Bioenergetic models for walleye and smallmouth bass to determine the number of rainbow trout and kokanee salmon they consume in the Sanpoil River Arm of Lake Roosevelt

By:

Dana H.P. Stroud[1]

Gerald C. Claghorn[1]

Katie A. Wagner[1]

Bret Nine[2]

Shay Wolvert[2]

Allan T. Scholz [1]

[1] Eastern Washington University
Fisheries Research Center
Department of Biology
258 Science Hall
Cheney, Washington 99004

[2] Confederated Tribes of the Colville Indian Reservation
Fish and Wildlife Department
P.O. Box 150
Nespelem, Washington 99155

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EXECUTIVE SUMMARY

The purpose of this investigation was to determine the number of hatchery–produced kokanee salmon, *Oncorhynchus nerka*, and naturally–produced rainbow trout, *Oncorhynchus mykiss*, migrating out of the Sanpoil River into Lake Roosevelt that were consumed by walleye, *Sander vitreus,* and smallmouth bass, *Micropterus dolomieu*. Expansion of data from a rotary screw trap near the mouth of the Sanpoil River, operated by the Colville Confederated Tribes (CCT) Fish and Wildlife Department, yielded estimates that 22,095 (95% CI = 15,685 – 37,367) rainbow trout and 10,283 (95% CI = 4,925 – 15,641) kokanee salmon had migrated into the study area between April 1 and July 2, 2009.

In trials to measure efficiency of the rotary screw trap, 177 rainbow trout were marked by cutting a notch in the caudal fin, released 0.5 km above the trap and later recaptured in the trap. Since the trap captured 1,189 rainbow trout, 22 of which were marked with a caudal notch, this resulted in a12.4 % efficiency (22 / 177 = 12.4 %) and a population estimate of 22,095 (95 % CI = 15,685 – 37,367). In the Sanpoil Arm of Lake Roosevelt below the trap we captured 330 rainbow trout between 33 and 275 mm (the sizes marked in the screw trap) including 16 (4.85 %) marked with a caudal notch. Thus, our data tended to support the lower 95 % CI for the rainbow trout population migrating out of the Sanpoil River.

Kokanee (n = 1,233) caught in the screw trap averaged (ranged) 60 (24 – 87) mm TL and 1.1 (1.0 – 3.0) g in weight. Rainbow trout (n = 1,189) caught in the screw trap averaged (ranged) 137 (33 – 275) mm and 27 (1 – 153) g in weight. Most of the rainbow trout were either age 1 (n = 507) or age 2 (n = 512) smolts. Age 1 rainbow smolts averaged (ranged) 106 (76 – 130) mm TL and 10 (2 – 26) g in weight. Age 2 rainbow smolts averaged (ranged) 162 (131 – 200) mm TL and 39 (69 – 83) g in weight.

We captured 6,398 fish by 60 hours of electrofishing, 254 fish by 64 hours (11 net sets) of gill netting, and 16 fish by 72 hours (3 net sets) of fyke netting (see tables following). Each captured smallmouth bass and walleye > 170 mm TL were double marked with an elastomer mark and Floy tag, fish < 170 mm were given an elastomer mark.

Species, number, relative abundance (percent) and CPUE (fish/ hour) captured by electrofishing included:

Family	Scientific Name	Common Name	N	RA (%)	CPUE
Cyprinidae	*Cyprinus carpio*	carp	51	0.8%	0.9
	Ptychocheilus oregonensis	northern pikeminnow	224	3.5%	3.7
	Tinca tinca	tench	1	<0.1%	<0.1
	Mylocheilus caurinus	peamouth	1	<0.1%	<0.1
Catostomidae	*Catostomus catostomus*	longnose sucker	3	<0.1%	0.1
	Catostomus columbianus	bridgelip sucker	4	0.1%	0.1
	Catostomus macrocheilus	largescale sucker	66	1.0%	1.1
Ictaluridae	*Ameiurus nebulosus*	brown bullhead	8	0.1%	0.1
Salmonidae	*Oncorhynchus mykiss*	rainbow trout	364	5.7%	6.1
	Onchorhynchus nerka	kokanee	28	0.4%	0.5
	Prosopium williamsoni	mountain whitefish	4	0.1%	0.1
	Salvelinus fontinalis	brook trout	1	<0.1%	<0.1
Lotidae	*Lota lota*	burbot	8	0.1%	0.1
Cottidae	*Cottus asper*	prickly sculpin	28	0.4%	0.5
	Cottus bairdii	mottled sculpin	33	0.5%	0.6
	Cottus confusus	shorthead sculpin	30	0.5%	0.5
Centrachidae	*Micropterus dolomieu*	smallmouth bass	4,624	72.3%	77.1
	Micropterus salmoides	largemouth bass	2	<0.1%	<0.1
	Pomoxis nigromaculatus	black crappie	16	0.3%	0.3
Percidae	*Perca flavescens*	yellow perch	125	2.0%	2.1
	Sander vitreus	walleye	777	12.1%	13.0
Total			**6,398**	**100.0%**	**106.6**

Species, numbers, relative abundance (percent) and CPUE (fish / net set) captured by 11 gill net sets included:

Family	Scientific Name	Common Name	N	RA (%)	CPUE
Cyprinidae	*Ptychocheilus oregonensis*	northern pikeminnow	14	5.5%	0.2
Catostomidae	*Catostomus macrocheilus*	largescale sucker	3	1.2%	<0.1
Salmonidae	*Oncorhynchus mykiss*	rainbow trout	3	1.2%	<0.1
Centrachidae	*Micropterus dolomieu*	smallmouth bass	87	34.3%	1.4
Percidae	*Perca flavescens*	yellow perch	9	3.5%	0.1
Percidae	*Sander vitreus*	walleye	138	54.3%	2.2
Total			**254**	**100.0%**	**4.0**

Species, numbers, relative abundance (percent) and CPUE (fish / net set) captured by 3 fyke net sets included:

Family	Scientific Name	Common Name	N	RA (%)	CPUE
Cyprinidae	*Ptychocheilus oregonensis*	northern pikeminnow	9	56.3%	0.1
Centrachidae	*Micropterus dolomieu*	smallmouth bass	4	25.0%	<0.1
Percidae	*Sander vitreus*	walleye	2	12.5%	<0.1
Catostomidae	*Catostomus macrocheilus*	largescale sucker	1	6.2%	<0.1
Grand Total			**16**	**100.0%**	**0.2**

Scales collected from a representative sample of walleye (n = 540) and smallmouth bass (n = 654) were used to age the fish. This information was used to: (1) compute the average length (± SD) and average weight (± SD) for each age class of fish; (2) back-calculate the length at the formation of each annulus;

and (3) construct an age/length frequency table, which was used to assign ages to fish from which scales were not collected.

The average total length (mm) ± SD and weight (g) ± SD of each age class of walleye was: age 0 + (n = 24, 83 ± 11 mm TL, 7 ± 3 g), age 1 + (n = 271, 225 ± 31 mm TL, 99 ±41 g), age 2 + (n = 206, 343 ± 41 mm TL, 354 ± 143 g), age 3 + (n = 65, 396 ± 28 mm TL, 524 ± 131 g), age 4 + (n = 17, 456 ± 27 mm TL, 832 ± 195 g), age 5 + (n = 6, 498 ± 15 mm TL, 935 ± 291 g), age 6 + (n = 3, 561 ± 28 mm TL, 1,494 ± 645 g), age 7 + (n = 0), age 8 + (n = 1, 680 mm TL, 2,570 g), and age 9 + (n = 2, 743 ± 4 mm TL, 3,560 ± 509 g). Back-calculated total length of walleye (n = 540) at annulus formation averaged 192 mm (age 1), 281 mm (age 2), 383 mm (age 3), 444 mm (age 4), 501 mm (age 5), 563 mm (age 6), 634 mm (age 7), 680 mm (age 8), and 731 mm (age 9). For the age length frequency distribution, 540 scales were aged to estimate the ages of 916 walleye. The age length frequency distribution compiled for 916 total fish provided data that walleye at age 0 (n = 77) ranged from 30 – 110 mm TL, at age 1 (n = 401) ranged from 160 – 300 mm TL, at age 2 (n = 295) ranged from 230 – 420 mm TL, at age 3 (n = 93) ranged from 340 – 460 mm TL, at age 4 (n = 18) ranged from 380 – 490 mm TL, at age 5 (n = 11) ranged from 490 – 530 mm TL, at age 6 (n = 5) ranged from 530 – 590 mm TL, at age 7 (n = 0), at age 8 (n = 1) was 680 mm TL, and at age 9 (n = 2) ranged from 740 – 750 mm TL. Tagged walleye (n = 27) grew at an average of 0.32 g weight per day and average of 0.9 mm TL for each day at large (2 – 144 days) between the day of initial capture and the day of recapture, which comported well with the length and weight gains in each year class.

The average total length (mm) ± SD and weight (g) ± SD of each age class of smallmouth bass was: age 1 + (n = 3,765, 105 ± 20 mm TL, 13 ± 11 g), age 2 + (n = 352, 169 ± 14 mm TL, 73 ± 22 g), age 3 + (n = 208, 224 ± 12 mm TL, 150 ± 30 g), age 4 + (n = 177, 252 ± 11 mm TL, 213 ± 40 g), age 5 + (n = 72, 278 ± 6 mm TL, 292 ± 40 g), age 6 + (n = 47, 295 ± 5 mm TL, 347 ± 56 g), age 7 + (n = 45, 323 ± 20 mm TL, 439 ± 147 g), age 8 + (n = 16, 367 ± 20 mm TL, 674 ± 145 g), age 9 + (n = 24, 404 ± 25 mm TL, 859 ± 284 g), age 10 + (n = 2, 448 ± 26 mm TL, 1,339 ± 243 g), and age 11+ (n = 3, 457 ± 1 mm TL, 1,489 ±

139 g). Backcalculated total lengths of smallmouth bass (n = 654) at annulus formation averaged 100 mm (age 1), 157 mm (age 2), 201 mm (age 3), 234 mm (age 4), 263 mm (age 5), 291 mm (age 6), 325 mm (age 7), 366 mm (age 8), 399 mm (age 9), 428 mm (age 10) and 433 mm (age 11). For the age length frequency distribution analysis, 654 scales were aged to estimate the ages of 4,714 smallmouth bass. The age length frequency distribution data compiled from 4,711 total smallmouth bass provided data that smallmouth bass at age 1 (n = 3,752) ranged from 60 – 150 mm, at age 2 (n = 338) ranged from 150 – 210 mm, at age 3 (n = 222) ranged from 200 – 250 mm, at age 4 (n = 172) ranged from 220 – 280 mm, at age 5 (n = 75) ranged from 260 – 290 mm, at age 6 (n = 47) ranged from 280 – 300 mm, at age 7 (n = 46) ranged from 300 – 380 mm, at age 8 (n = 16) ranged from 330 – 390 mm, at age 9 (n = 19) ranged from 360 – 460 mm, at age 10 (n = 3) ranged from 420 – 470 mm, and at age 10 (n = 1) was 450 mm. Tagged smallmouth (n = 258) grew an average of 0.6 g weight per day and average of 1.0 mm TL each day at large (2 – 43 days) between the day of initial capture and the day of recapture, which comported well with the length and weight gains in each year class.

Stomach contents of walleye and smallmouth bass were removed by gastric lavage. Lavage efficacy was determined for walleye (n = 36) and smallmouth bass (n = 24) by first pumping the stomach, then killing the fish and removing the stomach contents to determine what remained. The number and weight of individual kinds of organisms removed by the lavage technique or remaining in the stomach was assessed. Lavage efficacy in walleye was 99.75 % by number (805 items removed by lavage and 2 remaining in stomach) and 91.43 % by weight percent (27.4 g removed by lavage and 2.57 g remaining in stomach). Lavage efficacy in smallmouth bass was 97.40 % by number (300 items moved by lavage and 8 items remaining in stomach) and 92.84 % by weight (72.24 g removed by lavage and 5.57 g remaining in stomach). Most organisms were successfully (100 %) removed by the lavage technique in both smallmouth bass and walleye except for crayfish (91 and 88 % by number and weight) and sculpins (97 and 87 % by number and weight).

Walleye (n = 481) from 27 May to 9 September, 2009 consumed a total of 16,877 food items totaling 495.1 g in weight, including 14 rainbow trout weighing 135.4 g and 14 kokanee salmon weighing 15.2 g. The numerical and weight percentages of rainbow trout in the diet of walleye were 0.1 % and 27.3 % respectively. The numerical and weight percentages of kokanee salmon in the diet of walleye were 0.1 % and 3.0 % respectively. The smallest walleye that consumed rainbow trout was 212 mm TL. The smallest walleye that consumed kokanee salmon was 178 mm TL.

Smallmouth bass (n = 395) from 27 May to 9 September consumed a total of 9,520 food items totaling 650 g in weight, including 13 rainbow trout weighing 125.7 g and 28 kokanee salmon weighing 30.2 g. The numerical and weight percentages of rainbow trout in the diet of smallmouth bass were 0.1 and 19.3 % respectively. The numerical and weight percentages of kokanee salmon in the diet of smallmouth bass were 0.3 and 4.7 %, respectively. The smallest smallmouth bass that consumed rainbow trout was 198 mm TL. The smallest smallmouth bass that consumed kokanee salmon was 175 mm TL.

No salmonids were found in walleye or smallmouth bass stomachs after July 7, 2009, so we applied that as a cutoff date for the bioenergetics modeling portion of the dietary analysis. Smallmouth bass (n = 181) of sizes (> 175 mm) capable of eating a kokanee between 27 May and 7 July, 2009 consumed 8,327 food items weighing 448.0 g. Of this total, 28 were kokanee weighing 30.2 g. The numerical and weight percentages of kokanee salmon in the diet of smallmouth bass were 0.3 and 6.6 % respectively. Smallmouth bass (n = 165) of sizes capable of eating a rainbow trout (> 198 mm) between 27 May and 7 July, 2009 consumed 7,573 food items weighing 427.1 g. Of this total, 13 were rainbow trout weighing 125.7 g. The numerical and weight percentages of kokanee salmon in the diet of smallmouth bass were 0.2 and 29.4 %, respectively.

Walleye (n = 121) of sizes (> 178 mm) capable of eating a kokanee between 27 May and 7 July, 2009 consumed 14,592 food items weighing 326.2 g. Of this total, 14 were kokanee weighing 15.2 g. The numerical and weight percentages of kokanee salmon in the diet of walleye were 0.1 and 4.7 %, respectively. Walleye (n = 80) of sizes capable of eating a rainbow trout (> 212 mm) between 27 May and

7 July, 2009 consumed 10,917 food items weighing 294.9 g. Of this total, 13 were rainbow trout weighing 125.7 g. The numerical and weight percentages of kokanee salmon in the diet of walleye were 0.1 and 42.6 % respectively.

Based on applying the Wisconsin Bioenergetics Model 3.0 from 27 May to 7 July 2009, an individual walleye > 178 mm consumed an average of 59.7 g of prey, of which 2.0 % (1.2 g) was kokanee. Walleye > 212 mm consumed an average of 74.7 g of prey, of which 43.0 % (32.1 g) was rainbow trout. An individual smallmouth bass > 175 mm consumed an average of 68.1 g of prey, of which 7.0 % (4.8 g) was kokanee salmon. Smallmouth bass > 198 mm ate 119.7 g of prey, of which 29.4 % (35.2 g) was rainbow trout.

We used the computer software program CAPTURE to estimate the populations of walleye and smallmouth based on mark-recapture data employing multiple census techniques. The population of walleye (± 95 % CI) in the study area was estimated at 25,068 (13,793 – 46,059) based on 708 fish marked and 11 fish recaptured on 15 sampling occasions. The population of each age class of walleye was determined by calculating the percentage of fish in each age of the walleye age/length frequency distribution and multiplying this percentage by the estimated walleye population. This procedure yielded population estimates of 12,429 (age 1), 8,679 (age 2), 2,739 (age 3), 716 (age 4), 253 (age 5), 126 (age 6), 0 (age 7), 1 (age 8) and 2 (age 9). A total of 805 of the 916 captured walleye (805 ÷ 916 = 87.9 %) that comprised the age/length frequency distribution were over 178 mm TL (the minimum length of walleye that consumed kokanee salmon). Thus, 22,029 walleye (87.9 % of the 25,068 population estimate) are of a size that could potentially consume kokanee salmon in the Sanpoil River. A total of 718 of 916 captured walleye (718 ÷ 916 = 78.4 %) that comprised the age/length frequency distribution were over 212 mm TL, which was the minimum length of walleye that consumed rainbow trout. Thus, 19,648 walleye (78.4 % of the 25,068 population estimate) were of a size that could potentially consume rainbow trout in the Sanpoil River.

The population of smallmouth bass (± 95 % CI) in the study area was estimated at 36,285 (32,080 - 41,127) based on 4,328 fish marked and 262 total recaptures on 15 sampling occasions. The population of each age class of smallmouth bass was determined by calculating the percentage of fish in each age of the smallmouth bass age length frequency distribution and multiplying this percentage by the estimated bass population. This procedure yielded population estimates of 28,999 (age 1), 2,711 (age 2), 1,602 (age 3), 1,363 (age 4), 555 (age 5), 362 (age 6), 347 (age 7), 123 (age 8), 185 (age 9), 15 (age 10), and 23 (age 11). A total of 702 of the 4,711 captured smallmouth (702 ÷ 4,711 = 14.9 %) that comprised the age length frequency distribution were over 175 mm TL (the minimum length of smallmouth that consumed a kokanee salmon). Thus, 5,411 smallmouth bass (14.9 % of the 36,285 population estimate) were of a size that could potentially consume kokanee salmon in the Sanpoil River. A total of 632 of the 4,711 captured smallmouth bass (632 ÷ 4,711 = 13.41 %) in the length frequency distribution were over 198 mm TL, which was the minimum length of smallmouth that consumed a rainbow trout. Thus, 4,865 smallmouth bass (13.41 % of the 36,285 population estimate) were of a size that could potentially consume rainbow trout in the Sanpoil River.

By conducting laboratory and field studies to determine tag loss values, we tested the assumptions that: marked and unmarked fish have same mortality rates; marks are retained throughout the study period; and that emigration during recapture period was negligible. In our tag – retention study, we marked 51 smallmouth bass with elastomer marks and 12 with Floy tags and held them for seven weeks in a test tank. All of the fish retained both types of marks for all seven weeks, although the elastomer mark was beginning to fade in 12 % of the fish by that time. We also held 51 unmarked smallmouth bass in the test tank over the same period, and kept track of the percent mortality in each group. At the end of the 7th week, six of the marked fish had died and nine of the unmarked fish had died. There was no significant difference in mortality rates of marked and unmarked fish in this study ($t = 0.8911$, $p = 0.2035$, $df = 6$).

Additionally, fish in the field were given elastomer mark and a Floy tag to evaluate tag retention. A total of 561 smallmouth bass were given both types of tags, elastomer and Floy tags, and a total of 33 were recaptured. Of these recaptured fish 33 (100 %) had retained their Floy tags, and 27 (82 %) had retained their elastomer marks. A total of 581 walleye were given both elastomer and Floy tags. A total of 11 were recaptured. Of this recaptured fish, 11 (100 %) had retained both their Floy tags and elastomer marks.

We also tested the assumption of population closure by examining locations of recaptured fish. Of 29 walleye recaptured, 11 were caught in the Sanpoil River by electrofishing or gill netting as a part of this study from 27 May to 4 August, and 18 were recaptured by anglers between 15 June and 20 September. Of those captured by anglers, 15 were captured in the Sanpoil River from 15 June to 20 September, one was taken in the Spokane River upstream from Porcupine Bay on 22 June, one was taken in the Columbia River near Enterprise on 1 September, and one was taken in the Columbia River near Hunters on 24 August. Walleye generally moved from about 0 to 13 km between their capture and recapture site within the Sanpoil River.

Of 258 smallmouth bass recaptured, 246 were caught in the Sanpoil by electrofishing (n = 243) or gillnetting (n = 3) as part of this study from 2 June to 4 August and 13 were captured by anglers between 2 June and 12 September. Of those captured by anglers, 10 were caught in the Sanpoil River between 2 June and 19 September, one was caught at Spring Canyon on 12 September and one was caught at Hunters on 23 July. The smallmouth generally moved from about 0 to 13 km between their capture and recapture sites within the Sanpoil River.

Both walleye and smallmouth bass seemed to move freely within the Sanpoil River embayment of Lake Roosevelt but had little tendency to leave it. A total of 2 of 262 smallmouth bass (0.7 %) and 3 of 29 walleye (10.3 %) tagged in the Sanpoil River embayment were recovered outside of it. Two of the three walleye and one of the two bass were caught after our population estimation work was completed on 4 August. Thus, these data generally supported the assumption of population closure.

Multiplying the individual consumption rates (in grams) by the population of walleye (n = 19,468) and smallmouth (n = 4,865) that could consume rainbow trout, yielded totals of 631.0 kg and 171.2 kg of rainbow trout consumed by walleye and smallmouth bass from 27 May to 7 July, respectively.

Multiplying these values by the population of walleye (n = 22,029) and smallmouth bass (n = 5,411) that consumed kokanee salmon yielded totals of 26.3 kg and 25.8 kg of kokanee salmon consumed, respectively.

Consumption rates were converted to numbers of rainbow trout and kokanee salmon by dividing the total grams found in all predators' stomachs by the average weight of rainbow and kokanee found in their stomachs. The weight of a rainbow trout was 34 g in walleye stomach and 7.3 g in smallmouth bass stomachs. The weight of a kokanee salmon was about 1.1 g in the stomach of both species of predators.

The bioenergetic models predicted that from 27 May to 7 July 2009, walleye consumed 18,562 (84 %) rainbow trout and 23,832 (232 %) kokanee salmon, and smallmouth bass consumed 23,459 (106 %) rainbow trout and 23,464 (228 %) kokanee salmon. Combined, this means that 190 % of 22,095 available rainbow trout, and 515 % of 10,283 kokanee are potentially being consumed by smallmouth bass and walleye by 7 July.

Smallmouth bass predation on rainbow (n = 23,458) by itself, could also consume all of the rainbow trout migrating down the Sanpoil River (n = 22,095). Additionally, rainbow trout were consumed by walleye (n = 18,562). Since larger numbers of kokanee were consumed by smallmouth bass (n = 23,464), walleye (n = 23,831) and than those that migrated down the Sanpoil River, (n = 10,283 , 95% CI = 4,925 – 15,641) we conclude that either predator, by itself, could consume all of the kokanee salmon migrating down the Sanpoil River.

These results are consistent with: (1) our observations that rainbow trout were present in the diets of walleye and smallmouth bass until about 7 July, then disappeared from them entirely. Our bioenergetics models predicted that by 7 July walleye and smallmouth had consumed all available rainbow trout and kokanee salmon; and (2) the Colville Tribes observation that very few rainbow trout or kokanee return to the Sanpoil River as sexually mature adults.

After completing the study, we have three main recommendations for future Sanpoil Predation studies: (1) We monitor predation and check the screw trap simultaneously from 25 March until 7 July, to most efficiently capture salmonids as well as lavage the predators at a time when they are most actively consuming the salmonids. This is because we probably have underestimated the extent of walleye and smallmouth bass predation in the present study because the number of rainbow would have been significantly depleted by the time we started sampling on 27 May and (2) We include northern pikeminnow, *Ptychocheilus oregonensis,* as a predator to monitor, being that they are "*the major smolt predator in the Columbia River*" (Rieman et al. 1991; Ward et al. 1995). We captured 247 (3.7 % of the relative abundance) northern pikeminnow in our study, mainly in the free–flowing areas, where the river enters the estuary of the Sanpoil Arm of Lake Roosevelt. In order to better understand northern pikeminnow predation on rainbow trout and kokanee salmon, we plan to conduct a food habit investigation, develop a bioenergetic model, and estimate the population size of northern pikeminnow in 2010; and (3) The Colville Tribe should conduct sonic tracking studies on walleye, smallmouth bass and northern pikeminnow, so that we can better assess the assumption of population closure.

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INTRODUCTION

In the Sanpoil River, the Colville Confederated Tribes (CCT) have been working to improve rainbow trout (*O. mykiss*) and kokanee salmon (*O. nerka*) fisheries through stream enhancement and by stocking hatchery raised kokanee. Both species make adfluvial downstream migrations into Lake Roosevelt where they feed and grow to maturity and return to the Sanpoil River to spawn. Throughout this smolt migration out of the free flowing Sanpoil River into the section that is impounded by Lake Roosevelt, they are exposed to predation by multiple piscivorous species, mainly walleye (*Sander vitreus*) and smallmouth bass (*Micropterus dolomieu)*. The goal of the present investigation was to determine the number of rainbow trout and kokanee salmon that were consumed by the populations of walleye and smallmouth bass residing in the Sanpoil Arm of Lake Roosevelt, compare these values to the number of rainbow trout and kokanee emigrating out of the Sanpoil River, and to determine the percentage consumed by these piscivores.

Salmonid Consumption by Walleye and Smallmouth Bass

A number of studies have documented that walleye (Vigg et al. 1991; Baldwin et al. 2003) and smallmouth bass (Rieman et al. 1991; Tabor et al. 1993) are important consumers of rainbow trout, kokanee salmon and other salmonids. For example, Fritts and Pearsons (2004) studied the food habits of smallmouth bass that migrated from the Columbia River into the Yakima River at the time juvenile salmon and steelhead were emigrating downstream out of the Yakima River. They determined that 200,405 salmonids were eaten annually from March to June 1998 – 2001. Using mark-recapture methods, they found that the smallmouth population (> 150 mm FL) in the lower Yakima River averaged 3,347 in late March and 19,438 in early June. This population of smallmouth consumed an estimated average of 103,310 wild fall Chinook salmon, 47,529 hatchery fall salmon, 2,948 wild spring Chinook and coho salmon and 541 hatchery spring Chinook and coho salmon, and 46,607 mountain whitefish per year (1998 – 2001).

In a study that used methods similar to the approach that was employed in the present investigation, bioenergetic modeling was used to determine the impact of walleye predation on kokanee and rainbow trout in Lake Roosevelt (Baldwin et al. 2003). The objective of the study was to determine the number of kokanee and rainbow trout released from Sherman Creek hatchery that were consumed by walleye within 27 km (upstream and downstream) from Sherman Creek. Walleye food habits were determined in order to estimate the percentage of kokanee salmon and rainbow trout consumed during 41 days following their release. A bioenergetics model was then used to determine how many rainbow and kokanee were consumed on average by an individual walleye, in 1999 and 2000. A mark/recapture population estimate was used to estimate the walleye population in the study area. In 1999, a population of 16,610 walleye in the study area consumed 54,073 kokanee or about 15 % of 360,487 kokanee released from Sherman Creek hatchery within 41 days of release (Baldwin et al. 2003). In 2000, a population of 12,233 walleye consumed 34,076 kokanee or about 9.4 % of 362,521 kokanee, and 4,839 rainbow trout or about 7.3 % of 66,288 rainbow trout, released from Sherman Creek hatchery within 41 days of release (Baldwin et al. 2003).

Rainbow trout and kokanee salmon have previously been found in the diets of walleye and smallmouth bass throughout Lake Roosevelt. Salmonids comprised on average 33.6 % of the diet by weight of walleye (n = 2,342) in Lake Roosevelt between 1988 and 2006 (Peone et al. 1990; Griffith and Scholz 1991; Thatcher et al. 1993, 1994; Underwood and Shields 1996a, 1996b; Underwood et al. 1996; Cichosz et al. 1998, 1999; Spotts et al. 2002; McLellan et al. 2003, Lee et al. 2003; Scofield et al. 2004; Fields et al. 2004; Pavlik – Kunkel et al. 2005; Lee et al. 2006; Scofield et al. 2007; Pavlik – Kunkel et al. 2008). The amount of salmonids by weight in the diets of walleye in Lake Roosevelt has increased from an average (range) of 13.3 (0 – 26.5) % in 1988 – 1994 (Peone et al. 1990; Griffith and Scholz 1991; Thatcher et al. 1993, 1994; Underwood and Shields 1996a; Underwood et al. 1996) to 48.0 (7.3 – 69.0) % in 1995 – 2006 (Underwood and Shields 1996b; Cichosz et al. 1998, 1999; Spotts et al. 2002; McLellan et al. 2003; Lee et al. 2003, 2006; Scofield et al. 2004, 2007; Fields et al. 2004; Pavlik – Kunkel et al. 2005, 2008). Salmonids comprised an average (range) of 6.3 (0.3 – 16.7) % of the diet by weight of smallmouth bass (n = 484) in Lake Roosevelt between 1999 and 2006 (McLellan et al. 2003; Lee et al. 2003, 2006; Scofield et al. 2004, 2007; Fields et al. 2004; Pavlik – Kunkel et al. 2005, 2008).

Objectives

In the present study, to quantify the impact of walleye and smallmouth bass predation on rainbow trout and kokanee salmon smolts migrating out of the Sanpoil River, we had the following specific objectives:

1. Collect information about the number, age, length and weight of rainbow trout and kokanee salmon migrating down the Sanpoil River through a screw trap, and expand the data to obtain total numbers of rainbow and kokanee that migrated into the study area between 1 April – 2 July, 2009;

2. Obtain data about the relative abundance and catch–per–unit–effort of fish species in the area by using a combination of capture techniques (electrofishing, gill netting and fyke netting);

3. Obtain data on age, length, mortality and weight of walleye and smallmouth bass. Collect scales from 30 fish of each 10 mm length class for both species. Construct the following tables:

    i. Average length and weight (± SD) of each age class of each species;
    ii. Back–calculated total length of each species based on annuli laid down on scales;
    iii. Age/length frequency keys that allows assignment of ages to individuals from which scales were not collected; and
    iv. Total length and weight relationships.

4. Determine the number, weight and percent composition (by number and weight), frequency of occurrence and index of relative abundance of rainbow trout and kokanee salmon and other prey items in the diets of walleye and smallmouth bass. Collect information about total length and weight of each type of prey in the diet;

5. Stratify the dietary analysis for walleye and smallmouth bass from 27 May – 9 September (the start and end of the study period) and for 27 May – 7 July (the start of the study period and the date when the last rainbow trout or kokanee was found in their diets). Stratify the dietary analysis for smallmouth bass and walleye large enough to consume rainbow trout and kokanee salmon. Use the Wisconsin Bioenergetics Model 3.0 to determine the total grams of rainbow trout and kokanee salmon consumed by individual walleye and smallmouth bass;

6. Estimate the populations (± 95 % CI) of walleye and smallmouth bass using mark/recapture methods, with fish that were double tagged, using CAPTURE software. Test for heterogeneity, behavioral responses and temporal effects. Evaluate assumptions such as closure;

7. Determine the percentage of walleye and smallmouth bass captured that were of rainbow trout and kokanee salmon – eating size; multiply by the population estimate (Objective 6) to determine the number of total predators capable of consuming a salmonid;

8. Test assumptions of population estimates by conducting laboratory and field studies to determine whether marked fish retained their marks and if the mortality of marked fish was the same as for unmarked fish. Examine distances between site of capture and recapture of marked fish to assess population closure;

9. Estimate the total weight of rainbow trout and kokanee salmon consumed by the population of walleye and smallmouth bass in the study area between 27 May and 9 September (the start and end of the study period) and between 27 May and 7 July (the start of the study period and the last day a salmonid appeared in their diet) by multiplying the weight of rainbow trout and kokanee salmon consumed by an individual predator by the population estimate of predators capable of consuming a salmonid (Objective 7) between the specified dates;

10. Compare the number of rainbow trout and kokanee salmon migrating out of the Sanpoil River to the number of rainbow trout and kokanee salmon consumed by walleye and smallmouth bass to determine the percentage lost to predators; and

11. Back-calculate daily consumption rates from Wisconsin Bioenergetics 3.0 to determine the date that all rainbow trout and kokanee salmon where consumed by either smallmouth bass or walleye populations.

MATERIALS AND METHODS

Study Area

The Sanpoil River forms a 13 km long arm of Lake Roosevelt (Figure 1). Lake Roosevelt is a reservoir of the Columbia River, created in 1941 by the construction of Grand Coulee Dam at river mile RKM 956. The reservoir extends 241 km upstream from the dam, is 1–3 km wide and has a maximum depth of 122 m. The Sanpoil River Subbasin originates in the Okanogan Highlands in north central Washington, and flows south for approximately 94.5 km through the Colville National Forest and Colville Indian Reservation, and enters Lake Roosevelt at RKM 992. The Sanpoil River has no significant blockages and is accessible for virtually its entire length to migratory fish.

The length of the Sanpoil River Arm of Lake Roosevelt is approximately 13 km. It has an average (maximum) depth[1] of 40 (85) m. The perimeter of the Sanpoil River was divided into 27 one kilometer long sections (SP 1 – SP 27) and four embayments (SPE1– SPE4), sites 25 and 26 had flowing water (Figure 1). Twenty six of the segments and all 4 embayments were inundated by Lake Roosevelt.

The average (range) discharge (cubic feet per second) of three sites within the Sanpoil River over the period of record (1972 – 2008) was 76.1 (8.3 - 176.6) CFS (Table 1). The mean monthly discharge during a water year averaged 13.9 CFS (October), 24.0 (November), 40.3 (December), 62.0 (January), 52.4 (February), 134.8 (March), 250 (April), 214.2 (May), 92.3 (June), 25.3 (July), 11.0 (August), and 9.4 (September) (Table 2).

Field Collection

Rotary Screw Trap

A 1.52 m (5 ft) rotary screw trap (RST), operated by the Colville Confederated Tribes (CCT) Fish and Wildlife Department was used to estimate the populations of juvenile rainbow trout and kokanee salmon migrating out of the Sanpoil River in 2009. The trap was located 1.7 kilometers above the confluence with Lake Roosevelt (river / lake interface) and was operated and checked Monday through Thursday of each week beginning March 31,

[1] These values were taken off a nautical map (Franklin D. Roosevelt Lake Nautical Map ISBN 1–885151–004). Maximum depth was determined from the deepest record off the map. Average depth was determined by summing the recorded depths and dividing by the number of depths summed.

