Downstream Fall Migrations of Native Salmonids from Major Tributaries Associated with the Hells Canyon Complex - Snake River

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Abstract

Major tributaries associated with the Hells Canyon Complex and one reference tributary below Hells Canyon Dam were monitored for downstream movements of salmonid fish species during fall months of 1998 and 1999. During 1998, the Wildhorse River and Indian Creek were monitored. During 1999, Indian Creek, Pine Creek, and Sheep Creek were monitored. The Wildhorse River enters the Snake River within Oxbow Reservoir. Indian Creek and Pine Creek enter within Hells Canyon Reservoir, and Sheep Creek enters the mainstem Snake River below Hells Canyon Dam at river kilometer 369 (river mile 229.4). With the exception of Pine Creek, wild rainbow trout were the dominant fish species captured in both weirs. The Pine Creek weir was only operated for a one month period, and was washed out prior to the peak capture of salmonids observed in the other tributaries. Catches of rainbow trout in the other streams increased once water temperatures began to drop below 10□C. Bull trout were not captured in the Wildhorse River or the Pine Creek weirs. In the Indian Creek weir, F1 Bull Trout x Eastern Brook Trout hybrids were the dominant char captured. Two Eastern brook trout and two fish field identified as bull trout were also captured in the Indian Creek weir. The Sheep Creek weir captured five bull trout, including a spawned out female. Species collected in the Wildhorse River and Pine Creek were similar, and collectively included 12 species of fish representing five families. Bridgelip suckers, smallmouth bass, and channel catfish comprised the highest percentage of nonsalmonid species captured. With the exception of one smallmouth bass in the Indian Creek captures, no warmwater fish were captured in either Indian Creek or Sheep Creek. Sheep Creek captures included only three species of fish representing only the Salmonidae family.

Introduction

Potamodromy is a widely recognized life history trait among salmonids. Although recognized, it has been only recently that the complexity and significance associated with these life history traits has begun to be realized (Northcote 1997; Rieman and McIntyre 1993). Habitat fragmentation and population isolation through loss of connectivity by the creation of barriers (physical, thermal, water quality) has led to losses of various life history forms.

The construction of the Hells Canyon Complex (Brownlee, Oxbow and Hells Canyon dams) on the Snake River may have potential impacts to native resident salmonids beyond the obvious alteration of physical habitat from a riverine environment to a reservoir environment. The two primary species of concern include bull trout (*Salvelinus confluentus*) and redband trout (*Oncoryhnchus mykiss*). The construction of the Complex fragmented the river into reservoir sections, limiting access to other stream basins within the complex. Furthermore, downstream movement within the Complex could lead to movement out of a reservoir section with no subsequent means of returning to the tributary.

The tributaries within the Hells Canyon Complex that still support both species are limited to the Wildhorse River (tributary to Oxbow Reservoir), and Indian Creek and Pine Creek (tributary to Hells Canyon Reservoir)(Figure 1). Upper portions of the Powder River basin support some bull trout populations although their population status was described as moderate to high risk by Buchanan et al. (1997). Dams such as Thief Valley have eliminated connectivity to the Snake River from streams in the upper portions of the Powder River. Eagle Creek, a tributary to the Powder River immediately above the confluence with Brownlee Reservoir, historically supported both species. However, bull trout are now thought to probably be extinct from Eagle Creek (Buchanan et al. 1997). Recent work has described characteristics of bull trout populations within the Pine Creek basin (Buchanan et al. 1997; Chandler et al. forthcoming) and Indian Creek (Janssen et al. 1997), however the status of the Wildhorse River remains unclear (Nelson 1998; Scott Grunder, IDFG, personal communication). Furthermore, the presence of fluvial fish from these basins and the use of the reservoirs to overwinter is not well documented or understood. Bull trout have recently been captured in Hells Canyon Reservoir during winter months (IPC, unpublished data). However, no bull trout have been documented in Oxbow Reservoir or Brownlee Reservoir in recent times.

Bull trout have been documented in several of the tributaries and in the mainstem Snake River below Hells Canyon Dam. Bull trout are distributed throughout the larger tributaries of the Snake River such as the Imnaha, Grande Ronde and Salmon rivers. Fluvial fish from the Imnaha and Grande Ronde rivers have been documented to move into the mainstem Snake River to (Buchanan et al. 1997; ODFW, personal communication; IPC, unpublished data). Bull trout have also been documented in several of the smaller tributary basins to the Snake River such as Granite Creek and Sheep Creek (Buchanan et al. 1997; IDFG, personal communication). These basins are more comparable in size to the tributary basins that enter the Hells Canyon Complex.

The goal of this study is to describe the temporal distribution and magnitude of fall downstream migrations of native salmonids in the tributaries associated with the Hells Canyon Complex and compare these basins to Sheep Creek, a reference tributary below Hells Canyon Dam.

Study Area

The Hells Canyon Complex is a series of three dams that impound the Snake River over a distance of almost 150 km (Figure 1). Brownlee Reservoir, constructed in 1958, is the uppermost in the series. Brownlee Reservoir is a large storage reservoir (91 km long) with approximately 1,000,000 acre-feet of active storage. Oxbow Reservoir, constructed in 1961, is a small run-of-the-river reservoir, approximately 19 km long. The Snake River from the tailrace of Brownlee Dam to the mouth of the Wildhorse River (1.6 km) is a high-velocity narrow channel. Oxbow is relatively narrow and shallow, with maximum depths approaching 24 m to 30 m. The unique design of the Oxbow powerhouse and dam leaves a 3 km stretch of the original river channel from Oxbow Dam to the outflow of the powerhouse with a minimum flow of 100 cfs. This creates a relatively shallow backwater with low velocities. Indian Creek enters the Snake River in this reach. Pine Creek enters the Snake River at the upper end of Hells Canyon Reservoir, approximately 2.9 km downstream of Indian Creek. Hells Canyon Reservoir, constructed in 1967, is 35 km long, and approaches a maximum depth of 60 m. Sheep Creek, below Hells Canyon Dam, enters the Snake River at RK 369 (RM 229.4)

Sheep Creek drains off the west face of the Seven Devil Mountains in Idaho and is contained almost entirely within the Hells Canyon Recreation Wilderness Area. The basin drains approximately 10,500 ha. The upper portion of the Sheep Creek basin includes two subbasins - the East Fork and West Forks of Sheep Creek. The West Fork originates from several high mountain lakes at elevations approaching 2,400 m. Indian Creek originates in the southern portion of the Seven Devil Mountains at an elevation of approximately 2,250 m. Indian Creek is comparable in size to Sheep Creek with a drainage basin of 10,350 ha. Indian Creek enters the Snake River within the Oxbow Bypass at an elevation of about 515 m (1685 ft) near RK 436 (RM 270). The Wildhorse River basin is approximately 45,750 ha and is comprised of three sub-basins: Bear Creek, Lick Creek and Crooked River. The Wildhorse River is formed by the confluence of Bear Creek and Crooked River. Bear Creek and Lick Creek (tributary to Bear Creek) both originate in the southern end of the Seven Devil Mountains, while Crooked River originates from the northwest face of Cuddy Mountain. The Wildhorse River enters the Snake River at approximately RK 455 (RM 284) at an elevation of approximately 542 m. The Pine Creek basin also originates at elevations near 2,400 m msl in the Oregon Wallowa mountains and encompasses a drainage area of approximately 78,400 ha. There are several major tributaries in the Pine Creek Basin including Clear Creek, East Pine, and North Pine.

