YAKIMA RIVER RADIO-TELEMETRY STUDY: STEELHEAD, 1989-93

by

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INTRODUCTION

The Northwest Power Planning Council Master Plan for the Yakima/Klickitat Fisheries Project was developed in 1987 to test the assumptions that artificial production methods can be used to 1) increase harvest opportunities, 2) enhance the natural production of depleted stocks in the Yakima and Klickitat Basins through supplementation, and 3) maintain genetic resources (Clune and Dauble 1991). In addition, the plan proposed the development and implementation of a program to monitor the status and productivity of salmon and steelhead in the Yakima and Klickitat Basins.

As part of the presupplementation planning, baseline data were collected on adult steelhead (*Oncorhynchus mykiss*) passage at Prosser Dam and productivity of the stocks in Satus and Toppenish Creek Basins (Fast et al. 1989). However, data regarding habitat use, delays in adult passage at irrigation diversions, migration rates, substock separation, and productivity above the confluence of Toppenish Creek were not collected.

In 1989, the National Marine Fisheries Service (NMFS) began a 4-year radio-telemetry study of steelhead in the Yakima River Basin. Specific objectives of the study were to:

1) Determine the run timing, passage patterns at irrigation diversion dams, and morphometric characteristics of different Yakima Basin steelhead substocks and determine where and when the substocks become separated.

2) Evaluate adult steelhead passage at Yakima River Basin diversion dams including Prosser, Sunnyside, Wapato, Roza, Cowiche, and Wapatox Dams.
3) Determine steelhead migration behavior, temporal distribution, and habitat utilization in the Yakima River Basin.
4) Identify spawning distribution and timing of steelhead.
5) Determine the amount and cause of pre-spawning mortality of radio-tagged steelhead.

MATERIALS AND METHODS

Study Area

The Yakima River flows 349 km southeast from its headwaters in the Cascade Range (elevation 746 m) to its confluence with the Columbia River (elevation 91 m) near Richland, Washington, draining an area of 15,941 km^2 (Fig. 1). Its major tributaries include Satus Creek, Toppenish Creek, the Naches River, Taneum Creek, Swauk Creek, the Teanaway River and Cle Elum River.

Nine major diversion dams control water flow in the basin and provide irrigation to over 200,000 cultivated hectares. On the Yakima River, these dams are Horn Rapids (River Kilometer (RKm) 29), Prosser (RKm 75.8), Sunnyside (RKm 167.1), Wapato (RKm 171.6), Roza (RKm 205.9), Town Diversion (RKm 258.6), and Easton (RKm 326) Dams. The major diversion dams on the Naches River are Cowiche (RKm 5.8) and Wapatox (RKm 27.5) Dams. All of these dams are equipped with adult fish-passage facilities.

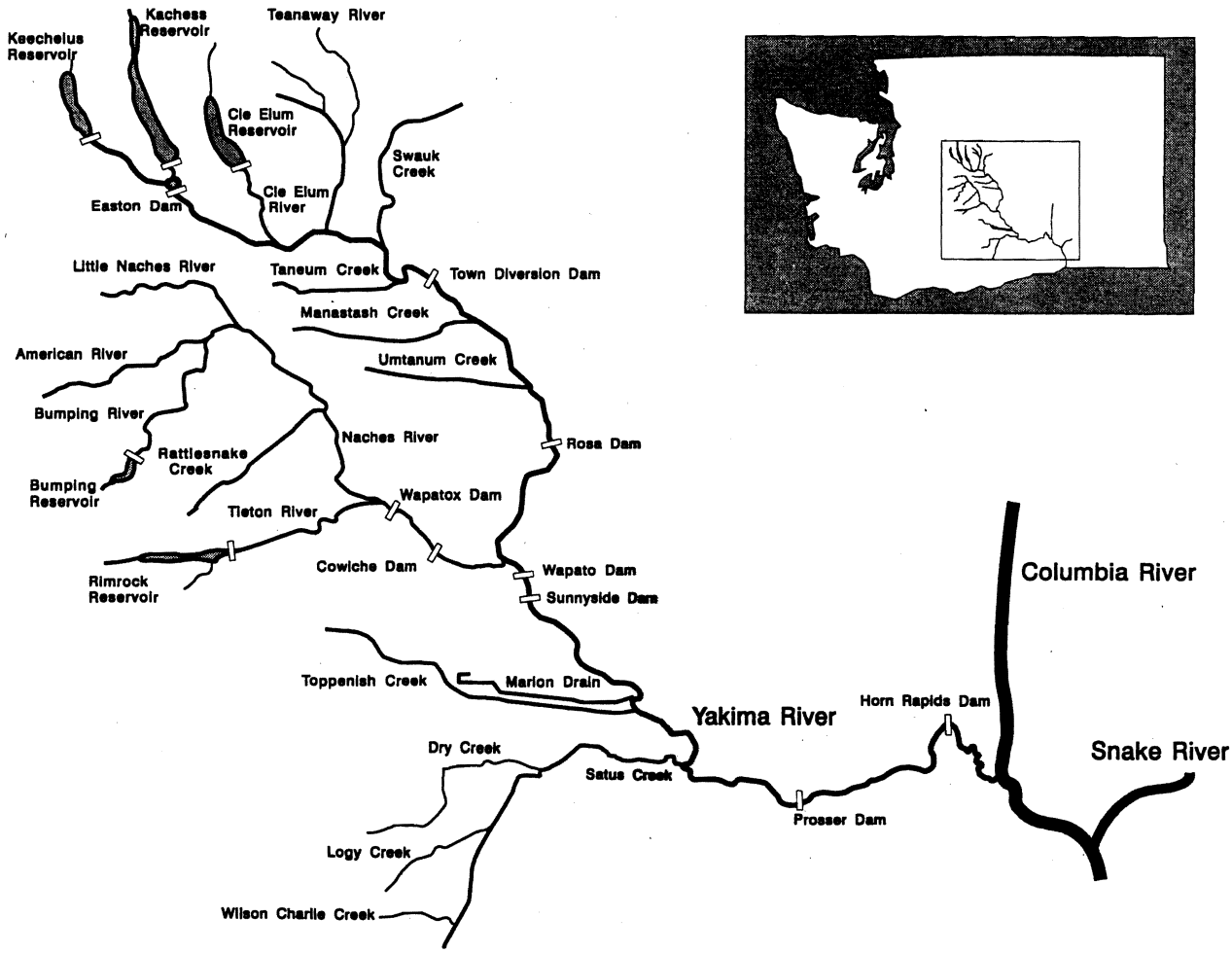


Figure 1. Study area of 1989-93 radio-telemetry studies.

In addition to the irrigation diversion dams, reservoirs on the Yakima, Cle Elum, Tieton, and Bumping Rivers regulate flows and store water during the winter to supplement irrigation from March through October. These reservoirs include Keechulus and Kachess on the Yakima River, Cle Elum on the Cle Elum River, and Rimrock and Bumping Reservoirs in the Naches River Basin. None of the dams associated with the reservoir system have adult fish-passage facilities. Johnson (1964) and Fast et al. (1989) provide additional descriptions of the Yakima River Basin.

Trapping and Tagging

Steelhead were collected and tagged at Prosser Dam by NMFS and Yakama Indian Nation (YIN) personnel from 1989 through 1992. Tagging procedures were developed and modified throughout the study. Fish were tagged and released in proportion to temporal abundance based on passage information from McNary and Prosser Dams. We collected steelhead by blocking upstream movement with a lead gate in the right-bank fish ladder at Prosser Dam. We inserted a steep-pass denil ladder into the pool below the lead gate. Fish ascended the denil ladder to a flume that then diverted them into an anesthestic tank containing a solution of tricaine methanesulfonate (MS-222).

After examination for marks, tags, or injuries, fish were weighed, measured, and scale samples were taken. Each fish was then placed in a tagging cradle, and a radio transmitter was inserted through its mouth and into its stomach (Mellas and Haynes 1985). To minimize tag regurgitation, we radio tagged only fish larger than 60-cm fork length. The entire tagging

procedure took 2-5 minutes per fish. Following tagging, fish were allowed to recover for up to 24 hours in a transport truck with circulating river water. During the recovery period, a receiver was used to monitor transmitters for frequency drift. After recovery, tagged fish during 1989 were released 0.5 km downstream from Prosser Dam and 0.2 km (Prosser, Washington) and 20.4 km upstream from Prosser Dam (Mabton-Sunnyside Bridge) to evaluate release-site locations on behavior. After 1989, all steelhead were released 0.5 km downstream from Prosser Dam due to a high incidence of fallback over Prosser Dam associated with releases made upstream from the dam. After recovering from anesthesia, non-target species and target species in poor condition or of insufficient size were released into the fish ladder upstream from the lead gate.

During spring 1990 and fall 1992, additional steelhead were collected and tagged in a trap at the exit of the Roza Dam fish ladder. Steelhead were also collected by Washington Department of Fish and Wildlife (WDFW) in spring 1993 by electrofishing the mainstem upper Yakima River and by trapping at weirs in Taneum and Swauk Creeks. Fish collected above Roza Dam were not collected in proportion to temporal abundance but were tagged in order to collect additional spawning information upstream from Roza Dam.

Ages were determined by WDFW personnel from radio-tagged steelhead scale samples.

Radio Tags

Radio tags were purchased from Advanced Telemetry Systems, Inc.[1]

Each tag was powered by one 3.7-V lithium battery and had a life span of at least 7 months.

The transmitter and battery were sealed in a 6.0-cm length x 1.6-cm diameter epoxy capsule and weighed 26 g in air. Each transmitter had a 12.0-cm flexible external whip antenna attached to one end. The tags transmitted on 1 of 9 frequencies spaced 10 Khz apart (30.17 MHz to 30.25 MHz). The bandwidth of each pulse provided individual identification codes for each tag. Each tag also contained a motion sensor which added extra pulses to the base rate when activated by movement.

Surveillance Equipment and Procedures

Two types of telemetry receivers were used for locating tagged fish during the study. Both types operated on 12-V DC and consisted of a radio receiver, data processor, internal clock, and data logger. Data loggers recorded month, day, hour, minute, tag code, and antennae number. The first type of receiver (Model SRX-400) was purchased from Lotek Engineering Inc., Newmarket, Ontario, Canada. These units were used in vehicles, boats, and as fixed-site monitors. The second type of receiver was developed and manufactured by NMFS electronics shop personnel and had a higher scanning rate than Lotek receivers (1.5 vs. 13.5

[1] Reference to trade names does not imply endorsement by National Marine Fisheries Service.

seconds). These units were used in vehicles, boats, airplanes, and as fixed-site monitors.

Self-contained fixed-site monitors were installed to record the presence and activities of radio-tagged fish in specific areas. Fixed-site monitors collected run-timing and passage information at irrigation diversion dams. A fixed-site monitor consisted of a receiver system, power supply, antenna switching box, and either a single antenna or a series of antennae. Fixed-site surveillance data were downloaded and processed at least once per week.

Two types of antennae were used. Underwater antennae were suspended in fish ladders and consisted of coaxial cable with 10 cm of shielding stripped from the distal end. Tuned-loop antennae were used to monitor fish in a general area or to monitor fish-passage by the combination of two antennae (one upstream and one downstream). Locations and antennae configuration for fixed-site telemetry monitors are presented by study year in Appendix Tables A.1-A.4.

Aerial surveillance of the Yakima River and its major tributaries was conducted once per week, weather permitting. Locations of radio-tagged individuals were determined from latitude and longitude coordinates provided by a global positioning system.

Mobile telemetry receivers were used once per week, and more frequently when personnel were available, to collect more precise information on fish locations. This information was used to develop data on habitat utilization and fish behavior. Activity

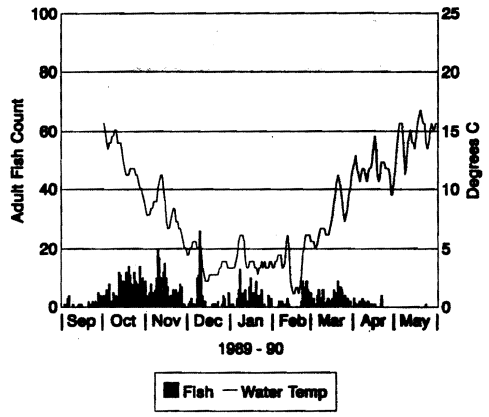
in the radio-tag motion switch and upstream movement were interpreted as indications of live fish. In addition, attempts were made to recover carcasses of stationary individuals.

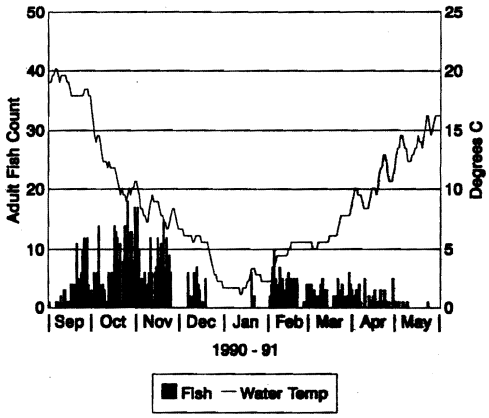
RESULTS

Spawning Population Segregation

Adult steelhead migrated into the Yakima River and passed Prosser Dam from September through April in all 3 years (Fig. 2). The Prosser Dam migration was bimodal, with peaks in the fall and spring. A total of 186 wild and 8 hatchery steelhead were radio tagged from the fall of 1989 through the spring of 1993 in the Yakima River Basin. Of the 194 tagged steelhead, 182 were collected at Prosser Dam. An additional three steelhead in spring 1990 and one steelhead in fall 1992 were collected in a trap at the exit of the Roza Dam fish ladder. In spring 1993, seven steelhead were collected from traps at tributary weirs or by electrofishing above Roza Dam. Fish collected at Roza Dam and upstream from Roza Dam were tagged to collect additional information on time of spawning and location in the upper Yakima River. Due to tag losses from regurgitation (27 fish), disappearances (27 fish), and mortality (26 fish), only 114 radio-tagged steelhead were followed through spawning.

Returning adult steelhead exhibited three behavioral phases similar to those described for Atlantic salmon (*Salmo salar*) by Baglinie're et al. (1991). These phases consisted of a migratory phase, a winter holding phase, and a spawning phase.





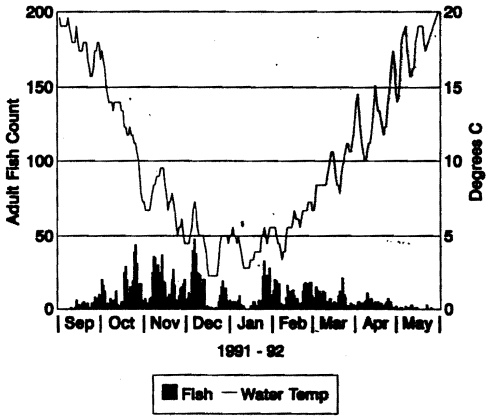


Figure 2. Steelhead adult counts and mean daily water temperature at Prosser Dam, 1989-92.

The following substocks or spawning populations of steelhead were identified in the Yakima River Basin: upper Yakima River above Ellensburg, Washington; Teanaway River; Swauk Creek; Taneum Creek; Roza Canyon section of the mainstem Yakima River; mainstem Yakima River between the Naches River confluence and Roza Dam; Bumping River; Little Naches River; Naches River; Rattlesnake Creek; Toppenish Creek; Marion Drain; and Satus Creek.

Although some sample sizes were small, passage data indicated that substocks were mixed and could not be segregated based on time of passage at Prosser, Sunnyside, Wapato, or Cowiche Dams (Figs. 3-6). In addition, spawning populations were not segregated on the basis of fish-ladder selection at Yakima River diversion dams with multiple fish ladders (Prosser, Sunnyside and Wapato Dams) (Figs. 7-9). Steelhead substocks remained mixed throughout the winter and did not become segregated until entry into tributaries or arrival at spawning locations in the mainstem.

Length and age characteristics of radio-tagged steelhead were analyzed to determine if substocks could be separated based on those characteristics. Length, age, and last observations of individual radio-tagged fish are indicated in Appendix Tables B.1-B.4. Radio-tagged steelhead spent from 1 to 2 years in freshwater followed by 1 to 3 years in the ocean prior to returning to spawn in the Yakima River Basin. The majority (91.9%) of steelhead tagged at Prosser Dam were either 3-year-old or 4-year-old fish (Table 1). The oldest steelhead tagged (a 5-year-old fish) spawned in the Naches River Basin.

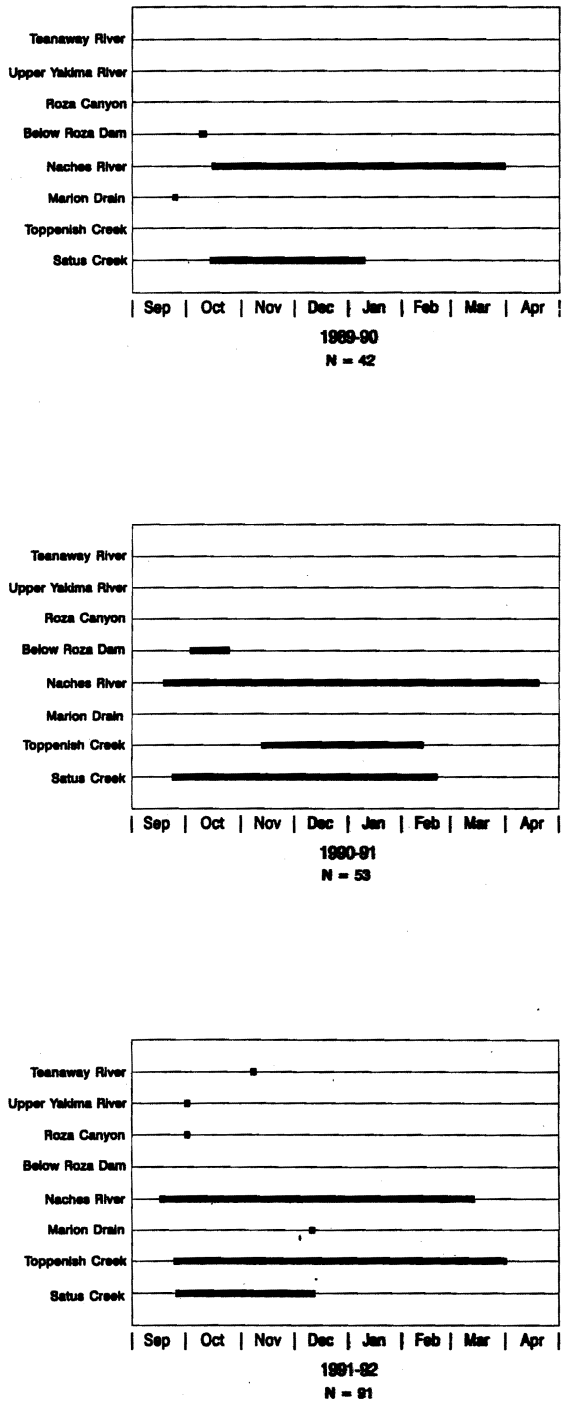


Figure 3. Tagging dates of steelhead substocks at Prosser Dam, 1989-92.