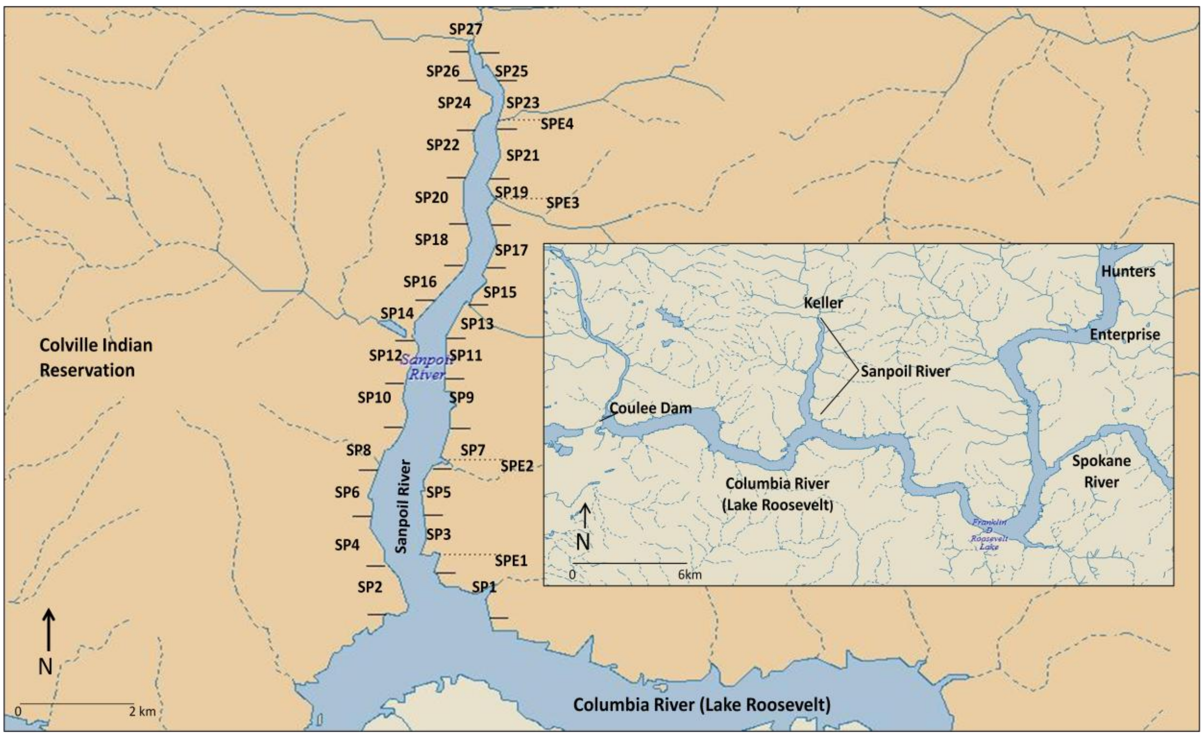

Figure 1. Map of the sites surveyed along the Sanpoil River arm of the Columbia River (Lake Roosevelt) 2009.

Table 1. Average annual flows (CFS) per Sanpoil River site. Data from USGS Surface-Water Monthly Statistics (1972 – 2008).

Year	West Fork	Jack Creek	13 Mile Cr.	Yr. Average
1972	15.8	–	62.4	39.1
1973	47.3	–	30.7	39.0
1974	197.9	–	155.2	176.6
2005	9.8	–	6.9	8.3
2006	125.9	74.0	73.6	91.2
2007	52.9	184.5	33.9	90.5
2008	46.62	180.58	36.54	87.9
Average	**70.88**	**146.36**	**57.03**	**76.08**

Table 2. Average monthly flows (CFS) of three sites across the Sanpoil River from 1972 – 2008. Data from USGS Surface-Water Monthly Statistics (1972 – 2008)

Month	1972	1973	1974	2005	2006	2007	2008	Avg
Jan	–	15.2	207.7	–	28.8	36.2	22.1	62.0
Feb	–	21.8	127.8	–	36.2	51.3	25.2	52.4
March	109.3	56.1	194.2	–	69.7	297.1	82.6	134.8
April	145.1	95.7	–	–	505.6	341.6	162.1	25<0.1
May	169.4	78.6	–	–	320.8	181.0	321.3	214.2
June	100.7	28.8	–	–	135.9	71.1	125.4	92.3
July	30.5	8.0	–	–	32.6	25.6	29.7	25.3
Aug	16.0	3.0	–	–	10.4	12.7	12.8	11.0
Sept	12.9	5.3	–	–	8.2	10.8	1<0.1	9.4
Oct	13.8	9.5	–	9.2	22.1	15.0	–	13.9
Nov	17.0	37.6	–	8.5	39.1	17.7	–	24.0
Dec	14.2	108.7	–	7.3	45.7	25.4	–	40.3
Average	**62.9**	**39.0**	**176.6**	**8.3**	**104.6**	**90.5**	**87.9**	**81.5**

2009, the trap became inoperable by July 2, 2009 due to decreased flows which stopped the rotation of the trap drum. Fish captured and held in the trap holding box each day were identified, enumerated, measured (TL mm), and weighed (g). Scales were also taken from rainbow trout to determine the age structure. These scales have not yet been analyzed, and instead ages were determined by constructing a length/frequency distribution and ages assigned by counting the number of normal distributions within the length/frequency distribution.

Mark/recapture methods were used to estimate the efficiency of the RST. A series of seven marking events were conducted between April 9, 2009 and May 13, 2009. Rainbow trout were marked by cutting a notch in the upper caudal fin. Marked fish were immediately transported to two pools located approximately 0.5 km above the RST and released. Subsequently, the number of these marked fish that reentered the RST were enumerated as were the number of unmarked fish. A Peterson estimator, with Chapman modification was used to estimate the population sizes of rainbow trout and kokanee salmon:

$$N=\frac{(M+1)(C+1)}{R+1}$$

Where:

N = population estimate;
M = number of fish marked and released above the trap;
C = total number of fish (marked and unmarked) caught in the trap on the second sample; and
R = number of marked fish in the second sample.

In order to calculate the 95 % confidence intervals associated with the population estimate, we first calculated the standard error, which requires first determining the variance. The variance equation used was:

$$V(N)=\frac{N^2(C-R)}{(C+1)(R+2)}$$

Where:

V(N) = variance of N;
N = population estimate;
C = total number of fish (marked and unmarked) caught in the trap on the second sample; and
R = number of marked fish in the second sample.

The standard error was calculated using the variance above:

$$SE = \sqrt{\text{Variance of N}}$$

Where:

SE = standard error; and
N = population estimate.

The 95 % confidence intervals were calculated for the population estimate:

$$95\% \ CI = N \pm 1.96 \times SE$$

Where:

N = population estimate;
CI = confidence interval; and
SE = standard error.

The results from the modified Peterson population estimate were used to calculate a per day average. The daily average was then applied to the number of days in each month (April –June) to determine the average monthly population. Monthly estimates were then summed to create a total estimate. This method was used because trapping events were not continuous throughout the sampling season.

Electrofishing, Gill netting, and Fyke netting Surveys

Field sampling to mark and recapture fish for population estimates, and to collect data for assessing growth and food habits of walleye and smallmouth bass, was conducted on 16 dates: May 27th, June 3rd, June 10th, June 16th, June 18th, June 23rd, June 25th, June 29th, July 1st, July 7th, July 14th, July 21st, July 28th, August 4th, August 12th and September 9th. Typically, surveys started at about noon and lasted until about midnight, although on one date the surveys started at about 9 AM and extended until about 9 AM the following day to collect food habits data over a 24 hour period. Fish were captured using a combination of electrofishing, gill netting and fyke netting.

Approximately 13 electrofishing transects (Figure 1, p 6), 10 – 20 minutes long, were employed on each date (20 transects during the 24 hour survey) with a total of 208 electrofishing transects and 3,359 electrofishing minutes expended during the entire study (Table 3). Sites were selected on each date using a random number generator. About 22.1 % of the electrofishing effort (46 of 208 sites) was used to sample sites SP1 to SP9. Each site was sampled 3 to 7 times, with the exception of SP1 which was sampled once. About 27.4 % of the electrofishing effort (57 of 208 sites) was used to sample sites SP10 to SP18. Each site was sampled 3 – 10 times. About 30.8 % of the electrofishing effort (64 of 208) was used to sample sites SP18 to SP27. Each site was sampled 3 – 15 times, with the exception of site SP 20, which was sampled only once. About 19.7 % of the electrofishing effort (41 of 208 sites) was used to sample the embayment sites SPE1– SPE4. Each site was sampled 6 – 13 times. It was decided to put slightly more effort into the embayment sections (SPE1– SPE4) and upstream sections SP19 – SP27, by stratifying the randomization process, since these sections produced substantially more fish than the other sites.

Gill nets (n = 6) were set to obtain fish occupying deeper water than could be captured by electrofishing. Gill nets were set toward the end of the study because they killed fish, which required them to be removed from the study population. Early in the study, we tried to mark and release alive as many fish as possible to ensure that we would recapture a sufficient number to validate the population estimation procedure. Six gill nets were deployed on the bottom at a depth of about 10 meters in section SP25 and SP26. Each gill net was fished for roughly 10 hours, from about 1200 hours to 2200 hours. Gill nets were about 61 m long x 2 m deep, with 4 panels (each panel 15.25 m by 2 m, made of graded monofilament mesh ranging from 25 to 75 mm). Fyke nets made out of 25 mm stretch cotton mesh, with a 50 m long lead and 1.5 m hoops were set in site SP27. Fyke nets were set for approximately 24 hours per day over three days.

All fish collected were measured and weighed (because so many smallmouth were caught, a representative sample were weighed). Scales were collected from an appropriate location (at the posterior end of the pectoral fin) for age determination (Jearld 1983). All walleye and smallmouth were examined for elastomer marks, and Floy tags. Rainbow trout caught were examined for caudal notches.

Table 3. Amount of effort (# of electroshock transects and minutes) expended in each portion of the Sanpoil River Arm during 2009.

Sites	ES Transects (#)	ES Transect (%)	ES Time (min)	ES Time (%)	Min– Max (#) transects/site
SP1– SP9 [1]	46	22.1 %	691	20.6 %	3 – 7
SP10– SP18	57	27.4 %	837	24.9 %	3 – 10
SP19–SP27[2]	64	30.8 %	1,123	33.4 %	3 – 15
SPE1– SPE4	41	19.7 %	709	21.1 %	6 – 13
Total	**208**	**100 %**	**3,359**	**100 %**	

[1] Except for site SP1 (sampled once only). [2]Except for site SP20 (sampled once only).

Age and Growth

All walleye and smallmouth bass > 75 mm – 169 mm TL were marked with fluorescent elastomer (green, yellow, orange, pink, or red) that was injected into the anal, pelvic, or pectoral fins using 26.5 gauge hypodermic syringe. A unique color and fin combination was used to identify each date. Additionally, all walleye and smallmouth bass > 170 mm TL were marked with a combination of elastomer marks and individually numbered Floy tags (Floy Tag, Inc. Seattle, WA; Model FD–94, T–shaped anchor). Orange and yellow Floy tags were inserted into the dorsal musculature at the posterior base of the spiny dorsal fin such that the T–bar anchor became lodged between the pterygiophores (bony elements that support the dorsal spines) (Guy et al. 1996). Each tag bore an inscription –EWU– along with a unique number and a telephone number. To determine the amount of tag loss we kept track of the number of double marked fish that had lost one type of tag or the other. We also conducted an in-lab tag retention study.

A poster campaign was conducted by placing signs at all the boat launches on the reservoir instructing anglers to telephone information about any recapture to EWU. Information related to the tagging program was also published online on the Lake Roosevelt Forum website (LRF.org). Anglers who sent tags or telephoned EWU about tagged fish were entered into a biannual drawing to receive gift certificates from a local sporting goods store (Cabelas) in order to encourage information sharing. Also, the Colville Confederated Tribes, Spokane Tribes and Washington Department of Fish and Wildlife (WDFW) creel clerks, who were conducting a creel census on Lake Roosevelt, were alerted to be on the lookout for tagged walleye and smallmouth bass. This enabled us to collect information about the assumption of population closure in making our population estimate (see 'testing assumption of population closure...' p 59).

Diet

Diet samples from 268 walleye and 364 smallmouth bass were collected via gastric lavage (Light et al. 1983) Unruly fish were anesthetized using CO_2. Stomach contents were aspirated and collected on a fine mesh screen with a piece of tubing connected to a commercial sprayer that was pushed down the esophagus into the stomach.

Stomach contents were preserved in 95 % ethanol and placed in jars labeled with the fish ID #, species, location and date.

Lavage efficacy was determined for walleye (n = 36) and smallmouth bass (n = 24) by first pumping the stomach and placing the contents into a jar, then killing the fish and removing the stomach by cutting anterior to the esophagus and posterior to the pyloric sphincter and placing it in a separate jar labeled with the same information as the first jar. Lavage efficacy was determined by comparing the number and weight of each type of prey removed with the lavage technique -vs- the number and weight of each type of prey remaining in the stomach.

Laboratory Procedures

Age and Growth

In the laboratory, scales were read using an Eyecom Model 3000 microfiche reader. The image of the scale was projected on the viewing screen and the number of annuli counted (Lux 1971, Jerald 1983; Devries and Frie 1996). Individual annuli were recognized by analyzing the distribution of circuli. Circuli are closely spaced just before the line that marks the annulus, and are more widely spaced just outside of it. The closely spaced circuli mark winter growth. The widely spaced circuli marks the next growing season. Lengths of the fish at formation of each annulus were backcalculated from scales using the Fraser–Lee method (Carlander 1982) because it accounts for the period of growth prior to scale development. The equation used for Fraser–Lee backcalculated was:

$$L_i = \frac{(L_c - a)}{S_c}\ (S_i + a)$$

Where:

L_i = backcalculated fish body length at age i;
L_c = fish body length at capture;
S_i = mean scale length at annulus I;
S_c = mean scale total length; and
a = the mean scale length, or y intercept from the regression of the body length.

The y-intercept parameter was obtained by graphing the total body length at the time of capture (y-axis) to the $\log_{10}$ scale radius (from focus to the edge of the scale) at time of capture (x-axis) for the entire population of fish in the sample (walleye or smallmouth bass). A regression line was fitted to these points. The point where the regression line passed through the y-axis was a, and represented the length of the scale at the time of the first scale was laid down.

A Fulton-type condition factor (K_{TL}) determines the physiological state of a fish. Condition factors were calculated using the equation (Anderson and Neuman 1996):

$$K_{TL} = \frac{Wt}{TL^3} \times 10^5$$

Where:

K_{TL}= condition factor;
Wt = weight (g); and
TL = total length (mm).

Generally, the heavier a fish is per length class, the higher fitness it has. For most salmonids, a condition factor ranging from 0.9 – 1.1 indicates that growth is normal (Carlander 1969). For walleye and smallmouth bass condition factors normal ranges are 0.7 – 1.2 and 1.2 – 1.9, respectively (Carlander 1977, 1997). Condition factors below these levels indicate competition for limited food resources or that, for some reason, the fish is burning energy instead of storing it as biomass. Another potential reason for low condition factors is that the fish is living in a sub–optimal temperature for growth. Condition factors above these levels indicate that food resources are abundant.

After all collected scales were aged, an age/length key was developed to assign ages to fish from which scales were not obtained (Devries and Frie 1996). Age frequency information was then used to estimate mortality by constructing a catch curve of age distribution for each species with the total number in the age class (y-axis) plotted against the age in years (x-axis). Small fish were underrepresented in the sample because they were incompletely recruited by the fishing gear, so the slope of the descending limb (from the peak age represented in the sample to the older fish represented in the sample) was used to estimate the mortality rate (Ricker 1975).

Mean annual survival was calculated by:

$$S = e^{-z}$$

Where:

S = mean annual survival;
e = natural log constant (2.718); and
Z = instantaneous rate of mortality.

Annual survival between age classes was calculated using the formula:

$$S = \frac{N_{t+1}}{N}$$

Where:

S = annual survival;
Nt = number of age t fish collected; and
N t+1 = number of age t + 1 fish collected.

The mean annual mortality between age classes was calculated using the equation (Ricker 1975)

$$A = 1 - s$$

Where:
A = annual mortality; and
S = annual survival.

Diet

In the lab, numbers of each type of prey organism in each walleye or smallmouth bass stomach were counted using a multi–port tally counter. All prey were identified using a Nikon SMZ–10 stereozoom dissecting microscope. A Nikon Optiphot phase contrast compound microscope was used to assist in identification of zooplankton. Weights of the prey were measured, after blotting dry, to the nearest <0.11 gram using a Mettler (mg) analytical balance.

Zooplankton prey were identified to Genus and aquatic/terrestrial insect prey to Family using appropriate taxonomic keys (Hansel et al. 1988; Frost 2003; EWU Bone Collection). Fish prey were identified to the lowest taxonomic level possible (usually species) using taxonomic keys to diagnostic bones (Hansel et al. 1988; Frost

2003); and by comparison to a fish bone reference collection housed at the EWU Biology Department, which contains bones and equations that relate the length of certain diagnostic bones to the total length and weight of the fish species they were derived from. When prey fish were partially digested, first an attempt was made to identify fish prey from partially digested remains. If unidentifiable by sight, diagnostic bones were found. For bone identification, we used the EWU fish bone reference collection, Hansel et al. (1988), and bone keys and sketches produced and provided by the USGS (Frost 2003). Fish prey identified by bones were estimated by counting the numbers of several different diagnostic bones from one side of the body. Standard equations presented by Hansel et al. (1988) and equations that we developed for the EWU fish bone reference collection were used to estimate the length and weight of each prey fish in the sample at the time it was ingested (Table 4). For fish that were identified by bones, we used linear regression equations that related the length of the bone to the length of the fish to determine the living weight of the fish. Those numbers were applied to estimate the weight of consumed fish per stomach sample. The reason for doing this was because the length and weight of all the benthic invertebrates did not change as rapidly as the fishes. The fish are digested at a more rapid rate, causing quicker breakdown within the predators' stomachs.

Stomach contents containing large numbers of *Daphnia* and Chironomidae larvae or pupae were subsampled. Other food items were removed and counted, leaving the *Daphnia* and Chironomidae, which were placed in a beaker. The volume was brought up to 100 mL and three 2 mL aliquots were counted. The total number of *Daphnia* and/or Chironomidae contained in the samples were calculated using the formula:

$$\text{Total}\,\# = \sum_{n=1}^{3} \frac{(\text{DV/SV} \times \text{T}_n)}{3}$$

Table 4. Regression equations from the EWU bone reference collection*, which relate fish length (mm) to bone length.

Common name	**Bone**	**Measurement**	**N**	**Equation**	**R^2**	**Fish size range (mm)**
Kokanee	Cleithrum	CL:TL	17	y = 23.53 + 8.19x	0.96	89–360
Yellow perch	Cleithrum	CL:TL	64	y = 11.87 + 6.46x	0.98	64–292
Northern pikeminnow	Cleithrum	CL:TL	66	y = 33.42 + 7.82x	0.98	82–553
Tench	Cleithrum	CL:TL	40	y = 10.47 + 6.38x	0.97	70–406
Largemouth bass	Cleithrum	CL:TL	46	y = 16.26 + 5.39x	0.99	58–330
Pumpkinseed	Cleithrum	CL:TL	17	y = 12.16 + 4.2x	0.98	70–146
Bluegill	Cleithrum	CL:TL	19	y = 15.29 + 4.05x	0.98	63–190
Sunfish	Cleithrum	CL:TL	28	y = 14.72 + 4.07x	0.98	63–190
Black crappie	Cleithrum	CL:TL	18	y = 8.1 + 5.11x	0.98	30–209
Rainbow trout	Cleithrum	CL:TL	45	y = –25.33 + 10.42x	0.94	100–300
Kokanee	Dentary	DM:TL	17	y = 128.51 + 7.25x	0.83	89–360
Yellow perch	Dentary	DM:TL	42	y = 17.9 + 21.17x	0.99	93–292
Northern pikeminnow	Dentary	DM:TL	65	y = 51.59 + 11.36x	0.96	82–461
Tench	Dentary	DM:TL	39	y = 2.93 + 18.64x	0.98	70–406
Largemouth bass	Dentary	DM:TL	46	y = 25.69 + 12.88x	0.97	58–330
Pumpkinseed	Dentary	DM:TL	9	y = –34.49 + 33.4x	0.91	70–120
Bluegill	Dentary	DM:TL	19	y = –5.39 + 24.63x	0.94	63–190
Sunfish	Dentary	DM:TL	28	y = 0.41 + 23.86x	0.93	63–190
Black crappie	Dentary	DM:TL	19	y = 40.77 + 11.54x	0.72	30–209
Rainbow trout	Dentary	DM:TL	43	y = 16.81 + 16.64x	0.90	146–300
Kokanee	Opercle	OM:TL	17	y = 44.26 + 12.27x	0.93	89–360
Yellow perch	Opercle	OM:TL	65	y = 17.38 + 11.33x	0.99	58–292
Northern pikeminnow	Opercle	OM:TL	68	y = 24.9 + 13.52x	0.97	82–553
Tench	Opercle	OM:TL	40	y = 21.03 + 8.86x	0.98	70–406
Largemouth bass	Opercle	OM:TL	40	y = 18 + 9.69x	0.99	58–325
Pumpkinseed	Opercle	OM:TL	17	y = 9.16 + 8.44x	0.93	70–146
Bluegill	Opercle	OM:TL	19	y = 17.82 + 7.76x	0.98	63–190
Sunfish	Opercle	OM:TL	28	y = 18.01 + 7.75x	0.97	63–190
Black crappie	Opercle	OM:TL	18	y = 17.91 + 8.56x	0.91	30–209
Rainbow trout	Opercle	OM:TL	41	y = 39.36 + 16.24x	0.84	100–300
Kokanee	Preopercle	POM:TL	10	y = 73.04 + 9.17x	0.73	256–333
Yellow perch	Preopercle	POM:TL	42	y = 6.1 + 9.25x	0.99	93–292
Northern pikeminnow	Preopercle	POM:TL	37	y = 32.19 + 10.94x	0.99	137–461
Tench	Preopercle	POM:TL	32	y = 15.15 + 8.62x	0.99	70–403
Largemouth bass	Preopercle	POM:TL	40	y = 7.38 + 7.37x	0.99	58–325
Pumpkinseed	Preopercle	POM:TL	9	y = 10.32 + 6.16x	0.95	70–120
Bluegill	Preopercle	POM:TL	19	y = 16.03 + 5.99x	0.98	63–190
Sunfish	Preopercle	POM:TL	28	y = 12.94 + 6.11x	0.98	63–190
Rainbow trout	Preopercle	POM:TL	38	y = –23.1 + 13.95x	0.87	146–300
Northern pikeminnow	Pharyngeal arch	PL:TL	61	y = 35.38 + 12.51x	0.96	118–553
Tench	Pharyngeal arch	PL:TL	40	y = 2<0.1 + 11.65x	0.98	70–406

*EWU fish bone reference collection by Gunnarson, Bean & Baker (unpublished), who referenced Jennifer Scott (2002), Master's thesis.

Where:

DV = total diluted volume (100 mL);
SV = total subsample volume (2mL); and
T_n = total # of zooplankton in the subsample.

Quantitative analysis of stomach contents were performed using frequency of occurrence (i.e., presence/absence of prey items in the stomach), percent composition by number and percent composition by weight methods (Hynes 1950; Hyslop 1980; Bowen 1983; 1996). Numerical percentages were determined by dividing the number of a particular prey organism found in the stomach of a fish by the total number of all prey organisms found in the stomach for that fish. Food habits of individual fish belonging to a particular species were summed and divided by the number of fish sampled in that month to determine the monthly percentage (± standard deviation) of a particular prey in their diet. The monthly percentages were summed and divided by the number of months to determine the annual numerical percentage (± standard deviation) of that prey in the diet. Weight percentages of a particular prey item were determined by dividing the blotted wet weight of that prey by the sum of the blotted wet weights of all prey items to determine the weight percentage of a particular food item in the diet. The monthly and annual averages were determined by the same procedure described for estimating the numerical percent of the diet.

To determine frequency of occurrence of a particular prey item in the diet, the presence or absence of a particular prey organism in the stomach contents of an individual fish was determined. Each month, the number of stomachs that contained at least one individual of a particular prey organism was divided by the total number of stomachs collected, resulting in the percent frequency of occurrence. The annual average was determined by the same procedure described for estimating the numerical percent of the diet.

Frequency of occurrence, percent by number and percent by weight of prey organisms are all biased if used individually when assessing the bioenergetic contribution of each prey item to a fish's metabolic requirements or the overall importance of a particular prey organism to a fish species. For example, percent by number may overemphasize small organisms in the diet, such as *Daphnia* or Chironomids that are abundant in the environment but do not weigh much and so do not contribute much to the bioenergetic requirements of fish.

Percent by weight may overemphasize the importance of large organisms in the diet that are infrequently consumed by the fish (Windell 1971; Bowen 1996; Murphy and Willis 1996).

The index of relative importance (George and Hadley 1979) was used to combine the data from frequency of occurrence, numerical percent and weight percent of the diet into a hybrid index. The index of relative importance (IRI) formula is:

$$RI_a = \frac{100AI_a}{\sum_{a=1}^{n} AI_a}$$

Where:

Ri_a = relative importance of food item a;
AI_a = absolute importance of food item a (i.e., FO + numerical frequency + weight percentage of prey a); and
n = number of different food types.

IRI values range from <0.1 to 1.0, and sum to equal one exactly. IRIs were calculated for each species of prey in the diet each month, in the annual diet, and with each stratification we applied. As this study was focused on bioenergetics, the most important of these different methods to assess the relative importance of different prey items was the percent by weight.

Bioenergetics

Bioenergetics traces energy through a system, be it an individual or a whole ecosystem. Consumed energy (food) can be followed back out of the system (feces, nitrogenous waste), be used by the organism metabolically, or be retained within the organism in the form of newly created mass (tissue, fat buildup, gamete production). What bioenergetics modeling does is estimate the rate of energy intake compared to the energy required by each of these processes. Within the bioenergetic software, the ‘daily meal’ calculations are accomplished by estimating the rate of gastric evacuation, which varies for each type of prey consumed and increases as temperature increases (He and Wurtsbaugh 1993). We used bioenergetics models that were already developed for walleye (Kitchell et al.1977; Madson and Culver 1993; Hanson et al. 1997; Baldwin et al. 2003) and smallmouth bass (Hanson et al. 1997; Whitledge et al. 2002, 2003) to transform our food habits data into

Table 5. Bioenergetic modeling parameters for consumption, egestion & excretion, predator caloric densities and respiration.

Parameter Names [4,6,8]	Parameters Used		Parameters in Literature				
	WAL	SMB	[1]SMB	[5]SMB (subadult)	[7]SMB (Age0)	[2]WAL (Adult)	[3]WAL (Juv.)
Consumption Variables							
Intercept:C_{max} vs predator mass	0.25	0.25	0.25	0.34	0.25	0.25	0.45
Slope: C_{max} vs predator mass	-0.27	-0.31	-0.31	-0.31	-0.31	-0.27	-0.27
Proportion of C_{max} at CQ	<0.1	<0.1	-	-	-	-	-
Proportion of C_{max} at CTL	<0.1	<0.1	-	-	-	-	-
Temperature for CK1 (Celsius)	2.30	3.80	3.8	4.2 / 1.95[X]	3.8	2.3	2.3
Temperature for CK4 (Celsius)	<0.1	<0.1	-	-	-	-	-
High optimum temperature (Celsius)	28.00	36.00	36	37	36	28	28
Low optimum temperature (Celsius)	22.00	29.00	29	22	29	22	25
Egestion & Excretion Variables							
Proportion of consumption egested	0.16	0.10	0.14	0.10	0.10	0.16	0.25
Coefficent of water temperature dependence on egestion	-0.22	<0.1	-	-	-	-0.22	-
Coefficent of p-value as a function of egestion	0.63	<0.1	-	-	-	0.63	-
Proportion of consumption excreted	<0.1	<0.1	1.07	<0.18	<0.18	<0.15	<0.1
Coefficent of water temperature dependence on excretion	0.58	<0.1	-	-	-	0.58	-
Coefficent of p-value as a function of excretion	-0.30	<0.1	-	-	-	-0.30	-
Predator Caloric Density Variables							
Calories (energy density)	4,186	4,186	4,186	-	-	4,186	3,349
Respiration Variables							
Activity multiplier	1.00	2.00	2.0	3.0	-	1.0	3.0
Intercept: R vs predator mass	<0.1	<0.1	<0.1	0.24	<0.1	<0.18	<0.14
Slope: R vs predator mass	-0.20	-0.21	-<0.1	-0.76	-0.21	-0.2	-0.22
Swimming speed ($cm{*}s^{-1}$)	<0.1	<0.1	-	-	-	-	-
Water temperature dependence coefficient	2.10	3.30	3.3	1.8	3.3	2.1	2.1
Maximum water temperature	32.00	37.00	37.0	37.0	37.0	32.0	32.0
Activity coefficient	27.00	30.0	30.0	30.0	30.0	27.0	27.0
Specific dynamic action	0.17	0.16	<0.16	0.16	0.16	0.17	0.1

[1.]Shuter and Post (1990); [2.]Kitchell et al. (1977); [3].Madon and Culver (1993); [4.]Petersen and Ward (1999); [5.]Whitelodget et al. (2003); [6.]Boldt and Haldorson (2002); [7.]Hewett and Johnson (1992); [8.]Hewett and Johnson (1987); [X.] Dependent on temperature.

total consumption of a particular species of prey by an individual fish. After calculating individual fish consumption, we then expanded the estimate to the population level (Stewart et al. 1981; Stewart et al. 1983; Yule and Luecke 1993; Hartman and Brandt 1995; Baldwin et al 2000; Baldwin et al. 2003). The Wisconsin Fish Bioenergetics Model 3.0 computer program (Hanson et al. 1997) was used to estimate the consumption of rainbow trout and kokanee salmon by individual walleye and smallmouth bass. For each species a specific bioenergetic model was developed to generate daily consumption estimates (focusing on consumption of rainbow trout and kokanee) by each age class of walleye and smallmouth bass. We calculated salmonid consumption by providing data on growth, proportion by weight diet information, prey and predator caloric density, and thermal experience to bioenergetic models that simulate species and size specific physiology to allow estimation of consumption. This software uses a mass–balanced energetics based approach that focuses on the physiological processes that regulate growth by individual fish. Bioenergetics modeling has proven effective for quantifying the impact of predators on prey populations in many systems for both planktivores and piscivores (Stewart et al. 1981; Ney 1990; Yule and Luecke 1993; Beauchamp et al. 1995; Hartman and Brandt 1995; Baldwin et al. 2003).

Growth over time for our species was accomplished by determining the average weight differences in Floy–tagged fish that we recaptured at a later date, and calculated the average weight gain (g) per day (see Appendix III, p. 99). We then determined the minimum length of a smallmouth bass and walleye that ate a rainbow trout and kokanee salmon and determined its respective weight by using the regression equations we developed for captured smallmouth bass and walleye (Figure 4, p 39, and Figure 7, p 44). We multiplied the average growth per day, by the number of days we modeled (t). Lastly, we added that growth over period t to the minimum length of a smallmouth bass or walleye.

In general terms, bioenergetics mathematically determines consumed energy needed by an organism, where:

$$C = R + F + U + G \qquad \text{Eqn 1}$$

Where:

C = rate of energy consumed;
R = total metabolic rate;
F = fecal waste;
U = urinary waste; and
G = growth (somatic and gametic).

U and F are usually fixed values that vary as a function of temperature. After computing each variable in this equation, and determining the total consumption per fish, we then multiplied this value by the weight percentage determined for individual types of prey by the diet analysis to estimate the percentage that each type of prey contributed to the daily meal.

There are many different calculations one must employ in order to determine the bioenergetic daily meal. The following equations were all computed using the Wisconsin Bioenergetics Software 3.0. Total metabolic rate can be calculated by the equation:

$$R = M_r + M_a + SDA \qquad \text{Eqn 2}$$

Where:

R = total metabolic rate;
M_r = standard metabolic rate;
M_a = elevated metabolism due to movement; and
SDA =standard dynamic action, the amount of energy that is lost in the assimilation of the prey.

In essence this equation states that energy in = energy turned into biomass or gametes + energy consumed + energy wasted. The respiration term is generally determined by measuring the fishes routine and active metabolism in a respirometer at different temperatures. Energy density of the prey (i.e., the number of calories contained per unit weight of a prey) is also important in this calculation because two prey species of the same biomass may provide the predator with differing amounts of useful energy depending on their individual energy densities. Since there is more energy contained in a gram of fat (roughly 9 cal/g) than a gram of either proteins or carbohydrates (roughly 4 cal/gram), organisms with a higher fat content usually have a higher energy density than organisms with less fat. Bioenergetics equations have terms that account for energy density of prey species. Urinary and fecal excretions are both based upon temperature.

The growth term is made up of two possible areas of possible growth: somatic growth and gonad growth:

$$G = G_s + G_r \qquad \text{Eqn 3}$$

Where:

G_s= somatic growth; and

G_r $=G_r$ = gonad growth.

Metabolic rates of fishes are determined by fish mass, temperature of the environment, and several fixed constants.

$$R_{total}=aM^{b}f(T)ACT \qquad \text{Eqn 4}$$

Where:

R_{total} = mass specific metabolic rate (grams of 02/g/day);

M= fish mass (g);

f(T)= temperature dependent function;

ACT= activity multiplier;

a and b = fixed constants (Kitchell et al. 1977); and

f(T) = Eqn 5 defines ideal environmental temperature.