Methods

Temporary downstream migrant weirs were constructed in each of the streams near their confluence with the Snake River. (Figure 1). The weirs were a picket-style weir constructed of 1.7-cm-diameter electrical conduits spaced 1.3 cm apart as described by Elle et al. (1994)(Figure 2). A single 15-cm-diameter PVC pipe formed an intake to a trap box constructed of perforated metal. The trap box dimensions were 1.2 m x 0.6 m x 0.8 m with a solid front face to provide calm water refugia for captured fish. The Pine Creek weir had two trap boxes installed on each side of the weir.

A continuous recording (hourly) thermometer was placed in the vicinity of each weir to record water temperature. Weirs were cleaned and checked daily. All fish captured were identified to species and measured for total length and weight and released downstream of the weir. Hatchery rainbow trout were subjectively distinguished from wild rainbow trout based on appearance of the dorsal fin. Fin-clips were taken on char species for genetic verification of species identification.

Results

Weirs were installed on 27 August 1998 for both Indian Creek and the Wildhorse River. Weirs were operated until 21 November 1998 and 24 November 1998 for the Wildhorse River and Indian Creek, respectively. During 1999, weirs were installed approximately one month later based on the period of salmonid captures observed during 1998. Weirs were installed in Pine Creek, Indian Creek and Sheep Creek between 27 and 29 September, 1999. Operations of the weirs were discontinued generally from early to middle November. Each weir had brief periods of down time primarily because of short-term high flow events associated with weather systems. During 1998, down times on the Indian Creek weir were relatively minor and allowed for quick repair with the exception of the 21 November period which required complete reconstruction of the weir. Down times on the Wildhorse weir were generally longer, and usually involved major repair to sections of the weir. During 1999, the Indian Creek weir was operable the entire time. The Pine Creek weir was operable until 28 October when a heavy rain event caused flows to increase rapidly and washed out the weir. Damage to the weir was severe enough to not allow reconstruction. The Sheep Creek weir was operable the entire time, however, there was a brief period that the weir boards that anchor the PVC trap intake were undercut which could have allowed an escape route for fish.

Indian Creek

During 1998 and 1999, the Indian Creek weir captured five species of salmonids (Table 1), with the dominant catch being wild rainbow trout (presumably redband trout). Other salmonids were captured in relatively low numbers. Sculpin (*Cottus* spp.) and speckled dace (*Rhinichthys osculus*) were the only non-salmonid species captured in the Indian Creek weir during 1998 and smallmouth bass (*Micropterus dolomieu*) and speckled dace were the only non-salmonids during

1999. During 1998, catches were almost non-existent during the first month of effort, however once water temperatures dropped to below 10°C, catch rates continued to increase (Figure 3).

The majority of redband trout captured were less than 200 mm TL during both years accounting for 61 percent and 84 percent of the redband catch during the two years (Tables 2 and 3). Length frequencies differed between the two years, with a larger proportion of fish less than 100 mm during 1999 (Figure 4).

The majority of the char captured in the Indian Creek weir were determined to be F1 bull trout x Eastern brook trout (*Salvelinus fontinalis*) hybrids from genetic analysis (Table 1). During 1998, one Eastern brook trout and ten hybrids were captured. During 1999, one Eastern brook trout and three hybrids were captured. In addition, two char were captured and field identified as bull trout. No fin clips were removed for verification of species identification for these two fish. However, our field identification of bull trout has been correct 86.4 percent of the time according to DNA verification (IPC, unpublished data). Misidentified bull trout have been an F1 hybrid crossed with a pure bull trout or an F1 hybrid. Char were captured in the Indian Creek during the same time period as the majority of redband trout captures (Figure 5).

Wildhorse River

The only salmonids captured in the Wildhorse weir were wild rainbow trout (redband trout), hatchery stocked rainbow trout and mountain whitefish (*Prosopium williamsoni*) (Table 4). However, a diverse group of non-salmonid species were captured relative to the Indian Creek and Sheep Creek weirs and collectively comprised approximately 40% of the catch. Bridgelip suckers (*Catostomus columbianus*), smallmouth bass (*Micropterus dolomieu*), and channel catfish (*Ictalurus punctatus*) were the dominant non-salmonid species.

Catches of non-salmonid fish dominated during the first month of effort. The majority of the non-salmonid catch occurred during the month of September, although captures continued throughout the entire trapping period (Figure 6). Similar to Indian Creek, catches of redband trout peaked primarily from mid-October to mid-November. Unfortunately, the thermograph for the Wildhorse weir failed, and complete temperature information is not available. However, spot checks of temperature during periods of checking suggests that similar to Indian Creek, peak salmonid catches began once river temperatures dropped to below 10°C. On 30 September, water temperature was 13.5°C. By 9 October, the water temperature was 10°C, and on 15 October, water temperature was reported at 8°C.

The sizes of rainbow trout captured in the Wildhorse weir were primarily from 100 to 300 mm (Table 5). Redband trout greater than 300 mm only comprised about 9 percent of the redband catch. Larger rainbow trout were frequently observed in the pool created by the weir, and suggested that trap avoidance by larger redband trout may have been a problem.

Pine Creek

Non-salmonid fishes dominated the catch in the Pine Creek weir and the species composition closely resembled that of the Wildhorse River. Smallmouth bass and Northern pikeminnow were the dominant species captured (Table 6). Unfortunately, the weir was washed out prior to the time period when captures in the other weirs were dominated by redband trout. The Pine Creek basin is the largest of the basins sampled and flow volume can change rapidly. On 28 October 1999, a rain event caused flows to increase more than 300 percent within a 12 hour period (Figure 7). The accompanying small debris load was probably the primary factor leading to the failure of the weir. Efforts to sample downstream migrants in Pine Creek will need to rely on other collection methods such as a screw trap or permanent type weir structure capable of handling a wide range of flows and debris.

Sheep Creek

Catches in the Sheep Creek weir were much lower relative to Indian Creek, a comparable size drainage. The catch was dominated by redband trout (Table 7). The majority of the redband trout ranged in lengths between 160 and 240 mm and bull trout were all greater than 350 mm (Table 8). Bull trout were the second most abundant fish, however, only five individuals were captured. One of the bull trout was a spawned out female with a highly eroded caudal fin. The overall condition factor of this fish was very low and the body cavity was flaccid. Bull trout were captured almost immediately following installation of the weir (Figure 8). Sheep Creek may be a colder basin relative to Indian Creek and Pine Creek as observed during early October of 1999 (Figure 9). Downstream migrations from Sheep Creek may occur earlier than observed in the basins above Hells Canyon Dam. The Sheep Creek weir will be installed in early September during 2000 to account for a possible earlier migration. One residual hatchery steelhead (ad-clipped) was captured in the weir. It is possible that the redband trout captured in the weir were steelhead. As part of the genetic evaluation of redbands in the Hells Canyon Complex, a collection of 30 individuals were removed from the lower section of Sheep Creek. These 30 fish will also be checked to determine if the maternal source of these fish were anadromous steelhead (Kalish 1990). Four bull trout were radio-tagged from the Sheep Creek weir and over-wintered in the mainstem Snake River. Results of radio-tracking studies will be presented in a separate report.

Discussion

Downstream migrations during fall months by salmonids was described early by Bjornn and Mallet (1964) and Bjornn (1971). Bjornn (1971) suggested that movement downstream may be triggered by lower water temperatures and fish seeking suitable over-winter cover. Northcote (1997) refers to these types of migrations as refuge migrations to localized survival habitats. Movements into the Snake River from both tributaries were associated with declining stream temperatures and suggest this type of pattern. Results from on-going radio-telemetry studies will further define the period of over-winter use and movements within these reservoirs as well as

their return to the tributaries. Bull trout were not observed in the Wildhorse River weir. The status of bull trout in the Wildhorse River is unclear. Recently, two bull trout were observed in the upper portions of Bear Creek, and two bull trout were observed in Crooked River, both tributaries to the Wildhorse River (Grunder, IDFG, personal communication). However, bull trout have not been observed in the Oxbow Reservoir in recent years to suggest even a remnant of a fluvial life history form.