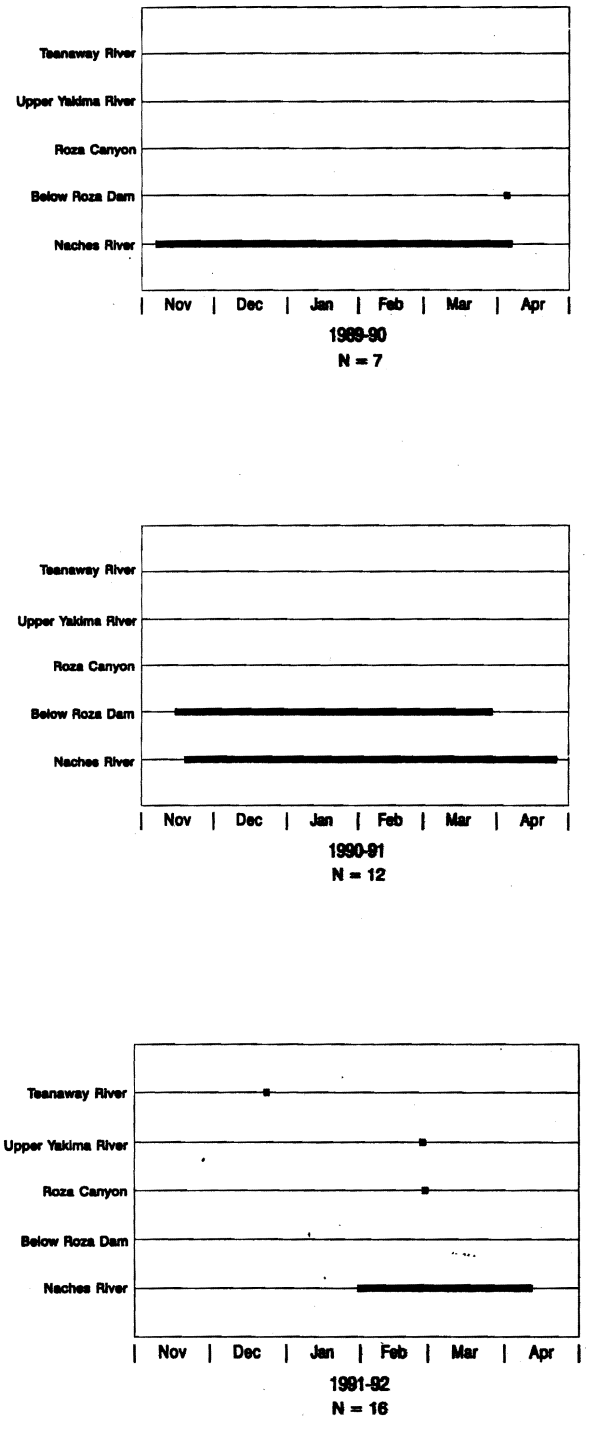


Figure 4. Passage dates of steelhead substocks at Sunnyside Dam, 1989-92.

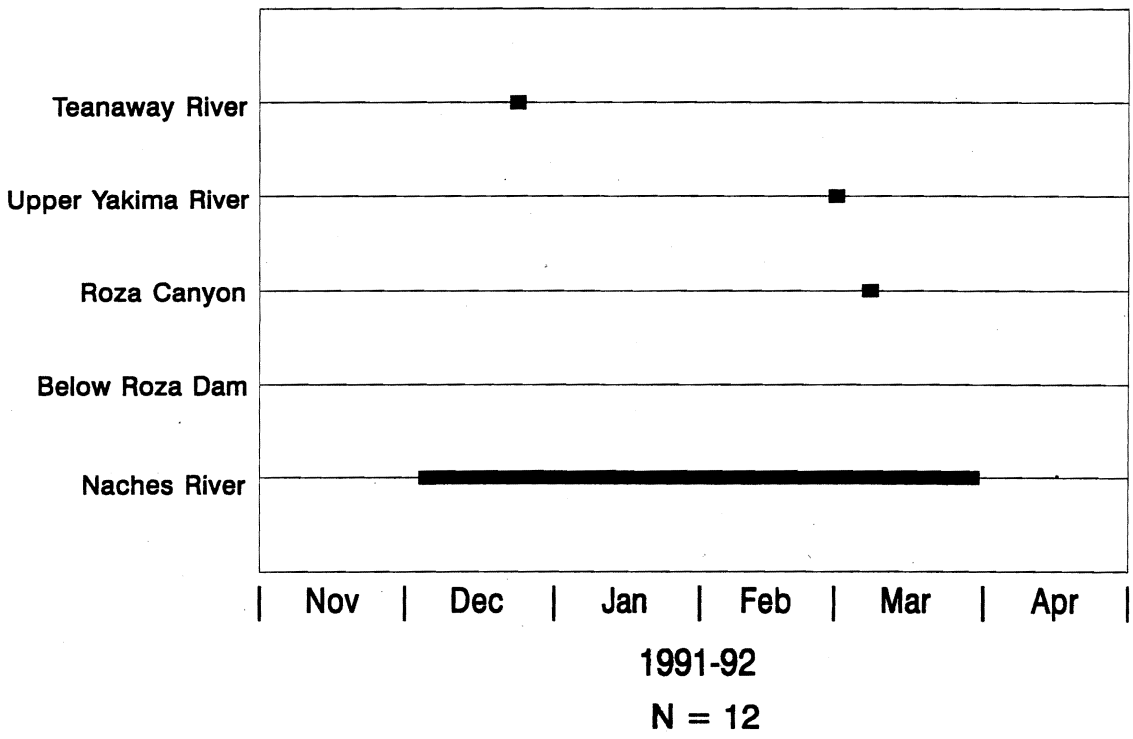
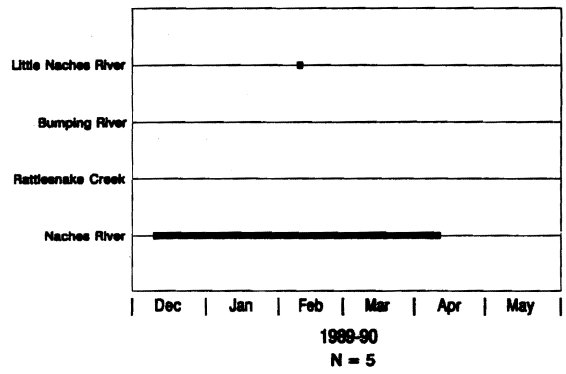
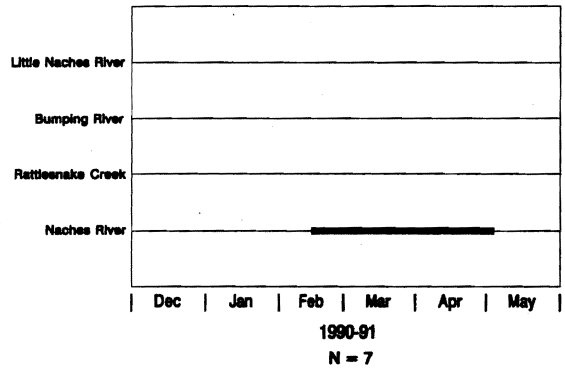


Figure 5. Passage dates of radio-tagged steelhead substocks at Wapato Dam, 1991-92.





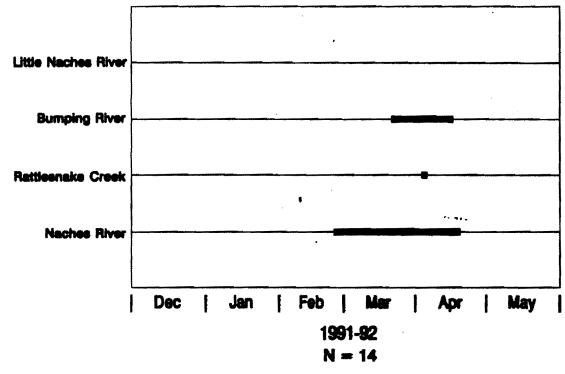


Figure 6. Passage dates of steelhead substocks at Cowiche Dam, 1989-92.

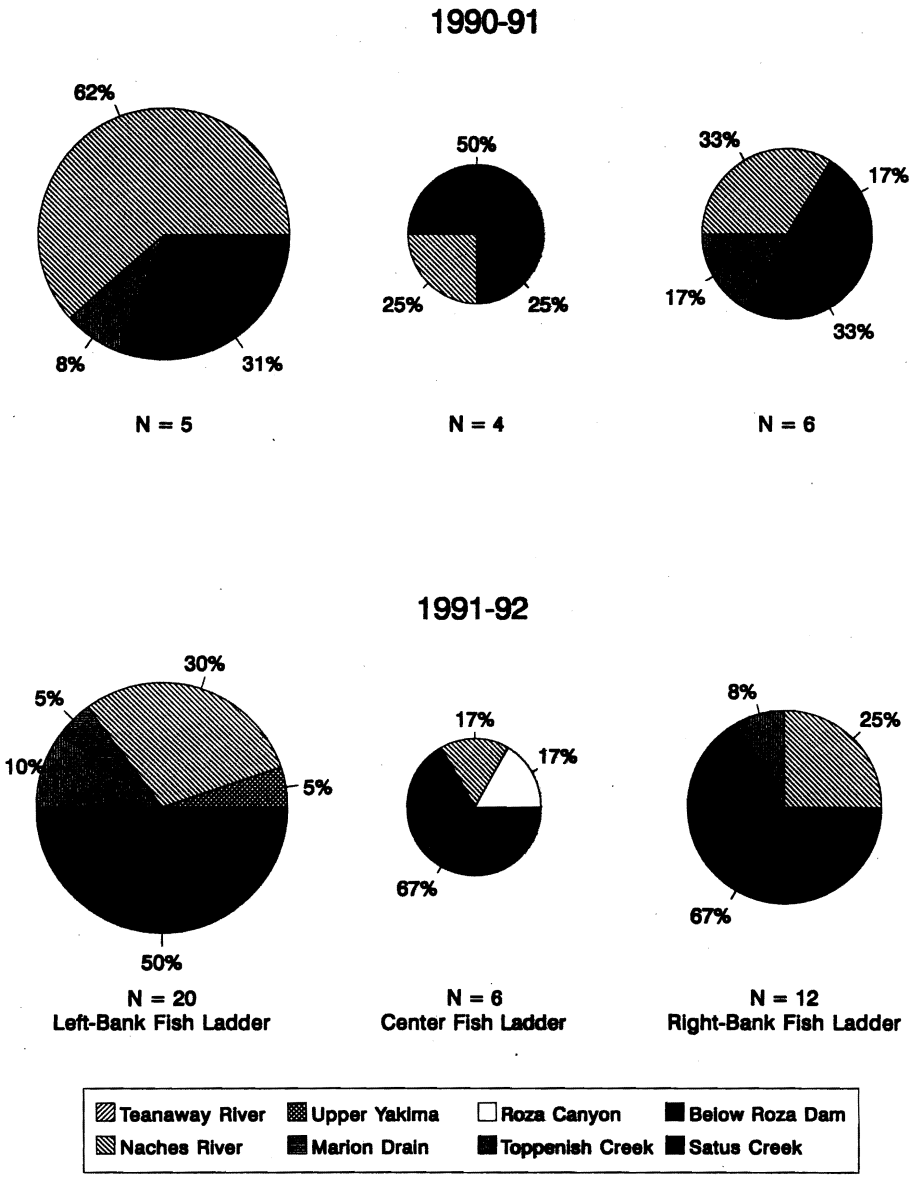


Figure 7. Fish-ladder selection by radio-tagged steelhead substocks at Prosser Dam, 1990-92.

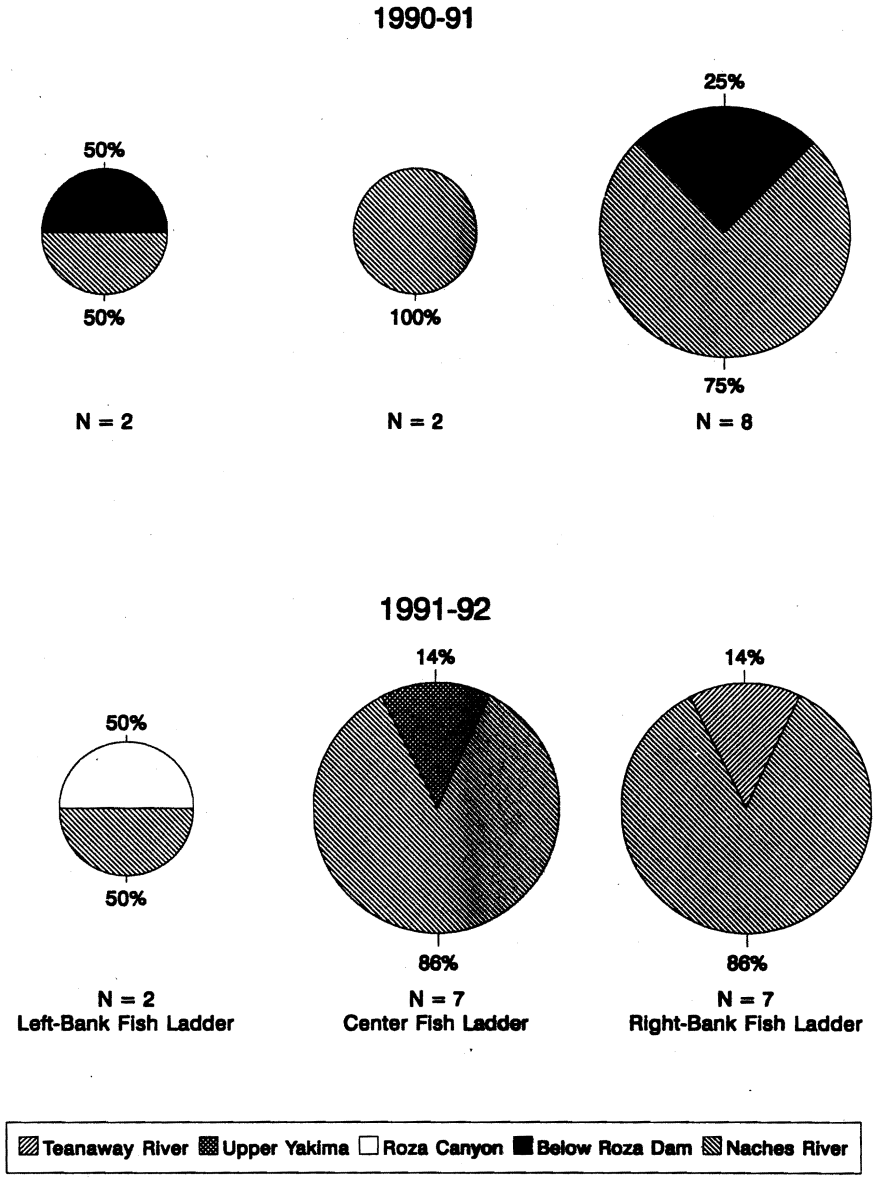


Figure 8. Fish-ladder selection by radio-tagged steelhead substocks at Sunnyside Dam, 1990-92.

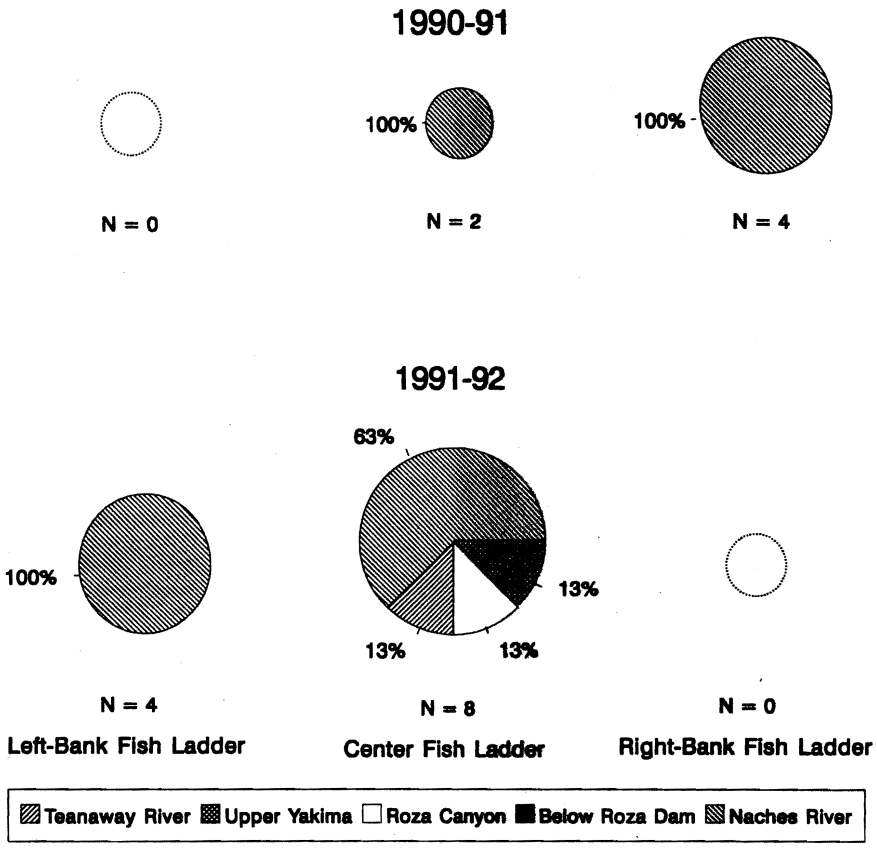


Figure 9. Fish-ladder selection by radio-tagged steelhead substocks at Wapato Dam, 1990-92.

Table 1. Age composition of radio-tagged steelhead substocks, 1989-93.

Substock	Age 1/1[a]	1/2	2/1	2/2	2/3	2/1/1/1[b]
Satus Creek	3	11	10	15		
Toppenish Creek	1		1	4		1
Marion Drain						
Naches River	1	3	5	11	1	1
Below Roza Dam		1		1		
Roza Canyon			1			
Upper Yakima River			1			
Teanaway River			1	1		
Total	5	15	19	32	1	2

[a] First numeral indicates years spent in freshwater. Second numeral indicates years spent at sea.

[b] Repeat spawners with the third numeral indicating a spawning migration with as much as a year in freshwater and the fourth numeral indicating another year at sea after spawning.

Three repeat spawners were radio-tagged. One of these fish disappeared within the study area. One each of the remaining two fish spawned in Toppenish Creek and the Naches River.

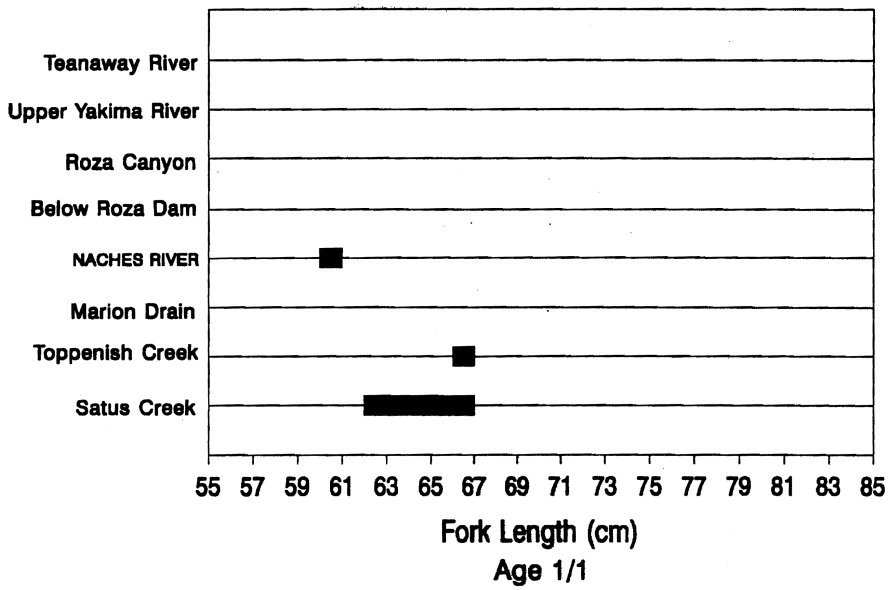
Lengths of fish by age from individual substocks overlapped considerably (Figs. 10-11). The largest radio-tagged fish were part of the Naches River population.

Passage Evaluation

Individual radio-tagged steelhead passage times and ladder use at Yakima River irrigation diversion dams are indicated in Appendix Tables C.1-C.3. Passage times at all dams were similar among years and were pooled to increase the sample size for passage evaluation. Fish-ladder selection at Prosser, Sunnyside, Wapato, and Cowiche Dams was evaluated for the 1990-91 and 1991-92 runs only.

Prosser Dam

Passage delay at Prosser Dam ranged from 0.1 to 128.3 days for 100 fish (median 5.9 days). Thirty-seven percent of the radio-tagged steelhead passed Prosser Dam within 2 days (Fig. 12). As water temperature decreased, fish passage also decreased (Fig. 2). Below 4^0C, migration past Prosser Dam stopped and did not resume until water temperature increased.