The ideal environmental temperatures for fishes was determined with this equation originally in Hewett and Johnson (1992).

$$f(T)=\left[\left(T_{lethal}-T\right)\left(T_{lethal}-T_{optR}\right)^{-1}\right]^{\left\{<0.125\left[z^2\sqrt{(1+40y^{-1})}\right]^2\right\}} e^{\left\{<0.125\left[z^2\sqrt{(1+40y^{-1})}\right]^2\right\}\left[\left(T_{lethal}-T_{optR}\right)\left(T_{lethal}-T_{optR}\right)^{-1}\right]} \qquad \text{Eqn 5}$$

Where:

T_{Lethal}= lethal water temperature (°Celsius);

T_{optR}= optimum water temperature for respiration (° Celsius); and

Z and Y are defined by:

$$Z=ln(RQ)*(RTM\text{-}RTO) \qquad \text{Eqn 6}$$

$$Y=ln(RQ)*\left(RTM\text{-}RTO+2\right) \qquad \text{Eqn 7}$$

Before incorporating metabolic data into the model, the y-intercept and slope of the allometric mass function were calculated:

$$\frac{R}{(f(T*ACT))}=A*M^b \qquad \text{Eqn 8}$$

Where:

R = mass specific metabolic rate;
ACT = activity multiplier;
a = intercept of the allometric mass function;
^{b} = slope of the allometric mass function; and
M = fish mass (g).

The activity multiplier is a constant times resting metabolism, otherwise known as the “Winberg multiplier.” Activity may be a large and variable component of the total energy budget and be influenced by environmental and physiological factors (Madon and Culver 1993). The temperature dependent function f(T) is described by the equation:

$$f(T)=V^X*e^{(X(1-V))} \qquad \text{Eqn 9}$$

Where:

$$V=\frac{(RTM-T)}{(RTM-RTO)} \qquad \text{Eqn 10}$$

$$X=\frac{Z^2*\left(1+\left(1+\frac{40}{Y}\right)^{0.5}\right)^2}{400} \qquad \text{Eqn 11}$$

$$Z=ln(RQ)*(RTM-RTO) \qquad \text{Eqn 12}$$

$$Y=ln(RQ)*(RTM-RTO+2) \qquad \text{Eqn 13}$$

And where:

ln (RQ) = natural log of the Q_{10} rate;
RTM = maximum lethal water temperature (°Celsius);
RTO = optimum temperature for respiration (° Celsius); and
RQ = approximate Q_{10} rate.

Q10 was determined by the equation:

$$Q_{10}=\frac{R_{(T+10)}}{T_{t°}} \qquad \text{Eqn 14}$$

Where:

R_T = mass specific metabolic rate at a given temperature; and
$R_{(T+10)}$ = mass specific metabolic rate 10° C greater than the initial temperature.

Consumption rate is an estimate of the proportion of maximum daily ration for a fish at a given temperature and weight. It was determined by the consumption function:

$$C=\alpha M^{\beta} f(T) \qquad \text{Eqn 15}$$

Where:

α = the intercept of the allometric mass function;
M = mass of the fish (g);
$^{\beta}$ = the slope of the allometric function;
f (T) = dome shaped temperature function; and
F (T) is defined in Equation 16:

$$f(T)=\left[(max\text{-}T)(T_{max}\text{-}T_{optR})^{-1}\right]^{\left\{<0.125\left[z^{2}\sqrt{(1+40y^{-1})}\right]^{2}\right\}} e^{\left\{<0.125\left[z^{2}\sqrt{(1+40y^{-1})}\right]^{2}\right\}\left[(T_{max}\text{-}T)(T_{lmax}\text{-}T_{optR})^{-1}\right]} \qquad \text{Eqn16}$$

Where:

T = water temperature;
T_{max}= maximum water temperature above which consumption stops;
T_{opt} = optimum temperature for maximum food consumption; and
Z and Y are defined by the equations:

$$Z= ln(CQ)\ (T_{max\text{-}}T_{opt}) \qquad \text{Eqn 17}$$

$$Y= ln(CQ)\ (T_{max\text{-}}T_{opt}+2) \qquad \text{Eqn 18}$$

Where:

CQ = the Q_{10} rate for consumption (Paakkonen et al. 2003);
ln (CQ) = natural log of the Q_{10} consumption rate;
T_{max}= maximum water temperature above which consumption stops;
Topt = optimum temperature for maximum food consumption.

Metabolic rates can be either absolute metabolic rates or mass–specific metabolic rates, based on mass of the individual. The relationship between the two are best described by the equations:

$$R=aM^{b} \qquad \text{Eqn 19}$$

or

$$\log(R) =b \log(M) +\log(a) \qquad \text{Eqn 20}$$

Where:

R = metabolic rate;
M = mass;
a = intercept of the allometric mass function (Xiaojun and Ruyung 1990); and
b= slope of the allometric mass function.

A log transformed relationship was analyzed using linear regression. The relationship between absolute metabolic rates and mass specific metabolic rates with temperature was described by the equations:

$$R_1 = A(T)^B \quad \text{Eqn 21}$$

or

$$\log(R_1) = B(T) + \log(A) \quad \text{Eqn 22}$$

Where:

R = metabolic rate;
M = mass;
a = intercept of the allometric mass function; and
b= slope of the allometric mass function.

The semi–logarithmic transformation can then be analyzed using linear regression.

Temperature Data

We deployed Hobo temperature loggers set on the surface and bottom at three locations (Keller Park Campground, the middle and the mouth of the San Poil River) to collect temperature data. These loggers were set up for the duration of the study (June to mid–November) and downloaded at approximately monthly intervals. This enabled us to determine the thermal experience of the predators, which is an important input variable to the bioenergetics model because consumption rates, metabolic rates, and excretion rates increase as temperature increases. To supplement this data, we also randomly took temperature samples while collecting fish. Moreover, we compared temperatures with the Spokane Tribe as well as USGS and the Department of Ecology to check precision of the temperatures. For days that we did not collect field samples or have the HOBO loggers in place, we averaged temperature data from these other sources. Daily temperatures used in bioenergetics modeling are recorded in Table 6.

Caloric Densities of Prey

We determined energy density for prey items in joules / g wet mass by perusing the literature for values. For species we couldn't find in literature, we used the given software values. The Wisconsin Bioenergetics Model 3.0 Appendix 2 has values to use for many types of prey organisms provided in the model software manual. The energy densities we used in the software are in Table 7. After finding individual consumption rates as well as population estimates, we scaled consumption to the population– level and determined the percentage of hatchery kokanee and wild rainbow migrating down the Sanpoil River that were consumed in 2009. We did this by first defining the number of rainbow and kokanee consumed per individual walleye and smallmouth bass, and multiplying that consumption rate by the population of salmonid–eating smallmouth and walleye.

Population Estimation

The computer program CAPTURE was used to estimate walleye and smallmouth bass population sizes, standard errors, ± 95 % confidence intervals, and goodness–of–fit values from mark/recapture data collected in the field (Otis et al. 1978; White et al. 1982; Chao 1989; Rexstad and Burnham 1991). Every CAPTURE model has a different set of assumptions. The general assumptions for capture/recapture models are:

1. The population is closed. No fish can move into or out of the study area, additionally there are no births and no mortality (or mortality can be estimated) for the duration of the marking and recapturing.
2. Marks are not lost throughout the sampling period;
3. Every animal has an equal and constant chance of being captured. For example, capture doesn't affect the subsequent catachability of the animal, e.g. by causing behavioral avoidance or by being attracted to certain kinds of fishing gear. Mortality of marked fish should be equal to that of unmarked fish.

Equal catchability was determined using the CAPTURE program's model selection procedure (Otis et al. 1978; White et al. 1982). CAPTURE has the ability to select the most appropriate model of 11 choices, arranged to compensate for heterogeneity in capture probabilities. The CAPTURE program also helped us ascertain the best model to use for estimating the populations because it evaluates how well our data met the assumptions of various models used for estimating populations. The models are: Mo, the null model which assumes there are no

Table 6. Temperatures (C °) used in bioenergetic modeling for period from 27 May (day 1) to 9 September (day 152).

Day	Temp (C °)	Day	Temp (C °)	Day	Temp (C °)	Day	Temp (C °)
1	18.00	39	17.83	77	23.31	115	21.04
2	18.00	40	18.88	78	23.20	116	20.79
3	18.00	41	19.02	79	23.22	117	20.69
4	18.00	42	18.62	80	22.97	118	20.67
5	18.00	43	17.76	81	23.50	119	20.66
6	18.00	44	18.07	82	23.82	120	20.64
7	18.00	45	17.59	83	23.82	121	20.70
8	18.00	46	17.50	84	23.59	122	20.83
9	18.00	47	16.95	85	23.44	123	20.96
10	18.00	48	17.37	86	23.36	124	20.94
11	18.00	49	18.85	87	23.39	125	21.06
12	18.00	50	19.97	88	23.31	126	21.01
13	18.00	51	20.96	89	23.08	127	20.76
14	18.00	52	21.25	90	23.09	128	20.45
15	18.00	53	20.99	91	22.69	129	20.25
16	18.00	54	20.26	92	21.92	130	20.14
17	17.83	55	19.87	93	21.89	131	2<0.1
18	17.83	56	20.63	94	21.67	132	20.18
19	17.83	57	20.34	95	21.81	133	20.19
20	17.83	58	20.13	96	21.93	134	20.12
21	17.83	59	20.38	97	22.16	135	19.90
22	17.83	60	20.36	98	22.53	136	19.67
23	17.83	61	20.20	99	22.51	137	19.57
24	17.83	62	2<0.1	100	22.42	138	19.34
25	17.83	63	20.14	101	22.07	139	19.24
26	17.83	64	20.56	102	21.89	140	19.22
27	17.83	65	20.83	103	21.75	141	18.95
28	17.83	66	19.87	104	21.68	142	18.66
29	17.83	67	20.42	105	21.67	143	18.57
30	17.83	68	21.25	106	22.04	144	18.47
31	17.83	69	22.18	107	22.18	145	18.35
32	17.83	70	21.21	108	22.29	146	18.28
33	17.83	71	20.83	109	22.26	147	18.09
34	17.83	72	21.06	110	22.57	148	17.93
35	17.83	73	21.88	111	22.49	149	17.73
36	17.83	74	22.71	112	22.05	150	17.53
37	17.83	75	23.33	113	21.85	151	17.36
38	17.83	76	23.34	114	21.41	152	17.26

Table 7. Table of energy densities (Joules / gram) used in bioenergetic modeling.

Class	Order	Family	Genus species	Common name	Energy density	Reference
Actinopterygii	Fishes (misc.)			Ray finned fish misc.	6,250	Cummins K.W. & J.C. Wuycheck (1971)
Actinopterygii	Non–Salmoniformes (misc.)			Non salmonid fishes	4,602	Pope et al. (2001)
Actinopterygii	Cypriniformes	Cyprinidae		Minnows	5,218	Baldwin et al. (2000)
Actinopterygii	Cypriniformes	Cyprinidae	*Cyprinus carpio*	Common carp	5,218	Baldwin et al. (2000)
Actinopterygii	Cypriniformes	Cyprinidae	*P.oregonensis*	Northern pikeminnow	5,218	Baldwin et al. (2000)
Actinopterygii	Gadiformes	Gadidae	*Lota lota*	Burbot	5,125	Johnson et al. (1999)
Actinopterygii	Perciformes	Centrachidae	*M.dolomieu*	Smallmouth bass	5,475	Liao et al (2004)
Actinopterygii	Perciformes	Centrachidae	*P.nigromaculatus*	Black crappie	4,853	Pope et al. (2001)
Actinopterygii	Perciformes	Percidae	*Perca flavescens*	Yellow perch	2,512	Hanson et al. (1997)
Actinopterygii	Perciformes	Percidae		Perch family misc.	5,000	Craig (1977)
Actinopterygii	Salmoniformes	Salmonidae		Salmonid family misc.	4,510	Antolos et al. (2005)
Actinopterygii	Salmoniformes	Salmonidae	*O.mykiss*	Rainbow trout	5,727	Cummins K.W. & J.C. Wuycheck (1971)
Actinopterygii	Salmoniformes	Salmonidae	*O.nerka*	Kokanee	5,333	Beauchamp et al. (1989)
Actinopterygii	Scorpaeniformes	Cottidae		Sculpin misc.	4,532	Moss (2001)
Actinopterygii	Scorpaeniformes	Cottidae	*Cottus asper*	Prickly sculpin	4,532	Moss (2001)
Actinopterygii	Scorpaeniformes	Cottidae	*Cottus bairdi*	Mottled sculpin	4,532	Moss (2001)
Actinopterygii	Scorpaeniformes	Cottidae	*Cottus confusus*	Shorthead sculpin	4,532	Moss (2001)
Actinopterygii	Scorpaeniformes			Scorpaeniformes misc.	4,857	Bryan et al. (1996)
Arachnida	Araneae			Spiders	4,184	Beauchamp and VanTassell (2001)
Branchiopoda	(misc.)			Crustacean misc.	2,930	Cummins and Wuycheck (1971)
Branchiopoda	Cladocera	Daphniidae	*Daphnia spp.*	Daphnia	3,800	Beauchamp et al. (1995)
Branchiopoda	Cladocera	Leptodoridae	*Leptodora kindtii*	Leptodora	900	Cummins and Wuycheck (1971)
Ostracoda				Seed shrimp	4,396	Pope et al. (2001)
Insecta	(misc.)			Insect misc.	4,396	Pope et al. (2001)
Insecta	Coleoptera			Beetles	5,648	Tabor et al. (2004)
Insecta	Diptera	Chironomidae	(adult)	Chironomidae adult	2,744	Cummins K.W. & J.C. Wuycheck (1971)
Insecta	Diptera	Chironomidae	(Larval)	Chironomidae larva	4,902	Cummins K.W. & J.C. Wuycheck (1971)
Insecta	Diptera	Chironomidae	(Pupal)	Chironomidae (pupa)	2,744	Cummins K.W. & J.C. Wuycheck (1971)
Insecta	Diptera	Chironomidae		Chironomidae misc.	5,648	Roell and Orth (1993)
Insecta	Diptera	(misc.)		True fly misc.	1,500	Hewett and Johnson 1992
Insecta	Ephemeroptera			Mayfly	4,710	Cummins K.W. & J.C. Wuycheck (1971)
Insecta	Hemiptera			Grasshoppers /crickets / katydids	4,605	Pope et al. (2001)
Insecta	Hymenoptera	(misc.)		Bees/ Ants/ Wasps	5,648	Roell and Orth (1993)
Insecta	Hymenoptera	Formicidae		Ants	5,648	Roell and Orth (1993)
Insecta	Odonata			Dragonflies	4,396	Cummins K.W. & J.C. Wuycheck (1971)
Insecta	Orthoptera			Insects with paurometabolous	5,648	Roell and Orth (1993)
Insecta	Plecoptera			Stoneflies	5,648	Roell and Orth (1993)
Insecta	Raphidioptera			Snakeflies	5,648	Roell and Orth (1993)
Insecta	Trichoptera	(adult)		Caddisfly adult	5,648	Roell and Orth (1993)
Insecta	Trichoptera	(nymph)		Caddisfly nymph	5,648	Roell and Orth (1993)
Malacostraca	Amphipoda			Scud	2,930	Cummins K.W. & J.C. Wuycheck (1971)
Malacostraca	Decapoda			Crayfish	2,963	Cummins K.W. & J.C. Wuycheck (1971)
Other invertebrates	(misc.)			Invertebrates misc.	2,930	Cummins K.W. & J.C. Wuycheck (1971)
Phylum Annelida	(misc.)			Segmented worms	5,648	Tabor et al. (2004)

effects on recapture probabilities; Mb, which accounts for differences in behavior for individuals within the population; Mt, which deals with differences in capture methods or environmental conditions, such as day and night; M_h which accounts for differences in individual differences in capture rate, trap accessibility based on sex, territory, age, dominance, etc.; and all of the possible combinations of these main models (M_{tb}, M_{th}, M_{bh}, M_{tb} and M_{tbh}). It also models a removal method, and two bias–corrected estimators. All the models are designed to relax the assumptions of equal catchability.

Schnabel's (1938) approximation to the maximum likelihood estimator of population (N) from multiple census (Ricker 1975), as adjusted by Chapman (1952, 1954) was used to determine which model was selected

$$N = \sum_{i=1}^{n} \frac{C_i M_i}{R+1}$$

Where:

N= the estimated population;
m = the number of marking periods;
M_i = total marked fish at the start of the ith sampling period;
C_i = total number of fish captured in period I (recaptured fish + unmarked fish);
R_i = number of recaptures in sample C_i; and
R = sum of R_i total recaptures during the study.

We used the Peterson estimator to estimate N, which is adjusted for bias (Ricker 1975; Seber 1982):

$$N = \frac{(C_i + 1)(M_i + 1)}{(R_i + 1)}$$

Where:

N= the estimated population;
m = the number of marking periods;
M_i = total marked fish at the start of the $_i$th sampling period;
C_i = total number of fish (recaptured fish + unmarked fish) captured in period I;
R_i = number of recaptures in sample C_i; and
R = sum of R_i total recaptures during the study.

The 95 % confidence limits of this estimate were calculated using the following formula:

$$SE\ (N) = \frac{N\ (N-M_i)\ (N-C_i)}{(M_i C_i)\ (N-1)}$$

Where:

N= the estimated population;
m = the number of marking periods;
M_i = total marked fish at the start of the $_i$th sampling period;

C_i = total number of fish (recaptured fish + unmarked fish) captured in period I;
R_i = number of recaptures in sample C_i; and
R = sum of R_i total recaptures during the study.

The 95 % confidence intervals were defined by:

$$95\%\ C.I. = 1.96 \times SE(N)$$

Where:

95 % C.I. = 95 % confidence interval; and
SE = standard error.

We calculated mortality in an individual cohort using a simple exponential decay model:

$$Nt = N_o e^{-mt}$$

Where:

N_o and N_t = the number of fish at time 0 and time t; and
m = the total daily instantaneous mortality rate that occurred in the population.

The population of each age class of walleye and smallmouth bass was determined by calculating the percentage of fish in each age of the walleye and smallmouth bass age length frequency distributions, and multiplying this percentage by the estimated populations.

Calculating the Percent of Salmonids Consumed

Weight percentage of prey items were input into Wisconsin Fish Bioenergetics 3.0. Salmonid consumption rates per day were determined ($Sal_{g,day}$). These values were summed for rainbow trout and kokanee over the simulation period, 27 May to 7 July (42 days), to determine the weight of salmonids eaten per individual predator ($Sal_{g,ind}$).

$$Sal_{g,ind} = Sal_{g,day1} + Sal_{g,day2} + Sal_{g,day3} \cdots Sal_{g,day42}$$

Total predator population estimates were split into two categories: predators large enough to eat salmonids ($Pred_{lrg}$), and those that were too small ($Pred_{sml}$). There were separate stratifications for each predator species based on rainbow trout and kokanee salmon sizes.

$$\text{Total predator pop.} = Pred_{lrg} + Pred_{sml}$$

Individual predator salmonid consumption ($Salg_{g,ind}$) values were multiplied by the percent of the predator population large enough to eat them ($Pred_{lrg}$) to determine total weight of salmonids consumed by predator populations ($Sal_{g,pop}$):

$$Sal_{g,pop} = Sal_{g,ind} \times Pred_{lrg}$$

Total numbers of salmonids eaten ($Sal_{n,pop}$) were calculated by dividing the total weight of salmonids consumed by predator populations ($Sal_{g,pop}$) by the average weight of rainbow and kokanee found in their stomachs (Wt_{sal}).

$$Sal_{n,pop} = \frac{Sal_{g,pop}}{Wt_{Sal}}$$

Finally, the total percent of consumed salmonids were calculated by dividing the number of salmonids consumed by predator populations ($Sal_{n,pop}$) values by the estimated population sizes of rainbow trout and kokanee salmon (Pop_{Sal})

$$\%\ \text{Salmonids Consumed} = \frac{Sal_{n,pop}}{Pop_{Sal}}$$

RESULTS

Field Collection

Rotary Screw Trap

The screw trap was in operation for 39 days between March 31, 2009 and July 2, 2009. Flows ranged from 67 – 423 cfs from the July to April sampling period. Rainbow trout captures peaked April 30, 2009 (n = 105) a week after peak flows; however, higher flows did not correspond with higher catch rates as is typical in other systems (Figure 2). Trap monitoring was limited during the week of June 8, 2009 so fish accumulated in the trap for several days, which explains the spike in rainbow trout outmigrating on June 11, 2009. Meadow Creek kokanee fry (n = 582,140, 1–3 g) were raised at the Spokane Tribal Hatcheries and released in the West Fork Sanpoil River on June 9–10, 2009. A total of 1,233 kokanee were captured in the RST from 16 June to 23 June (Figure 3). Eighty–nine percent (1,103) were captured June 17–18, 2009.

A total of 1,189 rainbow trout and 1,233 kokanee salmon were captured in the RST in 2009. Efficiency trial of marked/recaptured rainbow trout established a 12.4 % (22 of 177 rainbow trout) efficiency of the rotary screw trap. Rainbow trout caught in the trap were marked by cutting a notch in the caudal fin, released 0.5 km above the trap and later recaptured in the trap. Since the trap captured 1,189 rainbow trout, this resulted in a population estimate of 22,095 (95 % CI = 15,685 – 37,367). In other words, 177 of 22,095 (0.8%) rainbow trout were marked. From this, a daily population estimate was created. The daily estimates were averaged and multiplied by the number of days in each month to determine monthly estimates. From this, an approximate population size for the entire period based on these averages (± 95 % CI) was 22,095 (15,685 – 37,367) (Table 8). Based on simple mark/recapture technique, the estimated population size (± 95 % CI) of kokanee salmon for the period was 10,283 (4,925 – 15,641) (Table 10).

On average, kokanee (n = 1,233) caught in the screw trap measured (± SD) 60 (24 – 87) mm TL and weighed (± SD) 1.1 (1.0 – 3.0) g in weight (Table 9). Rainbow trout (n = 1,189) caught in the screw trap averaged (ranged) 137 (33 – 275) mm and 27 (1 – 153) g in weight (Table 9). Most of the rainbow trout were either age 1 (n = 507) or age 2 (n = 512) smolts. Age 1 rainbow smolts averaged (ranged) 106 (76 – 130) mm TL and 10 (2 – 26)

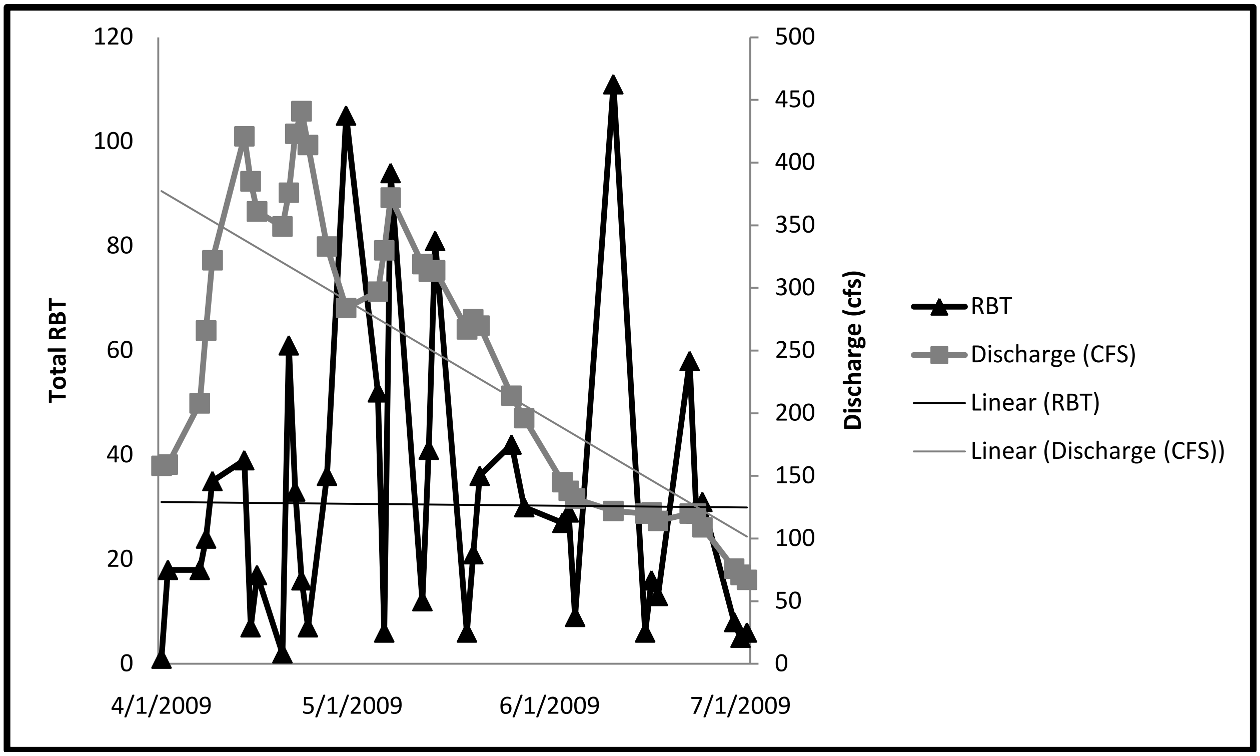

Figure 2. Comparisons between rainbow trout captured and discharge (cubic feet per second) from April 1, 2009 to July 2, 2009 with linear trend lines.

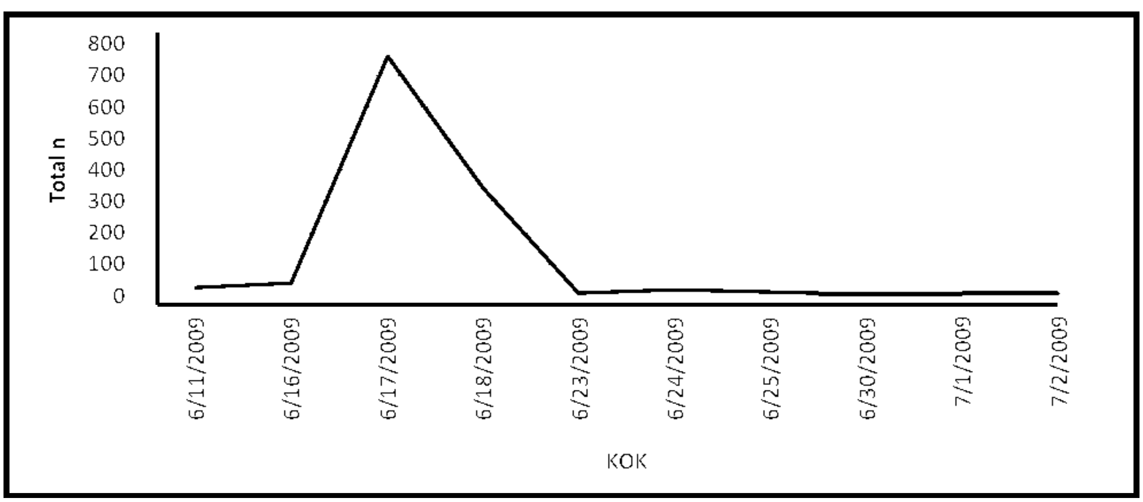

Figure 3. Number of kokanee collected by day in the rotary screw trap.

Table 8. Population estimates and lower and upper 95% confidence intervals (95 % CI) for rainbow trout based on a trap efficiency of 12.4 %.

Month	Population Estimate	Lower 95 % CI	Upper 95 % CI
April	5,736	4,072	9,701
May	9,204	6,534	15,565
June	7,155	5,079	12,101
Total	**22,095**	**15,685**	**37,367**

*Adjusted estimates are based on daily averages that are extrapolated to monthly totals. The total represents an approximate population estimate for the entire migration (April – June).

Table 9. Hatchery release, total catch, trap efficacy, population estimates, and 95% confidence intervals for kokanee salmon.

Released	Total Catch	Trap Eff.	Pop. Estimate	Lower 95% CI	Upper 95% CI	Method/Source
582,140	1,233	35%	3,526	2,406	4,645	Humble et al. (2006)
582,140	1,233	12%*	10,283	4,925	15,641	Mathews and Bocking (2007)
582,140	1,233	40%	3,054	2,168	4,002	Mathews and Bocking (2009)

*Population estimates for kokanee salmon were based on a 12 % RST trapping efficiency.

Table 10. Total number, average, minimum and maximum length and weight data for kokanee and rainbow trout in the Sanpoil River.

Species	#	Avg. TL (mm)	Min. TL (mm)	Max. TL (mm)	Avg. Wt (g)	Min. Wt. (g)	Max. Wt. (g)
KOK	1,233	59.8	24	87	1.1*	1	3
RBT (total)	1,189	136.6	33	275	27.0	1	153
RBT (Age 1)	507	106.0	76	130	9.7*	2	26
RBT (Age2)	512	161.6	131	200	38.8	16	85

* Values used as average weights of kokanee salmon and rainbow trout consumed, input in bioenergetics modeling.

g in weight. Age 2 rainbow smolts averaged (ranged) 162 (131 – 200) mm TL and 39 (69 – 83) g in weight.

Electrofishing, Gill netting, and Fyke netting Surveys

Total numbers of fish captured from 27 May to 9 September, are summarized in Table 11, Table 12, and Table 13) for electrofishing, gill netting and fyke netting, respectively. A total of 6,398 fish were captured by electrofishing, 254 by gill netting, and 16 by fyke netting. A total of 4,209 and 674 smallmouth bass and walleye were marked with elastomer throughout the study period; whereas 573 and 581 received a combination of elastomer and a Floy tag. We recaptured 248 (5.3 % of 4,714 captured) and 11 (1.2 % of 916 captured) smallmouth bass and walleye marked with elastomer. We recaptured 35 (0.72 % of 4,714 captured) and 11 (1.2 % of 916 captured) smallmouth bass and walleye marked with a combination of elastomer and Floy tags.

Laboratory Analysis

Age and Growth

The mean (± SD) TL (mm), weight (g), and condition factor (K_{TL}) for each age class of smallmouth bass (n = 4,711) was recorded on Table 14. Smallmouth bass length/weight relationships are shown in Figure 4, a log transformed figure of $\log_{10}$ length and weight is found in Figure 5. Weight gain was described by the equation $y=1E05x^{3.0001}$. (R^2 = 0.958). Figure 6 indicates that weight was added geometrically per increment of length gain. A linear regression line was plotted to determine the length of the fish when the scale was laid down (R^2 = 0.9493). The point where the regression line passed through the y-axis was used to determine the value (37.5 mm) for smallmouth bass. Backcalculated total lengths of smallmouth bass (n = 725) at annulus formation averaged 100 mm (age 1), 157 mm (age 2), 201 mm (age 3), 234 mm (age 4), 263 mm (age 5), 291 mm (age 6), 325 mm (age 7), 366 mm (age 8), 399 mm (age 9), 428 mm (age 10) and 433 mm (age 11). An age/length frequency key was constructed by aging 654 scales and using them to assign ages to 4,060 smallmouth bass that we did not collect scales from. Age 1 fish (n = 3,752) ranged from 60 – 150 mm TL. Age 2 fish (n = 338) ranged from 150 – 210 mm TL. Age 3 fish (n = 222) ranged from 200 – 250 mm TL. Age 4 fish (n = 172) ranged from 220 – 280 mm TL. Age 5 fish (n = 75) ranged from 260 – 290 mm TL. Age 6 fish (n = 47) ranged from 280 – 300 mm TL. Age 7 fish (n = 48) ranged from 300 – 380 mm TL. Age 8 fish (n = 16) ranged from

Table 11. Scientific and common names of species electroshocked (60 h) in our research, with average lengths (mm) from N (TL) fish sampled, weights (g) from N (Wt) fish sampled, relative abundance and catch–per–unit–effort (per hr) values per species.

Family	Scientific Name	Common Name	N (TL)	TL (range)	N (Wt.)	Wt (range)	RA (%)	CPUE
Cyprinidae								
	Cyprinus carpio	carp	51	382 (75-923)	44	3,038 (6-14,600)	0.8%	0.9
	Ptychocheilus oregonensis	northern pikeminnow	224	214 (52-560)	208	217 (1-1,750)	3.5%	3.7
	Tinca tinca	tench	1	546 (546-546)	1	2,488 (2,488-2,488)	<0.1%	<0.1
	Mylocheilus caurinus	peamouth	1	17 (17-17)	1	1 (1-1)	<0.1%	<0.1
Catostomidae								
	Catostomus catostomus	longnose sucker	3	180 (150-220)	3	65 (33-110)	<0.1%	0.1
	Catostomus columbianus	bridgelip sucker	4	171 (106-301)	3	123 (5-346)	0.1%	0.1
	Catostomus macrocheilus	largescale sucker	66	333 (84-629)	60	752 (7-2750)	1.0%	1.1
Ictaluridae								
	Ameiurus nebulosus	brown bullhead	8	269 (74-355)	6	593 (483-724)	0.1%	0.1
Salmonidae								
	Oncorhynchus mykiss	rainbow trout	364	197 (30-1668)	310	86 (2-1373)	5.7%	6.1
	Onchorhynchus nerka	kokanee	28	246 (42-591)	27	1,102 (1-2090)	0.4%	0.5
	Prosopium williamsoni	mountain shitefish	4	241 (217-312)	4	165 (86-379)	0.1%	0.1
	Salvelinus fontinalis	brook trout	1	168 (168-168)	1	48 (48-48)	<0.1%	<0.1
Lotidae								
	Lota lota	burbot	8	232 (145-495)	8	101 (15-481)	0.1%	0.1
Cottidae								
	Cottus asper	prickly sculpin	28	63 (51-79)	28	2 (1-6)	0.4%	0.5
	Cottus bairdii	mottled sculpin	33	70 (52-101)	33	4 (1-12)	0.5%	0.6
	Cottus confusus	shorthead sculpin	30	55 (15-75)	30	2 (1-4)	0.5%	0.5
Centrachidae								
	Micropterus dolomieu	smallmouth bass	4,624	127 (11-515)	2,805	63 (1-1,785)	72.3%	77.1
	Micropterus salmoides	largemouth bass	2	477 (458-495)	2	1,830 (1,680-1,980)	<0.1%	<0.1
	Pomoxis nigromaculatus	black crappie	16	145 (50-335)	7	277 (2-527)	0.3%	0.3
Percidae								
	Perca flavescens	yellow perch	125	99 (42-304)	75	34 (1-465)	2.0%	2.1
	Sander vitreus	walleye	777	268 (32-745)	755	255 (1-3920)	12.1%	13.0
Grand total			**6,398**				**100.0%**	**106.6**

Table 12. Species gill–netted (n = 64 h) in our research, with average lengths (mm) from N (TL) fish sampled, weights (g) from N (Wt) fish sampled, relative abundance and catch–per–unit–effort (per net set) values per species.