Bull trout have been documented in the extreme upper portions of the Indian Creek drainage (Janssen et al. 1997) and the capture of two bull trout and several F1 hybrids in the downstream traps during 1999 suggests that a remnant fluvial life history remains in Indian Creek. The high percentage of hybridization observed from char captured in the Indian Creek weir is cause for concern on the genetic integrity of the Indian Creek population. Of the 17 char captured in the Indian Creek weir, 13 (76%) were determined to be hybrids. Janssen et al. (1997) sampled three different areas in the upper portions of the Indian Creek basin. Bull trout were captured only in the upper most site sampled. At this site, 40 percent of the bull trout captured were reported to be hybrids based on visual identification (n=15 char). In addition, 10 char were sampled while collecting redband trout for genetic analysis (IPC unpublished data) from the upper portions of Indian Creek in the same vicinity as the upper site sampled by Janssen et al. (1997). The genetic analysis of these 10 char resulted in 6 pure bull trout, 2 F1 x bull trout hybrids and 2 F1 hybrids.

Bull trout within the Pine Creek basin have a much greater distribution in terms of basin area than Indian Creek. It is likely that Pine Creek still supports a remnant fluvial population of bull trout. Since 1993, several bull trout have been captured in Hells Canyon Reservoir during late fall and winter months. In November of 1998, a bull trout was captured in the Oxbow bypass prior to the removal of the Indian Creek weir, which suggests a Pine Creek origin. In addition, two bull trout radio-tagged in the reservoirs made movements up into the Pine Creek drainage (IPC unpublished data). One tagged fish moved as far as the confluence of Lake Creek and North Pine Creek and subsequently moved back into the reservoir. The other moved up Pine Creek approximately 8 km and apparently fell victim to a terrestrial predator (tag was recovered on the bank). There is also some evidence of exchange between Pine Creek and Indian Creek. One F1 hybrid that was radio-tagged in Indian Creek during the fall of 1999, has presently moved up into the North Fork of Pine Creek.

Historically, all of these basins supported anadromous runs of spring chinook and steelhead, and likely supported fluvial forms of bull trout. Construction of the Hells Canyon Complex eliminated anadromous fish from these basins. Fluvial bull trout were likely present in the Eagle Creek basin as recently as the 1940 s and 1950 s (Gildemeister 1992). A 300 mm bull trout was captured in a net set in Brownlee Reservoir in 1965 (Buchanan et al. 1997), which may be the last report of a bull trout in the mainstem Snake River above Brownlee Dam.

The mechanism of the loss of fluvial bull trout in basins associated with the Hells Canyon Complex is not known. The loss of anadromous fish altered the trophic structure of all of these basins. In addition, introductions of exotic species such as Eastern brook trout as well as land

management practices within the basins have likely all contributed to the current status of bull trout within these basins. The effects of the presence of the reservoirs and the present lack of fish passage remains unclear. If overwinter movements into the reservoirs resulted in bull trout leaving the reservoir system, then a gradual loss of fluvial fish has likely been a major contribution to the current status of bull trout. Understanding movements of bull trout and redband trout within the reservoir system is crucial to understanding the present status of these native fish within these tributaries.

The Snake River below the Hells Canyon Complex may offer the best means of understanding historical use of the river system and how the reservoirs may be influencing or have influenced present status. Bull trout are still present in many of the tributaries below the Hells Canyon Complex (IDFG unpublished information; Bellerud, ODFW, personal communication; Buchanan et al. 1996). Anecdotal information from anglers (IPC unpublished data) as well as radio-tag information from the Grand Ronde River basin (Bellerud, ODFW, personal communication) suggests a widespread presence of fluvial bull trout below Hells Canyon Dam. However, the abundance of fluvial fish is unknown.

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Table 1. Total number of fish captured by species in the Indian Creek downstream migrant weir during 1998 and 1999.

Common Name	Scientific Name	1998		1999	
		n	%	n	%
Salmonidae					
Redband Trout[1]	*Oncorhynchus mykiss gairdneri*	197	82.1	359	96.2
Hatchery Rainbow Trout	*O. mykiss*	14	5.8	6	1.6
Brook Trout	*Salvelinus fontinalis*	1	0.4	1	0.27
Bull Trout[1]	*Salmo trutta*			2	0.54
F1 Hybrid		10	4.2	3	0.8
Mountain Whitefish[1]	*Prosopium williamsoni*	2	0.8		
Brown Trout	*Salmo trutta*	2	0.8		
Centrarchidae					
Smallmouth bass	*Micropterus dolomieu*			1	0.27
Cyprindae					
Speckled dace	*Rhinichthys osculus*			1	
Cottidae[1]					
Mottled sculpin	*Cottus bairdi*	2	0.8		
Sculpin spp.	*Cottus spp.*	12	5		

[1] Native species

Table 2. Frequency and mean weight (g) within 10 mm total length increments of salmonid species captured in the Indian Creek weir during 1998. Frequencies reflect only fish with both length and weight measurements.

Length Group (mm)	Brown Trout		Brook Trout		Bull x Brook F1 Hybrids		Wild Rainbow Trout	
	No.	Weight	No.	Weight	No.	Weight	No.	Weight
0								
10								
20								
30								
40								
50								
60								
70								
80								
90							1	6.7
100								
110							2	15.2
120							3	20.3
130							12	23.5
140							33	31
150							26	33.4
160							25	45.1
170							12	44.47
180							6	59.8
190							1	61.7
200							2	73
210			1	78.8	1	89.5	6	109.6
220					2	95.8	4	98.9
230					2	108.5	7	126
240					2	130.5	1	134.1
250							2	154.9
260	1	147.6			2	170.0	5	149.6
270							2	196.4
280					1	175.5	7	198.3
290							7	226.2
300	1	226.4					6	246.4
310							6	274.4
320							5	284.5
330							2	312
340							1	341
350							2	395.5
360							1	419.9
370							2	428.1
380							1	542.7
390							1	520.7
400								
410								
420							2	751.9
430								
440								

Table 3. Frequency and mean weight (g) within 10 mm total length increments of salmonid species captured in the Indian Creek weir during 1999. Frequencies reflect only fish with both length and weight measurements.

Length Group (mm)	Bull Trout		Bull x Brook F1 Hybrids		Brook Trout		Rainbow Trout	
	No.	Weight	No.	Weight	No.	Weight	No.	Weight
0								
10								
20								
30								
40								
50								
60							1	3
70							10	5.8
80							26	6.8
90							53	8.1
100							42	10.8
110							59	13.6
120							59	17.4
130							34	21.6
140							8	30.125
150							1	30
160							3	36
170							3	49.6
180							2	69.5
190					1	67	1	112
200							8	83.8
210							5	90.4
220			1	89			6	106.1
230	1	118					7	131.7
240							1	129
250							4	154.7
260							2	223.5
270	1	188					2	191.5
280			1	202			3	213.3
290							3	235
300			1	251			2	230
310							5	277.6
320							1	263
330							1	350
340							2	310
350								
360							1	392
370								
380								
390								
400							1	619
410							1	518
420								
430								
440							1	381

Table 4. Total number of fish captured by species in the Pine Creek and the Wildhorse River downstream migrant traps during 1999 and 1998, respectively.

