. Similarly, anglers in previous years have found "pockets" of NPm along the bottom of the tailrace of the first powerhouse. The predators seem able to occupy and to feed in some exceptionally high-velocity areas, perhaps by exploiting small eddies and boundary layers near the shoreline and bottom. Experienced anglers are typically more productive than novices, even though knowledge seems to be shared freely among individuals and crews. The value of experience has also been noted for angling conducted at public utility district dams in the mid-Columbia (West 2000).

At John Day Dam – the second most productive site (Table C-1) – the highest weekly catches and catch rates were obtained in September (Table C-3), as they were in 1998 (Beaty 1999). This seasonal pattern is opposite that of Bonneville Dam, and angling crews adapted by shifting effort from Bonneville to John Day in September. Large increases in angler success obtained in September at Rock Island and Rocky Reach dams in the mid-Columbia were attributed to recovery from post-spawning lethargy and reduction in high water temperatures (West 2000). Most of the effort and catch at John Day occurred at night from the tailrace deck, although catches could vary considerably among nights. For example, the highest one-day catch at John Day was 98 on the night of 9/13-9/14 (effort = 30.8 hr, CPAH = 3.2), but the following night only 13 fish were caught (effort = 35.3 hr, CPAH = 0.37).

The Dalles Dam had relatively low catches and CPAHs, with the highest numbers in July, similar to Bonneville Dam (Table C-3). Catch at McNary Dam returned to a relatively low level (691) in 1999 after a substantial increase in 1998 (Beaty 1999). McNary's CPAH in 1999 (0.7) was the lowest among the four dams (Table C-1). Boat angling in the tailrace at McNary Dam was much less successful (CPAH = 0.19) than angling from the dam during the same weeks (CPAH = 0.45; Table C-4).

Total incidental catch was low again in 1999 (3.5%, Table C-5), comparable to that in 1998 (3.3%, Beaty 1999). Incidental catch rate in 1999 was highest at The Dalles (12.9%), where bass (*Micropterus* sp.) composed 66.7% of the incidental catch. Two salmonids were caught at Bonneville Dam: an adult that was cut free before it was landed, and a juvenile that was unhooked and released in good condition.

Table C-2. Northern pikeminnow (NPm) catch, effort (angler hr), and catch per angler hour (CPAH) for hook-and-line angling at Columbia and Snake river dams, 1991-1999.

		COLUMBIA RIVER DAMS					SNAKE RIVER DAMS					GRAND
		Bonneville	The Dalles	John Day	McNary	Season	Ice Harbor	Lower Mon.	Little Goose	Lower Granite	Season	TOTALS
1991	NPm	8,131	3,674	5,004	8,348	25,157	1,486	3,313	4,915	4,480	14,194	39,351
	Effort	2,621	1,333	2,816	3,416	10,186	2,052	2,471	2,140	2,448	9,112	19,298
	CPAH	***3.1***	***2.8***	***1.8***	***2.4***	***2.5***	***.7***	***1.3***	***2.3***	***1.8***	***1.6***	***2.0***
1992	NPm	4,814	7,561	3,427	7,297	23,099	278	475	1,664	2,352	4,769	27,868
	Effort	1,781	2,496	2,775	2,523	9,575	298	943	3,062	2,880	7,183	16,758
	CPAH	***2.7***	***3.0***	***1.2***	***2.9***	***2.4***	***.9***	***.5***	***.5***	***.8***	***.7***	***1.7***
1993	NPm	5,836	2,712	2,509	5,148	16,205	122	105	100	678	1,005	17,210
	Effort	1,991	1,992	1,561	2,780	8,324	404	396	378	734	1,911	10,235
	CPAH	***2.9***	***1.4***	***1.6***	***1.9***	***1.9***	***.3***	***.3***	***.3***	***.9***	***.5***	***1.7***
1994	NPm	5,238	4,393	3,083	2,556	15,270	23	27	92	685	827	16,097
	Effort	2,232	2,064	1,649	2,966	8,910	141	55	203	692	1,092	10,002
	CPAH	***2.3***	***2.1***	***1.9***	***.9***	***1.7***	***.2***	***.5***	***.5***	***1.0***	***.8***	***1.6***
1995	NPm	2,422	409	950	1,002	4,783	9	1	186	320	516	5,299
	Effort	2,823	920	777	1,670	6,190	80	38	183	798	1,099	7,289
	CPAH	***.9***	***.4***	***1.2***	***.6***	***0.8***	***.1***	***.0***	***1.0***	***.4***	***.5***	***.7***
1996	NPm	1,135	623	1,278	2,184	5,220	0	27	96	112	235	5,455
	Effort	693	338	618	1,372	3,022	56	75	206	307	645	3,666
	CPAH	***1.6***	***1.8***	***2.1***	***1.6***	***1.7***	***0***	***.4***	***.5***	***.4***	***.4***	***1.5***
1997	NPm	1,086	1,084	1,086	263	3,519	–	–	–	–	–	3,519
	Effort	784	826	857	746	3,214	0	0	0	0	0	3,214
	CPAH	***1.4***	***1.3***	***1.3***	***.4***	***1.1***	***–***	***–***	***–***	***–***	***–***	***1.1***
1998	NPm	829	800	945	1,106	3,680	–	–	–	–	–	3,680
	Effort	538	758	902	1,356	3,554	0	0	0	0	0	3,554
	CPAH	***1.5***	***1.1***	***1.0***	***.8***	***1.0***	***–***	***–***	***–***	***–***	***–***	***1.0***
1999	NPm	1,926	506	853	452	3,737	–	–	–	–	–	3,737
	Effort	1,249	540	726	691	3,206	0	0	0	0	0	3,206
	CPAH	***1.5***	***.9***	***1.2***	***.7***	***1.2***	***–***	***–***	***–***	***–***	***–***	***1.2***
Total	NPm	31,417	21,762	19,135	28,356	100,670	1,918	3,948	7,053	8,627	21,546	122,216
	Effort	14,712	11,267	12,681	17,520	56,181	3,031	3,979	6,172	7,859	21,041	77,223
	CPAH	***2.1***	***1.9***	***1.6***	***1.6***	***1.8***	***.6***	***1.0***	***1.1***	***1.1***	***1.0***	***1.6***

Table C-3. Distribution of 1999 dam angling catch of northern pikeminnow (NPm) by river reach or reservoir.

Reach or Reservoir	NPm Catch
Bonneville Tailrace	1,784
Bonneville Reservoir	644
The Dalles Reservoir	857
John Day Reservoir	452
McNary Reservoir	0
TOTAL	3,737

Table C-4. Results of angling from a boat in the tailrace of McNary Dam compared to results of angling from the dam during the same weeks in 1999.

	Boat			Dam		
Week	NPm	Effort (hr)	CPAH	NPm	Effort (hr)	CPAH
23	0	4.5	0	2	21.3	.09
24	0	4.4	0	11	27.9	.39
25	2	9.4	.21	9	43.3	.21
27	4	9.0	.44	24	51.6	.47
29	0	3.9	0	43	53.3	.81
	6	31.3	.19	89	197.4	.45

Table C-5. NPm catch and incidental catch for the dam angling fishery in 1999, by dam.

	NPm Catch		Incidental Catch								
	≥ 250mm	< 250mm	Salmonids								*% of*
Dam	FL	FL	Juv.	Ad.	Sturgeon	Bass	Catfish	Walleye	Shad	Other	*Total*
Bonneville	1,926	5	1	1	18	4	0	0	3	1	*1.4*
The Dalles	506	0	0	0	16	50	1	4	0	4	*12.9*
John Day	853	0	0	0	1	0	1	0	1	0	*.4*
McNary	452	0	0	0	10	3	18	0	0	0	*6.4*
Total	**3,737**	**5**	**1**	**1**	**45**	**57**	**20**	**4**	**4**	**5**	***3.5***

REFERENCES

Beaty, R. E. 1999. Controlled angling for northern pikeminnow at the four Lower Columbia River dams in 1998 Report C *in* F. R. Young, editor. Development of a system-wide predator control program: stepwise implementation of a predator index, predator control fisheries, and evaluation plan in the Columbia River Basin. 1998 Annual Report. Contract DE-BI79-90BP07084, Bonneville Power Administration, Portland, Oregon.

Beaty, R. E., B. L. Parker, K. Collis, and K. McRae. 1993. The use of controlled angling to manage northern squawfish populations at selected dams on the Columbia and Snake rivers. Pages 111-185 *in* C. F. Willis and A. A. Nigro, editors. Development of a system-wide predator control program: stepwise implementation of a predator index, predator control fisheries, and evaluation plan in the Columbia River Basin. 1991 Annual report. Contract DE-BI70-90BP07084, Bonneville Power Administration, Portland, Oregon.

Collis, K., K. McRae, J. McCormack, and R. E. Beaty. 1997. Controlled angling for northern squawfish at selected dams on the Columbia and Snake rivers in 1994. Pages 181-207 *in* F.R. Young, editor. 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. 1995 Annual Report. Contract DE-BI79-90BP07084, Bonneville Power Administration, Portland, Oregon.

CRITFC. 1994. Controlled angling for northern squawfish at selected dams on the Columbia and Snake rivers in 1993. Pages 163-220 *in* C. F. Willis and D. L. Ward, editors. 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. 1993 Annual Report. Contract DE-BI79-90BP07084, Bonneville Power Administration, Portland, Oregon.

CRITFC. 1995. Controlled angling for northern squawfish at selected dams on the Columbia and Snake rivers in 1994. Pages 103-152 *in* C. F. Willis and F. R. Young, editors. 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. 1994 Annual Report. Contract DE-BI79-90BP07084, Bonneville Power Administration, Portland, Oregon.

Parker, B. L., K. Collis, B. Ashe, R. E. Beaty, and K. McRae. 1993. Controlled angling for northern squawfish at selected dams on the Columbia and Snake rivers in 1992. Pages 129-182 *in* C. F. Willis and A. A. Nigro, editors. 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. 1992 Annual Report. Contract DE-BI79-90BP07084, Bonneville Power Administration, Portland, Oregon.

Raymond, H. L. 1979. Effects of dams and impoundments on migrations of juvenile chinook salmon and steelhead from the Snake River, 1966 to 1975. Transactions of the American Fisheries Society 108:505-529.

Rieman, B. E., R. C. Beamesderfer, S. Vigg, and T. P. Poe. 1991. Estimated loss of juvenile salmonids to predation by northern squawfish, walleye, and smallmouth bass in John Day Reservoir, Columbia River. Transactions of the American Fisheries Society 120:448-458.

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. Pages 261-326 *in* A. A. Nigro, editor. 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. 1990 Annual Report. Contract DE-BI79-90BP07084, Bonneville Power Administration, Portland, Oregon.

West T. R. 2000. Northern pikeminnow (*Ptychocheilus oregonensis*) population reduction program Rocky Reach Dam and Rock Island Dam 1999. Unpubl. MS Rep., Public Utility District No. 1 of Chelan County, Wenatchee, WA.

REPORT D
Site-specific Gillnetting for Northern Pikeminnow in the Lower Columbia River in 1999

prepared by

Roy E. Beaty

Columbia River Inter-Tribal Fish Commission
729 NE Oregon, Suite 200
Portland, OR 97232

1999 Annual Report

ACKNOWLEDGEMENTS

Thanks to George Lee of the Confederated Tribes and Bands of the Yakama Nation (YN), Manuel Villalobos of the Nez Perce Tribe (NPT), and Colleen Fagan (formerly) of the Confederated Tribes of the Warm Springs Reservation of Oregon (CTWS) and their crews for conducting the field work and providing the data reported here.

This work was funded by Fish and Wildlife Program mitigation funds of the Bonneville Power Administration (John Skidmore, COTR) through the Northern Pikeminnow Management Program administered by the Pacific States Marine Fisheries Commission (Russell Porter, Program Manager) with coordination by the Columbia Basin Fish and Wildlife Authority (Frank Young, Program Coordinator).

ABSTRACT

Four crews fished small-meshed gillnets at nine locations in Bonneville Reservoir and other areas of the lower Columbia River in 1999 as part of the on-going program to control the abundance of northern pikeminnow (NPm) and their predation on juvenile salmonids *Oncorhynchus* spp. In the May 3 to June 22 season, 1,891 NPM were caught in a total of 1,110 net·hr of effort, for a catch-per-net-hour (CPNH) of 1.7. Compared to 1998, effort decreased 13% and catch decreased 38%, which combined for a 29% reduction in CPNH. Drano Lake and the mouth of the Klickitat River again produced most (76.1%) of the catch (1,440 NPm, total). Incidental species composed 61.6% of the total catch; suckers *Catostomus* spp. accounted for almost half (47.9%) of the incidentals. Compared to 1998, the incidental catch of adult salmon and steelhead was high, due primarily to the abundance of jack spring chinook salmon in the river.

INTRODUCTION

Implemented in 1990, the Northern Pikeminnow Management Program seeks to increase survival of juvenile salmonids by controlling the abundance of predaceous-sized (e.g., > 250 mm FL) northern pikeminnow *Ptychocheilus oregonensis* (NPm) in the lower Columbia and Snake rivers. One component of this program, the site-specific gillnet fishery, was first tested in 1993 and since then has been employed to target predators where they are known to concentrate, such as near hatchery-release points in Bonneville Reservoir (Collis et al. 1995). The objective of the fishery again in 1999 was to catch NPm as efficiently as possible while keeping incidental impacts to salmonids to a minimum. The NPT, CTWS, and YN were contracted to conduct the fishing; the Columbia River Inter-Tribal Fish Commission supported their work through procurement, coordination, data management, and reporting.

METHODS

Four boats and crews fished small-meshed gillnets1 at nine locations in the lower Columbia River between the tailrace of Bonneville Dam and the mouth of the Deschutes River (Fig. D-1). Effort was focussed in the most productive locations based on results from 1998 and in-season (1999) catches. The fishery commenced May 3 and ended June 22, when sockeye were caught incidentally.

Operational criteria to reduce impacts to salmonids were essentially the same as in previous years (Collis et al. 1995; Hatch et al. 1998). For example, fishing was conducted only at night, and nets were fished only about 45 minutes so that incidentally caught salmonids could be quickly discovered and released. Each crew fished three to five nets simultaneously, pulling, checking, and resetting the nets in a regular rotation.

Fishing effort for each net was measured from the time the net was set until it was pulled. Fork lengths were recorded on up to three NPm taken from each net. Numbers of salmonids (by species) and white sturgeon *Acipenser transmontanus* were recorded for each net set based on the condition of the fish at release. Numbers (but not condition) of other gamefishes were recorded by species, and numbers and coarse identifications (e.g., "suckers" for *Catostomous* spp.) of nongame fishes were recorded as a note. Data were recorded on paper forms that were faxed to the CRITFC office in Portland. CRITFC then entered the data into computer database (Microsoft Access) files and summarized them for weekly reports that were submitted to the Program Coordinator. Some data, perhaps up to 2% of the total records, were not received in condition that would allow inclusion in the database.

1 Gillnets were 2.4 m deep by 45.6 m long with mesh of 4.4 cm and/or 5.1 cm bar measures.

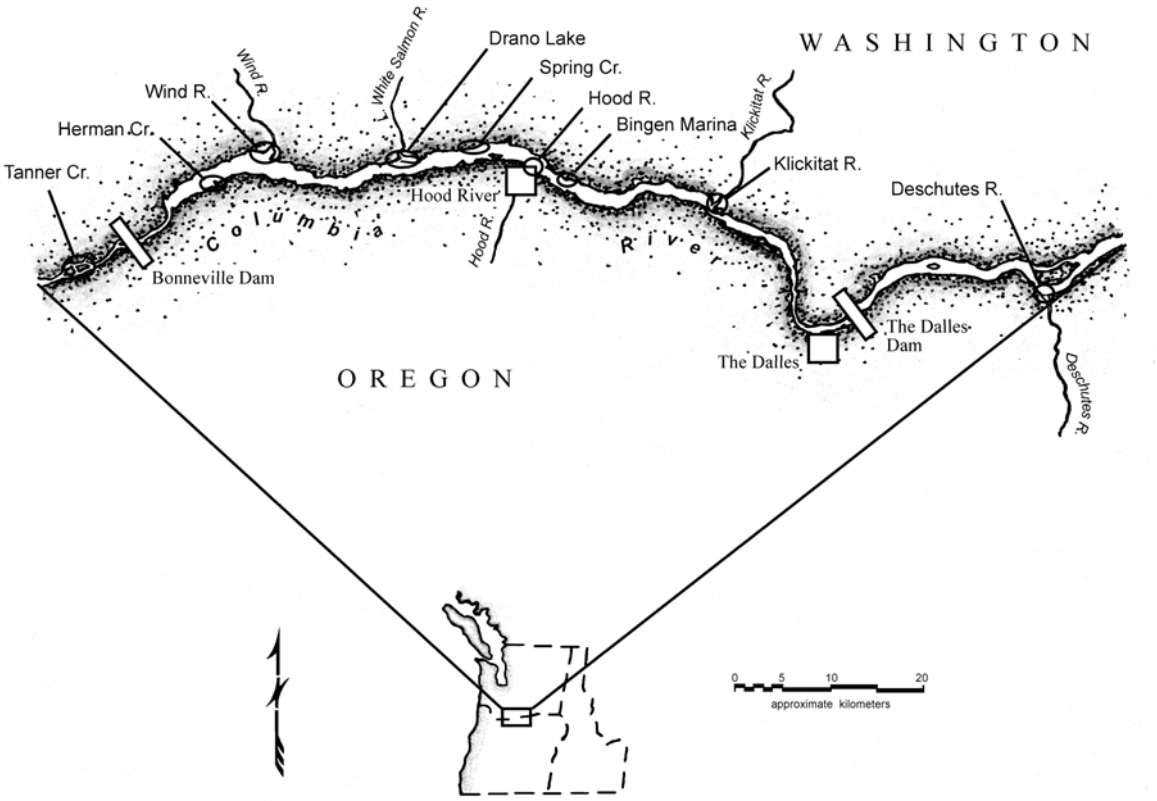


Figure D-1. Locations of site-specific gillnetting in 1999.