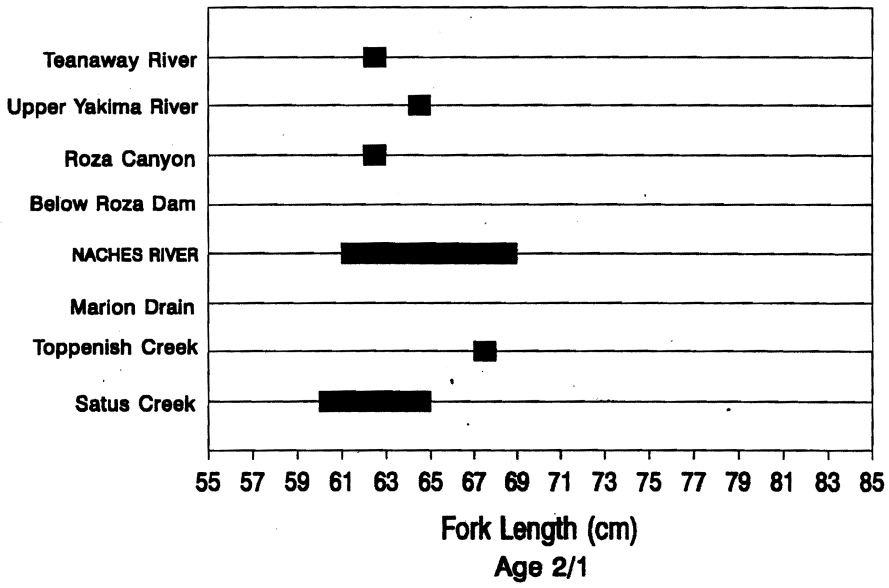
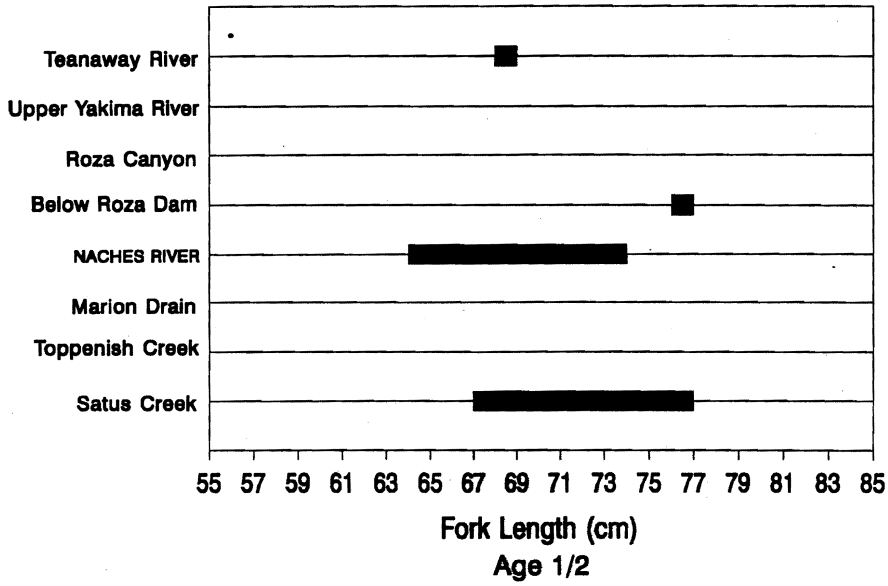


Figure 10. Fork lengths (cm) of age 1/1 and 2/1 radio-tagged steelhead by substock, 1989-93.



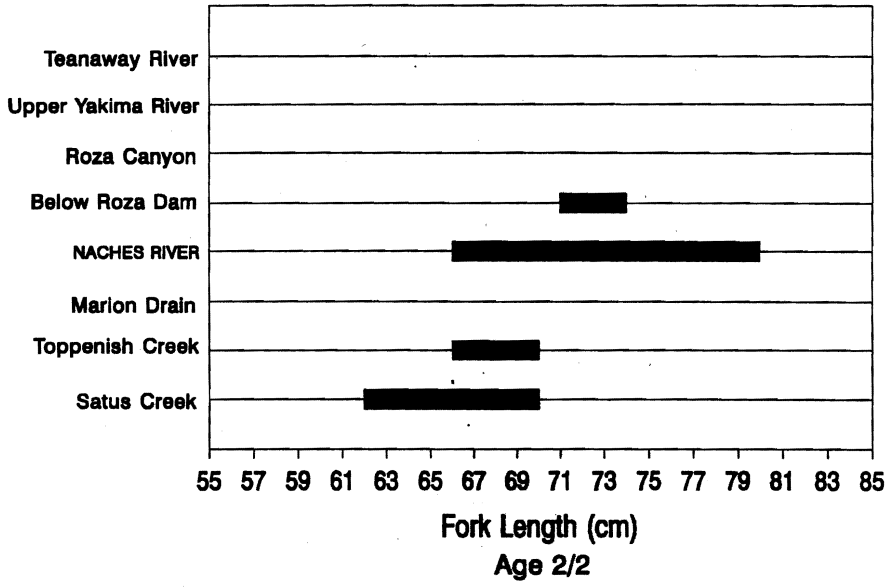


Figure 11. Fork lengths (cm) of age 2/1 and 2/2 radio-tagged steelhead by substock, 1989-93.

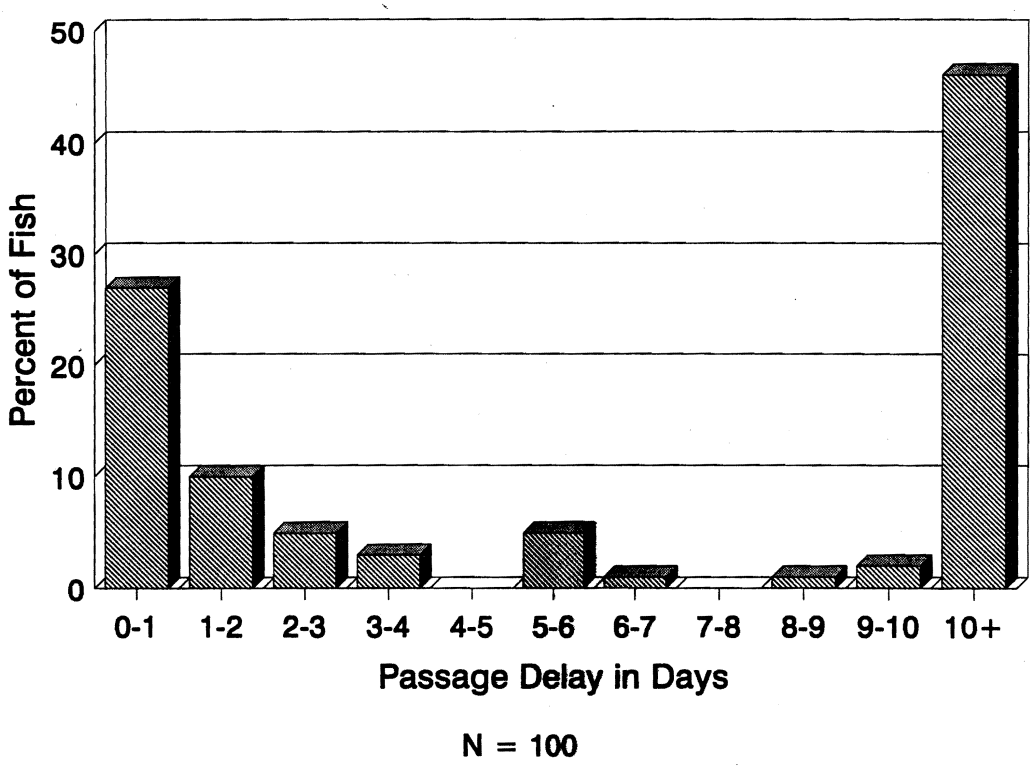


Figure 12. Passage delay of radio-tagged steelhead at Prosser Dam, 1989-92.

Fish-ladder selection by radio-tagged steelhead was similar between years; however, selection was different than that of the total steelhead run, according to fish-ladder videotape monitoring (Fig. 13). No conclusions regarding fish-ladder selection in relation to flow were possible due to variability in discharge below the dam, ladder operations, environmental conditions, and fluctuations in run composition.

Sunnyside Dam

Steelhead passed Sunnyside Dam from October through April with 72.5% passing after 1 February. Passage delay for 40 steelhead at Sunnyside Dam ranged from <0.1 to 43.1 days (median 0.4 days). Ninety-three percent of the radio-tagged steelhead passed Sunnyside Dam within 2 days (Fig. 14). A majority of tagged fish (67%) used the right-bank fish ladder during the 1990-91 run (Fig. 15). During the 1991-92 run, the majority of tagged steelhead (78%) were evenly distributed between the center and right-bank fish ladders.

Wapato Dam

Wapato Dam passage was monitored for the 1990-91 and 1991-92 steelhead run only. Steelhead passed Wapato Dam from December through April with 89.5% passing after 1 February. Passage delay for 19 fish ranged from <0.1 to 31.3 days (median 6.9 days). Forty-three percent of the radio-tagged steelhead passed Wapato Dam within 2 days (Fig. 16). Fish-ladder preference differed between years (Fig. 15). A majority of the fish (57%) used the right-bank fish ladder during the 1990-91 run. However, during

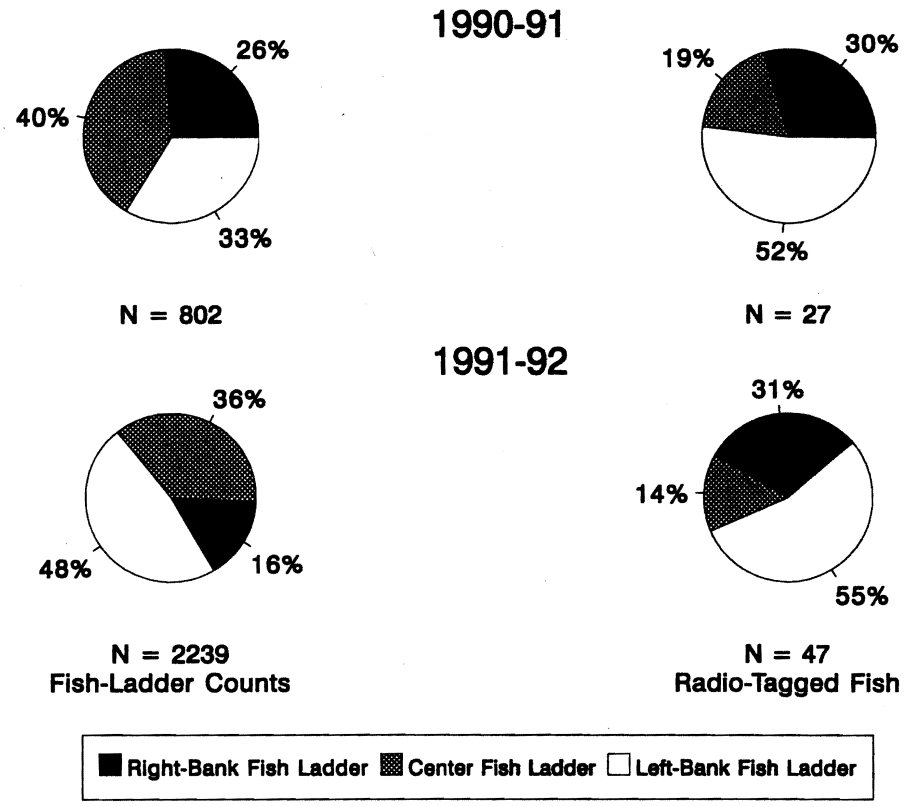


Figure 13. Comparison between fish-ladder counts of the steelhead run and fish-ladder selection by radio-tagged steelhead at Prosser Dam, 1989-92.

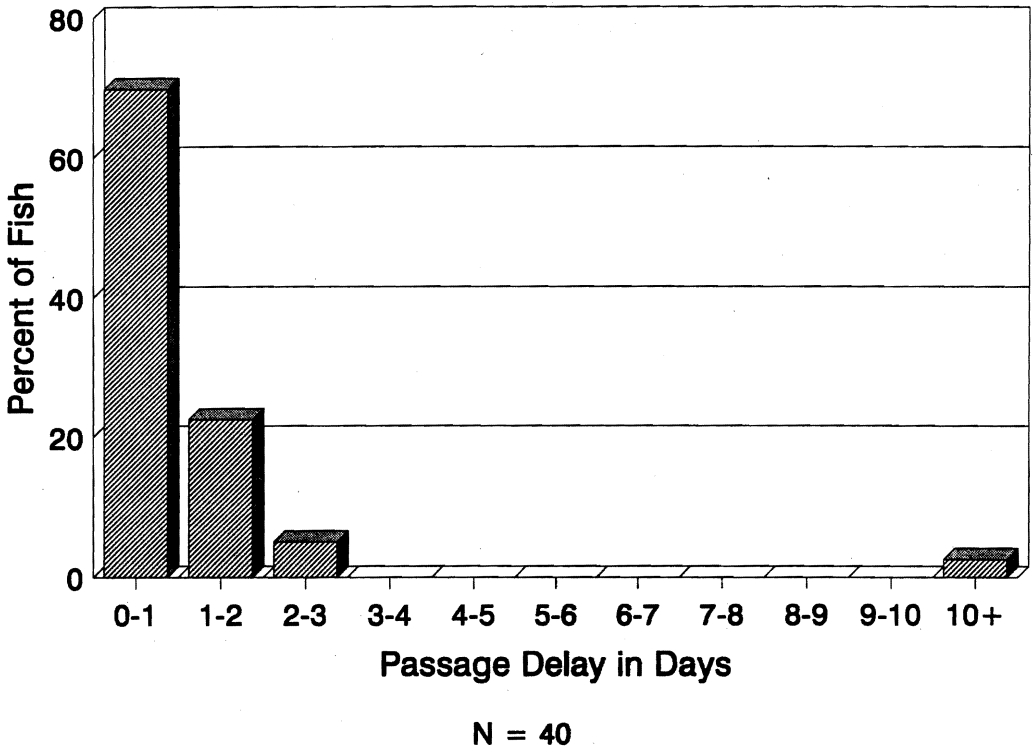


Figure 14. Passage delay of radio-tagged steelhead at Sunnyside Dam, 1989-92.

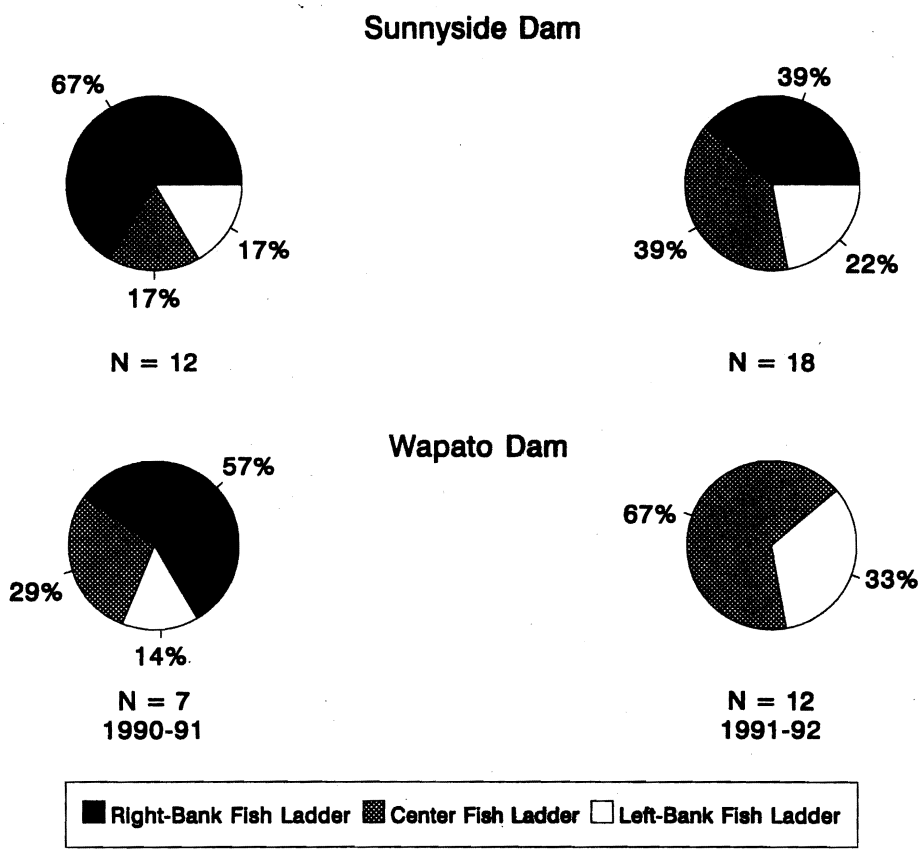


Figure 15. Fish-ladder selection by radio-tagged steelhead at Sunnyside and Wapato Dams, 1990-92.

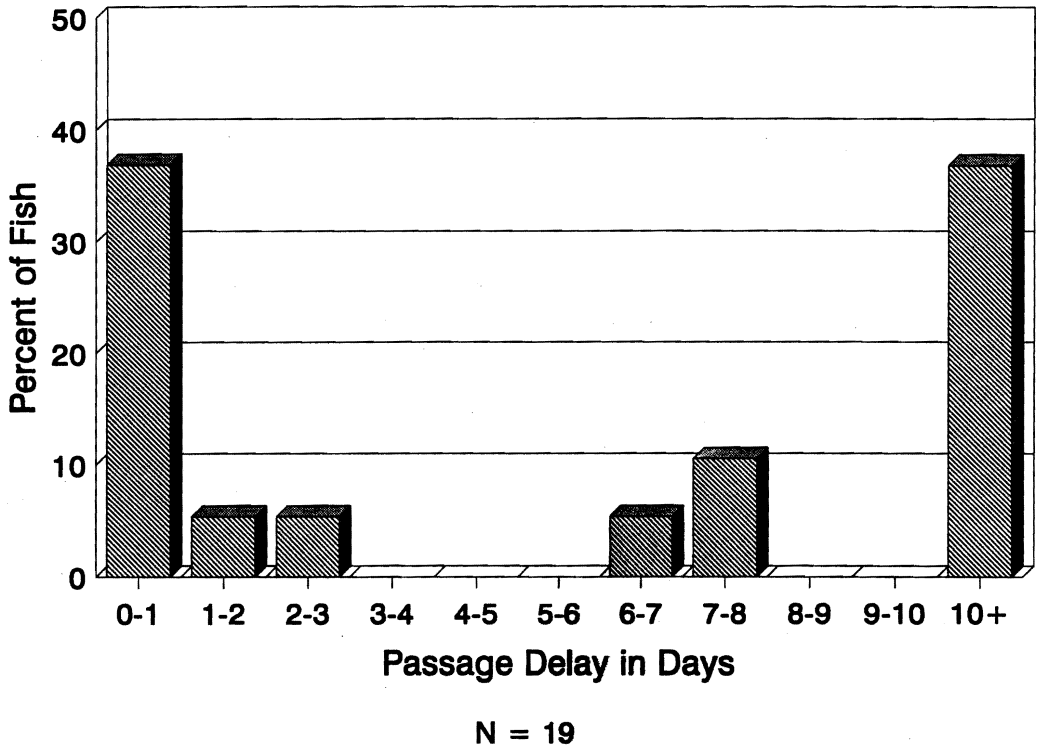


Figure 16. Passage delay of radio-tagged steelhead at Wapato Dam, 1989-92.

the 1991-92 run, no steelhead used the right-bank fish ladder and the majority (67%) used the center fish ladder.

Roza Dam

Steelhead passed Roza Dam from November through March, with 75.0% passing after mid-March. Passage delay at Roza Dam for 5 fish ranged from 1.3 to 16.7 days (median 1.9 days). Sixty percent of the radio-tagged steelhead passed Roza Dam within 2 days (Fig. 17).

Fish passage at Roza Dam is possible by the left-bank fish ladder or by a gallery on the right-bank shoreline which connects to the left-bank fish ladder (Fig. 18). Use of the gallery and fall-back of steelhead at Roza Dam were evaluated during 1991-92 only. No fall-backs were observed. Two of the three radio-tagged steelhead passing Roza Dam migrated upstream through the gallery. However, these fish then migrated down the fish ladder into the tailrace on the left-bank shoreline after exiting the gallery. Successful passage of Roza Dam for all steelhead occurred only by fish entering the left-bank fish ladder entrance and migrating up the fish ladder. No steelhead passed downstream (from the fish ladder to the right-bank shoreline) through the gallery.

Median passage time for fish that used the gallery (3.2 days) was more than twice as long as median passage time for fish that did not use the gallery (1.3 days).

