Abundance, Activity, and Diet of Littoral Fish in Lake Billy Chinook, Lake Simtustus, and Reregulating Reservoir, Oregon, 1997–1999

Pelton Round Butte Hydroelectric Project

FERC No. 2030

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ABSTRACT

From 1997 to 1999, littoral fish were capture using Merwin traps in Lake Billy Chinook and Lake Simtustus, Oregon. A total of 34,464 fish were capture over the three years. Smallmouth bass *Micropterus dolomieu* were the most abundant fish captured in 1997 and 1998, at 1,312 and 3,316, respectively. Kokanee *Oncorhynchus nerka* were the most abundant fish capture in 1999 at 15,003. Most fish did not become considerably active until April or May. During 1998 and 1999, piscivorous fish had stomachs sample taken to determine diet content. Many different prey items were found among all piscivores. Smallmouth bass did not appear to be major consumers of fish.

INTRODUCTION

As part of Portland General Electric's proposal to reestablish anadromous fish populations upstream of the Pelton Round Butte Hydroelectric Project (Project) (Ratliff et al. 1996), a technical subcommittee was formed to help determine the feasibility of fish passage and how it could be accomplished. Critical uncertainties for reestablishing populations of the various fish species were designated using a structured decision-making process. Predation of sockeye salmon *O. nerka* and spring and fall chinook salmon *O. tshawytscha* during juvenile rearing and migrating life history stages was identified as a critical uncertainty for reestablishing runs of these species. To better understand this uncertainty, this study was designed to determine relative abundance, activity, and diet of piscivorous littoral fish in Lake Billy Chinook, Lake Simtustus, and the Reregulating Reservoir.

STUDY AREA

The Project is located on the Deschutes River in central Oregon 161 km upriver from the Columbia River. The Reregulating Dam is the lowermost dam of the Project, and the reservoir that it forms is 4 km long, approximately 14 m deep, and has a shoreline of 10 km (Figure 1). The reservoir is used to ameliorate peaking flows from upstream dams, and consequently, the water level fluctuates approximately 6 m daily.

Lake Simtustus, formed by Pelton Dam in 1956, is 11 km long, 47 m deep, and has a shoreline of 31.5 km. Being confined to the Deschutes River canyon, it is narrow with steep sides and has a shoal area (i.e., the lake surface area with a depth < 3.3 m) of 12% (Johnson et al. 1985); (Figure 1).

The uppermost reservoir, Lake Billy Chinook, was filled in 1964 with the completion of Round Butte Dam. Based on limnological characteristics, Lake Billy Chinook is classified as a eutrophic warm-monomictic reservoir (Wetzel 1983). Lake Billy Chinook has a surface area of 1,585 ha, a shoreline of 100 km, and an elevation of 593 m above sea level at full pool (Johnson et al. 1985). The Crooked, Deschutes, and Metolius River arms comprise 23%, 26%, and 51% of

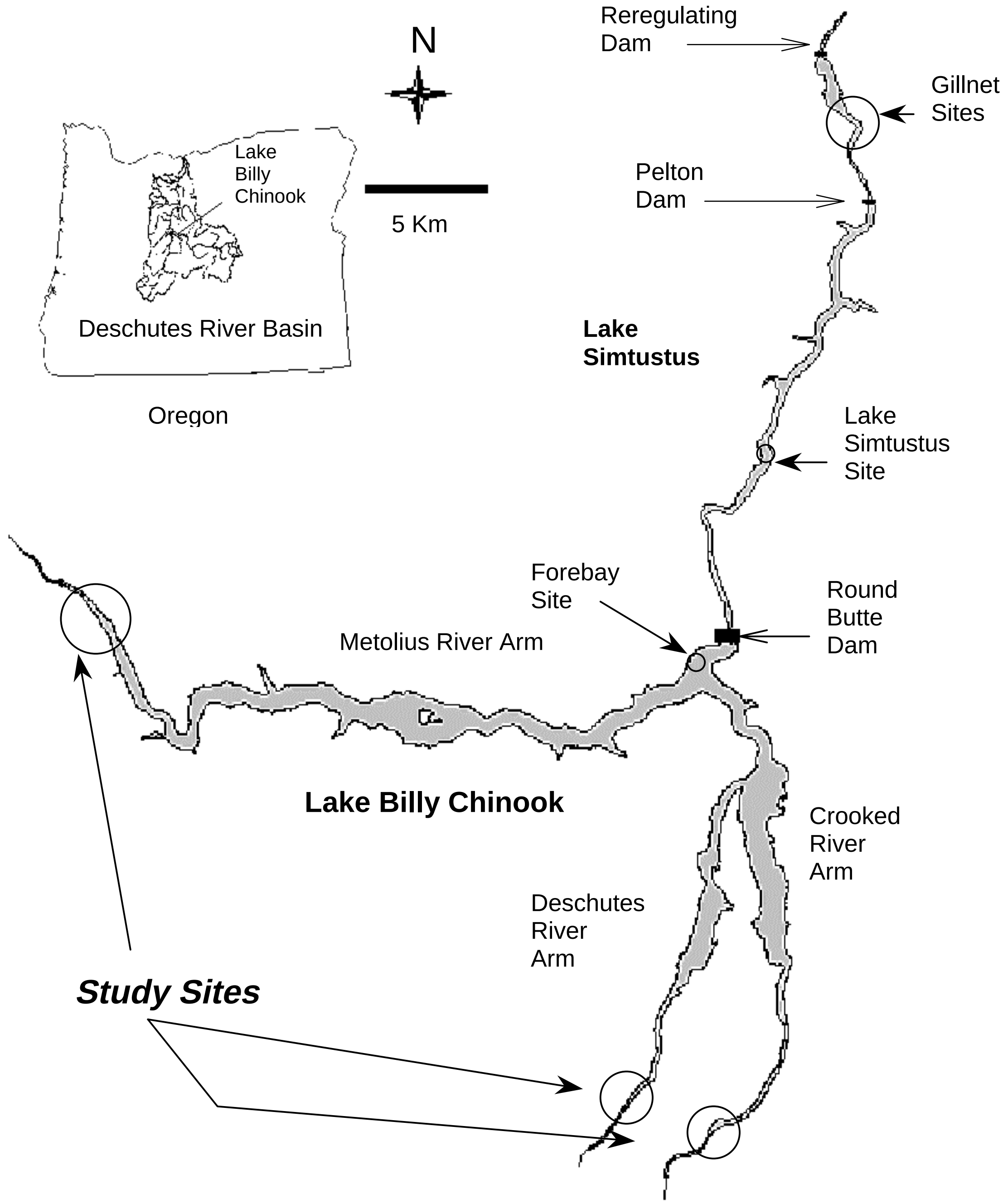

Figure 1. Location of Lake Billy Chinook in the Deschutes River Basin of Oregon. Location of the six sampling areas for 1997-1999 are identified.

the total reservoir surface area, respectively. The respective length of each arm is 10.5 km, 14.0 km, and 19.5 km (Figure 1). Lake Billy Chinook has a volume of 487,872,000 m^3, a maximum depth of 126 m, and a mean depth of 31 m (Johnson et al. 1985). Like Lake Simtustus, Lake Billy Chinook is confined by steep canyons and has a shoal area of only 5%. Both reservoirs are typically thermally stratified from May through September.

The Deschutes River Basin upstream of the Project has an area of 19,327 km^2 and receives an annual precipitation ranging from 25 to 229 cm. The primary study sites include the upper 1.5 km of the Crooked River arm, the upper 1.75 km of the Deschutes River arm, the upper 1.5 km of the Metolius River arm, one trap site in the forebay of Round Butte Dam, one trap site in Lake Simtustus, and two gillnet sites in the Reregulating Reservoir (Figure 1).

METHODS

Littoral fish species were captured using Merwin traps in Lake Billy Chinook (1997–1999) and Lake Simtustus (1998–1999) and using gillnets in the Reregulating Reservoir (1998–1999). Gillnets were used in the Reregulating Reservoir because a Merwin trap could not be operated with large fluctuating water levels. The Merwin traps were operated primarily from March through June. Gillnets were set once per month, from April through June in 1998 and March through June in 1999. In 1997, only the three upper arms of Lake Billy Chinook were trapped. In 1998, a trap was added to the forebay of Round Butte Dam. The traps were operated for 8 weeks in 1997, 21 weeks in 1998, and 17 weeks in 1999. The traps in Lake Billy Chinook were primarily operated for a rainbow trout study, and any movements of the traps were at the discretion of the study researchers (Groves et al. 1999). A Merwin trap is a modified version of a net trap that floats on the water surface with the aid of pontoons. The traps had a 15 m X 4.5 m lead net set perpendicular to shore to direct fish swimming along the shoreline out the lead net and into the pot and spiller (i.e., holding pen) of the trap (see Appendix 1 for schematic and trap terminology). The forebay trap had a 33 m-long lead net. The traps were typically operated four days per week. When the traps were not in use, the spiller fyke was pulled to keep fish from entering the trap. For a more complete description of Merwin trap methods, see Hiatt et al. 1997.

All fish captured were enumerated by species, and a representative number of total lengths were measured. Stomachs contents of known piscivorous fish, including bull trout *Salvelinus confluentus,* brown trout *Salmo trutta*, northern pikeminnow *Ptychocheilus oregonensis,* and smallmouth bass, were evacuated and preserved using the a gastric lavage method (Schulz et al. 1997) during 1998 and 1999. All fish were released on the opposite shore after data collection. Bull trout diet information from 1998 is described in Beauchamp and Van Tassell (1999). Stomach contents were identified by major taxonomic groups for invertebrates and by species for vertebrates. Because the potential effects of piscivores on the reintroduction of anadromous fish were the main reason for sampling stomachs, the data were analyzed by counting the items found, rather than by determining relative composition by weight, for example. This is not to imply that dietary importance of fish for these piscivores is any more or less critical, but the population level effects of predation by the piscivores were deemed more important for the purposes of this study.

RESULTS

Abundance

1997

A total of 4,817 fish, representing 15 species, were captured from the upper portion of the three arms of Lake Billy Chinook during 1997 (Table 1). The nine native species captured in order of abundance were: chiselmouth *Acrocheilus alutaceus*, largescale sucker *Catostomus. macrocheilus*, rainbow trout *O. mykiss*, bridgelip sucker *C. columbianus*, bull trout, northern pikeminnow, kokanee, mountain whitefish *Prosopium williamsoni*, and sculpin *Cottus* sp. The six introduced species captured in order of abundance were: smallmouth bass, brown trout, brown bullhead *Ameiurus nebulosus*, black crappie *Pomoxix nigromaculatus*, coho *O. kisutch*, and tui chub *Gila bicolor*. The three most abundant species among all traps were smallmouth bass, chiselmouth, and largescale sucker and represented 1,312, 1,133, and 713 of the total catch, respectively (Table 1).

Table 1. Total number of fish captured in Merwin traps for each species during 1997 at three locations.