Common Name	Scientific Name	Pine Creek		Wildhorse River	
		n	%	n	%
Salmonidae					
Redband Trout[1]	*Oncorhynchus mykiss gairdneri*	4	0.7	234	47.5
Hatchery Rainbow Trout	*O. mykiss*			39	7.9
Mountain Whitefish[1]	*Prosopium williamsoni*	22	4	22	4.5
Catostomidae[1]					
Bridgelip sucker	*Catostomus columbianus*	15	2.7	71	14.4
Largescale sucker	*C. macrocheilus*	10	1.8	3	0.6
sucker	*C. species*			1	0.2
Cyprinidae					
Northern pikeminnow[1]	*Ptychocheilus oregonensis*	88	15.8	9	1.8
Speckled dace[1]	*Rhinichthys osculus*			1	0.2
Longnose dace[1]	*R. cataractae*			1	0.2
Chiselmouth[1]	*Mylocheilus caurinus*	2	0.4	8	1.6
Common carp	*Cyprinus carpio*	9	1.6		
Redside shiner[1]	*Richardsonius balteatus*	1	0.18		
Centrarchidae					
Smallmouth bass	*Micropterus dolomieu*	372	67	74	15.0
Bluegill	*Lepomis macrochirus*	25	4.5		
Ictaluridae					
Channel catfish	*Ictalurus punctatus*	6	1.1	30	6.1

[1] Native species

Table 5. Frequency and mean weight (g) by 10 mm total length increments for common species captured in the Wildhorse River weir. Frequencies reflect only fish with both length and weight measurements.

Length Group (mm)	Channel Catfish		Wild Rainbow Trout		Hatchery Rainbow Trout		Smallmouth Bass		Mountain Whitefish		Bridgelip Sucker	
	No.	Weight	No.	Weight	No.	Weight	No.	Weight	No.	Weight	No.	Weight
0												
10												
20												
30											3	1
40											12	1.1
50											8	1.5
60											1	3
70												
80												
90												
100												
110											1	13.1
120												
130												
140			1	22.6							2	30
150			2	35.7							1	29
160			15	39.3	1	42			1	38	2	46.5
170			23	47.3	1	47	1	63			2	54.5
180			27	55.0	2	59					12	70.8
190			32	65.8	3	70.1					3	81.7
200			37	75.1	6	75.1					1	94.9
210			30	87.5	6	86.3	1	130				
220			17	100.1	4	107.6	1	176			1	126
230			17	110.4	3	120.3	1	179			2	140
240			3	123.6	2	132	7	202.2			3	151
250			4	147.5	1	141.1	4	246.3			2	209.5
260			1	150	1	164	10	236.1	1	224	1	202
270							12	280.2	1	236		
280					3	209	15	297.1	1	191	1	69.2
290					1	226	7	293.4	2	225.5		
300			3	241.8	1	291.8	5	386.2	2	294		
310			3	255.3	3	233.1	3	413.3	1	276		
320			1	319			1	454	2	361.5		
330			7	328.4			2	459	2	411		
340			2	355					3	390		
350									3	452.7		
360			1	472					1	486		
370	1	382										
380			1	533.9								
390	3	513.3									1	664
400	1	572	2	585.3								
410	4	568.3	1	593.4								
420												
430	3	658.3										
440	4	732	1	651.3								
450	2	964.1										
460	3	832										
470	2	923										
480												
490	1	558										

Table 6. Frequency and mean weight (g) within 10 mm total length increments of salmonid species captured in the Pine Creek weir. Frequencies reflect only fish with both length and weight measurements.

Length Group (mm)	Rainbow Trout		Mountain whitefish		Bridgelip Sucker		Largescale Sucker	
	No.	Weight	No.	Weight	No.	Weight	No.	Weight
30					4	1		
40					2	1		
50								
60								
70								
80								
90								
100								
110								
120								
130								
140			1	26				
150			2	28				
160			2	32.5				
170								
180			2	56				
190			1	58	1	87		
200								
210	2	89	1	284				
220					2	116.5		
230	1	115	1	119				
240			1	139				
250			3	162.3				
260	1	171						
270			2	186				
280			1	229				
290			1	237				
300			1	237				
310								
320								
330								
340			1	436				
350			1	377				
360			1	446				
370								
380								
390							1	536
400							1	581
410								
420					1	660		
430					1	662		
440							4	956.3
450					1	939	2	1045
460								
470								
480							1	1194
490								
500								
510								
520								
530								
540								
550								
560							1	904

Table 6 (cont.). Frequency and mean weight (g) within 10 mm total length increments of salmonid species captured in the Pine Creek weir. Frequencies reflect only fish with both length and weight measurements.

Length Group (mm)	Smallmouth Bass		Bluegill		Northern Pikeminnow		Channel Catfish	
	No.	Weight	No.	Weight	No.	Weight	No.	Weight
50								
60								
70								
80								
90								
100								
110								
120			4	36.25				
130			9	51.44				
140			5	64.6				
150	1	82	4	77				
160			1	86				
170								
180	2	82.5			2	52.5		
190	19	92.7			2	74		
200	67	108.6			2	67.5		
210	71	125.7			4	75		
220	23	146.7			3	90.7		
230	9	159.7			5	117.4		
240	6	195.7			7	123.6		
250	7	197.1			1	397		
260	4	236.5						
270	7	269			2	170		
280	24	297.1			1	198		
290	36	335.4			1	207		
300	51	377.9			3	250		
310	22	412			2	264.5		
320	11	443.5	1	428	7	292.9		
330	4	525.8			4	351.8		
340	1	551			9	416.9		
350	1	523			10	391.1		
360					9	421.8		
370					6	480.8		
380					3	556		
390	1	219			2	486.5		
400					1	585		
410	1	378						
420					2	734.5		
430								
440								
450								
460							1	923
470							1	798
480	1	1040					1	596
490								
500	1	1060						
510								
520							1	1117
530							1	1147
540								
550								
560								

Table 7. Total number of fish captured by species in the Sheep Creek downstream migrant weir, 1999.

