FISHERY RESEARCH

IRRIGATION DIVERSION FISH LOSS REDUCTION

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Project 7—Irrigation Diversion Fish Loss Reduction

Subproject 1: Big Wood River and Silver Creek Canal Investigations
Subproject 2: Henrys Lake Tributaries Canal Investigations

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ANNUAL PERFORMANCE REPORT
SUBPROJECT #1: BIG WOOD RIVER AND SILVER CREEK CANAL INVESTIGATIONS

State of: Idaho

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Subproject #1: Big Wood River and Silver Creek Canal Investigations

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ABSTRACT

A total of five irrigation canals on the Big Wood River and Silver Creek were trapped to estimate season-long salmonid exploitation rates. The canal exploitation rate is defined as the proportion (%) of a fish population that is intercepted by an irrigation canal. Trout were captured in the canals with picket weirs, fyke nets, and box traps. The trap catch was evaluated by species and size groups (TL >80 mm, TL <80 mm). Rainbow trout *Oncorhynchus mykiss* <80 mm dominated the trap catch followed by brook trout *Salvelinus fontinalis* and mountain whitefish *Prosopium williamsoni* in the Big Wood River canals. Most rainbow trout young-of-year were captured in Big Wood River canals from the end of September to early November. The combined rainbow trout exploitation rate of two Big Wood River canals was estimated at approximately 7.9%. No salmonids were trapped in the Silver Creek Canal. Low recapture rates precluded canal exploitation estimates for other salmonid species in the Big Wood River and Silver Creek canals. Rainbow trout were diverted at higher rates into the larger Big Wood River canals than the smaller ones regardless of canal headgate characteristics.

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INTRODUCTION

Idaho fishery managers have long suspected that significant numbers of resident salmonids are lost to irrigation diversions. However, there are little quantitative data available to assess the impacts of those losses on stream populations or to determine whether a widespread problem exists (Der Hovanisian 1995). Hundreds of Idaho streams are diverted for agricultural purposes statewide, and such diversions may affect trout populations in adjacent stream reaches. Canals in Idaho divert water at rates ranging from <1 m^3/s to 126 m^3/s. Although the majority of diversions in the Salmon River drainage and a few diversions in southeastern Idaho are screened to protect against fish loss, most irrigation diversions in the state are not.

The goal of this research project is to determine under what circumstances and to what degree sport-fishing opportunities could be enhanced by minimizing losses of resident salmonids to irrigation diversions. This report will evaluate the impact of these losses on the related fishery by estimating fish lost to a variety of canals. If exploitation by irrigation diversions is shown to be high, then I will classify diversions by canal characteristics associated with the highest exploitation rates and identify potential problem canals.

This was the fourth year of a five-year study. Field operations during 1998 focused on estimating trout exploitation rates for canals on the Big Wood River and Silver Creek. The Big Wood River and Silver Creek canals provided the opportunity to investigate fish loss to canals from nonmigratory resident fish populations.

RESEARCH GOAL

To determine under what circumstances and to what degree minimizing losses of resident salmonids to irrigation diversions could enhance sport-fishing opportunities.

OBJECTIVES

1. To assess the population effects of resident salmonid losses to irrigation diversions.

Tasks

1. To estimate exploitation of trout by irrigation diversions on the Big Wood River and Silver Creek during the 1998 irrigation season.

2. Use radio telemetry to determine if salmonids in the canals can reenter the Big Wood River.

DESCRIPTION OF STUDY AREA

Canals were sampled on the mainstem Big Wood River (BWR) and one canal on Silver Creek (SC) (Figures 1 and 2). The BWR is free flowing with a natural, seasonally influenced hydrograph, whereas SC is spring fed, and its hydrograph is not seasonally influenced. In 1998, BWR flows ranged from 4.4 m^3/s to 69.7 m^3/s (USGS 1998). The BWR is a meandering stream with a substrate of mainly rubble followed by boulder, sand, and gravel (Partridge and Warren 1994). Silver Creek is spring fed and has a fairly uniform annual discharge cycle. In 1998, SC flows ranged from 3.5 m^3/s to 11.8 m^3/s. Silver Creek is a meandering stream with abundant riparian and in-stream vegetation, deep undercut banks, and a substrate comprised mainly of sand, gravel, and silt. Stream flows in all study areas were subject to irrigation water withdrawals.

Five canals were trapped during the field season in 1998. Four BWR canals (Hiawatha, Osborn, Cove, and District canals) and one SC Canal (Iden Canal) were investigated. The Big Wood River study canals divert water between Bellevue and Ketchum, Idaho (river km 129 to 145). The headgate of the Silver Creek Canal (Iden Canal) is located approximately 2.5 km west of Picabo, Idaho where Silver Creek passes under U.S. Highway 20.

Canal characteristics as described in Der Hovanisian (1997) varied among the canals trapped in 1998 (Appendix A). Of the four Big Wood River canals, District Canal had the highest flows, followed by Hiawatha, Cove, and Osborn canals. All BWR and SC canals had diversion structures associated with their headgates except Osborn Canal. None of the BWR and SC canals were screened, necessitating the use of various short-term trapping methods. The period of canal operation generally ranged from May to November 1998 (Table 1).

The fish communities were similar among the two study waters. Rainbow trout *Oncorhynchus mykiss*, brown trout *Salmo trutta*, brook trout *Salvelinus fontinalis*, and mountain whitefish *Prosopium williamsoni* make up the salmonid community in the BWR (Thurow 1990). Rainbow trout are the predominant trout species in the BWR study area. The SC salmonid community is comprised of rainbow and brown trout with few mountain whitefish (Steve Elle, Idaho Fish and Game, unpublished data).

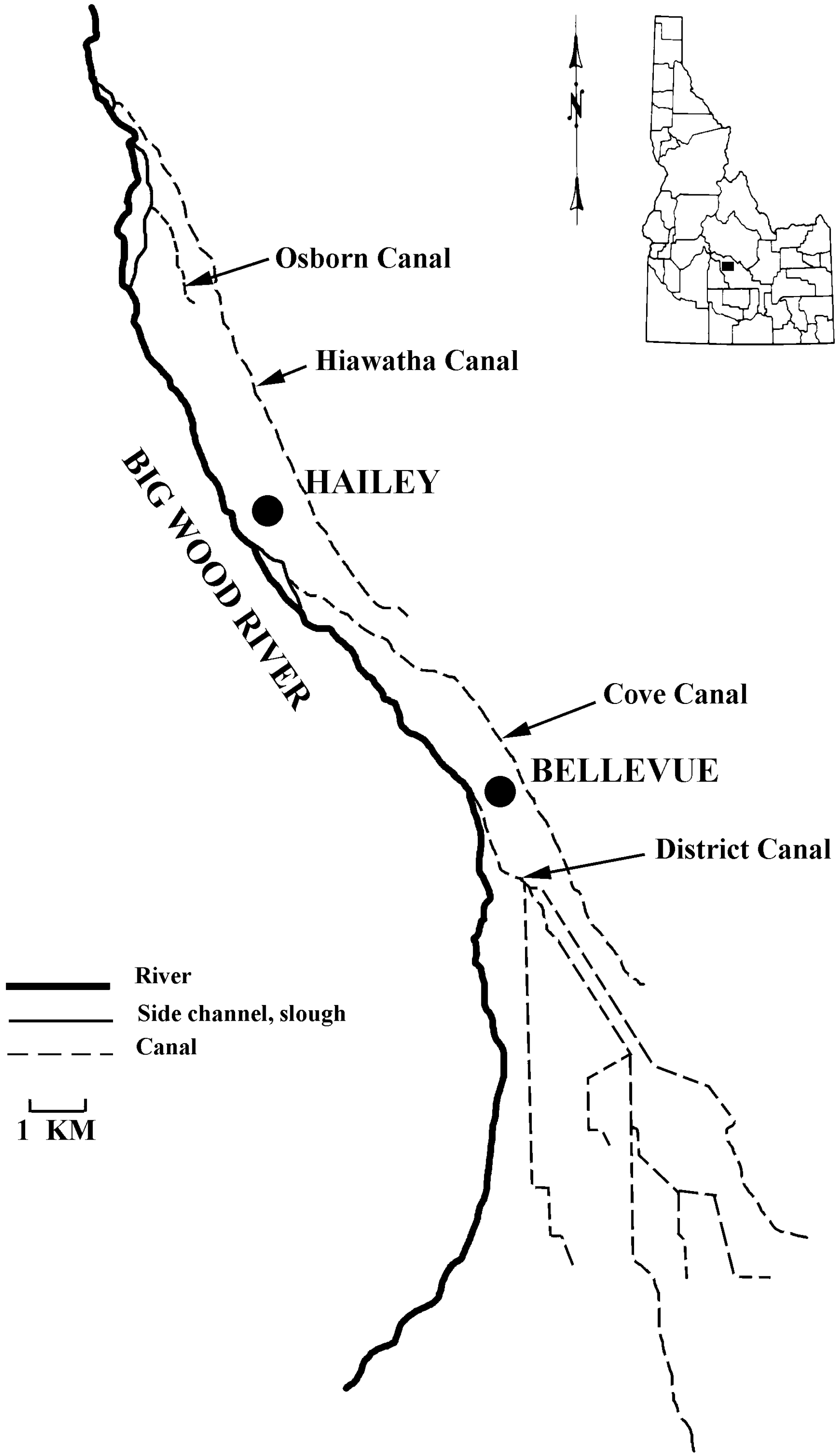

Figure 1. Big Wood River study area including Hiawatha, Osborn, Cove, and District canals.

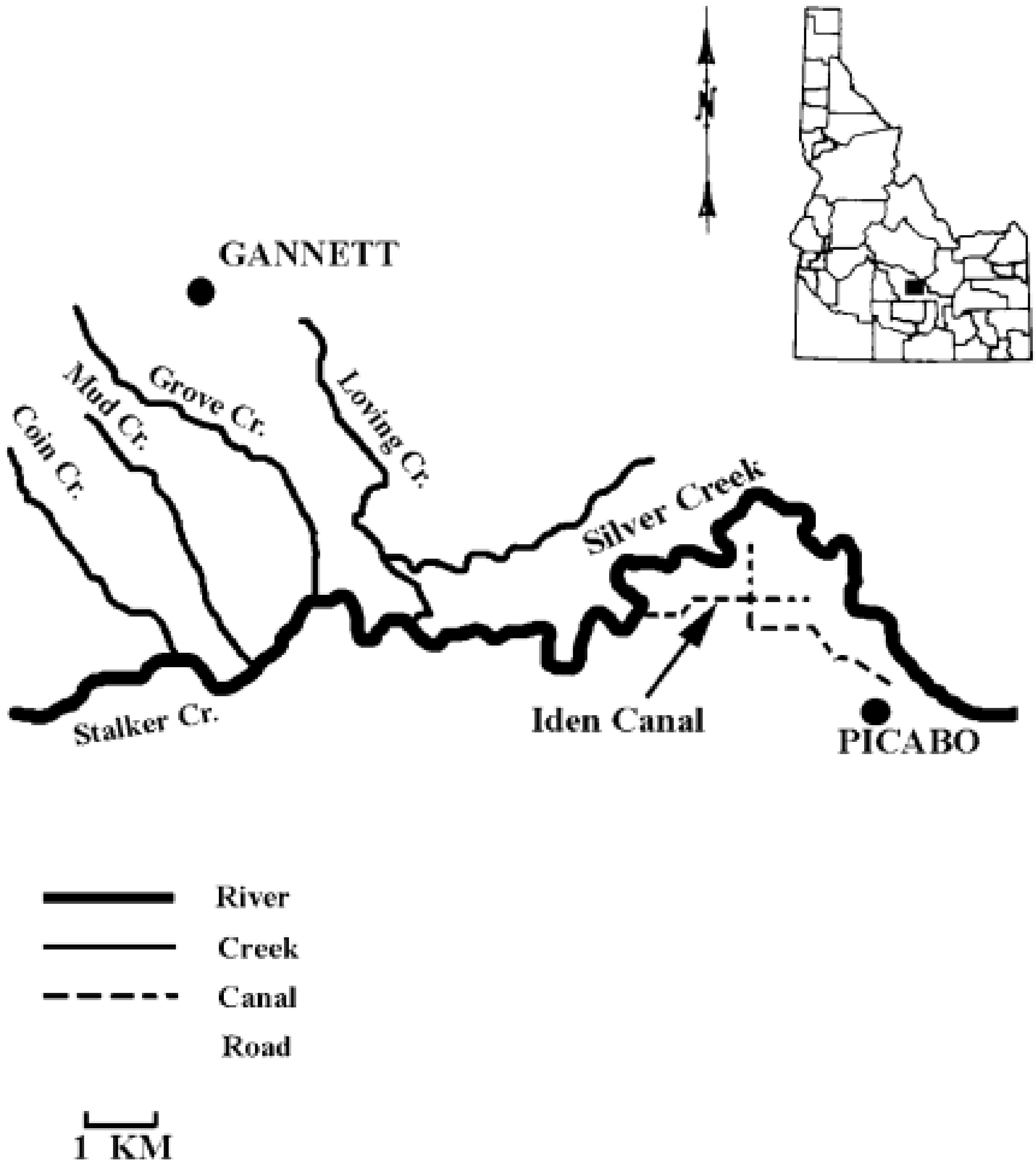

Figure 2. Silver Creek study area including the location of the Iden Canal.