Species	Merwin Trap Locations			Total
	Crooked River Arm	**Deschutes River Arm**	**Metolius River Arm**	
Black Crappie	1			1
Bridgelip Sucker	83	174	136	393
Brown Bullhead	1	16		17
Brown Trout	57	96	19	170
Bull Trout	56	70	**133**	259
Chiselmouth	643	487	3	1,133
Coho		1		1
Kokanee	8	24	27	59
Largescale Sucker	589	75	49	713
Mountain Whitefish	1	32	23	56
Northern Pikeminnow	238	19		257
Rainbow Trout	168	178	101	447
Sculpin	1			1
Smallmouth Bass	**663**	**676**	3	**1,312**
Tui Chub		1		1
Total	2,479	1,846	492	***4,817***

The abundance of fish in the Crooked and Deschutes River arms was relatively similar. The most abundant species captured was smallmouth bass in both arms. The main differences were that more bridgelip suckers and brown bullheads were captured in the Deschutes River arm and more largescale suckers and northern pikeminnow were captured in the Crooked River arm (Table 1).

The total number of fish captured in the Metolius River arm was smaller than in the other two arms of the reservoir. Another notable difference from the other two arms was that there was a general lack of warm water species captured in the Metolius River arm. The most abundant species captured in Metolius River arm was bull trout. There were no northern pikeminnow and only three chiselmouth captured.

1998

A total of 10,160 fish, representing 18 species, were captured from Lake Billy Chinook, Lake Simtustus, and the Reregulating Reservoir during 1998 (Table 2). Three additional introduced species that were captured in 1998 that were not observed in 1997 were bluegill *Lepomis macrochirus*, goldfish *Carassius auratus*, and three-spine stickleback *Gasterosteus aculeatus*. Like in 1997, the three most abundant species among all sampling areas were smallmouth bass, largescale sucker, and chiselmouth and represented 3,316, 2,009, and 1,325 of the total catch, respectively (Table 2).

Again, the Crooked and Deschutes River arms were relatively similar in abundance and number of species captured. In 1998, there was a dramatic increase of largescale suckers, the most abundant species, captured in the Crooked River arm and a corresponding decrease of smallmouth bass.

The Metolius River arm sampling produced results similar to 1997. Bull trout were the most abundant, and the most notable change was a moderate increase of smallmouth bass catch from 3 to 85 (Tables 1 and 2).

The abundance and number of species captured at the Round Butte Dam forebay site were similar to all three upper arm areas. The most abundant species at the forebay site was smallmouth bass at 1,454 (Table 2).

Lake Simtustus and the Reregulating Reservoir were very similar to each other in the number of species captured. The only difference was that eight mountain whitefish were captured in the Reregulating Reservoir while none were captured in Lake Simtustus. The actual number of rainbow trout captured in Lake Simtustus in 1998 was less than what Table 2 indicates because post-smolt steelhead released into Lake Simtustus and captured were included with the rainbow trout. In 1999, steelhead and rainbow trout were separated.

Table 2. Total number of fish captured in Merwin traps and gillnets for each species during 1998 at five locations.

	Merwin Trap Locations					Gillnet Location	
Species	**Crooked River Arm**	**Deschutes River Arm**	**Metolius River Arm**	**Round Butte Dam Forebay**	**Lake Simtustus**	**Reregulating Reservoir**	**Total**
Black Crappie	30	16		33			79
Bluegill		1	1	1			3
Bridgelip Sucker	238	512	194	27	41	8	1,020
Brown Bullhead	5	28		1			34
Brown Trout	14	38	16	44	1	5	118
Bull Trout	47	18	**258**	65	1	3	392
Chiselmouth	893	139	1	66	166	60	1,325
Goldfish	9	91		11			111
Kokanee	6	4	79	118			207
Largescale Sucker	**1,269**	219	5	33	406	77	2,009
Longnose Dace	1	1	15				17
Mountain Whitefish	14	12	8	1		6	41
Northern Pikeminnow	237	20		19	**443**	**117**	836
Rainbow Trout	189	157	90	165	42	1	644
Sculpin	1	1					2
Smallmouth Bass	448	**1,329**	85	**1,454**			**3,316**
Three-Spine Stickleback				1			1
Tui Chub		4		1			5
Total	3,401	2,590	752	2,040	1,100	277	***10,160***

1999

A total of 19,487 fish, representing 16 species, were captured from Lake Billy Chinook, Lake Simtustus, and the Reregulating Reservoir during 1999 (Table 3). No goldfish or tui chub were captured during 1999. The primary differences between the Crooked and Deschutes River arms during 1999 were the dramatic increase from 1998 in kokanee for the Crooked River arm and a decrease of smallmouth bass for the Deschutes River arm (Tables 2 and 3). The most abundant species captured in the Crooked River arm was again largescale sucker at 870, and in the Deschutes River arm, rainbow trout were the most abundant at 184.

In the Metolius River arm, there were decreases in catch for bridgelip suckers, bull trout, and smallmouth bass from 1998 levels, and increases in catch for other species. The most abundant species captured was kokanee at 141 (Table 3).

The catch at the forebay site for 1999 decreased from 1998 levels for all species except kokanee and bull trout. The bull trout catch increased only slightly, but the increased catch of kokanee was staggering. There were only 118 kokanee captured at this site in 1998 and 14,065 during 1999 (Tables 2 and 3).

The total number of fish captured in Lake Simtustus during 1999 was very similar to 1998. There was a decrease in chiselmouth and northern pikeminnow and an increase of largescale suckers (Tables 2 and 3).

Gillnet sampling in the Reregulating Reservoir during 1999 produced considerable reductions from 1998 in catch for chiselmouth, largescale suckers, and northern pikeminnow, the three most abundant species in the reservoir (Tables 2 and 3).

Table 3. Total number of fish captured in Merwin traps and gillnets for each species during 1999 at five locations.

Species	Merwin Trap Locations					Gillnet Location	Total
	Crooked River Arm	Deschutes River Arm	Metolius River Arm	Round Butte Dam Forebay	Lake Simtustus	Reregulating Reservoir	
Black Crappie	8	2	2	7			19
Bluegill	4						4
Bridgelip Sucker	58	178	8	4	87		335
Brown Bullhead		34					34
Brown Trout	25	37		5		2	69
Bull Trout	54	19	74	57	2	3	209
Chiselmouth	61	15	1	7	209	10	303
Kokanee	756	36	**141**	**14,065**	5		**15,003**
Largescale Sucker	**870**	59	7	2	**451**	22	1,411
Longnose Dace			2	2			4
Mountain Whitefish	48	23	1		1	4	77
Northern Pikeminnow	87	2		7	275	**70**	798
Rainbow Trout	223	**184**	19	20	7	10	463
Sculpin	3	2		1		1	7
Smallmouth Bass	314	81	9	317			721
Steelhead Trout					29		29
Three-Spine Stickleback				1			1
Total	2,868	672	264	14,495	1,066	122	***19,487***

Activity

Crooked River Arm

The activity of piscivorous fish in the Crooked River arm during the three years of sampling had generally similar patterns from year to year. In 1997, the catch was primarily northern pikeminnow with about equal numbers of the other piscivores during April and the first two weeks in May. The mean total catch for the first six weeks was approximately 65 fish per week (Figure 2). Once the epilimnion reached about 13 °C, during the third week in May, the smallmouth bass catch dramatically increased to over 500.

During 1998, the trap was operated from March through July. During March, few piscivores were captured, but all species were represented (Figure 2). Catch increased starting in April through the first two weeks in May. The catch decreased and remained low through the second week in June. For the remaining six weeks of the sampling period, smallmouth bass were the primary species captured at about 60 per week.

In 1999, the catch of northern pikeminnow, bull trout, and brown trout through the fourth week in May was < 25 total fish per week (Figure 2). Again, after the epilimnion temperature exceeded 13 °C, smallmouth bass was the primary species captured. From the last week in May through the end of the sampling, the smallmouth bass catch averaged about 65 per week (Figure 2).

Deschutes River Arm

The activity of piscivorous fish in the Deschutes River arm for the three years was variable for both the number and species captured. During 1997, brown trout and bull trout dominated the catch from the last week in March through the first week in May (Figure 3). During the third week in May the water temperature exceeded and remained above 13 °C, which corresponded to increased activity of smallmouth bass for the remainder of the sampling period (Figure 3).

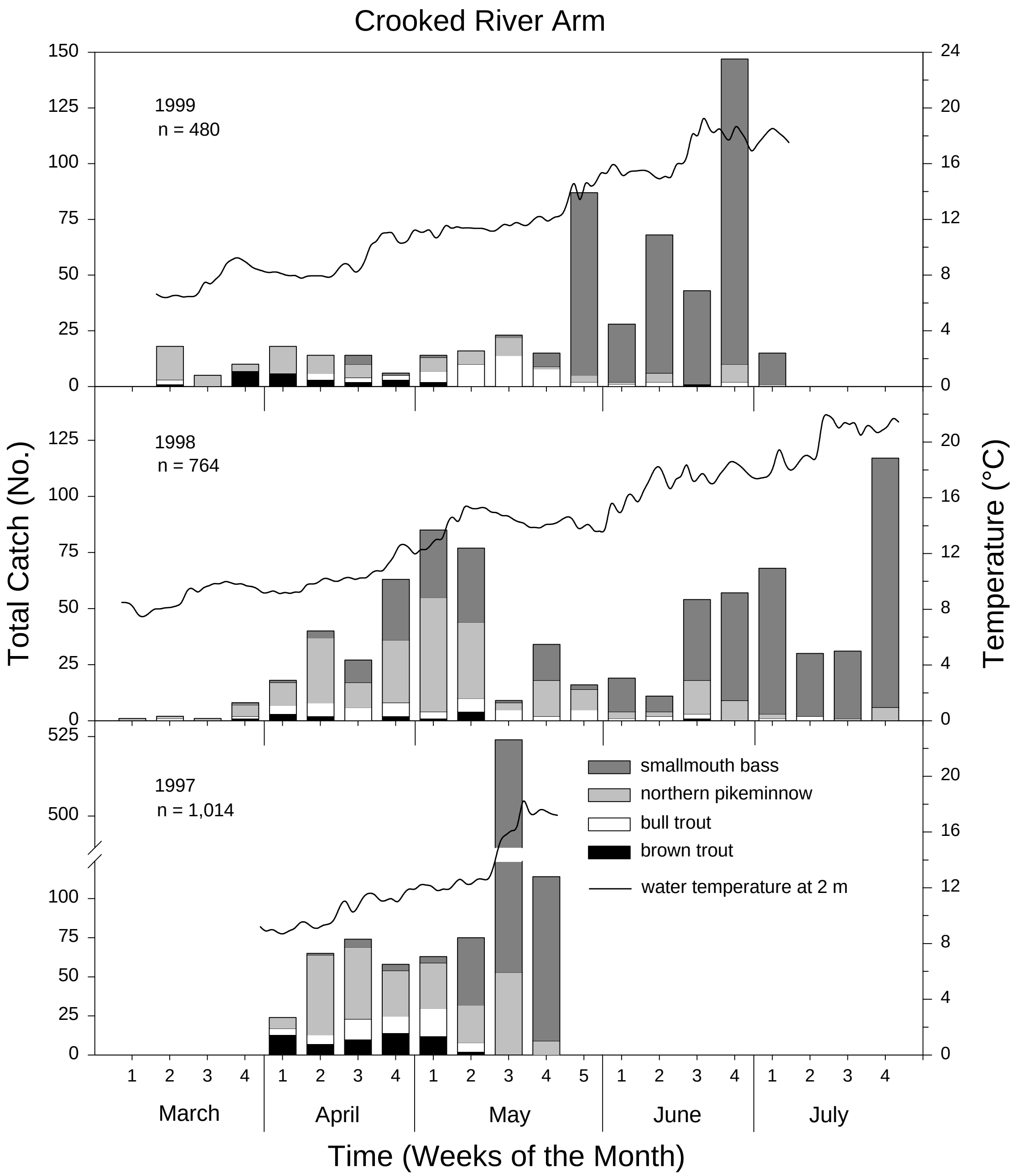

Figure 2. Total number of captured smallmouth bass, northern pikeminnow, bull trout, and brown trout by week in the Crooked River arm for 1997–1999. Plotted line is the mean daily temperature at 2 m and also indicates the period of trap operation.