Family	Scientific Name	Common Name	N (TL)	TL (range)	N (Wt)	Wt (range)	RA (%)	CPUE
Cyprinidae	*Ptychocheilus oregonensis*	northern pikeminnow	14	442 (297-538)	13	870 (554-1,302)	5.5%	0.2
Catostomidae	*Catostomus macrocheilus*	largescale sucker	3	463 (448-480)	3	1,187 (1,138-1,284)	1.2%	<0.1
Salmonidae	*Oncorhynchus mykiss*	rainbow trout	3	482 (445-545)	1	868 (868-868)	1.2%	<0.1
Centrachidae	*Micropterus dolomieu*	smallmouth bass	87	277 (160-461)	57	333 (85-1,390)	34.3%	1.4
Percidae	*Perca flavescens*	yellow perch	9	251 (181-325)	4	354 (263-428)	3.5%	0.1
Percidae	*Sander vitreus*	walleye	138	319 (113-567)	114	277 (15-644)	54.3%	2.2
Total			**254**				**100.0%**	**4.0**

Table 13. Scientific and common names of species fyke–netted (n = 72 h) in our research, with average lengths (mm) from N (TL) fish sampled, weights (g) from N (Wt) fish sampled, relative abundance and catch–per–unit–effort (per net set) values per species.

Family	Scientific Name	Common Name	N (TL)	TL (range)	N (Wt)	Wt (range)	RA (%)	CPUE
Cyprinidae	*Ptychocheilus oregonensis*	northern pikeminnow	9	431 (300-861)	9	499 (262-833)	56.3%	0.1
Centrachidae	*Micropterus dolomieu*	smallmouth bass	4	295 (283-302)	4	361 (318-416)	25.0%	<0.1
Percidae	*Sander vitreus*	walleye	2	369 (243-402)	2	431 (316-546)	12.5%	<0.1
Catostomidae	*Catostomus macrocheilus*	Largescale sucker	1	566 (566-566)	0	--	6.2%	<0.1
Total			**16**				**100.0%**	**0.2**

Table 14. Smallmouth bass (n = 744) mean total length (± SD) (mm), weight (± SD) (g) and condition factor (KTL) (± SD) for each age class of smallmouth bass. n = # in sample.

Annulus	n	Avg. length (± SD)	Avg. Growth	Avg. wt. (± SD)	K_{TL} (± SD)
1	252	106 ± 24	106	18 ± 18	1.27 ± 0.73
2	145	172 ± 13	66	69 ± 19	1.34 ± 0.19
3	103	217 ± 11	45	132 ± 23	1.28 ± 0.11
4	79	246 ± 9	29	197 ± 43	1.34 ± 0.19
5	49	269 ± 5	23	259 ± 33	1.33 ± 0.16
6	34	283 ± 4	14	303 ± 38	1.34 ± 0.15
7	30	297 ± 5	14	352 ± 51	1.34 ± 0.23
8	15	315 ± 6	18	418 ± 83	1.32 ± 0.21
9	13	347 ± 19	32	527 ± 126	1.51 ± 0.21
10	4	358 ± 7	11	624 ± 132	1.37 ± 0.36
11	1	366 ± —	8	669 ± —	1.27 ± —

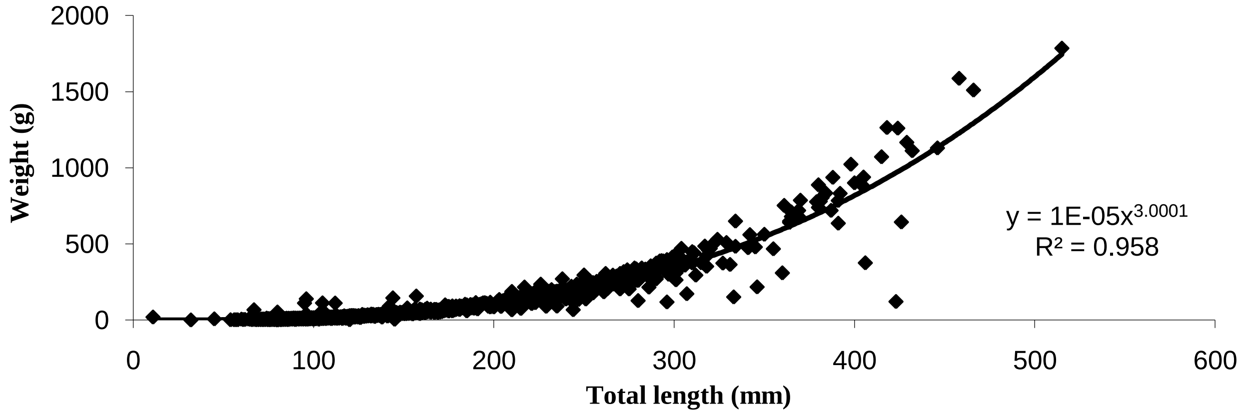

Figure 4. Smallmouth bass total length compared to total weight

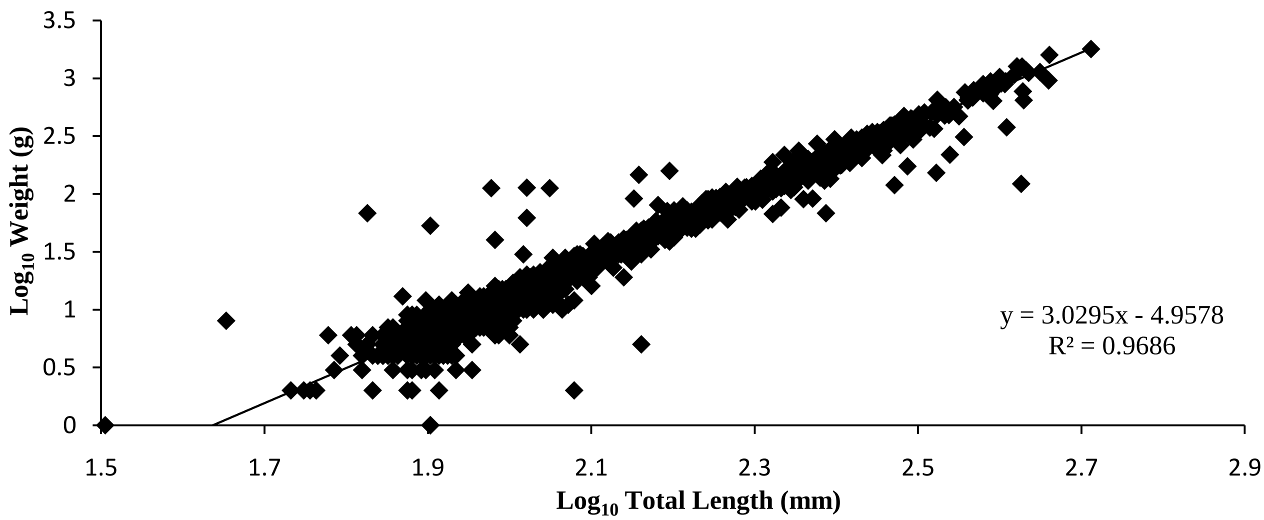

Figure 5. Smallmouth bass (n = 747) $\log_{10}$ total length to weight regression.

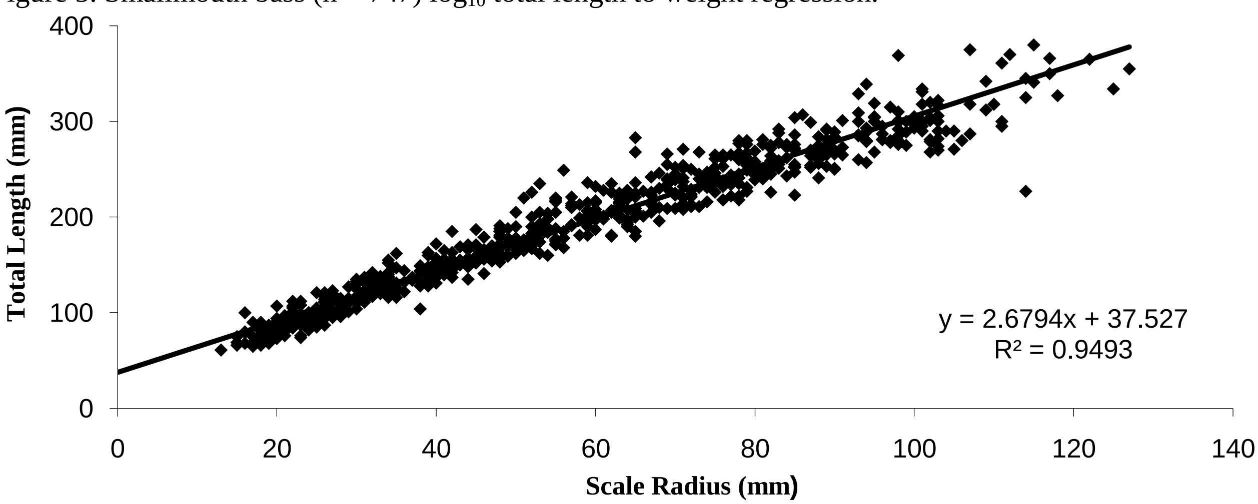

Figure 6. Smallmouth bass total length compared to scale length

330 – 390 mm TL. Age 9 fish (n = 19) ranged from 360 – 460 mm TL. Age 10 fish (n = 3) ranged from 420 – 470 mm TL. Age 11 fish (n = 1) was 450 mm TL. Tagged smallmouth (n = 258) grew an average of 0.58 g weight and 1.03 mm TL per day (See appendix III, Table A1) each day at large (2 – 43 days) between the day of initial capture and the day of recapture, which comported well with the length and weight gains in each year class (Table 14).

The mean (± SD) TL (mm), weight (g), and condition factor (K_{TL}) for each age class of walleye (n = 916) was recorded on Table 17. Figure 8 indicates that weight is added geometrically per increment of length gain, it's a $\log_{10}$ plot of weights -vs- total length. Weight gain per unit length gain is described by the equation $y=3E\text{-}05x^{2.7519}$, ($R^2 = 0.9666$). Figure 9 shows the total length at time of capture -vs- scale radius at capture. A linear regression line was plotted to determine the value for the length of the fish when the scale is laid down ($R^2 = 0.905$). The point when the regression line passed through the y–axis was used to determine this value (49.75 mm) for walleye. Back-calculated total length of walleye (n = 571) at annulus formation averaged 192 mm (age 1), 281 mm (age 2), 383 mm (age 3), 444 mm (age 4), 501 mm (age 5), 563 mm (age 6), 634 mm (age 7), 680 mm (age 8), and 731 mm (age 9). For the age/length frequency distribution, 595 scales were aged to estimate the ages of 916 walleye (Table 19). The age/length frequency distribution compiled for 916 total fish provided data that walleye at age 0 (n = 77) ranged from 30– 110 mm TL, at age 1 (n = 401) ranged from 160 – 300 mm TL, at age 2 (n = 295) ranged from 230 – 420 mm TL, at age 3 (n = 93) ranged from 340 – 460 mm TL, at age 4 (n = 18) ranged from 380 – 490 mm TL, at age 5 (n = 11) ranged from 490 – 530 mm TL, at age 6 (n = 5) ranged from 530 – 590 mm TL, at age 7 (n =0), at age 8 (n = 1) was 680 mm TL, and at age 9 (n = 2) ranged from 740 – 750 mm TL. Tagged walleye (n = 27) grew at an average of 2.6 g weight and 0.9 mm TL per day for each day at large (2 – 144 days) between the day of initial capture and the day of recapture, which comported well with the length and weight gains in each year class.

Diet

Diet analysis for smallmouth bass and walleye were performed for smallmouth bass and walleye of all sizes

Table 15. Backcalculated total length (mm) of 11 cohorts of smallmouth bass (n = 725) at the formation of each annulus with the average (± SD) for all cohorts combined.

		Annulus Length (mm) per Cohort										
Cohort	**n**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
1998	1	110	168	206	235	275	315	345	369	403	419	443
1999	4	111 ± 3	166 ± 14	204 ± 15	240 ± 18	276 ± 26	316 ± 27	351 ± 31	383 ± 35	410 ± 32	431 ± 32	—
2000	13	115 ± 11	169 ± 20	208 ± 24	242 ± 27	273 ± 28	307 ± 29	340 ± 28	369 ± 27	395 ± 25	—	—
2001	15	108 ± 7	167 ± 5	203 ± 7	236 ± 9	269 ± 10	301 ± 12	332 ± 16	360 ± 18	—	—	—
2002	30	106 ± 7	157 ± 13	194 ± 14	228 ± 15	260 ± 18	287 ± 19	313 ± 22	—	—	—	—
2003	34	100 ± 4	157 ± 11	195 ± 11	229 ± 8	258 ± 7	283 ± 6	—	—	—	—	—
2004	49	103 ± 7	157 ± 13	198 ± 13	233 ± 12	263 ± 9	—	—	—	—	—	—
2005	79	104 ± 8	157 ± 11	202 ± 11	236 ± 10	—	—	—	—	—	—	—
2006	103	100 ± 8	157 ± 12	205 ± 12	—	—	—	—	—	—	—	—
2007	145	105 ± 7	154 ± 13	—	—	—	—	—	—	—	—	—
2008	252	93 ± 16	—	—	—	—	—	—	—	—	—	—
Average		**100 ± 12**	**157 ± 13**	**201 ± 13**	**234 ± 13**	**263 ± 14**	**291 ± 20**	**325 ± 26**	**366 ± 24**	**399 ± 26**	**428 ± 28**	**443**

Table 16. Age/length key for smallmouth bass (n = 4,714) including the number sampled in each 10 mm length group and the number in the subsample whose scales were collected for aging.

			Aged Smallmouth Bass										
TL	**# in sample**	**# (age) in subsample**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
10	1	–											
20	–	–											
30	1	–											
40	6	–											
50	8	–											
60	29	1(1)	29										
70	244	20(1)	244										
80	667	35(1)	667										
90	761	33(1)	761										
100	638	34(1)	638										
110	528	29(1)	528										
120	340	28(1)	340										
130	292	29(1)	292										
140	202	34(1)	202										
150	156	27(1)	51	105									
160	107	29(2)		107									
170	62	33(2)		62									
180	36	36(2)		36									
190	28	24(2)		28									
200	36	17(3)			36								
210	55	31(3)			55								
220	59	31(3), 2(4)			55	4							
230	69	15(3), 13(4)			37	32							
240	79	13(3), 16(4)			36	43							
250	45	2(3), 32(4)			3	42							
260	50	14(4), 3(5)				41	9						
270	39	6(4), 24(5)				7	32						
280	45	2(4), 23(5), 4(6)				3	32	10					
290	25	2(5), 19(6)					2	23					
300	28	10(6), 9(7)						15	13				
310	13	7(7)							13				
320	8	8(7)							8				
330	5	3(7), 2(8)							3	2			
340	5	2(7)							5				
350	2	1(7), 1(8)							1	1			
360	9	2(8), 1(9)								6	3		
370	2	1(7), 1(8)							1	1			
380	9	2(2), 4(8), 3(9)							2	4	3		
390	4	3(8), 1(9)								3	1		
400	6	3(9)									6		
410	2	–											
420	5	2(9), 1(10)									3	2	
430	1	1(9)									1		
440	1	–											
450	3	1(11)											3
460	2	1(9),1(10)									1	1	
470	–	–											
480	–	–											
490	–	–											
500	–	–											
510	1	–											
Total	**4,714**	**654**	**3,752**	**338**	**222**	**172**	**75**	**47**	**46**	**16**	**19**	**3**	**3**

How to read this table. # in sample indicates the number of fish collected in each 10 mm length group (59 fish collected in the 220 – 229 mm length group). The third column indicates fish that were aged, with age assigned in parenthesis. e.g. of the 59 fish in the 220 – 229 mm length class scales of 33 fish were aged, with 31 assigned age 3, and 2 assigned age 4. Thus, 31 of 33 fish (93.9 %) aged at age 3 and 2 of 33 fish (6.1 %) were aged at age 3. To assign ages to all fish in the length class 59 total fish in sample x 0.939 = 55 were assigned to age 3, and 59 x .061 = 4 were assigned to age 4.

Table 17. Walleye (n = 595) mean total length (± SD) (mm), weight (± SD) (g) and condition factor (± SD) (K_{TL}) for each age class of walleye. n = # in sample.

Annulus	n	Avg. length (± SD)	Avg. growth	Avg wt. (± SD)	K_{TL} (± SD)
0	24	83.2 ± 11	83.2	7.2 ± 2.8	1.25 ± 0.39
1	271	225 ± 30.6	141.8	98.5 ± 41.4	0.81 ± <0.1
2	206	343.3 ± 41.2	118.3	354.1 ± 142.6	0.84 ± 0.16
3	65	395.5 ± 27.9	52.2	523.6 ± 131.3	0.83 ± <0.1
4	17	455.8 ± 27	60.3	831.8 ± 194.5	0.86 ± 0.11
5	6	497.7 ± 15.2	41.9	934.8 ± 291.1	0.76 ± 0.25
6	3	561.3 ± 27.7	63.6	1,494.3 ± 644.5	0.82 ± 0.25
7	0	—	—	—	—
8	1	680 ± —	—	2,570 ± —	0.81 ± —
9	2	742.5 ± 3.5	62.5	3,560 ± 509.1	0.87 ± 0.11

Table 18. Backcalculated total length (mm) of 9 cohorts of walleye at the formation of each annulus with the average (± SD) for all cohorts combined.

		Annulus Length (mm) per Cohort								
Cohort	**n**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
2000	2	274 ± 6	360 ± 17	415 ± 28	470 ± 27	538 ± 19	584 ± 11	638 ± 4	688 ± 7	731 ± 1
2001	1	239	348	427	503	540	593	627	665	—
2002	0	—	—	—	—	—	—	—	—	—
2003	3	242 ± 27	309 ± 28	373 ± 20	431 ± 22	495 ± 13	540 ± 14	—	—	—
2004	6	246 ± 22	331 ± 29	402 ± 19	444 ± 8	486 ± 9	—	—	—	—
2005	17	227 ± 23	316 ± 43	389 ± 22	439 ± 20	—	—	—	—	—
2006	65	206 ± 18	278 ± 29	378 ± 25	—	—	—	—	—	—
2007	206	192 ± 18	277 ± 27	—	—	—	—	—	—	—
2008	271	185 ± 21	—	—	—	—	—		—	—
Average	**571**	**192 ± 23**	**281 ± 31**	**383 ± 26**	**444 ± 23**	**501 ± 25**	**563 ± 18**	**634 ± 7**	**680 ± 14**	**731 ± 1**

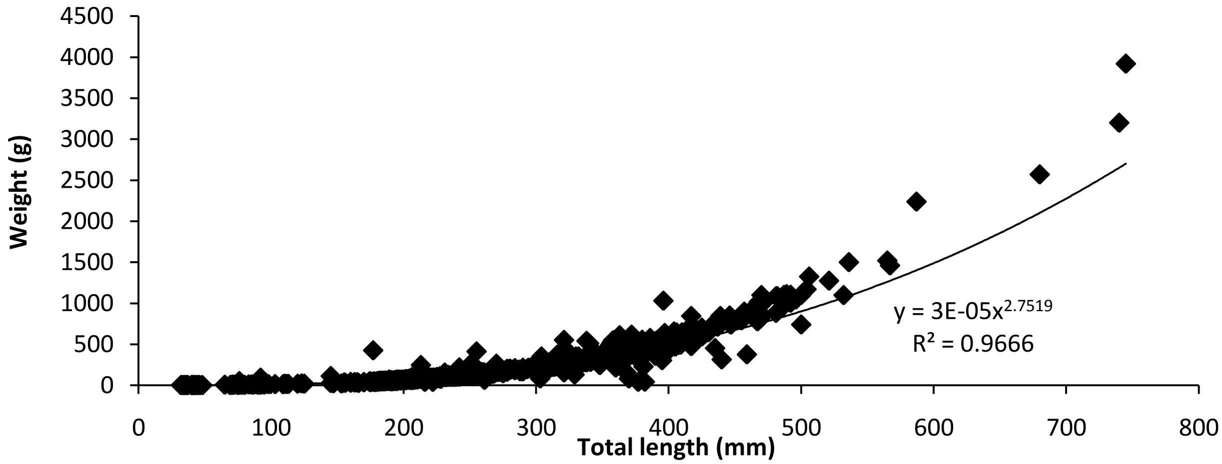

Figure 7. Walleye regression of total length (mm) to weight (g).

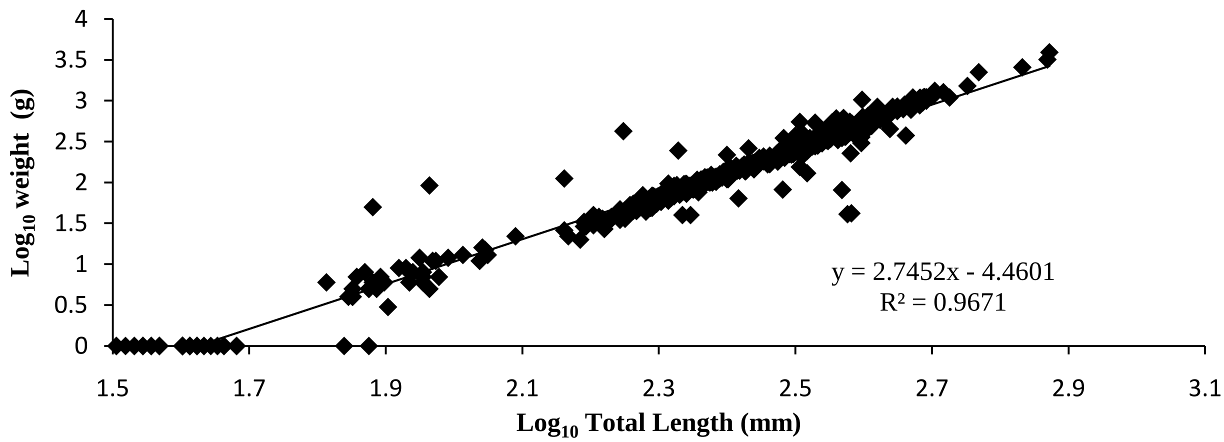

Figure 8. Walleye (n = 595) log_{10} weight to and length regression.

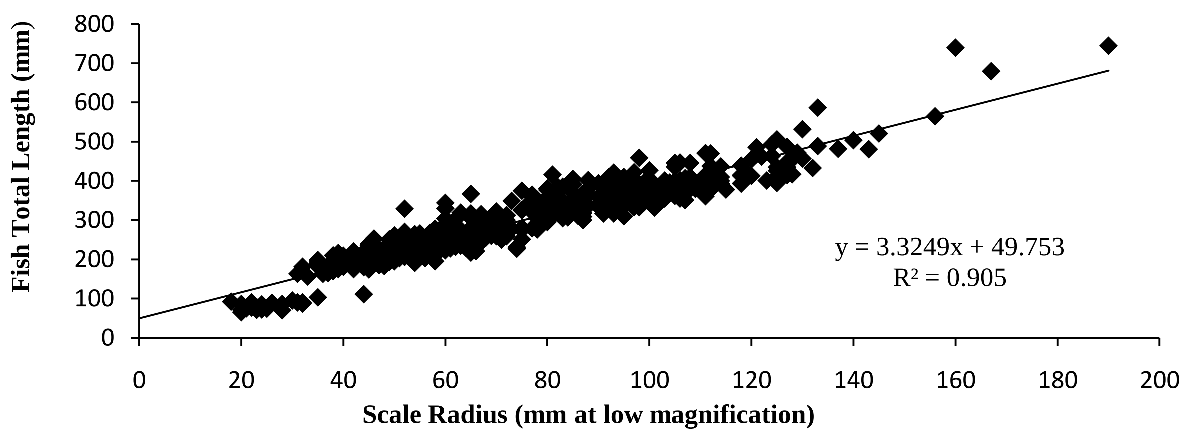

Figure 9. Walleye total length compared to scale length.

Table 19. Age/length key for walleye (n = 916) including the number sampled in each 10 mm length group and the number in the subsample whose scales were collected for aging.

			Sample allocated per age group									
TL	**# in sample**	**# (age) in subsample**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
30	14											
40	25											
50												
60	2											
70	14	6(0)	14									
80	9	6(0)	9									
90	9	9(0)	9									
100	2	2(0)	2									
110	4	1(0)	4									
120	3											
130												
140	3											
150	5											
160	9	3(1)		9								
170	15	4(1)		15								
180	41	19(1)		41								
190	43	27(1)		43								
200	44	27(1)		44								
210	43	25(1)		43								
220	41	28(1)		41								
230	43	27(1), 6(2)		37	6							
240	27	29(1)		27								
250	42	22(1), 6(2)		33	9							
260	35	23(1), 3(2)		32	3							
270	23	23(1)		23								
280	14	12(1), 6(2)		9	5							
290	11	3(2)			11							
300	22	2(1), 8(2)		4	18							
310	26	16(2)			26							
320	23	12(2)			23							
330	27	18(2)			27							
340	34	24(2), 1(3)			33	1						
350	41	19(2), 4(3)			34	7						
360	24	21(2), 3(3)			21	3						
370	31	13(2), 8(3)			19	12						
380	35	9(2), 13(3), 1(4)			14	20	1					
390	29	2(19), 7(3)			21	8						
400	20	11(2), 7(3)			12	8						
410	18	7(2), 5(3)			10	8						
420	13	3(2), 9(3)			3	10						
430	9	2(3), 1(4)				6	3					
440	8	4(3), 2(4)				6	2					
450	4	2(3), 2(4)				2	2					
460	5	2(3), 3(4)				2	3					
470	3	2(4)					3					
480	6	2(3), 4(5)					2	4				
490	4	2(3), 2(5)					2	2				
500	4	1 (5)						4				
510												
520	1	1(5)						1				
530	2	1(6)							2			
540												
550												
560	2	1(6)							2			
570												
580	1	1(6)							1			
590												
//												
680	1	1(8)									1	
690												
700												
710												
720												
730												
740	2	1(9)										2
Total	**916**	**540**	**38**	**401**	**295**	**93**	**18**	**11**	**5**	**0**	**1**	**2**

How to read this table. # in sample indicates the number of fish collected in each 10 mm length group (42 fish collected in the 250 – 259 mm length group). The third column indicates fish that were aged, with age assigned in parenthesis, e.g. of the 42 fish in the 250 – 259 mm length class scales of 28 fish were aged, with 22 assigned age 1, and 6 assigned age 2. Thus, 22 of 28 fish (78.5 %) aged at age 1 and 6 of 28 fish (21.4 %) were aged at age 2. To assign ages to all fish in the length class 42 total fish in sample x 0.785 = 33 were assigned to age 1, and 42 x 0.214 = 9 were assigned to age 2.

caught during the entire study from 27 May to 9 September, and two size stratifications for each species (from 27 May to 7 July) > 175 mm (the minimum size that a smallmouth bass ate a kokanee salmon), > 178 mm (the minimum size that a walleye ate a kokanee salmon), > 198 mm (the minimum size that a smallmouth ate a rainbow trout), and > 212 mm (the minimum size that a walleye ate a rainbow trout).

In total, smallmouth bass from 27 May to 9 September (n = 395) consumed 9,521 food items weighing 650 g, including 13 rainbow trout weighing 125 g and 28 kokanee salmon weighing 30.2 g. The numerical and weight percentages of rainbow trout in the diet of smallmouth bass were 0.1 and 19.3 % respectively. The numerical and weight percentages of kokanee salmon in the diet of smallmouth bass were 0.3 and 4.7 %, respectively (Table 20). For smallmouth bass captured from 27 May to 9 September, the most important prey item in their diet according to the weight percentage were crayfish (49.0 %), rainbow trout (19.3 %) and sculpins (15.5 %). For that same period, the most important prey item in smallmouth bass diets according to the numerical percentage were *Leptodora* (60.9 %), *Daphnia* (13.3 %) and sculpins (10.9 %). The smallest smallmouth bass that consumed kokanee salmon was 175 mm TL. The smallest smallmouth bass that consumed rainbow trout was 198 mm TL.

No salmonids were found in smallmouth bass stomachs after July 7, 2009, so we applied that as a cutoff date for dietary analysis. Smallmouth bass (n = 248) between 27 May and 7 July, 2009 consumed 8,558 food items weighing 446.2 g, including 13 rainbow trout weighing 125.7 g and 28 kokanee weighing 30.2 g. The numerical and weight percentages of rainbow trout in the diet of smallmouth bass were 0.2 and 27.0 % respectively. The numerical and weight percentages of kokanee salmon in the diet of smallmouth bass were 0.3 and 6.5 respectively. For that same period, the most important prey item in their diet according to the weight percentage were crayfish (40.1 %), rainbow trout (27.0 %) and sculpins (14.0 %). For that same period, the most important prey item in smallmouth bass diets according to the numerical percentage were *Leptodora* (67.7 %), *Daphnia* (10.6 %), sculpins (7.7 %) and Chironomidae (midges) (5.6 %).

Table 20. Food habits of smallmouth bass (n = 395) of all sizes for the period of 27 May to 9 September, 2009. # = the number of fish that consumed the N items.

Prey Item	Common name	#	N	Wt (g)	% by #	% by Wt	FO	IRI
Actinopterygii (misc.)	Fishes (misc.)	8	28	0.1	0.3%	<0.1%	2.0%	<0.1%
Actinopterygii: Centrachidae	Bass, Sunfish	9	14	4.4	0.1%	0.7%	2.3%	<0.1%
Actinopterygii: Cottidae	Sculpin	149	1,039	100.7	10.9%	15.5%	37.7%	25.9%
Actinopterygii: Cyprinidae	Minnows	2	4	3.7	<0.1%	0.6%	0.5%	<0.1%
Actinopterygii: Gadidae	Burbot	4	77	5.7	0.8%	0.9%	1.0%	<0.1%
Actinopterygii: non–salmonidae	Non–salmonids (misc.)	49	232	11.1	2.4%	1.7%	12.4%	1.3%
Actinopterygii: Percidae	Percids	9	18	5.6	0.2%	0.9%	2.3%	0.1%
Actinopterygii: Salmonidae (misc.)	Salmonids (misc.)	3	12	13.0	0.1%	2.0%	0.8%	<0.1%
Actinopterygii: Salmonidae: O. *mykiss*	Rainbow trout	9	13	125.7	0.1%	19.3%	2.3%	1.2%
Actinopterygii: Salmonidae: O. *nerka*	Kokanee salmon	9	28	30.2	0.3%	4.7%	2.3%	0.3%
Amphipoda (misc.)	Scuds (misc.)	5	5	<0.1	0.1%	<0.1%	1.3%	<0.1%
Annelida (misc.)	Earthworms/aquatic worms	1	3	5.9	<0.1%	0.9%	0.3%	<0.1%
Arachnid (misc.)	Misc. spider	10	10	0.3	0.1%	<0.1%	2.6%	<0.1%
Branchiopoda: Cladocera: *Daphnia*	Daphnia	41	1,269	1.5	13.3%	0.2%	10.4%	3.7%
Branchiopoda: Cladocera: *Leptodora*	Leptodora	49	5,802	15.4	60.9%	2.4%	12.4%	20.4%
Decapoda: Astacidae	Signal crayfish	129	216	318.4	2.3%	49.0%	32.7%	43.5%
Insecta (misc.)	Insect (Misc.)	2	2	<0.1	<0.1%	<0.1%	0.5%	<0.1%
Insecta: Coleoptera (misc.)	Beetle (Misc.)	1	1	<0.1	<0.1%	<0.1%	0.3%	<0.1%
Insecta: Coleoptera: Cantharidae	Soldier beetle	1	1	<0.1	<0.1%	<0.1%	0.3%	<0.1%
Insecta: Coleoptera: Chrysomelidae	Leaf beetle	1	1	<0.1	<0.1%	<0.1%	0.3%	<0.1%
Insecta: Coleoptera: Dytiscidae	Diving beetle	4	6	0.1	0.1%	<0.1%	1.0%	<0.1%
Insecta: Coleoptera: Elmidae	Riffle beetle	1	1	0.1	<0.1%	<0.1%	0.3%	<0.1%
Insecta: Coleoptera: Gyrinidae	Whirligig beetle	1	1	<0.1	<0.1%	<0.1%	0.3%	<0.1%
Insecta: Coleoptera: Hydrophilidae	Water scavenger beetle	1	1	0.1	<0.1%	<0.1%	0.3%	<0.1%
Insecta: Coleoptera: Staphylinidae	Rove beetle	1	1	<0.1	<0.1%	<0.1%	0.3%	<0.1%
Insecta: Coleopteria: Curculionidae	Weevil	2	2	<0.1	<0.1%	<0.1%	0.5%	<0.1%
Insecta: Diptera (misc.)	Flies (misc.)	4	4	<0.1	<0.1%	<0.1%	1.0%	<0.1%
Insecta: Diptera: Asilidae	Robber flies	1	1	<0.1	<0.1%	<0.1%	0.3%	<0.1%
Insecta: Diptera: Bombyliidae	Bee flies	2	3	0.3	<0.1%	0.1%	0.5%	<0.1%
Insecta: Diptera: Calliphoridae	Blow flies	1	1	<0.1	<0.1%	<0.1%	0.3%	<0.1%
Insecta: Diptera: Cecidomyiidae	Gall midges, gall gnats	1	2	<0.1	<0.1%	<0.1%	0.3%	<0.1%
Insecta: Diptera: Chironomidae	Non–biting midges	88	488	1.3	5.1%	0.2%	22.3%	3.1%
Insecta: Diptera: Coenagrionidae	Narrow winged damselflies	1	1	<0.1	<0.1%	<0.1%	0.3%	<0.1%
Insecta: Diptera: Muscidae	House flies	1	1	<0.1	<0.1%	<0.1%	0.3%	<0.1%
Insecta: Diptera: Simuliidae	Black flies	1	1	<0.1	<0.1%	<0.1%	0.3%	<0.1%
Insecta: Diptera: Tabanidae	Fruit flies	8	12	0.5	0.1%	0.1%	2.0%	<0.1%
Insecta: Ephemeroptera	Mayflies	4	4	<0.1	<0.1%	<0.1%	1.0%	<0.1%
Insecta: Hemiptera	True bugs	20	26	0.7	0.3%	0.1%	5.1%	<0.1%
Insecta: Hymenoptera	Bees, wasps, ants	31	119	1.8	1.2%	0.3%	7.8%	0.3%
Insecta: Hymenoptera: Formicidae	Ants	1	2	<0.1	<0.1%	<0.1%	0.3%	<0.1%
Insecta: Lepidoptera	Moths and butterflies	1	1	<0.1	<0.1%	<0.1%	0.3%	<0.1%
Insecta: Odonata	Damsel and dragonflies	16	16	0.7	0.2%	0.1%	4.1%	<0.1%
Insecta: Orthoptera	Insects with incomplete metamorphosis	1	1	0.6	<0.1%	0.1%	0.3%	<0.1%
Insecta: Plecoptera	Stoneflies	4	4	0.8	<0.1%	0.1%	1.0%	<0.1%
Insecta: Raphidoptera	Snakeflies	1	1	<0.1	<0.1%	<0.1%	0.3%	<0.1%
Insecta: Trichoptera	Caddisflies	17	38	0.5	0.4%	0.1%	4.3%	0.1%
Isopoda	Sow bugs	1	1	<0.1	<0.1%	<0.1%	0.3%	<0.1%
Invertebrate (misc.)	Invertebrates (misc.)	1	1	<0.1	<0.1%	<0.1%	0.3%	<0.1%
Myriapoda: Chilopoda	Centipedes	1	1	<0.1	<0.1%	<0.1%	0.3%	<0.1%
Ostracoda	Seed shrimp	3	3	<0.1	<0.1%	<0.1%	0.8%	<0.1%
Platyhelminthes: Cestoda	Fish tapeworms/flatworm	2	2	0.1	<0.1%	<0.1%	0.5%	<0.1%
Total		**713**	**9,521**	**650**	**100.0%**	**100.0%**		**100.0%**

Smallmouth bass > 175 mm between 27 May and 7 July, 2009 (n = 181) consumed 8,326 food items weighing 460.3 g, of this total, 28 were kokanee weighing 30.2 g (Table 21). The numerical and weight percentages of kokanee salmon in the diet of smallmouth bass were 0.3 and 6.6 % respectively. The most important prey item in their diet according to the weight percentage were crayfish (40.5 %), rainbow trout (27.3 %) and sculpins (13.3 %). For this same period, the most important prey item in their diet according to the numerical percent were *Leptodora* (68.7 %), *Daphnia* (1<0.1 %) and sculpins (7.5 %).