Table 1. Trapping and canal operation periods for study canals on the Big Wood River and Silver Creek, Idaho during the 1998 irrigation season.

River	Canal	Trap type	No. of traps	Trap period: May June July Aug. Sept. Oct. Nov. Dec.
Big Wood	Hiawatha	Canal operation		|xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx|
		Weir	1	|--|
		Fyke Net	2	|---|
	Osborn	Canal operation		|xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx|
		Weir	1	|---|
	District	Canal operation		|xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx|
		Fyke Net[1]	3	|-------------------------|
	Cove	Canal operation		|xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx|
		Weir	1	|---|
		Fyke Net	2	|--|
Silver Creek	Iden	Canal operation		|xxxx| |xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx|
		Weir	1	|--|

[a] District fyke net array was never completely operational. High flows made holding traps in place difficult.

METHODS

Sampling Periods

This project's intent was to sample the irrigation canals from the onset of canal operation to the point where the headgates were closed for the season. Most canals in the BWR and SC study areas were opened in early May at very low levels to saturate the earthen canal substrates before normal operation. It was necessary to have the canals running at standard flows in order to effectively install picket weirs or fyke nets. Consequently, initial fish trapping in the BWR and SC canals began slightly later than the initial canal opening (Table 1).

Fish Traps

Fish entering canals within each study area were sampled using a combination of sampling techniques. Since none of the canals in the BWR or SC study areas were screened, fish were trapped with either a picket weir, fyke net array, or a combination of the two methods (Appendices B and C). Trapped fish passed through 15 cm flexible PVC pipe (3 m long) into the trap boxes. The boxes were designed to provide slack water to prevent fish mortality through exhaustion. Trap boxes were fixed on fence posts and adjusted periodically to maintain maximum holding capacity (water level) without overflow. Fish captured in fyke nets or picket weirs were held in the trap boxes overnight.

The trap boxes were slightly different from the basic bypass trap configuration and design as described in Der Hovanisian and Megargle (1998). The trap boxes were made of

1.9 cm marine grade plywood. Box dimensions varied depending upon the size of the stream. Only the rear panel of each bypass trap box was screened with nylon mesh (2.4 mm bar) to allow water to flow through the boxes. Specific box dimensions are described in Appendix B.

Picket weirs were made of angle-iron frames and 12.7 mm electrical conduit. Each weir panel was approximately 1 m high and 3 m long. The picket weirs were installed approximately 100 m below the canal headgate at a 45^0 angle to the canal flow. The weirs were reinforced with tripods and steel cables secured to upstream fence posts. Sandbags and irrigation tarps were used to stabilize the canal bed around the weir. Two trap boxes were attached to the weirs to collect fish moving both upstream and downstream (Appendix C). Weir and box dimensions are described in Appendix B.

Fyke nets (wingless) were used to increase fish capture rates within the BWR canals. Initially, nylon mesh screens (6.4 mm mesh) were attached to the weir face to increase trap efficiencies for smaller fish. If the added mesh reduced flows through the weir and backed up water, then the mesh was removed, and fyke nets were installed approximately 20 m below the weir. Multiple fyke net arrays were installed until approximately 75% of canal flow was sampled. If more than one fyke net was needed, then the nets were staggered horizontally (Appendix C). The fyke nets were reinforced with sandbags, steel cables, and fence posts. Fyke net dimensions are described in Appendix B.

Trap Catch

All canal traps were checked daily. Captured trout and char were: 1) anesthetized in an MS-222 aqueous solution; 2) enumerated by species; 3) measured to the nearest mm (TL); 4) examined for tags, marks, or fin clips; 5) tagged (or clipped, if necessary); and 6) released. All other fish species captured in the traps were counted and released.

Trapped salmonids were tagged or fin clipped to allow identification at recapture. Salmonids $\geq$80 mm (large trout) were injected with passive integrated transponder (PIT) tags in the BWR and SC study areas. All fish that received PIT tags also received a left ventral (LV) fin clip. Salmonids <80 mm (small trout) received either an upper caudal (UC) or lower caudal (LC) fin clip depending upon the direction they were moving when captured (i.e., UC=upstream movement, LC=downstream movement).

Captured fish were released in the canal to estimate trap efficiency. All upstream-traveling trout were marked (tagged) and released approximately 50 m downstream from the trap. Trout captured while moving downstream were tagged and released 50 m upstream. Any recaptured trout was recorded and released at the trap site to resume its direction of travel. It was assumed that each marked trout resumed moving in the same direction it was traveling before its initial capture.

Trap Efficiency

Trap efficiencies were used to expand trap catches to estimate the number of trout entering a canal. Release (D) and recovery (d) data were combined over consecutive time periods with similar canal flows (Der Hovanisian and Megargle 1998) to determine the trap efficiencies (d/D). The relationship between the F and binomial distributions provided confidence intervals for the trap efficiencies (Zar 1984).

Trap efficiencies were stratified by canal flow, trap type, trout species, and trout size. Efficiency estimates were determined for both weir trap boxes. Trap efficiencies were stratified by canal flows only if flows varied substantially ($\pm$5 m^3/s). The District Water Master provided canal flow data until October 1998, at which point canal flows were determined using staff-gauge/flow models. If more than one fyke net was used in a canal, then one trap efficiency estimate was determined for all fyke nets combined. Only trout marked and recaptured with the same trap type were used to determine the trap efficiency. Trout were stratified into two length groups: trout <80 mm (small size group) and trout $\geq$80 mm (large size group) (Der Hovanisian and Megargle 1998). Trout in the small size group generally represented the young-of-year (YOY) age class, and trout in the large size group represented trout that were age-1 and older (Der Hovanisian and Megargle 1998).

During the study, it was suspected that picket weirs were blocking trout movement within the canals. If the weirs were blocking trout movement downstream, then densities would be expected to be higher above the weir than below. Depletion estimates were used to estimate trout densities in two 100 m long transects located above and below the weir. Population estimates within each transect were generated for each trout size group using MicroFish 3.0 software (Van Deventner and Platts 1989).

Trout Exploitation by Canals

The canal exploitation rate is defined as the proportion of a fish population that is intercepted by an irrigation canal. This technique required canal-trapped fish to be marked and released in the river above the headgate. The number of recaptures from this marked group was expanded using the trap efficiencies, and canal exploitation rates were calculated (Der Hovanisian and Megargle 1998). In many cases, no fish were recaptured and no exploitation estimates were calculated (Der Hovanisian and Megargle 1998). Too few fish may have been released in the river to provide recaptures (John Der Hovanisian, Idaho Fish and Game, personal communication). Therefore, the river adjacent to the canal headgate was electrofished and all captured trout were tagged to enlarge the marked population available to determine the exploitation rate.

Exploitation estimates were calculated for the Iden Canal (on SC) using the technique described above. Four hundred twenty-two trout (brown and rainbow) were PIT tagged in the adjacent river two weeks before the irrigation season. Trout were captured in a 2 km reach of SC extending from 1 km upstream to 1 km downstream from the canal headgate. Fish were captured using a drift boat electrofishing setup. The captured fish were PIT tagged and released in the same area in which they were captured.

Only a rough exploitation estimate could be determined for the BWR irrigation canals. No trout were tagged in the BWR before canal openings due to high river flows. Additionally, low numbers of trout captured in the BWR canals made it difficult to provide enough marked trout for both efficiency and exploitation estimates. Therefore, all canal-trapped fish were used to determine trap efficiencies, and the canal exploitation rate estimate could not be determined using the technique described in Der Hovanisian and Megargle (1998). A rough estimate of BWR canal exploitation rate was made using the estimate of fish entering each canal (expanded trap catch) in relation to past fish population estimates in the adjacent BWR. Past BWR estimates were found in Thurow (1990), Partridge and Corsi (1990, 1993), Partridge and Warren (1994), Warren and Partridge (1994,1995).

Trout Movement

Rainbow trout movement within District, Hiawatha, and Cove canals was monitored using radio telemetry. Radio-tagged trout were released and tracked in District, Hiawatha, and Cove canals in July 1998 to monitor fish movement during the normal canal operations. Radio-tagged trout were released again in District and Hiawatha canals in October 1998 to monitor fish movement during the period of canal closure.

Rainbow trout were collected from both the BWR and the irrigation canals for the radio telemetry effort. If insufficient samples of rainbow trout were collected from the canals, then they were collected from the river immediately adjacent to the canal headgate. Rainbow trout were collected from the canals using a Coffelt backpack electrofishing unit and with hook and line in the BWR. The total weight of each fish collected was measured to assure that the radio tags only represented 2% of the body weight. High flows prevented the efficient use of electrofishing capture techniques in the BWR. Immediately following collection, radio tags and PIT tags were surgically inserted into the rainbow trout viscera. Following surgery, all trout were held overnight and released the following day.

Overall, 51 radio tags were implanted in rainbow trout, which were released in the BWR canals. Thirty radio-tagged fish (10 tagged fish per canal) were released in Cove, District, and Hiawatha canals in July 1998. In October, 18 tagged fish were released in District Canal, and 3 were released in Hiawatha Canal. Radio-tagged trout were tracked weekly (30 in July and 21 in October) until the tags failed to produce a signal (30-50 d). The radio-tagged trout were relocated from a vehicle or on foot using a directional or whip antenna. A fixed-wing aircraft was used to locate fish not found from the ground. The telemetry tags produced a pulsating signal for a 36 h period once a week.

Staged Drawdown

A staged drawdown of Hiawatha Canal was attempted in order to determine if the drawdown would stimulate fish movement toward the BWR. Hiawatha Canal flows were reduced by approximately 80% seven days before canal closure (Reiland 1994). Immediately following the headgate closure, a 100 m transect located just below the headgate was shocked to estimate fish density. This density was compared to that of the previous July estimate within the same transect. If the drawdown successfully encouraged fish movement toward the canal headgate following headgate closure, then fish densities would likely increase following the drawdown. The population estimate within the transect was generated with MicroFish 3.0 software (Van Deventner and Platts 1989).

Radio-tagged trout were used to monitor fish movement during the staged drawdown. Three radio-tagged trout were released in the canal in October. Movement of these trout was monitored during the staged drawdown and following the canal headgate closure.

RESULTS

Trap Catch

Rainbow trout (n=1295) were the predominant salmonid species captured moving downstream in the BWR canals, followed by brook trout (n=51) and mountain whitefish (n=10). However, no salmonids were captured in Iden Canal. District Canal was not trapped for the entire irrigation season due to high flows, but the few fish captured before trap removal were YOY rainbow trout. Most rainbow trout captured in the remaining four BWR canals ranged from 0 mm TL to 200 mm TL (Appendices D and E).

During the 1998 irrigation season, most trout in BWR canals were captured from mid-August to November (Appendices F-H). The majority of rainbow trout YOY were trapped in the canals during this period. Larger salmonids (≥80 mm) were trapped at lower rates than the YOY, but were trapped consistently throughout the irrigation season. In most instances, only large trout were intercepted moving upstream within the canal. This upstream movement generally occurred before the influx of YOY captured in the traps in mid-August.

Trap Efficiency

Trap efficiencies varied among trap types and canals in the BWR study area. Trap efficiencies were estimated for rainbow trout in all four canals, but for brook trout only in Cove Canal (Table 2). Weir trap efficiency estimates for large rainbow trout ranged from 0.067-0.143, and from 0.143-1.000 for small rainbow trout. Fyke net trap efficiency estimates for large rainbow trout ranged from 0.045-0.060, and from 0.053-0.266 for rainbow trout <80 mm. Since canal flows were relatively constant, trap efficiencies were not stratified by canal flows, and efficiency estimates are season-long estimates (Appendix I). No efficiency estimates were determined in the SC canal, as no trout were trapped.

The picket weir blocked fish movement within the Hiawatha Canal. Over five times as many rainbow trout were captured above the weir (n=78) as below the weir (n=14) in 100 m transects. The mean TL of the small rainbow trout above and below the weir was 68 mm (SD=10) and 74 mm (SD=3), respectively. The mean TL of the large rainbow trout was 214 mm (SD=146) above and 93 mm (SD=13) below the weir. These data indicate that only the larger trout were blocked by the weir.