RESULTS & DISCUSSION

In 1999, 1,891 NPm > 250mm FL were caught in 1,110 net hr of fishing, for a catch-per-net-hour (CPNH) of 1.7 (Table D-1). Relative to 1998, effort decreased 13% and catch decreased 38%. CPNH also decreased, by 29%, to approximately the same level as obtained in 1997 (1.8). The fishery continued to focus on Bonneville Reservoir, which again accounted for the vast majority (88.4%) of the NPm caught. Drano Lake and the Klickitat River remained the most fruitful locations, together producing 76.1% of the catch (Table D-2). Since its inception in 1993, this fishery has removed 32,209 predators from Bonneville Reservoir (Table D-1).

In response to relatively high CPNH below Bonneville in 1998 (Beaty 1999), 66 additional net hours of fishing effort (3.4-fold increase) were placed at Tanner Creek in 1999. The catch rate at Tanner Creek in 1999 (CPNH=2.0) was exceeded only by that for Drano Lake, but incidental catches were exceptionally high at Tanner Creek.

Incidental species composed 61.6% (3,314/5,218) of the total catch in 1999 (Table D-3), a slight increase over 1998. A 25% increase in the incidental catch of adult salmon and steelhead from

Table D-1. Northern pikeminnow catch, effort (net hr), and catch per net hour (CPNH) for the site-specific gillnet fishery, 1993-99. Rounding may cause some apparent discrepancies.

		Columbia River						Snake River					GRAND TOTAL (mean)
			Reservoirs					Reservoirs					
		Below Bon'ville	Bon'ville	The Dalles	John Day	McNary	Season	Ice Harbor	Lwr Mon-umental	Little Goose	Lower Granite	Season	
1993	Catch	–	1,772	–	–	–	1,772	–	–	–	–	–	**1,772**
	Effort	0	394	0	0	0	394	0	0	0	0	0	**394**
	CPNH	**–**	***4.5***	**–**	**–**	**–**	***4.5***	**–**	**–**	**–**	**–**	**–**	***4.5***
1994	Catch	–	8,890	5	42	10	8,947	–	5	–	72	77	**9,024**
	Effort	0	1,195	18	43	67	1,323	0	17	0	102	120	**1,442**
	CPNH	**–**	***7.4***	***.3***	***1.0***	***.2***	***6.8***	**–**	***.3***	**–**	***.7***	***.6***	***6.3***
1995	Catch	263	8,668	25	136	57	9,149	231	22	22	60	335	**9,484**
	Effort	166	1,844	19	139	45	2,214	112	26	13	66	217	**2,431**
	CPNH	***1.6***	***4.7***	***1.3***	***1.0***	***1.3***	***4.1***	***2.1***	***.8***	***1.7***	***.9***	***1.5***	***3.9***
1996	Catch	38	5,822	232	63	11	6,166	–	–	–	–	–	**6,166**
	Effort	35	2,584	121	91	47	2,878	0	0	0	0	0	**2,878**
	CPNH	***1.1***	***2.3***	***1.9***	***.7***	***.2***	***2.1***	**–**	**–**	**–**	**–**	**–**	***2.1***
1997	Catch	1	2,538	226	35	23	2,823	–	8	–	–	8	**2,831**
	Effort	4	1,296	172	84	28	1,583	0	25	0	0	25	**1,608**
	CPNH	***.2***	***2.0***	***1.3***	***.4***	***.8***	***1.8***	**–**	***.3***	**–**	**–**	***.3***	***1.8***
1998	Catch	76	2,847	111	1	–	3,035	–	–	–	–	–	**3,035**
	Effort	28	1,119	108	15	0	1,271	0	0	0	0	0	**1,271**
	CPNH	***2.7***	***2.5***	***1.0***	***.1***	**–**	***2.4***	**–**	**–**	**–**	**–**	**–**	***2.4***
1999	Catch	186	1,672	33	–	–	1,891	–	–	–	–	–	**1,891**
	Effort	94	970	46	0	0	1,110	0	0	0	0	0	**1,110**
	CPNH	***2.0***	***1.7***	***.7***	**–**	**–**	***1.7***	**–**	**–**	**–**	**–**	**–**	***1.7***
Total	**Catch**	**564**	**32,209**	**632**	**277**	**101**	**33,783**	**231**	**35**	**22**	**132**	**420**	**34,203**
	Effort	**327**	**9,403**	**484**	**373**	**186**	**10,773**	**112**	**68**	**13**	**168**	**362**	**11,135**
	CPNH	**1.7**	**3.4**	**1.3**	**.7**	**.5**	**3.1**	**2.1**	**.5**	**1.7**	**.8**	**1.2**	**3.1**

Table D-2. NPm (>250mm FL) catch, effort, and catch per net hour (CPNH) by location, 1999.

Area/Location	NPm Catch	Effort (net hr)	CPNH
Below Bonneville			
Tanner Cr.	186	94.4	2.0
Bonneville Reservoir			
Herman Cr.	14	32.6	.4
Wind R.	102	70.7	1.4
Drano Lake	688	320.9	2.1
Spring Cr.	23	24.1	1.0
Hood R.	13	16.2	.8
Bingen Marina	80	71.9	1.1
Klickitat R.	752	433.7	1.7
The Dalles Reservoir			
Deschutes R.	85	65.3	1.3
TOTAL	**1,891**	**1,110.3**	**1.7**

69 in 1998 to 86 in 1999 was largely due to the high numbers of jack spring chinook salmon present this year. The fishery ended the night of June 22, when three sockeye salmon were caught below Bonneville. Nine of the incidentally caught adult salmon and steelhead are known to have died, including one sockeye salmon. Suckers (*Catostomus* spp.) again were the most commonly caught incidental species, accounting for roughly half (47.9%) of all incidentals.

REFERENCES

Beaty, R. 1999. Site-specific gillnetting for northern pikeminnow in the lower Columbia River in 1998. Report D *in* F. R. Young, editor. Development of a system-wide predator control program: stepwise implementation of a predator index, predator control fisheries, and evaluation plan in the Columbia River Basin. 1998 Annual Report. Contract DE-BI79-90BP07084, Bonneville Power Administration, Portland, Oregon.

Collis, K., R. E. Beaty, and B. R. Crain. 1995. Changes in catch rate and diet of northern squawfish associated with the release of hatchery-reared juvenile salmonids in a Columbia River reservoir. North American Journal of Fisheries Management 15:346-357.

Hatch, K., J. McCormack, and R. Beaty. 1998. Site-gillnetting for northern pikeminnow concentrated to feed on hatchery-released juvenile salmonids in the lower Columbia River in 1997. Report D *in* F. R. Young, editor. Development of a system-wide predator control program: stepwise implementation of a predator index, predator control fisheries, and evaluation plan in the Columbia River Basin. 1997 Annual Report. Contract DE-BI79-90BP07084, Bonneville Power Administration, Portland, Oregon.

Table D-3. Species composition of the site-specific gillnet fishery catch in 1999. Condition codes for salmonids: 1 = minimal injury, certain to survive; 2 = moderate injury, may or may not survive; 3 = dead, nearly dead, or certain to die.

Species		No.
Ptychocheilus oregonensis **(northern pikeminnow)**	≥ 250mm	1,891
	< 250mm	20
Oncorhynchus **spp. (salmon & steelhead)**	*Condition*	
Juveniles (undetermined spp.)	*1*	6
	2	0
	3	1
Adults		
O. tshawytscha (chinook)	*1*	52
	2	2
	3	6
O. mykiss (steelhead)	*1*	19
	2	2
	3	2
O. nerka (sockeye)	*1*	2
	2	0
	3	1
unspecified		3
Total Salmon and Steelhead		**93**

Species	No.
Game fishes	
Acipenser transmontanus (white sturgeon)	1,042
Alosa sapidissima (American shad)	286
Stizostedion vitreum (walleye)	65
Micropterus spp. (bass)	62
Prosopium williamsoni (mountain [illegible])	19
Ictalurus spp. (catfish/bullhead)	9
Salvelinus spp. (char)	8
O. mykiss (rainbow trout)	5
Pomoxis spp. (crappie)	4
unspecified	7
Non-game fishes	
Catostomus spp. (suckers)	1,539
Cyprinids (carp, peamouth, chiselmouth)	93
unspecified	72
Total Game and Non-game	**3,214**
Total Catch	**5,218**

REPORT E
Development of a Systemwide Predator Control Program: Indexing and Fisheries Evaluation

Prepared by

Mark P. Zimmerman, Thomas A. Friesen, David L. Ward, and Howard K. Takata
Oregon Department of Fish and Wildlife
Columbia River Investigations
17330 S.E. Evelyn Street
Clackamas, Oregon 97015

ACKNOWLEDGMENTS

We are particularly grateful to project personnel that worked long hours in the field to collect the data presented in this report. Thanks to Andrea Adamson, Chris Burnside, Ian Chane, Steve Gray, Matt Howell, Michele Hughes, Kyle Martens, and George Reed. Thanks also to Lisa Burner and Ruth Farr for filling in when we were short-handed.

This research was funded by the Bonneville Power Administration, John Skidmore, Project Manager (Contract DE-B1719-90BP07084). Dave Ward of the Oregon Department of Fish and Wildlife, Frank Young of the Columbia Basin Fish and Wildlife Authority, and Russell Porter of the Pacific States Marine Fisheries Commission administered the contract and/or critically reviewed the manuscript.

We thank Roy Beaty and his staff (Columbia River Inter-Tribal Fish Commission) and Lyle Fox and his staff (Washington Department of Fish and Wildlife) for their cooperation with project coordination. We also thank the U.S. Army Corps of Engineers for coordinating the use of their project facilities.

ABSTRACT

Predator control fisheries aimed at reducing predation on juvenile salmonids by northern pikeminnow *Ptychocheilus oregonensis* were implemented for the tenth consecutive year in the mainstem Columbia and Snake rivers. In this report, we (1) evaluate northern pikeminnow exploitation rate and catch rate of incidentally-harvested fishes among the three management fisheries in 1999, (2) estimate reductions in predation on juvenile salmonids since implementation of the fisheries, (3) compare current northern pikeminnow population parameters (relative abundance, consumption, size and age structure, growth, and fecundity) to parameters measured in 1990-1996, and (4) compare current information on abundance and consumption of smallmouth bass *Micropterus dolomieu* and walleye *Stizostedion vitre*um to information collected from 1990-1996.

Systemwide exploitation of northern pikeminnow ≥250 mm fork length was 12.5% for sport-reward, 0.0% for dam-angling (no tagged fish recovered), and 0.2% for site-specific gill-net fisheries (one tagged fish recovered). Exploitation was lowest in Lower Monumental and Little Goose reservoirs (0.0%) and highest in The Dalles Reservoir (16.1%). The dam-angling fishery had the lowest percentage (5.3%) of incidental catch relative to the total number of fish caught. Incidental catch was 31.6% in the sport-reward fishery and 63.8% in the gill-net fishery.

If exploitation rates remain similar to mean 1994-1999 levels, we estimate that potential predation by northern pikeminnow on juvenile salmonids in 2000 will be approximately 75% of predation levels prior to the implementation of removal fisheries. Further reductions in predation are unlikely unless average exploitation in future years is higher than recent levels.

Relative abundance of northern pikeminnow was lower in 1999 than mean abundance from 1994-1996. Indices of consumption and predation of northern pikeminnow were generally greater in 1999 than 1996, particularly in spring. However, predation in 1999 was less than average predation from 1994-1996 at most locations. Relative density and juvenile salmonid consumption of smallmouth bass was similar to or less than density and consumption from 1990 to 1996.

Proportional stock density of northern pikeminnow in 1999 was similar to previous years. We found no evidence that northern pikeminnow have compensated in fecundity or condition (relative weight) in response to sustained exploitation in the lower Columbia River.

Relative abundance of smallmouth bass was similar to or less than abundance from 1990 to 1996. Consumption indices for smallmouth bass were low in both spring and summer. Diet of walleye was similar to that in previous years.

INTRODUCTION

The goal of the Northern Pikeminnow Management Program (NPMP) is to reduce mainstem mortality of juvenile salmonids attributed to predation by northern pikeminnow *Ptychocheilus oregonensis*, formerly known as northern squawfish (Nelson et al. 1998), in the lower Columbia River basin. We established baseline levels of predation and described northern pikeminnow population characteristics prior to the implementation of sustained predator control fisheries by estimating northern pikeminnow abundance, consumption, and predation in Columbia River reservoirs in 1990 (Vigg et al. 1990), Snake River reservoirs in 1991 (Ward et al. 1993), and the unimpounded lower Columbia River downstream from Bonneville Dam in 1992 (Parker et al. 1994). We sampled Columbia River impoundments again in 1993 to evaluate changes from 1990 (Zimmerman et al. 1995). From 1994-1996 we sampled in areas where sufficient numbers of northern pikeminnow could be collected to compare changes in predation among years (Zimmerman and Ward 1999). Ward (1997) provided a comprehensive summary of NPMP evaluation from 1990-1996. In this report we describe our activities and findings for 1999, and wherever possible, evaluate changes from previous years.

Our objectives in 1999 were to (1) evaluate the relative efficiency of each northern pikeminnow fishery by comparing exploitation rate and incidental catch, (2) estimate reductions in predation on juvenile salmonids since the implementation of the NPMP, and (3) update information on population dynamics of northern pikeminnow, smallmouth bass *Micropterus dolomieu* and walleye *Stizostedion vitreum*, including relative abundance, consumption, diet, year-class strength, size structure, relative weight, and fecundity.

METHODS

Fishery Evaluation and Loss Estimates

Field Procedures

Three northern pikeminnow fisheries were conducted in 1999. The sport-reward fishery was implemented by the Washington Department of Fish and Wildlife (WDFW) from May 3 to October 10 throughout the lower Columbia and Snake rivers. The dam-angling fishery was implemented by the Columbia River Inter-Tribal Fish Commission (CRITFC), Confederated Tribes of the Warm Springs Reservation of Oregon (CTWS), Confederated Tribes of the Umatilla Indian Reservation, and the Confederated Tribes and Bands of the Yakama Indian Nation (YIN) from June 7 to October 22 at Bonneville, The Dalles, John Day, and McNary dams. A site-specific gill-net fishery was implemented by CRITFC, YIN, and CTWS from May 3 to June 22 downstream from Bonneville Dam and in Bonneville and The Dalles reservoirs.

We tagged and released northern pikeminnow to estimate exploitation rates for each fishery. We used electrofishing boats and sinking gill nets to collect northern pikeminnow from April 5-June 24. We allocated equal sampling effort in all river kilometers (RKm) from RKm 79 through Priest Rapids Dam tailrace (RKm 637) on the lower Columbia River, and on the Snake River from RKm 82 through RKm 248 (detailed methods are given in Friesen and Ward 1999).

Northern pikeminnow were tagged with a serially-numbered spaghetti tag. To account for potential growth during the fishery season, we tagged all northern pikeminnow greater than 240 mm fork length. Tags were recovered from each fishery from May 3 to October 22.

Data Analysis

We used mark-and-recapture data to compare exploitation rates of northern pikeminnow ≥ 250 mm fork length among fisheries and reservoirs in 1999. Weekly estimates of exploitation for each fishery were calculated by dividing the number of tagged northern pikeminnow recovered by the number of tagged fish at large and summed to yield total exploitation rates (Beamesderfer et al. 1987). We assumed a 4.2 % rate of tag loss (Friesen and Ward 1999).

We used two methods to calculate 95% confidence intervals for the number of tagged fish recovered each week. We calculated confidence intervals for variables distributed in a Poisson distribution from Ricker (1975) for weeks when tagging and fishing occurred simultaneously. After tagging was complete, we calculated confidence intervals using the formula

$$m \pm 1.96 \sqrt{m/n} \quad (\text{if } mn > 30),$$

where

n = the number of sampling periods (weeks) remaining, and
m = the mean number of tagged fish recovered per week (Elliott 1977).

We summed estimates for each week to give overall confidence limits.

We compared incidental catch among fisheries for 1999 by determining the percent of the total catch composed of fish other than northern pikeminnow ≥ 250 mm fork length.

We used the "Loss Estimate Spreadsheet Model" (Friesen and Ward 1999) to estimate predation on juvenile salmonids relative to predation prior to implementation of the NPMP. The model incorporates age-specific exploitation rates on northern pikeminnow and resulting changes in age structure to estimate changes in predation. We used a 10-year "average" age structure (based on catch curves) for a pre-exploitation base, and assumed constant recruitment. Age-specific consumption was incorporated; however, potential changes in consumption, growth, and fecundity due to removals were not considered likely. The model therefore estimates changes in potential predation related directly to removals. This in effect allowed us to estimate the effects of removals if all variables except exploitation were held constant.

We estimated the potential relative predation in 1999 based on observed exploitation rates, and the eventual minimum potential predation assuming continuing exploitation at mean 1994-1999 levels. Because inputs to the model included three potential relationships between age of northern pikeminnow and consumption, and three estimates of exploitation (point estimate plus confidence limits), we computed nine estimates of relative predation for each year (Friesen and Ward 1999). We report the maximum, median, and minimum estimates.

Biological Evaluation

Field Procedures

To evaluate changes in relative abundance and consumption of northern pikeminnow, smallmouth bass, and walleye, we used boat electrofishing to collect biological data in spring (April 27 - June 3) and summer (June 29 - August 6) in the following areas: downstream from Bonneville Dam (RKm 117-121, RKm 171-177, and RKm 178-183), Bonneville Dam tailrace, Bonneville Reservoir, , John Day Dam tailrace, John Day Reservoir, Little Goose Dam tailrace, Lower Granite Dam tailrace, and upper Lower Granite Reservoir (RKm 221-229). Sampling methods and gear specifications have been previously described (Ward et al. 1995; Zimmerman and Ward 1999). Digestive tract contents from northern pikeminnow and walleye ≥250 mm fork length, and from smallmouth bass ≥200 mm fork length were preserved using methods described by Ward et al. (1995).