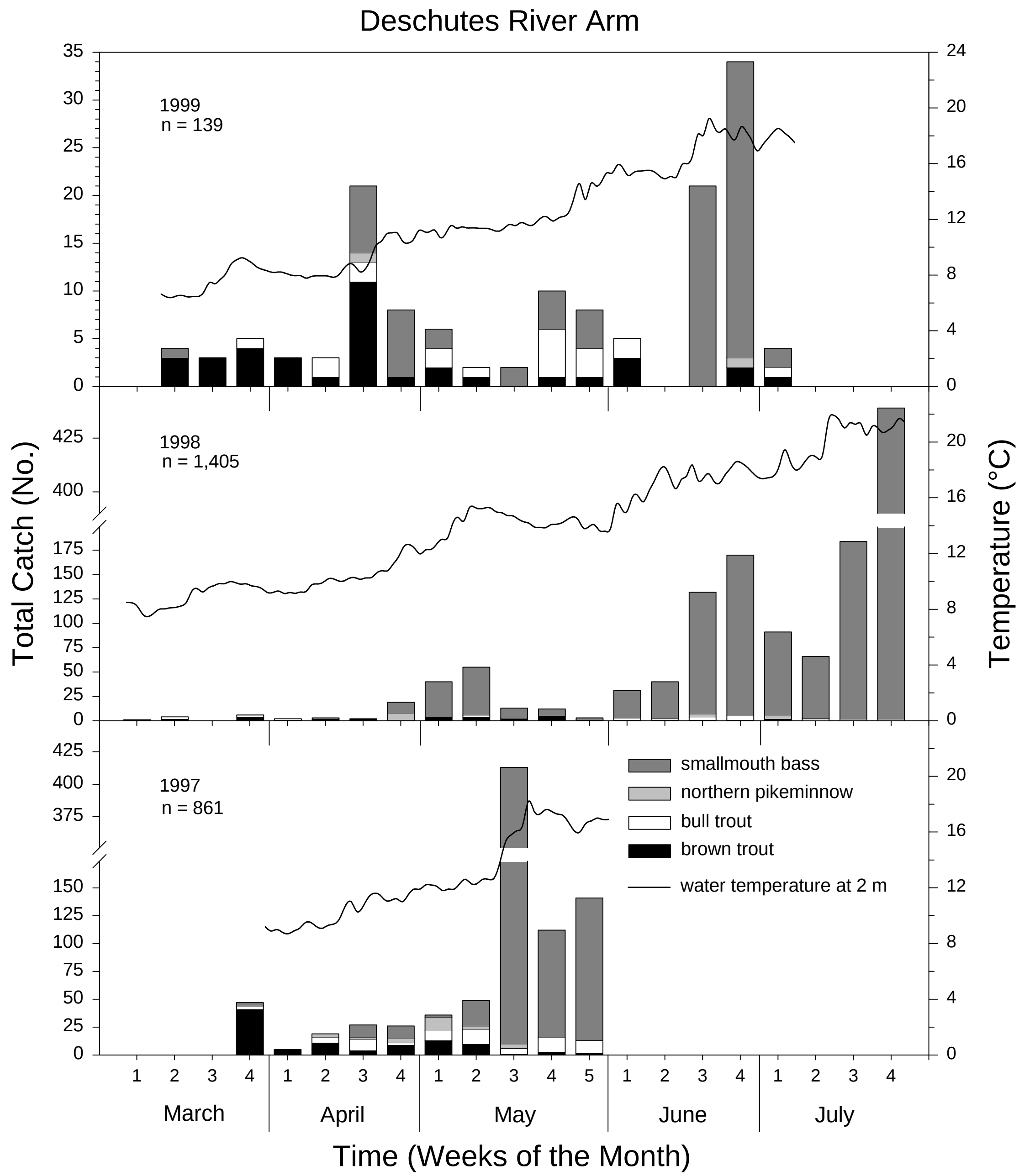

Figure 3. Total number of captured smallmouth bass, northern pikeminnow, bull trout, and brown trout by week in the Deschutes River arm for 1997–1999. Plotted line is the mean daily temperature at 2 m and also indicates the period of trap operation.

The catch during 1998 followed a different pattern than 1997. Fewer brown trout and bull trout appeared to be active in the sampling area during March through May (Figure 3). When the temperature rose above 13 °C during the first week of May, there was a slight increase in smallmouth activity, but then it decreased through the end of May. Smallmouth bass were the primary species captured and generally increased throughout the remainder of the sampling period (Figure 3).

The activity during 1999 was similar to 1998 with one notable exception: the number of active smallmouth bass after the temperature rose above 13 °C was much reduced (Figure 3).

Metolius River Arm

Bull trout dominated the weekly catch of piscivorous fish in the Metolius River arm for all three years of sampling (Figure 4). During 1997, bull trout catch increased from less than 10 fish per week in the third week of May to more than 30 per week at the end of June. The catch of brown trout over the sampling period remained relatively stable at about three fish per week.

Activity of bull trout during 1998 was relatively constant throughout the sampling period and averaged about 14 fish per week. Brown trout catch was sporadic; most were captured during June and July (Figure 4). There were 77 smallmouth bass captured during the first week of May and a few the week before and after. No other smallmouth bass were captured for the remainder of the sampling period. No northern pikeminnow were captured in 1998.

In 1999, bull trout catch peaked the second week in April at 15 fish, and it remained about five fish per week for the remainder of the sampling period (Figure 4). A total of nine smallmouth bass were captured from fourth week in May to the second week in June. No brown trout or northern pikeminnow were captured in 1999.

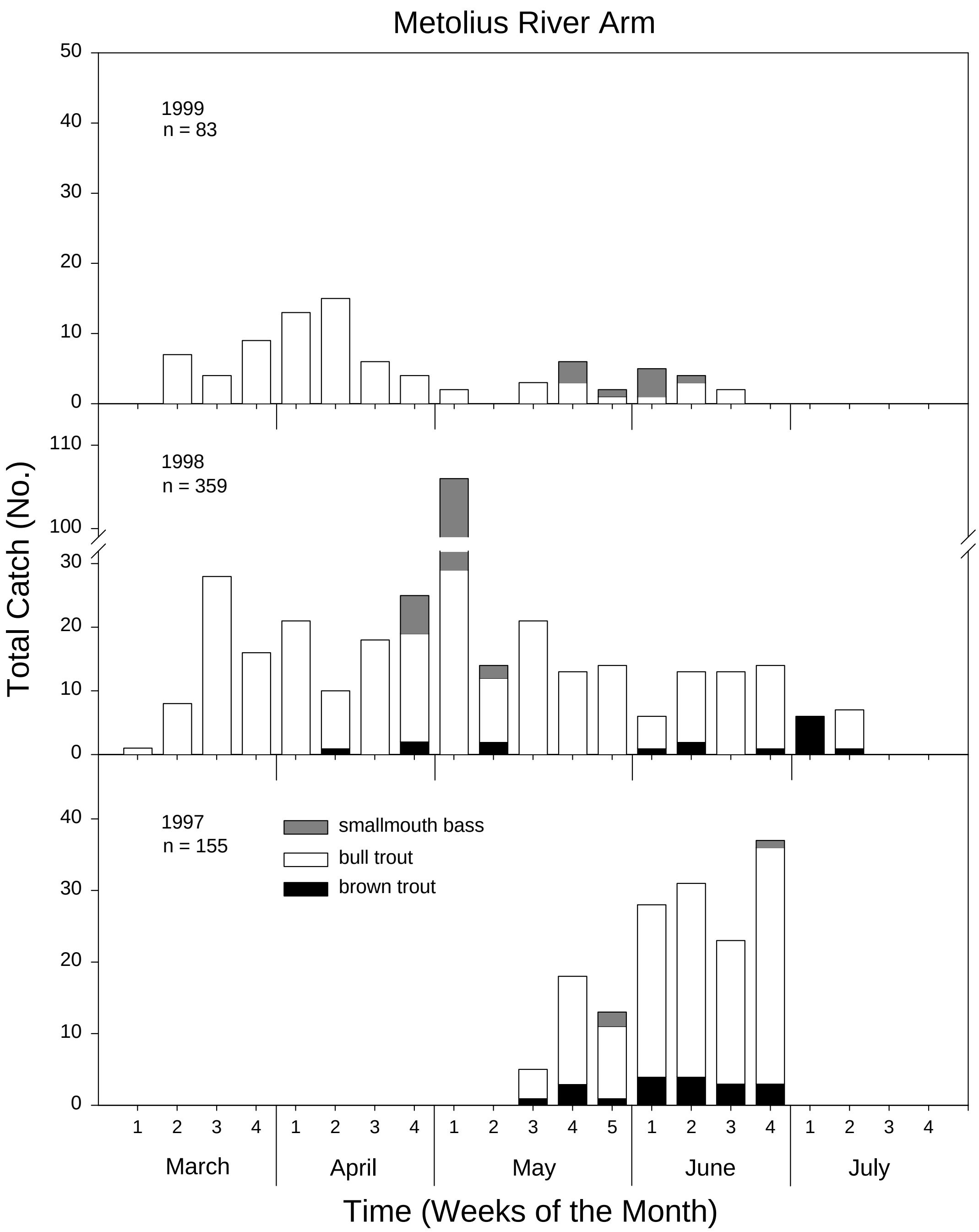

Figure 4. Total number of captured smallmouth bass, bull trout, and brown trout by week in the Metolius River arm for 1997–1999. The period of trap operation for each year was the same as for other locations.