Trout Exploitation by Canals

Season-long estimates of trout lost in BWR irrigation canals varied among canals, species, and size groups (Table 2). Brook trout and mountain whitefish exploitation rates were not evaluated beyond estimating total trout passage (expanded trap counts). Rainbow trout made up the largest portion of trout that entered canals during the 1998 irrigation season (Table 2). Of the two size groups, canals exploited a greater number of small trout than large trout (Table 2).

The combined Hiawatha and Cove canals exploitation rate for age-1 rainbow trout was 7.9%. Only Hiawatha and Cove canals were considered, because too few fish were captured in

Osborn Canal, and District Canal was not sampled for the complete irrigation season. The expanded trap catch estimates were 3,723 and 3,240 for small and large trout, respectively. By using past length-at-age data (Thurow 1990), it was determined that these two groups were largely made up of YOY and age-1 trout. Past abundance estimates for age-1 (large group strata) rainbow trout in an upstream 30 km reach of the BWR were 40,830 fish (Steve Elle, Idaho Fish and Game, personal communication). The expanded trap catch of large rainbow trout made up approximately 7.9% of the upstream river population. There were no past YOY rainbow trout data to compare the canal catch data to; therefore, no exploitation estimate was determined.

Trout Movement

The radio telemetry results indicated that fish movement from the canal to the main river is possible. From July to September 1998, nearly half (12 of 30) of the radio-tagged rainbow trout left the canals and reentered the BWR (Appendix K). Only one fish exited Cove Canal during this period. Most fish emigrated from the canals from late July through early August. None of the radio-tagged fish released in October left the canal before canal closure (Appendix L). Of 12 rainbow trout tagged and released in District secondary canals in October, only one reentered the main canal, and none returned to the BWR. The radio-tagged rainbow trout ranged from 150 to 362 mm (TL) and weighed from 30 to 450 g. No radio-tagged trout released in Hiawatha, Cove, or District main canals moved into any secondary canals. Specific tag and fish characteristics are described in Appendix J.

Following their release, most radio-tagged fish initially moved slightly upstream or downstream. Radio-tagged fish generally moved from the release site to the nearest available habitat within the canal. Many fish either remained in the same location or moved relatively small distances throughout the tracking period. The distance radio-tagged trout moved within the canal was usually <1.5 km (Appendix I). One exception was a radio-tagged trout that was released in a District secondary canal that moved approximately 3 km upstream to the plunge pool at the headgate. No radio-tagged trout released in the main canal ever entered a secondary canal.

Some radio-tagged trout were removed from the canal before the radio tags quit transmitting. Three radio-tagged trout in District Canal and one in Hiawatha Canal were killed by predators. One tag was found in coyote scat, and two tags were relocated periodically on land, indicating they were probably inside a moving animal.

Table 2. Trap efficiencies and expanded catch by canal trap type, fish size group (TL), and wild fish species in the Big Wood River canals, Idaho during the 1998 irrigation season.

		No. trapped (M / R)		Trap efficiency (95% CI)		Expanded catch (95% CI)	
Trap	Canal	Rbt	Ebt	Rbt	Ebt	Rbt	Ebt
Weir (upstream trap)							
< 80 mm	Hiawatha	1 / 0	0	- na -	- na -	- na -	- na -
	Osborn[a]	2 / 0	0	- na -	- na -	- na -	- na -
	District[b]	---	---	---	---	---	---
	Cove	1 / 1	0	1.000 (0.250 - 1.000)	- na -	1 (1 - 40)	- na -
	Silver Cr.[a]	0	0	- na -	- na -	- na -	- na -
≥ 80 mm	Hiawatha	3 / 0	0	- na -	- na -	- na -	- na -
	Osborn	21 / 3	0	0.143 (0.031 - 0.362)	- na -	147 (58 - 677)	- na -
	District	---	---	---	---	---	---
	Cove	23 / 1	4 / 0	0.043 (0.001 - 0.220)	- na -	529 (105 - 20,919)	- na -
	Silver Cr.	0	0	- na -	- na -	- na -	- na -
Weir (downstream trap)							
< 80 mm	Hiawatha	42 / 6	0	0.143 (0.054 - 0.286)	- na -	294 (147 - 775)	- na -
	Osborn	6 / 0	0	- na -	- na -	- na -	- na -
	District	---	---	---	---	---	---
	Cove	0	0	- na -	- na -	- na -	- na -
	Silver Cr.	0	0	- na -	- na -	- na -	- na -
≥ 80 mm	Hiawatha	30 / 2	0	0.067 (0.008 - 0.220)	- na -	450 (136 - 3,675)	- na -
	Osborn	11 / 0	0	- na -	- na -	- na -	- na -
	District	---	---	---	---	---	---
	Cove	106 / 21	33 / 7	0.198 (0.126 - 0.290)	0.212 (0.560 - 0.386)	535 (365 - 841)	156 (85 - 589)
	Silver Cr.	0	0	- na -	- na -	- na -	- na -
Fyke Net (downstream trap)							
< 80 mm	Hiawatha	736 / 166	0	0.226 (0.198 - 0.227)	- na -	3257 (3242 - 3717)	- na -
	Osborn	---	---	---	---	---	---
	District	38 / 2	0	0.053 (0.006 - 0.178)	- na -	722 (214 - 5,908)	- na -
	Cove	124 / 33	2 / 0	0.266 (0.188 - 0.356)	- na -	466 (348 - 660)	- na -
	Silver Cr.	---	---	---	---	---	---
≥ 80 mm	Hiawatha	130 / 7	1 / 0	0.054 (0.022 - 0.108)	- na -	2407 (1204 - 5909)	- na -
	Osborn	---	---	---	---	---	---
	District	22 / 1	0	0.045 (0.001 - 0.229)	- na -	484 (96 - 19,140)	- na -
	Cove	50 / 3	115 / 18	0.060 (0.013 - 0.165)	0.157 (0.094 - 0.243)	833 (303 - 3846)	732 (473 - 1223)
	Silver Cr.	---	---	---	---	---	---

[a] Canal was trapped only with a picket weir
[b] Canal was trapped only with fyke nets

Staged Drawdown

The staged drawdown failed to promote fish emigration towards the headgate in Hiawatha Canal. Following the drawdown, 459 small trout (<80 mm) and 16 large trout (≥80 mm) were caught in a 100 m transect at the headgate. The total catch for each size strata was lower than the total catch from a similar effort completed earlier in the irrigation season when 616 small trout and 31 large trout were caught. In addition, none of the three radio-tagged fish moved substantially towards the headgate during the staged drawdown or following the headgate closure.

DISCUSSION

There are potential biases in the efficiency and exploitation estimates. First, we may have violated some mark-recapture assumptions. If tagged fish were sedentary or emigrated upstream and out of the canal following marking and release, then trap efficiencies would be underestimated, thus overestimating the expanded catch rates and canal exploitation. I observed marked trout holding in the canal above the picket weirs, which indicated they were not vulnerable to my traps. Second, my trap methods were likely biased against larger trout. Some larger trout were able to leave the canal during the normal irrigation season. Additionally, there is evidence that the picket weir blocked the larger trout. Therefore, the exploitation estimates for the BWR canals should be considered a liberal estimate.

Older trout age classes (age-2 and older) were not well represented in the BWR canal trap catches when compared to the YOY and age-1 rainbow trout. The small rainbow trout were likely exploited passively by the canals and simply drifted into the canals with the diverted water. Fyke nets passively sample fish moving downstream with the current. The small rainbow trout were vulnerable to this trap type, but larger trout were not. For example, large trout were occasionally seen holding in front of the fyke nets. Fish that are actively moving through an aquatic system are vulnerable to picket weirs. Only the large trout were vulnerable to my picket weir traps since YOY trout could pass through the gaps in the pickets. Large trout that were caught in the picket weir and subsequently tagged and released often were not found again in the canal. I suspect some of these large, tagged trout avoided the trap and succumbed to harvest or depredation, or they returned to the BWR. The combined low picket weir total catch and evidence of blocking suggested that my trap methods were likely biased against the large trout.

Larger canals generally exploited more fish than smaller canals in the BWR. Decreed water rights showed District Canal to be the largest canal followed by Hiawatha, Cove and Osborn canals. The total catch of rainbow trout (<80 mm) entering BWR canals was highest in Hiawatha Canal followed by District, Cove and Osborn canals. I suspect District Canal exploitation estimates would have been much larger than Hiawatha estimates had I trapped the canal the full season. Osborn Canal was the smallest of the BWR canals, and it had the lowest total catch of the four canals.

Most fish were captured in irrigation canals during the low BWR flows. During this period, irrigation canals diverted a larger proportion of the BWR flow than during the high flows in spring. As the BWR flows decreased, diversion structures were used at most canals to divert a larger relative portion of river flow into the canals than during the high river flows. Past studies have also shown that fish vulnerability to canal exploitation increases with the proportion of river flow diverted into canals (Spindler 1955, Thurow 1990). In addition, the amount of BWR usable trout habitat may have decreased with decreased flows (decreased wetted streambed area) forcing YOY trout to disperse and seek suitable, unoccupied habitat or starve (Chapman 1966). Since trout fry are territorial, competition may lead to starvation or emigration of displaced fry, or a density-dependent population reduction (McFadden 1969). The resultant density-dependent YOY movement combined with the increased diversion of BWR flows could explain the timing and prevalence of YOY rainbow trout movement into irrigation canals.

Iden Canal had no detectable impact upon the adjacent SC fish population. No fish were captured in the picket weir within the canal. The absence of trout in the canal may have been related to the irrigation diversion's characteristics. Water diverted into Iden Canal first moved through a 50 m long reach of marsh habitat before reaching the headgate. This poor quality habitat, combined with low canal water velocities, may have deterred fish from entering the canal. Fish did not likely enter Iden Canal passively. I saw some trout in the canal just below the headgate, but they moved easily in and out of the canal. Additionally, since SC is spring-fed and not subject to extreme seasonal flow variations, the density-dependent dispersal that was described in the BWR might not occur in SC.

Although I estimated a cumulative exploitation of 7.9% for large rainbow trout in the two canals, this loss may not affect the resident fish population. First, the 7.9% exploitation is a liberal estimate. Second, I suggest that most YOY trout diverted into BWR canals are fish that are displaced when habitat is reduced during low river flows. The canals may be diverting trout that were displaced and were likely to perish naturally. The rate trout are artificially removed from a stable river population may be below its natural mortality rate and therefore not adversely affect the population (Kelly 1993). Fish losses to the BWR canals probably result in a decreased density-dependent mortality within the stream. If the BWR canals were screened, a reciprocal increase in density-dependent stream mortality would likely occur.

The summer telemetry results showed that nearly half of the July radio-tagged fish reentered the river, but none of the fish tagged in October reentered the river. For the July telemetry effort, I had to collect fish from the river to radio tag and release in the canals because I could not collect enough large fish from the canals. When fish were removed from the river and placed in the canals, many returned to their original location in the river. However, all fish used in the fall telemetry effort were collected from the canal. The fact that many river-captured fish left the canal and the canal-captured fish stayed may suggest that the river fish were removed from preferred habitat. Those fish that freely entered the canal might have been displaced in the BWR and actively entered the canals seeking better habitat. These fish probably entered the canals and remained where they found suitable habitat (Clothier 1953,1954, Evarts et al. 1991).

MANAGEMENT RECOMMENDATIONS

1. Do not screen Iden Canal on Silver Creek in the future.

2. Screening of the Osborn, Hiawatha, and Cove canals on the BWR would be a low priority.

3. Do not use picket weirs to trap fish in irrigation canals associated with a resident trout population.

4. Because of severe problems in obtaining reliable estimates of canal exploitation, I recommend this project be terminated one year early.

ACKNOWLEDGEMENTS

I would like to thank the following persons for allowing me to sample the canals on the Big Wood River and Silver Creek: Dave Cropper, Bud Purdy, Tinker Disbennet, Wayne Burke, and Jim Eakin. Without their interest and cooperation, I could not have completed this study. Dave Cropper showed concern and interest in minimizing fish lost to Hiawatha Canal. He proposed and assisted me in an experimental drawdown of Hiawatha Canal. Shannon Troop and Fred Allen were invaluable in the field. Additionally, I would like to thank Dan Schill, Dave Teuscher, Steve Elle, Jeff Dillon, Liz Mamer, Tony Lamansky, and personnel from Regions 4 and 6 for their assistance in the field. Jeff Dillon, Chris Downs, Dave Teuscher, Dan Schill, and Steve Yundt provided thoughtful reviews of this manuscript. Cheryl Leben finalized the document.