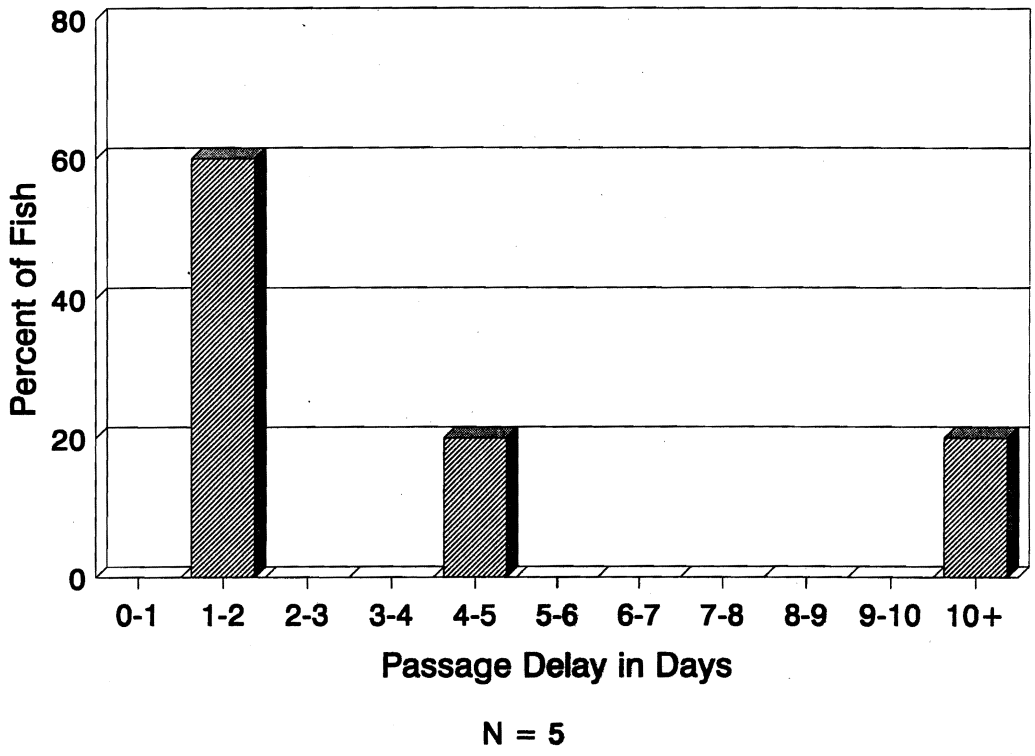


Figure 17. Passage delay of radio-tagged steelhead at Roza Dam, 1989-92.

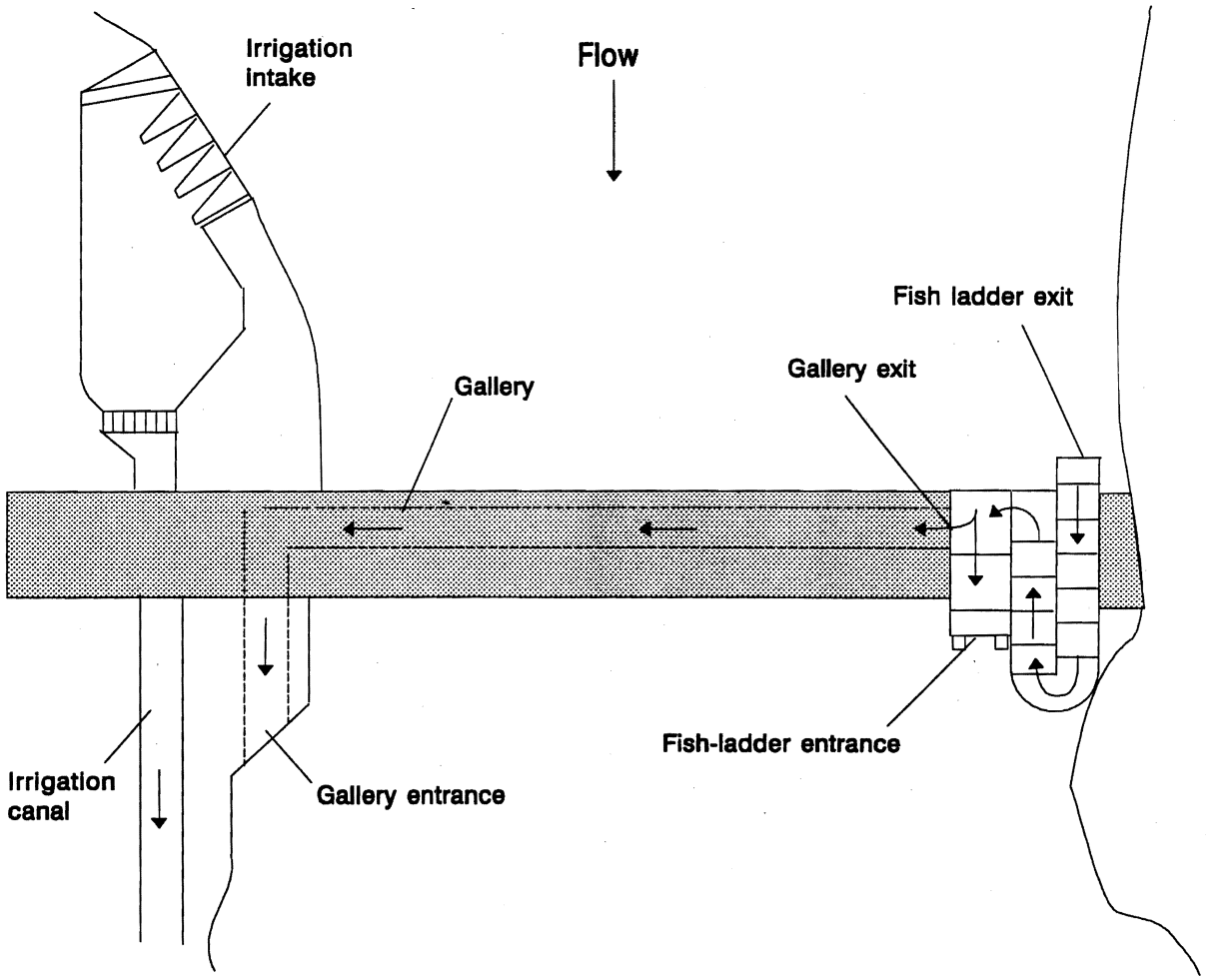


Figure 18. Adult fish-passage facility at Roza Dam.

Cowiche Dam

Steelhead passed Cowiche Dam from December through May, with 80.8% passing after mid-March. Passage delay for 26 steelhead ranged from <0.1 to 25.3 days (median 1.5 days). Sixty-seven percent of the radio-tagged steelhead passed Cowiche Dam within 2 days (Fig. 19). Ladder passage was minimal, 43 and 21% in 1990-91 and 1991-92, respectively, with most fish jumping over the dam instead (Fig. 20).

Wapatox Dam

Steelhead passed Wapatox Dam from March through May, with 93.3% passing after mid-March. Passage delay for radio-tagged steelhead ranged from 0.1 to 14.9 days (median 1.5 days) for 15 fish during 1990-91 and 1991-92. Sixty-seven percent of the radio-tagged steelhead passed Wapatox Dam within 2 days (Fig. 21).

Migration Behavior

Steelhead migrating into the Yakima River during fall and early winter settled into winter holding areas. Upon arrival at winter holding areas, steelhead established small home ranges (average 10.6 km) from October through February. Winter holding areas were occupied from 28 to 167 days (average 77 days) (Table 2). The majority (62%) of the radio-tagged steelhead wintered between Prosser and Sunnyside Dams (Fig. 22). Twenty-eight percent of the radio-tagged steelhead wintered downstream from Prosser Dam.

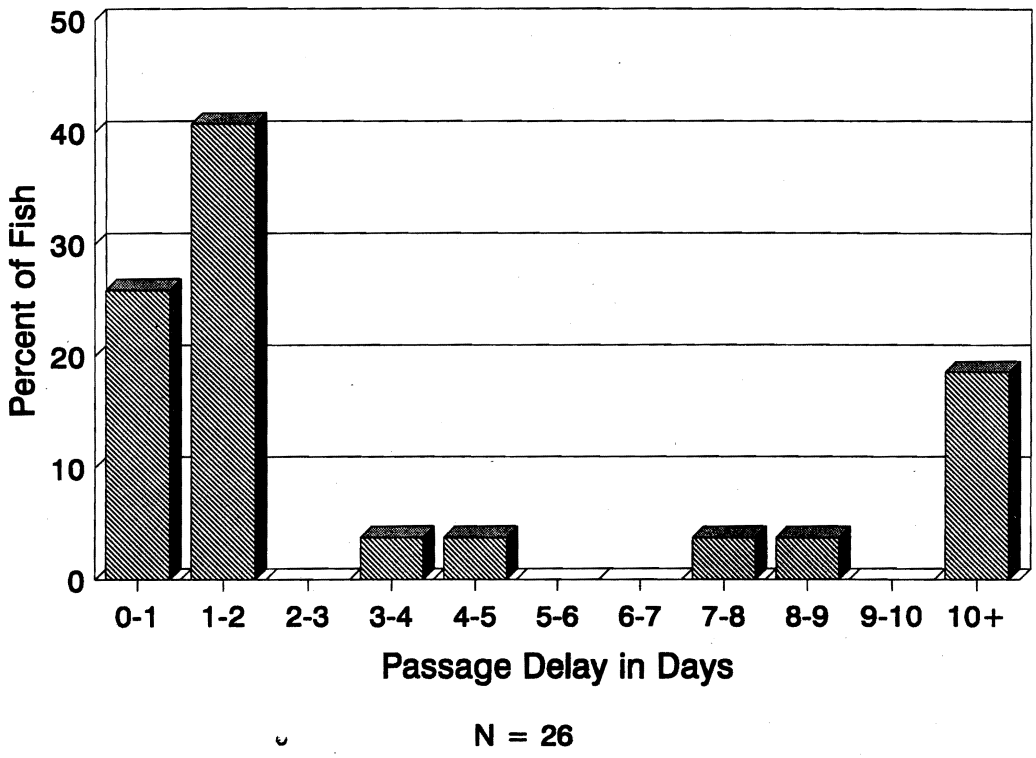


Figure 19. Passage delay of radio-tagged steelhead at Cowiche Dam, 1989-92.

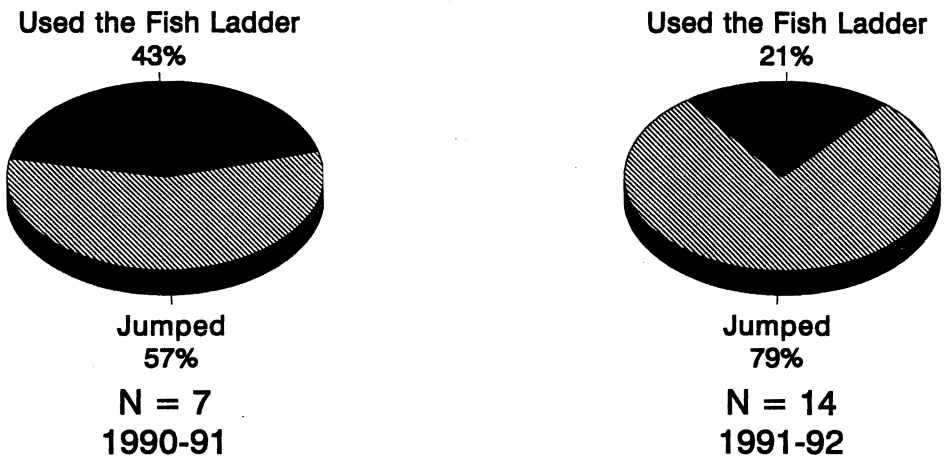


Figure 20. Fish-ladder use at Cowiche Dam by radio-tagged steelhead, 1990-92.

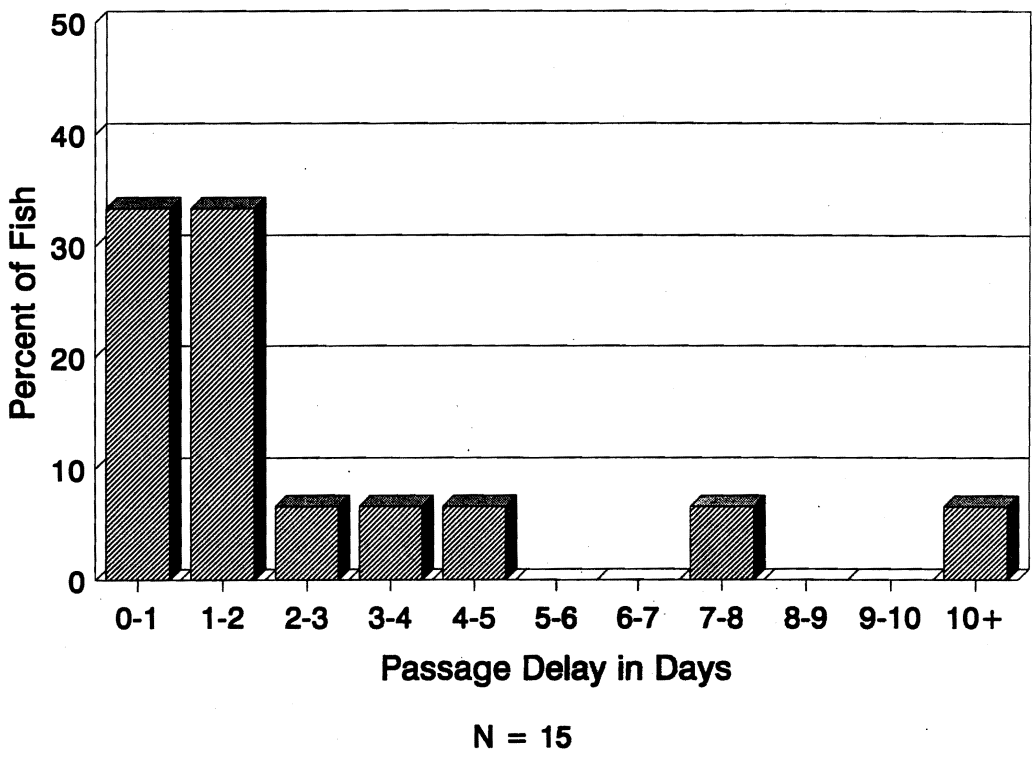


Figure 21. Passage delay of radio-tagged steelhead at Wapatox Dam, 1989-92.

Table 2. Length of time radio-tagged steelhead substocks occupied winter holding areas in 1989-92.

Substock	Number of Fish	Range (days)	Mean (days)
Satus Creek Basin	46	35-129	65
Toppenish Creek Basin	8	33-113	71
Marion Drain	2	28-70	49
Naches River Basin	20	51-134	91
Below Roza Dam	4	85-167	118
Roza Canyon	1	116	116
Teanaway River Basin	1	48	48
Upper Yakima River	1	116	116
Overall	83	28-167	77

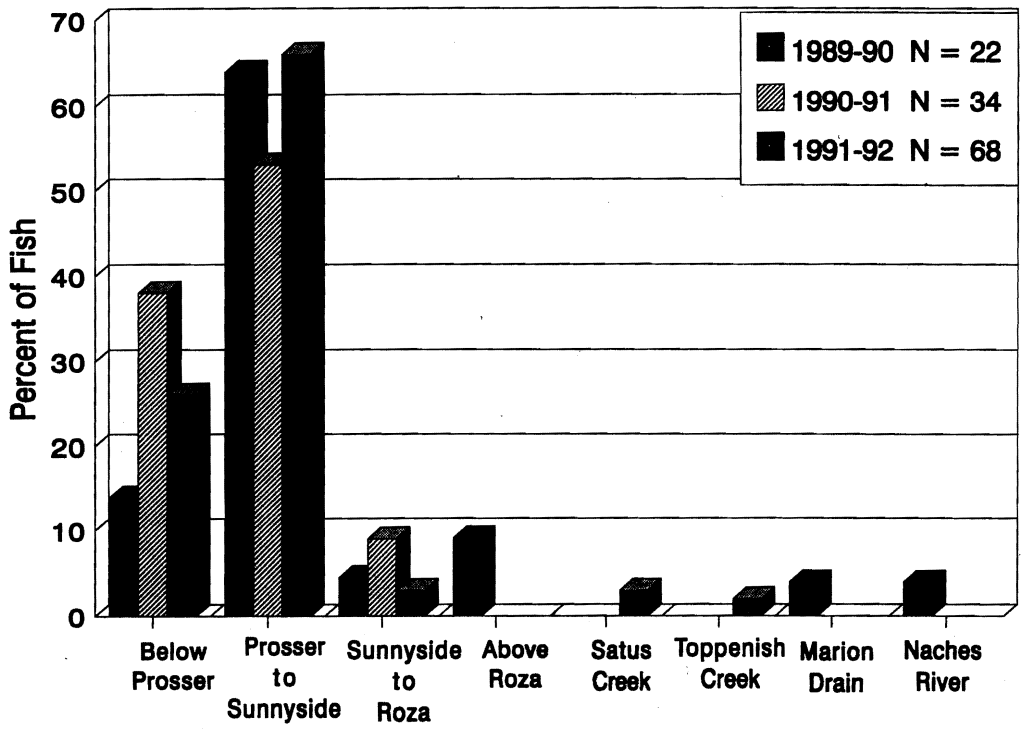


Figure 22. Winter holding locations of radio-tagged steelhead, 1989-92.

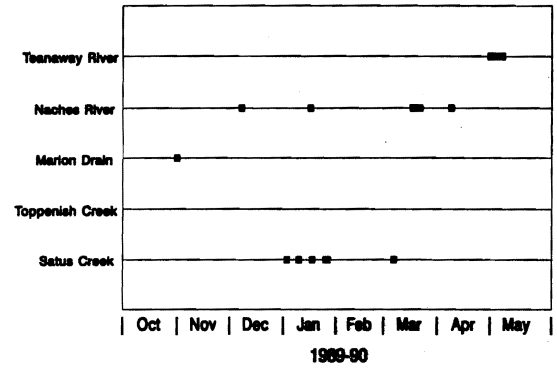
Over the course of the study only 4, 5, and 1% of the population wintered in tributaries, between Sunnyside and Roza Dams, and above Roza Dam, respectively.

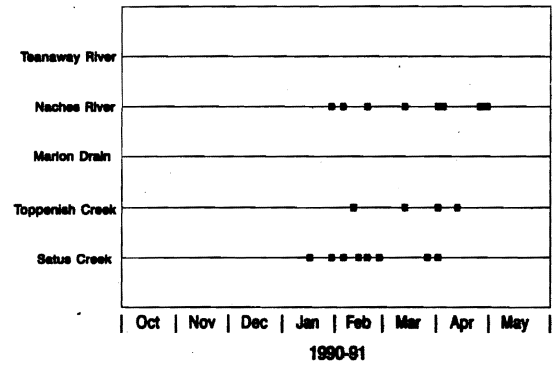
Habitat utilization in winter holding areas was limited to deep areas with low water velocity. Beginning in January and continuing into May, radio-tagged steelhead entered tributaries to spawn (Fig. 23). In general, steelhead entering lower elevation tributaries (e.g., Satus Creek) left winter holding areas before those entering higher elevation tributaries (e.g., Teanaway River and Naches River). Ninety-seven percent of steelhead entering the Naches River to spawn entered after water temperature had increased above 3° C (Fig. 24).

Spawning Behavior

Spawning location was determined for 59% of the radio-tagged steelhead from 1989-93. The majority (90%) spawned in tributaries. Ten spawning areas (Satus Creek, Toppenish Creek, Marion Drain, Naches River, the mainstem Yakima River below Roza Dam, the mainstem Yakima River in the Roza Canyon, Taneum Creek, Swauk Creek, the upper Yakima River [above Ellensburg, WA], and Teanaway River) were identified by radio telemetry. The majority (80%) of steelhead tagged at Prosser Dam spawned in the Satus Creek or Naches River Basins (Fig. 25).

Spawning occurred earlier in areas of lower elevation and where water temperature was warmer (e.g., Satus Creek) than in areas of higher elevation and cooler water temperature (e.g., Naches and Teanaway Rivers) (Fig. 26).





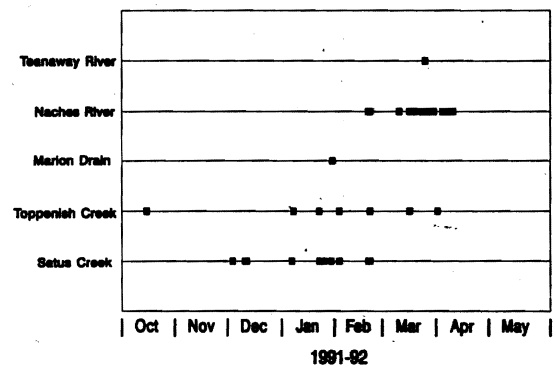


Figure 23. Tributary entry timing of radio-tagged steelhead, 1989-92.