Smallmouth bass > 198 mm captured between 27 May and 7 July, 2009 (n = 165) consumed 7,573 food items weighing 427.1 g, of this total, 13 were rainbow trout weighing 125.7 g (Table 22). The numerical and weight percentages of rainbow trout in the diet of smallmouth bass were <0.1 and 29.4 % respectively. The most important prey item in their diet according to the percentage by weight were crayfish (39.9 %), rainbow trout (29.4 %) and sculpins (13.1 %). For this same period, the most important prey item in their diet according to the numerical percent were *Leptodora* (73.6 %), sculpins (7.1 %) and *Daphnia* (6.8 %).

Walleye from 27 May to 9 September, 2009 (n = 481) consumed a total of 16,876 food items totaling 492.9 g in weight, including 14 rainbow trout weighing 135.4 g and 13 kokanee salmon weighing 15.2 g (Table 23). The numerical and weight percentages of rainbow trout in the diet of walleye were 0.1 % and 27.3 % respectively. The numerical and weight percentages of kokanee salmon in the diet of walleye were 0.1 % and 3.0 % respectively. The most important prey item in their diet according to the percentage by weight were rainbow trout (27.3 %), Cyprinidae (14.2 %), Percidae (13.3 %) and sculpins (11.6 %). For this same period, the most important prey item in their diet according to the numerical percent were *Leptodora* (87.2 %), *Daphnia* (6.0 %) and sculpins (3.4 %). The smallest walleye that consumed kokanee salmon was 178 mm TL. The smallest walleye that consumed rainbow trout was 212 mm TL.

No salmonids were found in walleye stomachs after July 7. So we restricted the dates to end on that period. Walleye (n = 233) between 27 May and 7 July, 2009, consumed 14,839 food items, weighing 330.95 g, including 13 rainbow trout weighing 125.71 g and 14 kokanee salmon weighing 15.12 g. The numerical and

Table 21. Food habits of smallmouth bass (n = 181) > 175 mm (minimum length that ate a kokanee) for the period of 27 May to 7 July, 2009. # = the number of fish that consumed the N items.

Prey Item		**#**	**N**	**Wt (g)**	**% by #**	**% by Wt**	**FO**	**IRI**
Platyhelminthes, Cestoda	Fish tapeworm	1	1	<0.1	<0.1%	<0.1%	0.4%	<0.1%
Annelida (misc.)	Earthworms/aquatic worms	1	3	5.9	<0.1%	1.3%	0.4%	<0.1%
Arachnid (misc.)	Spiders (misc.)	9	9	0.3	0.1%	0.1%	3.5%	<0.1%
Branchiopoda (misc)	Crustacean (misc.)	2	2	0	<0.1%	<0.1%	0.8%	<0.1%
Leptodora	Leptodora	42	5,717	15.3	68.7%	3.3%	16.5%	<0.1%
Daphnia	Daphnia	35	831	0.99	10.0%	0.2%	13.8%	3.5%
Amphipoda (misc.)	Scuds (misc.)	5	5	<0.1	0.1%	<0.1%	2.0%	<0.1%
Decapoda, Astacidae	Signal Crayfish	89	140	186.4	1.7%	40.5%	35.0%	37.2%
Isopoda	Sow bugs	1	1	<0.1	<0.1%	<0.1%	0.4%	<0.1%
Ostracoda	Seed shrimp	3	3	<0.1	<0.1%	<0.1%	1.2%	<0.1%
Coleoptera (misc.)	Beetles (misc.)	1	1	<0.1	<0.1%	<0.1%	0.4%	<0.1%
Coleoptera, Cantharidae	Soldier beetle	1	1	<0.1	<0.1%	<0.1%	0.4%	<0.1%
Coleoptera, Chrysomelidae	Leaf beetle	1	1	<0.1	<0.1%	<0.1%	0.4%	<0.1%
Coleoptera, Dytiscidae	Diving beetle	4	6	0.1	0.1%	<0.1%	1.6%	<0.1%
Coleoptera, Elmidae	Riffle beetle	1	1	<0.1	<0.1%	<0.1%	0.4%	<0.1%
Coleoptera, Gyrinidae	Whirligig beetle	1	1	<0.1	<0.1%	<0.1%	0.4%	<0.1%
Coleoptera, Hydrophilidae	Water scavenger beetle	1	1	<0.1	<0.1%	<0.1%	<0.1%	<0.1%
Coleoptera, Staphylinidae	Rove beetle	1	1	<0.1	<0.1%	<0.1%	0.4%	<0.1%
Coleopteria, Curculionidae	Weevil	2	2	<0.1	<0.1%	<0.1%	0.8%	<0.1%
Diptera, Bombyliidae	Bee flies	1	2	<0.1	<0.1%	<0.1%	0.4%	<0.1%
Diptera, Calliphoridae	Blow flies	1	1	<0.1	<0.1%	<0.1%	0.4%	<0.1%
Diptera, Cecidomyiidae	Gall midges, gall gnats	1	2	<0.1	<0.1%	<0.1%	0.4%	<0.1%
Diptera, Chironomidae	Non–biting midges	81	473	1.29	5.7%	0.3%	31.9%	4.8%
Diptera, Coenagrionidae	Narrow winged damselfies	1	1	<0.1	<0.1%	<0.1%	0.4%	<0.1%
Hymenoptera, Formicidae	Ants	1	2	<0.1	<0.1%	<0.1%	0.4%	<0.1%
Diptera (misc.)	Flies (misc.)	3	3	<0.1	<0.1%	<0.1%	1.2%	<0.1%
Diptera, Muscidae	House flies	1	1	<0.1	<0.1%	<0.1%	0.4%	<0.1%
Diptera, Simuliidae	Black flies	1	1	<0.1	<0.1%	<0.1%	0.4%	<0.1%
Diptera, Tabanidae	Fruit flies	7	11	0.46	0.1%	0.1%	2.8%	<0.1%
Insecta (misc.)	Insects (misc.)	2	2	<0.1	<0.1%	<0.1%	0.8%	<0.1%
Insecta, Ephemeroptera	Mayflies	3	3	<0.1	<0.1%	<0.1%	1.2%	<0.1%
Insecta, Hemiptera	True bugs	19	25	0.53	0.3%	0.1%	7.5%	0.1%
Insecta, Hymenoptera	Bees, wasps, ants	30	118	1.80	1.4%	0.4%	11.8%	0.5%
Insecta, Lepidoptera	Moths, butterflies	1	1	<0.1	<0.1%	<0.1%	0.4%	<0.1%
Insecta, Odonata	Damsel and dragonflies	12	12	0.54	0.1%	0.1%	4.7%	<0.1%
Insecta, Plecoptera	Stoneflies	4	4	0.82	<0.1%	0.2%	1.6%	<0.1%
Insecta, Raphidoptera	Snakeflies	1	1	<0.1	<0.1%	<0.1%	0.4%	<0.1%
Insecta, Trichoptera	Caddisflies	12	23	0.14	0.3%	<0.1%	4.7%	<0.1%
Invertebrate (misc.)	Invertebrates (misc.)	1	1	<0.1	<0.1%	<0.1%	0.4%	<0.1%
Myriapoda, Chilopoda	Centipedes	1	1	<0.1	<0.1%	<0.1%	0.4%	<0.1%
Actinopterygii (misc.)	Fishes (misc.)	5	5	0.15	0.1%	<0.1%	2.0%	<0.1%
Non–salmonidae	Non–salmonid fish	25	137	6.47	1.6%	1.4%	9.8%	0.8%
Centrachidae	Bass, sunfish	6	9	0.39	0.1%	0.1%	2.4%	<0.1%
Cyprinidae	Minnows	1	1	<0.1	<0.1%	<0.1%	0.4%	<0.1%
Gadidae	Burbot	3	75	5.7	0.9%	1.2%	1.2%	0.1%
Percidae	Percids	3	8	2.1	0.1%	0.5%	1.2%	<0.1%
Salmonidae (misc.)	Salmonids (misc.)	3	12	12.9	0.1%	2.8%	1.2%	0.1%
O. *mykiss*	Rainbow trout	9	13	125.7	0.2%	27.3%	3.5%	2.4%
O. *nerka*	Kokanee salmon	9	28	30.24	0.3%	6.6%	3.5%	0.6%
Cottidae (misc.)	Sculpin	98	624	61.4	7.5%	13.3%	38.6%	20.2%
Total		**546**	**8,326**	**460.3**	**100.0%**	**100.0%**		**100.0%**

Table 22. Food habits of smallmouth bass (n = 165) > 198 mm (minimum length that ate a rainbow) for the period of 27 May to 7 July, 2009. # = the number of fish that consumed the N items.

Prey Item	Common name	#	N	Wt (g)	% by #	% by Wt	FO	IRI
Platyhelminthes: Cestoda	Fish tapeworm	1	1	<0.1	<0.1%	<0.1%	0.4%	<0.1%
Annelida (misc.)	Earthworms/aquatic worms	1	3	5.9	<0.1%	1.4%	0.4%	<0.1%
Arachnid (misc.)	Misc. spiders	5	5	<0.1	0.1%	<0.1%	2.0%	<0.1%
Branchiopoda (misc.)	Misc. crustaceans	2	2	<0.1	<0.1%	<0.1%	0.8%	<0.1%
Leptodora	Leptodora	36	5,572	14.9	73.6%	3.5%	14.8%	31.5%
Daphnia	Daphnia	31	512	0.6	6.8%	0.1%	12.7%	2.4%
Amphipoda (misc.)	Misc. scuds	3	3	<0.1	<0.1%	<0.1%	1.2%	<0.1%
Decapoda, Astacidae	Signal crayfish	81	129	170.3	1.7%	39.9%	33.2%	38.2%
Isopoda	Sow bugs	1	1	<0.1	<0.1%	<0.1%	0.4%	<0.1%
Ostracoda	Seed shrimp	3	3	<0.1	<0.1%	<0.1%	1.2%	<0.1%
Coleoptera, Cantharidae	Soldier beetle	1	1	<0.1	<0.1%	<0.1%	0.4%	<0.1%
Coleoptera, Chrysomelidae	Leaf beetle	1	1	<0.1	<0.1%	<0.1%	0.4%	<0.1%
Coleoptera, Dytiscidae	Diving beetle	4	6	0.1	<0.1%	<0.1%	1.6%	<0.1%
Coleoptera, Hydrophilidae	Water scavenger beetle	1	1	<0.1	<0.1%	<0.1%	<0.1%	<0.1%
Coleoptera, Staphylinidae	Rove beetle	1	1	<0.1	<0.1%	<0.1%	0.4%	<0.1%
Coleoptera, Curculionidae	Weevil	2	2	<0.1	<0.1%	<0.1%	0.8%	<0.1%
Diptera, Bombyliidae	Bee flies	1	2	<0.1	<0.1%	<0.1%	0.4%	<0.1%
Diptera, Calliphoridae	Blow flies	1	1	<0.1	<0.1%	<0.1%	0.4%	<0.1%
Diptera, Cecidomyiidae	Gall midges, gnats	1	2	<0.1	<0.1%	<0.1%	0.4%	<0.1%
Diptera: Chironomidae	Non–biting midges	65	349	1.0	4.6%	0.2%	26.6%	3.6%
Diptera: Coenagrionidae	Narrow winged damselfies	1	1	<0.1	<0.1%	<0.1%	0.4%	<0.1%
Diptera (misc.)	Misc. flies	3	3	<0.1	<0.1%	<0.1%	1.2%	<0.1%
Diptera: Muscidae	House flies	1	1	<0.1	<0.1%	<0.1%	0.4%	<0.1%
Diptera: Simuliidae	Black flies	1	1	<0.1	<0.1%	<0.1%	0.4%	<0.1%
Diptera: Tabanidae	Fruit flies	5	8	<0.1	0.1%	<0.1%	2.0%	<0.1%
Insecta (misc.)	Misc. insects	2	2	0.1	<0.1%	<0.1%	0.8%	<0.1%
Insecta, Ephemeroptera	Mayflies	3	3	<0.1	<0.1%	<0.1%	1.2%	<0.1%
Insecta, Hemiptera	True bugs	13	17	0.5	0.2%	0.1%	5.3%	<0.1%
Insecta, Hymenoptera	Bees, wasps, ants	23	87	1.5	1.1%	0.4%	9.4%	0.4%
Insecta, Lepidoptera	Moths, butterflies	1	1	<0.1	<0.1%	<0.1%	0.4%	<0.1%
Insecta, Odonata	Damsel and dragonflies	12	12	0.5	0.2%	0.1%	4.9%	<0.1%
Insecta, Plecoptera	Stoneflies	4	4	0.8	0.1%	0.2%	1.6%	<0.1%
Insecta, Trichoptera	Caddisflies	12	23	0.1	0.3%	<0.1%	4.9%	<0.1%
Misc. Invertebrate	Misc. Invertebrates	1	1	<0.1	<0.1%	<0.1%	0.4%	<0.1%
Actinopterygii (misc.)	Misc. fishes	4	4	0.1	0.1%	<0.1%	1.6%	<0.1%
Non–salmonidae	Non–salmonids	24	136	6.5	1.8%	1.5%	9.8%	0.9%
Cntrachidae	Bass, sunfish	5	8	0.4	0.1%	0.1%	2.0%	<0.1%
Cyprinidae	Minnows	1	1	<0.1	<0.1%	<0.1%	0.4%	<0.1%
Gadidae, *Lota lota*	Burbot	3	75	5.7	1.0%	1.3%	1.2%	0.1%
Percidae	Percids	2	7	2.1	0.1%	0.5%	0.8%	<0.1%
Salmonidae (misc.)	Misc. salmonids	3	12	12.9	0.2%	3.0%	1.2%	0.1%
O. *mykiss*	Rainbow Trout	9	13	125.7	0.2%	29.4%	3.7%	3.0%
O. *nerka*	Kokanee salmon	7	19	20.5	0.3%	4.8%	2.9%	0.4%
Cottidae	Sculpin	86	537	56.1	7.1%	13.1%	35.2%	19.7%
Total		**467**	**7,573**	**427.1**	**100%**	**100%**		**100%**

Table 23 Food habits of walleye (n = 481) of all sizes for the period of 27 May to 9 September, 2009. # = the number of fish that consumed the N items.

Prey Item		**#**	**N**	**Wt (g)**	**% by #**	**% by Wt**	**FO**	**IRI**
Fishes (misc.)	Fishes (misc.)	9	9	1.8	0.1%	0.4%	1.9%	<0.1%
Catasomidae	Suckers	2	2	0.2	<0.1%	<0.1%	0.4%	<0.1%
Centrachidae	Bass, sunfishes	23	30	46.0	0.2%	9.3%	4.8%	2.5%
Cottidae	Sculpin	108	574	57.2	3.4%	11.6%	22.5%	18.6%
Cyprinidae	Minnows	12	13	70.1	0.1%	14.2%	2.5%	2.0%
Non–Salmonidae (misc.)	Non– salmonid fish	34	50	14.6	0.3%	3.0%	7.1%	1.3%
Percidae	Percids	25	80	65.6	0.5%	13.3%	5.2%	4.0%
O. *mykiss*	Rainbow trout	13	14	135.4	0.1%	27.3%	2.7%	4.1%
O. *nerka*	Kokanee salmon	8	14	13.0	0.1%	2.6%	1.7%	0.2%
Amphipoda (misc.)	Scuds (misc.)	4	19	0.1	0.1%	<0.1%	0.8%	<0.1%
Daphnia	Daphnia	36	1,008	1.0	6.0%	0.2%	7.5%	2.6%
Leptodora	Leptadora	54	14,725	39.2	87.3%	7.9%	11.2%	59.3%
Decapoda, Astacidae	Signal crayfish	39	51	44.5	0.3%	9.0%	8.1%	4.2%
Diptera (misc.)	Flies (misc.)	3	3	<0.1	<0.1%	<0.1%	0.6%	<0.1%
Diptera, Cecidomyiidae	Gall midges, gall gnats	1	1	<0.1	<0.1%	<0.1%	0.2%	<0.1%
Diptera, Chironomidae	Non–biting midges	46	260	3.8	1.5%	0.8%	9.6%	1.2%
Insecta, Hymenoptera	Bees, wasps, ants	1	1	<0.1	<0.1%	<0.1%	0.2%	<0.1%
Insecta, Odonata	Damsel and dragonflies	3	3	0.1	<0.1%	<0.1%	0.6%	<0.1%
Insecta, Trichoptera	Caddisflies	5	9	0.1	0.1%	<0.1%	1.0%	<0.1%
Isopoda	Sow bugs	1	10	0.2	0.1%	<0.1%	0.2%	<0.1%
Grand Total		**427**	**16,876**	**492.9**	**100%**	**100%**		**100%**

weight percentages of rainbow trout in the diet of a walleye were 0.1 % and 38.0 % respectively. The numerical and weight percentages of kokanee salmon in the diet of a walleye were 0.1 % and 4.6 % respectively. The most important prey item in their diet according to the weight percentage were rainbow trout (38.0 %), Percidae (16.2 %) and crayfish (12.4 %). For this same period, the most important prey item in their diet according to the numerical percent were *Leptodora* (92.4 %), *Daphnia* (3.2 %) and Chironomidae (1.7 %).

Walleye > 178 mm between 27 May and 7 July, 2009 (n = 121) consumed 14,592 food items weighing 326.2 g, of this total, 14 were kokanee weighing 15.12 g (Table 24). The numerical and weight percentages of kokanee salmon in the diet of walleye were 0.1 and 4.7 % respectively. The most important prey item in their diet according to the weight percentage were rainbow trout (38.5 %), Percidae (15.4 %), crayfish (12.6 %) and *Leptodora* (11.1 %). For this same period, the most important prey item in their diet according to the numerical percent were *Leptodora* (93.3 %), *Daphnia* (2.5%) and sculpin (1.3 %).

Walleye > 212 mm between 27 May and 7 July, 2009 (n = 80) consumed 10,917 food items weighing 294.9, of this total, 13 were rainbow trout weighing 125.7 g (Table 25). The numerical and weight percentages of rainbow trout in the diet of walleye were .01 and 42.6 % respectively. The most important prey item in their diet according to the weight percentage were rainbow trout (42.6 %), Percidae (16.0 %) crayfish (14.0 %) and *Leptodora* (9.8 %). For this same period, the most important prey item in their diet according to the numerical percent were *Leptodora* (95.9 %), and Chironomidae (1.1 %).

Based on applying the Wisconsin Bioenergetic Model 3.0 from 27 May to 7 July 2009, an individual walleye > 178 mm consumed an average of 59.70 g of prey, of which 2.0 % (1.2 g) was kokanee. Individual walleye > 212 mm consumed an average of 74.7 g of prey, of which 43.0 % (32.1 g) was rainbow trout. An individual smallmouth bass > 175 mm consumed an average of 68.1 g of prey, of which 7.0 % (4.8 g) was kokanee salmon. An individual smallmouth bass > 198 mm ate 119.7 g of prey, of which 29.4 % (35.2 g) was rainbow trout.

Lavage Efficacy

Lavage efficacy for each species found in stomachs of smallmouth bass and walleye are recorded in Table 26

Table 24. Food habits of walleye (n = 121) > 178 mm (minimum length that ate a kokanee) for the period of 27 May to 7 July, 2009. # = the number of fish that consumed the N items.

Prey Item		#	N	Wt (g)	% by #	% by Wt	FO	IRI
Leptodora	Leptodora	42	13,623	36.4	93.4%	11.1%	18.0%	75.8%
Daphnia	Daphnia	26	372	0.3	2.5%	0.1%	11.2%	1.2%
Amphipoda (misc.)	Scuds (misc.)	3	17	<0.1	0.1%	<0.1%	1.3%	<0.1%
Decapoda, Astacidae	Signal crayfish	22	31	41.2	0.2%	12.6%	9.4%	4.9%
Isopoda	Sow bugs	1	10	0.2	0.1%	0.1%	0.4%	<0.1%
Diptera, Chironomidae	Non–biting midges	37	209	3.6	1.4%	1.1%	15.9%	1.6%
Diptera (misc.)	Flies (misc.)	1	1	<0.1	<0.1%	<0.1%	0.4%	<0.1%
Insecta, Hymenoptera	Bees, wasps, ants	1	1	<0.1	<0.1%	<0.1%	0.4%	<0.1%
Insecta, Odonata	Damsel and dragonflies	3	3	<0.1	<0.1%	<0.1%	1.3%	<0.1%
Insecta, Trichoptera	Caddisflies	5	9	0.1	0.1%	<0.1%	2.1%	<0.1%
Catasomidae	Suckers	2	2	0.2	<0.1%	0.1%	0.9%	<0.1%
Centrachidae	Bass, sunfish	5	11	10.1	0.1%	3.1%	2.1%	0.3%
Fish (misc.)	Fishes (misc.)	5	5	1.4	<0.1%	0.4%	2.1%	<0.1%
Non–salmonidae (misc.)	Non–salmonids (misc.)	13	16	8.3	0.1%	2.5%	5.6%	0.6%
Cyprinidae	Minnows	3	4	19.0	<0.1%	5.8%	1.3%	0.3%
Percidae	Percids	11	56	50.3	0.4%	15.4%	4.7%	3.0%
O. *mykiss*	Rainbow Trout	12	13	125.7	0.1%	38.5%	5.2%	8.0%
O. *nerka*	Kokanee salmon	8	14	15.1	0.1%	4.6%	3.4%	0.7%
Cottidae	Sculpin	37	195	14.2	1.3%	4.4%	15.9%	3.6%
Total		**237**	**14,592**	**326.23**	**100%**	**100%**		**100%**

Table 25. Food habits of walleye (n = 80) > 212 mm (minimum length that ate a rainbow trout) for the period of 27 May to 7 July, 2009. # = the number of fish that consumed the N items.

Prey Item	Common Name	#	N	Wt (g)	% by #	% by Wt	FO	IRI
Leptodora	Leptodora	27	10,474	28.8	95.9%	9.8%	11.6%	72.7%
Branchiopoda (misc.)	Crustaceans (misc.)	1	10	<0.1	0.1%	<0.1%	0.4%	<0.1%
Daphnia	Daphnia	15	97	<0.1	0.9%	<0.1%	6.4%	0.3%
Amphipoda (misc.)	Scuds (misc.)	1	4	<0.1	<0.1%	<0.1%	0.4%	<0.1%
Decapoda, Astacidae	Signal crayfish	20	29	41.2	0.3%	14.0%	8.6%	7.2%
Isopoda	Sow bugs	1	10	0.2	0.1%	0.1%	0.4%	<0.1%
Dipter, Chironomidae	Non–biting midges	26	119	2.7	1.1%	0.9%	11.2%	1.3%
Insecta, Hymenoptera	Bees, wasps, ants	1	1	<0.1	<0.1%	<0.1%	0.4%	<0.1%
Insecta, Odonata	Damsel and dragonflies	2	2	<0.1	<0.1%	<0.1%	0.9%	<0.1%
Insecta, Trichoptera	Caddisflies	4	8	0.1	0.1%	<0.1%	1.7%	<0.1%
Fishes (misc.)	Fishes (misc.)	5	5	1.4	<0.1%	0.5%	2.1%	0.1%
Non–salmonidae (misc.)	Non–salmonids (misc.)	9	12	8.0	0.1%	2.7%	3.9%	0.7%
Catasomidae	Suckers	2	2	0.2	<0.1%	0.1%	0.9%	<0.1%
Centrachidae	Bass, sunfish	4	7	9.7	0.1%	3.3%	1.7%	0.3%
Cyprinidae	Minnows	3	4	19.0	<0.1%	6.5%	1.3%	0.5%
Percidae	Percids	7	33	47.1	0.3%	16.0%	3.0%	2.9%
O. *mykiss*	Rainbow Trout	12	13	125.7	0.1%	42.6%	5.2%	13.1%
O. *nerka*	Kokanee salmon	4	5	5.4	<0.1%	1.8%	1.7%	0.2%
Cottidae	Sculpin	16	82	5.2	0.8%	1.8%	6.9%	1.0%
Total		**160**	**10,917**	**294.9**	**100.0%**	**100.0%**		**100.4%**

Table 26. Smallmouth bass lavage efficacy per species by number and weight.

		Efficacy by Number			Efficacy by Weight		
Order	**Family**	**Lavaged (#)**	**Stomach (#)**	**Efficacy**	**Lavaged (g)**	**Stomach (g)**	**Efficacy**
Actinopterygii	Unidentified	3	–	100 %	2.08	–	100 %
Aranea	Arachnidae	4	–	100 %	2.25	–	100 %
Branchiopoda	*Leptodora*	2	–	100 %	8.69	–	100 %
Cladocera	*Daphniidae*	12	–	100 %	2.38	–	100 %
Diptera	Chironomidae	107	–	100 %	0.82	–	100 %
Decopoda	Astacidae	57	5	91 %	22.43	2.59	88 %
Scorpaeniformes	Cottidae	88	3	97 %	23.14	2.98	87 %
Perciformes	Percidae	1	–	100 %	1.34	–	100 %
Perciformes	Centrarchidae	26	–	100 %	9.11	–	100 %
Total		**300**	**8**		**72.24**	**5.57**	

Table 27. Walleye lavage efficacy per species by number and weight.

Prey Item		Efficacy by number			Efficacy by weight		
Order	**Family**	**Lavage (#)**	**Stomach (#)**	**Efficacy**	**Lavage (g)**	**Stomach (g)**	**Efficacy**
Actinopterygii	Unidentified	39	2	95 %	6.30	2.57	71 %
Amphipoda	Gammeridae	1	–	100 %	<0.1	–	100 %
Aranea	Arachnidae	1	–	100 %	<0.1	–	100 %
Branchiopoda	*Leptodora*	684	–	100 %	1.82	–	100 %
Cladocera	*Daphniidae*	3	–	100 %	0.0	–	100 %
Cypriniformes	Cyprinidae	3	–	100 %	7.16	–	100 %
Decopoda	Astacidae	8	–	100 %	0.54	–	100 %
Diptera	Chironomidae	10	–	100 %	<0.1	–	100 %
Gadoformes	Gadidae	1	–	100 %	<0.1	–	100 %
Hymenoptera	Formicidae	1	–	100 %	<0.1	–	100 %
Perciformes	Centrarchidae	2	–	100 %	0.47	–	100 %
Perciformes	Percidae	2	–	100 %	0.58	–	100 %
Scorpaeniformes	Cottidae	50	–	100 %	10.58	–	100 %
Total		**805**	**2**		**27.45**	**2.57**	

and Table 27. Lavage efficacy in walleye was 99.75 % by number (805 items removed by lavage and 2 remaining in stomach) and 91.43 % by weight percent (27.4 g removed by lavage and 2.57 g remaining in stomach). Most organisms were successfully (100 %) removed from walleye with the exception of some unidentified fishes (95 and 71 % by number and weight). Lavage efficacy in smallmouth bass was 97.40 % by number (300 items moved by lavage and 8 items remaining in stomach) and 92.84 % by weight (72.24 g removed by lavage and 5.57 g remaining in stomach). Most organisms were successfully (100 %) removed by the lavage technique for smallmouth bass with the exception of crayfish (91 and 88 % by number and weight) and sculpins (97 and 87 % by number and weight).

Population Estimation

Using CAPTURE we came up with 11 total population estimates for smallmouth and walleye in the Sanpoil. Smallmouth bass CAPTURE population estimates ranged from 4,528 to 41,889 (Table 28). Walleye CAPTURE population estimates ranged from 709 to 25,068 (Table 29). The population of smallmouth bass (± SE) in the study area was estimated at 36,285 (± 2,303) based on 4,328 fish marked and 262 total recaptures on 15 sampling occasions. The population of walleye (± 95 % CI) in the study area was estimated at 25,068 (13,793– 46,059) based on 708 fish marked and 11 fish recaptured on 15 sampling occasions.

Smallmouth bass population estimates derived from CAPTURE software, which analyzed the mark-recapture data we collected from 27 May through 4 August, 2009. CAPTURE determined goodness–of–fit values for each test it ran in order to determine how well that model fit the data presented. The smallmouth bass population tested positive for temporal effects, meaning that bass had differing likelihoods of recapture depending on the time we collected them in the field. The goodness–of–fit test for smallmouth was 1.00, the highest ranking fitness possible.

Walleye population estimates derived from CAPTURE software, which analyzed the mark-recapture data were collected from 27 May through 4 August, 2009. CAPTURE determined goodness–of–fit values for each test it ran. The walleye population tested positive for heterogeneity, meaning that each individual walleye had differing likelihoods of recapture during the population estimate study period. The goodness–of–fit value test for

Table 28. Smallmouth bass population estimates (± standard deviation) and goodness–of–fit (GOF) test values.

Test	Pop. Estimate	± SD	GOF
M (t)	37,634	2,297	1.00
M (t), bias corrected	36,285*	2,303	1.00
M (th)	37,933	2,308	0.63
M (tb)	41,889	29,284	0.34
M (o)	38,072	2,344	0.14
M (bh)	4,528	39	<0.1
M (h)	19,187	299	<0.1
M (h), bias corrected	39,402	2,531	<0.1

* Value used for population estimate.

Table 29. Walleye population estimates (± standard deviation) and goodness–of–fit (GOF) test values.

Test	Pop. Estimate	± SD	GOF
M (h), bias corrected	25,068*	7,922	0.91
M (h)	3,436	119	0.91
M (o)	23,780	7,433	0.80
M (tb)	8,495	—	0.45
M (th)	25,023	7,942	0.31
M (bh)	709	2	0.14
M (t)	7,080	920	<0.1
M (t), bias corrected	19,950	5,984	<0.1

* Value used for population estimate.

walleye was 0.91, which shows a high fitness for this particular test. The jackknife estimator removed bias in the M (h) model because "*The assumption of heterogeneity can render some individuals nearly "invisible" with respect to any estimation procedure based on marking methods because such individuals have nearly zero catchability*" (Otis et al. 1978).

Estimating the Population of each Age Class that Consumed Rainbow Trout and Walleye

The population of each age class of smallmouth bass was determined by calculating the percentage of fish in each age of the smallmouth bass age/length frequency distribution and multiplying this percentage by the estimated bass population. This procedure yielded population estimates of 28,999 (age 1), 2,711 (age 2), 1,602 (age 3), 1,363 (age 4), 555 (age 5), 362 (age 6), 347 (age 7), 123 (age 8), 185 (age 9), 15 (age 10), and 23 (age 11) (Table 30). A total of 702 of the 4,711 captured smallmouth (702 ÷ 4,711 = 14.9 %) that comprised the age/length frequency distribution were over 175 mm TL (the minimum length of smallmouth that consumed a kokanee salmon). Thus, 5411 smallmouth bass (14.9 % of the 36,285 population estimate) were of a size that could potentially consume kokanee salmon in the Sanpoil River. A total of 632 of the 4,711 captured smallmouth bass (632 ÷ 4,711 = 13.41 %) in the length frequency distribution were over 198 mm TL, which was the minimum length of smallmouth that consumed a rainbow trout. Thus 4,865 smallmouth bass (13.41 % of the 36,285 population estimate) were of a size that could potentially consume rainbow trout in the Sanpoil River.