We collected biological data from all northern pikeminnow collected by electrofishing and from subsamples of fish harvested by the sport-reward fishery to evaluate changes in population structure, growth, and reproduction. We determined fork length (mm), total body weight (g), sex (male, female or undetermined), and maturity (undeveloped or immature, developing, ripe, or spent), and collected gonad (ripe females only) and scale samples. Fork length data for northern pikeminnow harvested by the sport-reward fishery were provided by WDFW, and data on fork lengths of fish caught in the dam angling and site-specific gillnet fisheries were provided by CRITFC. We also collected scale samples from smallmouth bass and walleye.

Laboratory Procedures

We examined digestive tract contents of northern pikeminnow, smallmouth bass, and walleye to measure relative consumption rates of juvenile salmonids. Details of laboratory methods are given in Ward et al. (1995). We collected scale samples from northern pikeminnow downstream from Bonneville Dam, and in Bonneville, John Day, and Lower Granite reservoirs. Methods of age determination were described by Parker et al. (1995). We estimated fecundity of ripe female northern pikeminnow using procedures described by Parker et al. (1995).

Data Analysis

We used catch per unit effort of standardized electrofishing runs as an index of density for northern pikeminnow and smallmouth bass. We calculated indices of northern pikeminnow abundance as the product of the density index and reservoir or area-specific surface area (Ward et al. 1995). We compared density and abundance indices of northern pikeminnow in 1999 with those from 1990-1996.

The following formulas were developed as consumption indexes (CI) for northern pikeminnow (Ward et al. 1995) and smallmouth bass (Ward and Zimmerman 1999):

$$CI_{NPM} = 0.0209 \cdot T^{1.60} \cdot MW^{0.27} \cdot (S \cdot GW^{-0.61}),$$

and

$$CI_{SMB} = 0.0407 \cdot e^{(0.15)(T)} \cdot MW^{0.23} \cdot (S \cdot GW^{-0.29}),$$

where

CI_{NPM} = consumption index for northern pikeminnow,
CI_{SMB} = consumption index for smallmouth bass,
T = water temperature (^{O}C),
MW = mean predator weight (g),
S = mean number of salmonids per predator, and
GW = mean gut weight (g) per predator.

The consumption index is not a rigorous estimate of the number of juvenile salmonids eaten per day by an average predator; however, it is linearly related to the consumption rate of northern pikeminnow (Ward et al. 1995) and smallmouth bass (Ward and Zimmerman 1999). Spring (April-June) and summer (June-August) consumption indices were compared with those from 1990-1996 for all sampling areas. We calculated and compared smallmouth bass CI's between two size groups: ≥150 mm and ≥200 mm fork length.

We used the product of abundance and consumption indices to calculate predation indices for northern pikeminnow for spring and summer periods, and compared northern pikeminnow predation among years for reservoirs and areas where data had been collected each year. We plotted the daily juvenile salmonid passage index at lower Columbia and Snake River dams to compare timing of consumption index sampling with concentrations of juvenile salmonids present in each area.

We used the method of El-Zarka (1959) to index year-class strengths of northern pikeminnow cohorts (1985-1995) based on their relative abundance in standardized electrofishing catches downstream from Bonneville Dam and in Bonneville Reservoir. Because the relative abundances of year classes in electrofishing catches were biased by exploitation rates that varied among years (Friesen and Ward 1999), we limited our comparisons to abundance of northern pikeminnow large enough to be effectively sampled and small enough to be excluded from the NPMP (ages 3-5).

Because fishery exploitation rates are greater on larger pikeminnow than on smaller pikeminnow (Zimmerman et al. 1995), sustained fisheries should decrease the abundance of large fish relative to the abundance of smaller fish. We used proportional stock density (PSD; Anderson 1980), where PSD = 100 •(number of fish at least quality length / number of fish at least stock length) to compare size structure of northern pikeminnow populations among years in the Columbia River downstream from Bonneville Dam, and in Bonneville and John Day reservoirs. Stock and quality sizes for northern pikeminnow have been defined as 250 and 380 mm fork length, respectively (Beamesderfer and Rieman 1988; Parker et al. 1995).

We used mean relative weight (W_r) to compare condition of northern pikeminnow in 1999 with previous years (Anderson and Gutreuter 1983). We used the standard weight (W_s) equation for northern pikeminnow developed by Parker et al. (1995), $\log_{10}(W_s) = -4.886 + 2.986[\log_{10}(\text{fork length})]$, in calculations ($W_r = 100[\text{weight}]/W_s$). We calculated W_r for male and female pikeminnow downstream from Bonneville Dam and in Bonneville Reservoir.

We calculated mean fecundity (number of developed eggs per female) and mean relative fecundity (number of developed eggs per gram of body weight) of northern pikeminnow from the Columbia River downstream from Bonneville Dam, and from Bonneville and John Day reservoirs.

RESULTS

Fishery Evaluation and Loss Estimates

We tagged and released 750 northern pikeminnow throughout the lower Columbia and Snake rivers in 1999. A total of 84 tagged fish were recaptured in the three fisheries: 83 in the sport-reward fishery, none in the dam-angling fishery, and one in the site-specific gill-net fishery. A total of 119,280 northern pikeminnow ≥250 mm were harvested in 1999: 114,687 in the sport reward fishery, 3,737 in the dam angling fishery, and 1,891 in the gill-net fishery. Total exploitation of northern pikeminnow in 1999 was 12.7%, which exceeded the 1992-1998 average of 11.8 % (Figure 1; **Appendix A**). Exploitation of northern pikeminnow in the sport-reward fishery was 12.5%; the second-highest rate observed since the program's inception. This year's sport-reward exploitation in Bonneville and The Dalles reservoirs was the highest since 1991, whereas exploitation upstream of Lower Granite Dam was lower than all previous years. The 95% confidence intervals around the system-wide exploitation estimate were 7.5 and 22.8% for all fisheries combined (Figure 1).

We did not sample the catch of northern pikeminnow in each fishery in 1999 to estimate mean size of harvested fish. The WDFW reported a mean fork length of 326 mm

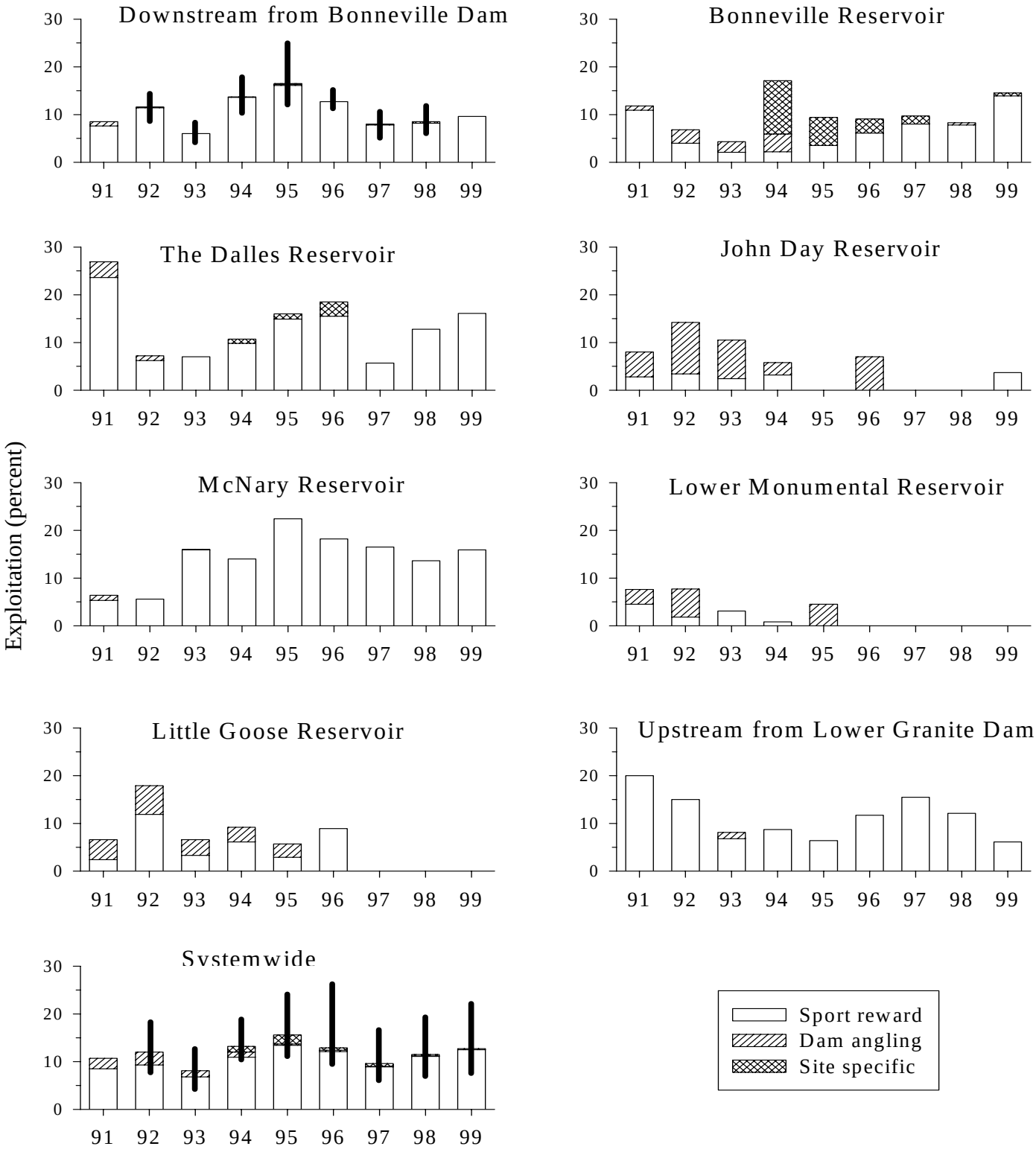


Figure 1. Exploitation of northern pikeminnow ≥ 250 mm fork length by fishery and area, 1991-99. Vertical bars are 95% confidence intervals for all fisheries combined downstream from

Bonneville Dam and system-wide.
(N=79,084) for northern pikeminnow ≥250 mm fork length at all check stations (Fox et al. 2000). This was very similar to the means of 332 mm in 1996, 329 mm in 1997, and 325 mm in 1998. A representative sample of northern pikeminnow was not available for the dam-angling fishery. Mean size among 1,405 northern pikeminnow harvested primarily in Bonneville Reservoir by the site-specific fishery was 390 mm (Roy Beaty, CRITFC, personal communication). This was less than the mean of 412 mm for fish harvested by gill nets in Bonneville Reservoir from 1994-1996.

Incidental catch among all fisheries in 1999 was 56,817, or 32.0% of all captured fish. The incidental catch rate was 31.6% in the sport-reward fishery, 5.3% in the dam-angling fishery, and 63.8% in the gill-net fishery (Table 1). The proportion of predator-sized (≥250 mm fork length) northern pikeminnow relative to the total number of northern pikeminnow harvested was highest in the dam-angling fishery (99.9%) and lowest in the sport-reward fishery (80.1%).

Salmonids made up only 0.5% of the total catch and 1.7% of the incidental catch for all fisheries combined in 1999. The combined incidental catch for all fisheries was primarily composed of cyprinids (including northern pikeminnow <250 mm), averaging 67% of non-targeted fish from 1995 to 1999 for all fisheries combined (Figure 2). Predator species other than northern pikeminnow (mostly smallmouth bass, channel catfish, and walleye) averaged 11.9%, catostomids averaged 9.0%, and white sturgeon averaged 6.2% of incidental catch from 1995 to 1999.

Results from the "Loss Estimate Spreadsheet Model" indicated that potential predation by northern pikeminnow on juvenile salmonids in 1999 ranges from 63% to 88% of pre-program levels, with a median estimate of 75% (Figure 3). Continued exploitation at mean 1994-99 levels will probably not result in further reductions in predation.

Biological Evaluation

Timing of predator sampling near Columbia and Snake River dams generally coincided with peaks in juvenile salmonid passage indices (**Appendix B**). However, we were unable to sample within the boat-restricted zone at most of the dams because of high spill levels in 1999. Density indices for northern pikeminnow in 1999 were among the lowest measured since 1990 (**Appendix Table C-2**). Catch of northern pikeminnow at Snake River sites in spring was zero in Little Goose Dam tailrace, four in Lower Granite Dam tailrace, and 16 upstream of Lower Granite Dam. Compared to mean abundance from 1994-1996, relative abundance of northern pikeminnow in 1999 was 24% lower downstream from Bonneville Dam (excluding the tailrace BRZ), 49% lower in Bonneville Reservoir (excluding the tailrace BRZ), and 53% lower in John Day Reservoir forebay and tailrace outside the BRZ (Figure 4; **Appendix Table C-3**).

The frequency of occurrence of salmonids among northern pikeminnow was slightly (3.8%) greater in 1999 than 1996 (**Appendix Table E-1**). In 1999, spring consumption index values were greater than the 1994-1996 mean values in Bonneville Dam tailrace, the mid-

Table 1. Number of northern pikeminnow and incidentally-caught fish by species or family in each fishery in 1999. Sport reward catches of salmonids and northern pikeminnow ≥250 mm are

estimates based upon returning and non-returning anglers. Sport reward catches of all other taxa are by returning anglers only.

Species or family	Sport Reward	Dam Angling	Gill Net
Northern pikeminnow			
≥250 mm fork length	115,093	3,737	1,891
<250 mm fork length	28,541	5	20
White sturgeon[a]	3,048	113	1,042
American shad[a]	376	4	286
Salmonidae[a]			
Chinook (adult)	59	0	60
Chinook (juvenile)	176	--[b]	--[b]
Sockeye (adult)	0	0	3
Sockeye (juvenile)	0	--[b]	--[b]
Steelhead (adult)	81	0	23
Steelhead (juvenile)	355	--[b]	--[b]
Unknown salmon	0	1	3
Other	171	39	
Cyprinidae (minnows)	12,799	2	93
Catostomidae (suckers)	71	0	1,539
Channel catfish[a]	1,039	21[c]	9[c]
Smallmouth bass[a]	4,354	57[d]	62[d]
Walleye[a]	431	4	65
Other/unidentified	1,780	1	83
Total (all species)	168,374	3,946	5,218
Percent incidental catch	31.6	5.3	63.8

[a] Salmonidae = *Oncorhynchus*, *Salmo*, *Salvelinus*, and *Prosopium* spp. White sturgeon = *Acipenser transmontanus*, American shad = *Alosa sapidissima*, channel catfish = *Ictalurus punctatus*, smallmouth bass = *Micropterus dolomieu*, walleye = *Stizostedion vitreum*.

[b] Juvenile salmonids were not identified to species. One was captured by dam angling and seven were captured by gill net. All are listed under "Other".

[c] Includes all Ictalurid species.

[d] Includes all *Micropterus* species.

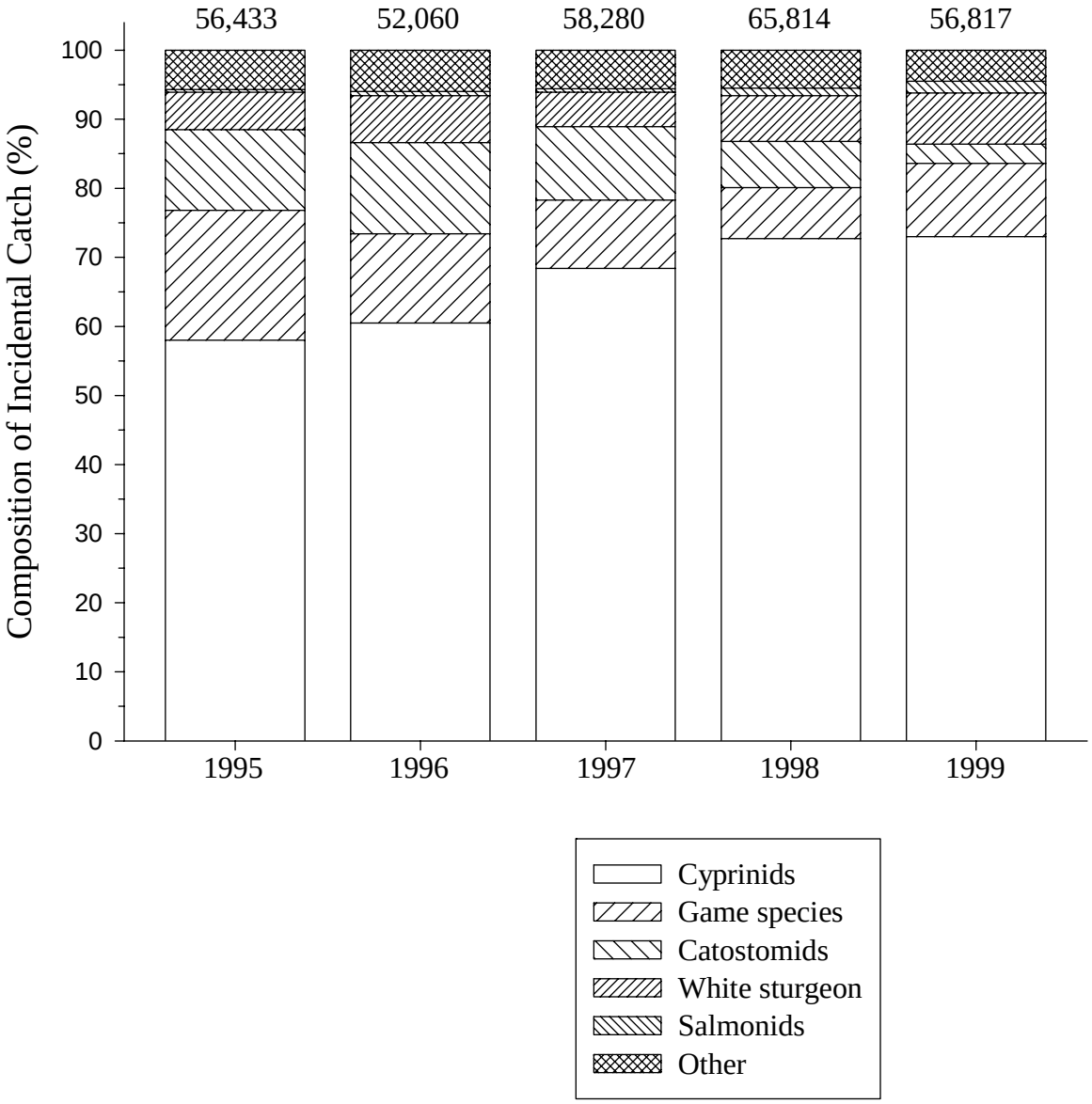


Figure 2. Taxonomic composition (percent) of incidentally-caught fish in all fisheries combined from 1995 to 1999. Figures above bars are total number of incidentally-caught fish. Cyprinids include northern pikeminnow <250 mm fork length. Game species include smallmouth bass, channel catfish, and walleye caught in the sport reward fishery, and *Micropterus* species, Ictalurid species, and walleye caught in the dam angling and gill-net fisheries.