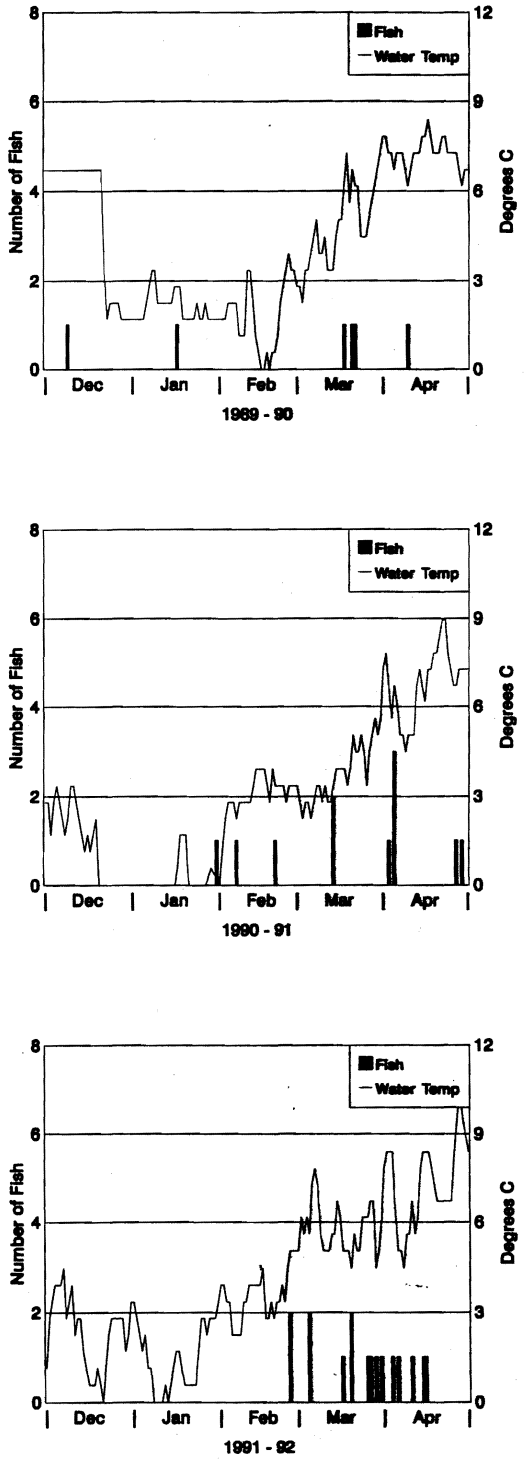


Figure 24. Water temperature during entry into the Naches River by radio-tagged steelhead, 1989-92.

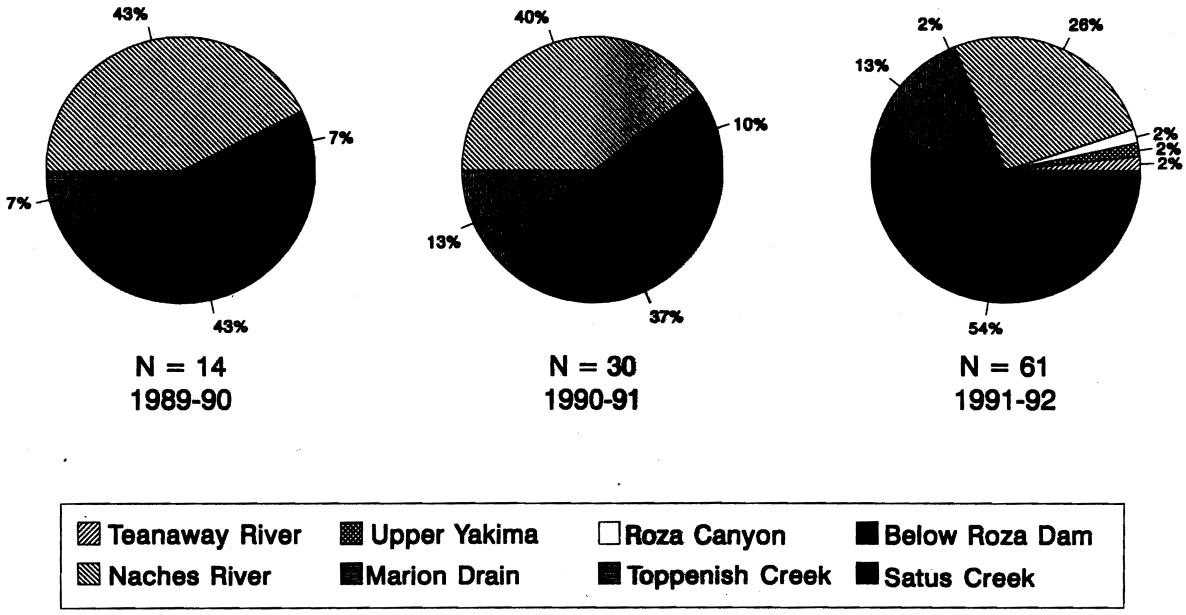
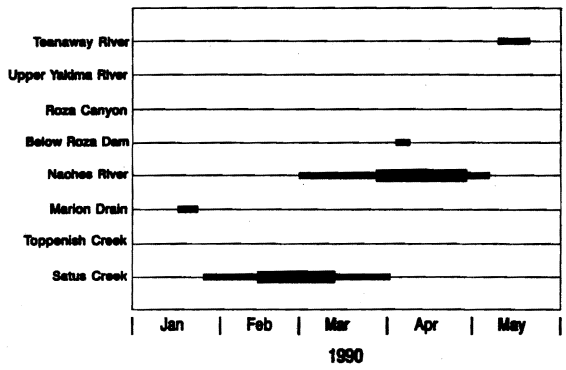
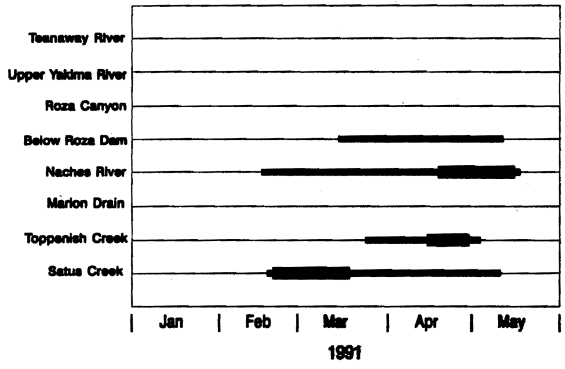


Figure 25. Spawning distribution of radio-tagged steelhead collected at Prosser Dam, 1989-92.





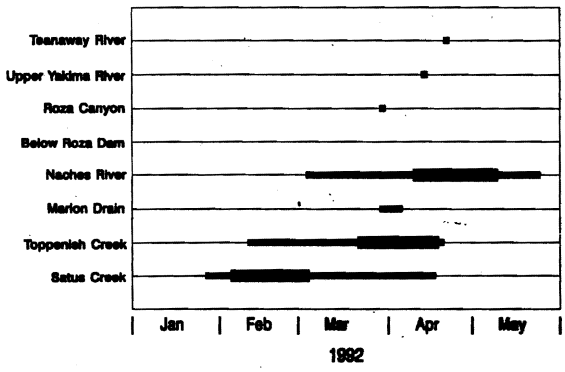


Figure 26. Range and concentrated spawning period by area for radio-tagged steelhead in the Yakima River Basin, 1990-92.

The distance from winter holding areas to spawning areas ranged from 0 to 200 km (average 74.7 km), with 80% of the radio-tagged steelhead moving more than 40 km from winter holding areas to spawn (Fig. 27). Steelhead that spawned in the upper Yakima River, Teanaway River, Naches River Basin, and Toppenish Creek migrated the greatest distance from winter holding areas (Table 3). Steelhead that spawned in the Marion Drain, below Roza Dam, and in the Roza Canyon sections of the Yakima River made the shortest migrations from winter holding areas.

Satus Creek

The majority (48%) of the steelhead tagged at Prosser Dam spawned in the Satus Creek Basin. Tributary entry and spawning within the Yakima River Basin occurred earliest in the Satus Creek Basin. Steelhead spawning was distributed among the mainstem, Dry Creek, Logy Creek, and Wilson Charlie Creek (Fig. 28). Radio-tagged steelhead spawned in the mainstem from RKm 8.0 to RKm 72.4 with the majority (83.3%) spawning above RKm 27.0. Steelhead spawned in Dry Creek from RKm 1.0 to RKm 33.8 with the majority (90.9%) spawning above RKm 8.0. Steelhead spawned in Logy Creek from RKm 1.0 to RKm 12.9 with the majority (75.0%) spawning above RKm 6.0. Spawning in Wilson Charlie Creek was within the lower 2 RKm.

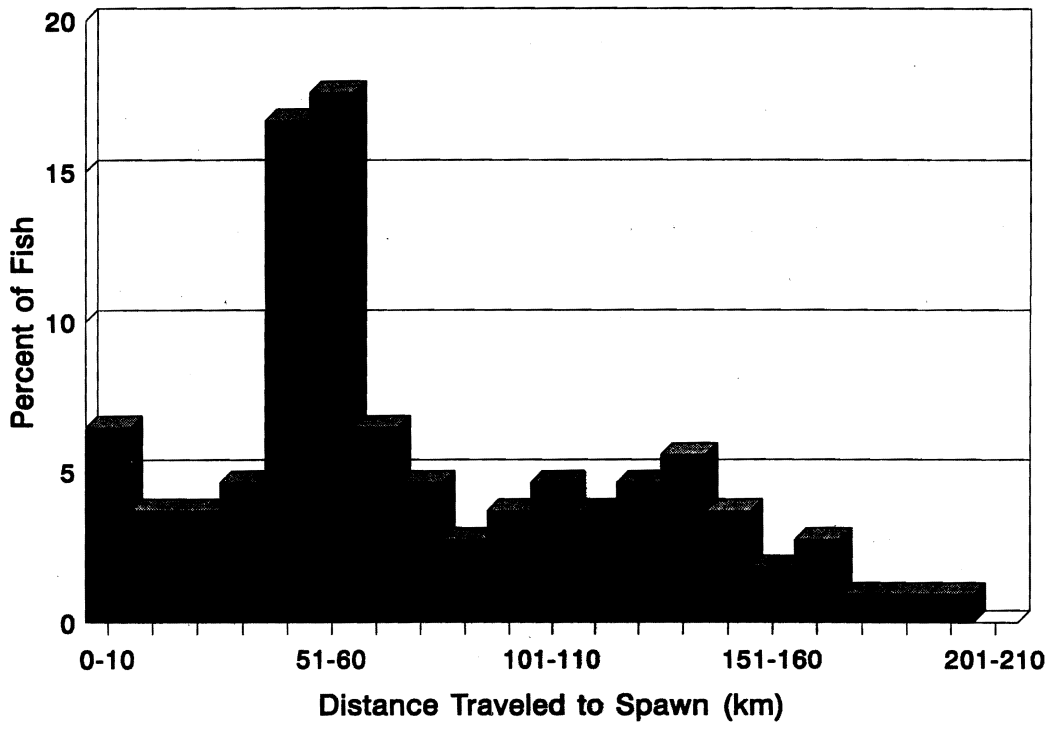


Figure 27. Distance traveled from winter-holding areas to spawning locations for radio-tagged steelhead in the Yakima River Basin, 1989-92.

Table 3. Distance traveled from winter holding areas to spawning locations by spawning location for radio-tagged steelhead, 1989-92.

Spawning Location	Number of Fish	Range (km)	Mean (km)
Satus Creek Basin	50	2-121	56.6
Toppenish Creek Basin	12	16-143	85.9
Marion Drain	2	18-29	23.3
Naches River Basin	33	10-200	108.1
Below Roza Dam	5	0-60	28.3
Roza Canyon	3	8-50	24.6
Teanaway River Basin	2	108-127	117.5
Upper Yakima River	1	142	142.0
Overall	108	0-200	74.7

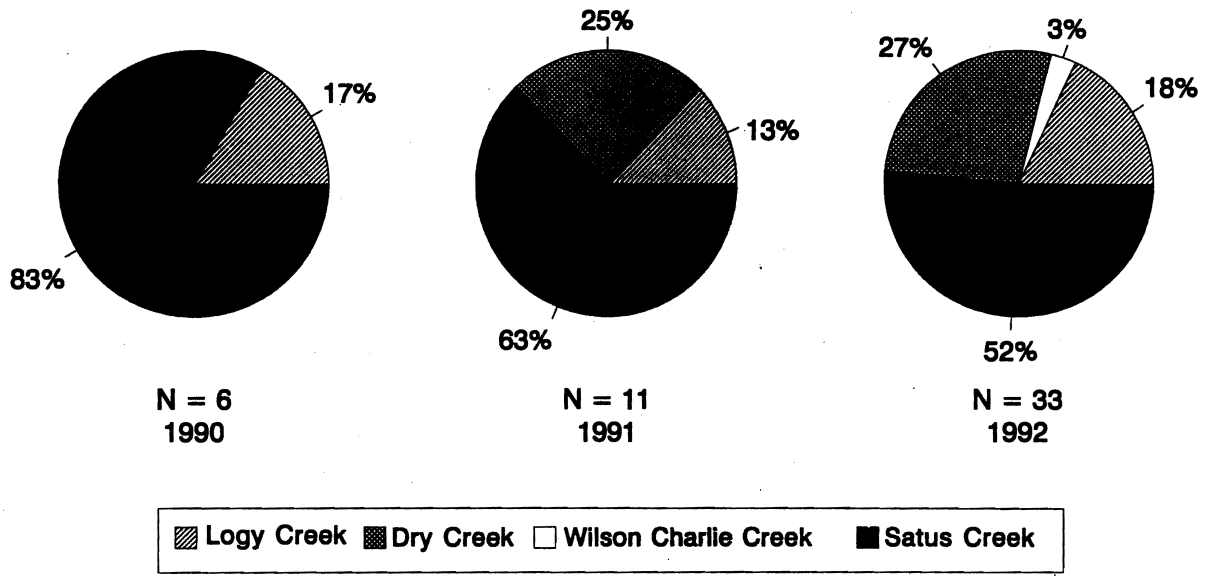


Figure 28. Spawning distribution of radio-tagged steelhead in the Satus Creek Basin, 1990-92.

Toppenish Creek

Eleven percent of the steelhead tagged at Prosser Dam spawned in Toppenish Creek. The peak spawning period in Toppenish Creek occurred 4 weeks after the peak spawning period in Satus Creek. Radio-tagged steelhead spawned from RKm 35.4 to RKm 90.1, with the majority (83.3%) spawning above RKm 48.3. Radio-tagged steelhead were not observed spawning in tributaries of Toppenish Creek.

Marion Drain

Two percent of the steelhead tagged at Prosser Dam spawned in the Marion Drain between RKm 22.5 and RKm 29.0.

Naches River

Thirty-two percent of the steelhead tagged at Prosser Dam spawned in the Naches River Basin. Spawning was distributed among the mainstem, Rattlesnake Creek, the Bumping River, and the Little Naches River (Fig. 29). Radio-tagged steelhead spawned in the mainstem from RKm 4.8 to RKm 69.2, with the majority (70.5%) spawning above RKm 24.0. Spawning locations in Rattlesnake Creek were not determined due to the remoteness of the tributary. Steelhead spawned in the Bumping River from RKm 14.5 to RKm 16.1. Spawning in the Little Naches River was within the lower 5 RKm. Hatchery steelhead spawned only in the mainstem Naches River and the Little Naches River. The peak spawning period in the Naches River Basin occurred 2 weeks after the peak spawning period in Toppenish Creek and 6 weeks after the peak spawning period in Satus Creek.

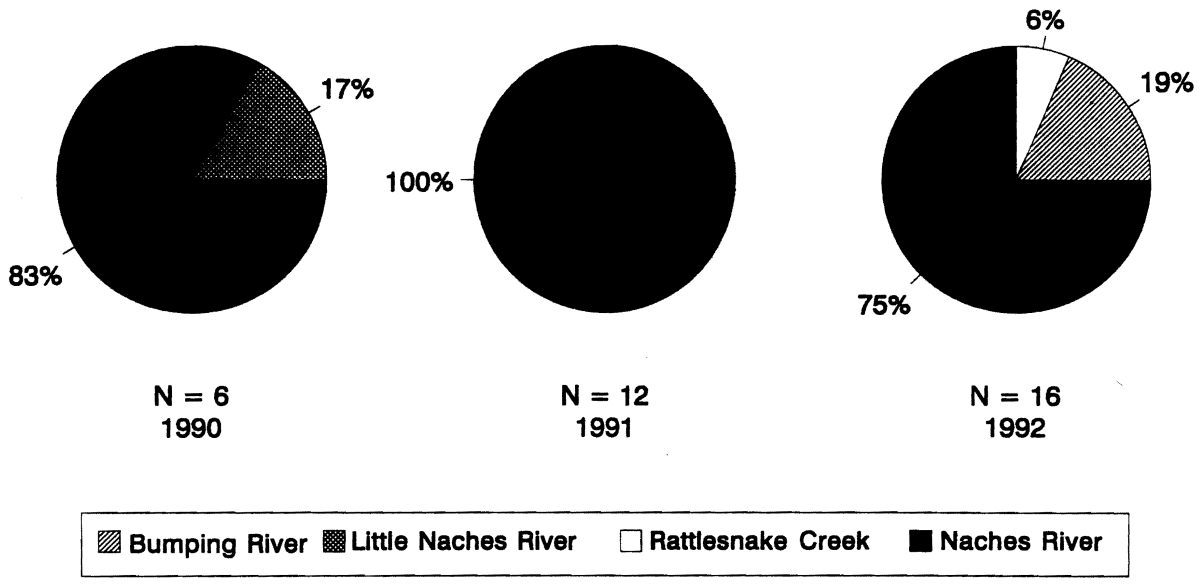


Figure 29. Spawning distribution of radio-tagged steelhead in the Naches River Basin, 1990-92.

Below Roza Dam

Four percent of the steelhead tagged at Prosser Dam spawned between Wapato and Roza Dams, from RKm 178.6 to RKm 202.8.

Roza Canyon

One percent of the steelhead tagged at Prosser Dam spawned within the Roza Canyon section of the mainstem Yakima River. An additional two steelhead tagged at Roza Dam also spawned in the Roza Canyon. Spawning in the Roza Canyon section occurred between RKm 206.0 and RKm 218.9.

Taneum Creek

Three steelhead were collected, tagged and released upstream from the Taneum Creek weir in 1993; however, only one spawned in Taneum Creek (RKm 2.4).

Swauk Creek

During 1993, two steelhead were collected and tagged at the Swauk Creek weir; however, both were found dead and unspent 3 days later upstream from the weir.

Upper Yakima River

One percent of the steelhead tagged at Prosser Dam spawned in the mainstem upper Yakima River. In 1993, two steelhead collected and tagged at the Taneum Creek weir also spawned in the mainstem Yakima River near the Taneum Creek confluence (267.1 RKm). It was not possible to determine if these fish migrated out of Taneum Creek prior to spawning because they had strayed into Taneum Creek or in response to capture and tagging.

An additional steelhead collected by electrofishing near Swauk Creek and tagged in 1993 also spawned in the mainstem upper Yakima River. Spawning occurred between RKm 267.1 and RKm 297.7.

Teanaway River

One percent of the steelhead tagged at Prosser Dam spawned in the Teanaway River Basin. An additional two fish collected at Roza Dam and one fish collected by electrofishing the mainstem Yakima River in the Roza Canyon also spawned in the Teanaway River Basin. Spawning in Teanaway River Basin was distributed between the mainstem, the North Fork, and the West Fork. Spawning locations in the mainstem Teanaway River were not determined due to the remoteness of the area. Steelhead spawned in the North Fork Teanaway River from RKm 8.0 to RKm 9.7. Spawning in the West Fork Teanaway River occurred within the first RKm. The time of spawning in the Teanaway River Basin was the latest within the Yakima River Basin.