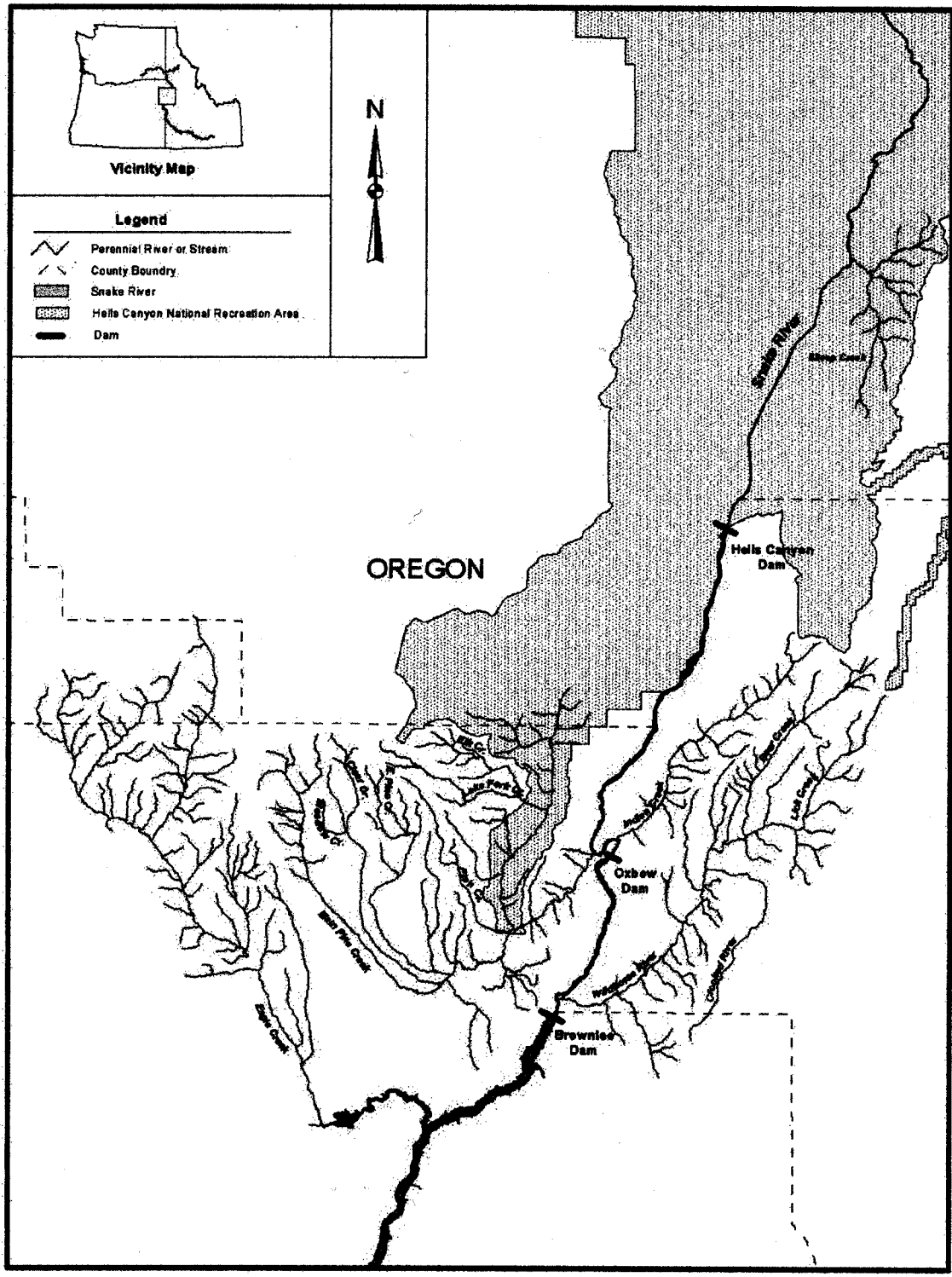
Common Name	Scientific Name	1999	
		n	%
Salmonidae[1]			
Redband Trout	*Oncorhynchus mykiss gairdneri*	37	84.1
Hatchery Rainbow Trout[1]	*O. mykiss*	1	2.3
Bull Trout	*Salmo trutta*	5	11.4
Mountain Whitefish	*Prosopium williamsoni*	1	2.3

[1] Residual Ad-clip steelhead

Table 8. Frequency and mean weight (g) within 10 mm total length increments of salmonid species captured in the Sheep Creek weir. Frequencies reflect only fish with both length and weight measurements.

Length Group (mm)	Rainbow Trout		Residual Steelhead		Bull Trout	
	No.	Weight	No.	Weight	No.	Weight
10						
20						
30						
40						
50						
60						
70	3	5				
80						
90	1	8				
100						
110						
120						
130						
140						
150						
160	2	39.5				
170	1	48				
180	6	59.7				
190	5	64				
200	4	72.1				
210	5	89				
220	2	95				
230	1	134				
240	3	134				
250						
260	2	186				
270						
280						
290	2	270.5				
300						
310						
320						
330						
340			1	427		
350					1	289
360					3	397.7
370						
380						
390						
400						
410						
420						
430					1	649
440						

Figure 1. Map of study area.



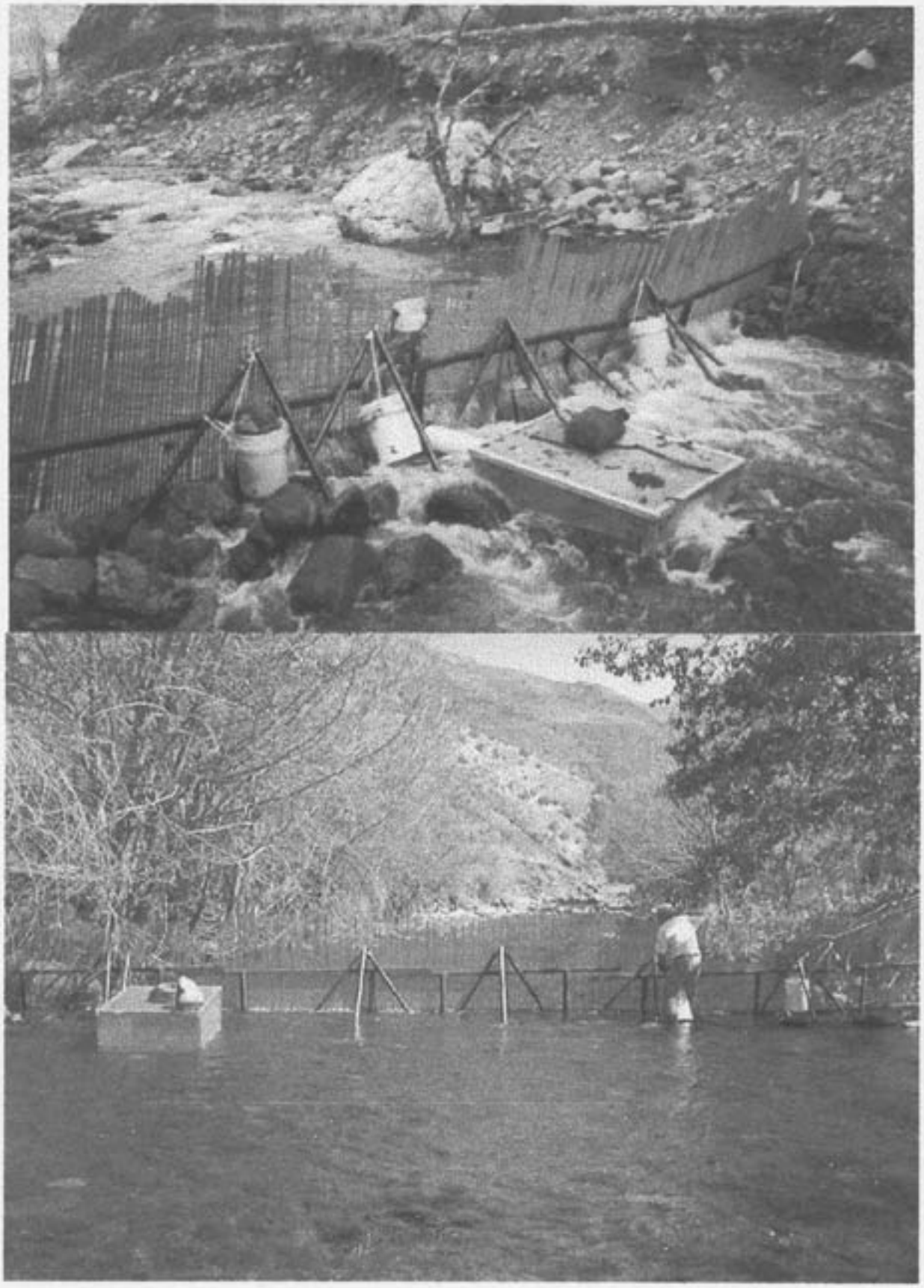


Figure 2. **Picket style weir used in Indian Creek (top) and Wildhorse River (bottom).**