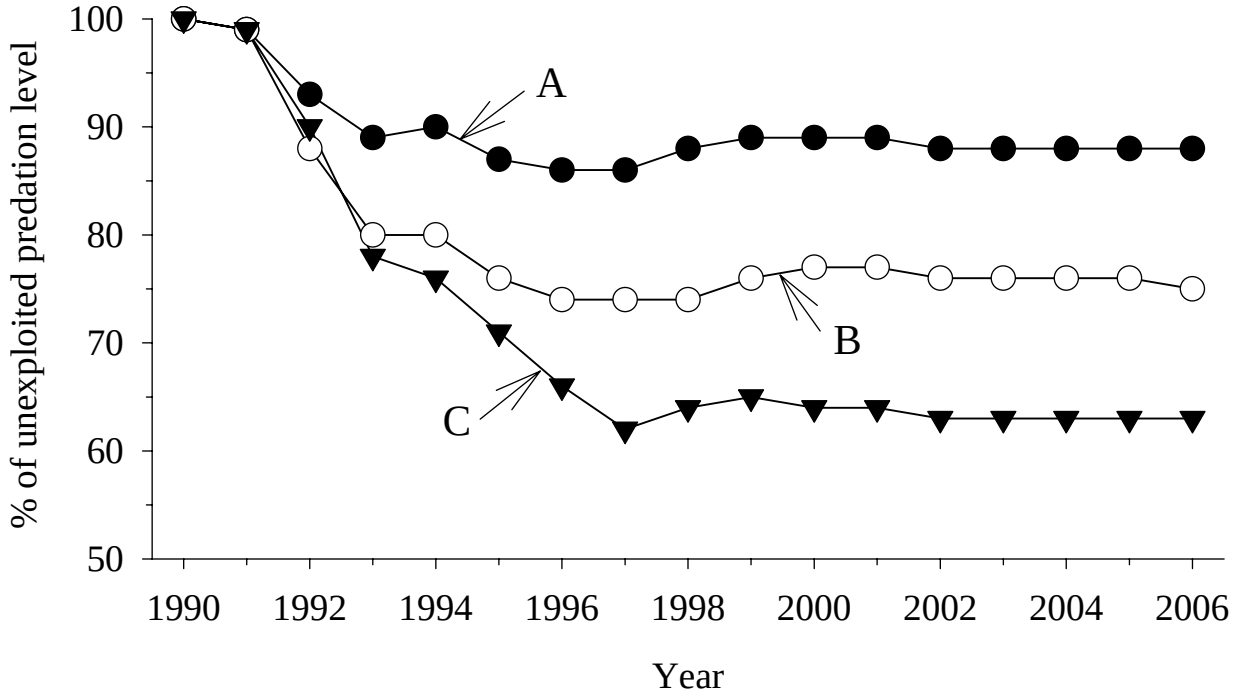


Figure 3. Maximum (A), median (B), and minimum (C) estimates of potential predation on juvenile salmonids by northern pikeminnow relative to predation prior to implementation of the northern pikeminnow management program. Trends after 2000 indicate predation in future years if exploitation is maintained at mean 1994-99 levels.

reservoir of Bonneville Reservoir, John Day Dam tailrace, and the upper portion of Lower Granite Reservoir (**Appendix Table C-4**). Consumption indices in spring were similar or lower than 1994-1996 means in the remaining locations. Summer consumption indices were equal to or lower than 1994-1996 means at all locations (**Appendix Table C-5**).

Predation indices in spring were greater in 1999 than 1996 except in Bonneville Dam tailrace (Figure 5; **Appendix Table C-6**). Predation in spring 1999 was generally lower than the mean index values from 1994-1996. In summer, the sum of predation index values downstream from Bonneville Dam in 1999 was greater than 1996, but less than mean predation from 1994-1996 (Figure 6; **Appendix Table C-7**). Predation indices at impounded sites upstream from Bonneville Dam were mostly negligible in summer 1999.

Year-class strengths of northern pikeminnow downstream from Bonneville Dam were highest in 1985 and 1991, and lowest in 1987 (Figure 7). In Bonneville Reservoir, strong year classes occurred in 1985, 1987, and 1991, and year-class strength was lowest in 1988. Estimates of PSD and W_r (Table 2) and fecundity (Table 3) of northern pikeminnow in 1999 were within the ranges of estimates in previous years.

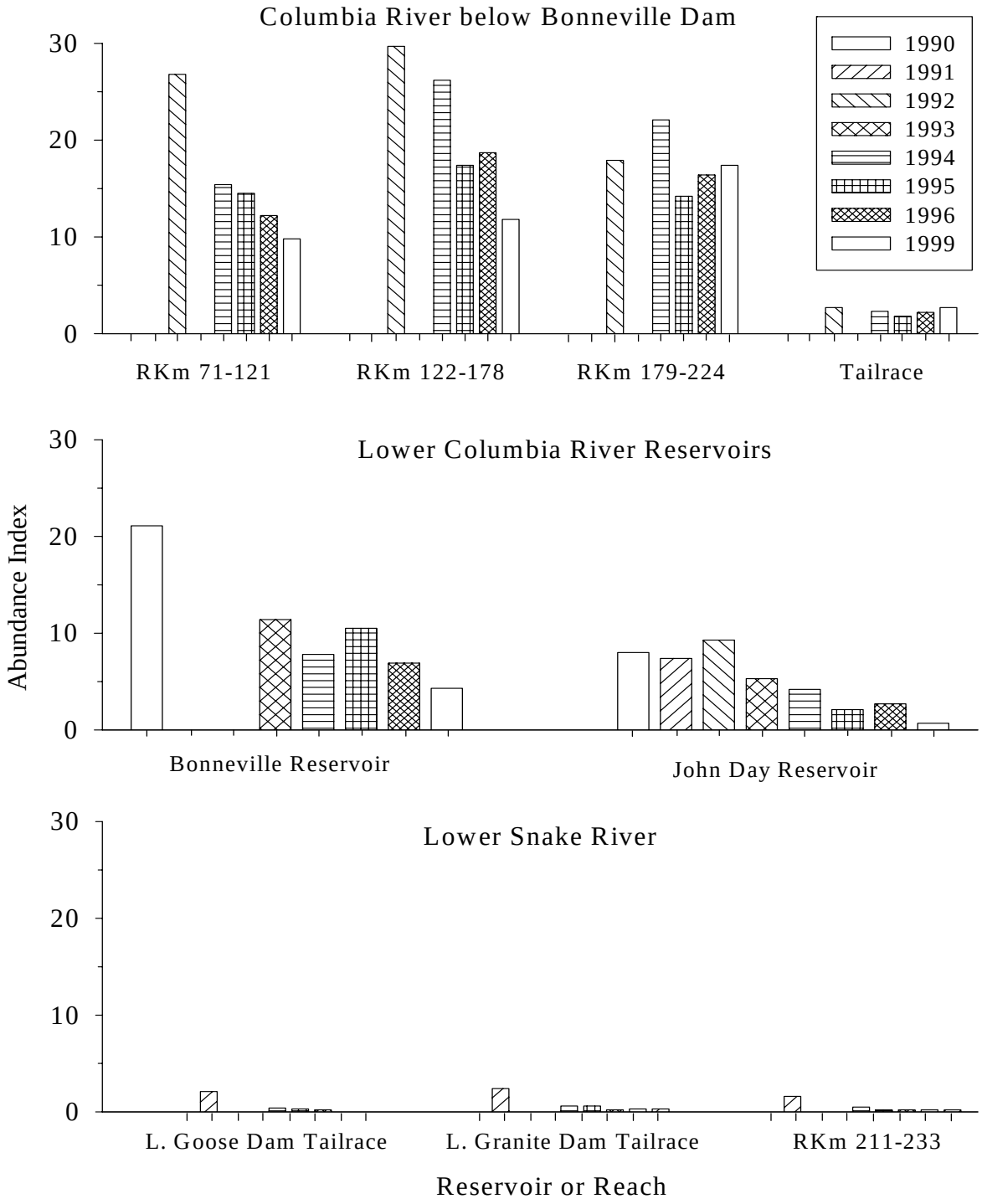


Figure 4. Index of northern pikeminnow abundance from 1990-96 and 1999 for sampling locations in the lower Columbia and Snake rivers. RKm = river kilometer.

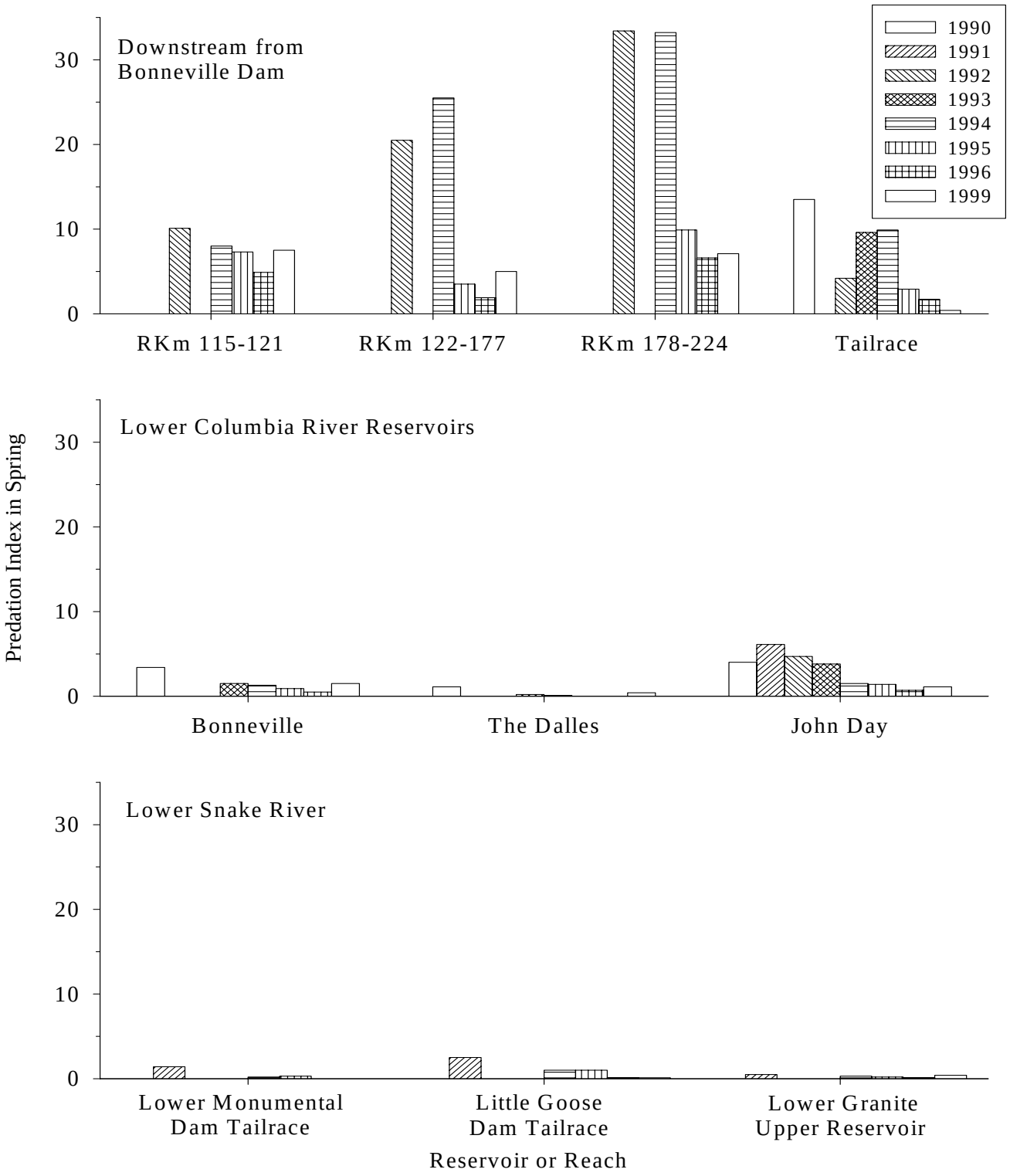


Figure 5. Index of predation by northern pikeminnow during spring in 1990-1996 and 1999 for sampling locations in the lower Columbia and Snake rivers. RKm = river kilometer.

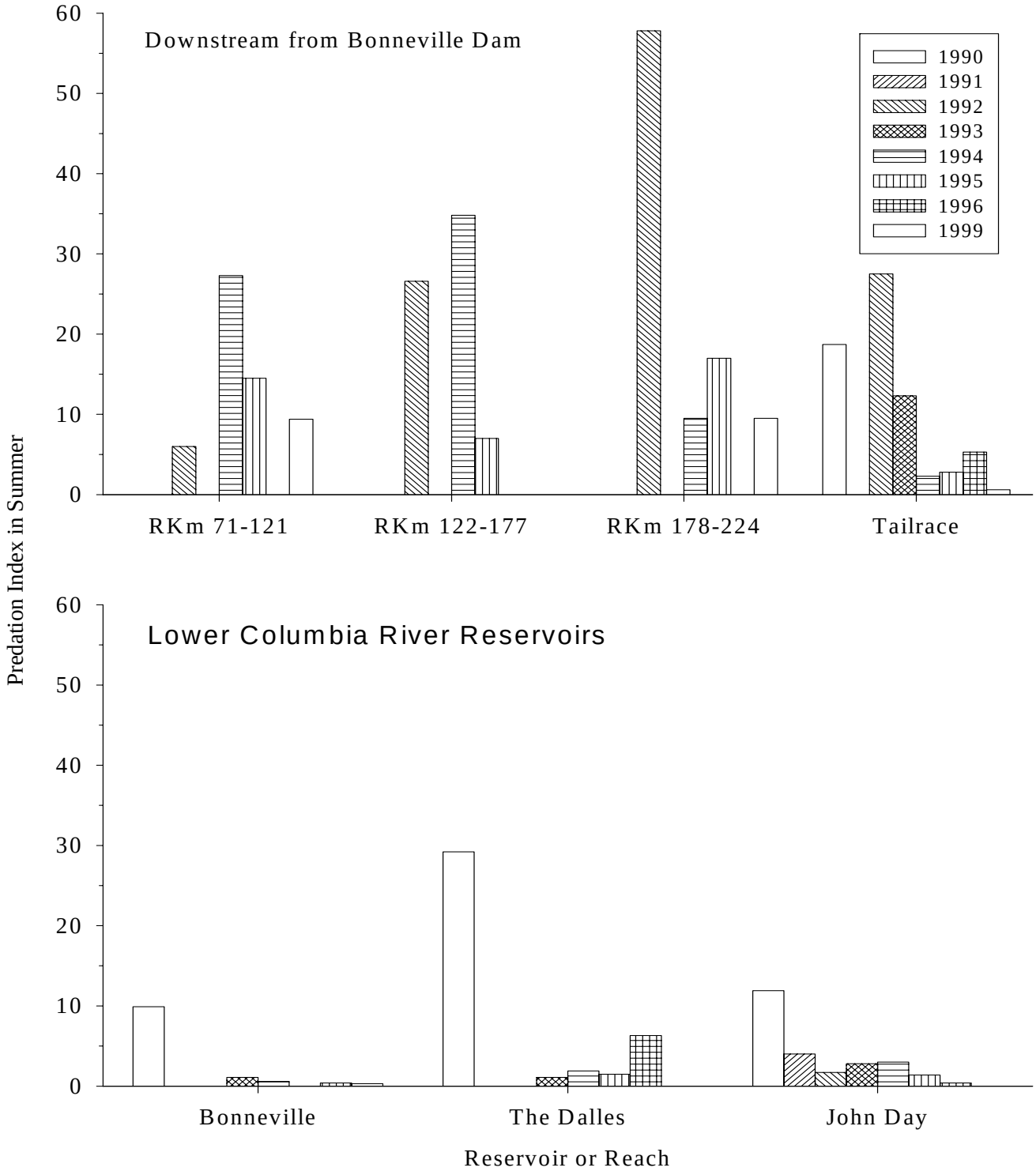


Figure 6. Index of predation by northern pikeminnow during summer in 1990-1996 and 1999 for sampling locations in the lower Columbia River. Predation indices for The Dalles Reservoir excludes the mid-reservoir and forebay. RKm = river kilometer.