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APPENDICES

Appendix A. Physical characteristics of canals on the Big Wood River and Silver Creek, Idaho during the 1998 irrigation season.[a]

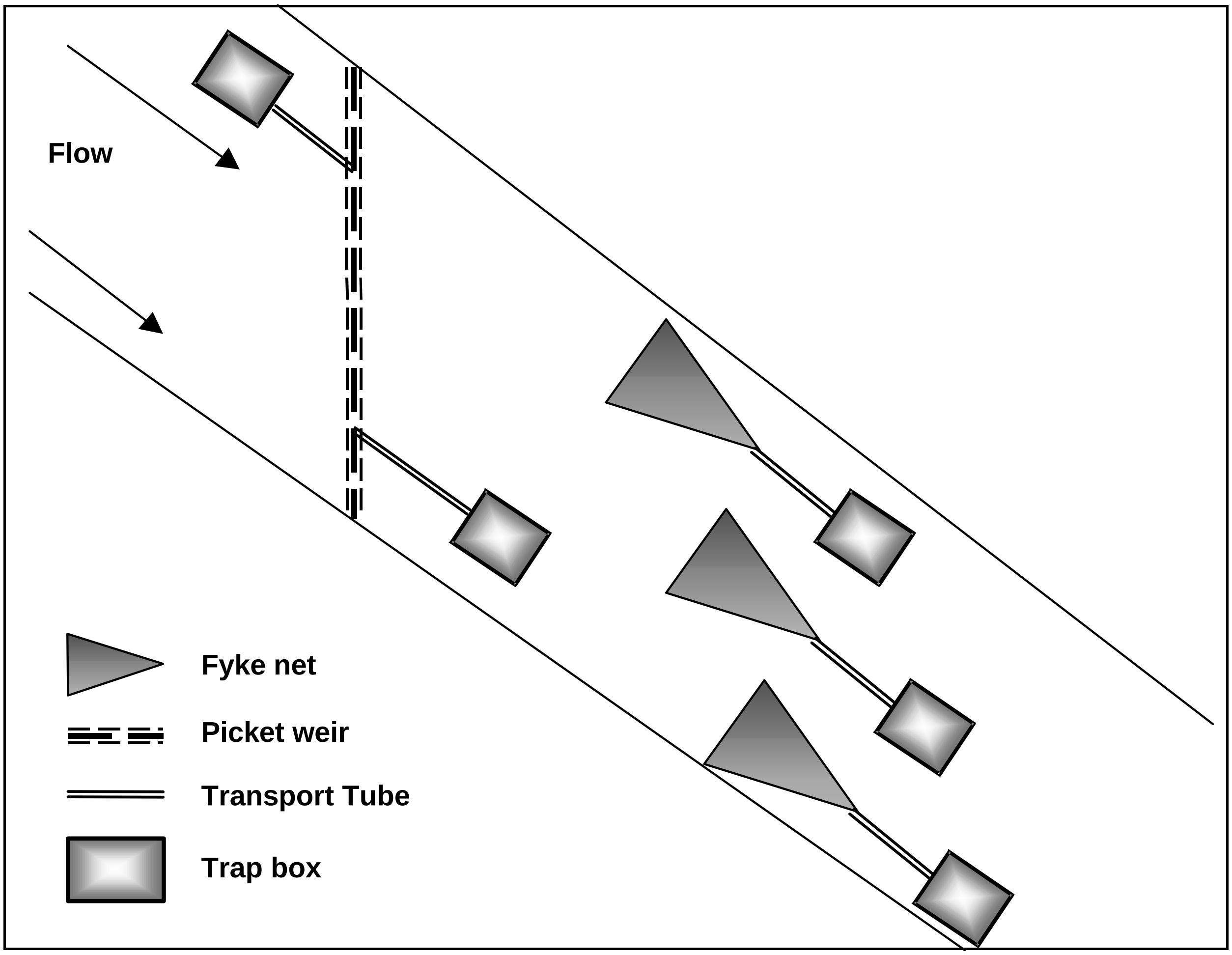
Diversion	River Dewatered	Headgate Location/ Kind	Diversion Dam	Drop Structure (m)	Relation to River	Decreed (m^3/s)	Velocity (m/s)	Gradient (%)	Width (m)	Depth (m)	Canal Angle
Big Wood River											
Hiawatha	N	river/vert	Y	N	outside bend	2.8[b]	0.5	-1.0	7.4	0.47	75
Osborn	N	canal/vert	N	N	outside bend	0.4[b]	0.1	-0.5	1.7	0.11	37
District	N	river/vert	Y	N	outside bend	10.6[b]	0.8	-1.0	12.1	0.52	60
Cove	N	canal/vert	Y	N	straight	0.6[b]	0.3	-1.0	2.6	0.24	49
Silver Creek											
Iden	N	canal/vert	Y	N	outside bend	—[b]	0.2	-0.5	6.2	1.10	78

[a] See Der Hovanisian 1997 for methods and definitions.
[b] Water right information obtained from Idaho Department of Water Resources, Twin Falls, Idaho.

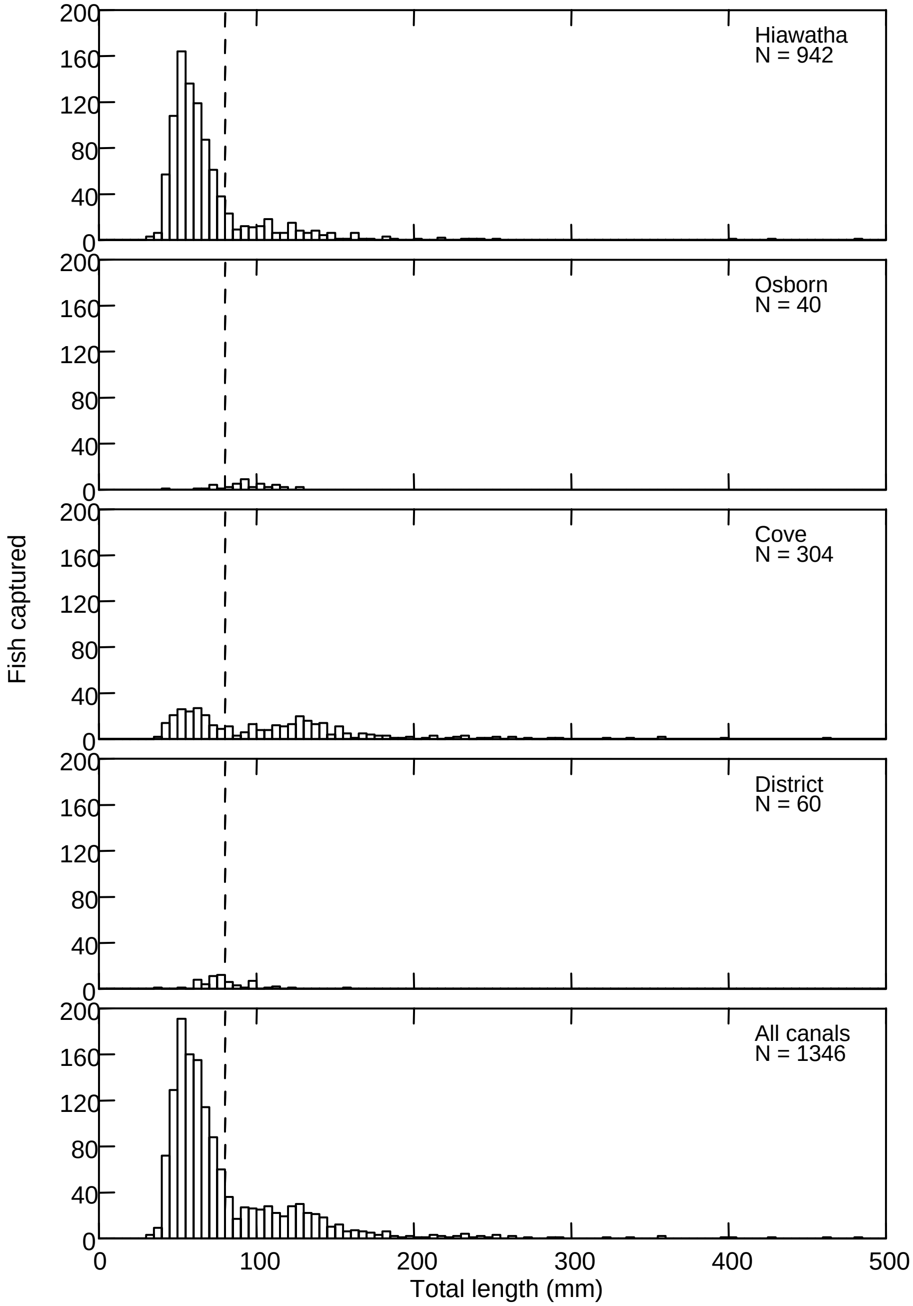
Appendix B. Trap characteristics for all canal traps in the Big Wood River and Silver Creek, Idaho during the 1998 irrigation season.

			Weir					Fyke Net			Trap Box	
River	Canal	Trap Type	No. of Traps	No. of Panels	Panel Length (m)	Picket Gap (cm)	Mesh on Weir (Y/N)	Frame Dimensions (m) (WxH)	Depth of Net (m)	Mesh Size (mm)	Trap Box Dimensions (m) (LxWxH)	Mesh Size on Trap Box (mm)
Big Wood	Hiawatha	Weir	1	4	3.7	1.6	N	—	—	—	1.2 x 0.9 x 0.6	6.4
		Fyke Net	2	—	—	—	—	1.2 x 1.2	3.7	6.4	1.2 x 0.9 x 0.6	6.4
	Osborn	Weir	1	1	3.0	1.3	Y (6.4 mm)	—	—	—	0.8 x 0.6 x 0.6	6.4
	District	Fyke Net	3	—	—	—	—	1.2 x 1.2	3.7	6.4	1.2 x 0.9 x 0.6	6.4
	Cove	Weir	1	2	3.0	1.3	N	—	—	—	0.9 x 0.6 x 0.6	6.4
		Fyke Net	1	—	—	—	—	1.2 x 1.2	3.7	6.4	0.9 x 0.6 x 0.6	6.4
Silver Creek	Iden	Weir	1	3	3.0	1.3	N	—	—	—	1.2 x 0.9 x 0.6	6.4

Appendix C. Trap configuration within some BWR canals. The placements of fyke nets in relation to picket weir are not drawn to scale.



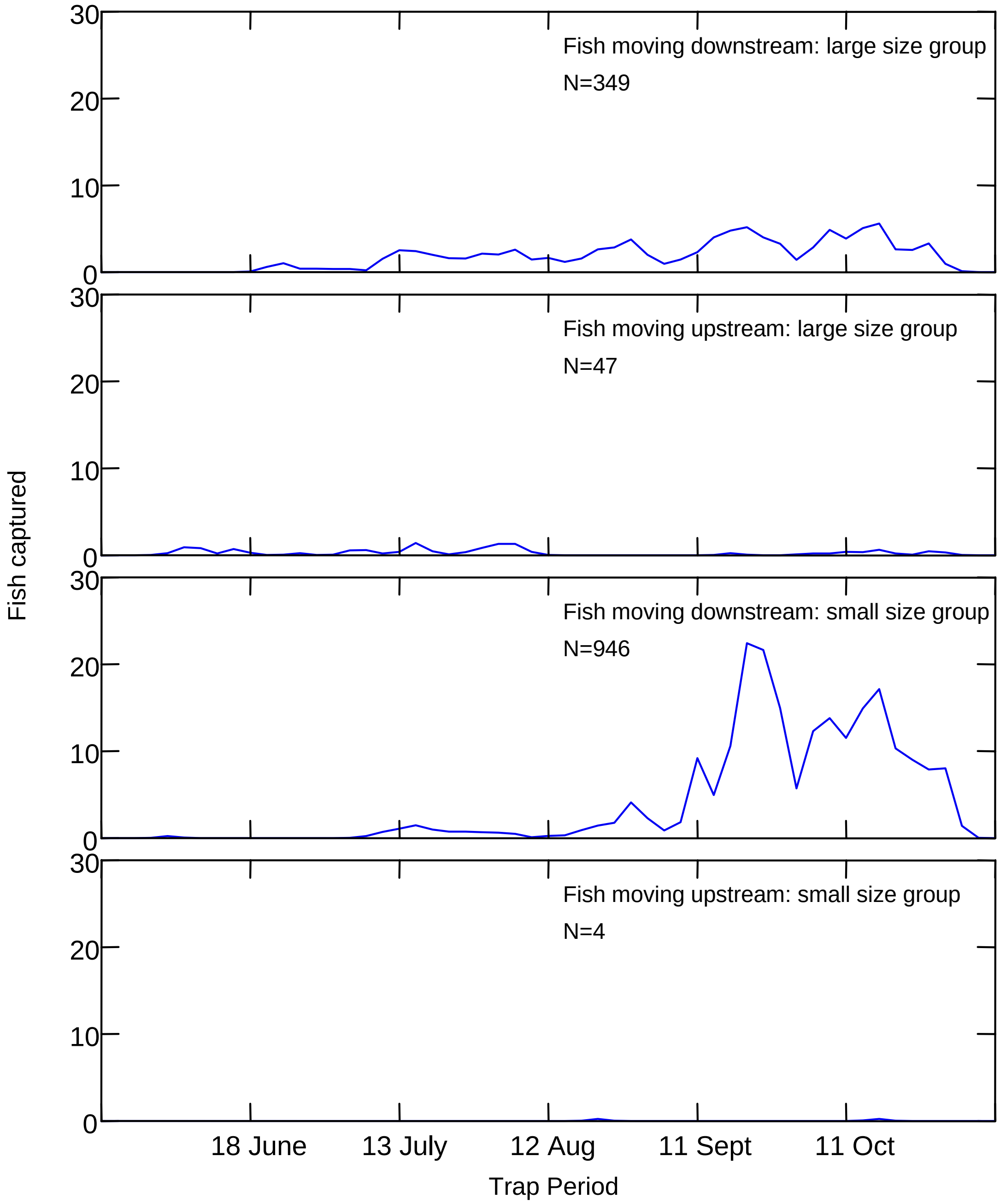
Appendix D. Length frequency (5 mm bins) of rainbow trout trapped in BWR, Idaho canals during the 1998 irrigation season. Dashed line divides distribution into small (<80 mm TL) and large (≥80 mm TL) size groups.