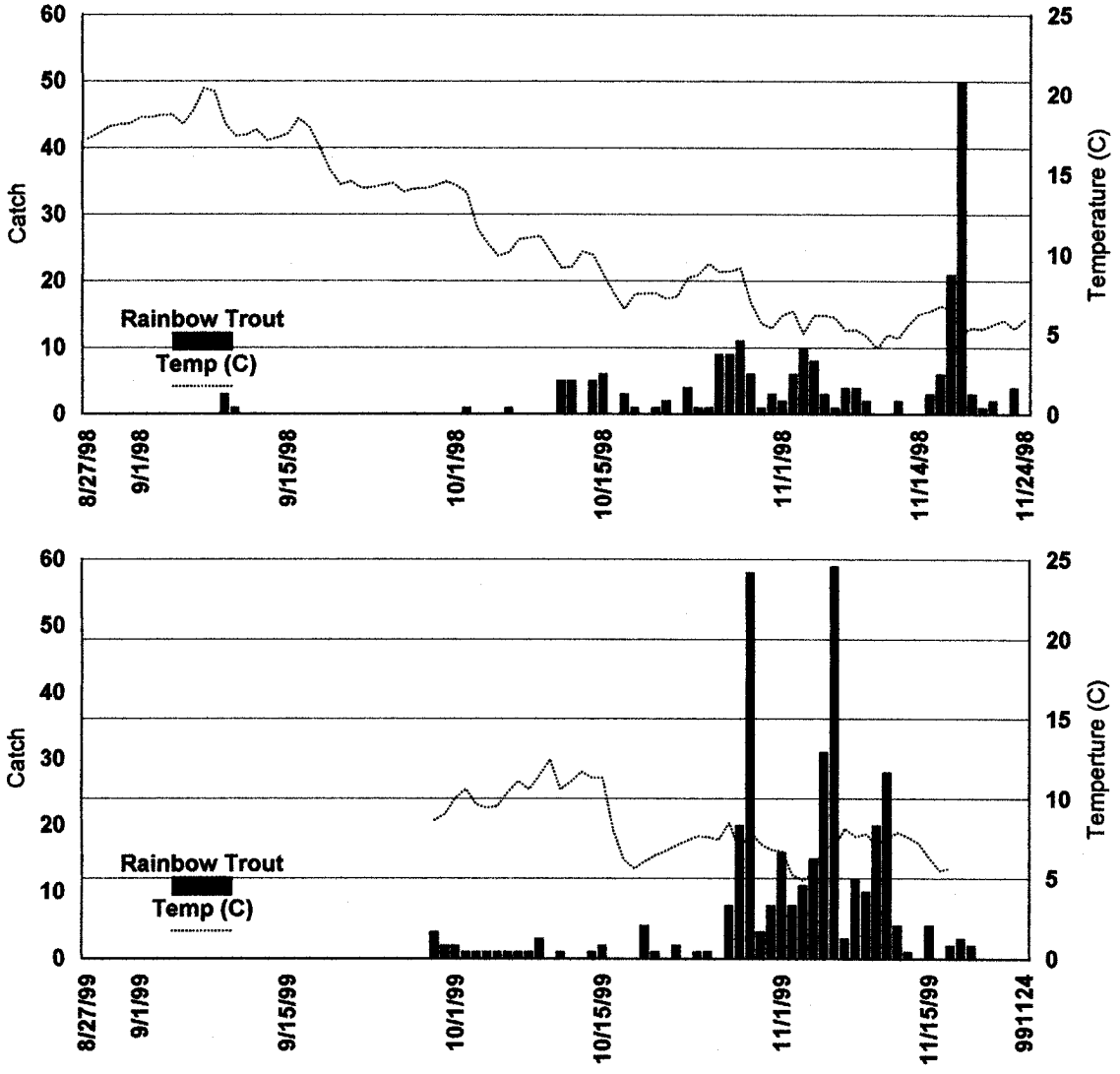


Figure 3. Daily catch rates (1st Y axis) in the Indian Creek weir for wild rainbow trout relative to water temperature (2nd Y axis).

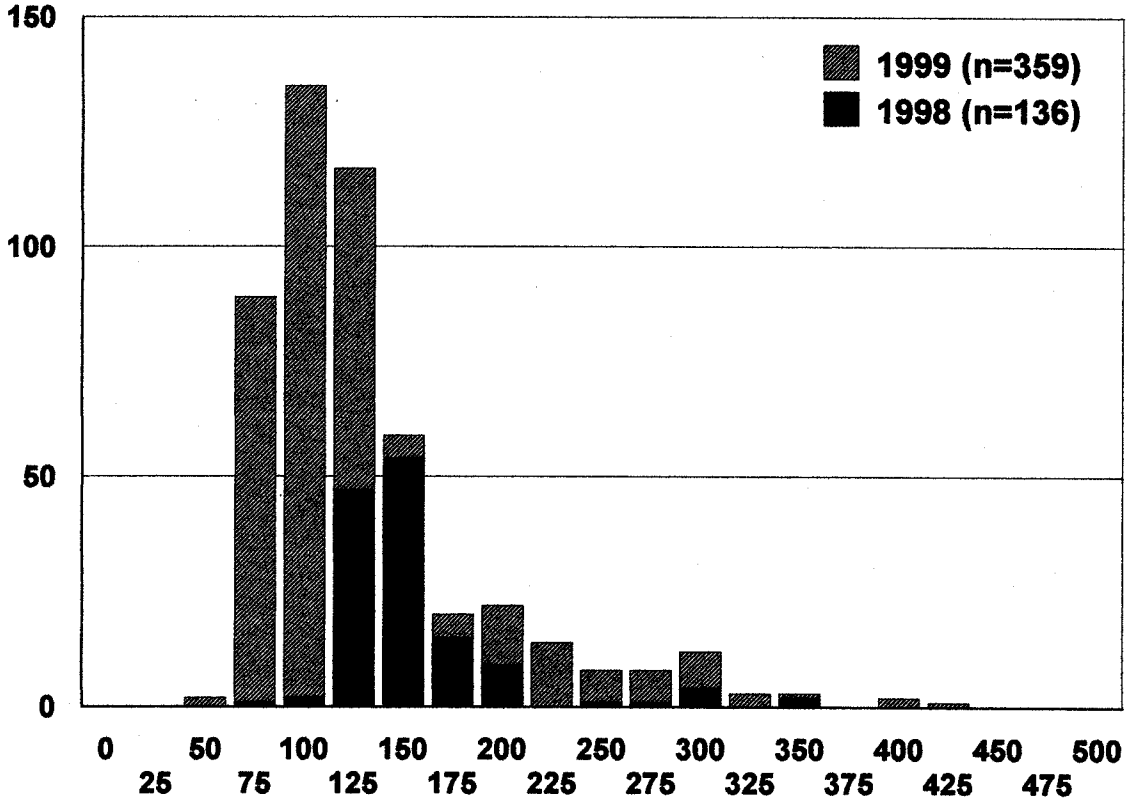


Figure 4. Length frequencies (TL) of wild rainbow trout captured in the Indian Creek downstream migrant weir during 1998 and 1999.