Mortality

Observed mortality of the 194 radio-tagged steelhead was 13.4% (Table 4). Tagging accounted for 57.5% of the observed mortality (7.7% of the total fish tagged). Fish that died during migration (1.0%), and fish that died during winter holding (2.6%) accounted for 26.9% of the observed mortality (3.6% of the total fish tagged). Sport fishing on the Yakima River accounted for 8.1% of the observed mortality. However, harvest estimates for the Yakima River Basin from steelhead punch card returns to WDFW and from the tribal subsistence fishery ranged from 7.0% to 15.2%

(9.4% overall) for 1989-93. During the study, 18 radio-tagged steelhead (9.3%) disappeared within the study area (between monitoring sites) prior to spawning, and 9 fish (4.6%) disappeared downstream from the lowest monitoring site. Fish disappearing below the lowest monitoring location were probably strays into the Yakima River Basin. However, steelhead disappearing between monitoring sites were probably due to either unreported harvest or radio transmitters which malfunctioned. The remoteness of spawning areas and water turbidity precluded observation of pre-spawning mortality on the spawning grounds.

DISCUSSION

Based on the final distribution of radio-tagged steelhead to various spawning areas in the Yakima River Basin, we could not separate substocks by size, age, run timing, or fish-ladder selection when they passed Prosser Dam during the fall and early winter. The different substocks remained mixed throughout the winter and did not become segregated until entry into tributaries or arrival at spawning locations.

Radio-telemetry data identified potential problems with monitoring, broodstock collection, and substock separation at Cowiche Dam. Seventy-one percent of the radio-tagged steelhead jumped Cowiche Dam rather than using the fish ladder, thereby avoiding the locations of the proposed trapping and monitoring facilities. Operation of a trap in the fish ladder may delay passage or increase the portion of the run jumping the dam. The fish-ladder entrance at Cowiche Dam opens into the spill basin

rather than the downstream face of the fish ladder. This may account for the low use of the fish ladder. In addition, the run timing of Naches River Basin spawning populations was mixed while passing Cowiche Dam and remained mixed until fish entered tributaries or arrived at spawning areas.

Separation of substocks based on age or length was not possible due to the overlap of length and age classes among most spawning populations.

This study could not determine if spawning fish in a given location were part of the population or strays from other populations. Nonetheless, straying within the study area was observed for only two fish tagged at the Taneum Creek weir, and these fish may have left Taneum Creek due to the effects of trapping and tagging. The nine fish tagged at Prosser Dam that disappeared below the lowest monitoring station may have also been strays from other tributaries within the Columbia River Basin, since they apparently left the Yakima River prior to spawning.

Median passage rates for radio-tagged steelhead at Yakima River Basin dams were similar to median passage rates at Snake River dams (Bjorn et al. 1994). Migration delays at Prosser Dam were likely influenced by decreasing fall water temperatures which resulted in some fish over wintering below Prosser Dam. Similarly, delays at Wapato Dam were influenced by wintering below Wapato Dam and the effect of Naches River water temperatures. Steelhead migration, passage at irrigation diversions, and tributary entry within the Yakima River Basin

were delayed when water temperatures decreased below 3°C. Bjorn and Perry (1992) and Bjorn et al. (1994) described similar effects of water temperatures on steelhead migrations in the Snake and Columbia Rivers during winter. Jensen et al. (1989) found that Atlantic salmon were unable to pass falls during periods of low water temperature. Since fish are poikilothermal animals, they are less active at low than high water temperatures (Jonsson 1991).

Steelhead had a similar fish-ladder distribution in all years at Prosser Dam. However, ladder distribution at Sunnyside and Wapato Dams was different among years. The cause of these differences was not determined. Steelhead passage at dams above Prosser Dam occurred primarily after 1 February.

Migrational delays at Roza Dam were greater for steelhead using the gallery. Hockersmith et al. (1994) described similar increased passage delay for chinook salmon using the gallery at Roza Dam.

Steelhead tagged at Prosser Dam in the fall and early winter settled into winter holding areas primarily between Prosser and Sunnyside Dams and below Prosser Dam. Habitat utilization while holding was limited to areas with slow water velocity and depth. Lough (1980), Spence (1981), Burger et al. (1983) also described periods of inactivity during the winter followed by a rapid spawning migration for steelhead. Entry into tributaries occurred shortly before spawning. Tributary flow rates and water temperature were believed to cue tributary entry.

Spawning locations averaged 74.7 km in distance from winter holding areas. The times of spawning were tributary-specific, with spawning occurring earlier in areas of lower elevation than in areas of higher elevation.

The Yakima River historically supported abundant runs of steelhead. However, current populations spawning in the mainstem Yakima River and in tributaries in the upper watershed (above Roza Dam) are nearly extinct (Campton and Johnston 1985). From 1939 through 1988, steelhead were unable to pass Roza Dam during most of the migration period because in the winter water in the fish ladder froze and during the summer there was a lack of water (Fast et al. 1989). Roza Dam fish-ladder modifications, completed in winter 1988, currently provide passage for steelhead throughout the migration. The single population spawning between Roza and Wapato Dams and the small spawning populations spawning above Roza Dam are probably due to the 50-year period of limited fish passage. Due to the large population of rainbow trout and small remnant populations of steelhead spawning above Roza Dam, the opportunity for spawning interactions between rainbow trout and steelhead are high (Pearsons et al. 1993).

Fish disappearing within the study area comprised 9.4% of the radio-tagged steelhead. Although tag failure may account for these losses, similar studies in the Yakima River Basin with spring chinook salmon using identical tags, did not identify similar disappearances (Hockersmith et al. 1994). Therefore, unreported harvest was probably the cause of these disappearances. In addition, winter holding mortality may also

have been associated with harvest. Although reported harvest for all steelhead was 9.4% during the study, the adjusted harvest rate for radio-tagged steelhead may have been as high as 13.5%.

RECOMMENDATIONS

Based on results of the 1989-93 radio-telemetry studies, we developed the following recommendations:

1) Broodstock for supplementation should be collected from tributaries to maintain genetic separation, since steelhead substocks remained mixed prior to tributary entry. The number of fish collected for broodstock should be based on total number of steelhead that pass Prosser Dam. The effects of broodstock collection on non-collected steelhead should be evaluated.
2) If broodstock collection or monitoring is to occur at Cowiche Dam, the fish-ladder entrance should be moved to the downstream face of the fish ladder. Also, the height of Cowiche Dam may need to be raised during migration periods to increase the numbers of fish using the fish ladder.
3) To reduce passage delay associated with use of the gallery, structural modifications or changes in attraction flows for the gallery at Roza Dam should be considered.
4) When numbers increase from supplementation, spawning areas may provide an opportunity to assess interactions

of resident rainbow trout and steelhead populations in the upper Yakima River Basin.

5) Radio-telemetry studies should be conducted on adults produced from the supplementation program to evaluate straying, intra-specific competition, mortality rates, and the overall effects supplementation programs have on wild populations.

6) Because harvest of steelhead is the highest inriver mortality source, harvest rates should be restricted to limit the impact on current population levels and supplementation programs.

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APPENDIX TABLES

Appendix Table A.1. Locations and antennae configuration for fixed-site telemetry monitors, 1989-90.

Monitor location	Monitor number	Monitor type	River	River km	Antennae number	Antennae location
Chandler Juvenile Facility	1	NMFS	Yakima	74.1	1	Across
Prosser Dam Left-Bank	4	NMFS	Yakima	75.4	1	Across
Sunnyside Dam Left-Bank	7	NMFS	Yakima	166.1	1	Across
Roza Dam Left-Bank	11	NMFS	Yakima	204.6	1	Downstream
Satus Creek	20	NMFS	Satus	19.3	1	Across
Cowiche Dam Left-Bank	40	NMFS	Naches	5.8	1	Downstream

Appendix Table A.2. Locations and antennae configuration for fixed-site telemetry monitors, 1990-91.

Monitor location	Monitor number	Monitor type	River	River km	Antennae number	Antennae location
Chandler Juvenile Facility	1	NMFS	Yakima	74.1	1	Across
Prosser Dam Right-Bank	2	NMFS	Yakima	75.4	1	Ladder entrance
Prosser Dam Right-Bank	2	NMFS	Yakima	75.4	2	Ladder exit
Prosser Dam Center	3	NMFS	Yakima	75.4	1	Ladder exit
Prosser Dam Left-Bank	4	NMFS	Yakima	75.4	1	Ladder exit
Prosser Dam Left-Bank	4	NMFS	Yakima	75.4	2	Downstream
Sunnyside Dam Right-Bank	5	NMFS	Yakima	166.1	1	Ladder exit
Sunnyside Dam Center	6	NMFS	Yakima	166.1	1	Ladder exit
Sunnyside Dam Left-Bank	7	NMFS	Yakima	166.1	1	Ladder exit
Sunnyside Dam Left-Bank	7	NMFS	Yakima	166.1	2	Downstream
Wapato Dam Left-Bank	8	Lotek	Yakima	170.6	1	Ladder exit
Wapato Dam Center	9	Lotek	Yakima	170.6	1	Ladder exit
Wapato Dam Center	9	Lotek	Yakima	170.6	2	Downstream
Wapato Dam Right-Bank	10	Lotek	Yakima	170.6	1	Ladder exit
Wapato Dam Right-Bank	10	Lotek	Yakima	170.6	2	Downstream
Roza Dam Left-Bank	11	NMFS	Yakima	204.6	1	Ladder exit
Roza Dam Left-Bank	11	NMFS	Yakima	204.6	2	Downstream
Roza Dam Right-Bank	12	NMFS	Yakima	204.6	1	Gallery inside
Roza Dam Right-Bank	12	NMFS	Yakima	204.6	2	Gallery outside
Satus Creek	20	Lotek	Satus	19.3	1	Across
Toppenish Creek	30	Lotek	Toppenish	16.1	1	Downstream
Toppenish Creek	30	Lotek	Toppenish	16.1	2	Upstream
Cowiche Dam Left-Bank	40	NMFS	Naches	5.8	1	Ladder exit
Cowiche Dam Left-Bank	40	NMFS	Naches	5.8	2	Downstream
Wapatox Dam Left-Bank	41	Lotek	Naches	27.4	1	Downstream
Wapatox Dam Left-Bank	41	Lotek	Naches	27.4	2	Upstream

Appendix Table A.3. Locations and antennae configuration for fixed-site telemetry monitors, 1991-92.

Monitor Monitor location	Monitor number	type	River River	Antennae km	Antennae number	location
Horn Rapids Dam	72	Lotek	Yakima	28.8	1	Downstream
Horn Rapids Dam	72	Lotek	Yakima	28.8	2	Upstream
Chandler Juvenile Facility	1	NMFS	Yakima	74.1	1	Across
Prosser Dam Right-Bank	2	NMFS	Yakima	75.4	1	Denil pool
Prosser Dam Right-Bank	2	NMFS	Yakima	75.4	2	Ladder exit
Prosser Dam Right-Bank	70	NMFS	Yakima	75.4	1	Ladder entrance
Prosser Dam Center	3	NMFS	Yakima	75.4	1	Ladder entrance
Prosser Dam Center	3	NMFS	Yakima	75.4	2	Ladder exit
Prosser Dam Left-Bank	4	NMFS	Yakima	75.4	1	Ladder entrance
Prosser Dam Left-Bank	4	NMFS	Yakima	75.4	2	Ladder exit
Prosser Dam Left-Bank	71	Lotek	Yakima	75.4	1	Downstream
Sunnyside Dam Right-Bank	5	NMFS	Yakima	166.1	1	Ladder exit
Sunnyside Dam Center	6	NMFS	Yakima	166.1	1	Ladder exit
Sunnyside Dam Left-Bank	7	NMFS	Yakima	166.1	1	Ladder exit
Sunnyside Dam Left-Bank	7	NMFS	Yakima	166.1	2	Downstream
Wapato Dam Left-Bank	8	NMFS	Yakima	170.6	1	Ladder exit
Wapato Dam Center	9	NMFS	Yakima	170.6	1	Ladder exit
Wapato Dam Center	9	NMFS	Yakima	170.6	2	Downstream
Wapato Dam Right-Bank	10	NMFS	Yakima	170.6	1	Ladder exit
Wapato Dam Right-Bank	10	NMFS	Yakima	170.6	2	Downstream
Roza Dam Left-Bank	11	NMFS	Yakima	204.6	1	Ladder exit
Roza Dam Left-Bank	11	NMFS	Yakima	204.6	2	Downstream
Roza Dam Right-Bank	12	NMFS	Yakima	204.6	1	Gallery inside
Roza Dam Right-Bank	12	NMFS	Yakima	204.6	2	Gallery outside
Town Diversion Dam	13	Lotek	Yakima	257.0	1	Downstream
Town Diversion Dam	13	Lotek	Yakima	257.0	2	Upstream
Easton Dam	14	Lotek	Yakima	324.0	1	Ladder exit
Easton Dam	14	Lotek	Yakima	324.0	2	Downstream
Satus Creek	20	Lotek	Satus	19.3	1	Across
Toppenish Creek	30	Lotek	Toppenish	16.1	1	Downstream
Toppenish Creek	30	Lotek	Toppenish	16.1	2	Upstream
Cowiche Dam Left-Bank	40	NMFS	Naches	5.8	1	Ladder entrance
Cowiche Dam Left-Bank	40	NMFS	Naches	5.8	2	Ladder exit
Cowiche Dam Left-Bank	43	Lotek	Naches	5.8	1	Downstream
Wapatox Dam Left-Bank	41	Lotek	Naches	27.4	1	Downstream
Wapatox Dam Left-Bank	41	Lotek	Naches	27.4	2	Upstream
Rattlesnake Creek	42	NMFS	Rattlesnake	0.8	1	Across

Appendix Table A.4. Locations and antennae configuration for fixed-site telemetry monitors, 1992-93.

Monitor location	Monitor number	Monitor type	River	River km	Antennae number	Antennae location
Prosser Dam Left-Bank	71	Lotek	Yakima	75.4	1	Across
Roza Dam Right-Bank	12	NMFS	Yakima	204.6	1	Across
Town Diversion Dam	13	Lotek	Yakima	257.0	1	Downstream
Town Diversion Dam	13	Lotek	Yakima	257.0	2	Upstream
Easton Dam	14	Lotek	Yakima	324.0	2	Downstream
Wilson Creek	51	NMFS	Wilson	0.8	1	Across
Cherry Creek	52	NMFS	Cherry	0.2	1	Across
Manatash Creek	53	NMFS	Manatash	0.4	1	Across
Teanaway River	54	NMFS	Teanaway	0.4	1	Across

Appendix Table B.1. Tagging data and last observations of radio-tagged steelhead, 1989-1990.

Serial number	Collection site	Tagging date	Release site river name	RKm	Length (cm)	Weight (kg)	Sex	Age Fresh	Age Salt	Last observation
B004	Prosser Dam	10/18/89	Yakima	96	60	2.2	F	1	1	Naches River Basin spawner
B005	Prosser Dam	10/5/89	Yakima	96	61	2.2	F			Harvest mortality
B006	Prosser Dam	9/20/89	Yakima	76	65	3.1	F	2	1	Disappear above Prosser Dam
B007	Prosser Dam	1/9/90	Yakima	75	67	2.9	F	2	2	Naches River Basin spawner
B008	Prosser Dam	9/29/89	Yakima	76	76	4.4	M			Disappear above Prosser Dam
B009	Prosser Dam	10/2/89	Yakima	76	67	2.5	F			Disappear below Prosser Dam
B010	Prosser Dam	01/09/90	Yakima	75	76	4.3	F	2	2	Satus Creek Basin spawner
B011	Prosser Dam	9/25/89	Yakima	76	64	2.7				Marion Drain spawner
B012	Prosser Dam	10/4/89	Yakima	96	65	2.6	M			Harvest mortality
B015	Prosser Dam	10/23/89	Yakima	96	65	2.9	F	r	2	Satus Creek Basin spawner
B016	Prosser Dam	10/5/89	Yakima	96	76	4.2	M			Regurgitation
B018	Prosser Dam	9/21/89	Yakima	76	81	5.0				Disappear above Roza Dam
B023	Prosser Dam	10/3/89	Yakima	96	71	3.6	F			Disappear above Prosser Dam
B024	Prosser Dam	9/27/89	Yakima	76	70	3.3	F			Tagging mortality
B025	Prosser Dam	10/10/89	Yakima	96	70	3.6	F			Migration mortality
B026	Prosser Dam	10/4/89	Yakima	96	67	2.7	F			Disappear below Roza Dam
B027	Prosser Dam	10/2/89	Yakima	76	66	2.6	F			Disappear above Prosser Dam
B029	Prosser Dam	10/5/89	Yakima	96	59	2.2	F			Disappear above Satus Creek confluence
B030	Prosser Dam	9/29/89	Yakima	76	74	3.7	M			Disappear above Satus Creek confluence
B031	Prosser Dam	10/23/89	Yakima	96	70	3.4	F	2	2	Satus Creek Basin spawner
B032	Prosser Dam	10/11/89	Yakima	96	69	3.9	F			Below Naches River confluence spawner
B033	Prosser Dam	10/16/89	Yakima	96	60	2.3	F	2	1	Satus Creek Basin spawner
B035	Prosser Dam	10/17/89	Yakima	96	62	2.6	F			Naches River Basin spawner
B037	Prosser Dam	11/6/89	Yakima	96	58	2.2	F	1	1	Disappear above Toppenish Creek confluence
B038	Prosser Dam	3/22/90	Yakima	75	62	2.3	F	4	1	Tagging mortality

Appendix Table B.1. Continued.

Serial number	Collection site	Tagging date	Release site River name	RKm	Length (cm)	Weight (kg)	Sex	Age Fresh	Age Salt	Last observation
B041	Prosser Dam	10/23/89	Yakima	96	72	3.4	F	2	2	Satus Creek Basin spawner
B045	Prosser Dam	4/2/90	Yakima	75	64	2.3	F	1	1	Disappear below Prosser Dam
B048	Roza Dam	4/3/90	Yakima	206	63		M			Teanaway River Basin spawner
B051	Prosser Dam	4/12/90	Yakima	75	62	2.0	F	2	1	Tagging mortality
B052	Prosser Dam	10/24/89	Yakima	96	73	4.0	F			Regurgitation
B068	Prosser Dam	10/30/89	Yakima	96	76	4.1	F	2	2	Satus Creek Basin spawner
B070	Prosser Dam	3/30/90	Yakima	75	74	3.9	F	r	2	Naches River Basin spawner
B073	Prosser Dam	10/23/89	Yakima	96	61	2.4	F	2	1	Naches River Basin spawner
B074	Prosser Dam	10/23/89	Yakima	96	70	3.7	F	r	2	Naches River Basin spawner
B077	Prosser Dam	12/7/89	Yakima	75	81	5.0	F			Regurgitation
B078	Prosser Dam	11/14/89	Yakima	75	66	2.9				Regurgitation
B079	Prosser Dam	11/20/89	Yakima	75	66	2.9		1	2	Regurgitation
B080	Prosser Dam	12/7/89	Yakima	75	71	3.4	M	r	2	Regurgitation
B109	Prosser Dam	2/27/90	Yakima	75	73	3.5	F	2	2	Disappear below Prosser Dam
B110	Prosser Dam	3/22/90	Yakima	75	63	2.0	F	2	1	Disappear below Prosser Dam
B133	Roza Dam	5/7/90	Yakima	206	63	2.0	F			Roza Canyon spawner
B134	Roza Dam	5/7/90	Yakima	206	72	3.4	F			Roza Canyon spawner

r = Unreadable freshwater age.

Appendix Table B.2. Tagging data and last observations of radio-tagged steelhead, 1990-1991.