Round Butte Dam Forebay

The activity of piscivores in the forebay area was notably different between 1998 and 1999, given that the same trap was operated at the same locations both years. During 1998, catch was well distributed among all species from March through May, and was usually < 25 total fish per week (Figure 5). The exception was that smallmouth bass catch increased for three weeks and peaked the second week in May at 111. This increase in smallmouth catch corresponded to approximately when the water temperature reached 13 °C. From June through July, the catch was dominated by smallmouth bass and peaked the last week in July at 473. The activity of fish during 1999 was less during the first two months as compared to 1998 (Figure 5). The difference was mainly that fewer brown trout were captured. Once the temperature reached 13 °C, the smallmouth bass catch began to increase, and peaked it the last week in June at 253.

Lake Simtustus

Northern pikeminnow were the dominant piscivorous fish in Lake Simtustus during both 1998 and 1999. During both years, the catch of northern pikeminnow began to increase once the temperature exceeded about 9–10 °C (Figure 6). Catch peaked at 182 in 1998 and 80 in 1999. There were only three brown trout and one bull trout captured during the two years of trapping in Lake Simtustus.

Reregulating Reservoir

The activity of northern pikeminnow in the Reregulating Reservoir during 1998 was much different than in 1999. In 1998, the catch of northern pikeminnow increased with time and temperature (Figure 7). The catch went from about 20 in April to 40 in June. No gillnets were set in March. During 1999, the catch of northern pikeminnow in March was 22, then increased to 35 in April. It then decreased dramatically to < 10 during May and June (Figure 7). The mean monthly temperatures for both years were very similar, ranging from 7 °C in March to 12 °C in June.

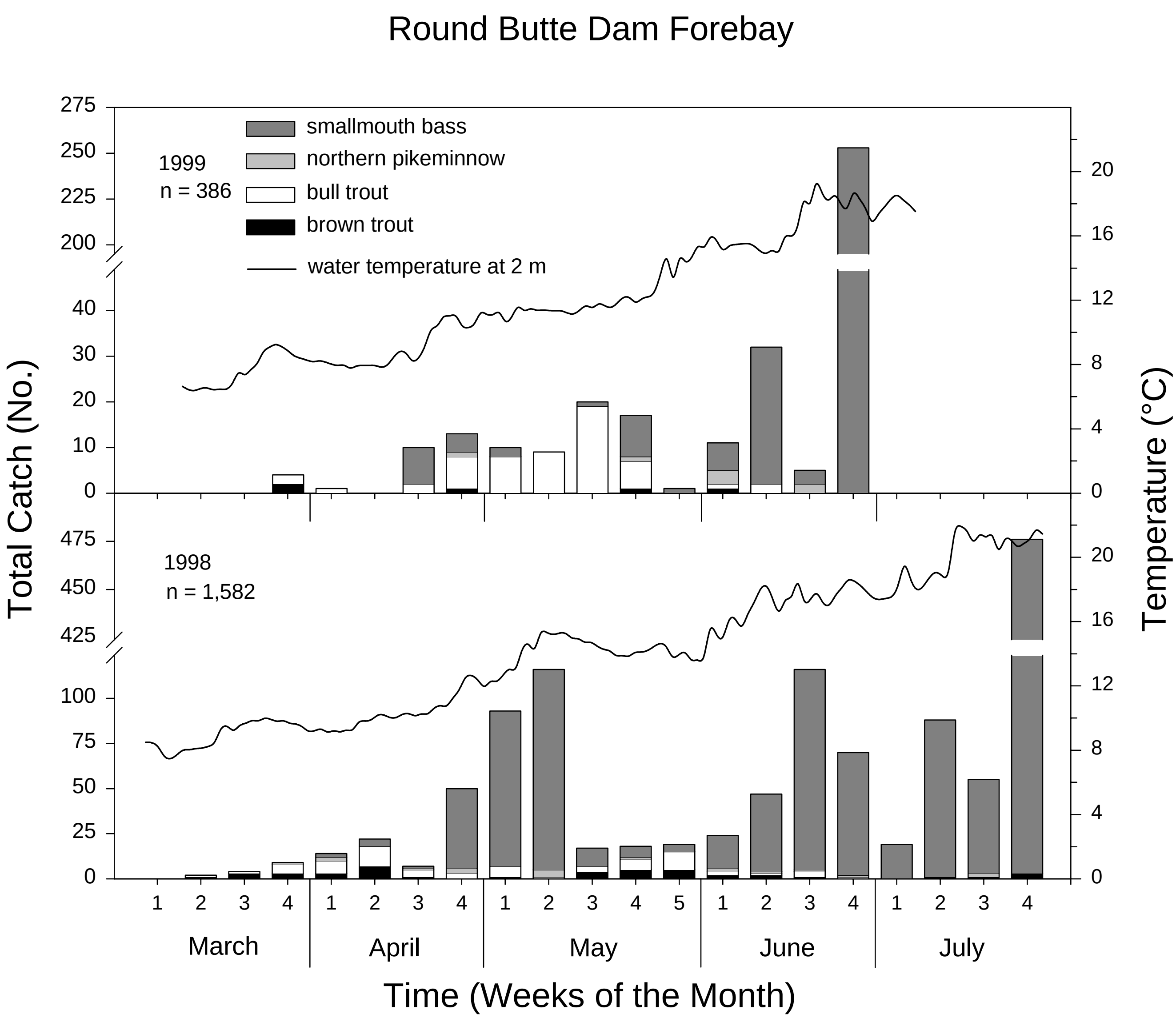

Figure 5. Total number of captured smallmouth bass, northern pikeminnow, bull trout, and brown trout by week in the Round Butte Dam forebay for 1998 and 1999. Plotted line is the mean daily temperature at 2 m and also indicates the period of trap operation.

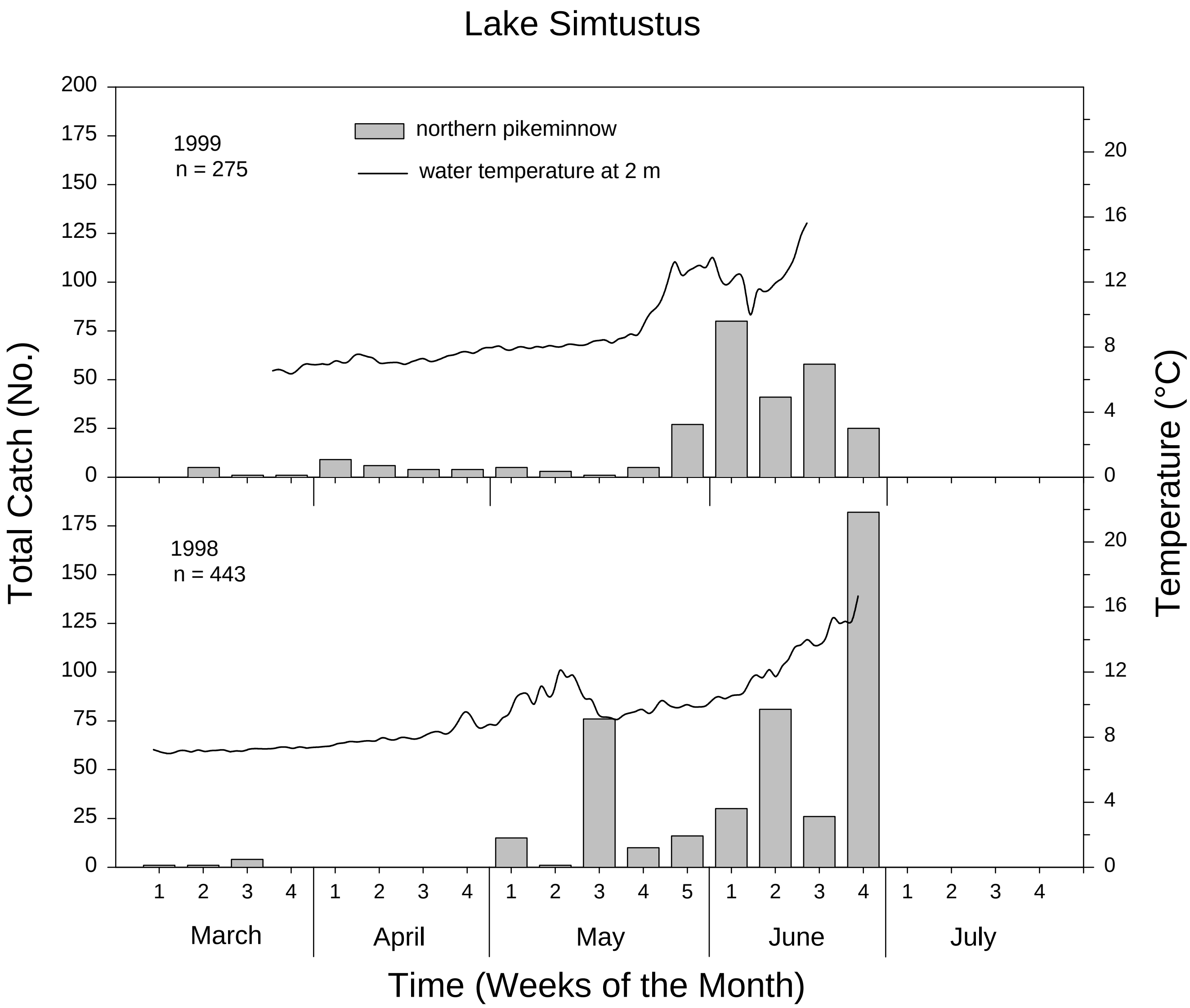

Figure 6. Total number of captured northern pikeminnow by week in Lake Simtustus for 1998 and 1999. Plotted line is the mean daily temperature at 2 m and also indicates the period of trap operation.