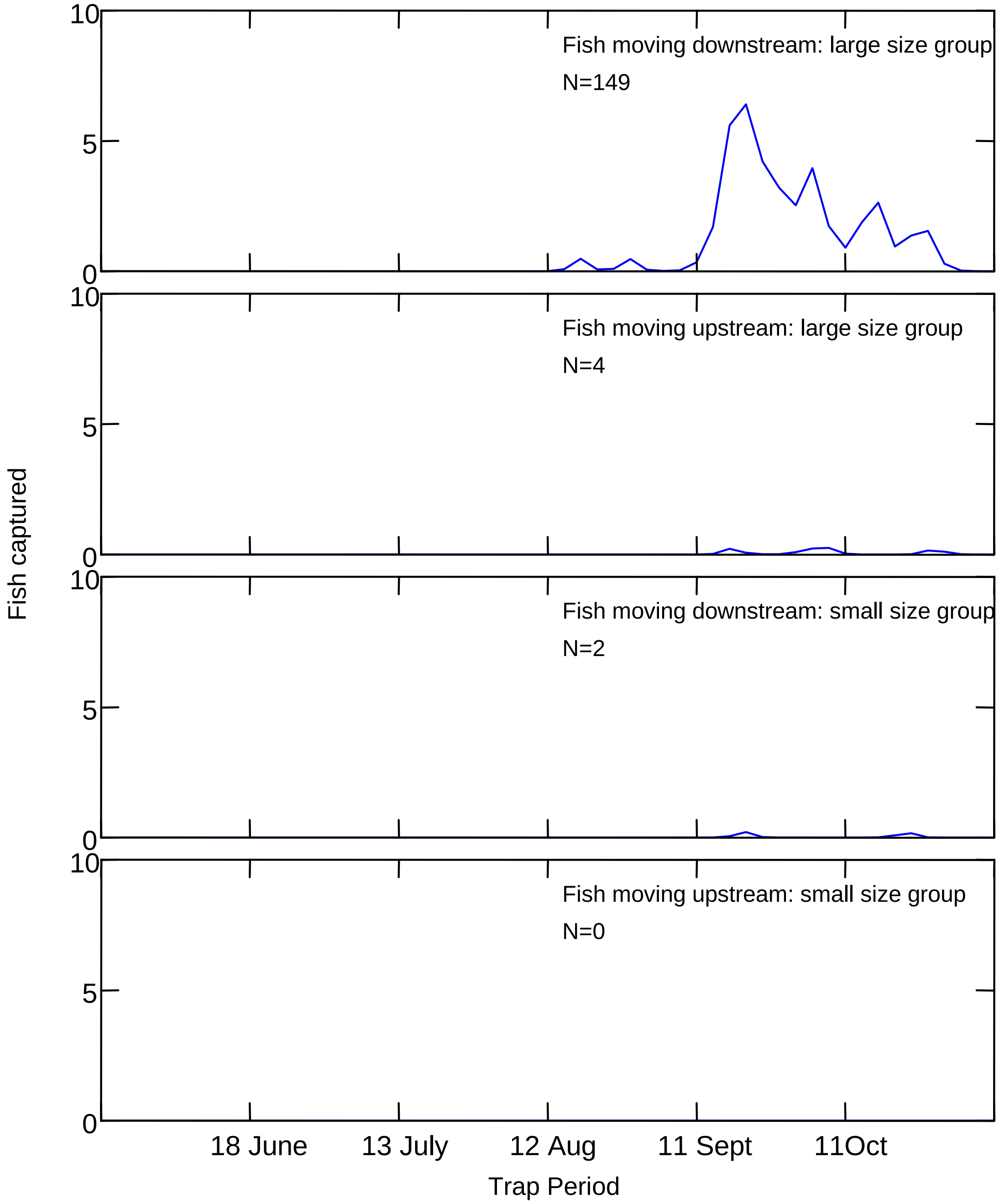
Appendix E. Average length (TL) of fish captured in Big Wood River canals, Idaho by species, size group, and movement direction during the 1998 irrigation season.

			TL ≥ 80 mm				TL < 80 mm			
Species	Fish movement	Canal	n	Range	Mean	SD	n	Range	Mean	SD
Rainbow trout	Downstream	Hiawatha	160	80-482	124	54	778	33-79	57	10
		Osborn	11	80-129	99	12	6	40-75	67	11
		District	22	80-462	144	57	38	37-79	58	10
		Cove	156	80-395	134	42	124	33-79	68	8
		Total	**349**				**946**			
	Upstream	Hiawatha	3	120-241	182	61	1	40	- na -	- na -
		Osborn	21	80-126	99	12	2	73-75	71	1
		District	0	- na -	- na -	- na -	0	- na -	- na -	- na -
		Cove	23	98-271	192	53	1	72	- na -	- na -
		Total	**47**				**4**			
Brook Trout	Downstream	Hiawatha	1	105	- na -	- na -	0	- na -	- na -	- na -
		Osborn	0	- na -	- na -	- na -	0	- na -	- na -	- na -
		District	0	- na -	- na -	- na -	0	- na -	- na -	- na -
		Cove	148	82-320	120	40	2	77-78	78	1
		Total	**149**				**2**			
	Upstream	Hiawatha	0	- na -	- na -	- na -	0	- na -	- na -	- na -
		Osborn	0	- na -	- na -	- na -	0	- na -	- na -	- na -
		District	0	- na -	- na -	- na -	0	- na -	- na -	- na -
		Cove	4	119-297	168	86	0	- na -	- na -	- na -
		Total	**4**				**0**			
Mountain Whitefish	Downstream	Hiawatha	2	114-129	122	11	1	58	- na -	- na -
		Osborn	1	81	- na -	- na -	0	- na -	- na -	- na -
		District	0	- na -	- na -	- na -	0	- na -	- na -	- na -
		Cove	6	95-135	110	15	0	- na -	- na -	- na -
		Total	**9**				**1**			
	Upstream	Hiawatha	0	- na -	- na -	- na -	0	- na -	- na -	- na -
		Osborn	0	- na -	- na -	- na -	2	62-65	63	2
		District	0	- na -	- na -	- na -	0	- na -	- na -	- na -
		Cove	0	- na -	- na -	- na -	0	- na -	- na -	- na -
		Total	**0**				**2**			

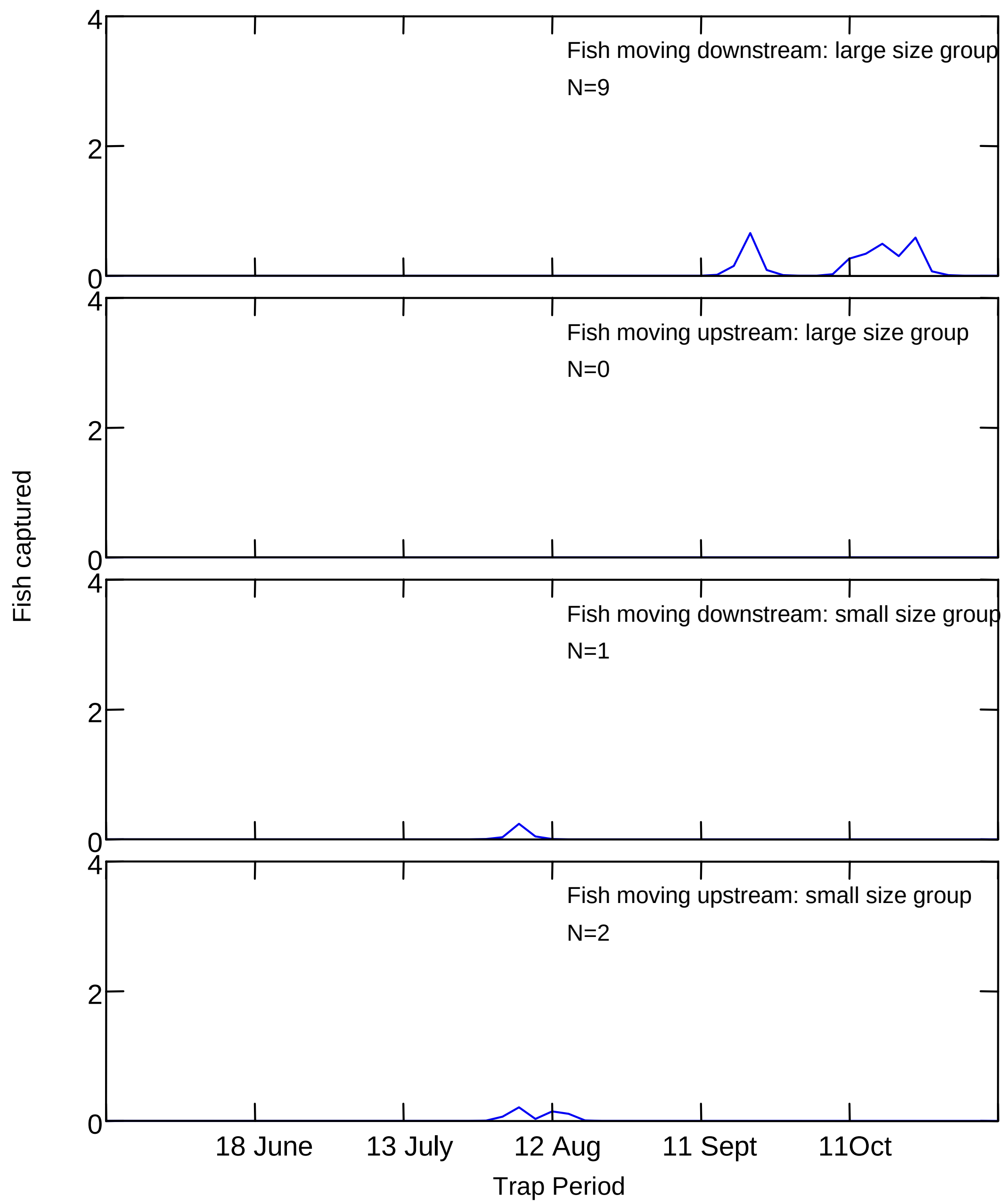
Appendix F. Trap catch of rainbow trout in Big Wood River canals, Idaho by size group and movement direction during the 1998 irrigation season. Large size group represents fish ≥80 mm and small size group represents fish <80 mm.