Serial Number	Collection site	Tagging date	Release site River name	RKm	Length (cm)	Weight (kg)	Sex	Age Fresh	Age Salt	Last observation
A002	Prosser Dam	02/17/91	Yakima	75	68	2.8	F	1	1	Regurgitation
A007	Prosser Dam	10/02/90	Yakima	75	72	2.9		2	2	Satus Creek Basin spawner
A011	Prosser Dam	11/13/90	Yakima	75	67	2.7		2	2	Tagging mortality
A015	Prosser Dam	02/20/91	Yakima	75	66	2.2	F			Satus Creek Basin spawner
A025	Prosser Dam	09/20/90	Yakima	75	70	3.2	F	1	2	Naches River Basin spawner
A028	Prosser Dam	02/05/91	Yakima	75	69	2.6	F			Regurgitation
A028	Prosser Dam	02/06/91	Yakima	75	62	1.9				Tagging mortality (reused tag)
A039	Prosser Dam	09/25/90	Yakima	75	75	3.9		2	2	Satus Creek Basin spawner
A043	Prosser Dam	09/27/90	Yakima	75	72	3.9		1	2	Holding mortality
A047	Prosser Dam	09/25/90	Yakima	75	76	4.0		2	2	Satus Creek Basin spawner
A050	Prosser Dam	03/04/91	Yakima	75	73	3.4	F			Regurgitation
A051	Prosser Dam	12/18/90	Yakima	75	68	2.4	F	2	2	Toppenish Creek spawner
A060	Prosser Dam	03/18/91	Yakima	75	75	3.7	F	2	2	Naches River Basin spawner
A065	Prosser Dam	02/12/91	Yakima	75	69	2.5		2	1	Toppenish Creek spawner
A068	Prosser Dam	03/27/91	Yakima	75	76	3.2	F	2	2	Tagging mortality
A074	Prosser Dam	12/12/90	Yakima	75	79	4.2	F	2	2	Harvest mortality
A085	Prosser Dam	09/27/90	Yakima	75	73	3.7		2	2	Holding mortality
A089	Prosser Dam	09/26/90	Yakima	75	66	2.3	F	2	2	Naches River Basin spawner
A097	Prosser Dam	02/17/91	Yakima	75	77	3.3	M	r	2	Regurgitation
A103	Prosser Dam	09/25/90	Yakima	75	67	2.7		2	2	Holding mortality
A116	Prosser Dam	02/17/91	Yakima	75	65	2.6	M		2	Naches River Basin spawner
A121	Prosser Dam	09/27/90	Yakima	75	74	3.4		2	2	Disappear below Prosser Dam
A124	Prosser Dam	04/18/91	Yakima	75	78	3.9	F	r	2	Naches River Basin spawner
A127	Prosser Dam	09/19/90	Yakima	75	72	3.5	F	2	2	Regurgitation
A128	Prosser Dam	11/19/90	Yakima	75	71	3.5	F	2	2	Satus Creek Basin spawner
A129	Prosser Dam	10/04/90	Yakima	75	75	4.0	F	2	2	Naches River Basin spawner

Appendix Table B.2. Continued.

Serial Number	Collection site	Tagging date	Release site River name	RKm	Length (cm)	Weight (kg)	Sex	Age Fresh	Age Salt	Last observation
A130	Prosser Dam	02/13/91	Yakima	75	69	2.9	F			Satus Creek Basin spawer
A132	Prosser Dam	10/31/90	Yakima	75	67	2.5	F	2	2	Naches River Basin spawner
A133	Prosser Dam	04/15/91	Yakima	75	71	3.5	F	2	2	Naches River Basin spawner
A140	Prosser Dam	10/05/90	Yakima	75	68	2.9		2	2	Satus Creek Basin spawner
A147	Prosser Dam	02/05/91	Yakima	75	69	2.6		2	2	Naches River Basin spawner
A161	Prosser Dam	11/08/90	Yakima	75	76	3.9	F	2	2	Naches River Basin spawner
A162	Prosser Dam	02/12/91	Yakima	75	68	2.9		2	2	Regurgitation
A166	Prosser Dam	11/01/90	Yakima	75	66	2.4	F			Naches River Basin spawner
A168	Prosser Dam	10/23/90	Yakima	75	69	2.8	F	1	1	Holding mortality
A171	Prosser Dam	10/11/90	Yakima	75	69	2.8	F	4	1	Satus Creek Basin spawner
A171	Prosser Dam	10/05/90	Yakima	75	68	0.0	F			Regurgitation (reused tag)
A179	Prosser Dam	03/28/91	Yakima	75	69	2.6	F	1	2	Tagging mortality
A193	Prosser Dam	10/05/90	Yakima	75	74	3.9	F	2	2	Satus Creek Basin spawner
A196	Prosser Dam	11/14/90	Yakima	75	73	3.4	F			Toppenish Creek spawner
A196	Prosser Dam	10/04/90	Yakima	75	64	2.5	M	2	2	Regurgitation (reused tag)
A198	Prosser Dam	10/24/90	Yakima	75	74	3.3	F	2	2	Roza Dam tailwater spawner
A201	Prosser Dam	12/18/90	Yakima	75	66	2.3	F	2	2	Tagging mortality
A203	Prosser Dam	10/24/90	Yakima	75	78	4.0	M	2	2	Naches River Basin spawner
A213	Prosser Dam	04/09/91	Yakima	75	71	2.9	F	r	2	Disappear below Horn Rapids Dam
A213	Prosser Dam	02/17/91	Yakima	75	77	3.9	F			Regurgitation
A217	Prosser Dam	02/20/91	Yakima	75	71	2.7	F			Regurgitation
A225	Prosser Dam	10/05/91	Yakima	75	71	3.4		2	2	Roza Dam tailwater spawner
A226	Prosser Dam	11/14/90	Yakima	75	73	3.2	F			Toppenish Creek spawner
A232	Prosser Dam	11/01/90	Yakima	75	68	2.8	F			Satus Creek Basin spawner
A234	Prosser Dam	10/11/90	Yakima	75	76	3.9	M	1	2	Roza Dam tailwater spawner
A242	Prosser Dam	02/17/91	Yakima	75	72	3.1	M			Regurgitation
A255	Prosser Dam	02/05/91	Yakima	75	68	2.5	F	2	2	Satus Creek Basin spawner

r = Unreadable freshwater age.

Appendix Table B.3. Tagging data and last observations of radio-tagged steelhead, 1991-1992.

Serial Number	Collection site	Tagging date	Release site River name	RKm	Length (cm)	Weight (kg)	Sex	Age Fresh	Age Salt	Last observation
C002	Prosser Dam	09/18/91	Yakima	75	66	2.7	M			Naches River Basin spawner
C005	Prosser Dam	11/14/91	Yakima	75	63	2.5	F	r	1	Disappear below Wapato Dam
C006	Prosser Dam	09/27/91	Yakima	75	64	2.5	M	2	1	Satus Creek Basin spawner
C007	Prosser Dam	10/04/91	Yakima	75	70	2.9	F			Naches River Basin spawner
C009	Prosser Dam	11/21/91	Yakima	75	63	2.7	F	1	1	Regurgitation
C012	Prosser Dam	12/06/91	Yakima	75	62	2.5	F	2	1	Satus Creek Basin spawner
C013	Prosser Dam	10/11/91	Yakima	75	67	2.9	M			Satus Creek Basin spawner
C021	Prosser Dam	12/11/91	Yakima	75	66	2.7	M	r	1	Marion Drain spawner
C024	Prosser Dam	03/03/92	Yakima	75	70	2.9	F	2	2	Regurgitation
C029	Prosser Dam	11/13/91	Yakima	75	62	2.3	F	2	1	Toppenish Creek spawner
C035	Prosser Dam	10/25/91	Yakima	75	69	3.2	F	1	2	Satus Creek Basin spawner
C036	Prosser Dam	09/26/91	Yakima	75	70	3.4	F	2	2	Toppenish Creek spawner
C038	Prosser Dam	10/03/91	Yakima	75	62	2.3	M	2	1	Satus Creek Basin spawner
C039	Prosser Dam	11/21/91	Yakima	75	67	2.9	M	1	1	Satus Creek Basin spawner
C041	Prosser Dam	10/11/91	Yakima	75	68	2.9	F	2	2	Toppenish Creek spawner
C043	Prosser Dam	12/05/91	Yakima	75	63	2.3	M			Satus Creek Basin spawner
C045	Prosser Dam	12/09/91	Yakima	75	65	2.5	F	2	2	Tagging mortality
C046	Prosser Dam	10/22/91	Yakima	75	62	2.3	M	1	1	Satus Creek Basin spawner
C048	Prosser Dam	02/26/92	Yakima	75	64	2.5	F	r	2	Regurgitation
C050	Prosser Dam	11/07/91	Yakima	75	73	3.6	f	2	2	Regurgitation
C050	Prosser Dam	11/12/91	Yakima	75	66	2.7	M	2	2	Harvest mortality (reused tag)
C051	Prosser Dam	03/31/92	Yakima	75	66	2.5	F	1	1	Toppenish Creek spawner
C053	Prosser Dam	10/18/91	Yakima	75	74	3.9	F	1	2	Naches River Basin spawner
C055	Prosser Dam	11/14/91	Yakima	75	65	2.9	F	2	1	Satus Creek Basin spawner
C071	Prosser Dam	09/18/91	Yakima	75	63	2.7	F	2	2	Holding mortality
C072	Prosser Dam	11/12/91	Yakima	75	62	2.3	F	r	1	Regurgitation

Appendix Table B.3. Continued.

Serial Number	Collection site	Tagging date	Release site River name	RKm	Length (cm)	Weight (kg)	Sex	Age Fresh	Age Salt	Last observation
C073	Prosser Dam	10/01/91	Yakima	75	61	2.3	F	2	1	Regurgitation
C074	Prosser Dam	11/15/91	Yakima	75	63	2.5	F	2	1	Naches River Basin spawner
C075	Prosser Dam	10/04/91	Yakima	75	71	3.4	F	1	2	Satus Creek Basin spawner
C076	Prosser Dam	11/22/91	Yakima	75	69	3.2	F	1	2	Satus Creek Basin spawner
C077	Prosser Dam	10/11/91	Yakima	75	63	2.3	F	2	1	Tagging mortality
C078	Prosser Dam	12/06/91	Yakima	75	64	2.7	M			Satus Creek Basin spawner
C079	Prosser Dam	12/13/91	Yakima	75	66	2.7	M	2	2	Toppenish Creek spawner
C083	Prosser Dam	10/28/91	Yakima	75	62	2.3	F	2	2	Regurgitation
C084	Prosser Dam	10/18/91	Yakima	75	62	2.3	F	2	2	Satus Creek Basin spawner
C087	Prosser Dam	03/06/92	Yakima	75	67	2.7	F	2	1	Toppenish Creek spawner
C106	Prosser Dam	09/27/91	Yakima	75	62	2.5	F	r	1	Naches River Basin spawner
C107	Prosser Dam	11/14/91	Yakima	75	79	5.0	F	2	2	Naches River Basin spawner
C108	Prosser Dam	11/20/91	Yakima	75	66	2.7	M	1	1	Migration mortality
C109	Prosser Dam	10/02/91	Yakima	75	69	3.4	F	2	2	Disappear below Toppenish Creek confluence
C110	Prosser Dam	10/11/91	Yakima	75	71	2.9	F	2	2	Satus Creek Basin spawner
C112	Prosser Dam	12/05/91	Yakima	75	67	2.7	M	r	1	Satus Creek Basin spawner
C116	Prosser Dam	10/24/91	Yakima	75	64	2.7	F	1	2	Naches River Basin spawner
C118	Prosser Dam	12/11/91	Yakima	75	62	2.3	M	2	1	Satus Creek Basin spawner
C119	Prosser Dam	02/28/92	Yakima	75	80	4.4	M	2	2	Naches River Basin spawner
C121	Prosser Dam	04/03/92	Yakima	75	69	2.9	M	2	2	Tagging mortality
C125	Prosser Dam	11/08/91	Yakima	75	68	2.9	M	1	2	Teanaway River Basin spawner
C144	Prosser Dam	10/02/91	Yakima	75	64	2.5	F	2	1	Upper Yakima River spawner
C145	Prosser Dam	10/04/91	Yakima	75	62	2.5	M	r	1	Tagging mortality
C146	Prosser Dam	11/13/91	Yakima	75	62	2.3	M			Toppenish Creek spawner
C147	Prosser Dam	11/20/91	Yakima	75	72	3.4	F	1	2	Satus Creek Basin spawner
C148	Prosser Dam	11/27/91	Yakima	75	72	3.4	F	2	2	Disappear below Horn Rapids Dam

Appendix Table B.3. Continued.

Serial Number	Collection site	Tagging date	Release site River name	RKm	Length (cm)	Weight (kg)	Sex	Age Fresh	Age Salt	Last observation
C153	Prosser Dam	12/06/91	Yakima	75	68	2.7	F	2	2	Regurgitation
C154	Prosser Dam	02/11/92	Yakima	75	68	2.7	F	r	2	Regurgitation
C155	Prosser Dam	10/16/91	Yakima	75	63	2.3	M	r	1	Satus Creek Basin spawner
C157	Prosser Dam	03/13/92	Yakima	75	61	2.0	M	2	2	Naches River Basin spawner
C158	Prosser Dam	10/18/91	Yakima	75	63	2.7	M	2	1	Disappear below Naches River confluence
C160	Prosser Dam	10/29/91	Yakima	75	80	5.2	F	2	3	Naches River Basin spawner
C211	Prosser Dam	09/26/91	Yakima	75	70	3.6	F	1	2	Tagging mortality
C212	Prosser Dam	11/13/91	Yakima	75	75	4.1	F	1	2	Satus Creek Basin spawner
C213	Prosser Dam	11/20/91	Yakima	75	69	3.4	F	1	2	Satus Creek Basin spawner
C214	Prosser Dam	10/02/91	Yakima	75	62	2.5	F	2	1	Roza Canyon spawner
C215	Prosser Dam	11/27/91	Yakima	75	66	2.9	F	r	2	Naches River Basin spawner
C216	Prosser Dam	12/06/91	Yakima	75	78	4.3	M	2	2	Satus Creek Basin spawner
C217	Prosser Dam	02/14/92	Yakima	75	64	2.2	M	2	1	Disappear below Horn Rapids Dam
C219	Prosser Dam	10/08/91	Yakima	75	68	2.9	M	2	1	Naches River Basin spawner
C223	Prosser Dam	10/15/91	Yakima	75	81	5.1	F	r	2	Disappear below Horn Rapids Dam
C224	Prosser Dam	03/16/92	Yakima	75	67	2.6	F	2	1	Naches River Basin spawner
C226	Prosser Dam	10/29/91	Yakima	75	62	2.5	M	2	1	Disappear above Prosser Dam
C233	Prosser Dam	10/18/91	Yakima	75	63	2.5	F	2	1	Satus Creek Basin spawner
C246	Prosser Dam	09/27/91	Yakima	75	61	2.5	F	2	1	Satus Creek Basin spawner
C247	Prosser Dam	11/14/91	Yakima	75	77	4.1	F	1	2	Satus Creek Basin spawner
C248	Prosser Dam	10/03/91	Yakima	75	61	2.5	F	2	1	Satus Creek Basin spawner
C249	Prosser Dam	11/22/91	Yakima	75	72	3.2	M	1	2	Satus Creek Basin spawner
C250	Prosser Dam	10/11/91	Yakima	75	63	2.3	M	1	1	Satus Creek Basin spawner
C251	Prosser Dam	12/05/91	Yakima	75	67	2.9	M	r	1	Regurgitation
C258	Prosser Dam	12/10/91	Yakima	75	75	4.1	F	2	2	Disappear below Satus Creek confluence
C259	Prosser Dam	10/25/91	Yakima	75	77	3.4	F	2	2	Satus Creek Basin spawner

Appendix Table B.3. Continued.

Serial Number	Collection site	Tagging date	Release site River name	RKm	Length (cm)	Weight (kg)	Sex	Age Fresh	Age Salt	Last observation
C260	Prosser Dam	02/29/92	Yakima	75	68	2.7	M	2	1	Naches River Basin spawner
C264	Prosser Dam	11/08/91	Yakima	75	62	2.3	M	r	1	Toppenish Creek spawner
C265	Prosser Dam	04/24/92	Yakima	75	70	3.4	M			Disappear below Prosser Dam
C283	Prosser Dam	11/13/91	Yakima	75	65	2.7	M	2	1	Disappear below Horn Rapids Dam
C284	Prosser Dam	12/04/91	Yakima	75	72	3.4	F	2	2	Naches River Basin spawner
C285	Prosser Dam	10/03/91	Yakima	75	67	2.7	F	2	2	Satus Creek Basin spawner
C287	Prosser Dam	10/09/91	Yakima	75	67	2.9	F	1	2	Satus Creek Basin spawner
C294	Prosser Dam	10/18/91	Yakima	75	69	3.2	F	1	2	Satus Creek Basin spawner
C295	Prosser Dam	12/10/91	Yakima	75	73	3.9	M	1	2	Satus Creek Basin spawner
C297	Prosser Dam	02/25/92	Yakima	75	62	2.3	M	2	1	Naches River Basin spawner
C301	Prosser Dam	03/18/92	Yakima	75	62	2.4	F	2	1	Disappear below Prosser Dam
C302	Prosser Dam	10/18/91	Yakima	75	64	3.1	F	2	1	Disappear below Horn Rapids Dam
C305	Prosser Dam	11/07/91	Yakima	75	61	2.3	F	2	1	Satus Creek Basin spawner

r = Unreadable freshwater age.

Appendix Table B.4. Tagging data and last observations of radio-tagged steelhead, 1992-1993.

Serial number	Collection site	Tagging date	Release site River name	RKm	Length (cm)	Weight (kg)	Sex	Age Fresh	Age Salt	Last observation
C020	Swauk Weir	05/13/93	Swauk Creek	0.2	66	2.8	F			Tagging mortality
C093	Taneum Weir	04/14/93	Taneum Creek	0.2	60	2.1	F			Upper Yakima River spawner
C113	Roza Trap	09/04/92	Yakima	206	62	2.3		2	1	Teanaway River Basin spawner
C156	Taneum Weir	04/14/93	Taneum Creek	0.2	59	2.1	M			Upper Yakima River spawner
C164	Swauk Weir	05/16/93	Swauk Creek	0.2	71	3.0	M			Tagging mortality
C174	Taneum Weir	05/11/93	Taneum Creek	0.2	54		F			Taneum Creek spawner
C235	Roza Canyon[a]	04/28/93	Yakima	232	70	2.8	F			Teanaway River Basin spawner
C315	Upper Yakima River[a]	03/18/93	Yakima	272						Upper Yakima River spawner

a = electrofishing

Appendix Table C.1. Passage times (days) for radio-tagged steelhead at Yakima River Basin irrigation diversion dams, 1989-90.

Serial number	Prosser Dam Passage time	Sunnyside Dam Passage time	Roza Dam Passage time	Cowiche Dam Passage time
B004		1.8		25.3
B005	13.1			
B006	2.7			
B007	56.6	<0.1		17.5
B008				
B009				
B010	33.0			
B011	19.8			
B012		0.2		
B015				
B016				
B018		0.1	1.7	
B023				
B024				
B025				
B026		0.4	16.7	
B027				
B029	13.1			
B030				
B031	36.8			
B032		0.3		
B033				
B035		0.1		1.0
B037				
B038				
B041				
B045				
B048				

Appendix Table C.1. Continued.

Serial number	Prosser Dam Passage time	Sunnyside Dam Passage time	Roza Dam Passage time	Cowiche Dam Passage time
B051				
B052				
B068				
B070	2.0	0.1		1.4
B073		0.1		
B074		0.3		0.8
B077				
B078				
B079				
B080				
B109				
B110				
B133				
B134				

Appendix Table C.2. Passage times (days) for and fish-ladder use by radio-tagged steelhead at Yakima River Basin irrigation diversion dams, 1990-91.

Serial number	Prosser Dam		Sunnyside Dam		Wapato Dam		Cowiche Dam		Wapatox Dam
	Fish ladder	Passage time	Fish ladder	Passage time	Fish ladder	Passage time	Fish ladder	Passage time	Passge time
A002									
A007	Left	24.0							
A011									
A015	Left	29.3							
A025	Left	36.1	Left	43.1	Center	6.9			
A028									
A028									
A039	Right	49.0							
A043									
A047	Right	21.4							
A050									
A051	Left	43.8							
A060		5.4					Yes	0.7	
A065	Right	2.1							
A068									
A074	Left	48.0			Left	11.8			
A085	Center	0.9							
A089	Center	28.2	Center	2.6	Right	7.9			
A097									
A103	Right	0.1							

Appendix Table C.2. Continued.

Serial number	Prosser Dam Fish ladder	Prosser Dam Passage time	Sunnyside Dam Fish ladder	Sunnyside Dam Passage time	Wapato Dam Fish ladder	Wapato Dam Passage time	Cowiche Dam Fish ladder	Cowiche Dam Passage time	Wapatox Dam Passge time
A116	Left	26.4			Right	<0.1	Yes	<0.1	1.1
A121									
A124	Left	1.2	Left	0.8			Yes	1.3	1.0
A127									
A128	Left								
A129	Left	16.1	Right	1.1					
A130									
A132	Right	10.4	Left	0.1	Left	0.8	No	4.1	
A133	Left	1.0	Left	<0.1			No	0.6	0.8
A140	Left	3.0							
A147	Left	11.5	Left	0.8			No	1.1	
A161	Left	1.3	Center	0.1			No	16.6	
A162									
A166	Left	0.1			Right	11.8			
A168	Right	<0.1							
A171		34.6							
A171		<0.1							
A179									
A193	Center	11.5							
A196	Release								

Appendix Table C.2. Continued.