The population of each age class of walleye was determined by calculating the percentage of fish in each age of the walleye age/length frequency distribution and multiplying this percentage by the estimated walleye population. This procedure yielded population estimates of 12,429 (age 1), 8,679 (age 2), 2,739 (age 3), 716 (age 4), 253 (age 5), 126 (age 6), 0 (age 7), 1 (age 8) and 2 (age 9) (Table 31). A total of 805 of the 916 captured walleye (805 ÷ 916 = 87.9 %) that comprised the age/length frequency distribution were over 178 mm TL (the minimum length of walleye that consumed kokanee salmon). Thus, 22,029 walleye (87.9 % of the 25,068 population estimate) are of a size that could potentially consume kokanee salmon in the Sanpoil River. A total of 718 of 916 captured walleye (718 ÷ 916 = 78.4 %) that comprised the age/length frequency distribution were over 212 mm TL, which was the minimum length of walleye that consumed rainbow trout. Thus, 19,648

Table 30. Percent of smallmouth bass population (n = 36,285) per age class[2], based on captured fish (n = 4,711).

Age	N	% Total	Pop.size
1	3,765	79.9%	28,999
2	352	7.5%	2,711
3	208	4.4%	1,602
4	177	3.8%	1,363
5	72	1.5%	555
6	47	1.0%	362
7	45	1.0%	347
8	16	0.3%	123
9	24	0.5%	185
10	2	<0.1%	15
11	3	0.1%	23
Total	**4,711**	**100.0%**	**36,285**

Table 31. Percent of walleye population (n = 25,068) per age class, based on captured fish (n = 916) .

Age	N	% Total	Pop. size
0	90	9.8%	2,463
1	431	47.1%	11,795
2	263	28.7%	7,197
3	95	10.4%	2,600
4	21	2.3%	575
5	9	1.0%	246
6	4	0.4%	109
8	1	0.1%	27
9	2	0.2%	55
Total	**916**	**100.0%**	**25,068**

[2] We may have overestimated the age one population estimate using this method, because there is only a 10 % survival between age one and two. Electrofishing gear only works in shallow water, where smaller fish often. This may underestimates older age classes which reside in deeper water. This estimate is mainly based on electrofishing (n = 6,398 fish) and not gill netting (n = 254 fish). However, it is possible that a 10 % survival is accurate due to food competition.

walleye (78.4 % of the 25,068 population estimate) were of a size that could potentially consume rainbow trout in the Sanpoil River.

Testing the Assumptions of Population Closure and Tag Retention

By conducting laboratory and field studies to determine tag loss values, we tested the assumptions that: marked and unmarked fish have same mortality rates; marks are retained throughout the study period; and that emigration during recapture period was negligible.

A field analysis of total recaptured smallmouth and walleye was accomplished in order to determine fish emigration over the study period. Of the 29 walleye recaptured overall, 11 were caught in the Sanpoil River by electrofishing or gill netting as a part of this study from 27 May to 4 August. Furthermore, 18 were captured by anglers between 15 June and 20 September. Of those captured by anglers, 15 were captured in the Sanpoil River from 15 June to 20 September, one was taken in the Spokane River upstream from Porcupine Bay on 22 June, one was taken in the Columbia River near Enterprise on 1 September and one was taken in the Columbia River near Hunters on 24 August. Walleye generally moved from about 0 to 13 km between their capture and recapture site within the Sanpoil River.

Of 258 total smallmouth bass that were recaptured, 246 were caught in the Sanpoil by electrofishing (n = 243) or gillnetting (n = 3) as part of this study from 2 June to 12 August. Additionally, 13 were captured by anglers between 2 June and 12 September. Of those captured by anglers, 10 were caught in the Sanpoil River between 2 June and 19 September, one was caught at Spring Canyon on 12 September and one was caught at Hunters on 23 July. The smallmouth generally moved from about 0 to 13 km between their capture and recapture sites within the Sanpoil River. Of the two bass were caught after our population estimation work was completed on 12 August. Thus, these data generally supported the assumption of population closure. Both walleye and smallmouth bass seemed to move freely within the Sanpoil River embayment of Lake Roosevelt but had little inclination to leave it.

We assessed the validity of our assumptions that no tags were lost and that mortality of marked fish was the same as unmarked fish by conducting laboratory and field studies. In our tag-retention study, we marked 51

Table 32. In–lab tag retention results for smallmouth bass.

Week	Elast. Marked	Mark Mortality	Elast. Unmarked	Unmarked Mortality	Floy Marked	Floy Mortality
1	51	0	51	0	12	0
2	50	1	50	1	12	0
3	48	2	49	1	12	0
4	46	2	49	0	12	0
5	46	0	43	6	12	0
6	46	0	42	1	12	0
7	45	1	42	0	12	0
Total		**6**		**9**		**0**

smallmouth bass with elastomer marks and 12 with Floy tags and held them for seven weeks in a test tank (Table 32). All of the fish retained both types of marks for all seven weeks.

We also held 51 unmarked smallmouth bass in the test tank over the same period, and kept track of the percent mortality in each group. At the end of the 7^{th} week, six of the marked fish had died and nine of the unmarked fish had died. There was no significant difference in mortality rates of marked and unmarked fish in this study (t value = 0.8911, p value = 0.2035, df = 6).

Additionally, fish in the field were given elastomer mark and a Floy tag to evaluate tag retention. A total of 561 smallmouth bass were given both types of tags and a total of 33 were recaptured: all 33 (100 %) had retained their Floy tags, and 27 had (82 %) retained their elastomer marks. A total of 581 walleye were given both elastomer and Floy tags. A total of 11 were recaptured: all 11 (100 %) had retained both their Floy tags and elastomer marks.

Mortality

Mortality was calculated for both species by fitting an exponential decay equation to the $\log_{10}$ frequency per age class data collected for the duration of our study in Figure 10 and Figure 11. Mortality rates are defined by the equations: y = - 0.5406x + 7.1276 (R^2 = 0.8867) for smallmouth bass and y = - 0.9234x + 7.0855 (R^2 = 0.9839) for walleye. Annual mortality for smallmouth bass between age 1 and 2, was 91 .%. Between ages 4 and 10, there was an average (range) annual mortality of 36 (4 - 64) %. Walleye between ages 2 and 6, had an average (range) annual mortality of 59 (39 - 78) %. In determining the instantaneous mortality for walleye, age 0+ were left out, but had a *ln*(N) value of 4.49, completing the catch curve. Instantaneous mortality (Z value) for smallmouth bass and walleye were -0.5406 and -0.9234.

Total Weight of Salmonids Consumed

In order to estimate the total grams of rainbow trout or kokanee salmon consumed by populations of walleye and smallmouth bass, we multiplied the population estimates for walleye and smallmouth bass by the number of grams rainbow trout or kokanee salmon individually.

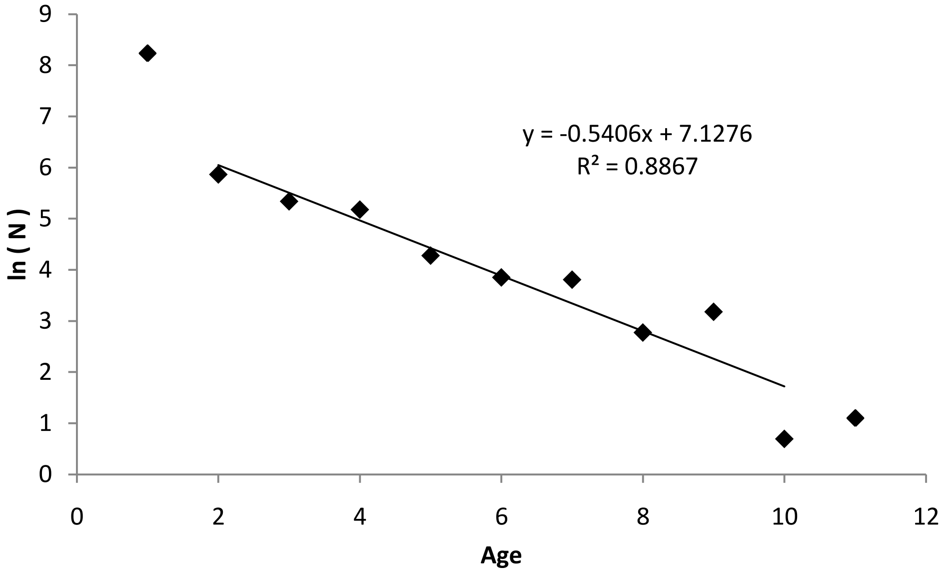

Figure 10. Smallmouth bass mortality regression and equation (R^2 = 0.8867).

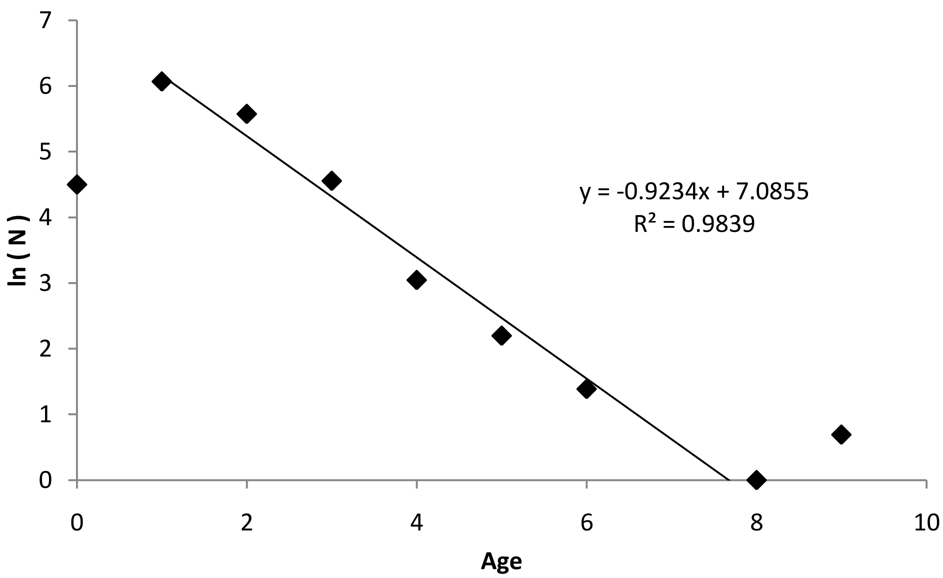

Figure 11. Walleye mortality regression and equation (R^2 = 0.9839).

Multiplying the individual consumption rates (g) of rainbow trout by the population of walleye (n = 19,468) and smallmouth (n = 4,865) that could consume them, yielded totals of 631.1 kg and 171.2 kg rainbow trout consumed by walleye and smallmouth bass from 27 May to 7 July, respectively. Multiplying the individual consumption rates of kokanee salmon by the population of walleye (n = 22,029) and smallmouth bass (n = 5,411) that consumed them yielded totals of 26.3 kg and 25.8 kg kokanee salmon consumed from 27 May to 7 July, respectively.

Consumption rates were converted to numbers of rainbow trout and kokanee salmon by dividing the total grams found in all predators stomachs by the average weight of rainbow and kokanee found in their stomachs. The weight of a rainbow trout was 34 g in walleye stomach and 7.3 g in smallmouth bass stomachs. The weight of a kokanee salmon was about 1.1 g in the stomach of both species of predators. The bioenergetic models predicted that from 27 May to 7 July 2009, walleye consumed 18,562 rainbow trout and 23,832 kokanee salmon, and smallmouth bass consumed 23,459 rainbow trout and 23,464 kokanee salmon. Combined, this means that 190 % of 22,095 available rainbow trout, and 515 % of 10,283 kokanee are being consumed by smallmouth bass and walleye by 7 July.

Table 33. Total consumption of rainbow trout and kokanee salmon by walleye and smallmouth bass from 27 May to 7 July.

Smallmouth bass consumption of rainbow trout	Consumption
Traditional diet analysis, summed from 27 May to 7 July	
Wt (g) of all prey found in individual stomach	108.7 g
Wt (g) of rainbow trout found in individual stomach	32.0 g
Bioenergetics modeling, summed from 27 May to 7 July	
Summed daily meal wt (g) total prey per individual	119.7 g
Summed daily meal wt (g) rainbow trout per individual	35.2 g
Smallmouth bass population estimate	
Population estimate (n = 36,285)	
Population eating rainbow trout (n = 4,865)	
4,865 individuals x 35.2 g per indivdual =	171.2 kg
Weight of a rainbow trout in a smallmouth stomach (7.3 g)	
171.2 kg by population/ 7.3 g per rainbow =	23,459 rainbow
Rainbow trout population estimate from screw trap	
n = 22,095 ± (15,685 - 37,367)	
2,3459 rainbow consumed / population estimate =	106 (62.7 - 149) %

Walleye consumption of rainbow trout	Consumption
Traditional diet analysis, summed from 27 May to 7 July	
Wt (g) of all prey found in individual stomach	163.0 g
Wt (g) of rainbow trout found in individual stomach	69.5 g
Bioenergetics modeling, summed from 27 May to 7 July	
Summed daily meal wt (g) total prey per individual	74.7 g
Summed daily meal wt (g) rainbow trout per individual	32.1 g
Walleye population estimate	
Population (n = 25,068)	
Population consuming rainbow trout (n = 19,648)	
19,648 individuals x 32.1 g per individual =	631.1 kg
Weight of a rainbow trout in a walleye stomach (34 g)	
631.1 kg by population / 34 g per rainbow =	18,562 rainbow
Rainbow trout population estimate from screw trap	
n = 22,095 ± 15,685 - 37,367	
1,8562 rainbow consumed / population estimate =	84 (50 - 118) %

Smallmouth bass consumption of kokanee	Consumption
Traditional diet analysis, summed from 27 May to 7 July	
Wt (g) of all prey found in individual stomach	100.6 g
Wt (g) of kokanee found in individual stomach	6.8 g
Bioenergetics modeling, summed from 27 May to 7 July	
Summed daily meal wt (g) total prey per individual	68.1 g
Summed daily meal wt (g) kokanee per individual	4.8 g
Smallmouth bass population estimate	
Population estimate (n = 36,285)	
Population eating kokanee (n = 5,411)	
5,411 individuals x 4.8 g per indivdual =	25.8 kg
Weight of a kokanee in a smallmouth stomach (1.1 g)	
25.8 kg by population / 1.1 g per kokanee =	23,464 kokanee
Kokanee population estimate from screw trap	
n = 10,283 ± (4,925 - 15,641)	
23,464 kokanee consumed / population estimate =	228 (150 - 477) %

Walleye consumption of kokanee	Consumption
Traditional diet analysis, summed from 27 May to 7 July	
Wt (g) of all prey found in individual stomach	126.9 g
Wt (g) of kokanee found in individual stomach	5.9 g
Bioenergetics modeling, summed from 27 May to 7 July	
Summed daily meal wt (g) total prey per individual	59.7 g
Summed daily meal wt (g) kokanee per individual	1.2 g
Walleye population estimate	
Population (n = 25,068)	
Population eating kokanee (n = 22,029)	
22,029 individuals x 1.2 g per indivdual =	26.3 kg
Weight of a kokanee in a walleye stomach (1.1 g)	
26.3 kg by population / 1.1 g per kokanee =	23,832 kokanee
Kokanee population estimate from screw trap	
n = 10,283 ± (4,925 - 15,641)	
23,832 kokanee consumed / population estimate =	232 (153 - 486) %

DISCUSSION

Relatively low numbers of rainbow trout (n = 1,189) and kokanee salmon (n = 1,233) migrated through the screw trap down the Sanpoil River. An unknown number of rainbow trout that were naturally produced in the Sanpoil River started their migration down the river, hence, there is no estimation for in-river mortality. Kokanee salmon (n = 582,140) from the Spokane Tribal hatchery were stocked in the West Fork Sanpoil River on 9 – 10 June, 2009 and 1,233 were estimated to have passed through the rotary screw trap between 11 and 23 June, with 89 % of them (n = 1,103) captured 17 and 18 June, 2009. The survival of kokanee was estimated at 0.2 % (1,233 / 582,140). In-river mortality in the Sanpoil was estimated at 99.8 %. It seems likely that there was probably also substantial in-river mortality on naturally produced rainbow trout. Thus, despite the high levels of mortality caused by smallmouth bass and walleye predation on rainbow trout and kokanee salmon in the Sanpoil estuary observed in the present study, it is possible that that in-river mortality was substantially higher.

A potential explanation for low numbers of rainbow trout and kokanee captured in the screw trap was in–river predation by northern pikeminnow. Northern pikeminnow prefer free flowing rather than stagnant waters (Wydoski and Whitney 2003). Northern pikeminnow are known to "*aggregate in areas where salmonid smolts are concentrated and vulnerable to predation*" (Thompson 1959; Collis et al. 1995). Northern pikeminnow are known to quickly switch over to prey on outmigrating smolts when they become abundant (Shively et al. 1996). Approximately 14 % (95 % CI = 9 – 19 %) of all salmon smolts (n = 2.7 million, 95 % CI = 1.9 – 3.3 million) migrating through John Day Reservoir on the Columbia River were consumed by fish predation, with 78 % of this consumption due to northern pikeminnow, 13% due to walleye and 9 % due to smallmouth bass predation (Rieman et al. 1991). Other explanations for the low numbers of rainbow trout and kokanee captured in the screw trap would be that kokanee didn't smolt and could smolt later in the year or the following spring; and that kokanee overwhelmed the screw trap, considering most were captured within a two day period. It is also possible that the screw trap location didn't sample the population effectively.

We captured 77.4 % of our northern pikeminnow in free flowing water below the trap within 2 km of the mouth of the river. In 2010, we plan to conduct backpack electrofishing surveys above the trap to test the hypothesis that northern pikeminnow predation above the trap is contributing to in–river mortality. We also plan to determine if northern pikeminnow predation, in addition to walleye and smallmouth predation, contributes to mortality of rainbow trout and kokanee salmon below the trap by conducting food habit analysis, developing a bioenergetics model, and estimating their population.

Combined, smallmouth bass and walleye make up 84 % of the relative abundance of fisheries in the Sanpoil River. With such a large number of the total fish in the river being piscivores, it is logical that the remaining fish are being consumed rapidly, and likely have been declining over time. Native species such as burbot, suckers, and cyprinids are likely being affected by this unhealthy balance. Burbot were caught at a relative abundance of < 1 % in electrofishing surveys and < 1 % in gill net surveys. Historically, burbot were caught at RA rates as high as 4 % in electrofishing surveys (Pavlik – Kunkel et al. 2008, Cichosz et al. 1999) and 13.5 % in gill net surveys (McLellan et al. 2003) (Appendix I, Table A7). There were a total of 77 larval burbot found in the stomachs of 4 smallmouth bass. It is likely that large numbers of burbot have been preyed upon by the smallmouth bass and, possibly, walleye residing in the Sanpoil River.

Our age/length key showed that Sanpoil River smallmouth bass initially grew slightly faster but ultimately achieved smaller lengths when compared to 34 other Washington water bodies (Table 34). For example, at age 7, the average length of smallmouth bass in the Sanpoil River was 325 mm TL, whereas the average TL of smallmouth bass in 22 water bodies in eastern Washington was 393 mm. These results are consistent with the idea that smallmouth in the Sanpoil River may have more limited food resources, such as macroinvertebrates, than at other locations or that they may suffer more competition from walleye than at other locations. Walleye growth in the Sanpoil slightly exceeded the growth of walleye at 13 other eastern Washington locations (Table 35). For example, at age 5 walleye grew to a length of 501 mm TL in the Sanpoil River compared to an average TL of 500 mm at 13 eastern Washington locations. At age 6 walleye in the Sanpoil averaged 563 mm TL compared to 551 mm at 13 other locations.

Frequency of occurrence, percent by number and percent by weight of prey organisms found in fish stomachs are all biased if used individually when assessing the relative importance of a prey item to a fish's metabolic

Table 34. Backcalculated total lengths of smallmouth bass populations in eastern Washington.

			Back–calculated TL (mm) at age													
County	**Location**	**n**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
[1]Adams/Grant	CNWR Ponds	5	79	190	224	–	–	–	–	–	–	–	–	–	–	–
[2]Adams/Lincoln	Sprague Lake	31	66	165	253	314	351	–	–	–	–	–	–	–	–	–
[3]Adams/Lincoln	Sprague Lake	20	101	145	188	238	285	328	361	384	402	–	–	–	–	–
[4]Adams/Lincoln	Sprague Lake	5	66	150	159	263	325	334	–	–	–	–	–	–	–	–
[5]Asotin/Benton	Yakima River	–	90	148	207	254	301	–	–	–	–	–	–	–	–	–
[6]Asotin/Benton	Yellepit Lake	4	60	144	273	343	375	413	–	–	–	–	–	–	–	–
[7]Benton/Franklin/Grant	Hanford Reach	–	–	–	196	223	244	274	302	315	363	376	–	–	–	–
[7]Benton/Franklin/Grant	White Bluffs	–	64	155	241	300	345	384	439	467	480	–	–	–	–	–
[8]Columbia/Garfield/Whitman	Little Goose Res.	494	71	132	190	244	298	336	363	390	411	434	454	478	479	–
[9]Franklin	Scooteney Res.	30	65	131	234	340	–	–	–	–	–	–	–	–	–	–
*Ferry	Sanpoil River	725	100	157	201	234	263	291	325	366	399	428	443	–	–	–
[8]Franklin/Walla Walla	Lower Mounumental Res.	53	72	132	188	242	–	–	–	–	–	–	–	–	–	–
[8]Columbia/Garfield/Whitman	Lower Granite Res.	107	71	124	184	235	283	–	–	–	–	–	–	–	–	–
[10]Grant	Alkali Lake	8	46	96	152	214	261	262	339	386	–	420	–	–	–	–
[11]Grant	Banks Lake	204	53	128	203	271	330	365	396	416	430	–	–	–	–	–
[12]Grant	Evergreen Reservoir	17	62	171	271	377	–	–	–	–	–	–	–	–	–	–
[2]Grant	Evergreen Reservoir	56	59	151	236	318	370	–	–	–	–	–	–	–	–	–
[13]Grant	Moses Lake	50	98	138	215	252	–	–	–	–	–	–	–	–	–	–
[14]Grant	Pothole Reservoir 00	95	79	163	246	333	392	434	452	490	–	–	–	–	–	–
[14]Grant	Pothole Reservoir 99	98	76	138	189	245	296	350	379	406	418	–	–	–	–	–
[15]Okanogan	Curlew Lake	1	63	108	162	–	–	–	–	–	–	381	–	–	–	–
[16]Okanogan	L. Osoyoos	8	56	105	163	214	257	298	339	357	377	–	–	–	–	–
[14]Okanogan	Palmer Lake	78	68	126	195	265	323	379	384	–	–	–	–	–	–	–
[17]Okanogan	Palmer Lake	90	50	121	197	272	338	389	417	446	–	–	–	–	–	–
[18]Pend Oreille	Boundary Reservoir	79	79	84	138	202	264	317	353	372	–	–	–	–	–	–
[19]Pend Oreille	Diamond Lake	77	79	153	209	24	310	384	358	428	506	–	–	–	–	–
[20]Pend Oreille	Fan Lake	37	76	215	327	386	424	499	508	–	–	–	–	–	–	–
[21]Pend Oreille	Horseshoe Lake	57	82	156	235	280	317	358	419	–	–	–	–	–	–	–
[22]Pend Oreille	Sacheen Lake	118	74	141	195	262	329	397	438	457	–	–	–	–	–	–
[23]Spokane	Chapman Lake	82	56	108	153	201	246	289	327	365	382	–	–	–	–	–
[24]Spokane	Eloika Lake	87	104	202	265	318	373	433	467	496	521	539	–	–	–	–
[25]Spokane	Liberty Lake	1	70	146	212	268	334	356	393	–	–	–	–	–	–	–
[14]Spokane	Long Lake Reservoir	127	67	185	287	348	421	460	452	–	–	–	–	–	–	–
[16]Spokane	Newman Lake	1	32	73	116	152	–	–	–	–	–	–	–	–	–	–
[26]Spokane	Newman Lake	33	48	112	203	288	–	–	–	–	–	–	–	–	–	–
[31]Spokane	Newman Lake 1996–1999	33	48	112	203	288	–	–	–	–	–	–	–	–	–	–
[27]Stevens	Deer Lake	61	53	115	185	250	309	349	380	389	409	–	–	–	–	–
[28]Stevens	Deer Lake	99	83	137	191	280	307	349	381	410	433	449	466	485	493	512
[29]Stevens	L. Roosevelt	449	83	149	207	250	265	323	423	–	–	–	–	–	–	–
[30]Stevens	Loon Lake	31	89	134	184	247	299	350	369	379	–	–	–	–	–	–
[33]Stevens	L. Spokane 1994–2000	127	67	185	287	348	421	460	452	–	–	–	–	–	–	–
[8]Walla Walla	Ice Harbor Reservoir	80	70	134	192	243	277	–	–	–	–	–	–	–	–	–
Average			**70**	**141**	**208**	**264**	**318**	**361**	**393**	**406**	**425**	**432**	**454**	**482**	**486**	**512**

1. Fletcher (1981); 2. Schmuck and Petersen (2006a); 3. Taylor (2000); 4. Jackson (2000); 5. Fritts and Pearsons (2006); 6. EWU Unpublished; 7. Wydoski and Whitney (2003); 8. Bennett et al. (1983); 9. Hisata (1999); 10. Osborne et al. (2001); 11. Woller et al. 2004; 12. Petersen and Osborne (2006); 13. Burgest (2000); 14. Osborne et al. (2003c); 15. Baker 2004; 16. Fletcher (1982); 17. Petersen and Schmuck (2006b); 18. McLellan (2001) 19. Phillips and Divens (2000) 20. Divens et al. (2002c); 21. McLellan et al. (2005); 22. Divens et al. (2002b); 23. Divens and Osborne (2004); 24. Divens et al. (2001); 25. Phillips et al. (1999); 26. Osborne et al. (2004); 27. Divens (2002); 28. McLellan et al. (2006); 29. McLellan et al. (2003), Lee et al. (2003), Scofford et al. (2004), Fields et al. (2004), Pavlik–Kunkel et al. (2005), Lee et al. (2006); 30. McLellan et al. (2007); 31.Osborne (2001); 32. Jackson and Caromile (2000); 33. Divens and Osborne (2001) *Current study

Table 35. Backcalculated lengths for walleye populations in eastern Washington.

			Back–calculated TL (mm) at age												
County	**Location**	**n**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
[1]Adams/Lincoln	Sprague Lake	189	158	238	311	374	439	488	545	593	634	694	–	–	–
[2]Benton/Klickitat	John Day Reservoir	446	258	391	486	546	605	660	704	743	–	–	–	–	–
[3]Franklin	Cox Lake	18	180	370	445	498	556	626	–	–	–	–	–	–	–
[4]Franklin	Scooteney Reservoir	1	136	303	–	–	–	–	–	–	–	–	–	–	–
[*]Ferry	Sanpoil River	571	192	281	383	444	501	563	634	680	731	–	–	–	–
[5]Grant	Banks Lake	26	152	322	414	456	509	–	–	–	–	–	–	–	–
[6]Grant	Billy Clapp Lake	15	179	285	416	496	506	–	–	–	–	–	–	–	–
[7]Grant	Moses Lake	110	190	271	343	407	462	462	487	547	–	–	–	–	–
[8]Grant	Potholes Reservoir	76	217	357	409	452	486	518	537	552	564	–	–	–	–
[9]Klickitat	John Day Reservoir	3,435	217	380	475	535	579	615	644	662	677	712	724	707	–
[10]Spokane	Clear Lake.	3	153	240	303	366	427	481	516	594	–	–	–	–	–
[11]Spokane	Liberty Lake	50	169	266	373	441	504	551	603	–	–	–	–	–	–
[12]Stevens	L. Roosevelt	7,379	190	282	369	431	493	553	609	658	693	721	747	775	793
[13]Stevens	L. Roosevelt, 1980–83	3,248	189	307	385	450	515	569	629	668	702	742	740	761	780
[14]Stevens	L. Roosevelt, 1988	369	104	273	348	410	470	532	590	635	688	689	–	–	–
[14]Stevens	L. Roosevelt, 1989	467	210	282	351	418	493	571	603	–	–	–	–	–	–
[15]Stevens	L. Roosevelt, 1990	311	184	295	380	439	511	597	651	698	734	–	–	–	–
[16]Stevens	L. Roosevelt, 1997	2,355	172	279	363	424	478	535	617	662	–	–	–	–	–
[17]Stevens	L. Roosevelt, 1998	320	179	290	364	427	481	530	576	616	667	717	748	801	829
[18]Stevens	L. Roosevelt, 1999	171	188	301	375	427	476	518	578	643	–	–	–	–	–
Average			**181**	**301**	**384**	**444**	**500**	**551**	**595**	**639**	**677**	**713**	**740**	**761**	**801**

1. Taylor (2000); 2. Beamesdefer and Nigro (1989); 3. Divens et al. (2001); 4. Hisata et al. (2003); 5. Woller et al. (2004); 6. Walton (1982); 7. Burgess (2000); 8. WDFW Scale Aging Lab; 9.Beckman et al. (1985); 10. Phillips and Divens (2000); 11. Phillips et al. (1999); 12. Beamesderfer et al. (1986)Beckman et al. (1985); 13. Beckman et al. (1985); 14.Peone et al. (1990); 15.Griffith and Scholz (1990); 16.Mclellan et al. (1998); 17. Mclellan et al. (1999); 18. Mclellan et al. (2002); *Current study

requirements or the overall importance of a particular prey organism to a fish species (Windell 1971; Bowen 1983). For example, numerical percentages may overestimate the relative importance of small organisms that are abundant in the diet but do not contribute as much biomass as a few relatively large prey. Similarly, weight percentages can overestimate the energetic contribution of a few large prey items that seldom occur in the diet. In this case, smaller prey may be more important in contributing to day–to–day bioenergetics than would be revealed by examining the weight percentages only. Furthermore, since all of the methods depend on the researcher's ability to identify prey in the stomach, they may overestimate the relative importance of prey species that are digested slowly. Bioenergetics modeling accounts for the rates at which different types of prey are digested.

Frequency of occurrence of salmonids in the diet of smallmouth bass and walleye was consistent across the spring and summer (Vigg et al. 1991) in the lower Columbia River, where approximately 16 million salmon and steelhead smolts were available throughout the summer (Zimmerman 1999). Our monthly stratification of both species diet compositions showed change across the summer. For example, walleye were found to eat rainbow trout at weight percentages of 61.0 % (May), 30.0 % (June), 19.3 % (July), <0.1 % (August), and <0.1 % (September) (Appendix II, Table A2). Walleye were found to eat kokanee at numerical percentages of <0.1 % (May), 9.4 % (June), <0.1 % (July), <0.1 % (August), <0.1 % (September). Smallmouth bass were found to eat rainbow trout at weight percentages of 52.3 % (May), 11.9 % (June), 23.7 % (July), <0.1 % (August). Smallmouth were found to eat kokanee at numerical percentages of <0.1 % (May), 10.2 % (June), 1.7 % (July), <0.1 % (August). We believe the reason salmonids declined in the diets is because they were experiencing population decline, due to smallmouth bass and walleye predation. Since no kokanee were found in the diet of either species until after hatchery kokanee were stocked on June 9 and 10, we infer that natural reproduction of kokanee in the Sanpoil River does not occur or is minimal. This is further supported by the screw trap data which showed that kokanee moved through the trap only between June 16 to June 23, which likely came from the recently released hatchery fish.

From our bioenergetic output, we were able to backcalculate the consumption of an individual predator, and determine at what point practically all of the kokanee salmon and rainbow trout were eaten by the populations of smallmouth bass and walleye. Smallmouth bass (> 198 mm) could eat 97 (57 – 137) % of the rainbow trout from 27 May to 5 July. Smallmouth bass (> 175 mm) could eat 99 (65 – 208) % of the kokanee salmon from 16 June (first day found at screw trap) – 3 July. Walleye (> 212 mm) could eat 99 (58 – 139) % of the rainbow trout from 27 May to 14 July. Walleye (> 178 mm) could eat 96 (63 – 201) % of the kokanee salmon from 16 June (first day found at screw trap) to 2 July.

Wydoski and Whitney (2003) noted that crayfish were an important component of smallmouth bass diets in Washington. Our results showed that crayfish were important to the diets of smallmouth bass in the Sanpoil River, accounting for 49.0 % of the weight percentage and 43.5 % of the IRI in the diet.

The closed population estimates used for walleye > 70 mm was 25,068 (± 7,922), with a goodness–of–fit value of 0.91(high confidence). Because the Sanpoil Bay of Lake Roosevelt is an extension of Lake Roosevelt itself an open estimator was attempted. An open population model (using Popan software) estimated a population of 93,978 (SE = ± 86,477). A comparison was made between previous walleye population estimates in Lake Roosevelt (McLellan et al. 2003; Baldwin et al. 2003). McLellan et al. (2003) estimated that the reservoir wide walleye population >150 mm (± 95 % CI) was 129,183 ± 45,578 walleye in 1998. Furthermore, Baldwin et al. (2003) analyzed walleye populations at Sherman Creek, and determined that in 1999 and 2000, there were 16,610 and 12,233 walleyes in the Columbia River within ± 27 km of Sherman Creek. This information supported the closed population estimator because it fell within the entire population estimate for Lake Roosevelt.

Additionally, recapture data supported using a closed population estimate. Of 29 walleye recaptured, 11 were caught in the Sanpoil River from 27 May to 12 August, and 18 were recaptured by anglers between 15 June and 20 September. Of those captured by anglers, 15 were captured in the Sanpoil River from 15 June to 20 September, one was taken in the Spokane River upstream from Porcupine Bay on 22 June, one was taken in the Columbia River near Enterprise on 1 September and one was taken in the Columbia River near Hunters on 24

August. Most (26 of 29) walleye were recaptured within the Sanpoil River during our population estimation period. Of the 3 that were found outside of the Sanpoil, 2 of them were outside of our population estimation period (27 May to 4 August) on 24 August and 1 September. There was only 1 of 29 walleye found outside of the Sanpoil River was within our population estimation period (on 22 June).