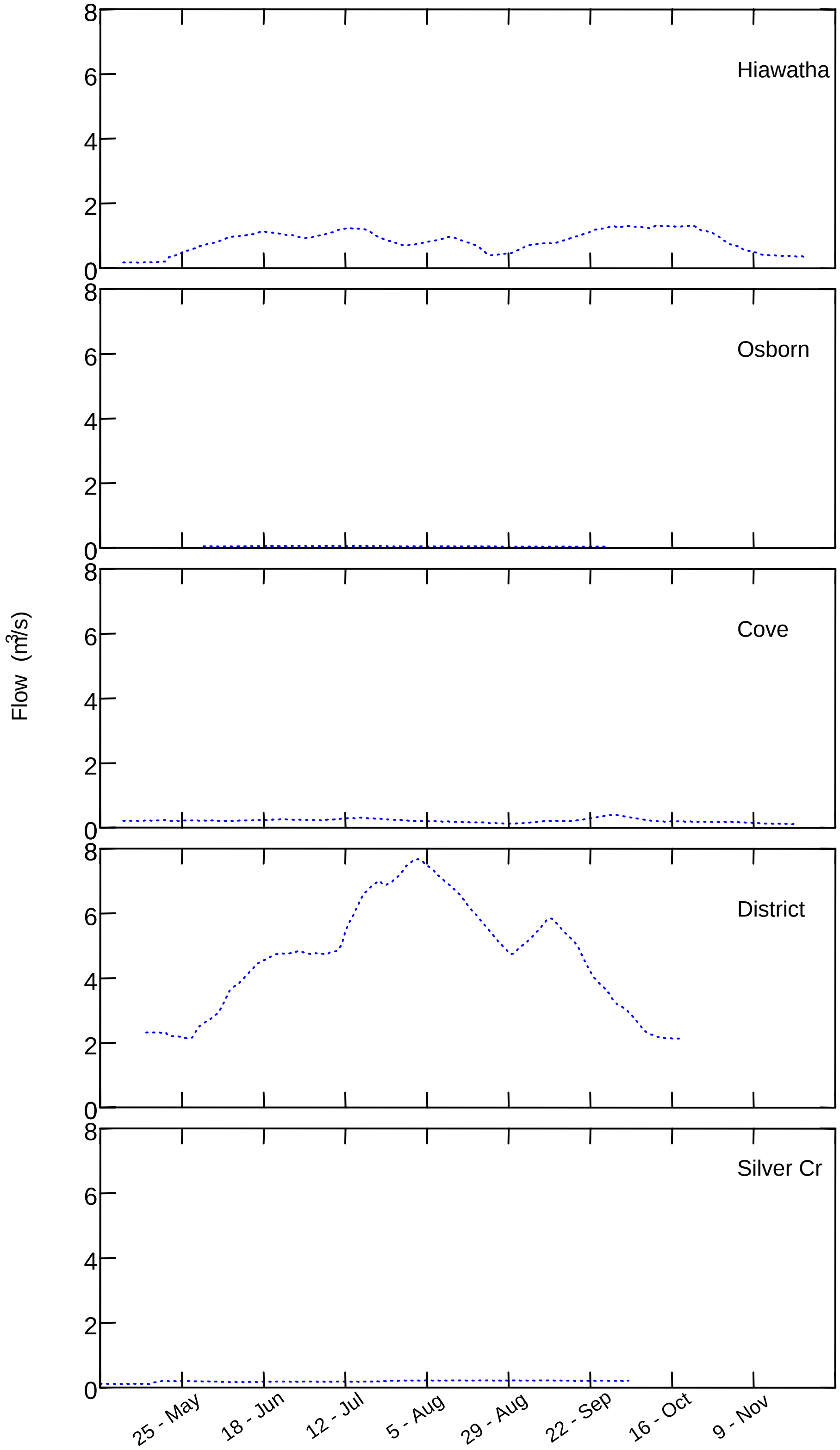
Appendix G. Trap catch of brook trout in Big Wood River canals, Idaho by size group and movement direction during the 1998 irrigation season. Large size group represents fish ≥80 mm and small size group represents fish <80 mm.



Appendix H. Trap catch of mountain whitefish in Big Wood River canals, Idaho by size group and movement direction during the 1998 irrigation season. Large size group represents fish ≥80 mm and small size group represents fish <80 mm.



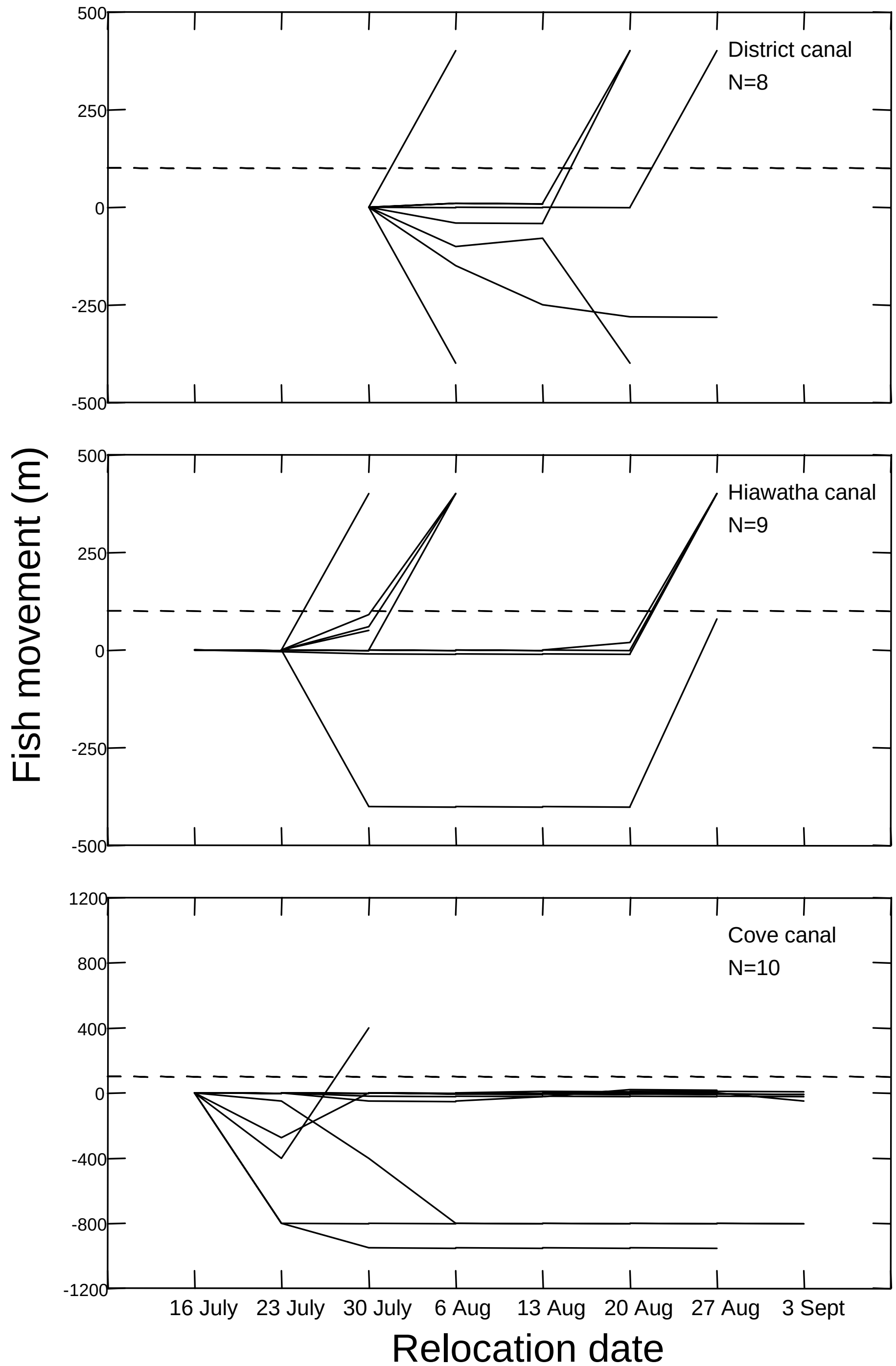
Appendix I. Big Wood River, Idaho canal flows during the 1998 irrigation sampling period.



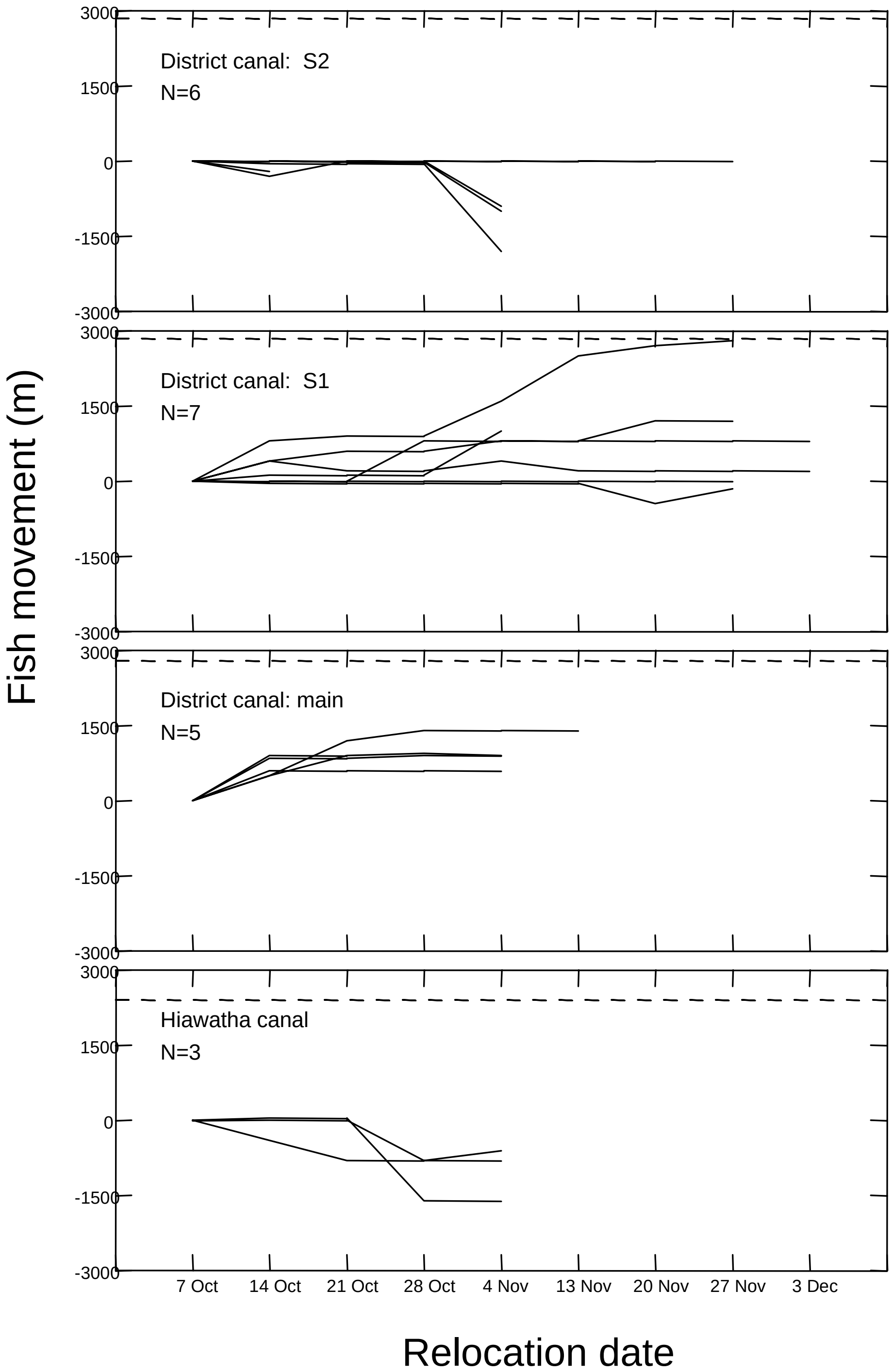
Appendix J. Radio telemetry data including fish, tag, and release site characteristics.

			Fish			Tag		
Telemetry launch date	Canal	Release site	Species	TL (mm)	Weight (g)	Tag Frequency	Submerged weight (g)	Tag weight / fish weight %
24-30 July	Hiawatha	M	Rbt	258	160	151.764	1.79	0.01
		M	Rbt	212	90	151.703	1.79	0.02
		M	Rbt	205	80	151.583	1.79	0.02
		M	Rbt	230	120	151.483	1.79	0.01
		M	Rbt	220	100	151.401	1.79	0.02
		M	Rbt	198	70	151.793	1.79	0.03
		M	Rbt	205	80	151.564	1.79	0.02
		M	Rbt	241	140	151.542	1.79	0.01
		M	Rbt	156	40	151.504	1.79	0.04
		M	Rbt	355	450	151.523	1.79	0.00
16-17 July	Cove	M	Rbt	150	30	151.605	1.79	0.06
		M	Rbt	235	130	151.463	1.79	0.01
		M	Rbt	150	30	151.425	1.79	0.06
		M	Rbt	240	150	151.643	1.79	0.01
		M	Rbt	238	140	151.744	1.79	0.01
		M	Rbt	196	80	151.725	1.79	0.02
		M	Rbt	167	40	151.683	1.79	0.04
		M	Rbt	212	110	151.663	1.79	0.02
		M	Rbt	195	85	151.744	1.79	0.02
		M	Rbt	260	185	151.623	1.79	0.01
8-10 Oct.	District	S1	Rbt	207	100	151.324	1.79	0.02
		S1	Rbt	214	120	151.363	1.79	0.01
		S1	Rbt	226	140	151.852	1.79	0.01
		S1	Rbt	229	130	151.892	1.79	0.01
		S1	Rbt	273	220	151.914	1.79	0.01
		S1	Rbt	198	90	151.383	1.79	0.02
		S1	Rbt	241	150	151.833	1.79	0.01
		S2	Rbt	214	120	150.022	1.25	0.01
		S2	Rbt	199	90	150.154	1.25	0.01
		S2	Rbt	228	150	150.431	1.25	0.01
		S2	Rbt	241	180	150.682	1.25	0.01
		S2	Rbt	208	100	150.982	1.25	0.01
		M	Rbt	185	80	150.052	1.25	0.02
		M	Rbt	211	110	150.083	1.25	0.01
		M	Rbt	198	80	150.114	1.25	0.02
		M	Rbt	194	85	150.541	1.25	0.01
		M	Rbt	201	90	150.621	1.25	0.01
8-10 Oct.	Hiawatha	M	Rbt	362	390	151.443	1.79	0.00
		M	Rbt	298	270	151.813	2.95	0.01
		M	Rbt	298	250	151.343	1.79	0.01

Appendix K. Movement of radio-tagged rainbow trout in District, Hiawatha, and Cove canals from July through September 1998. Positive values indicate upstream movement, and negative values indicate downstream movement. The dashed line represents the canal headgate.