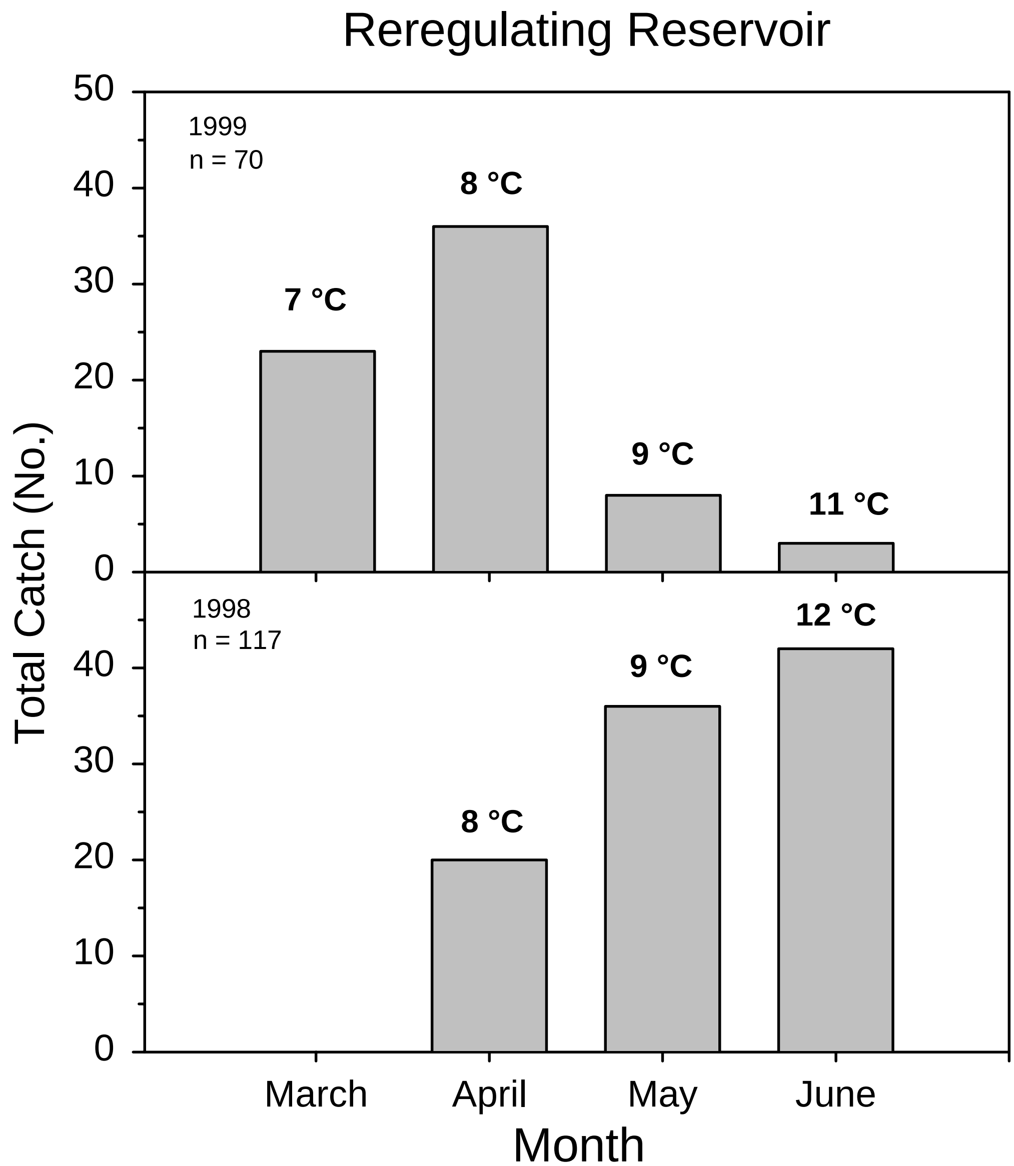

Figure 7. Total number of northern pikeminnow captured by month in gillnets from the Reregulating Reservoir during 1998 and 1999. No gillnets were set in March 1999. The mean monthly temperature is shown for each month.

Diet

1998

A total of 364 stomachs were evacuated and examined from brown trout, smallmouth bass, and northern pikeminnow among all five sampling areas. Of the total number of stomachs sampled, 45% were empty and the remaining 55% had some contents that were analyzed (Table 4). A total of 20 fish were found in stomach samples during 1998, primarily from brown trout and northern pikeminnow.

Stomachs of brown trout sampled from the Crooked River arm contained mainly aquatic insects and oligochaetes. Smallmouth bass stomachs contained primarily on zooplankton, and northern pikeminnow stomachs contained fish, signal crayfish *Pacifastacus leniusculus*, and aquatic insects (Table 4).

Among the samples from the Deschutes River arm, brown trout stomachs contained amphipods, aquatic insects, and mollusks. Smallmouth bass stomach samples consisted of zooplankton and aquatic insects. The stomachs of two northern pikeminnow that were sampled in the Deschutes River arm contained aquatic insects and fish eggs, and one contained a rainbow trout.

Stomachs of brown trout from the Metolius River arm contained primarily hemiptera and other aquatic insects.

Among the samples from the forebay site, brown trout and smallmouth bass stomachs contained similar items, but in different quantities. Amphipods, zooplankton, hemiptera, and aquatic insects were common to stomach samples from both species, whereas terrestrial insects and mollusks were found only in brown trout samples, and crayfish were found only in smallmouth bass samples.

Stomach samples from Lake Simtustus northern pikeminnow consisted of fish, crayfish, aquatic insects, oligochaetes, and fish eggs. Stomachs of brown trout from the Reregulating Reservoir contained fish, crayfish, and aquatic and terrestrial insects (Table 4).

Table 4. Stomach contents of brown trout, smallmouth bass, and northern pikeminnow captured in Merwin traps and gillnets at five locations during 1998.

	Merwin Trap Locations															Gillnet Location			
	Crooked R. Arm			Deschutes R. Arm			Metolious R. Arm			Forebay			Simtustus			Reregulating Res.			
Stomach Contents	**BRT**	**SMB**	**NPM**	**BRT**	**SMB**	**NPM**	**BRT**	**SMB**	**NPM**	**BRT**	**SMB**	**NPM**	**BRT**	**SMB**	**NPM**	**BRT**	**SMB**	**NPM**	**Total**
Chislemouth			1	1											1				3
Largescale Sucker							1												1
Smallmouth Bass																			1
Sculpin																3			3
Rainbow Trout			2			1													3
Bull Trout								1											1
Unknown Salmonid			1												1				2
Unknown Fish			4												1	2			6
Signal Crayfish		2	26		1		2				6	2			7	2			48
Amphipoda			4	225						73	7								309
Zooplankton		737			21		2			527	60								1,347
Hemiptera	2	17	9	1	2	1	44			5	51				1				133
Aquatic Insects	28	3	28	43	11	8	37			102	54	1			17	22			354
Terrestrial Insects										4						30		2	36
Oligochaetes	28														5			2	35
Mollusca				18			3			7									28
Fish Eggs			11			12									6				29
Summery Statistics																			
No. Full	5	10	47	18	10	6	11	1		14	12	2			21	4		1	162
Mean TL (mm)	327	196	363	317	227	357	312	204		302	211	323			339	442		242	
No. Empty	8	5	85	16	8	2	5			22	10	5			32	1		3	202
Mean TL (mm)	396	199	327	258	202	306	267			297	206	355			344	612		252	
Total No. Sampled	13	15	132	34	18	8	16	1		36	22	7			53	5		4	***364***

1999

A total of 342 stomachs were evacuated and examined from brown trout, smallmouth bass, northern pikeminnow, and bull trout among all five sampling areas. Of the total number of stomachs sampled, 66% were empty and the remaining 34% had some contents that were analyzed (Tables 5 and 6). A total of 39 fish were found in stomach samples during 1999, primarily from bull trout and northern pikeminnow.

Among the stomach samples from the Crooked River arm, all contained some fish. Other notable prey items counted were crayfish, amphipods, zooplankton, and aquatic and terrestrial insects.

A total of nine fish were contained in stomachs of smallmouth bass sampled in the Deschutes River arm. In addition, smallmouth bass stomach samples consisted of crayfish, amphipods, aquatic and terrestrial insects, and fish eggs. Of the two bull trout stomachs analyzed, one contained a fish, and both contained aquatic insects (Table 6).

Three smallmouth bass samples from the Metolius River arm were analyzed, and these contained many invertebrates and one fish. Eight fish and many aquatic insects were found in the stomachs of 18 bull trout sampled from the Metolius River arm (Table 6). Contents of stomach samples from fish captured at the forebay site were similar to the Metolius River arm samples (Table 5 and 6).

Stomach samples from northern pikeminnow capture in Lake Simtustus consisted primarily of fish and crayfish. By comparison, the stomachs of the smaller northern pikeminnow sampled in the Reregulating Reservoir contained more invertebrates and fish eggs (Table 5).

Length-Frequencies Distributions

A comparable number of fish were captured and measured over the three years of sampling. There did not appear to be substantial differences of total length for a given species and location (Figures 8 through 13).

Table 5. Stomach contents of brown trout, smallmouth bass, and northern pikeminnow captured in Merwin traps and gillnets at five locations during 1999.

	Merwin Trap Locations															Gillnet Location			
	Crooked R. Arm			Deschutes R. Arm			Metolious R. Arm			Forebay			Simtustus			Reregulating Res.			
Stomach Contents	**BRT**	**SMB**	**NPM**	**BRT**	**SMB**	**NPM**	**BRT**	**SMB**	**NPM**	**BRT**	**SMB**	**NPM**	**BRT**	**SMB**	**NPM**	**BRT**	**SMB**	**NPM**	**Total**
Northern Pikeminnow															1				1
Largescale Sucker															1				1
Mountain Whitefish					2														2
Sculpin			1												1	1			3
Rainbow Trout	1											1							2
Bull Trout																			
Stickleback					1														1
Unknown Fish		1	2		6			1							3	1		1	15
Signal Crayfish		4	6		7			45			16				5			3	86
Amphipoda			19		7						14								40
Zooplankton		10																	10
Diptera	5		12	6	91			453			142				2			4	715
Aquatic Insects	7		14	12	146			8			6				2			10	205
Terrestrial Insects		40			16						2								58
Oligochaetes																		1	1
Mollusca	1																		1
Fish Eggs					150													40	190
Summery Statistics																			
No. Full	3	6	8	4	21			3			12	1			13	1		12	84
Mean TL (mm)	324	198	340	314	195			230			190	410			356	561		267	
No. Empty	17	18	18	15	12					5	21				2	1		1	110
Mean TL (mm)	297	195	397	295	207					257	212				375	595		254	
Total No. Sampled	20	24	26	19	33			3		5	33	1			15	2		13	***194***

Table 6. Stomach contents of bull trout captured in Merwin traps at four locations during 1999.