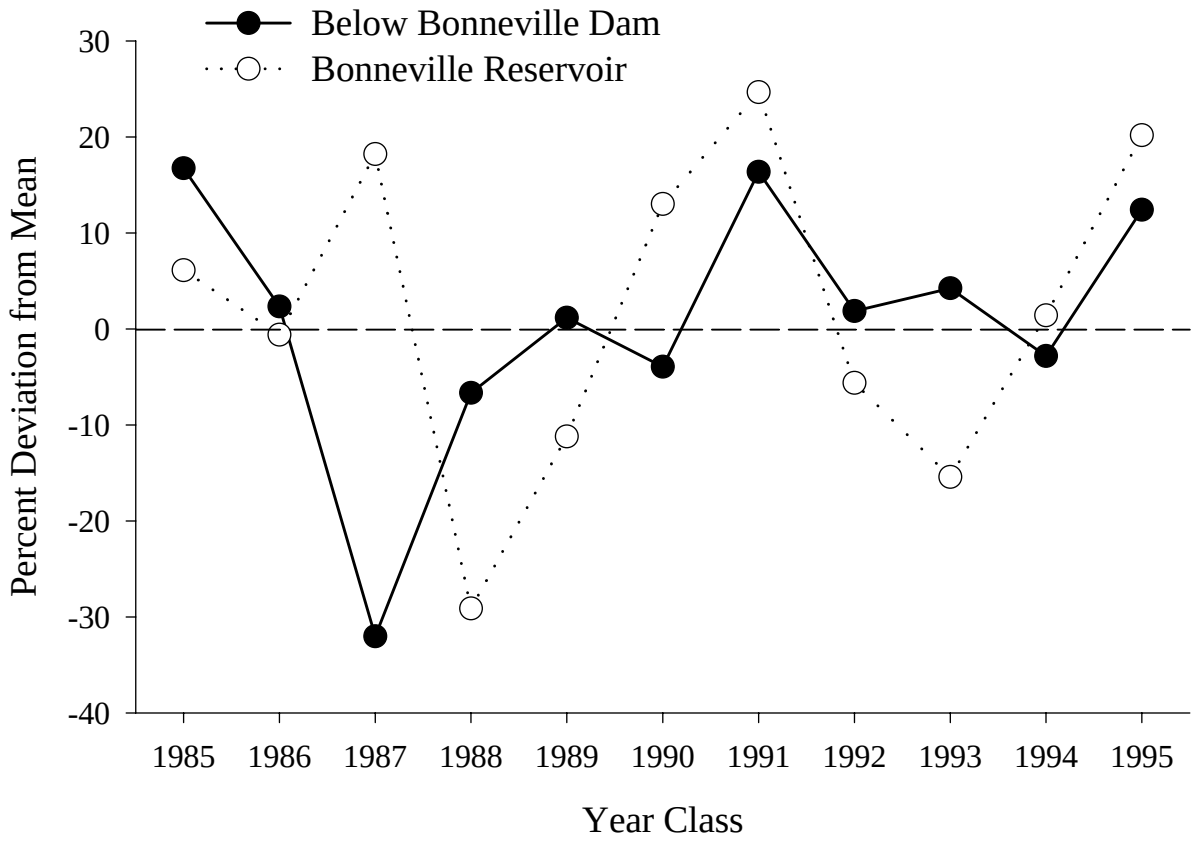


Figure 7. Index of relative year-class strength of northern pikeminnow in the Columbia River downstream from Bonneville Dam and Bonneville Reservoir from 1985 to 1995.

Relative density of smallmouth bass in 1999 was generally similar or less than density from 1990 to 1996 (**Appendix Tables D-1 and D-2**). Consumption indices for smallmouth bass were very low at all locations in both spring and summer (**Appendix Tables D-3 and D-4**). Consumption indices for smallmouth bass ≥150 mm were not statistically different from those computed for bass ≥200 mm during spring (P=0.79) and summer (P=0.90). The frequency of occurrence of salmonids among smallmouth bass in 1999 was similar to 1996 (**Appendix Table E-1**).

Table 2. Proportional stock density (PSD), mean relative weight (W_r), and sample size (N) of northern pikeminnow downstream from Bonneville Dam and in Bonneville Reservoir in 1999 and 1990-1996.

Location, parameter	1990	1991	1992	1993	1994	1995	1996	1999
Downstream from Bonneville Dam								
PSD	--	--	0.29	--	0.33	0.41	0.33	0.39
(N)	--	--	(682)	--	(401)	(206)	(245)	(226)
Mean W_r, males	--	--	88	--	93	88	87	92
(N)	--	--	(453)	--	(220)	(64)	(102)	(75)
Mean W_r, females	--	--	96	--	103	99	95	104
(N)	--	--	(494)	--	(340)	(156)	(171)	(146)
Bonneville Reservoir								
PSD	0.43	--	--	0.37	0.40	0.26	0.24	0.33
(N)	(245)	--	--	(148)	(378)	(319)	(199)	(169)
Mean W_r, males	85	81	--	97	99	95	92	96
(N)	(24)	(26)	--	(161)	(234)	(164)	(102)	(93)
Mean W_r, females	101	83	--	106	106	103	101	105
(N)	(71)	(37)	--	(153)	(304)	(161)	(113)	(72)

The proportion of walleyes that had consumed juvenile salmonids was 19.6% in spring and 18.5% in summer (**Appendix Table E-1**). Walleye stomachs contained 50 identifiable prey fish, 21 (42.0%) of which were salmonids (**Appendix Table E-2**).

DISCUSSION

Rieman and Beamesderfer (1990) predicted that sustained exploitation of northern pikeminnow >275 mm fork length at an annual rate of 10-20% would reduce losses of juvenile salmonids to predation by 50%. Total systemwide exploitation by the three fisheries in 1999 was 12.7%, exceeding the average rate of 11.8% from 1992-1998. As in previous years, sport-reward effort, harvest, and exploitation greatly exceeded other fisheries. The dam-angling and site-specific gill-net fisheries, while contributing less to exploitation, harvested localized concentrations of northern pikeminnow which may have aggregated to feed on juvenile salmonids (Collis et al. 1995).

Table 3. Mean fecundity (number of eggs per female), mean relative fecundity (MRF; number of eggs per gram of body weight), and sample size (N) of northern pikeminnow downstream from Bonneville Dam and in Bonneville Reservoir in 1999 and 1991-1996.

Location, parameter	1991	1992	1993	1994	1995	1996	1999
Downstream from Bonneville Dam							
Mean fecundity	37,500	25,069	22,410	26,717	18,865	24,047	22,117
MRF	40.01	38.74	37.68	37.37	31.32	40.79	38.43
(N)	(59)	(247)	(267)	(84)	(121)	(39)	(37)
Bonneville Reservoir							
Mean fecundity	31,225	33,640	30,444	29,313	18,550	26,413	20,768
MRF	45.17	35.96	32.15	32.43	22.27	33.90	24.13
(N)	(37)	(105)	(101)	(100)	(6)	(47)	(33)

If exploitation rates remain similar to mean 1994-99 levels, it is likely that no further reductions in potential predation will be realized. Predation will remain at approximately 75% of pre-program levels. Exploitation rates lower than mean 1994-99 levels will result in increases in potential predation.

Reducing the number of large northern pikeminnow may improve salmonid survival if remaining northern pikeminnow do not consume salmonids at a higher rate (Beamesderfer et al. 1996). Predation indices of northern pikeminnow in 1999 exceeded values from 1996 at many locations, but were generally similar or less than mean values from 1994-1996. Higher consumption indices for northern pikeminnow in 1999 relative to 1996 may be partially attributed to our sample timing which coincided particularly well with juvenile salmonid passage at most locations.

Consumption indices for smallmouth bass were low in 1999, and comparable to previous years. We speculated that previous indices of smallmouth bass consumption were biased low because we only sampled stomach contents of fish ≥200 mm fork length. This year we sampled smallmouth bass ≥150 mm and found that consumption indices were not significantly different between the two minimum length criteria. The incidence of juvenile salmonid predation by walleyes was greater in 1999 than previous years (Zimmerman 1999), perhaps reflecting increased abundance of juvenile salmonids when sampling was conducted. All indices for northern pikeminnow and smallmouth bass in the tailrace areas at most dams were biased low because river conditions and spill levels during 1999 prevented sampling effort in most of the boat-restricted zones.

Estimates of PSD were generally within the range from 1990-1996. Much of the variation in PSD undoubtedly resulted from fluctuating year-class strengths that influenced the number of stock-size fish (Mesa et al. 1990).

If northern pikeminnow compensate for sustained exploitation with increased growth or fecundity rates, relative benefits of the NPMP will be diminished (Beamesderfer et al. 1996). Our estimates of fecundity and relative weight of northern pikeminnow have not shown any increasing trends since 1990, and 1999 estimates were well within the ranges noted in previous years.

REFERENCES

Anderson, R. O. 1980. Proportional stock density (PSD) and relative weight (Wr): interpretive indices for fish populations and communities. Pages 27-33 *in* S. Gloss and B. Shupp, editors. Practical fisheries management: more with less in the 1980s. New York Chapter American Fisheries Society, Bethesda, MD.

Anderson, R. O., and S. J. Gutreuter. 1983. Length, weight, and associated structural indices. Pages 280-300 *in* L.A. Niesen and D.L. Johnson, editors. Fisheries Techniques. American Fisheries Society, Bethesda, Maryland.

Beamesderfer, R. C., B. E. Rieman, J.C. Elliott, A.A. Nigro, and D.L. Ward. 1987. Distribution, abundance, and population dynamics of northern squawfish, walleye, smallmouth bass, and channel catfish in John Day Reservoir, 1986. Oregon Department of Fish and Wildlife, Contract number DE-AI79-82BP35097. 1986 Annual Report to Bonneville Power Administration, Portland, Oregon.

Beamesderfer, R. C., and B. E. Rieman. 1988. Size selectivity and bias in estimates of population statistics of smallmouth bass, walleye, and northern squawfish in a Columbia River reservoir. North American Journal of Fisheries Management 8:505-510.

Beamesderfer, R. C. P., D. L. Ward, and A. A. Nigro. 1996. Evaluation of the biological basis for a predator control program on northern squawfish (Ptychocheilus oregonensis) in the Columbia and Snake rivers. Canadian Journal of Fisheries and Aquatic Sciences 53:2898-2908.

Collis, K., R. E. Beaty, and B. R. Crain. 1995. Changes in catch rate and diet of northern squawfish associated with release of hatchery-reared juvenile salmonids in a Columbia River reservoir. North American Journal of Fisheries Management 15:346-357.

El-Zarka, S. E. 1959. Fluctuations in the population of yellow perch, *Perca flavescens* (Mitchill) in Saginaw Bay Lake Huron. U.S. Fish and Wildlife Service Fishery Bulletin 151:365-415.

Elliott, J. M. 1977. Some methods for the statistical analysis of samples of benthic invertebrates, 2nd edition. Freshwater Biological Association Scientific Publication 25.

Fox, L. G. and five coauthors. 2000. Implementation of the northern pikeminnow sport-reward fishery in the Columbia and Snake rivers. Washington Department of Fish and Wildlife. Contract number DE-BI79-90BP07084. 1999 Annual Report to the Bonneville Power Administration, Portland, Oregon.

Knutsen C. J., and D. L. Ward. 1999. Biological characteristics of northern pikeminnow in the lower Columbia and Snake rivers before and after sustained exploitation. Transactions of the American Fisheries Society 128:1008-1019.

Mesa, M. G., S. D. Duke, and D. L. Ward. 1990. Spatial and temporal variation in proportional stock density and relative weight of smallmouth bass in a reservoir. Journal of Freshwater Ecology 5:323-339.

Nelson, J. S, and five coauthors. 1998. Recommended changes in common fish names: pikeminnow to replace squawfish. Fisheries 23(9):37.

Parker, R. M., M. P. Zimmerman, and D. L. Ward. 1994. Development of a system-wide predator control program: Indexing and fisheries evaluation. Oregon Department of Fish and Wildlife, Contract number DE-AI79-90BP07096. 1992 Annual Report to the Bonneville Power Administration, Portland, Oregon.

Parker, R. M., M. P. Zimmerman, and D. L. Ward. 1995. Variability in biological characteristics of northern squawfish in the lower Columbia and Snake rivers. Transactions of the American Fisheries Society 124:335-346.

Ricker, W. E. 1975. Computation and interpretation of biological statistics of fish populations. Fisheries Research Board of Canada Bulletin 191.

Rieman, B. E., and R. C. Beamesderfer. 1990. Dynamics of a northern squawfish population and the potential to reduce predation on juvenile salmonids in a Columbia River reservoir. North American Journal of Fisheries Management 10:228-241.

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. Oregon Department of Fish and Wildlife, contract number DE-BI79-90BP07084. 1990 Annual Report to the Bonneville Power Administration, Portland, Oregon.

Ward, D. L. 1997. Evaluation of the Northern Squawfish Management Program. Final Report of Research, 1990-96. Oregon Department of Fish and Wildlife, contract numbers DE-BI79-990BP07084 and 94BI24514. Final report of research, 1990-96 to the Bonneville Power Administration, Portland, Oregon.

Ward, D. L., and M. P. Zimmerman. 1999. Response of smallmouth bass to sustained removals of northern pikeminnow in the lower Columbia and Snake rivers. Transactions of the American Fisheries Society 128:1020-1035.

Ward, D. L., M. P. Zimmerman, R. M. Parker, and S. S. Smith. 1993. Development of a system-wide predator control program: Indexing, fisheries evaluation, and harvesting technology development. Oregon Department of Fish and Wildlife, Contract number DE-BI79-90BP07084. 1991 Annual Report to the Bonneville Power Administration, Portland, Oregon.

Ward, D. L., J. H. Petersen, and J. J. Loch. 1995. Index of predation on juvenile salmonids by northern squawfish in the lower and middle Columbia River and in the lower Snake River. Transactions of the American Fisheries Society 124:321-334.

Zimmerman, M. P. 1999. Food habits of smallmouth bass, walleyes, and northern pikeminnow in the lower Columbia River basin during outmigration of juvenile anadromous salmonids. Transactions of the American Fisheries Society 128:1036-1054.

Zimmerman, M. P, and D. L. Ward. 1999. Index of predation on juvenile salmonids by northern pikeminnow in the lower Columbia River basin, 1994-1996. Transactions of the American Fisheries Society 128:995-1007.

Zimmerman, M. P., C. Knutsen, D. L. Ward, and K. Anderson. 1995. Development of a system-wide predator control program: Indexing and fisheries evaluation. Oregon Department of Fish and Wildlife, Contract number DE-AI79-90BP07084. 1993 Annual Report to the Bonneville Power Administration, Portland, Oregon.

APPENDIX A
Exploitation of Northern Pikeminnow, 1992-1999

Appendix Table A-1. Total exploitation rates (%) of northern pikeminnow ≥250 mm fork length, 1992-1999.

Area or reservoir	1992	1993	1994	1995	1996	1997	1998	1999
Downstream from								
Bonneville Dam	11.7	6.0	13.8	16.5	12.7	8.0	8.4	9.6
Bonneville	6.8	4.3	11.2	9.4	9.1	9.7	9.2	14.5
The Dalles	7.2	7.0	10.7	16.0	15.5	5.8	12.8	16.1
John Day	14.2	10.5	5.8	0.0	7.0	0.0	0.0	3.7
McNary	5.6	16.0	14.0	22.4	18.2	16.5	13.6	15.9
Ice Harbor	--[a]	--[a]	--[a]	--[a]	--[a]	--[a]	--[a]	--[a]
Lower Monumental	7.7	3.1	0.8	4.5	0.0	0.0	0.0	0.0
Little Goose	17.9	6.6	9.2	5.7	8.9	0.0	0.0	0.0
Lower Granite	15.0	12.5	8.7	6.4	11.7	15.5	12.1	6.1
Systemwide	12.0	8.1	13.2	15.5	12.9	9.6	11.5	12.7

[a] No northern pikeminnow tagged.

Appendix Table A-2. Exploitation rates (%) of northern pikeminnow ≥250 mm fork length for the sport-reward fishery, 1992-1999.

Area or Reservoir	1992	1993	1994	1995	1996	1997	1998	1999
Downstream from								
Bonneville Dam	11.4	6.0	13.6	16.1	12.7	7.8	8.2	9.6
Bonneville	4.0	2.1	2.2	3.5	6.1	8.0	7.8	13.9
The Dalles	6.2	7.0	9.8	14.9	15.5	5.8	12.8	16.1
John Day	3.4	2.4	3.2	0.0[a]	0.0[a]	0.0[a]	0.0[a]	3.7
McNary	5.6	15.9	14.0	22.4	18.2	16.5	13.6	15.9
Ice Harbor	--[b]	--[b]	--[b]	--[b]	--[b]	--[b]	--[b]	--[b]
Lower Monumental	1.8	3.1	0.8	0.0[a]	0.0[a]	0.0[a]	0.0[a]	0.0[a]
Little Goose	11.9	3.3	6.1	2.9	8.9	0.0[a]	0.0[a]	0.0[a]
Lower Granite	15.0	12.5	8.7	6.4	11.7	15.5	12.1	6.1
Systemwide	9.3	6.8	10.9	13.4	12.1	8.9	11.1	12.5

[a] Northern pikeminnow harvested, but no tags recovered.
[b] No northern pikeminnow tagged.

Appendix Table A-3. Exploitation rates (%) of northern pikeminnow ≥250 mm fork length for the dam-angling fishery, 1992-1999.

Area or Reservoir	1992	1993	1994	1995	1996	1997	1998	1999
Downstream from Bonneville Dam	0.2	0.0[b]	0.1	0.2	0.0[b]	0.2	0.0	0.0[b]
Bonneville	2.8	2.2	3.7	0.0[b]	0.0[b]	0.0[b]	0.5	0.0[b]
The Dalles	1.0	0.0[b]	0.0[b]	0.0[b]	0.0[b]	0.0[b]	0.0[b]	0.0[b]
John Day	10.8	8.1	2.6	0.0[b]	7.0	0.0[b]	0.0[b]	0.0[b]
McNary	0.0[b]	0.1	0.0[b]	0.0[b]	0.0[b]	0.0[b]	0.0[b]	--[a]
Ice Harbor	--[c]	--[c]	--[c]	--[c]	--[c]	--[c]	--[c]	--[c]
Lower Monumental	5.9	0.0[b]	0.0[b]	4.5	0.0[b]	--[a]	--[a]	--[a]
Little Goose	6.0	3.3	3.1	2.8	0.0[b]	--[a]	--[a]	--[a]
Lower Granite	0.0[b]	0.0[b]	0.0[b]	0.0[b]	0.0[b]	--[a]	--[a]	--[a]
Systemwide	2.7	1.3	1.1	0.3	0.3	0.1	0.1	0.0

[a] No fishing effort.
[b] Northern pikeminnow harvested, but no tags recovered.
[c] No northern pikeminnow tagged.

Appendix Table A-4. Exploitation rates (%) of northern pikeminnow ≥250 mm fork length for the site-specific gill-net fishery, 1994-1999.