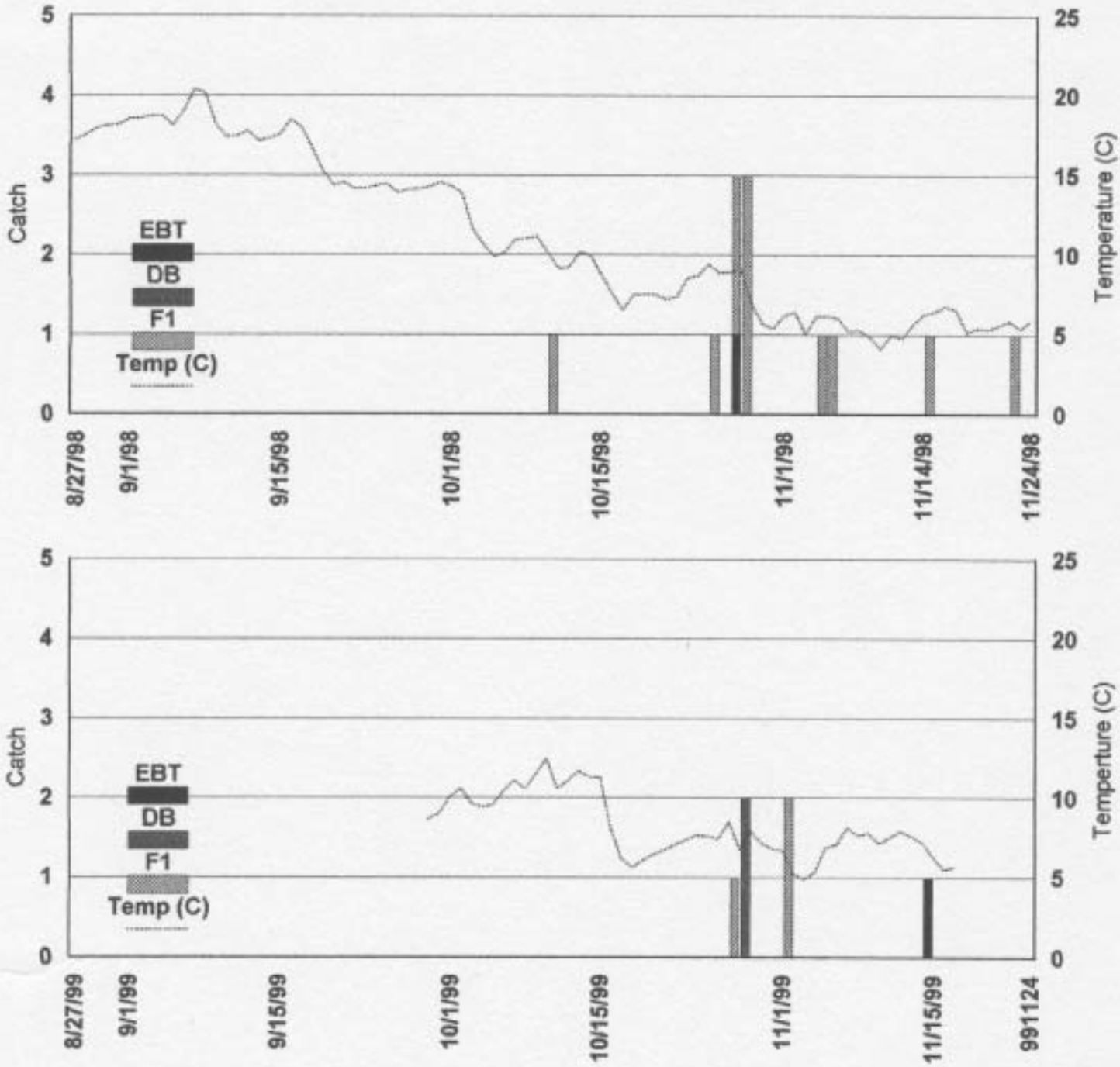


Figure 5. Daily catch rates (1st Y axis) in the Indian Creek weir during 1998 and 1999 for bull trout (DB) Eastern brook trout (EBT) and F1 hybrids (F1) relative to water temperature (2nd Y axis).

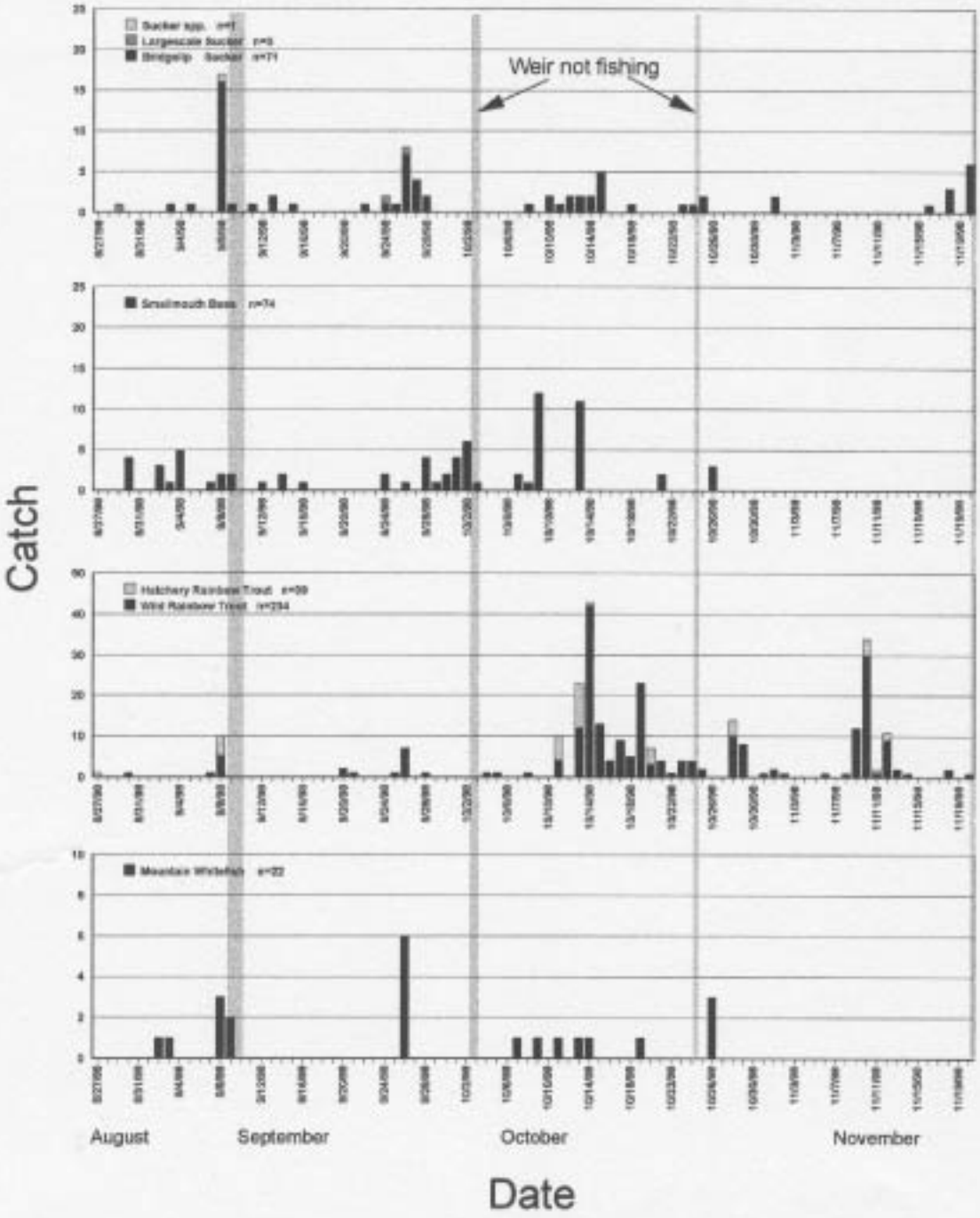


Figure 6. Daily catch rates in the Wildhorse River downstream migrant weir of sucker species, smallmouth bass, rainbow trout, and mountain whitefish. Vertical gray bars indicate periods of weir failure.