Therefore, our closed population estimate was more consistent (made more sense) with these earlier estimates than our open population model estimates. Our decent goodness–of–fit value, narrower confidence intervals and our recapture location information supported the use of the closed model rather than the open model.

After completing this study, we have three main recommendations for future Sanpoil predation studies:

1. We should monitor predation and check the screw trap simultaneously from 25 March until 7 July. In their 2004 publication, Fritts and Pearsons demonstrated that lavaged smallmouth bass (n = 3,159) consumed increasing numbers of fall Chinook salmon from late March to a peak in late May by methods very similar to the ones we used. We therefore would like to align our study with the time of peak salmonid consumption in order to most efficiently capture salmonids as well as lavage the predators at a time when they are most actively consuming the salmonids.

2. We plan to include northern pikeminnow (*Ptychocheilus oregonenesis)* as a predator to monitor in 2010, being that they are "the major smolt predator in the Columbia River" (Rieman et al. 1991; Ward et al. 1995). Northern pikeminnow at the Bonneville Dam, Columbia River downstream from Bonneville Dam, and the lower Snake River consumed more salmonids (in numerical frequency) per day (92.4, 82.5 and 85.3 respectively) than either smallmouth bass (12.4, 14.2 and 25.8 per day) or walleye (12.5, 13.8 and -- per day) (Zimmerman 1998). We captured 247 (3.7 %) northern pikeminnow in our study, mainly in the free–flowing sections of the Sanpoil River. So, we propose to analyze the stomachs of northern pikeminnow captured in the Sanpoil River and Sanpoil estuary in 2010 to determine their food habits and conduct population estimates. Since northern pikeminnow may have to be killed to collect their stomach contents, because gastric lavage is reportedly ineffective (Tabor et al. 2004), we may use a removal depletion estimator (rather than a mark/

recapture population estimator) to determine population size. We also plan to conduct weekly backpack electrofishing surveys in the Sanpoil River upstream from the trap to determine if northern pikeminnow are contributing to the in–river mortality of rainbow trout and kokanee salmon in the Sanpoil River.

3. The Colville Tribe should conduct sonic tracking studies on walleye, smallmouth bass and northern pikeminnow, so that we can better assess the assumption of population closure.

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APPENDIX 1. BURBOT PREDATION

Introduction

The Sanpoil predation contract was designed to determine the total percent of naturally produced rainbow trout and stocked hatchery kokanee salmon consumed by smallmouth bass, walleye and burbot. We did not capture enough burbot to determine their population size. Moreover, the burbot collected (n = 8) had no prey items in their stomachs. We therefore had insufficient data to enumerate the impact of native burbot on rainbow trout and kokanee salmon in the Sanpoil Arm of Lake Roosevelt in 2009. The data collected, as well as a summation of what is known about burbot in Lake Roosevelt is presented in this appendix. Our proposed 2010 study will exclude burbot and replace them with northern pikeminnow.

Methods

We attempted to capture burbot by boat electrofishing (n = 60 h), horizontal gill netting (n = 64 h), and fyke netting (n = 72 h) (Table A1). Burbot were measured and weighed on site, and given a unique ID number. Boat electrofishing effort consisted of 16 dates, on which approximately 13 transects of 10 – 20 minutes were performed for a total of 60 electrofishing hours. Transect locations were determined by previously established sites (See report Figure 1, p. 6). Each day, sites were selected using stratified random sampling. Six gill nets were deployed for approximately 10 hours each, from approximately 1200 hours to 2200 hours. In addition, one fyke net was set on three consecutive days for almost 24 hours each day. Upon capture, seven of eight fish were killed and the whole digestive tract or fish was immediately placed in a 95 % ethanol filled jar and labeled with the date, ID number, site name, species, fish weight and total length. In the lab, the digestive tracts were cut open and the contents examined under a Nikon SMZ – 10 stereozoom dissecting microscope. A Fulton – type condition factor (K_{TL}) was calculated using the equation (Anderson and Neuman 1996):

$$K_{TL} = \frac{W}{TL^3} \times 10^5$$

Where:

K_{TL}= Fulton-type condition factor;
W = weight (g); and
TL = total length (mm).

Results

Table A1 shows data collected for each of the 8 burbot we caught on the Sanpoil in 2009. The average length of captured burbot was 232 mm and the average weight was 101 g. The average condition factor (± standard deviation) was 0.52 ± 0.16. Seven of the eight were sub – adult fish 145 – 299 mm TL. All collected burbot stomachs were empty.

The average total length (mm), weight (g) and condition factor (K_{TL}) for burbot collected in Lake Roosevelt between 1999 – 2006 are reported in Table A2. The burbot captured in the Sanpoil River in 2009 were smaller in length and weight but had similar condition factors to burbot caught in Lake Roosevelt from 1999 to 2006. (Compare Tables A1 and A2.)

Carlander (1969) reported that the North American average K_{TL} for 575 burbot captured throughout the United States and Canada averaged between 0.67 and 0.81 (Table A3). Thus, the Sanpoil River burbot and other burbot captured in Lake Roosevelt put on much less weight per unit of length than is typical of burbot in North America. This is probably due to either limited food resources or competition with walleye and smallmouth bass since all three species are piscivorous and eat the same kinds of prey in Lake Roosevelt. (Prey of smallmouth bass and walleye are summarized in Tables 19 and 22 in the main report. Prey of burbot in Lake Roosevelt are summarized in Table A5.)

Mean catch–per–unit–effort (CPUE) and relative abundance (RA) of burbot caught by each fishing method are recorded in Table A4. Electrofishing CPUE for burbot was 0.13 fish / hour and relative abundance was 0.12 %. We did not catch any burbot in gill nets or fyke nets.

Table A1. Date, site number, method, length, weight, and stomach result for each burbot captured (n=8) (2009).

Date	**Site**	**Method**	**L (mm)**	**Wt (g)**	**K_{TL}**	**Stomach**
27 May	Sanpoil	Electrofishing	495	481	0.40	Not taken
25 June	SP9	Electrofishing	145	18	0.59	Taken – empty
7 July	SP27	Electrofishing	207	15	0.17	Taken – empty
21 July	SP27	Electrofishing	161	25	0.60	Taken – empty
27 July	SP27	Electrofishing	299	153	0.57	Taken – empty
4 August	SP26	Electrofishing	153	23	0.64	Taken – empty
4 August	SP27	Electrofishing	187	39	0.60	Taken – empty
4 August	SP27	Electrofishing	205	53	0.62	Taken – empty
Average (± SD):			**232 ± 117**	**101 ± 160**	**0.52 ± 0.16**	

Table A2. Condition factor s of burbot (n = 575) summed per age, caught in Lake Roosevelt from 1988 to 2006 by Carlander (1969).

Year	**n**	**TL (mm)**	**Wt (g)**	**K_{TL}**	**Reference**
1999	110	496 ± 62	713 ± 359	0.56 ± 0.12	McLellan et al. (2003)
2000	105	490 ± 55	639 ± 272	0.53 ± 0.14	Lee et al. (2003)
2001	74	489 ± 61	605 ± 254	0.50 ± 0.11	Scofield et al. (2004)
2002	84	519 ± 63	824 ± 347	0.57 ± 0.12	Fields et al. (2004)
2003	111	474 ± 76	685 ± 341	0.63 ± 0.15	Pavlik – Kunkel et al. (2005)
2004	152	482 ± 52	644 ± 200	0.57 ± 0.10	Lee et al. (2006)
2005	145	486 ± 46	644 ± 193	0.56 ± <0.1	Scofield et al. (2007)
2006	207	483 ± 56	626 ± 217	0.55 ± 0.13	Pavlik – Kunkel et al. (2008)
2009	8	232 ± 117	101 ± 160	0.52 ± 0.16	Present study (2010)
Total No =	**996**		**Avg K_{TL}=**	**0.55**	

Table A3. Total length (mm) and condition factor (K_{TL}) of age 3– 16 burbot (n = 575) captured at various locations in the United States and Canada (Data from Carlander 1969). K_{TL} for these fish averaged 0.81. Elsewhere in his book Carlander reported an average K_{TL} value for burbot in North America at 0.67 (Carlander 1969).

Age	n	TL (mm)	Wt (g)	K_{TL}
3	5	351	313	0.72
3	5	373	318	0.61
3	1	411	590	0.85
3	16	450	735	0.81
Total	**27**	**1,585**	**1,956**	**0.76**

Age	n	TL (mm)	Wt (g)	K_{TL}
4	29	460	816	0.84
4	16	490	998	0.85
4	5	427	1,034	1.33
4	13	465	1,275	1.27
Total	**63**	**1,842**	**4,123**	**0.97**

Age	n	TL (mm)	Wt (g)	K_{TL}
5	3	503	912	0.72
5	46	516	1,120	0.82
5	10	556	1,502	0.87
Total	**59**	**1,575**	**3,534**	**0.82**

Age	n	TL (mm)	Wt (g)	K_{TL}
6	1	427	454	0.58
6	3	523	989	0.69
6	71	551	1,393	0.83
6	15	577	1,588	0.83
Total	**90**	**2,078**	**4,424**	**0.82**

Age	n	TL (mm)	Wt (g)	K_{TL}
7	54	554	1,315	0.77
7	22	645	2,001	0.75
7	15	615	2,087	0.9
Total	**91**	**1,814**	**5,403**	**0.79**

Age	n	TL (mm)	Wt (g)	K_{TL}
8	1	508	1,361	1.04
8	50	587	1,675	0.83
8	28	681	2,467	0.78
8	6	676	2,722	0.88
Total	**85**	**2,452**	**8,225**	**0.82**

Age	n	TL (mm)	Wt (g)	K_{TL}
9	2	579	1,120	0.58
9	10	739	2,745	0.68
9	57	632	2,223	0.88
9	1	719	3,901	1.05
Total	**70**	**2,669**	**9,989**	**0.85**

Age	n	TL (mm)	Wt (g)	K_{TL}
10	1	789	3,175	0.65
10	20	668	2,223	0.75
10	4	719	3,810	1.03
Total	**25**	**2,176**	**9,208**	**0.79**

Age	n	TL (mm)	Wt (g)	K_{TL}
11	1	711	3,289	0.92
11	22	921	2,994	0.38
11	4	795	3,121	0.62
Total	**27**	**2,427**	**9,404**	**0.44**

Age	n	TL (mm)	Wt (g)	K_{TL}
12	1	820	4,309	0.78
12	18	782	3,538	0.74
12	1	833	4,309	0.75
Total	**20**	**2,435**	**12,156**	**0.74**

Age	n	TL (mm)	Wt (g)	K_{TL}
13	11	795	3,810	0.76
Total	**11**	**795**	**3,810**	**0.76**

Age	n	TL (mm)	Wt (g)	K_{TL}
14	6	787	3,357	0.69
Total	**6**	**787**	**3,357**	**0.69**

Age	n	TL (mm)	Wt (g)	K_{TL}
16	1	775	2,722	0.58
Total	**1**	**775**	**2,722**	**0.58**

Average K_{TL} for all ages	**0.81**

Table A4. Weight percentage of prey in the diet of 105 burbot collected on Lake Roosevelt from 1997 – 2006.

Prey Item	Year / # burbot	97[1] 29	99[2] 20	00[3] 15	01[4] 5	03[5] 5	04[6] 10	05[7] 15	06[8] 6	Total Avg.
Centrarchidae (sunfish)		–	0.5	–	–	–	–	15.2	–	7.8
Cottidae (sculpin)		19.9	32.8	11.6	6.4	–	1.2	0.3	84.3	22.4
Cyprinidae (minnows)		12.7	6.6	–	5.4	–	–	–	–	8.2
Ictaluridae (bullheads)		–	3.4	–	–	–	–	–	–	3.4
Percidae (perch, walleye)		–	–	39.8	52.4	58.1	94.9	32.4	3.5	46.8
Salmonidae (rainbow, kokanee)		–	–	33.6	33.6	– –	– –	40.7	–	36.0
Unid. Fish		23.1	16.4	3.9	2.2	16	3	0.7	–	9.3
Coleoptera (beetles)		–	–	1.1	–	–	–	–	–	1.1
Chironomids (midges)		3.7	0.6	–	–	–	–	–	–	2.2
Ephemeroptera (mayflies)		5.6	–	–	–	–	–	–	–	5.6
Leptodora		10.9	–	–	–	–	–	–	–	10.9
Daphnia		6.3	–	–	–	–	–	–	–	6.3
Decapoda (crayfish)		7.2	17.1	–	–	16	–	9.5	11.2	12.2
Gastropoda (snails)		1	–	–	–	5.1	–	–	–	3.1
Ostracods (seed shrimp)		1	–	–	–	–	–	–	–	1.0
Odonata (dragon/ damselflies)		–	2	–	–	–	–	–	–	2.0
Trichoptera (caddisflies)		–	1.9	< 0.1	–	–	–	–	–	1.9
Plecoptera (stoneflies)		–	9	–	–	–	–	–	–	9.0
Anura (frog tadpoles)		–	–	–	–	–	0.1	–	–	0.1
Other		8.6	8.7	10	–	4.8	0.9	0.5	–	5.6
Total		**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

[1]Cichosz et al. (1999), [2]McLellan et al. (2003), [3]Lee et al. (2003), [4]Scofield et al. (2004), [5]Pavlik – Kunkel et al. (2004), [6]Lee et al. (2006), [7]Scofield et al. (2007), [8]Pavlik – Kunkel et al (2008).

Table A5. Catch (n), effort (h), CPUE (fish/hour) and relative abundance for burbot (2009).

Method	n	Effort	CPUE	RA
Electrofishing	8	60.0	0.13	0.12 %
Gill netting	0	64.1	<0.0	<0.0
Fyke netting	0	72.0	<0.0	<0.0

Table A6**.** Number of burbot (n), relative abundance, and catch – per – unit effort (CPUE in fish / hour of effort) captured in Lake Roosevelt by electrofishing and gill netting over a 19 year period from 1988 to 2006.

	Electrofishing			**Gill netting**			**Reference**
Year	**n**	**RA**	**CPUE**	**n**	**RA**	**CPUE**	
1988	8	< 1 %	0.6	1	< 0.1%	0.3	Peone et al (1990)
1989	23	< 1%	0.9	4	< 0.1%	0.9	Peone et al (1990)
1990	10	< 1%	0.2	2	< 0.1%	0.4	Griffith and Scholz (1991)
1991	16	< 1%	0.7	1	< 0.1%	0.3	Thatcher et al (1993)
1992	11	< 1%	0.4	0	< 0.1%	0	Thatcher et al (1994)
1993	0	0%	0	3	< 0.1%	6.9	Underwood and Shields (1996a)
1994	– –	– –	– –	– –	– –	– –	Underwood et al. 1996)
1995	31	< 1%	0.3	46	2.3%	1.4	Underwood and Shields (1996b)
1996	96	3%	3.6	36	< 0.1%	0.2	Cichosz et al. (1997)
1997	139	4%	4.1	84	13.0%	< 0.1	Cichosz et al. (1999)
1998	126	2%	3	85	9.0%	< 0.1	Spotts et al. (2000)
1999	34	3%	0.8	76	13.5%	< 0.1	McLellan et al (2003)
2000	30	3%	0.7	75	12.8%	< 0.1	Lee et al. (2003)
2001	16	< 1%	0.4	58	8.8%	< 0.1	Scofield et al. (2004)
2002	12	< 1%	0.4	72	12.3%		Fields et al (2004)
2003	11	< 1%	0.3	99	11.2%	0.2	Pavlik – Kunkel et al. (2005)
2004	15	< 1%	0.4	137	12.3%	– –	Lee et al. (2006)
2005	26	< 1%	0.2	139	13.1%	– –	Scofield et al. (2007)
2006	7	4%	0.6	181	12.9%	0.1	Pavlik – Kunkel et al. (2008)
Total	**611**	**23**	**18**	**1,099**	**121**	**11**	
Avg.	**34**	**1**	**1**	**61**	**7.3**	**0.7**	

From 1988 – 2006, a total of 601 and 1,099 burbot were captured by electrofishing and in gill nets, respectively, throughout Lake Roosevelt (Table A6). The number of burbot captured by electrofishing over the interval averaged (ranged) 34 (0 – 139). Relative abundance and CPUE for electrofishing averaged (ranged) 1 (0 – 4) % and 1 (0.2 – 4.1), respectively. The number of burbot captured by gill netting averaged (ranged) 61 (0 – 181). The relative abundance and catch–per–unit–effort for gill netting averaged (ranged) 7.3 (0 – 13.5) and 0.7 (0 – 6.9) respectively.

In the years from 1989 – 1993 the relative abundance of burbot in Lake Roosevelt was less than 1 % for each year in both boat electrofishing and gill net surveys. An abrupt increase in burbot abundance was noted in both electrofishing and gill net surveys by 1994 (Table A5). This increase coincided with the first large scale plants of smolt size kokanee into Lake Roosevelt from the Spokane Tribal Hatchery, and an increase in the number of rainbow trout yearlings stocked into Lake Roosevelt net pens from the Spokane Tribal Hatchery. Stockings of salmonids may be providing the forage that enhanced the burbot populations. The number of burbot continued to increase in the reservoir as the number of kokanee and rainbow trout stocked in the reservoir continued to increase until 1997.

Beginning in 1998 burbot abundance began to decline in Lake Roosevelt. This was likely the result of extremely high dissolved gas levels (> 130 % saturation) occurring throughout the summer of 1997 that produced symptoms of acute and chronic gas – bubble trauma in 78 % of all the burbot that we examined that summer (Scholz, unpublished data). This was caused by high river discharge in the Columbia River in 1997, which caused water to be spilled at dams located upstream from Lake Roosevelt in the Columbia, Spokane, and Pend Oreille Rivers, producing the super – saturated water. This apparently caused extensive gas – bubble trauma in burbot in Lake Roosevelt that caused a decline in the abundance for the next several years. After 2003, their abundance began to increase again and has fluctuated since that time.

Fluctuation in burbot abundance may also be related to predation by smallmouth bass and walleye. For example, in the present study, we observed that four smallmouth bass collectively contained 77 juvenile burbot in their stomachs. We hypothesize that after nitrogen supersaturation resulted in high levels of mortality in 1997, that rebuilding of the burbot population has been difficult because smallmouth bass and possibly walleye predation has held burbot population growth in check.

Polacek et al. (2006) analyzed the stomach contents of 208 burbot (122 from near–shore habitats and 74 from offshore habitats) in Lake Roosevelt. Burbot collected from near–shore habitats consumed 57 % fish and 14 % crayfish by weight. Near–shore burbot also consumed isopods, insects and leaches. Burbot collected from offshore habits consumed 71 % isopods and 14 % fish by weight. Offshore burbot also ate insects and leaches. Types of fish prey in burbot diets included sculpins, kokanee and rainbow trout (Polacek et al. 2006). Unfortunately, no specific fish data were presented by Polacek et al. (2006). Overall, sculpins predominated and "*salmonids were not a consistent component*" of burbot diets in Lake Roosevelt (Polacek et al. 2006).

Similar observations were made by the Spokane Tribe of Indians who analyzed the food habits of 105 burbot collected from Lake Roosevelt between 1997 and 2006 (Cichosz et al. 1999; McLellan et al. 2003; Lee et al. 2003, 2006; Scofield et al. 2004, 2007; Pavlik – Kunkel et al. 2005, 2008). The three most important prey items in the diet of these fish, based on the weight percentage, were Percidae (yellow perch, walleye), Cottidae (sculpins), and Salmonidae (kokanee, rainbow trout), which respectively averaged (ranged) 35.1 (0 – 94.9) %, 19.6 (0 – 84.3) %, and 13.5 (0 – 40.7) % of the weight percentage of the diet during this eight year period (Table A4).As no bioenergetics modeling was attempted by either Polacek et al. (2006) or by the Spokane Tribes reports, the data they collected on salmon consumption may not reflect how burbot predation impacts salmonids in Lake Roosevelt.

We have also observed that adult burbot target sexually mature kokanee in Lake Roosevelt following them into the mouths of tributary streams during the spawning season. Furthermore, the Colville Confederated Tribes have captured burbot in their weird traps for kokanee (Nine, personal communication). EWU has witnessed several instances of burbot predation on kokanee at this time, including a 660 mm TL burbot that had swallowed a 279 mm TL kokanee whole (Scholz and McLellan 2009). Burbot spawn in late February or early March and have slow metabolic rates. Consumption of such large prey in the autumn, at a time when their basal metabolism is slowing down as the water temperature becomes colder, undoubtedly allows the burbot to partition more of the energy obtained from large kokanee into gamete production. Therefore, we hypothesize that consumption of large kokanee by burbot in the autumn is especially important for the successful completion of the burbot life cycle in Lake Roosevelt.

Discussion

Burbot in Banks Lake fed extensively on kokanee while the lake was being stocked with approximately one million kokanee annually between the mid – 1950's and mid – 1960's (Bonar et al. 1997, 2000; Wydoski and Whitney 2003). When the annual stocking of kokanee was terminated in the mid – 1960's, kokanee suffered an abrupt population decline.

Burbot in Lake Chelan, Chelan County and Palmer Lake, Okanogan County preyed extensively on kokanee salmon (Boner et al. 1997, 2000; Wydoski and Whitney 2003).

Diet of adult burbot (n = 72, 400 – 860 mm TL) in Sullivan Lake was comprised, by weight, of fish (83.3 %) and annelid worms (9.5 %) (Nine and Scholz 2005), midges (2.9 %), mayflies (1.8 %), amphipods, stone flies and spiders (each less than 1 %) also contributed to their diets. Fish prey consumed by burbot included kokanee salmon, reside shiner, and slimy sculpin, which accounted for 40, 35 and 25 % of all identified fish prey (Nine and Scholz 2005). Food habits were assessed monthly from April through November. During the spring (April and May) burbot were captured under stumps at the mouth of an inlet stream (Harvey Creek) where they fed primarily on kokanee larvae and annelids that were washed out of or migrated out of the creek into the lake. Juvenile burbot (n = 16, 58 – 378 mm TL) in Sullivan Lake consumed, by weight mayflies (58.8 %), amphipods (19.9 %), Cladocerans (15 %), snails (5 %) and Chironomids (1.3 %).

Diet of burbot (n = 19, 166 – 863 mm TL) in Bead Lake was composed of 65.8 % crayfish and 20.1 % kokanee salmon by weight (Rader et al. 2006). Weight percentages of other prey consumed by Bead Lake burbot included northern pikeminnow (5.8 %), chironomids (4.7 %), damselflies (3.4 %), amphipods (< 0.1 %), earthworms (< 0.1 %), and water mites (< 0.1 %).

Moan (2008) developed bioenergetics models to estimate the consumption of kokanee salmon by burbot in Bead and Sullivan lakes, Pend Oreille Co. Washington. In Bead Lake, the burbot population (n = 2,700) was predicted to consume 7.2 % of the kokanee (n = 1,122 of an estimated population of 15,432 kokanee). In Bead Lake, burbot appeared to have little impact on the kokanee population. In Sullivan Lake, the burbot population (n = 5,000) were predicted to consume 25.8 % of the kokanee (n = 17,423 of an estimated population of 67,000 kokanee) in 2003.

Our data collection efforts produced few burbot and for those we did catch their stomachs were empty. In 2010, we do not plan to attempt to estimate burbot population or food habits and instead will refocus our energy on obtaining estimates of northern pikeminnow population and food habits.

Condition factors of normal range in burbot typically fall between 0.67 and 0.81 (Carlander 1969) See Table A3. Condition factors below this normal range indicate competition for limited food resources or that, for some reason, burbot are burning energy instead of storing it as biomass. The burbot that we caught (n = 8) had condition factors averaging (± SD) 0.52 ± 0.16. The condition factor for burbot (n = 996) caught in Lake Roosevelt by the Spokane Tribe from 1999 – 2006 (Table A2) averaged (ranged) 0.55 (0.53 – 0.63). These averages show that Sanpoil River and

Lake Roosevelt burbot populations had poor growth in comparison to most burbot population in the United States and Canada.

Kokanee in the Sanpoil River Arm of Lake Roosevelt were released in the West Fork on June 9, 2009. Except for one burbot caught 27 May, we did not catch another burbot until June 25. Our bioenergetic modeling of smallmouth bass and walleye showed that it was possible for those two species to deplete the kokanee population in 9 days. Thus it was conceivable that by the time our second burbot was captured on 25 June, all the kokanee had already been consumed by walleye and smallmouth bass.

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APPENDIX II. DIET STRATIFIED MONTHLY

Smallmouth bass

We analyzed the data monthly, in order to hone in on seasonal affects on the diet. When we did this, smallmouth were found to eat rainbow trout at weight percentages of 52.3 % (May), 11.9 % (June), 23.7 % (July), <0.1 % (August). Smallmouth were found to eat kokanee at numerical percentages of <0.1 % (May), 10.2 % (June), 1.7 % (July), <0.1 % (August). The most important prey item in smallmouth bass diets according to the weight percentage in May were rainbow trout (52.3 %), crayfish (23.9 %) and sculpins (21.9 %) (Table A1)

According to the numerical percentage the most` important prey items were Chironomidae (32.4 %), sculpins (25.0 %) and caddisflies (11.8 %). The most important prey item in smallmouth bass diets according to the weight percentage in June were crayfish (42.7 %), sculpins (16.6 %), rainbow trout (11.9 %) and kokanee salmon (10.2 %). According to the numerical percentage the most important prey items were *Leptodora* (71.6 %), *Daphnia* (11.3 %) and Chironomidae (5.7%). The most important prey item in smallmouth bass diets according to the weight percentage in July were crayfish (51.2 %), rainbow trout (23.7 %) and sculpins (15.1 %). According to the numerical percentage the most important prey items were sculpins (29.6 %), *Leptodora* (26.5 %) and *Daphnia* (21.5 %). The most important prey item in smallmouth bass diets according to the weight percentage in August were crayfish (89.4 %) and sculpins (6.6 %). According to the numerical percentage the most important prey items were sculpins (48.4 %), non–salmonid fishes (27.4 %) and crayfish (22.6 %).

Table A1. Food habits of smallmouth bass (n = 395) of all sizes, for the period of 27 May to 9 September, stratified monthly.

Smallmouth bass in May

Prey Item	Common Names	N	#	Wt (g)	% by #	% by Wt	FO	IRI
Cottidae	Sculpin	11	17	8.09	25.0%	21.9%	40.7%	46.3%
O. mykiss	Rainbow trout	2	2	19.34	2.9%	52.3%	7.4%	9.9%
Decapoda, A*stacidae*	Crayfish	5	7	8.82	10.3%	23.9%	18.5%	15.3%
Coleopteria, Curculionidae	Beetles	2	2	<0.1	2.9%	<0.1%	7.4%	0.5%
Diptera, C*hironomidae*	Non–biting midges	8	22	<0.1	32.4%	0.2%	29.6%	23.3%
Diptera, C*oenagrionidae*	Damselfly	1	1	<0.1	1.5%	<0.1%	3.7%	0.1%
Diptera, Misc.	Flys	1	1	<0.1	1.5%	<0.1%	3.7%	0.1%
Diptera, Tabanidae	Deer Fly	2	5	0.39	7.4%	1.0%	7.4%	1.5%
Insecta, Odonata	Dragonflies	2	2	0.19	2.9%	0.5%	7.4%	0.6%
Insecta, Trichoptera	Caddisflies	2	8	<0.1	11.8%	0.1%	7.4%	2.1%
Platyhelminthes	Flatworms	1	1	<0.1	1.5%	0.1%	3.7%	0.1%
Total		**37**	**68**	**36.95**	**100%**	**100%**		**100%**

Smallmouth bass in June

Prey Item	**Common Names**	**N**	**#**	**Wt (g)**	**% by #**	**% by Wt**	**FO**	**IRI**
Misc. fish	Fish (misc.)	3	3	<0.1	<0.1%	<0.1%	1.8%	<0.1%
Centrachidae	Bass, sunfish	5	8	0.38	0.1%	0.2%	3.1%	<0.1%
Cottidae	Sculpin	66	381	40.51	5.2%	16.6%	40.5%	19.7%
Gadidae, *Lota lota*	Burbot	2	61	5.06	0.8%	2.1%	1.2%	0.1%
Non–Salmonidae	Non–salmonid fish	18	74	4.42	1.0%	1.8%	11.0%	0.7%
Percidae	Percids	3	3	1.31	<0.1%	0.5%	1.8%	<0.1%
Salmonidae *misc.*	Salmonid	1	8	8.64	0.1%	3.5%	0.6%	<0.1%
O. mykiss	Rainbow trout	3	3	29.01	<0.1%	11.9%	1.8%	0.5%
O. nerka	Kokanee salmon	8	23	24.84	0.3%	10.2%	4.9%	1.1%
Amphipoda: Misc.	Scuds	5	5	<0.1	0.1%	<0.1%	3.1%	<0.1%
Annelida: Misc.	Segmented worms	1	3	5.94	<0.1%	2.4%	0.6%	<0.1%
Arachnid: Misc.	Spiders	9	9	0.13	0.1%	0.1%	5.5%	<0.1%
Daphnia	Daphnia	29	826	0.98	11.3%	0.4%	17.8%	4.6%
Leptodora	Leptodora	33	5,251	14.04	71.6%	5.7%	20.2%	35.0%
Decapoda, Astacidae	Crayfish	55	66	104.5	0.8%	42.7%	33.1%	32.2%
Coleoptera , Misc.	Beetles	1	1	<0.1	<0.1%	<0.1%	0.6%	<0.1%
Coleoptera, Cantharidae	Soldier beetles	1	1	<0.1	<0.1%	<0.1%	0.6%	<0.1%
Coleoptera, Dytiscidae	Diving beetles	3	5	<0.1	0.1%	<0.1%	1.8%	<0.1%
Coleoptera, Elmidae	Riffle beetles	1	1	<0.1	<0.1%	<0.1%	0.6%	<0.1%
Coleoptera, Gyrinidae	Whirligig beetles	1	1	<0.1	<0.1%	<0.1%	0.6%	<0.1%
Coleoptera, Hydrophilidae	Water scavenger beetles			<0.1	<0.1%	<0.1%	<0.1%	<0.1%
Coleoptera, S*taphylinidae*	Rove beetles	1	1	<0.1	<0.1%	<0.1%	0.6%	<0.1%
Diptera, Calliphoridae		1	1	<0.1	<0.1%	<0.1%	0.6%	<0.1%
Diptera, Cecidomyiidae	Gall midges/gnats	1	2	<0.1	<0.1%	<0.1%	0.6%	<0.1%
Diptera, C*hironomidae*	Non–biting midges	61	416	1.11	5.7%	0.5%	37.4%	5.1%
Diptera, Misc.	Flies	1	1	<0.1	<0.1%	<0.1%	0.6%	<0.1%
Diptera, Muscidae	House fly	1	1	<0.1	<0.1%	<0.1%	0.6%	<0.1%
Diptera, Simuliidae	Black fly	1	1	<0.1	<0.1%	<0.1%	0.6%	<0.1%
Diptera, Tabanidae	Deer Fly	4	5	<0.1	0.1%	<0.1%	2.5%	<0.1%
Hemiptera		17	23	0.45	0.3%	0.2%	10.4%	0.1%
Hymenoptera	Bees, wasps, ants	25	110	1.39	1.5%	0.6%	15.3%	0.7%
Hymenoptera: Formicidae	Ants	1	2	<0.1	<0.1%	<0.1%	0.6%	<0.1%
Insecta, Lepidoptera	Moths and butterflies	1	1	<0.1	<0.1%	<0.1%	0.6%	<0.1%
Insecta, Misc.		2	2	<0.1	<0.1%	<0.1%	1.2%	<0.1%
Insecta, Odonata	Damselflies and dragonflies	6	6	0.25	0.1%	0.1%	3.7%	<0.1%
Insecta, Plecoptera	Stoneflies	4	4	0.82	0.1%	0.3%	2.5%	<0.1%
Insecta, Raphidoptera	Snakefly	1	1	<0.1	<0.1%	<0.1%	0.6%	<0.1%
Insecta, Trichoptera	Caddisfly	7	12	<0.1	0.2%	<0.1%	4.3%	<0.1%
Isopoda	Sow bug	1	1	<0.1	<0.1%	<0.1%	0.6%	<0.1%
Misc. Invertebrate		1	1	<0.1	<0.1%	<0.1%	0.6%	<0.1%
Myriapoda: Chilopoda	Centipedes	1	1	<0.1	<0.1%	<0.1%	0.6%	<0.1%
Ostracoda	Seed shrimp	3	3	<0.1	<0.1%	<0.1%	1.8%	<0.1%
Platyhelminthes: Cestoda	Tapeworms	1	1	<0.1	<0.1%	<0.1%	0.6%	<0.1%
Totals:		**387**	**7,326**	**244.54**	**100%**	**100%**		**100%**

Smallmouth bass in July

Prey Item	Common Names	N	#	Wt (g)	% by #	% by Wt	FO	IRI
Misc. fish	Fish (misc.)	5	25	0.45	1.2%	0.1%	3.1%	0.1%
Centrachidae	Bass, sunfish	3	5	3.15	0.2%	1.0%	1.9%	<0.1%
Cottidae	Sculpin	67	611	49.30	29.6%	15.1%	41.9%	39.8%
Cyprinidae	Minnows	2	4	3.72	0.2%	1.1%	1.3%	<0.1%
Gadidae, *Lota lota*	Burbot	2	16	0.66	0.8%	0.2%	1.3%	<0.1%
Non–Salmonidae	Non–salmonid fish	27	141	5.85	6.8%	1.8%	16.9%	3.1%
Percidae	Percids	6	15	4.24	0.7%	1.3%	3.8%	0.2%
Salmonidae misc.	Salmonids (misc.)	2	4	4.32	0.2%	1.3%	1.3%	<0.1%
O. mykiss	Rainbow trout	4	8	77.36	0.4%	23.7%	2.5%	1.3%
O. nerka	Kokanee salmon	1	5	5.40	0.2%	1.7%	0.6%	<0.1%
Araneae, Misc.	Spiders	1	1	0.16	<0.1%	<0.1%	0.6%	<0.1%
Daphniidae	Daphnia	12	443	0.54	21.5%	0.2%	7.5%	3.4%
Leptodora	Leptodora	13	546	1.41	26.5%	0.4%	8.1%	4.6%
Branchiopoda, Misc.		3	5	<0.1	0.2%	<0.1%	1.9%	<0.1%
Decapoda, A*stacidae*	Crayfish	61	129	167.03	6.3%	51.2%	38.1%	46.5%
Coleoptera, Chrysomelidae	Leaf beetle	1	1	<0.1	<0.1%	<0.1%	0.6%	<0.1%
Coleoptera, Dytiscidae	Diving beetles	1	1	<0.1	<0.1%	<0.1%	0.6%	<0.1%
Diptera, Asilidae		1	1	<0.1	<0.1%	<0.1%	0.6%	<0.1%
Diptera, B*ombyliidae*		2	3	0.33	0.1%	0.1%	1.3%	<0.1%
Diptera, Chironomidae	Non–biting midges	19	50	0.15	2.4%	<0.1%	11.9%	0.6%
Diptera, misc.	Flies	2	2	<0.1	0.1%	<0.1%	1.3%	<0.1%
Diptera, Tabanidae	Deer Fly	2	2	<0.1	0.1%	<0.1%	1.3%	<0.1%
Insecta, Ephemeroptera	Mayflies	4	4	<0.1	0.2%	<0.1%	2.5%	<0.1%
Insecta, Hemiptera		3	3	0.22	0.1%	0.1%	1.9%	<0.1%
Insecta, Hymenoptera	Bees, wasps, ants	6	9	0.42	0.4%	0.1%	3.8%	<0.1%
Insecta, Odonata	Damselflies and dragonflies	8	8	0.24	0.4%	0.1%	5.0%	<0.1%
Insecta, Orthoptera		1	1	0.63	<0.1%	0.2%	0.6%	<0.1%
Insecta, Trichoptera	Caddisfly	8	18	0.39	0.9%	0.1%	5.0%	0.1%
Total		**267**	**2,061**	**326.08**	**100%**	**100%**		**100%**

Smallmouth in August

Prey Item	Common Names	N	#	Wt (g)	% by #	% by Wt	FO	IRI
Centrachidae	Bass, sunfish	1	1	0.83	1.6%	2.0%	2.9%	0.3%
Cottidae	Sculpin	5	30	2.82	48.4%	6.6%	14.7%	21.3%
Non–Salmonidae *misc.*	Non–salmonid fish	4	17	0.86	27.4%	2.0%	11.8%	9.1%
Decapoda, Astacidae	Crayfish	8	14	37.96	22.6%	89.4%	23.5%	69.3%
Total		**18**	**62**	**42.46**	**100%**	**100%**		**100%**

Walleye

When analyzed the data monthly, walleye were found to eat rainbow trout at weight percentages of 61.0 % (May), 30.0 % (June), 19.3 % (July), <0.1 % (August), and <0.1 % (September) (Table A2). Walleye were found to eat kokanee at numerical percentages of <0.1 % (May), 9.4 % (June), <0.1 % (July), <0.1 % (August), <0.1 % (September). The most important prey item in walleye diets according to the weight percentage in May were rainbow trout (61.0 %) and crayfish (34.2 %). According to the numerical percentage the most important prey items were Chironomidae (66.2 %), crayfish (20.6 %) and rainbow trout (7.4 %). The most important prey item in walleye diets according to the weight percentage in June were rainbow trout (30.0 %), *Leptodora* (20.6 %), kokanee salmon (9.4 %) and Percidae (14.3 %). According to the numerical percentage the most important prey items were *Leptodora* (93.3 %), *Daphnia* (3.4 %) and Chironomidae (1.5 %). The most important prey item according to the weight percentage in July were Cottidae (22.6 %), Percidae (19.6 %) and rainbow trout (19.3 %). According to the numerical percentage the most important prey items were *Leptodora* (76.2 %), sculpin (16.0 %) and Percidae (2.1 %). The most important prey items according to the weight percentage in August were Centrarchidae (34.7 %) and sculpin (34.1 %), whereas according to the numerical percentage were *Leptodora* (92.3 %), and sculpin (5.5 %). The most important prey item in walleye diets according to the weight percentage in September were Cyprinidae (81.4 %) and Centrarchidae (7.3 %), whereas according to the numerical percentage were *Daphnia* (95.0 %), Centrarchidae (1.1 %) and Chironomidae (1.1 %).