Area or Reservoir	1994	1995	1996	1997	1998	1999
Downstream from Bonneville Dam	--	0.2	0.0[b]	0.0[b]	0.3	--[b]
Bonneville	5.3	5.9	3.0	1.7	0.9	0.6
The Dalles	0.9	1.1	0.0[b]	--[b]	--[b]	--[b]
John Day	0.0[b]	0.0[b]	0.0[b]	--[b]	--[b]	--[a]
McNary	0.0[b]	0.0[b]	0.0[b]	--[a]	--[a]	--[a]
Ice Harbor	--[c]	--[c]	--[c]	--[c]	--[c]	--[c]
Lower Monumental	0.0[b]	0.0[b]	--[a]	--[b]	--[a]	--[a]
Little Goose	--[a]	0.0[b]	--[a]	--[a]	--[a]	--[a]
Lower Granite	0.0[b]	0.0[b]	--[a]	--[a]	--[a]	--[a]
Systemwide	1.2	1.9	0.5	0.6	0.3	0.2

[a] No fishing effort.
[b] Northern pikeminnow harvested, but no tags recovered.
[c] No northern pikeminnow tagged.

Appendix Table A-5. Dates for each sampling period in 1999.

Period	Dates	Period	Dates
1	April 5 - April 11	16	July 19 - July 25
2	April 12 - April 18	17	July 26 - August 1
3	April 19 - April 25	18	August 2 - August 8
4	April 26 - May 2	19	August 9 - August 15
5	May 3 - May 9	20	August 16 - August 22
6	May 10 - May 16	21	August 23 - August 29
7	May 17 - May 23	22	August 30 - September 5
8	May 24 - May 30	23	September 6 - September 12
9	May 31 – June 6	24	September 13 - September 19
10	June 7- June 13	25	September 20 - September 26
11	June 14 - June 20	26	September 27 - October 3
12	June 21 - June 27	27	October 4 - October 10
13	June 28 - July 4	28	October 11 - October 17
14	July 5 - July 11	29	October 18 - October 24
15	July 12 - July 18		

Appendix Table A-6. Exploitation of northern pikeminnow downstream from Bonneville Dam in 1999.

Time period	Tagged	Recaptures			At Large	Exploitation		
		Sport	Dam	Net		Sport	Dam	Net
1	191	--	--	--	--	--	--	--
2	33	--	--	--	191	--	--	--
3	--	--	--	--	224	--	--	--
4	--	--	--	--	224	--	--	--
5	--	--	--	--	224	--	--	--
6	3	--	--	--	224	--	--	--
7	--	1	--	--	227	0.0044	--	--
8	--	--	--	--	226	--	--	--
9	--	--	--	--	226	--	--	--
10	--	2	--	--	226	0.0088	--	--
11	--	--	--	--	224	--	--	--
12	--	1	--	--	224	0.0045	--	--
13	--	2	--	--	223	0.0090	--	--
14	--	3	--	--	221	0.0136	--	--
15	--	5	--	--	218	0.0229	--	--
16	--	1	--	--	213	0.0047	--	--
17	--	--	--	--	212	--	--	--
18	--	--	--	--	211[a]	--	--	--
19	--	1	--	--	211	0.0047	--	--
20	--	2	--	--	210	0.0095	--	--
21	--	1	--	--	208	0.0048	--	--
22	--	--	--	--	207	--	--	--
23	--	--	--	--	207	--	--	--
24	--	--	--	--	207	--	--	--
25	--	1	--	--	207	0.0048	--	--
26	--	--	--	--	206	--	--	--
27	--	--	--	--	206	--	--	--
28	--	--	--	--	206	--	--	--
29	--	--	--	--	206	--	--	--
Total	227	20	0	0	--	0.0918	0.0000	0.0000
Adjusted for tag loss						0.0957	0.0000	0.0000

[a] A fish tagged downstream from Bonneville Reservoir was recaptured above Bonneville Dam.

Appendix Table A-7. Exploitation of northern pikeminnow in Bonneville Reservoir in 1999

Time period	Tagged	Recaptures			At Large	Exploitation		
		Sport	Dam	Net		Sport	Dam	Net
1	--	--	--	--	--	--	--	--
2	--	--	--	--	--	--	--	--
3	180	--	--	--	--	--	--	--
4	--	--	--	--	180	--	--	--
5	--	1	--	0	180	0.0056	--	--
6	--	1	--	0	178[a]	0.0056	--	--
7	--	1	--	0	177	0.0056	--	--
8	--	2	--	1	176	0.0114	--	0.0057
9	--	0	--	0	172[b]	--	--	--
10	--	1	0	0	172	0.0058	--	--
11	--	0	0	0	171	--	--	--
12	--	5	0	0	170[b]	0.0294	--	--
13	--	1	0	--	164[b]	0.0061	--	--
14	--	2	0	--	163	0.0123	--	--
15	--	3	0	--	160[b]	0.0188	--	--
16	--	4	0	--	155[b]	0.0258	--	--
17	--	0	0	--	150[a]	--	--	--
18	--	1	0	--	150[b]	0.0067	--	--
19	--	0	0	--	149	--	--	--
20	--	0	0	--	148	--	--	--
21	--	0	0	--	148	--	--	--
22	--	0	0	--	148	--	--	--
23	--	0	0	--	148	--	--	--
24	--	0	0	--	148	--	--	--
25	--	0	0	--	148	--	--	--
26	--	0	0	--	148	--	--	--
27	--	0	0	--	148	--	--	--
28	--	--	0	--	148	--	--	--
29	--	--	0	--	148	--	--	--
Total	180	22	0	1	--	0.1330	0.0000	0.0057
Adjusted for tag loss						0.1386	0.0000	0.0059

[a] A fish tagged in Bonneville Reservoir was removed by ODFW electrofishing crews.
[b] A fish tagged in Bonneville Reservoir was recaptured outside the reservoir.

Appendix Table A-8. Exploitation of northern pikeminnow in The Dalles Reservoir in 1999.

Time period	Tagged	Recaptures			At Large	Exploitation		
		Sport	Dam	Net[a]		Sport	Dam	Net[a]
1	--	--	--	--	--	--	--	--
2	--	--	--	--	--	--	--	--
3	--	--	--	--	--	--	--	--
4	--	--	--	--	--	--	--	--
5	41	--	--	--	41	--	--	--
6	--	--	--	--	41	--	--	--
7	--	--	--	--	41	--	--	--
8	--	--	--	--	41	--	--	--
9	--	--	--	--	41	--	--	--
10	--	--	--	--	41	--	--	--
11	--	2	--	--	41	0.0488	--	--
12	--	--	--	--	39	--	--	--
13	--	--	--	--	39	--	--	--
14	--	2	--	--	39	0.0513	--	--
15	--	1	--	--	37	0.0270	--	--
16	--	--	--	--	36	--	--	--
17	--	1	--	--	36	0.0278	--	--
18	--	--	--	--	35	--	--	--
19	--	--	--	--	35	--	--	--
20	--	--	--	--	35	--	--	--
21	--	--	--	--	35	--	--	--
22	--	--	--	--	35	--	--	--
23	--	--	--	--	35	--	--	--
24	--	--	--	--	35	--	--	--
25	--	--	--	--	35	--	--	--
26	--	--	--	--	35	--	--	--
27	--	--	--	--	35	--	--	--
28	--	--	--	--	35	--	--	--
29	--	--	--	--	35	--	--	--
Total	41	6	0	--	--	0.1549	0.0000	--
Adjusted for tag loss						0.1614	0.0000	--

[a] No fishing effort.

Appendix Table A-9. Exploitation of northern pikeminnow in John Day Reservoir in 1999.

Time period	Tagged	Recaptures			At Large	Exploitation		
		Sport	Dam	Net[a]		Sport	Dam	Net[a]
1	--	--	--	--	--	--	--	--
2	--	--	--	--	--	--	--	--
3	--	--	--	--	--	--	--	--
4	--	--	--	--	--	--	--	--
5	--	--	--	--	--	--	--	--
6	--	--	--	--	--	--	--	--
7	22	--	--	--	--	--	--	--
8	--	--	--	--	22	--	--	--
9	--	--	--	--	22	--	--	--
10	--	--	--	--	22	--	--	--
11	6	--	--	--	22	--	--	--
12	1	1	--	--	28	0.0357	--	--
13	--	--	--	--	28	--	--	--
14	--	--	--	--	28	--	--	--
15	--	--	--	--	28	--	--	--
16	--	--	--	--	28	--	--	--
17	--	--	--	--	28	--	--	--
18	--	--	--	--	27[b]	--	--	--
19	--	--	--	--	27	--	--	--
20	--	--	--	--	27	--	--	--
21	--	--	--	--	27	--	--	--
22	--	--	--	--	27	--	--	--
23	--	--	--	--	27	--	--	--
24	--	--	--	--	27	--	--	--
25	--	--	--	--	27	--	--	--
26	--	--	--	--	27	--	--	--
27	--	--	--	--	27	--	--	--
28	--	--	--	--	27	--	--	--
29	--	--	--	--	27	--	--	--
Total	29	1	0	--	--	0.0357	0.0000	--
Adjusted for tag loss						0.0372	0.0000	--

[a] No fishing effort.
[b] A fish tagged in John Day Reservoir was recaptured outside the reservoir.

Appendix Table A-10. Exploitation of northern pikeminnow in McNary Reservoir in 1999.

Time period	Tagged	Recaptures			At Large	Exploitation		
		Sport	Dam[a]	Net[a]		Sport	Dam[a]	Net[a]
1	--	--	--	--	--	--	--	--
2	--	--	--	--	--	--	--	--
3	--	--	--	--	--	--	--	--
4	--	--	--	--	--	--	--	--
5	--	--	--	--	--	--	--	--
6	96	--	--	--	--	--	--	--
7	--	2	--	--	96	0.0208	--	--
8	39	--	--	--	94	--	--	--
9	12	1	--	--	133	0.0075	--	--
10	--	1	--	--	144	0.0069	--	--
11	--	--	--	--	143	--	--	--
12	--	4	--	--	143	0.0280	--	--
13	--	1	--	--	139	0.0072	--	--
14	--	1	--	--	138	0.0072	--	--
15	--	5	--	--	137	0.0365	--	--
16	--	2	--	--	132	0.0152	--	--
17	--	1	--	--	130	0.0077	--	--
18	--	1	--	--	129	0.0078	--	--
19	--	--	--	--	128	--	--	--
20	--	--	--	--	128	--	--	--
21	--	--	--	--	128	--	--	--
22	--	--	--	--	128	--	--	--
23	--	--	--	--	128	--	--	--
24	--	1	--	--	128	0.0078	--	--
25	--	--	--	--	127	--	--	--
26	--	--	--	--	127	--	--	--
27	--	--	--	--	127	--	--	--
28	--	--	--	--	127	--	--	--
29	--	--	--	--	127	--	--	--
Total	147	20	--	--	--	0.1526	--	--
Adjusted for tag loss						0.1590	--	--

[a] No fishing effort.

Appendix Table A-11. Exploitation of northern pikeminnow in Lower Monumental Reservoir in 1999.

Time period	Tagged	Recaptures			At Large	Exploitation		
		Sport	Dam[a]	Net[a]		Sport	Dam[a]	Net[a]
1	--	--	--	--	--	--	--	--
2	--	--	--	--	--	--	--	--
3	--	--	--	--	--	--	--	--
4	--	--	--	--	--	--	--	--
5	--	--	--	--	--	--	--	--
6	--	--	--	--	--	--	--	--
7	--	--	--	--	--	--	--	--
8	--	--	--	--	--	--	--	--
9	--	--	--	--	--	--	--	--
10	11	--	--	--	--	--	--	--
11	--	--	--	--	11	--	--	--
12	--	--	--	--	11	--	--	--
13	--	--	--	--	11	--	--	--
14	--	--	--	--	11	--	--	--
15	--	--	--	--	11	--	--	--
16	--	--	--	--	11	--	--	--
17	--	--	--	--	11	--	--	--
18	--	--	--	--	11	--	--	--
19	--	--	--	--	11	--	--	--
20	--	--	--	--	11	--	--	--
21	--	--	--	--	11	--	--	--
22	--	--	--	--	11	--	--	--
23	--	--	--	--	11	--	--	--
24	--	--	--	--	11	--	--	--
25	--	--	--	--	11	--	--	--
26	--	--	--	--	11	--	--	--
27	--	--	--	--	11	--	--	--
28	--	--	--	--	11	--	--	--
29	--	--	--	--	11	--	--	--
Total	20	0	--	--	--	0.0000	--	--
Adjusted for tag loss						0.0000	--	--

[a] No fishing effort.

Appendix Table A-12. Exploitation of northern pikeminnow in Little Goose Reservoir in 1999.

Time period	Tagged	Recaptures			At Large	Exploitation		
		Sport	Dam	Net		Sport	Dam[a]	Net[a]
1	--	--	--	--	--	--	--	--
2	--	--	--	--	--	--	--	--
3	--	--	--	--	--	--	--	--
4	--	--	--	--	--	--	--	--
5	--	--	--	--	--	--	--	--
6	--	--	--	--	--	--	--	--
7	--	--	--	--	--	--	--	--
8	--	--	--	--	--	--	--	--
9	--	--	--	--	--	--	--	--
10	27	--	--	--	27	--	--	--
11	--	--	--	--	27	--	--	--
12	--	--	--	--	27	--	--	--
13	--	--	--	--	27	--	--	--
14	--	--	--	--	27	--	--	--
15	--	--	--	--	27	--	--	--
16	--	--	--	--	27	--	--	--
17	--	--	--	--	27	--	--	--
18	--	--	--	--	27	--	--	--
19	--	--	--	--	27	--	--	--
20	--	--	--	--	27	--	--	--
21	--	--	--	--	27	--	--	--
22	--	--	--	--	27	--	--	--
23	--	--	--	--	27	--	--	--
24	--	--	--	--	27	--	--	--
25	--	--	--	--	27	--	--	--
26	--	--	--	--	27	--	--	--
27	--	--	--	--	27	--	--	--
28	--	--	--	--	27	--	--	--
29	--	--	--	--	27	--	--	--
Total	27	0	--	--	--	0.0000	--	--
Adjusted for tag loss						0.0000	--	--

[a] No fishing effort.

Appendix Table A-13. Exploitation of northern pikeminnow in Lower Granite Reservoir in 1999.

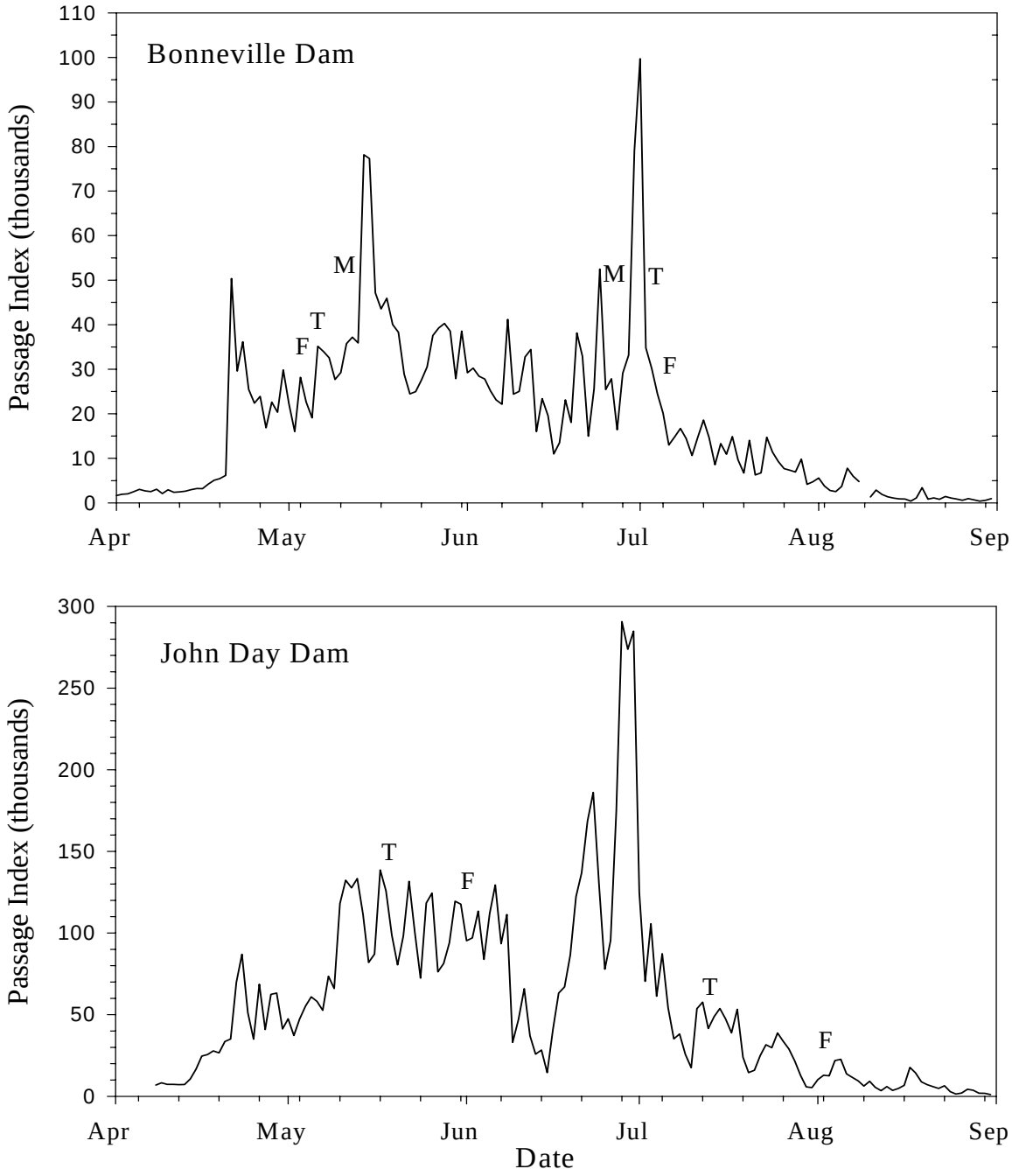
Time period	Tagged	Recaptures			At Large	Exploitation		
		Sport	Dam[a]	Net[a]		Sport	Dam[a]	Net[a]
1	--	--	--	--	--	--	--	--
2	--	--	--	--	--	--	--	--
3	--	--	--	--	--	--	--	--
4	88	--	--	--	--	--	--	--
5	--	--	--	--	88	--	--	--
6	--	--	--	--	88	--	--	--
7	--	--	--	--	88	--	--	--
8	--	--	--	--	88	--	--	--
9	--	--	--	--	88	--	--	--
10	--	--	--	--	88	--	--	--
11	--	--	--	--	88	--	--	--
12	--	1	--	--	88	0.0114	--	--
13	--	--	--	--	87	--	--	--
14	--	--	--	--	87	--	--	--
15	--	--	--	--	87	--	--	--
16	--	1	--	--	87	0.0115	--	--
17	--	1	--	--	86	0.0116	--	--
18	--	--	--	--	85	--	--	--
19	--	--	--	--	85	--	--	--
20	--	--	--	--	85	--	--	--
21	--	--	--	--	85	--	--	--
22	--	1	--	--	85	0.0118	--	--
23	--	--	--	--	84	--	--	--
24	--	--	--	--	84	--	--	--
25	--	--	--	--	84	--	--	--
26	--	1	--	--	84	0.0119	--	--
27	--	--	--	--	83	--	--	--
28	--	--	--	--	83	--	--	--
29	--	--	--	--	83	--	--	--
Total	88	5	--	--	--	0.0582	--	--
Adjusted for tag loss						0.0606	--	--

[a] No fishing effort.