Appendix L. Movement of radio-tagged rainbow trout in District and Hiawatha canals from October through December 1998. Positive values indicate upstream movement, and negative values indicate downstream movement. The dashed line represents the canal headgate.



ANNUAL PERFORMANCE REPORT
SUBPROJECT #2: HENRYS LAKE TRIBUTARIES CANAL INVESTIGATIONS

State of: Idaho

Grant No.: F-73-R-21, Fishery Research

Project No.: 7

Title: Irrigation Diversion Fish Loss Reduction

Subproject #2: Henrys Lake Tributaries Canal Investigations

Contract Period: July 1, 1998 to June 30, 1999

ABSTRACT

Four irrigation canals were trapped on Targhee Creek and Duck Creek to estimate season-long salmonid exploitation rates. The canal exploitation rate is defined as the proportion (%) of a fish population that is intercepted by an irrigation canal. All canals were screened with paddle-wheel-driven fish screens. Fish were captured in box traps attached to diversion screen bypass pipes. The traps captured from 24 to 3,564 young-of-year (YOY) Yellowstone cutthroat trout *O. clarki bouvieri* and some adult brook trout. One canal on Duck Creek exploited an estimated 17.9% of YOY Yellowstone cutthroat trout that were migrating to Henrys Lake. Low recapture rates precluded canal exploitation estimates for the remaining Duck Creek and Targhee Creek canals. Most trout were captured in July and early August. More trout were diverted into a canal with a headgate located on the outside bend of the creek than on the inside bend in Duck Creek.

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INTRODUCTION

Idaho fishery managers have long suspected that significant numbers of resident salmonids are lost to irrigation diversions. However, there are little quantitative data available to assess the impacts of those losses on stream populations or to determine whether a widespread problem exists (Der Hovanisian 1997). Hundreds of Idaho streams are diverted for agricultural purposes statewide, and such diversions may affect trout populations in adjacent stream reaches. Canals in Idaho divert water at rates ranging from <1 m^3/s to 126 m^3/s. Although the majority of diversions in the Salmon River drainage and a few diversions in southeastern Idaho are screened to protect against fish loss, most irrigation diversions in the state are not.

The goal of this research project is to determine under what circumstances and to what degree sport-fishing opportunities could be enhanced by minimizing losses of resident salmonids to irrigation diversions. This report will evaluate the impact of these losses on the related fishery by estimating fish lost to a variety of canals. If exploitation by irrigation diversions is shown to be high, then I will classify diversions by canal characteristics associated with the highest exploitation rates and identify potential problem canals.

This was the fourth year of a five-year study. Field operations during 1998 focused on estimating trout exploitation rates for canals on the Big Wood River, Silver Creek, and Targhee and Duck creeks (tributaries of Henrys Lake). The Big Wood River and Silver Creek canals provided the opportunity to investigate fish loss to canals from nonmigratory resident fish populations. Targhee and Duck Creek canals, all of which are screened, offered an opportunity to investigate canal diversion impacts on young-of-year (YOY) production from an adfluvial Yellowstone cutthroat trout population.

The existing irrigation canal screens and bypass pipes on Duck and Targhee creeks provided an opportunity to examine the potential impact of irrigation withdrawals on recruitment of YOY Yellowstone cutthroat trout to Henrys Lake. The screened canals were trapped to make estimates of the proportion of fish that would have been lost had the diversions not been installed. The exploitation estimates and canal characteristic data will be added to the past irrigation diversion database (Der Hovanisian 1997). The emphasis of this project was to estimate canal exploitation over a variety of situations (e.g. impacted fishery, canal characteristics, stream type) and develop a sense of what canal type would present the greatest problem to the related fishery.

RESEARCH GOAL

To determine under what circumstances and to what degree minimizing losses of resident salmonids to irrigation diversions could enhance sport-fishing opportunities.

OBJECTIVES

1. To assess the population effects of resident salmonid losses to irrigation diversions.

Tasks

1. To estimate exploitation of trout by irrigation diversions on Duck and Targhee creeks during the 1998 irrigation season.

DESCRIPTION OF STUDY AREA

Duck and Targhee creeks are spawning tributaries for adfluvial Yellowstone cutthroat trout *Oncorhynchus clarki bouvieri* in Henrys Lake. Targhee and Duck creeks are relatively small mountain streams that drain into Henrys Lake. Low summer flows may limit resident salmonid populations in Targhee and Duck creeks, but both cutthroat and brook trout are common. The screened canals trapped on Duck and Targhee creeks are located within 2 km of Henrys Lake (Figure 3). Two of the three existing canals on Targhee Creek were trapped, as well as two of the four existing canals on Duck Creek. Canal characteristics are described in Appendix M.

METHODS

Trap Period

The headgates in Duck and Targhee creek canals were not opened until late June. The irrigation canals were operated intermittently based on water demands (Table 3). The canal headgates were closed at times when the adjacent streams were flooding into the canals; however, the box traps were still in operation during these flood periods because trout were entering the canals with the floodwater. Trapping occurred from July to August when most emerging YOY Yellowstone cutthroat trout were moving into Henrys Lake (Rohrer 1980).

Fish Traps

Box traps placed on the terminal end of the bypass return pipe captured trout that entered the canal and were diverted by the fish screen (Der Hovanisian and Megargle 1998). Fish exiting the bypass pipes passed through a 3 m to 5 m section of six-inch flexible PVC pipe into trap boxes. Most fish screens were located 10 m to 50 m downstream from the canal from the headgate. Specific trap box dimensions are described in Appendix N.

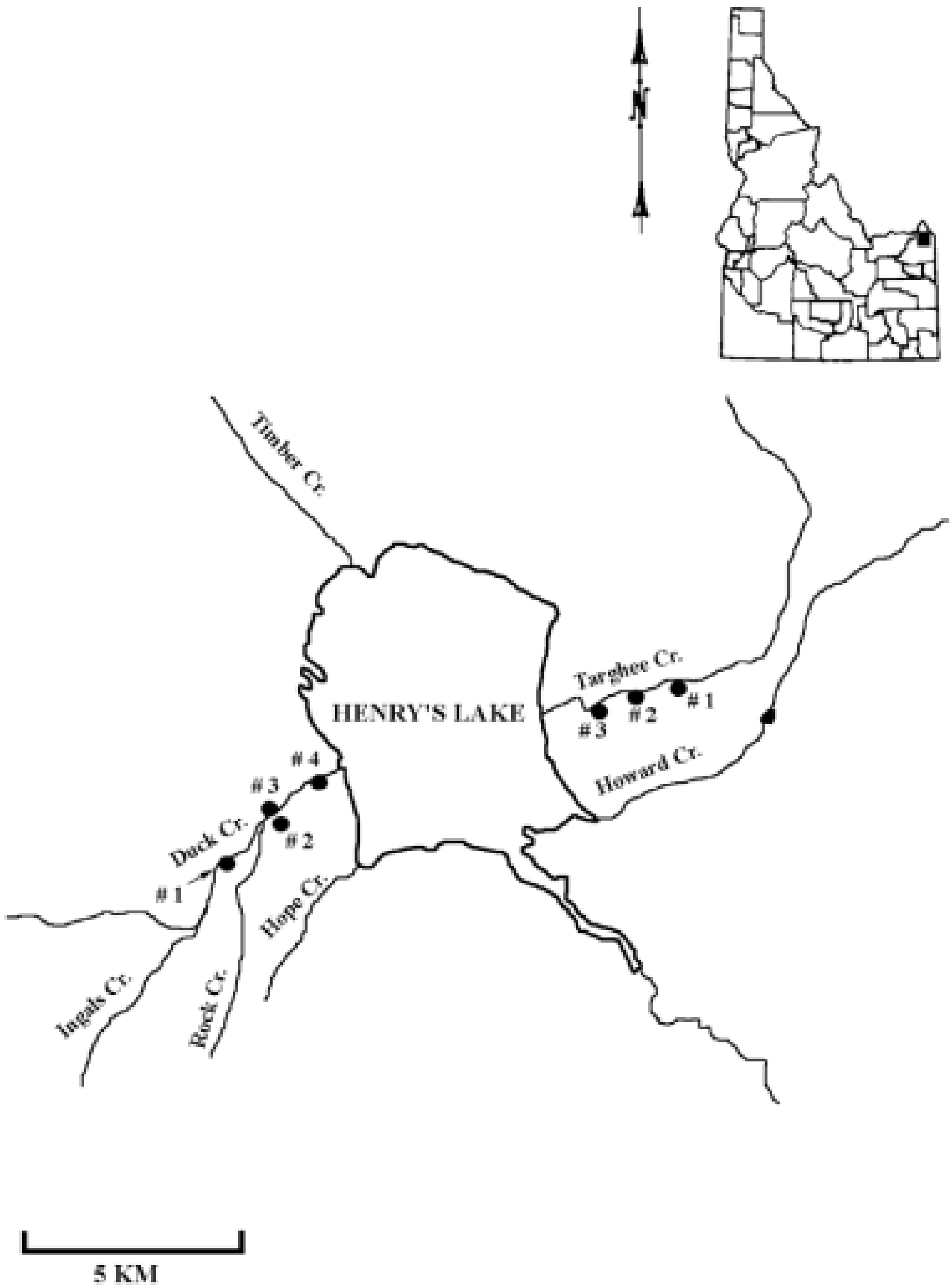

Figure 3. Henrys Lake study area, including the canal headgate locations on Duck and Targhee creeks.

Table 3. Trapping and canal operation periods for study canals on the Big Wood River and Silver Creek, Idaho during the 1998 irrigation season.

				Trap period							
River	Canal	Trap type	No. of traps	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Targhee	Canal #1	Canal operation				|xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx|					
		Diversion box	1			|---|					
	Canal #3	Canal operation				|xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx|					
		Diversion box	1			|--|					
Duck Creek	Canal #2	Canal operation				|xxxxxxxxxxxxxxxxxxxxxxxxxxxxxx|					
		Diversion box	1			|-------------------------|					
	Canal #3	Canal operation				|xxxxxxxxxxxxxxxxxxx|					
		Diversion box	1			|--------------------------|					

Trap Catch

Trapped trout were counted, marked, and released following capture. The trout were netted from the box trap, counted, and held in live wells until 100 fish were available for staining. Bismark Brown Y biological stain was used to dye-mark the YOY Yellowstone cutthroat trout. The YOY trout were immersed in a solution of 0.05 g stain per liter of water for 30 min. The brown-stained trout were held overnight to reduce the post-mark mortality effect on my trap efficiency estimates. The stained fish were either released in the canals to estimate trap efficiencies or released in the stream (100 m upstream) to estimate exploitation.

Trap Efficiency and Canal Exploitation

Trap efficiencies and exploitation rates were determined using the technique described in Der Hovanisian and Megargle (1998). However, insufficient sample sizes and intermittent use of the canals precluded efficiency and exploitation estimates in three of the four canals. Only one efficiency effort estimate was successfully completed during the 1998 irrigation season; that estimate was applied to the entire trapping period within that canal.

Trap efficiency and exploitation rate estimates efforts could not be made simultaneously. Trout were dyed using Bismark Brown Y biological stain. This marking method did not allow for unique tagging, and a batch of marked fish released for one estimate (efficiency or exploitation) could have mixed with a separate batch and biased the effort. Therefore, efficiency and exploitation mark-recapture efforts were alternated to prevent mixing of marked groups. No new batches of marked trout were released until two consecutive days passed without recaptures from the previous effort.