Table A2. Food habits of walleye (n = 481) of all sizes for the period of 27 May to 9 September, 2009, stratified monthly.

Walleye in May

Prey Item	Common Names	N	#	Wt (g)	% by #	% by Wt	FO	IRI
Misc. fishes		1	1	1.03	1.5%	1.3%	5.3%	0.2%
Catasomidae	Sucker	1	1	0.20	1.5%	0.2%	5.3%	0.2%
Non–Salmonidae	Non–salmonid fish	1	2	0.49	2.9%	0.6%	5.3%	0.3%
O. mykiss	Rainbow trout	5	5	48.35	7.4%	61.0%	26.3%	29.8%
Decapoda, A*stacidae*	Crayfish	7	14	27.12	20.6%	34.2%	36.8%	33.5%
Diptera, C*hironomidae*	Non–biting midges	6	45	2.06	66.2%	2.6%	31.6%	36.0%
Total		**20**	**67**	**78.22**	**98.5%**	**98.7%**		**99.8%**

Walleye in June

Prey Item	Common Names	N	#	Wt (g)	% by #	% by Wt	FO	IRI
Misc. fishes		2	2	<0.1	<0.1%	<0.1%	2.1%	<0.1%
Catasomidae	Sucker	1	1	<0.1	<0.1%	<0.1%	1.0%	<0.1%
Centrachidae	Bass, sunfish	2	5	9.88	<0.1%	6.1%	2.1%	0.3%
Cottidae	Sculpin	19	126	9.02	0.9%	5.6%	19.8%	3.2%
Cyprinidae	Minnows	2	3	15.20	<0.1%	9.4%	2.1%	0.5%
Non–Salmonidae	Non–salmonid fish	7	7	4.89	0.1%	3.0%	7.3%	0.6%
Percidae	Percids	3	18	23.02	0.1%	14.3%	3.1%	1.1%
O. mykiss	Rainbow trout	4	5	48.35	<0.1%	3<0.1%	4.2%	3.1%
O. nerka	Kokanee salmon	8	14	15.12	0.1%	9.4%	8.3%	2.0%
Amphipoda, misc.		4	19	<0.1	0.1%	0.1%	4.2%	<0.1%
Daphnia	Daphnia	23	458	0.41	3.4%	0.3%	24.0%	2.2%
Leptodora	Leptodora	29	12,404	33.15	93.3%	20.6%	30.2%	85.3%
Branchiopoda, Misc.		1	10	<0.1	0.1%	<0.1%	1.0%	<0.1%
Decapoda, Astacidae	Crayfish	8	8	0.34	0.1%	0.2%	7.3%	<0.1%
Diptera, Cecidomyiidae	Gall midges/gnats	1	1	<0.1	<0.1%	<0.1%	1.0%	<0.1%
Diptera, C*hironomidae*	Non–biting midges	27	196	1.57	1.5%	1.0%	28.1%	1.7%
Diptera, misc.	Flies	1	1	<0.1	<0.1%	<0.1%	1.0%	<0.1%
Insecta, Hymenoptera	Bees, wasps, ants	1	1	<0.1	<0.1%	<0.1%	1.0%	<0.1%
Insecta, Odonata	Damselflies and dragonflies	2	2	<0.1	<0.1%	<0.1%	2.1%	<0.1%
Insecta, Trichoptera	Caddisfly	2	3	<0.1	<0.1%	<0.1%	2.1%	<0.1%
Isopoda	Sow bug	1	10	0.18	0.1%	0.1%	1.0%	<0.1%
Total		**146**	**13,292**	**161.30**	**100%**	**100%**		**100%**

Walleye in July

Prey Item	Common Names	N	#	Wt (g)	% by #	% by Wt	FO	IRI
Misc. fishes		4	4	0.56	0.1%	0.3%	1.4%	<0.1%
Centrachidae	Bass, sunfish	13	16	30.69	0.6%	15.3%	4.5%	3.4%
Cottidae	Sculpin	85	432	45.17	16.0%	22.6%	29.3%	53.1%
Cyprinidae	Minnows	5	5	14.80	0.2%	7.4%	1.7%	0.6%
Non–Salmonidae, misc.	Non–salmonid fish	23	38	8.11	1.4%	4.1%	7.9%	2.0%
Percidae	Percids	18	58	39.30	2.1%	19.6%	6.2%	6.4%
O. mykiss	Rainbow trout	4	4	38.68	0.1%	19.3%	1.4%	1.3%
Daphnia	Daphnia	8	39	<0.1	1.4%	<0.1%	2.8%	0.2%
Leptodora	Leptodora	23	2,059	5.40	76.2%	2.7%	7.9%	29.4%
Decapoda, A*stacidae*	Crayfish	23	28	17.01	1.0%	8.5%	7.9%	3.6%
Diptera, C*hironomidae*	Non–biting midges	8	13	<0.1	0.5%	<0.1%	2.8%	0.1%
Insecta, Odonata	Damselflies and dragonflies	1	1	<0.1	<0.1%	<0.1%	0.3%	<0.1%
Insecta, Trichoptera	Caddisfly	3	6	0.10	0.2%	<0.1%	1.0%	<0.1%
Total		**218**	**2,703**	**20<0.1**	**100%**	**100%**		**100%**

Walleye in August

Prey Item	Common Names	N	#	Wt (g)	% by #	% by Wt	FO	IRI
Misc. fish	Misc. fish	1	1	0.14	0.4%	2.6%	2.0%	0.9%
Centrachidae	Bass, sunfish	2	3	1.82	1.1%	34.7%	4.1%	21.6%
Cottidae	Sculpin	3	15	1.78	5.5%	34.1%	6.1%	35.8%
Non–Salmonidae, misc.	Non–salmonid fish	2	2	0.82	0.7%	15.8%	4.1%	1<0.1%
Leptodora	Leptodora	1	252	0.67	92.3%	12.8%	2.0%	31.7%
Total		**9**	**273**	**5.23**	**100%**	**100%**		**100%**

Walleye in September

Prey Item	Common Names	N	#	Wt (g)	% by #	% by Wt	FO	IRI
Misc. fishes	Misc. fish	1	1	<0.1	0.2%	<0.1%	3.7%	<0.1%
Centrachidae	Bass, sunfish	6	6	3.61	1.1%	7.3%	22.2%	5.2%
Cottidae	Sculpin	1	1	1.24	0.2%	2.5%	3.7%	0.3%
Cyprinidae	Minnows	5	5	40.12	0.9%	81.4%	18.5%	41.8%
Non–Salmonidae, misc.	Non–salmonid fish	1	1	0.34	0.2%	0.7%	3.7%	0.1%
Percidae	Percids	4	4	3.29	0.7%	6.7%	14.8%	3.0%
Daphnia	Daphnia	5	511	0.57	95.0%	1.2%	18.5%	48.9%
Decapoda, Astacidae	Crayfish	1	1	<0.1	0.2%	<0.1%	3.7%	<0.1%
Diptera, C*hironomidae*	Non–biting midges	5	6	<0.1	1.1%	0.2%	18.5%	0.6%
Insecta, Diptera (misc.)	Misc. Flies	2	2	<0.1	0.4%	<0.1%	7.4%	0.1%
Total		**31**	**538**	**49.28**	**100%**	**100%**		**100%**

APPENDIX III. RECAPTURED PREDATOR GROWTH PER DAY

Table A1. Average length (mm TL) and weight (g) daily growth in recaptured walleye from 27 May to 9 September.

ID	Date Marked	Date Recaptured	Days	TL mark	TL recap	TL per day	Wt mark	Wt recap	Wt per day
185	5/27/2009	6/3/2009	7	426	430	0.57	635	644	1.29
388	6/23/2009	7/1/2009	8	334	341	.88	317	330	1.63
447	6/29/2009	7/28/2009	29	401	420	0.66	590	670	2.76
675	7/7/2009	7/21/2009	14	203	223	1.43	67	90	1.64
762	7/14/2009	7/21/2009	7	413	420	1.00	620	624	0.57
951	7/21/2009	7/28/2009	7	354	358	0.57	358	366	1.14
1055	7/28/2009	8/4/2009	7	354	355	0.14	360	382	3.14
1117	8/4/2009	8/12/2009	8	251	260	1.13	143	218	9.38
1156	8/4/2009	8/12/2009	8	235	250	1.88	114	127	1.63
5421	7/1/2009	7/7/2009	6	228	230	0.33	76	-	-
Average			**10.1**	**319.9**	**328.7**	**0.9**	**328.0**	**383.4**	**2.6**

Table A2. Average length (mm TL) and weight (g) daily growth in recaptured smallmouth bass from 27 May to 9 September. (Page 1 of 5)

ID#	Date Marked	Date Recaptured	Days	TL mark	TL recap	TL per day	Wt mark	Wt recap	Wt per day
25	5/27/2009	6/18/2009	22	210	211	<0.1	105	120	0.68
28	5/27/2009	7/1/2009	35	256	271	0.43	209	268	1.69
54	5/27/2009	7/1/2009	35	244	252	0.23	68	236	4.80
207	6/3/2009	6/29/2009	26	232	245	0.50	160	205	1.73
212	6/3/2009	6/25/2009	22	172	186	0.64	62	73	0.50
215	6/3/2009	7/14/2009	41	270	275	0.12	253	262	0.22
247	6/3/2009	6/10/2009	7	197	200	0.43	86	90	0.57
264	6/10/2009	7/21/2009	41	176	213	0.90	71	125	1.32
290	6/10/2009	6/16/2009	6	225	225	<0.1	134	152	3.00
304	6/16/2009	6/18/2009	2	185	190	2.50	80	80	<0.1
314	6/18/2009	7/21/2009	33	244	260	0.48	177	199	0.67
328	6/18/2009	7/1/2009	13	171	179	0.62	59	69	0.77
340	6/18/2009	7/28/2009	40	178	214	0.90	74	124	1.25
372	6/23/2009	9/9/2009	78	254	265	0.14	201	-	-
373	6/23/2009	7/7/2009	14	251	252	<0.1	189	190	<0.1
402	6/23/2009	8/4/2009	42	181	212	0.74	79	-	-
409	6/25/2009	7/28/2009	33	185	216	0.94	83	139	1.70
486	6/29/2009	7/14/2009	15	241	242	<0.1	195	170	-1.67
499	6/29/2009	7/1/2009	2	231	234	1.50	163	157	-3.00
524	7/1/2009	7/7/2009	6	90	178	14.67	76	-	-
536	7/1/2009	8/4/2009	34	190	214	0.71	84	120	1.06
544	7/1/2009	7/7/2009	6	235	238	0.50	171	180	1.50
552	7/1/2009	7/28/2009	27	276	296	0.74	311	397	3.19
556	7/1/2009	7/21/2009	20	214	226	0.60	134	166	1.60
557	7/1/2009	7/28/2009	27	193	225	1.19	107	162	2.04
559	7/1/2009	7/28/2009	27	215	238	0.85	129	178	1.81
612	7/7/2009	7/28/2009	21	210	231	1.00	123	-	-
628	7/7/2009	8/4/2009	28	235	266	1.11	171	-	-
642	7/7/2009	7/21/2009	14	277	292	1.07	294	326	2.29
702	7/7/2009	7/28/2009	21	208	224	0.76	156	165	0.43
705	7/7/2009	7/21/2009	14	294	300	0.43	388	400	0.86

Table A2(Continued). Smallmouth bass growth (Page 2 of 5).

ID#	Date Marked	Date Recaptured	Days	TL mark	TL recap	TL per day	Wt mark	Wt recap	Wt per day
777	7/14/2009	7/21/2009	7	242	250	1.14	190	206	2.29
790	7/14/2009	7/21/2009	7	266	315	7.00	286	-	-
1080	7/28/2009	8/4/2009	7	233	237	0.57	188	193	0.71
1179	5/27/2009	6/25/2009	29	80	95	0.52	1	11	0.34
1192	5/27/2009	7/7/2009	41	82	111	0.71	10	-	-
1206	5/27/2009	6/18/2009	22	77	79	<0.1	5	6	<0.1
1222	5/27/2009	6/29/2009	33	84	95	0.33	4	11	0.21
1226	5/27/2009	7/7/2009	41	78	109	0.76	5	-	-
1246	6/3/2009	6/25/2009	22	79	91	0.55	6	9	0.14
1247	6/3/2009	6/25/2009	22	78	92	0.64	3	10	0.32
1253	6/3/2009	6/25/2009	22	94	112	0.82	8	14	0.27
1258	6/3/2009	6/25/2009	22	77	93	0.73	4	9	0.23
1263	6/3/2009	6/25/2009	22	82	102	0.91	5	12	0.32
1264	6/3/2009	6/25/2009	22	76	98	1.00	2	12	0.45
1270	6/3/2009	6/25/2009	22	97	109	0.55	7	15	0.36
1277	6/3/2009	6/25/2009	22	112	128	0.73	16	23	0.32
1287	6/3/2009	7/1/2009	28	84	114	1.07	5	21	0.57
1293	6/3/2009	7/7/2009	34	68	85	0.50	2	-	-
1308	6/3/2009	7/7/2009	34	69	88	0.56	4	-	-
1310	6/3/2009	6/25/2009	22	74	92	0.82	5	9	0.18
1311	6/3/2009	6/25/2009	22	66	72	0.27	3	4	<0.1
1313	6/3/2009	6/25/2009	22	155	165	0.45	42	55	0.59
1332	6/3/2009	7/7/2009	34	79	99	0.59	4	-	-
1333	6/3/2009	6/25/2009	22	85	103	0.82	10	16	0.27
1344	6/3/2009	7/21/2009	48	79	127	1.00	6		-0.13
1346	6/3/2009	7/1/2009	28	78	108	1.07	4	16	0.43
1352	6/3/2009	6/25/2009	22	82	105	1.05	5	15	0.45
1356	6/3/2009	7/1/2009	28	107	135	1.00	13	36	0.82
1367	6/3/2009	6/25/2009	22	72	75	0.14	5	9	0.18
1368	6/3/2009	7/7/2009	34	76	100	0.71	4	-	-
1376	6/3/2009	6/10/2009	7	94	100	0.86	8	11	0.43
1377	6/3/2009	7/1/2009	28	75	101	0.93	8	-	-
1383	6/3/2009	7/7/2009	34	76	101	0.74	4	-	-
1389	6/3/2009	7/7/2009	34	78	95	0.50	4	-	-
1399	6/3/2009	7/1/2009	28	75	102	0.96	4	-	-
1441	6/10/2009	6/18/2009	8	81	89	1.00	4	11	0.88
1447	6/10/2009	6/25/2009	15	108	123	1.00	13	21	0.53
1464	6/10/2009	7/1/2009	21	109	135	1.24	16	-	-
1472	6/10/2009	6/25/2009	15	79	91	0.80	6	11	0.33
1507	6/10/2009	7/28/2009	48	104	152	1.00	12	49	0.77
1526	6/10/2009	7/21/2009	41	71	112	1.00	4	-	-
1539	6/10/2009	7/21/2009	41	72	117	1.10	4	-	-
1588	6/16/2009	6/23/2009	7	92	99	1.00	10	13	0.43
1589	6/16/2009	7/21/2009	35	81	113	0.91	8	19	0.31
1598	6/16/2009	6/23/2009	7	97	104	1.00	12	13	0.14
1608	6/16/2009	6/23/2009	7	124	131	1.00	27	28	0.14
1614	6/16/2009	6/23/2009	7	117	124	1.00	17	25	1.14
1621	6/16/2009	6/25/2009	9	89	96	0.78	10	12	0.22
1654	6/18/2009	6/25/2009	7	110	117	1.00	14	22	1.14
1671	6/18/2009	6/25/2009	7	110	117	1.00	12	22	1.43
1701	6/18/2009	7/28/2009	40	106	146	1.00	16	-	-
1705	6/18/2009	6/29/2009	11	115	125	0.91	21	26	0.45
1810	6/18/2009	7/14/2009	26	90	116	1.00	8	-	-
1865	6/18/2009	7/7/2009	19	95	113	0.95	12	-	-
1866	6/18/2009	8/4/2009	47	100	142	0.89	6	-	-
1867	6/18/2009	7/1/2009	13	99	112	1.00	13	-	-

Table A2 (Continued). Smallmouth bass growth (Page 3 of 5).

ID#	Date Marked	Date Recaptured	Days	TL mark	TL recap	TL per day	Wt mark	Wt recap	Wt per day
1889	6/18/2009	7/21/2009	33	129	151	0.67	30	53	0.70
1923	6/23/2009	7/7/2009	14	163	166	0.21	56	-	-
1925	6/23/2009	6/25/2009	2	94	96	1.00	9	11	1.00
1929	6/23/2009	6/25/2009	2	84	86	1.00	8	9	0.50
1938	6/23/2009	7/7/2009	14	80	93	0.93	7	-	-
1949	6/23/2009	7/1/2009	8	130	137	0.88	31	34	0.38
1955	6/23/2009	7/7/2009	14	100	112	0.86	13	-	-
1963	6/23/2009	7/14/2009	21	80	105	1.19	7	-	-
1976	6/23/2009	7/1/2009	8	92	98	0.75	10	12	0.25
1981	6/23/2009	6/29/2009	6	74	77	0.50	6	6	<0.1
1993	6/23/2009	7/1/2009	8	90	96	0.75	9	14	0.63
2003	6/23/2009	8/4/2009	42	111	153	1.00	18	'-	'-
2024	6/23/2009	7/7/2009	14	71	79	0.57	5	'-	'-
2067	6/23/2009	7/1/2009	8	98	104	0.75	11	16	0.63
2120	6/23/2009	7/1/2009	8	95	101	0.75	11	13	0.25
2121	6/23/2009	7/7/2009	14	71	80	0.64	6	-	-
2127	6/23/2009	7/1/2009	8	98	104	0.75	12	16	0.50
2140	6/23/2009	6/29/2009	6	95	98	0.50	12	-	-
2163	6/23/2009	7/28/2009	35	116	149	0.94	22	-	-
2170	6/23/2009	7/28/2009	35	120	169	1.40	26	-	-
2183	6/25/2009	6/29/2009	4	75	81	1.50	5	8	0.75
2193	6/25/2009	6/29/2009	4	75	83	2.00	5	9	1.00
2200	6/25/2009	7/7/2009	12	81	93	1.00	6	-	-
2202	6/25/2009	6/29/2009	4	61	71	2.50	3	4	0.25
2204	6/25/2009	6/29/2009	4	75	83	2.00	6	7	0.25
2232	6/25/2009	7/14/2009	19	65	151	4.53	5	48	2.26
2237	6/25/2009	6/29/2009	4	92	97	1.25	11	11	<0.1
2275	6/25/2009	7/7/2009	12	94	98	0.33	11	-	-
2283	6/25/2009	7/14/2009	19	79	105	1.37	6	-	-
2284	6/25/2009	6/29/2009	4	75	83	2.00	5	8	0.75
2293	6/25/2009	6/29/2009	4	80	86	1.50	7	10	0.75
2300	6/25/2009	8/4/2009	40	72	112	1.00	5	-	-
2338	6/25/2009	7/28/2009	33	100	127	0.82	14	-	-
2343	6/25/2009	7/7/2009	12	84	96	1.00	8	-	-
2345	6/25/2009	7/21/2009	26	100	126	1.00	12	-	-
2348	6/25/2009	7/28/2009	33	84	117	1.00	7	-	-
2376	6/25/2009	6/29/2009	4	80	86	1.50	8	9	0.25
2404	6/25/2009	7/28/2009	33	102	128	0.79	13	-	-
2419	6/25/2009	6/29/2009	4	80	87	1.75	53	8	-11.25
2432	6/25/2009	6/29/2009	4	157	162	1.25	49	52	0.75
2446	6/25/2009	6/29/2009	4	65	72	1.75	6	5	-0.25
2450	6/25/2009	7/28/2009	33	80	113	1.00	8	-	-
2470	6/25/2009	6/29/2009	4	91	95	1.00	12	12	<0.1
2522	6/25/2009	8/4/2009	40	103	143	1.00	13	-	-
2537	6/25/2009	6/29/2009	4	102	106	1.00	13	15	0.50
2538	6/25/2009	6/29/2009	4	84	88	1.00	7	9	0.50
2568	6/25/2009	7/7/2009	12	68	79	0.92	6	-	-
2582	6/25/2009	6/29/2009	4	103	107	1.00	14	20	1.50
2586	6/25/2009	6/29/2009	4	68	76	2.00	4	-	-
2595	6/25/2009	7/7/2009	12	66	79	1.08	3	-	-
2647	6/25/2009	6/29/2009	4	103	107	1.00	16	-	-
2660	6/25/2009	6/29/2009	4	69	79	2.50	4	6	0.50
2663	6/25/2009	6/29/2009	4	97	102	1.25	11	14	0.75
2670	6/25/2009	7/21/2009	26	102	128	1.00	13	-	-
2686	6/25/2009	6/29/2009	4	116	120	1.00	20	27	1.75
2698	6/25/2009	6/29/2009	4	88	92	1.00	6	9	0.75
2699	6/25/2009	7/7/2009	12	70	81	0.92	5	-	-

Table A2 (Continued). Smallmouth bass growth (Page 4 of 5).

ID#	Date Marked	Date Recaptured	Days	TL mark	TL recap	TL per day	Wt mark	Wt recap	Wt per day
2734	6/25/2009	7/28/2009	33	130	161	0.94	27	-	-
2758	6/29/2009	7/7/2009	8	103	111	1.00	13	-	-
2765	6/29/2009	7/21/2009	22	126	146	0.91	27	-	-
2782	6/29/2009	7/28/2009	29	90	112	0.76	12	-	-
2801	6/29/2009	8/4/2009	36	81	115	0.94	6	-	-
2802	6/29/2009	7/21/2009	22	82	103	0.95	8	-	-
2806	6/29/2009	8/4/2009	36	87	123	1.00	7	-	-
2807	6/29/2009	7/21/2009	22	114	136	1.00	17	-	-
2816	6/29/2009	7/14/2009	15	78	107	1.93	7	-	-
2818	6/29/2009	7/28/2009	29	91	120	1.00	10	-	-
2824	6/29/2009	7/28/2009	29	103	132	1.00	12	-	-
2841	6/29/2009	8/4/2009	36	88	124	1.00	9	-	-
2875	6/29/2009	7/21/2009	22	78	107	1.32	8	-	-
2906	6/29/2009	7/21/2009	22	82	104	1.00	6	-	-
3003	6/29/2009	7/28/2009	29	73	102	1.00	5	-	-
3013	6/29/2009	7/21/2009	22	81	101	0.91	-	-	-
3083	6/29/2009	7/14/2009	15	90	107	1.13	12	-	-
3101	6/29/2009	7/21/2009	22	100	122	1.00	-	-	-
3114	6/29/2009	7/14/2009	15	125	154	1.93	-	-	-
3142	6/29/2009	7/21/2009	22	90	112	1.00	-	-	-
3181	6/29/2009	7/21/2009	22	84	105	0.95	-	-	-
3198	6/29/2009	7/14/2009	15	102	117	1.00	-	-	-
3205	6/29/2009	8/4/2009	36	117	153	1.00	-	-	-
3213	6/29/2009	7/28/2009	29	126	-	-	-	-	-
3239	6/29/2009	8/4/2009	36	105	-	-	-	-	-
3281	7/1/2009	7/21/2009	20	172	-	-	67	-	-
3291	7/1/2009	7/7/2009	6	84	91	1.17	-	-	-
3308	7/1/2009	7/21/2009	20	83	104	1.05	-	-	-
3313	7/1/2009	7/28/2009	27	87	107	0.74	-	-	-
3331	7/1/2009	7/21/2009	20	85	105	1.00	-	-	-
3336	7/1/2009	7/7/2009	6	75	75	<0.1	-	-	-
3342	7/1/2009	7/7/2009	6	84	89	0.83	-	-	-
3351	7/1/2009	8/12/2009	42	99	132	0.79	39	-	-
3353	7/1/2009	7/7/2009	6	162	170	1.33	58	63	0.83
3371	7/1/2009	7/21/2009	20	102	122	1.00	-	-	-
3381	7/1/2009	7/7/2009	6	80	84	0.67	-	-	-
3385	7/1/2009	7/21/2009	20	116	136	1.00	-	-	-
3400	7/1/2009	7/28/2009	27	90	107	0.63	-	-	-
3405	7/1/2009	7/21/2009	20	119	139	1.00	-	-	-
3408	7/1/2009	7/28/2009	27	127	154	1.00	-	-	-
3409	7/1/2009	8/4/2009	34	98	132	1.00	-	-	-
3417	7/1/2009	7/21/2009	20	100	134	1.70	-	-	-
3434	7/1/2009	8/4/2009	34	122	151	0.85	-	-	-
3443	7/1/2009	7/7/2009	6	81	87	1.00	-	-	-
3450	7/1/2009	8/4/2009	34	121	155	1.00	-	-	-
3451	7/1/2009	7/21/2009	20	129	149	1.00	-	-	-
3473	7/1/2009	7/21/2009	20	119	139	1.00	-	-	-
3486	7/1/2009	7/21/2009	20	79	99	1.00	-	-	-
3491	7/1/2009	8/4/2009	34	94	128	1.00	-	-	-
3503	7/1/2009	8/4/2009	34	100	134	1.00	-	-	-
3526	7/1/2009	7/7/2009	6	94	100	1.00	-	-	-
3551	7/7/2009	8/4/2009	28	80	109	1.04	-	-	-
3562	7/7/2009	7/21/2009	14	90	104	1.00	15	-	-
3571	7/7/2009	7/28/2009	21	75	95	0.95	-	-	-
3598	7/7/2009	8/4/2009	28	111	132	0.75	-	-	-
3601	7/7/2009	7/21/2009	14	86	100	1.00	13	-	-
3623	7/7/2009	7/28/2009	21	91	112	1.00	-	-	-

Table A2 (concluded). Smallmouth bass growth (Page 5 of 5).

ID#	Date Marked	Date Recaptured	Days	TL mark	TL recap	TL per day	Wt mark	Wt recap	Wt per day
3629	7/7/2009	7/21/2009	14	109	123	1.00	-	-	-
3650	7/7/2009	7/21/2009	14	133	147	1.00	35	-	-
3653	7/7/2009	7/14/2009	7	145	151	0.86	5	-	-
3654	7/7/2009	7/14/2009	7	104	108	0.57	17	-	-
3667	7/7/2009	7/14/2009	7	100	106	0.86	-	-	-
3685	7/7/2009	7/21/2009	14	100	116	1.14	-	-	-
3705	7/7/2009	8/4/2009	28	90	113	0.82	-	-	-
3713	7/7/2009	8/12/2009	36	130	163	0.92	67	-	-
3742	7/7/2009	8/12/2009	36	120	152	0.89	55	-	-
3744	7/7/2009	7/28/2009	21	126	147	1.00	-	-	-
3745	7/7/2009	7/21/2009	14	118	119	<0.1	-	-	-
3756	7/7/2009	7/28/2009	21	102	122	0.95	-	-	-
3770	7/7/2009	7/28/2009	21	116	136	0.95	-	-	-
3780	7/7/2009	7/28/2009	21	142	161	0.90	-	-	-
3808	7/7/2009	7/28/2009	21	85	105	0.95	-	-	-
3883	7/14/2009	7/21/2009	7	97	106	1.29	-	-	-
3911	7/14/2009	7/21/2009	7	152	158	0.86	60	-	-
3921	7/14/2009	7/21/2009	7	129	137	1.14	-	-	-
3933	7/21/2009	7/28/2009	7	140	147	1.00	38	-	-
3959	7/21/2009	7/28/2009	7	162	169	1.00	65	-	-
3971	7/21/2009	7/28/2009	7	111	118	1.00	17	-	-
3992	7/21/2009	7/28/2009	7	119	125	0.86	-	-	-
4012	7/21/2009	7/28/2009	7	101	108	1.00	-	-	-
4079	7/21/2009	7/28/2009	7	151	157	0.86	47	-	-
4081	7/21/2009	7/28/2009	7	142	152	1.43	36	-	-
4088	7/21/2009	7/28/2009	7	131	138	1.00	-	-	-
4104	7/21/2009	7/28/2009	7	133	140	1.00	-	-	-
4128	7/21/2009	8/4/2009	14	117	124	0.50	-	-	-
4143	7/21/2009	7/28/2009	7	141	148	1.00	-	-	-
4153	7/21/2009	7/28/2009	7	109	116	1.00	-	-	-
4156	7/21/2009	7/28/2009	7	128	135	1.00	-	-	-
4160	7/21/2009	7/28/2009	7	110	115	0.71	-	-	-
4161	7/21/2009	7/28/2009	7	110	117	1.00	-	-	-
4169	7/21/2009	7/28/2009	7	164	170	0.86	58	-	-
4187	7/21/2009	7/28/2009	7	118	125	1.00	-	-	-
4204	7/21/2009	7/28/2009	7	109	116	1.00	-	-	-
4226	7/21/2009	8/4/2009	14	136	150	1.00	-	-	-
4253	7/21/2009	7/28/2009	7	124	131	1.00	-	-	-
4288	7/21/2009	8/4/2009	14	120	134	1.00	-	-	-
4309	7/21/2009	7/28/2009	7	148	154	0.86	51	-	-
4390	7/28/2009	8/4/2009	7	113	120	1.00	-	-	-
4467	7/28/2009	8/4/2009	7	117	124	1.00	-	-	-
4597	8/4/2009	8/12/2009	8	138	150	1.50	45	-	-
Average			**19**	**116**	**133**	**1.03**	**41.34**	**67.59**	**0.58**

APPENDIX IV: RAW DATA

Due to the large number of captured fish, an appendix of raw data would fill up approximately 120 pages. In lieu of a hard copy of our raw data, we would provide an electronic copy of all raw data to the Colville Tribe. Please contact Bret Nine of the Colville Tribe to obtain permission to view these data.