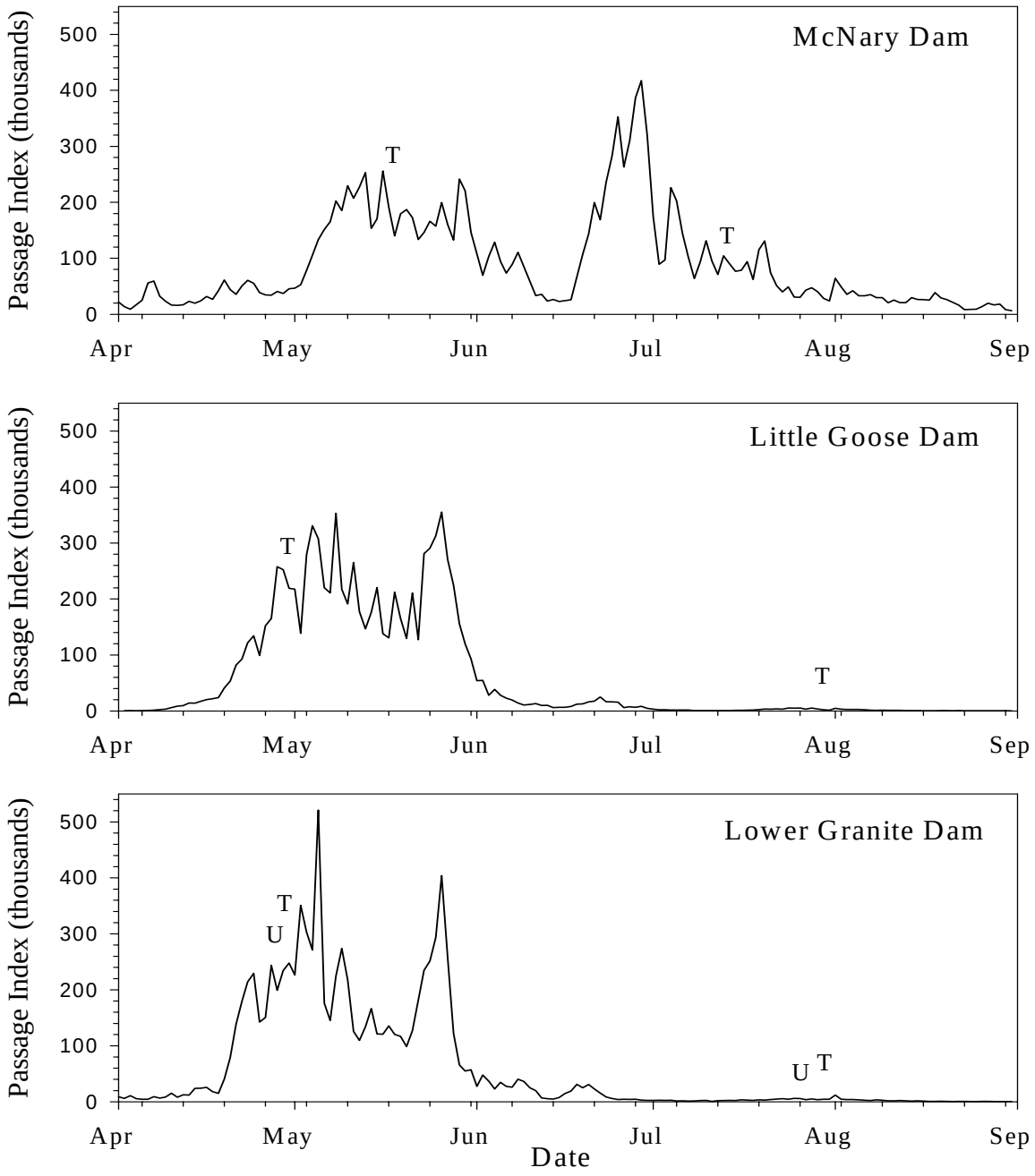
Appendix Table A-14. Exploitation of northern pikeminnow systemwide in 1999.

Time period	Tagged	Recaptures			At Large	Exploitation		
		Sport	Dam	Net		Sport	Dam	Net
1	191	--	--	--	--	--	--	--
2	33	--	--	--	191	--	--	--
3	180	--	--	--	224	--	--	--
4	88	--	--	--	404	--	--	--
5	41	1	--	--	492	0.0020	--	--
6	99	1	--	--	531	0.0019	--	--
7	22	4	--	--	629	0.0064	--	--
8	39	3	--	1	647	0.0046	--	0.0015
9	12	1	--	--	682	0.0015	--	--
10	38	4	--	--	693	0.0058	--	--
11	6	3	--	--	727	0.0041	--	--
12	1	13	--	--	730	0.0178	--	--
13	--	4	--	--	718	0.0056	--	--
14	--	9	--	--	714	0.0126	--	--
15	--	16	--	--	705	0.0227	--	--
16	--	8	--	--	689	0.0116	--	--
17	--	6	--	--	680	0.0088	--	--
18	--	2	--	--	674	0.0030	--	--
19	--	1	--	--	672	0.0015	--	--
20	--	2	--	--	671	0.0030	--	--
21	--	1	--	--	669	0.0015	--	--
22	--	1	--	--	668	0.0015	--	--
23	--	--	--	--	667	--	--	--
24	--	1	--	--	667	0.0015	--	--
25	--	1	--	--	666	0.0015	--	--
26	--	1	--	--	665	0.0015	--	--
27	--	--	--	--	664	--	--	--
28	--	--	--	--	664	--	--	--
29	--	--	--	--	664	--	--	--
Total	750	83	0	1	--	0.1203	--	0.0015
Adjusted for tag loss						0.1254	--	0.0016

APPENDIX B
Timing of 1999 Consumption Index Sampling in Relation to Juvenile Salmonid Passage Indices at Lower Columbia and Snake River Dams



Appendix Figure B-1. Timing of consumption index sampling with respect to juvenile salmonid passage indices at Bonneville and John Day dams in 1999. Sample times for forebay (F), tailrace (T), and areas downstream from Bonneville Dam tailrace (M) are shown.



Appendix Figure B-2. Timing of consumption index sampling with respect to juvenile salmonid passage indices at McNary, Little Goose, and Lower Granite dams in 1999. Sample times for tailraces (T) and upper Lower Granite Reservoir (U) are shown.

APPENDIX C
Electrofishing Effort, Density, Abundance, Consumption, and Predation Indices for Northern Pikeminnow in the Lower Columbia and Snake Rivers in 1990-1996 and 1999

Appendix Table C-1. Sampling effort (number of 15-minute electrofishing runs) in 1990-1996 and 1999 in the lower Columbia and Snake rivers. RKm = river kilometer, BRZ = boat restricted zone. Areas marked "ns" were not scheduled for sampling.

Location, area	Effort (number of electrofishing runs)							
	1990	1991	1992	1993	1994	1995	1996	1999
Below Bonneville Dam								
RKm 114-121	ns	ns	68	ns	36	45	43	44
RKm 172-178	ns	ns	65	ns	33	36	35	47
RKm 190-197	ns	ns	64	ns	43	40	40	40
Tailrace	26	ns	37	16	27	16	24	29
Tailrace BRZ	13	ns	23	9	8	8	7	0
Bonneville Reservoir								
Forebay	47	ns	ns	35	97	79	80	62
Mid-reservoir	52	ns	ns	28	84	45	57	57
Tailrace	37	ns	ns	25	60	80	69	71
Tailrace BRZ	15	ns	ns	6	8	0	0	0
The Dalles Reservoir								
Forebay	62	ns	ns	31	92	62	59	ns
Tailrace	45	ns	ns	21	40	27	28	71
Tailrace BRZ	11	ns	ns	5	8	8	3	0
John Day Reservoir								
Forebay	56	61	68	44	91	75	75	52
Mid-reservoir	61	58	62	43	43	94	94	0
Tailrace	39	44	47	37	60	80	80	62
Tailrace BRZ	16	15	17	9	14	0	0	0
Lower Monumental Res.								
Tailrace	ns	40	ns	ns	39	38	24	11
Tailrace BRZ	ns	16	ns	ns	5	8	8	3
Little Goose Reservoir								
Tailrace	ns	40	ns	ns	31	32	33	28
Tailrace BRZ	ns	17	ns	ns	8	8	4	1
Lower Granite Reservoir								
Upper reservoir	ns	55	ns	ns	85	89	89	75

Appendix Table C-2. Relative density (CPUE) of northern pikeminnow ≥250 mm fork length in the lower Columbia and Snake rivers in 1990-1996 and 1999. RKm = river kilometer, BRZ = boat restricted zone. Areas marked "ns" were not scheduled for sampling.

Location, area	Density index (CPUE)							
	1990	1991	1992	1993	1994	1995	1996	1999
Below Bonneville Dam								
RKm 114-121	ns	ns	1.3	ns	1.0	0.9	0.8	0.6
RKm 172-178	ns	ns	1.6	ns	2.1	1.4	1.5	0.9
RKm 190-197	ns	ns	2.4	ns	1.7	1.1	1.3	1.4
Tailrace	5.8	ns	3.4	9.6	2.9	2.2	2.8	3.5
Tailrace BRZ	13.7	ns	12.9	14.5	18.9	4.6	5.8	--
Bonneville Reservoir								
Forebay	5.7	ns	ns	2.2	2.4	2.4	1.3	1.0
Mid-reservoir	2.1	ns	ns	1.2	0.7	1.0	0.7	0.3
Tailrace	0.5	ns	ns	1.1	0.6	1.1	0.8	0.8
Tailrace BRZ	5.5	ns	ns	1.5	6.8	--	--	--
The Dalles Reservoir								
Forebay	1.1	ns	ns	1.2	0.6	0.6	0.4	ns
Tailrace	2.8	ns	ns	0.7	0.7	1.6	3.7	0.8
Tailrace BRZ	21.5	ns	ns	10.8	5.8	3.5	1.0	--
John Day Reservoir								
Forebay	0.7	0.7	1.3	0.6	0.7	0.3	0.3	0.2
Mid-reservoir	0.3	0.2	0.3	0.2	0.1	0.1	0.1	--
Tailrace	0.8	0.8	0.1	0.5	0.3	0.3	0.5	0.2
Tailrace BRZ	14.7	17.9	9.2	13.3	2.4	--	--	--
Lower Monumental Res.								
Tailrace	ns	1.5	ns	ns	0.3	0.1	0.2	0
Tailrace BRZ	ns	16.3	ns	ns	1.2	3.9	1.0	0
Little Goose Reservoir								
Tailrace	ns	1.6	ns	ns	0.4	0.1	0.3	0.3
Tailrace BRZ	ns	28.3	ns	ns	6.4	10.3	1.0	0
Lower Granite Reservoir								
Upper reservoir	ns	1.9	ns	ns	0.5	0.2	0.3	0.2

Appendix Table C-3. Abundance index values for northern pikeminnow ≥250 mm fork length in the lower Columbia and Snake rivers in 1990-1996 and 1999. RKm = river kilometer, BRZ = boat restricted zone. Areas marked "ns" were not scheduled for sampling.

Location, area	Abundance Index							
	1990	1991	1992	1993	1994	1995	1996	1999
Below Bonneville Dam								
RKm 71-121	ns	ns	26.8	ns	15.4	14.5	12.2	9.8
RKm 122-177	ns	ns	19.7	ns	26.2	17.4	18.7	11.8
RKm 178-224	ns	ns	17.9	ns	22.1	14.2	16.4	17.4
Tailrace	4.5	ns	2.7	7.6	2.3	1.8	2.2	2.7
Tailrace BRZ	3.0	ns	2.8	3.1	4.1	1.0	1.3	--
Bonneville Reservoir								
Forebay	5.5	ns	ns	2.1	2.3	2.3	1.3	1.0
Mid-reservoir	15.2	ns	ns	8.5	5.0	7.4	4.9	2.2
Tailrace	0.4	ns	ns	0.8	0.5	0.8	0.7	1.1
Tailrace BRZ	0.9	ns	ns	0.2	1.1	--	--	--
The Dalles Reservoir								
Forebay	1.4	ns	ns	1.6	0.7	0.5	0.6	ns
Tailrace	2.7	ns	ns	0.7	0.6	1.5	3.6	0.8
Tailrace BRZ	4.4	ns	ns	2.2	1.1	0.7	0.7	--
John Day Reservoir								
Forebay	1.4	1.3	2.5	1.2	1.4	0.5	0.6	0.3
Mid-reservoir	5.2	4.7	6.6	3.2	2.3	1.0	1.1	--
Tailrace	1.4	1.4	0.2	0.9	0.5	0.6	1.0	0.4
Tailrace BRZ	1.6	1.9	1.0	1.4	0.3	--	--	--
Lower Monumental Res.								
Tailrace	ns	1.3	ns	ns	0.3	0.1	0.1	0
Tailrace BRZ	ns	0.8	ns	ns	0.1	0.2	0.1	0
Little Goose Reservoir								
Tailrace	ns	0.7	ns	ns	0.2	<0.1	0.1	0.1
Tailrace BRZ	ns	1.7	ns	ns	0.4	0.6	0.1	0
Lower Granite Reservoir								
Upper reservoir	ns	1.6	ns	ns	0.5	0.2	0.2	0.2

Appendix Table C-4. Indices of northern pikeminnow consumption of juvenile salmonids from 1990-1996 and 1999 during spring. RKm = river kilometer, BRZ = boat-restricted zone. Parentheses indicate number of digestive tracts examined.

Reservoir or reach, area	Consumption index							
	1990	1991	1992	1993	1994	1995	1996	1999
Below Bonneville Dam								
RKm 114-121	--	--	0.5(102)	--	0.5(14)	0.5(25)	0.4(23)	0.8(21)
RKm 172-178	--	--	1.0(189)	--	1.1(34)	0.2(28)	0.1(43)	0.4(23)
RKm 190-197	--	--	1.1(126)	--	1.5(42)	0.7(25)	0.4(33)	0.4(22)
Tailrace	1.2(61)	--	0.5(22)	0.8(75)	3.2(57)	0.8(25)	0.4(29)	0.1(24)
Tailrace BRZ	2.7(86)	--	1.0(77)	1.1(63)	0.6(95)	1.7(17)	0.6(8)	--
Bonneville								
Forebay	0.6(153)	--	--	0.7(20)	0.2(116)	0.3(88)	0.0(59)	0.0(17)
Mid-reservoir	0.0(39)	--	--	0.0(14)	0.2(34)	0.0(26)	0.1(17)	0.6(9)
Tailrace	0.3(7)	--	--	0.0(18)	0.0(19)	0.2(22)	0.0(35)	0.2(43)
Tailrace BRZ	2.3(41)	--	--	--	--	--	--	--
The Dalles								
Forebay	0.8(38)	--	--	0.1(19)	0.1(22)	0.0(22)	0.0(15)	--
Tailrace	0.7(27)	--	--	0.0(8)	--	--	--	0.5(6)
Tailrace BRZ	0.9(50)	--	--	0.0(1)	--	--	--	--
John Day								
Forebay	1.5(38)	1.9(23)	1.9(38)	1.5(11)	1.0(11)	1.7(7)	0.7(4)	1.2(7)
Mid-reservoir	0.0(6)	0.5(6)	0.0(8)	0.0(2)	0.0(3)	0.0(1)	0.0(3)	--
Tailrace	1.5(17)	0.9(23)	0.0(9)	2.0(24)	0.3(13)	0.8(13)	0.5(14)	1.7(8)
Tailrace BRZ	2.5(60)	1.5(55)	0.9(35)	--	0.7(8)	--	--	--
Lower Monumental								
Tailrace	--	0.6(58)	--	--	0.7(9)	0.0(2)	0.0(2)	--
Tailrace BRZ	--	0.7(127)	--	--	--	1.3(7)	0.0(1)	--
Little Goose								
Tailrace	--	0.7(68)	--	--	1.9(12)	1.4(2)	0.7(7)	0.9(4)
Tailrace BRZ	--	1.2(126)	--	--	1.5(25)	1.6(63)	--	--
Lower Granite								
Upper reservoir	--	0.3(127)	--	--	0.6(41)	1.2(16)	0.2(23)	1.9(16)

Appendix Table C-5. Indices of northern pikeminnow consumption of juvenile salmonids from 1990-1996 and 1999 during summer. RKm = river kilometer, BRZ = boat-restricted zone.