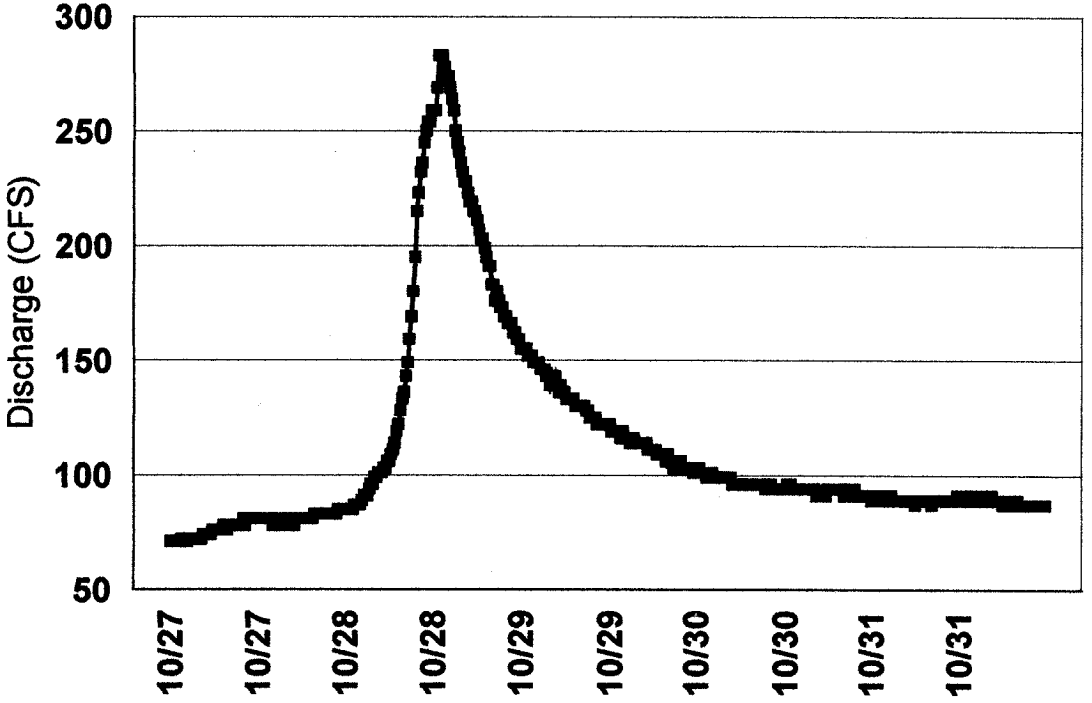


Figure 7. Hydrograph of Pine Creek from 27 October, 1999 - 31 October, 1999.

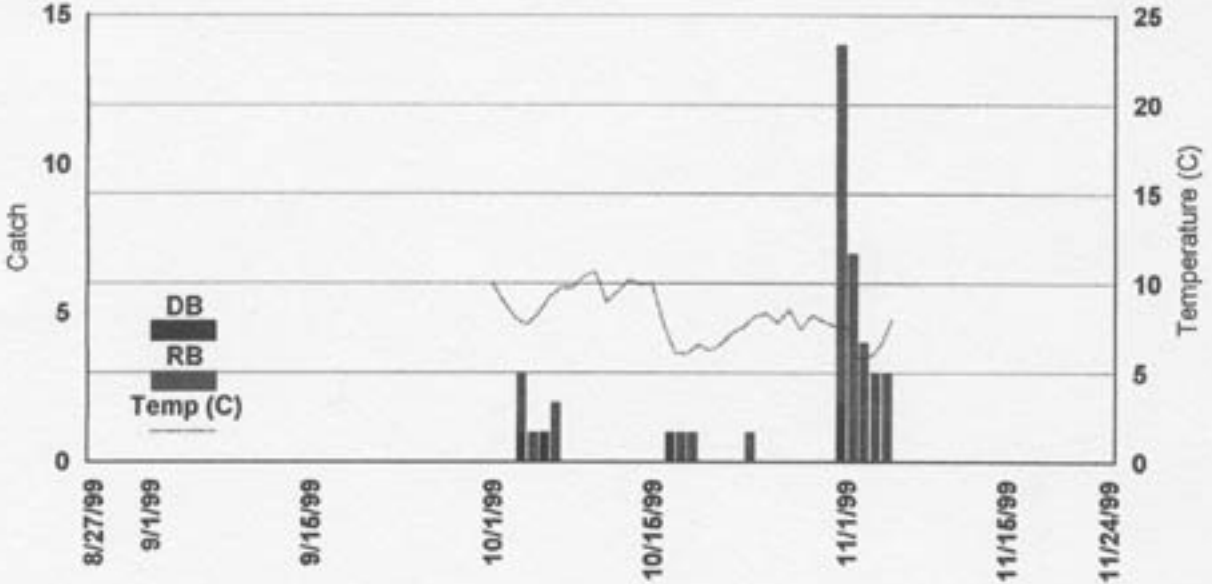


Figure 8. Daily catch rates (1st Y axis) in the Sheep Creek weir during 1999 for bull trout (DB) and rainbow trout (RB) relative to water temperature (2nd Y axis).

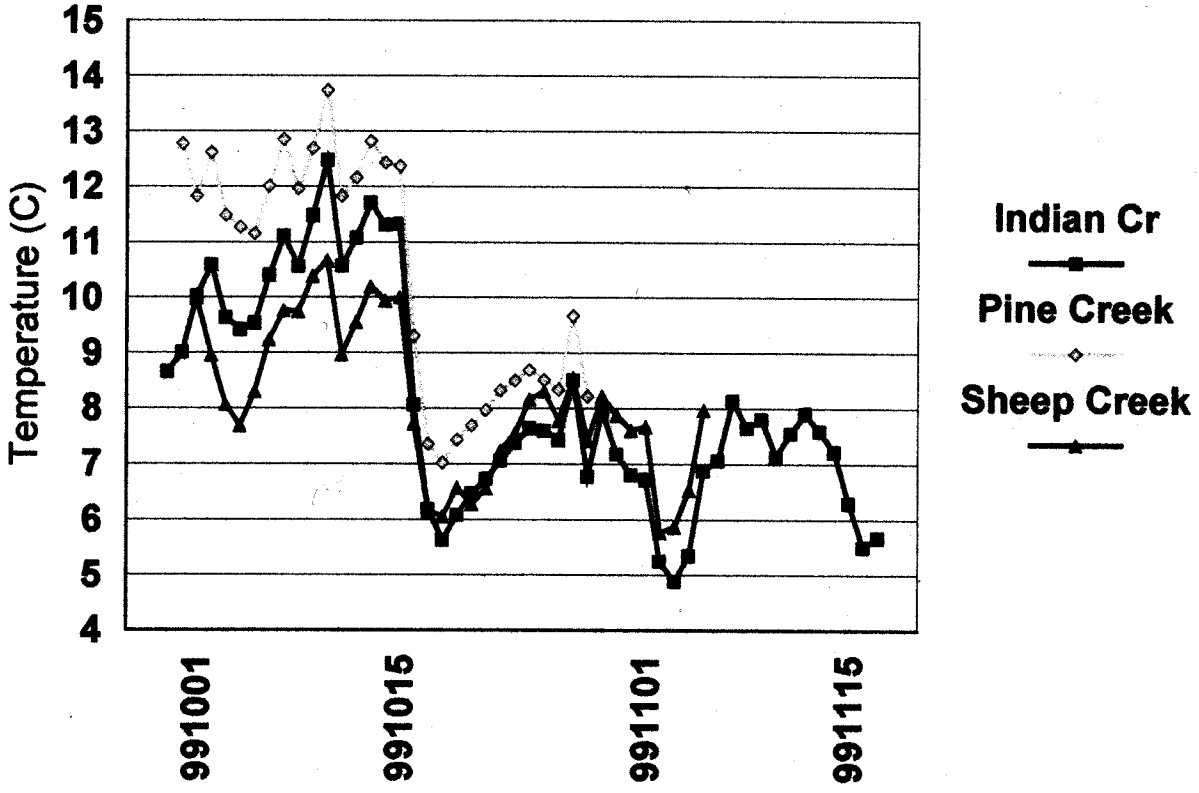


Figure 9. Mean daily water temperatures of Indian Creek, Pine Creek, and Sheep Creek during October and November, 1999.