Stomach Contents	Merwin Trap Locations				Total
	Crooked River Arm	**Deschutes River Arm**	**Metolius River Arm**	**Forebay**	
Kokanee	1		1	2	4
Unknown Fish	1	1	7	1	10
Amphipoda			1	1	2
Zooplankton			3	140	143
Diptera	5		188	31	224
Aquatic Insects	7	6	122	5	140
Mollusca		1			1
Amphipoda			5		
Oligochaetes			1	3	
Summary Statistics					
No. Full	6	2	18	6	32
Mean TL (mm)	327	372	254	306	315
No. Empty	45	15	8	48	116
Mean TL (mm)	317	369	220	329	309
Total No. Sampled	51	17	26	54	***148***

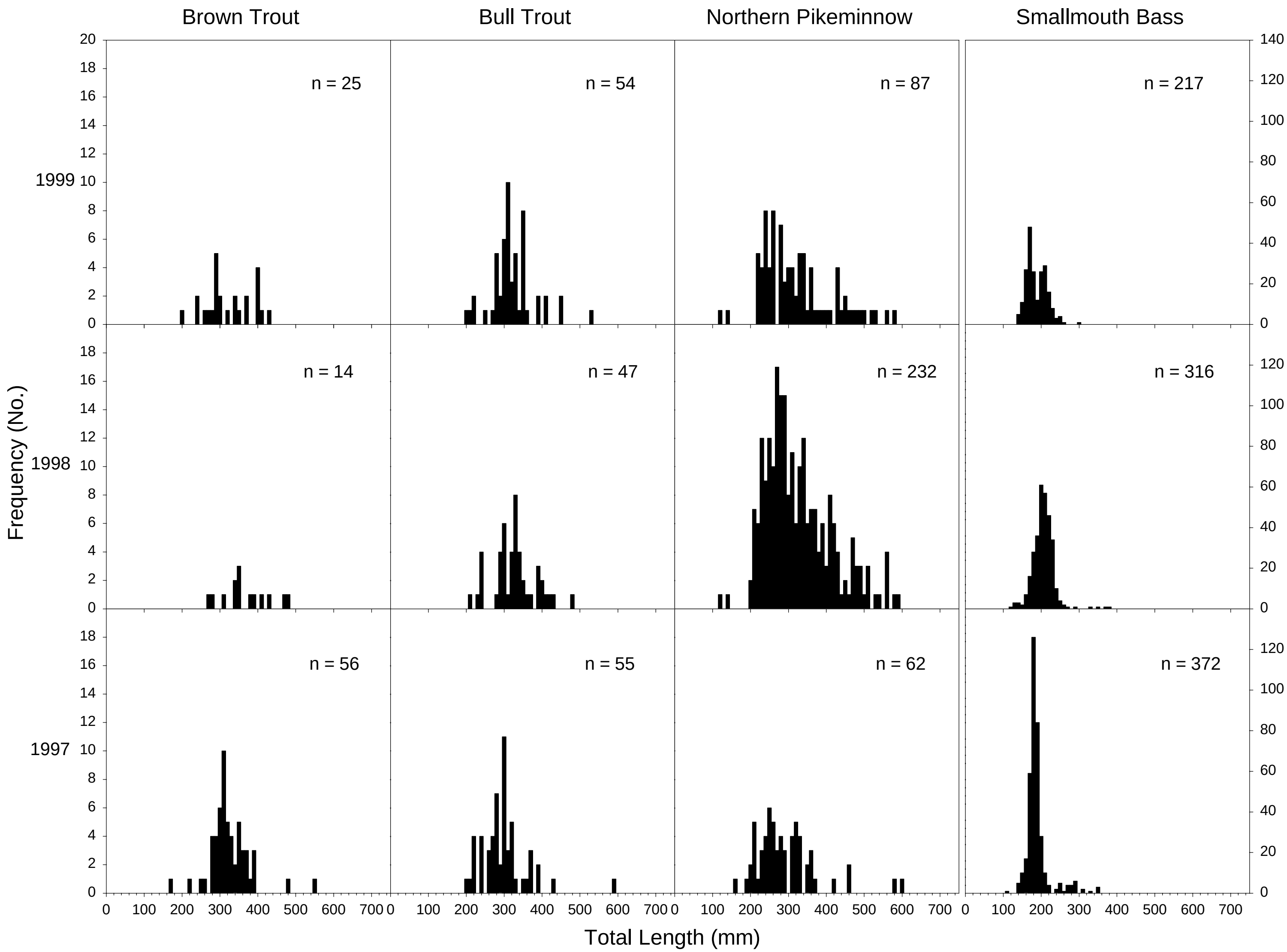

Figure 8. Length-frequency distributions for brown trout, bull trout, northern pikeminnow, and smallmouth bass captured in a Merwin trap from the Crooked River arm during 1997–1999.

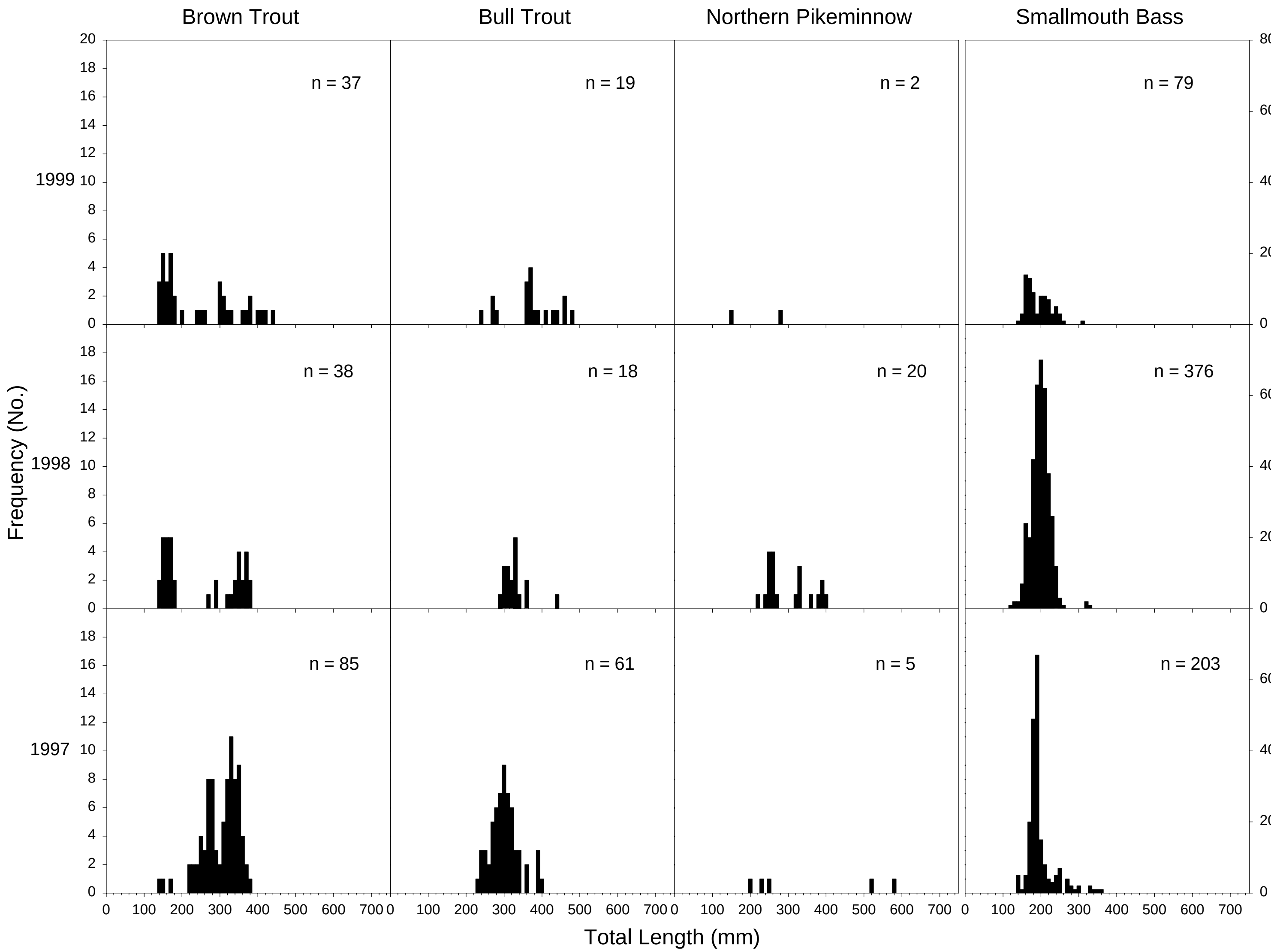

Figure 9. Length-frequency distributions for brown trout, bull trout, northern pikeminnow, and smallmouth bass captured in a Merwin trap from the Deschutes River arm during 1997–1999.

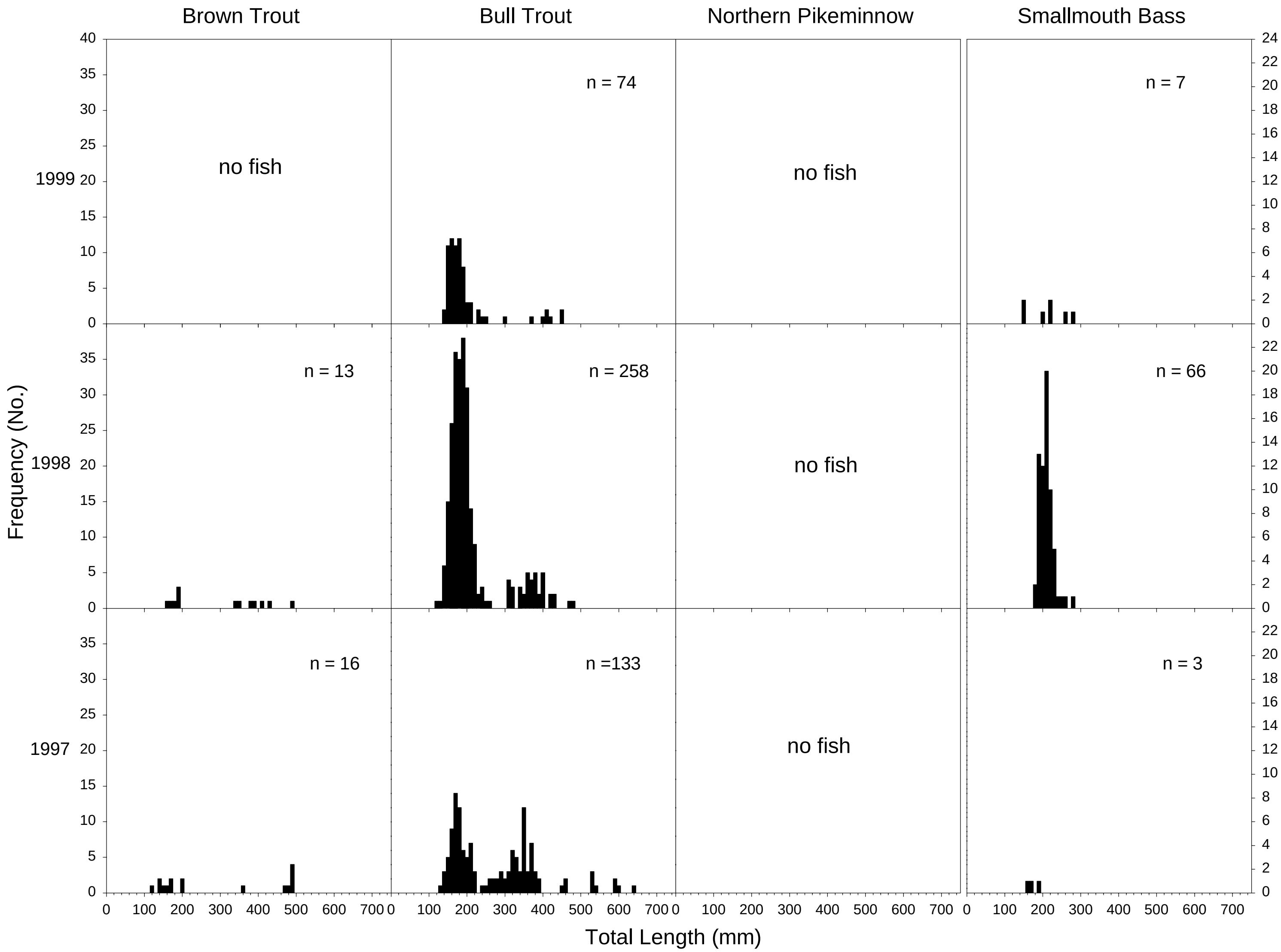

Figure 10. Length-frequency distributions for brown trout, bull trout, and smallmouth bass captured in a Merwin trap from the Metolius River arm during 1997–1999.