Bismark Brown dye was used to mark YOY Yellowstone cutthroat trout. Batches of at least 100 trout were soaked for approximately 30 min in the dye solution (0.05 g of stain per liter of water). The marked trout were held overnight to allow for mortality. The stained trout were released in the canals to estimate trap efficiency or released in the creek to estimate exploitation.

RESULTS

Yellowstone cutthroat trout were the predominant salmonid captured in Targhee and Duck Creek canals. A few adult brook and cutthroat trout were captured, but they made up an insignificant portion of the catch and were not reported in this study.

The majority of the trout were captured from mid-July to late August (Appendix O). The timing of peak trap rates coincided with past studies (Rohrer 1980). Very few fish were captured in September.

The total trap catch varied among canals. The total catches of YOY Yellowstone cutthroat trout varied among canals and ranged from 24 to 3,564 fish. More trout were captured in Duck Creek canals than in Targhee Creek canals. The bypass traps in Targhee Creek captured relatively few fish, many of which were found dead (17-30 %) (Table 4). The reason for the mortality was not determined.

A trap efficiency estimate was determined in one of the four canals trapped. The trap efficiency in Duck Creek #2 was 0.362. Trap mortality combined with low capture rates precluded efforts to estimate trap efficiencies in Duck Creek #3, Targhee Creek #1, and Targhee Creek #3 canal traps (Table 4).

An exploitation rate of 0.179 (SE=0.047) was estimated for Duck Creek Canal #2. A total of 189 marked YOY were released, and 12 were recovered. The actual number of fish recovered (n=12) was expanded using the trap efficiency resulting in an adjusted recapture of 34 trout.

Paired canals (canals #2 and #3) on Duck Creek diverted the YOY at different rates. Although both canals were located directly opposite each other, nearly 10 times as many YOY were trapped in Canal #2 (3,564 fish) than in Canal #3 (379 fish) (Table 4). Canal #2 was located on the outside bend of the creek and Canal #3 was located on the inside of the creek bend.

Table 4. Fish trapped, efficiency estimates, and exploitation estimates of Yellowstone cutthroat trout YOY trapped in Targhee and Duck Creek, Idaho canals during the 1998 irrigation season.

		Trapped fish			Efficiencies			Exploitation					
Trap period	Canal	Live	Morts	Total	Marked canal releases (D)	Recap. canal releases (d)	Canal trap efficiency	Marked steam releases (M)	Recap. stream releases (n)	Expand. recap. (N^)	SE [N^]	Exploit. rate [N^/M]	Exploit. SE [N^/M]
07/01-09/09	Duck #2	3190	374	3564	94	34	0.362	189	12	34	8.9	0.179	0.047
07/01-08/27	Duck #3	378	1	379	0	0	- na -	- na -	0	- na -	- na -	- na -	- na -
07/02-09/30	Targhee #1	6	18	24	0	0	- na -	- na -	0	- na -	- na -	- na -	- na -
07/02-10/02	Targhee #2	33	184	217	0	0	- na -	- na -	0	- na -	- na -	- na -	- na -

DISCUSSION

The trap catch varied among the canals. Very few fish were captured in the Targhee Creek canals compared to Duck Creek canals. There were more problems trapping fish in the Targhee box traps than in Duck Creek. In Targhee Creek, the box traps were prone to overflow due to debris blocking the screen outflows. However, I would have expected to see more fish in the traps if they were being diverted through the bypass pipe. It is possible that the rotary drum screens on the Targhee canals were less efficient and fish were moving into the canals instead of being diverted through the bypass pipe, but no trap efficiency estimate was determined to confirm this inference. Targhee Creek may provide less recruitment to Henrys Lake than Duck Creek.

I was unable to estimate the trap efficiency in three of four canals. The low catch rates made it difficult to accumulate enough trout (n $\geq$100) to estimate trap efficiencies. It often took up to three days to catch enough fish to mark and release, and the YOY did not survive in the live wells for that long a period of time. In addition, the intermittent use of the canals complicated the trapping effort. Trap efficiency estimates could not be completed quickly enough to stratify the efficiency by canal flows.

The trap efficiency of 0.362 was estimated for the trap on Duck Creek Canal #2. This trap efficiency represents the combined efficiency of both the box trap and the diversion screen. Several factors may have led to this low trap efficiency. Some of the marked and released trout may have died before reaching the diversion. Additionally, the canal headgates were sometimes closed during the mark-recapture efforts. The trout were likely vulnerable to predation and mortality due to habitat loss. Most importantly, YOY were seen in the canal below the fish screen. The rotating drum screens were not diverting a portion of the migrating YOY Yellowstone cutthroat trout. Additionally, it is possible that fish escaped from the trap box. If the trap efficiencies were indeed negatively biased, then the exploitation rate would be positively biased (inflated).

The exploitation rate (0.179) of Duck Creek Canal #2 supports the value of the fish screens currently in place. The potential compounding impact of the three other canals on the creek would be of concern if no screens were present. The Duck Creek Canal #3 trap caught very few trout, which suggests the exploitation rate was considerably lower than that of Canal #2.

Duck Creek canals #2 and #3 were both associated with the same diversion dam, yet substantially more fish entered Canal #2 than Canal #3. Both diversions were similar in size and headgate structure but differed in their association to the river channel. Canal #2 was located on the outside bend of the river, and Canal #3 was on the inside bend. This fact supports the observations that fish are more vulnerable to canals with headgates located on the outside bend of a river (Spindler 1955). Canals that withdraw water from the outside bend of a river should be considered first for new screen installations or repairs.

The impact of Duck and Targhee creek canals upon the Henrys Lake fish population is unclear. Currently, most canals are screened to maximize YOY Yellowstone cutthroat trout recruitment to Henrys Lake. Although they do divert most YOY back into the main river, there may be a problem with the efficiency of the current fish screens. Over the last 10 to 20 years, many changes have occurred on Henrys Lake which include: 1) variation in lake water levels; 2) changes in department management; 3) installation of fish screens on the tributaries, and

4) fencing of riparian zones associated with spawning tributaries. The specific effect these changes had on the Henrys Lake fish population is unknown. Therefore, it is unclear whether the screens themselves had a noticeable effect on the wild trout production within the lake.

MANAGEMENT RECOMMENDATIONS

1. Further work should be done to evaluate the current fish screens in Duck and Targhee creeks; they should be repaired or improved to maximize their efficiencies.

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APPENDICES

Appendix M. Physical characteristics of canals on Targhee Creek and Duck Creek, Idaho, during the 1998 irrigation season.[a]

Diversion	River Dewatered	Headgate Location/ Kind	Diversion Dam	Drop Structure (m)	Relation To River	Decreed (m^3/s)	Velocity (m/s)	Gradient (%)	Width (m)	Depth (m)	Canal Angle
Targhee Creek											
Canal #1	N	River/vert	Y	N	Straight	—[b]	0.7	-0.5	2.6	0.35	43
Canal #2	N	River/vert	Y	N	Outside bend	—[b]	0.2	-0.5	2.3	0.95	95
Canal #3	N	River/vert	Y	N	Straight	—[b]	0.2	-1.0	1.9	0.63	84
Duck Creek											
Canal #1	N	River/vert	Y	N	Straight	—[b]	0.5	-1.0	1.1	0.13	50
Canal #2	N	River/vert	Y	N	Outside bend	—[b]	0.4	-1.0	1.1	0.27	78
Canal #3	N	River/vert	Y	N	Inside bend	—[b]	0.5	-1.0	1.8	0.15	49
Canal #4	N	River/vert	Y	N	Straight	—[b]	0.4	-1.0	1.5	0.18	45

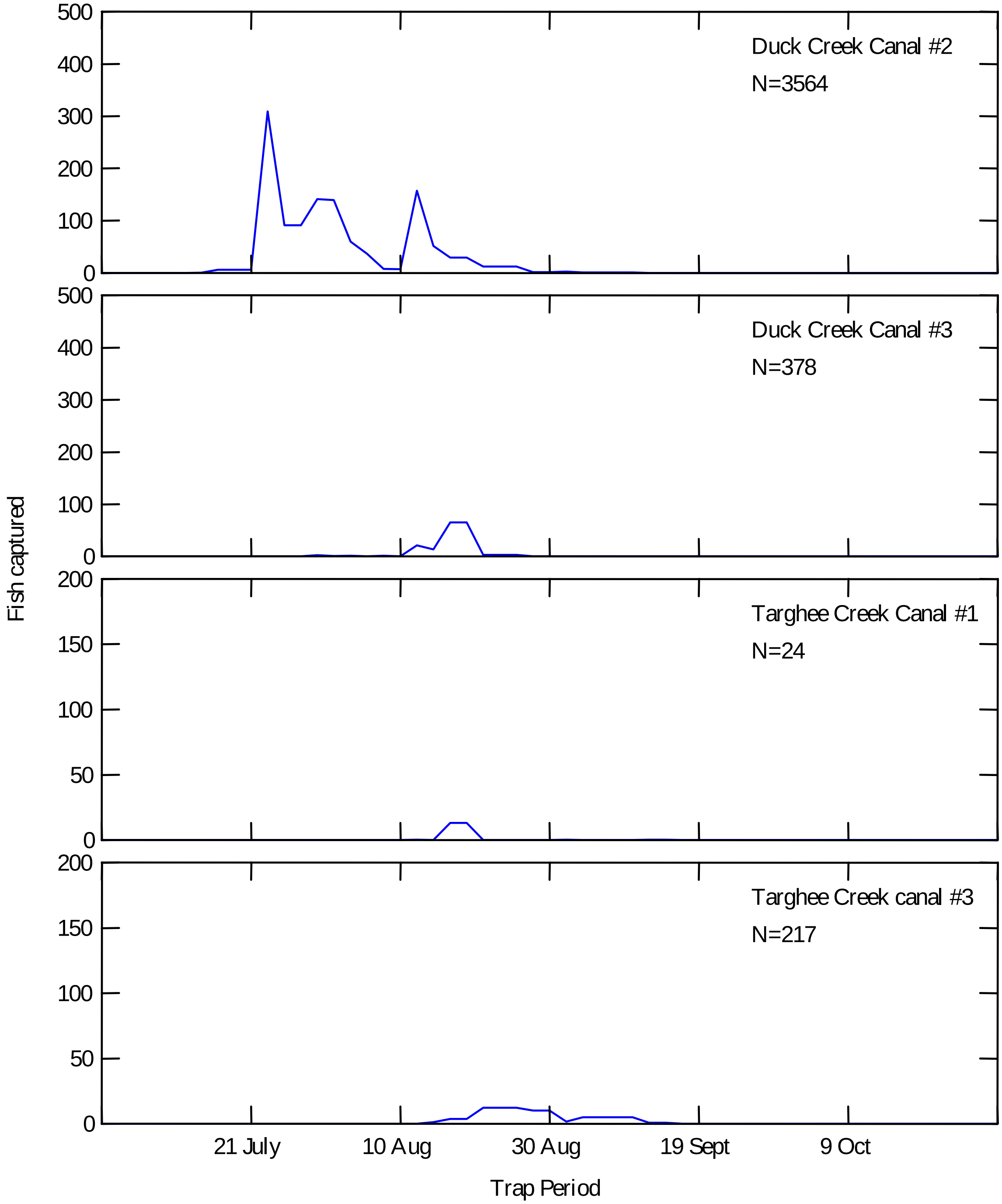
[a] See Der Hovanisian 1997 for methods and definitions.
[b] No data available: water right information obtained from Idaho Department of Water Resources, Idaho Falls, Idaho.

Appendix N. Trap characteristics for all canal traps in Targhee Creek and Duck Creek, Idaho during the 1998 irrigation season.

				Weir				Fyke Net			Trap Box	
River	Canal	Trap Type	No. of Traps	No. of Panels	Panel Length (m)	Picket Gap (cm)	Mesh on Weir (Y/N)	Frame Dimensions (m) (WxH)	Depth of Net (m)	Mesh Size (mm)	Trap Box Dimensions (m) (LxWxH)	Mesh Size on Trap Box (mm)
Targhee	Canal #1	Diversion Box	1	—	—	—	—	—	—	—	1.2 x 0.9 x 0.6	3.2
	Canal #3	Diversion Box	1	—	—	—	—	—	—	—	1.2 x 0.9 x 0.6	3.2
Duck Creek	Canal #2[a]	Diversion Box	1	—	—	—	—	—	—	—	1.2 x 0.9 x 0.6	3.2
	Canal #3	Diversion Box	1	—	—	—	—	—	—	—	1.2 x 0.9 x 0.6	3.2

[a] Trap box had all sides made of 6.4 mm mesh hardware cloth with 3.2 mm nylon mesh lined on the inside of the box

Appendix O. Trap catch of YOY Yellowstone cutthroat trout in Duck and Targhee creek canals, Idaho during the 1998 irrigation season.



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