Reservoir or reach, area	Consumption index							
	1990	1991	1992	1993	1994	1995	1996	1999
Below Bonneville Dam								
RKm 114-121	--	--	0.3(117)	--	1.8(22)	1.5(14)	0.0(9)	1.0(6)
RKm 172-178	--	--	1.3(136)	--	1.5(32)	0.4(22)	0.0(9)	0.0(21)
RKm 190-197	--	--	1.9(59)	--	0.4(32)	1.2(20)	0.0(20)	0.5(33)
Tailrace	0.5(45)	--	2.1(43)	1.2(81)	0.4(24)	0.9(11)	0.6(38)	0.2(77)
Tailrace BRZ	5.5(109)	--	7.8(147)	1.0(131)	2.1(56)	1.3(16)	3.1(33)	--
Bonneville								
Forebay	1.8(139)	--	--	0.5(95)	0.3(111)	0.0(96)	0.3(44)	0.0(45)
Mid-reservoir	0.0(42)	--	--	0.0(31)	0.0(24)	0.0(19)	0.0(21)	0.0(7)
Tailrace	0.0(4)	--	--	0.0(14)	0.0(15)	0.8(67)	0.0(23)	0.3(45)
Tailrace BRZ	0.8(61)	--	--	1.0(23)	3.2(54)	--	--	--
The Dalles								
Forebay	1.0(61)	--	--	0.0(28)	0.0(27)	0.0(15)	0.0(8)	--
Tailrace	0.0(46)	--	--	0.0(9)	0.8(27)	0.0(41)	0.7(92)	0.0(39)
Tailrace BRZ	6.4(50)	--	--	0.5(117)	1.2(43)	2.2(28)	5.4(3)	--
John Day								
Forebay	2.4(16)	3.1(17)	0.7(27)	0.6(40)	1.2(57)	2.0(13)	0.4(13)	0.0(1)
Mid-reservoir	0.9(7)	0.0(3)	0.0(13)	0.6(10)	0.6(5)	0.0(4)	0.0(0)	--
Tailrace	2.6(25)	0.0(19)	0.0(1)	0.0(11)	0.0(4)	0.6(13)	0.3(19)	0.0(7)
Tailrace BRZ	11.7(50)	2.8(77)	4.6(67)	0.6(119)	1.9(31)	--	--	--

Appendix Table C-6. Indices of northern pikeminnow predation of juvenile salmonids from 1990-1996 and 1999 during spring. RKm = river kilometer, BRZ = boat-restricted zone.

Reservoir or reach, area	Predation index							
	1990	1991	1992	1993	1994	1995	1996	1999
Below Bonneville Dam								
RKm 71-121	--	--	10.1	--	8.0	7.3	4.9	7.5
RKm 122-177	--	--	20.5	--	25.5	3.5	1.9	5.0
RKm 178-224	--	--	33.4	--	33.2	9.9	6.6	7.1
Tailrace	5.5	--	1.4	6.1	7.4	1.4	0.9	0.4
Tailrace BRZ	8.0	--	2.8	3.5	2.5	1.7	0.8	--
Bonneville								
Forebay	3.3	--	--	1.5	0.3	0.7	0.0	0.0
Mid-reservoir	0.0	--	--	0.0	1.0	0.0	0.5	1.3
Tailrace	0.1	--	--	0.0	0.0	0.2	0.0	0.2
Tailrace BRZ	2.0	--	--	--	--	1.5	--	--
The Dalles								
Forebay	1.1	--	--	0.2	0.1	0.0	0.0	--
Tailrace	1.9	--	--	0.0	--	--	--	0.4
Tailrace BRZ	3.9	--	--	0.0	--	--	--	--
John Day								
Forebay	2.1	2.4	4.7	1.9	1.3	0.9	0.4	0.4
Mid-reservoir	0.0	2.4	0.0	0.0	0.0	0.0	0.0	--
Tailrace	1.9	1.3	1.9	1.7	0.2	0.5	0.3	0.7
Tailrace BRZ	3.9	2.9	0.9	--	0.2	--	--	--
Lower Monumental								
Tailrace	--	0.8	--	--	0.2	0.0	0.0	--
Tailrace BRZ	--	0.6	--	--	--	0.3	0.0	--
Little Goose								
Tailrace	--	0.5	--	--	0.4	<0.1	0.1	0.1
Tailrace BRZ	--	2.0	--	--	0.6	1.0	--	--
Lower Granite								
Upper reservoir	--	0.5	--	--	0.3	0.2	0.1	0.4

Appendix Table C-7. Indices of northern pikeminnow predation of juvenile salmonids from 1990-1996 and 1999 during summer. RKm = river kilometer, BRZ = boat-restricted zone.

Reservoir or reach, area	Predation index							
	1990	1991	1992	1993	1994	1995	1996	1999
Below Bonneville Dam								
RKm 71-121	--	--	6.0	--	27.3	14.5	0.0	9.4
RKm 122-177	--	--	26.6	--	34.8	7.0	0.0	0.0
RKm 178-224	--	--	37.8	--	9.5	17.0	0.0	9.5
Tailrace	2.3	--	5.7	9.1	1.0	1.6	1.3	0.6
Tailrace BRZ	16.4	--	21.8	3.2	1.3	1.2	4.0	--
Bonneville								
Forebay	9.9	--	--	1.1	0.6	0.0	0.4	0.0
Mid-reservoir	0.0	--	--	0.0	0.0	0.0	0.0	0.0
Tailrace	0.0	--	--	0.0	0.0	0.6	0.0	0.3
Tailrace BRZ	0.7	--	--	0.2	3.5	--	--	--
The Dalles								
Forebay	1.4	--	--	0.0	0.0	0.0	0.0	--
Tailrace	0.0	--	--	0.0	0.5	0.0	2.5	0.0
Tailrace BRZ	27.8	--	--	1.1	1.4	1.5	3.8	--
John Day								
Forebay	3.4	4.0	1.7	0.8	1.6	1.0	0.2	0.0
Mid-reservoir	4.7	--	0.0	2.0	1.4	0.0	0.0	--
Tailrace	3.8	--	0.0	0.0	0.0	0.4	0.2	0.0
Tailrace BRZ	18.6	5.4	4.6	0.9	0.5	--	--	--

APPENDIX D
Relative Density and Consumption Indices for Smallmouth Bass in the Lower Columbia and Snake Rivers in 1990-1996 and 1999

Appendix Table D-1. Relative density of smallmouth bass 200 mm fork length and larger in the lower Columbia and Snake rivers during spring, 1990-1996 and 1999. Relative density = mean transformed catch (log10(catch+1)) per 15-minute electrofishing run.

Reservoir or reach, area	Relative density							
	1990	1991	1992	1993	1994	1995	1996	1999
Below Bonneville Dam								
RKm 71-121	--	--	0.0	--	0.0	<0.1	0.0	0.0
RKm 122-177	--	--	0.2	--	0.2	0.5	0.3	0.1
RKm 178-224	--	--	0.1	--	0.1	0.4	0.1	<0.1
Tailrace	--	--	0.1	--	0.1	0.4	0.1	0.1
Bonneville								
Forebay	<0.1	<0.1	--	0.1	<0.1	0.1	0.1	0.1
Mid-reservoir	0.3	<0.1	--	0.1	0.3	0.3	0.2	0.1
Tailrace	0.3	0.3	--	0.7	0.5	0.4	0.6	0.4
John Day								
Forebay	0.5	0.3	0.4	--	0.3	0.4	0.3	0.1
Mid-reservoir	0.5	0.6	0.2	--	0.3	0.4	0.5	--
Tailrace	<0.1	0.1	0.2	--	0.1	0.1	<0.1	<0.1
Lower Granite								
Upper reservoir	0.6	--	--	--	0.6	0.3	0.4	0.3

Appendix Table D-2. Relative density of smallmouth bass 200 mm fork length and larger in the lower Columbia and Snake rivers during summer, 1990-1996 and 1999. Relative density = mean transformed catch (log10(catch+1)) per 15-minute electrofishing run.

Reservoir or reach, area	Relative density							
	1990	1991	1992	1993	1994	1995	1996	1999
Below Bonneville Dam								
RKm 71-121	--	--	<0.1	--	0.1	<0.1	<0.1	0.0
RKm 122-177	--	--	0.1	--	0.2	0.2	0.1	0.1
RKm 178-224	--	--	0.1	--	0.1	0.2	0.1	0.1
Tailrace	--	--	0.2	--	0.1	0.2	0.1	0.2
Bonneville								
Forebay	0.1	0.0	--	0.1	<0.1	0.1	<0.1	0.2
Mid-reservoir	0.1	0.1	--	0.2	0.2	0.1	0.1	0.1
Tailrace	0.2	0.4	--	0.4	0.4	0.5	0.2	0.4
John Day								
Forebay	0.4	0.3	0.3	0.4	0.5	0.4	0.3	0.4
Mid-reservoir	0.2	0.1	0.3	0.4	0.2	0.6	0.4	--
Tailrace	0.1	0.1	0.1	0.3	0.1	0.1	0.1	0.1
Lower Granite								
Upper reservoir	--	0.6	--	--	0.3	0.4	0.1	0.0

Appendix Table D-3. . Indices of smallmouth bass (≥200 mm fork length) consumption of juvenile salmonids from 1990-1996 and 1999 during spring. RKm = river kilometer, BRZ = boat-restricted zone. Parentheses indicate number of digestive tracts examined.

Reservoir or reach, area	Consumption index							
	1990	1991	1992	1993	1994	1995	1996	1999
Below Bonneville Dam								
RKm 114-121	--	--	0.0(1)	--	0.0(0)	0.0(2)	--	--
RKm 172-178	--	--	0.1(12)	--	0.0(23)	0.1(47)	0.0(27)	0.0(4)
RKm 190-197	--	--	0.0(0)	--	0.3(10)	0.0(33)	0.0(11)	0.0(1)
Tailrace	--	--	0.0(4)	--	0.0(7)	0.0(26)	0.0(6)	0.0(3)
Bonneville								
Forebay	0.0(0)	--	--	0.0(2)	0.0(5)	0.1(12)	0.0(11)	0.0(6)
Mid-reservoir	0.0(0)	--	--	0.0(1)	0.0(47)	0.1(30)	0.0(17)	0.0(4)
Tailrace	0.0(10)	--	--	0.0(21)	0.0(58)	0.0(99)	0.0(123)	<0.1(46)
John Day								
Forebay	0.1(6)	0.0(41)	0.1(39)	0.0(37)	0.1(75)	0.0(76)	0.0(23)	0.1(13)
Mid-reservoir	0.0(17)	0.0(33)	0.0(14)	0.0(27)	0.0(45)	0.0(127)	0.0(72)	--
Tailrace	0.0(0)	0.0(4)	0.0(1)	0.0(3)	0.0(27)	0.0(11)	0.0(6)	0.0(5)
Lower Granite								
Upper reservoir	--	0.1(57)	--	--	0.2(48)	0.1(94)	<0.1(83)	0.1(68)

Appendix Table D-4. Indices of smallmouth bass (≥200 mm fork length) consumption of juvenile salmonids from 1990-1996 and 1999 during summer. RKm = river kilometer, BRZ = boat-restricted zone.

Reservoir or reach, area	Consumption index							
	1990	1991	1992	1993	1994	1995	1996	1999
Below Bonneville Dam								
RKm 114-121	--	--	0.0(0)	--	0.0(6)	0.0(2)	0.0(1)	--
RKm 172-178	--	--	0.0(7)	--	0.2(22)	0.3(18)	0.0(5)	0.0(8)
RKm 190-197	--	--	0.4(13)	--	0.3(9)	0.8(17)	0.0(7)	0.0(11)
Tailrace	--	--	0.0(2)	--	0.0(14)	0.0(8)	0.0(5)	0.0(13)
Bonneville								
Forebay	0.0(0)	--	--	0.0(2)	0.4(8)	0.0(13)	0.0(8)	0.2(28)
Mid-reservoir	0.0(3)	--	--	0.0(14)	0.0(32)	0.0(9)	0.0(13)	0.0(17)
Tailrace	0.0(3)	--	--	0.0(36)	0.1(77)	0.1(97)	0.0(25)	0.0(89)
John Day								
Forebay	0.3(10)	0.5(43)	0.2(35)	0.7(55)	0.2(137)	0.3(92)	0.1(36)	0.2(50)
Mid-reservoir	0.3(13)	0.0(40)	0.0(4)	0.1(65)	0.0(35)	0.0(182)	0.0(67)	--
Tailrace	0.0(10)	0.1(13)	0.0(6)	0.0(23)	0.0(19)	0.0(22)	0.0(9)	0.0(9)

APPENDIX E
Digestive Tract Contents and Comparison of Fish Diets of Northern Pikeminnow, Smallmouth Bass, and Walleye in 1999

We examined digestive tract contents of 487 northern pikeminnow, 554 smallmouth bass, and 73 walleye captured during 1999 index sampling (**Appendix Table E-1**). The systemwide frequency of occurrence (%FO) of salmonids *Oncorhynchus* spp. in predator digestive tracts was 10.7% for northern pikeminnow, 2.9% for smallmouth bass, and 19.2% for walleye, representing increases of 3.8%, 1.1%, and 14.0%, respectively, from 1996 (Friesen et al. 1997). As in other years, salmonids appeared more frequently in predator digestive tracts during spring (Friesen et al. 1997; Zimmerman 1999). We observed the greatest seasonal difference in northern pikeminnow, where %FO of salmonids was 20.5% in spring and 3.8% in summer for all areas combined. Spatial differences were uncertain due to small sample sizes in some areas; however, %FO of salmonids was generally greatest for northern pikeminnow in the lower Snake River (42.3%, n = 26), for smallmouth bass in the lower Snake River (6.7%, n = 150), and for walleye in lower Columbia River impoundments (19.0%, n = 63).

The composition of prey fish families found in northern pikeminnow, smallmouth bass, and walleye digestive tracts during 1999 was similar to previous years (Zimmerman 1999). Salmonids constituted the majority of prey fish consumed by northern pikeminnow, whereas sculpins *Cottus* spp. were consumed most frequently by smallmouth bass (**Appendix Table E-2**). Walleye utilized other fish families, primarily cyprinids and catostomids, more frequently than northern pikeminnow or smallmouth bass. The proportion of identifiable fish as salmonids in predator digestive tracts was higher in 1999 than in 1996 for all areas and predator species. Total number of prey fish per predator (all areas combined) was 0.86 for walleye, 0.40 for smallmouth bass, and 0.33 for northern pikeminnow. Values for 1996 were 0.59, 0.23, and 0.18, respectively (Friesen et al 1997). Observed increases in %FO of salmonids, proportion of diet as salmonids, and number of prey per predator from 1996 to 1999 may be partially attributed to increased abundance of salmonids during sampling periods. Field sampling in 1999 coincided with peaks in juvenile salmonid passage at dams, particularly during spring (**Appendix B**).

Appendix Table E-1. Number of northern pikeminnow, smallmouth bass, and walleye digestive tracts examined (N) from the lower Columbia and Snake rivers in 1999 that contained food, fish, and juvenile salmonids (Sal).

Period:	Northern pikeminnow				Smallmouth bass				Walleye			
Reservoir or area	N	Food	Fish	Sal	N	Food	Fish	Sal	N	Food	Fish	Sal
Spring:												
Below Bonneville Dam tailrace	66	33	27	17	5	3	1	0	2	2	2	2
Bonneville Dam tailrace	24	10	8	2	3	3	2	0	2	2	2	0
Bonneville	69	27	8	3	56	48	18	1	2	1	1	0
The Dalles	6	4	4	2	31	23	4	0	20	17	10	4
John Day	15	6	6	6	18	14	4	0	19	13	12	3
Lower Mon.	0	--	--	--	40	36	18	1	1	1	1	0
Little Goose	4	1	1	1	30	23	15	1	0	--	--	--
Lower Granite	16	11	10	10	68	57	31	7	0	--	--	--
Total	200	92	64	41	251	207	93	10	46	36	28	9
Summer:												
Below Bonneville Dam tailrace	60	35	14	7	19	15	5	0	2	1	1	0
Bonneville Dam tailrace	77	29	12	2	13	11	10	0	3	2	2	0
Bonneville	97	37	5	2	134	109	31	1	4	2	1	0
The Dalles	39	4	1	0	66	52	15	0	10	8	8	2
John Day	8	3	1	0	59	49	25	4	8	7	7	3
Lower Mon.	0	--	--	--	0	--	--	--	0	--	--	--
Little Goose	5	4	0	0	0	--	--	--	0	--	--	--
Lower Granite	1	1	0	0	12	8	3	1	0	--	--	--
Total	287	113	33	11	303	244	89	6	27	20	19	5

Appendix Table E-2. Sample size and percentage of salmonids, cottids, and other fish families in northern pikeminnow, smallmouth bass, and walleye digestive tracts that contained identifiable fish in three reaches of the lower Columbia and Snake rivers, 1999. DBD = downstream from Bonneville Dam, COL = lower Columbia River reservoirs, and SNK = lower Snake River reservoirs.

Sample size, family	Northern pikeminnow			Smallmouth bass			Walleye		
	DBD	COL	SNK	DBD	COL	SNK	DBD	COL	SNK
Digestive tracts	227	234	26	40	364	150	9	63	1
Total fish	71	31	57	29	122	73	11	51	1
Identifiable fish	53	24	51	23	71	45	11	39	0
% Salmonidae	67.9	79.2	100.0	8.7	12.7	22.2	36.4	43.6	0.0
% Cottidae	24.5	16.7	0.0	91.3	63.4	48.9	36.4	15.4	0.0
% Other taxa	7.6	4.2	0.0	0.0	23.9	28.8	27.3	41.1	0.0
% Cyprinidae	5.7	4.2	0.0	0.0	2.8	2.2	27.3	15.4	0.0
% Catostomidae	0.0	0.0	0.0	0.0	14.1	2.2	0.0	20.5	0.0
% Ictaluridae	0.0	0.0	0.0	0.0	2.8	8.9	0.0	2.6	0.0
% Percopsidae	0.0	0.0	0.0	0.0	2.8	0.0	0.0	2.6	0.0
% Gasterosteidae	0.0	0.0	0.0	0.0	0.0	2.2	0.0	0.0	0.0
% Centrarchidae	1.9	0.0	0.0	0.0	1.4	13.3	0.0	0.0	0.0
% Percidae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

REFERENCES

Friesen, T.A., M.P. Zimmerman, and D.L. Ward. 1997. Development of a system-wide predator control program: indexing and fisheries evaluation. Oregon Department of Fish and Wildlife. 1996 Annual Report to Bonneville Power Administration, Portland, Oregon.

Zimmerman, M. P. 1999. Food habits of smallmouth bass, walleyes, and northern pikeminnow in the lower Columbia River basin during outmigration of juvenile anadromous salmonids. Transactions of the American Fisheries Society 128:1036-1054.