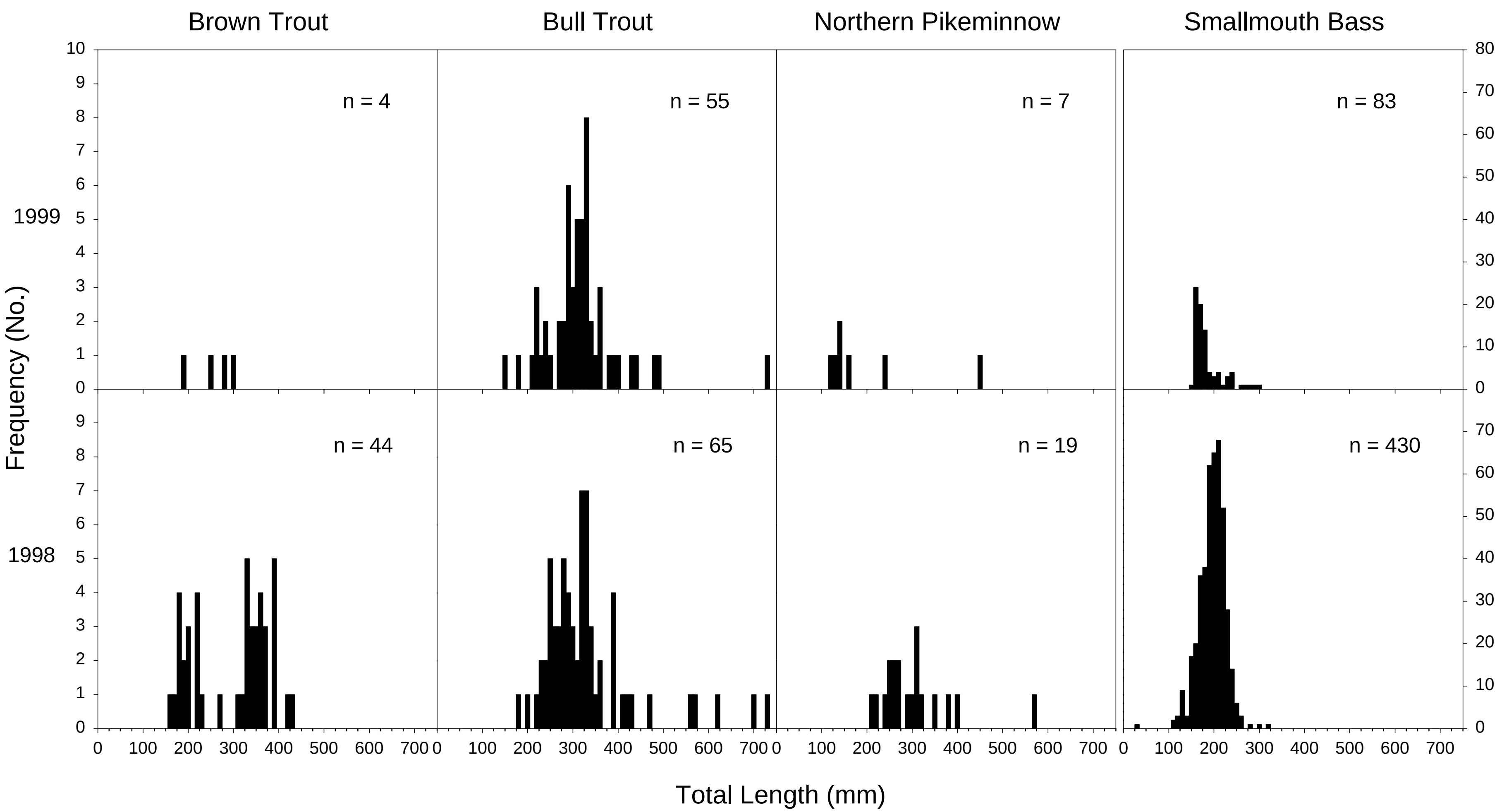

Figure 11. Length-frequency distributions for brown trout, bull trout, northern pikeminnow, and smallmouth bass captured in a Merwin trap from the Round Butte Dam forebay during 1998 and 1999.

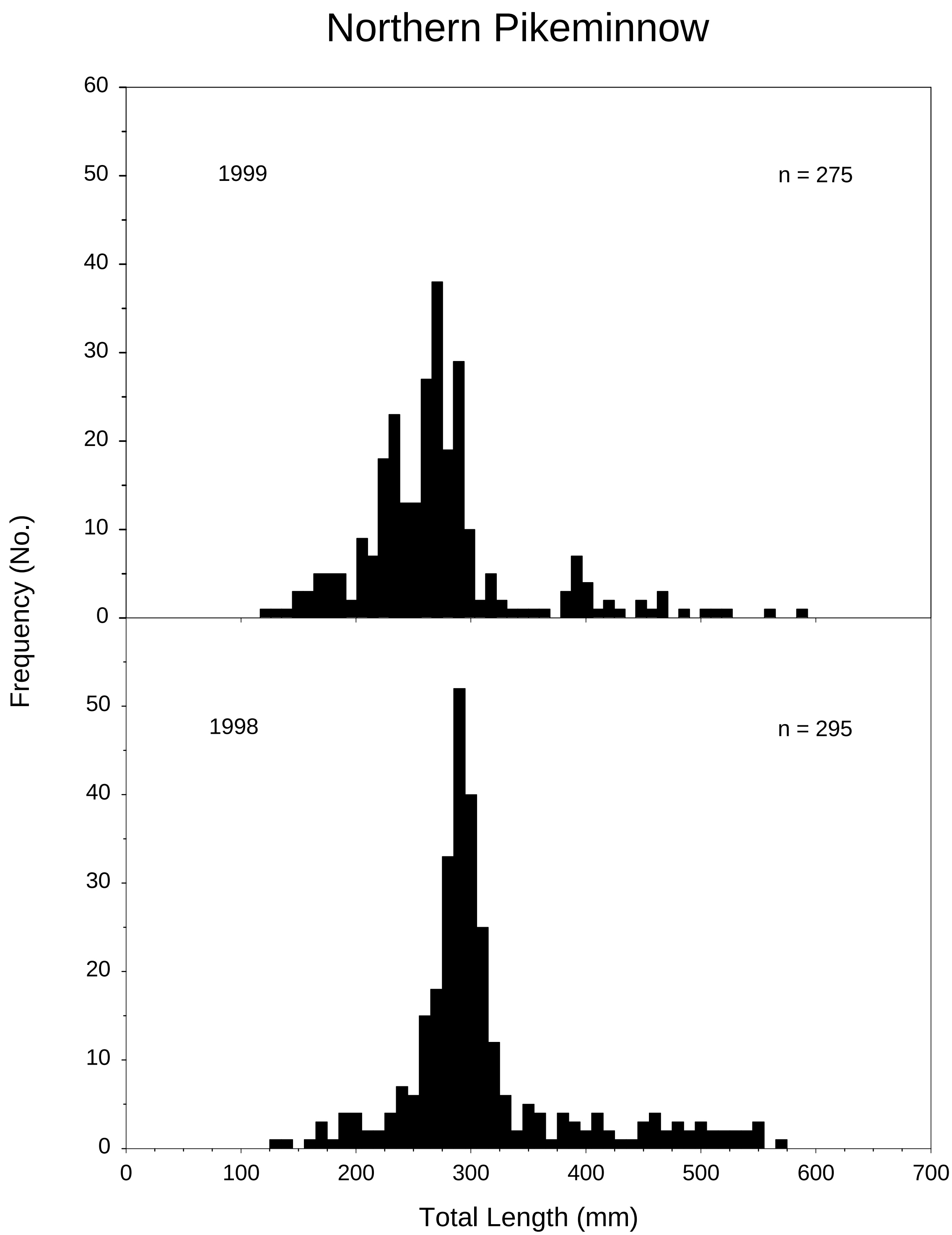

Figure 12. Length-frequency distributions for northern pikeminnow captured in a Merwin trap from Lake Simtustus during 1998 and 1999.

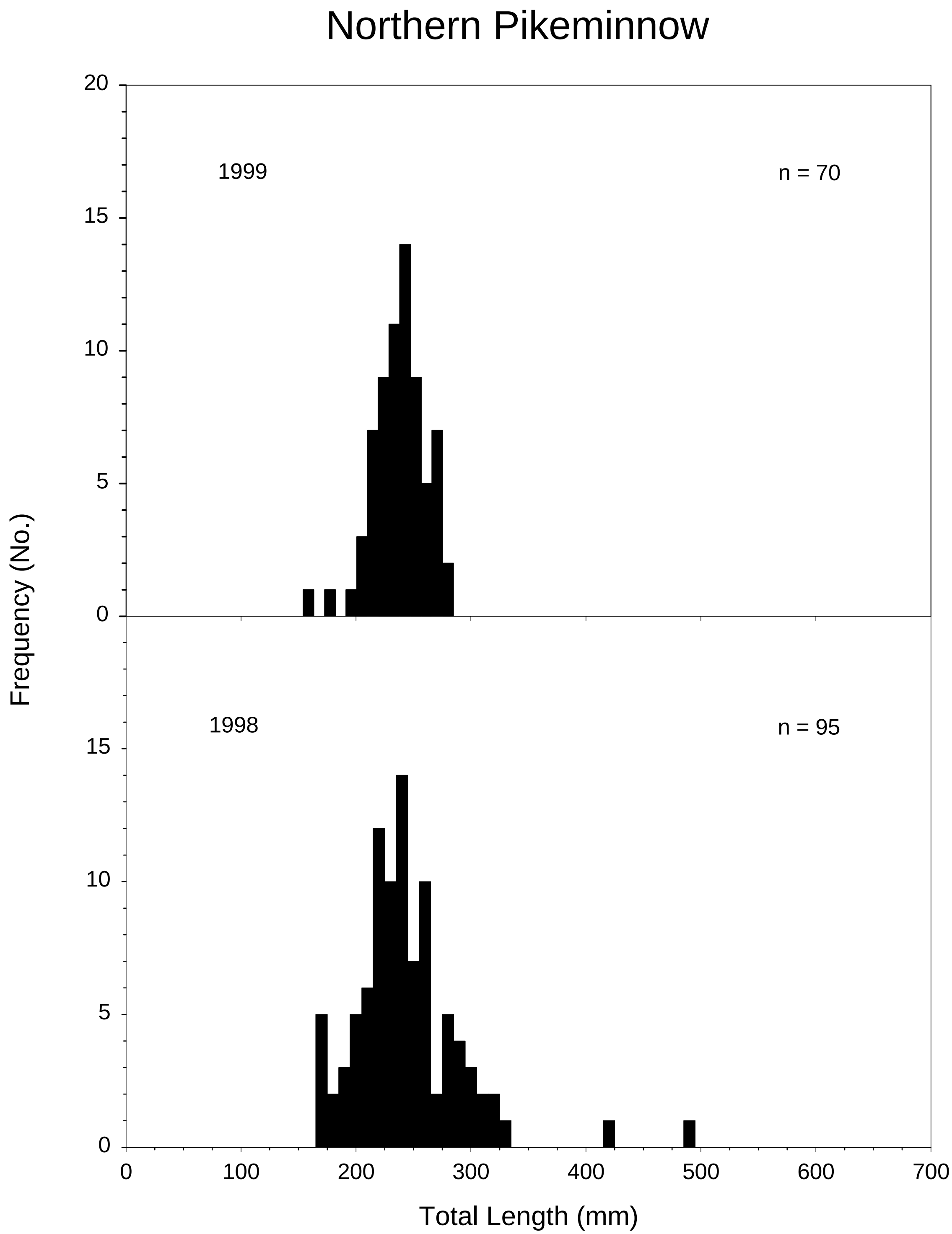

Figure 13. Length-frequency distributions for northern pikeminnow captured in gillnets from the Reregulating Reservoir during 1998 and 1999.

DISCUSSION

Abundance

The relative abundance of the fish species captured from 1997 to 1999 varied dramatically for some species and little for others. The method of trap operation had a significant effect on the number of fish captured. For example, during 1997 in the Crooked River arm, the catch of smallmouth bass dropped during the last week of operation (Figure 2). This corresponded to the movement of the trap closer to the river inflow area. In addition, the duration the traps were operated at a given location probably affected the total number of fish captured.

Environmental conditions could have also played a role in determining the number of fish captured. For example, the catch of smallmouth bass in the Deschutes River arm from 1998 to 1999 went from about 1,300 to only 80. I observed that the river/reservoir transition zone (i.e., the point where the colder river water flows under the warmer reservoir water) was farther downstream in 1999 than in 1998 and hypothesized that the river flow might have been higher and colder. Data from the US Geological Survey indicated that the Deschutes River flow was about 19% higher in 1999. Temperature data from the Deschutes River indicated that in 1999, the river was about 1.5 °C cooler than 1998 (Portland General Electric, unpublished data). Since the traps were operated in approximately the same area as in 1998, the larger amount of colder water could have functioned as a thermal barrier to smallmouth bass and decreased the total catch in 1999 compared to 1998.

The change in relative abundance suggested by the catch data could also be real. The total catch of smallmouth bass in the forebay, and for all traps in Lake Billy Chinook, decreased from 1998 to 1999 (Tables 2 and 3). However, the forebay trap was not moved between years or within each year, and the temperature was similar (Figure 5). This indicates that the catch would have been representative of the actual abundance of smallmouth bass in the forebay area. The differences were probably not due to a missing cohort because the length-frequency distributions among all locations and years remained approximately the same (Figures 8–11). The total catch of kokanee increased from about 100 in 1998 to just over 14,000 in 1999. However, this change did correspond to an increase of about 330% in 1999 in the estimated age 1 kokanee population, the most abundant cohort captured both years (Thiesfeld et al. 1999).

Activity

Activity, as indicated by trap catch, also appeared to be related to several variables. As stated previously, location and movement of a trap had a significant influence on trap catch. The temperature of the epilimnion appeared to be the best indicator of smallmouth bass activity. Constantly among locations and years, the smallmouth bass catch would increase dramatically once the temperature rose above 13 °C. The increase in temperature to 13 °C happened all three years during the month of May. The temperature at which increased activity occurs is consistent with that observed for other smallmouth bass populations (Carlander 1977). The activity of northern pikeminnow and brown trout began to increase at about 8–9 °C, and this occurred typically during April in Lake Billy Chinook and during May in Lake Simtustus (Figures 2 and 6). The activity of bull tout appeared to be inversely related to temperature. The activity of bull trout, as well as northern pikeminnow and brown trout, in the epilimnion decreased with increasing temperature.

Moon phase also appeared to affect the activity of littoral fish catch. Among years, trap locations, and species captured, there was an increase in weekly catch on full moons and a corresponding decrease in catch during new moons. The hypothesis is that fish were more active throughout the night when there is moonlight.

The activity of fish, based on Merwin traps, is most applicable to the epilimnion water, and to completely extrapolate these results to all depths of the reservoirs would probably be invalid. Activity of northern pikeminnow in the Reregulating Reservoir may have also been influenced by flow. There was a significant positive correlation of catch with mean monthly flow ($p = 0.02$, $r^2 = 0.77$, linear regression) for the months that the temperature was ≥ 8 °C.

Diet

Smallmouth bass did not seem to be substantial consumers of fish in Lake Billy Chinook. This result concurs with previous work conducted at Lake Billy Chinook. Lewis (1997), using boat electrofishing, found that the diet of smallmouth bass in Lake Billy Chinook, by volume, was 95.3% crayfish. In addition, out of 203 smallmouth bass sampled, only one fish was found consumed, and it was a smallmouth bass < 60 mm (Lewis 1997). The only fish predation by smallmouth bass observed during this study was in the Crooked and Deschutes River arms. It may be that once the water temperature no longer acts as a thermal barrier to movement into the free-flowing rivers, smallmouth bass foraging in the rivers were captured in the Merwin trap downstream. I have observed smallmouth bass in the Deschutes River 300 m upstream from the reservoir when the mean daily temperature was 14.5 °C (Portland General Electric, unpublished data).

Beauchamp and Van Tassell (1999) found that bull trout became more piscivorous with increasing size, and bull trout ≥ 450 mm in length consumed predominantly fish. Kokanee and other salmonids represented the largest proportion of the bull trout fish diet, which occurred primarily during the fall for kokanee and winter to summer for other salmonids.

The relative potential for predation by northern pikeminnow in Lake Billy Chinook would be probably by different than in Lake Simtustus. The water temperature in Lake Billy Chinook increases to activity-inducing levels earlier in the year than in Lake Simtustus. The thermal lag-time is caused by the source of water for Lake Simtustus being the hypolimnion of Lake Billy Chinook. The activity of northern pikeminnow increased typically during April in Lake Billy Chinook but not until May in Lake Simtustus.

The method of capture used in this study must be considered an important potential bias when evaluating the effects of predation. Merwin traps concentrate both predators and prey in the same area, where predation can therefore occur. Plastic artificial habitat was placed in the spiller portion of the trap to reduce in-trap predation, but the effect was not determined. Because of this potential in-trap predation, the numbers of fish consumed as determined from the stomach samples most likely overestimate actual predation in the reservoir.

SUMMARY

Merwin traps were an efficient method of capturing many species of littoral fish in Lake Billy Chinook and Lake Simtustus. Trap catch increased for cool-water piscivorous species during April and warm-water species during May. Trap location may have played an important role in determining species composition of the catch. Even a relatively small distance (e.g., 30 m) appeared to produce significantly different results. The use of Merwin traps for the collection of unbiased diet information could prove to be difficult if in-trap predation cannot be eliminated or accounted for. Many variables act individually, and probably interactively as well, to determine the catch of littoral fish with Merwin traps.

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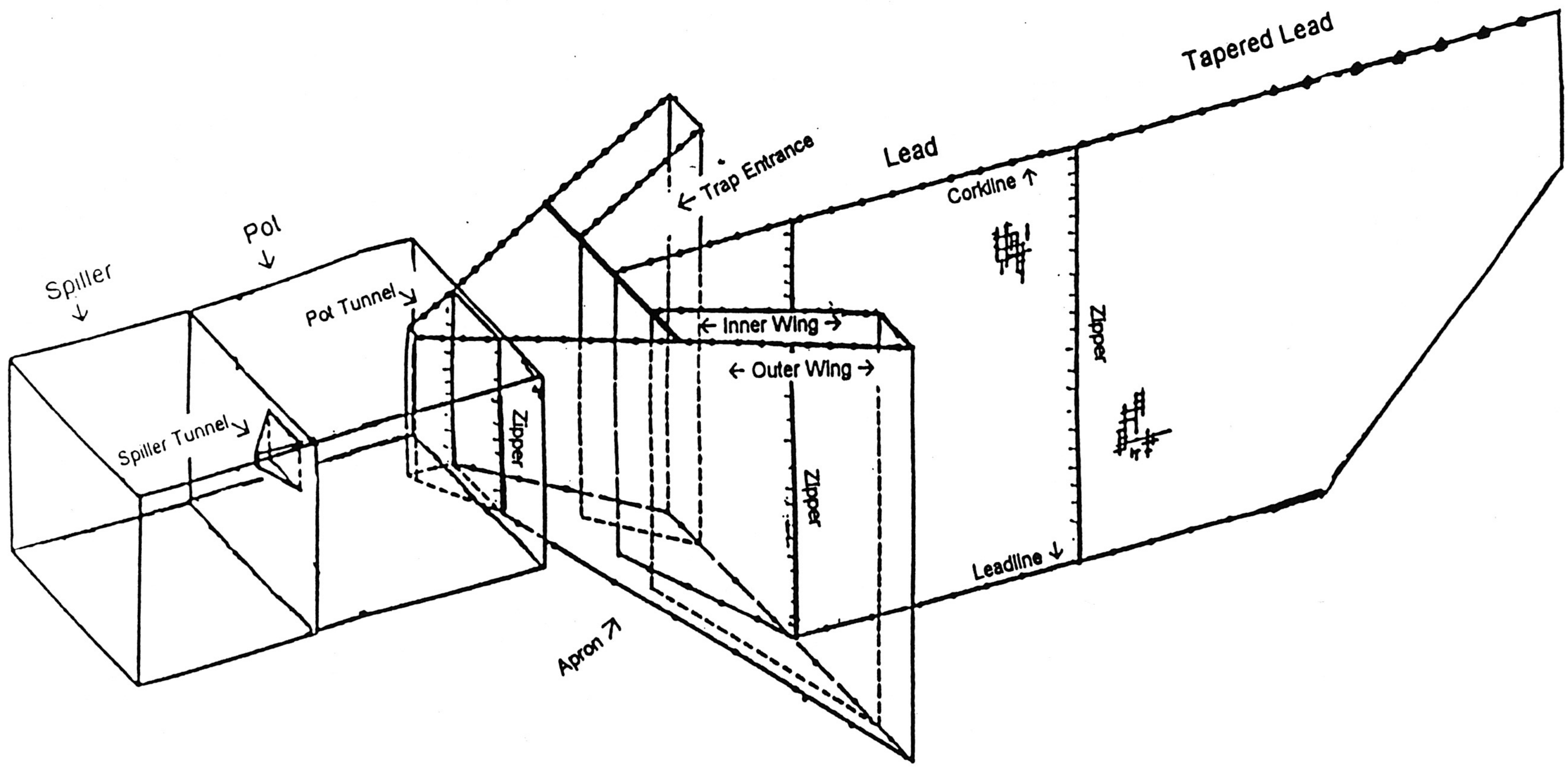
APPENDIX 1

MERWIN TRAP SCHEMATIC AND TERMINOLOGY



Appendix 1. Merwin trap schematic and terminology.