Serial number	Prosser Dam Fish ladder	Prosser Dam Passage time	Sunnyside Dam Fish ladder	Sunnyside Dam Passage time	Wapato Dam Fish ladder	Wapato Dam Passage time	Cowiche Dam Fish ladder	Cowiche Dam Passage time	Wapatox Dam Passge time
A196									
A198	Right	0.4	Right	0.1					
A201									
A203	Right	0.4	Left	<0.1	Right	0.1			<0.1
A213									
A213									
A217									
A225	Center	20.3	Left	0.8					
A226		93.3							
A232		95.3							
A234	Center	12.6	Left	0.2					
A242									
A255		43.5							

Appendix Table C.3. Passage times (days) for and fish-ladder use by radio-tagged steelhead at Yakima River Basin irrigation diversion dams, 1991-92.

Serial number	Prosser Dam Fish ladder	Prosser Dam Passage time	Sunnyside Dam Fish ladder	Sunnyside Dam Passage time	Wapato Dam Fish ladder	Wapato Dam Passage time	Roza Dam Passage time	Cowiche Dam Fish ladder	Cowiche Dam Passage time	Wapatox Dam Passage time
C002		35.3	Left	<0.1	Left	0.1		No	7.2	3.5
C005		9.7	Right	1.5						
C006	Left	18.0								
C007	Left	8.6			Center	12.5				
C009										
C012	Right	1.6								
C013	Left	0.6								
C021	Left	5.0								
C024										
C029		5.2								
C035	Right	0.2								
C036	Left	1.1								
C038	Left	0.1								
C039		63.9								
C041	Right	0.5								
C043		0.2								
C045										
C046	Right	0.3								
C048										
C050										
C050		0.3								

Appendix Table C.3. Continued.

Serial number	Prosser Dam Fish ladder	Prosser Dam Passage time	Sunnyside Dam Fish ladder	Sunnyside Dam Passage time	Wapato Dam Fish ladder	Wapato Dam Passage time	Roza Dam Passage time	Cowiche Dam Fish ladder	Cowiche Dam Passage time	Wapatox Dam Passage time
C051										
C053	Left	0.1	Right	1.3	Left	11.7		Yes	1.1	14.9
C055	Right	0.3								
C071	Left	28.4								
C072										
C073										
C074		0.9	Left	1.6				No	0.7	4.9
C075	Center	17.4								
C076	Left	56.1								
C077										
C078		0.3								
C079	Left	44.0								
C083										
C084		27.8								
C087		10.5								
C106	Right	128.3	Center	0.9				No	1.9	1.5
C107	Right	3.4	Center	0.9				No	3.6	3.0
C108										
C109	Left	0.6								
C110	Left	0.5								
C112		6.2								
C116	Left	22.6								

Appendix Table C.3. Continued.

Serial number	Prosser Dam Fish ladder	Prosser Dam Passage time	Sunnyside Dam Fish ladder	Sunnyside Dam Passage time	Wapato Dam Fish ladder	Wapato Dam Passage time	Roza Dam Passage time	Cowiche Dam Fish ladder	Cowiche Dam Passage time	Wapatox Dam Passage time
C118	Right	49.6								
C119	Left	3.3	Center	0.9				Yes	1.7	
C121										
C125		0.5	Left	0.8	Center	0.1	1.9			
C144	Left	1.6	Center	1.9	Center	1.2	1.3			
C145										
C146		28.1								
C147										
C148										
C153										
C154										
C155	Center	57.2								
C157		1.5	Left	<0.1				No	0.5	2.0
C158	Right	105.7	Right	1.4						
C160	Center	8.3	Center	<0.1	Center	10.6		Yes	8.5	
C211										
C212		24.4								
C213		14.1								
C214	Center	19.3	Right	2.0	Center	7.4	4.6			
C215	Right	88.2			Center	24.3		No	1.0	0.1
C216	Right	0.9								
C217										

Appendix Table C.3. Continued.

Serial number	Prosser Dam Fish ladder	Prosser Dam Passage time	Sunnyside Dam Fish ladder	Sunnyside Dam Passage time	Wapato Dam Fish ladder	Wapato Dam Passage time	Roza Dam Passage time	Cowiche Dam Fish ladder	Cowiche Dam Passage time	Wapatox Dam Passage time
C219		2.8	Center	2.5	Left	31.4		No	1.7	1.3
C223										
C224	Left	19.3	Left	<0.1				No	1.8	0.4
C226	Left	43.9								
C233	Right	19.7								
C246	Left	20.8								
C247		0.2								
C248	Left	0.6								
C249		5.6								
C250	Left	1.7								
C251										
C258		0.7								
C259		0.6								
C260		5.4	Center	1.4	Left	0.1		No	18.5	
C264		1.0								
C265										
C283										
C284		0.8	Left	0.1	Center	2.0		No	1.2	7.9
C285	Center	113.6								
C287	Left	1.7								
C294	Center	0.1								
C295	Left	3.0								
C297	Left	9.3	Left	0.1	Center	0.2		No	1.7	1.5

Appendix Table C.3. Continued.

Serial number	Prosser Dam Fish ladder	Prosser Dam Passage time	Sunnyside Dam Fish ladder	Sunnyside Dam Passage time	Wapato Dam Fish ladder	Wapato Dam Passage time	Roza Dam Passage time	Cowiche Dam Fish ladder	Cowiche Dam Passage time	Wapatox Dam Passage time
C301										
C302										
C305	Right	0.9								

Appendix Table D.1. Pre-spawning, winter holding, and spawning behavior of radio-tagged steelhead in the Yakima River Basin, 1989-90.

Serial number	Holding location River name	RKm	Holding dates	Spawning drainage entry date	Spawning location River name	RKm	Spawning dates
B004	Yakima	170-183		1/16/90	Little Naches	5	4/4-4/11
B005	Yakima	96-130	11/8/89-?[a]				
B006	Yakima	98-101	09/27/89-03/18/90				
B007	Yakima	<76		3/20/92	Naches	26	4/17-4/28
B008	Yakima	106-114	10/12/89-03/13/90				
B009							
B010	Yakima	<76		3/7/90	Satus Creek	27	3/13-4/3
B011	Marion Drain	5	11/01/89-01/10/90	11/1/89	Marion Drain	22	1/17-1/24
B012	Yakima	104-156	10/12/89-02/23/90				
B015	Yakima	101-117	10/25/89-01/10/90	1/17/90	Satus Creek	>6	2/14-3/17
B016							
B018							
B023							
B024							
B025	Yakima	177-190	11/15/89-02/08/90		Yakima	178	2/21-3/6
B026							
B027	Yakima	108-111	10/12/89-12/20/89				
B029	Yakima	111-127	10/25/89-03/22/90				
B030	Yakima	119-124					
B031	Yakima	119-124	12/20/89-01/24/90	1/25/90	Logy Creek	2	3/13-4/1
B032	Yakima	99-122	10/12/89-03/28/90		Yakima	180	4/3-4/9

Appendix Table D.1. Continued.

Serial number	Holding location River name	RKm	Holding dates	Spawning drainage entry date	Spawning location River name	RKm	Spawning dates
B033	Yakima	96-135	10/18/89-01/03/90	1/3/90	Satus Creek	40	1/26-2/23
B035	Naches	5-24	12/08/89-03/01/90	12/8/89	Naches	>24	>3/1
B037							
B038							
B041	Yakima	104-116	10/25/89-01/03/90	1/10/90	Satus Creek	45	2/14-2/23
B045							
B048	Yakima	202		5/1/90-5/8/90	North Fork Teanaway	10	5/15-5/30
B051							
B052							
B068	Yakima	109-119	11/14/89-01/24/90	1/26/90	Satus Creek	>3	>1/26
B070	Yakima	<76		4/9/90	Naches	24	4/17-5/8
B073	Yakima	191	11/15/89-02/23/90	3/21/90	Naches	>10	3/29-5/1
B074	Yakima	153-156	11/15/89-03/06/90	3/17/90	Naches	>5	3/17-4/3
B077							
B078							
B079							
B080							
B109							
B110							
B133	Yakima	<203			Yakima	219	5/8-5/15
B134	Yakima	<203			Yakima	211	5/9-5/14

[a]-Sport catch

Appendix Table D.2. Pre-spawning, winter holding, and spawning behavior of radio-tagged steelhead in the Yakima River Basin, 1990-91.

Serial number	Holding location River name	RKm	Holding dates	Spawning drainage entry date	Spawning location River name	RKm	Spawning dates
A002							
A007	Yakima	106-113	10/31/90-01/30/91	1/30/91	Satus Creek	64	2/20-3/8
A011							
A015	Yakima	<76		4/2/91	Satus Creek	19	4/3
A025	Yakima	167-170	12/11/90-02/13/91	2/20/91	Naches	13	3/13-3/26
A028							
A028							
A039	Yakima	100-113	11/20/90-01/30/91	2/6/91	Dry Creek	11	3/13-317
A043							
A047	Yakima	106-113	10/31/90-01/30/91	2/6/91	Satus Creek	58	3/5-3/12
A050							
A051	Yakima	<76		3/13/91	Toppenish Creek	74	4/17-4/23
A060	Yakima	<76		4/5/91	Naches	55	5/20
A065	Yakima	<76		4/2/91	Toppenish Creek	90	5/6
A068							
A074	Yakima	76	12/12/90-01/30/91				
A085	Yakima	132	10/23/90-?[a]				
A089	Yakima	122-144	10/31/90-01/23/91	3/13/91	Naches	13	4/2
A097							
A103	Yakima	127-132	10/2/90-?[a]				

Appendix Table D.2. Continued.

Serial number	Holding location River name	RKm	Holding dates	Spawning drainage entry date	Spawning location River name	RKm	Spawning dates
A116	Yakima	<76		4/5/91	Naches	27	4/18
A121							
A124	Yakima	<76		4/30/91	Naches	34	5/13-5/20
A127							
A128	Yakima	84	12/14/90-01/30/91	2/6/91	Logy Creek	8	4/12
A129	Yakima	183	12/11/90-02/06/91	2/6/91	Naches	27	3/25
A130	Yakima	<76		2/20/91-3/5/91	Satus Creek	8	2/20-3/13
A132	Yakima	85-96	11/20/90-03/13/91	4/5/91	Naches	8	4/30-5/13
A133	Yakima	<76		4/26/91	Naches	29	5/5-5/20
A140	Yakima	111-113	10/10/90-01/08/91	1/16/91	Satus Creek	63	2/18-2/21
A147	Yakima	<76		4/28/91	Naches	>5	>4/29
A161				1/30/91	Nahces	>5	2/16-3/13
A162							
A166	Yakima	100-129	11/06/90-01/30/91	3/13/91	Naches	27	3/26-4/21
A168	Yakima	101-103	11/6/90-?[a]				
A171	Yakima	101-109	11/20/90-02/20/91	2/27/91	Satus Creek	30	3/5-3/30
A171							
A179							
A193	Yakima	108-148	10/18/90-02/06/91	2/15/91	Satus Creek	63	3/12-3/26
A196	Yakima	104-129	11/20/90-03/13/91	4/12/91	Toppenish	58	4/24
A196							
A198	Yakima	143-156	11/06/90-01/30/91		Yakima	203	3/16-5/14

Appendix Table D.2. Continued.

Serial number	Holding location River name	RKm	Holding dates	Spawning drainage entry date	Spawning location River name	RKm	Spawning dates
A201							
A203	Yakima	93-101	11/06/90-03/05/91	4/2/91	Naches	69	4/30-5/13
A213	Yakima	< 76					
A213							
A217							
A225	Yakima	202	12/13/90-03/15/91		Yakima	202	3/15-5/8
A226	Yakima	129-132	12/18/90-02/12/91	2/12/91-3/13/91	Toppenish	>22	3/26-4/16
A232	Yakima	<76	11/01/90-02/05/91	2/20/91	Dry Creek	34	3/19
A234	Yakima	162-166	11/14/90-03/28/91		Yakima	203	4/1
A242							
A255	Yakima	<76		3/26/91	Satus Creek	40	4/12-5/13

[a]-Holding mortality.

Appendix Table D.3. Pre-spawning, winter holding, and spawning behavior of radio-tagged steelhead in the Yakima River Basin, 1991-92.

Serial number	Holding location River name	RKm	Holding dates	Spawning drainage entry date	Spawning location River name	RKm	Spawning dates
C002	Yakima	117-148	10/28/91-03/10/92	3/16/92	Bumping	14	4/17-5/7
C005	Yakima	104-117	12/04/91-03/04/92				
C006	Satus	19	12/11/91-01/15/92	12/11/91	Wilson Charlie Creek	2	02/25
C007	Yakima	170-182	11/21/91-02/21/92	2/21/92-3/4/92	Naches	5	3/4-3/10
C009							
C012	Yakima	101	0.0128244943462	1/30/92	Logy Creek	11	02/11
C013	Yakima	109	10/28/91-01/22/92	1/30/92	Satus Creek	58	03/4-3/10
C021	Yakima	104-132	01/02/92-01/30/92	1/30/92-2/11/92	Marion Drain	29	3/31-4/8
C024							
C029	Yakima	109-137	11/19/91-01/09/92	1/8/92-2/26/92	Toppenish Creek	77	04/23
C035	Yakima	117	11/12/91-01/23/92	1/23/92-1/30/92	Dry Creek	16	>02/11
C036	Yakima	129-132	10/01/91-01/22/92	1/22/92-2/4/92	Toppenish Creek	48	3/11-3/19
C038	Yakima	124-148	10/08/91-02/04/92	02/4/92-2/11/92	Satus Creek	47	03/10-4/8
C039	Yakima	68	11/26/91-01/22/92	01/24/92-1/30/92	Satus Creek	47	03/10-3/19
C041	Toppenish	19	10/28/91-01/22/92	10/15/91-10/28/91	Toppenish Creek	35	02/11
C043	Yakima	90-102	12/10/91-01/23/92	01/23/91-1/30/92	Satus Creek	55	02/22
C045	Yakima	40-47	12/12/91-02/21/92				
C046	Yakima	108-113	10/28/91-01/23/92	01/23/92-1/30/92	Satus Creek	42	>02/21
C048	Yakima						
C050	Yakima						
C050	Yakima						

Appendix Table D.3. Continued.

Serial number	Holding location River name	RKm	Holding dates	Spawning drainage entry date	Spawning location River name	RKm	Spawning dates
C051	Yakima	<76		4/2/92-4/8/92	Toppenish Creek	48	04/23
C053	Yakima	125-161	10/28/91-01/08/92	2/22/92-2/25/92	Naches	42	3/23-4/13
C055	Yakima	95-114	11/19/91-01/23/92	01/23/92-1/30/92	Satus Creek	42	02/22
C071	Yakima	143-146	10/22/91-?[a]				
C072	Yakima						
C073	Yakima						
C074	Yakima	92-137	11/19/91-02/21/92	3/10/92-3/19/92	Naches	48	4/15-4/28
C075	Yakima	108	10/28/91-01/22/92	1/22/92-1/28/92	Satus Creek	49	2/4-2/9
C076	Yakima	69	11/26/91-01/07/92	1/30/92	Satus Creek	72	03/04
C077	Yakima						
C078	Yakima	85-116	12/10/91-01/30/92	1/30/92-2/4/92	Satus Creek	53	2/19-2/22
C079	Yakima	72	12/13/91-01/25/92	2/22/92-3/4/92	Toppenish	60	3/11
C083	Yakima						
C084	Yakima	100-108	11/19/91-01/23/92	1/23/92-2/1/92	Dry Creek	24	2/21-3/12
C087	Yakima	<76		3/16/92-3/19/92	Toppenish	79	04/08
C106	Yakima	40-68	10/01/91-01/22/92	3/31/92-4/5/92	Naches	66	4/23-5/1
C107	Yakima	108-119	12/04/91-03/05/92	4/8/92-4/14/92	Naches	68	4/23-5/1
C108	Yakima						
C109	Yakima	122-126	10/08/91-01/30/92				
C110	Satus Creek	19	12/17/91-01/27/92	12/10/91-12/17/91	Dry Creek	10	1/27-2/4
C112	Yakima	92-95	12/12/91-01/23/92	1/23/92-1/29/92	Satus Creek	58	03/10

Appendix Table D.3. Continued.

Serial number	Holding location River name	RKm	Holding dates	Spawning drainage entry date	Spawning location River name	RKm	Spawning dates
C116	Yakima	113-117	11/19/91-02/21/92	2/21/92-3/4/92	Naches	50	3/10-4/15
C118	Yakima	69-72	12/12/91-01/26/92	2/21/92-2/29/92	Satus Creek	61	4/8-4/20
C119	Yakima	<76		3/19/92-3/26/92	Naches	27	4/22-5/6
C121							
C125	Yakima	182	01/22/91-03/10/92	3/25/92-3/31/92	North Fork Teanaway	8	04/23
C144	Yakima	143-156	10/28/91-02/21/92		Yakima	298	04/15
C145							
C146	Yakima	109	01/02/92-02/04/92	2/4/92-2/26/92	Toppenish	84	3/19-3/31
C147	Yakima	117-122	12/04/91-01/23/92	01/23/92-1/31/92	Satus Creek	48	2/11-2/21
C148	Yakima	72-76					
C153							
C154							
C155	Yakima	71	10/16/91-12/05/91	1/23/92-1/27/92	Dry Creek	30	02/11
C157	Yakima	<76		4/5/92-4/15/92	Bumping	16	5/06-5/13
C158	Yakima	69-71	10/20/91-01/27/92				
C160	Yakima	126-129	11/13/91-02/11/92	3/16/92-3/19/92	Naches	26	4/15-4/20
C211							
C212	Yakima	101-109	12/10/91-01/22/92	01/22/92-1/30/92	Logy Creek	8	3/3-3/7
C213	Yakima	104-109	12/10/91-01/22/92	01/22/92-1/30/92	Dry Creek	11	2/4-2/12
C214	Yakima	126-156	10/28/91-02/21/92		Yakima	205	03/31
C215	Yakima	69-72	11/27/91-02/11/92	3/25/92	Naches	53	4/7-4/20
C216	Yakima	108-114	12/10/91-01/23/92	1/23/92-1/29/92	Dry Creek	47	2/4-2/11

Appendix Table D.3. Continued.

Serial number	Holding location River name	RKm	Holding dates	Spawning drainage entry date	Spawning location River name	RKm	Spawning dates
C217							
C219	Yakima	100-103	10/28/91-01/22/92	3/28/92-3/30/92	Bumping	14	5/4-5/7
C223	Yakima	27					
C224	Yakima	<76		4/10/92	Naches	61	4/17-5/1
C226							
C233	Yakima	109-117	11/19/91-01/23/92	1/23/92-1/29/92	Logy Creek	6	1/30-2/6
C246	Yakima	114-117	10/28/91-01/30/92	1/30/92	Dry Creek	19	02/11
C247	Yakima	113-119	11/19/91-01/30/92	1/30/92-2/4/92	Dry Creek	2	3/1-3/10
C248	Yakima	109-143	10/08/91-01/30/92	1/30/92-2/4/92	Satus Creek	19+	2/26-3/12
C249	Yakima	108-117	12/03/91-01/23/92	1/23/92-1/26/92	Logy Creek	8	2/4-2/11
C250	Yakima	113	10/15/91-02/21/92	2/22/92-3/4/92	Satus Creek	40	03/04
C251							
C258	Yakima	95-113	01/02/92-02/21/92				
C259	Yakima	109-117	10/28/91-01/23/92	1/22/92-1/30/92	Satus Creek	56	2/4-2/6
C260	Yakima	<76		3/23/92-3/28/92	Naches	16	5/6
C264	Yakima	88-124	11/12/91-01/22/92	1/22/92-2/4/92	Toppenish Creek	82	03/31
C265							
C283	Yakima	68-76					
C284	Yakima	96-156	12/10/91-01/30/92	2/21/92-2/25/92	Naches	27+	3/10-3/27
C285	Yakima	47	10/08/91-01/22/92	1/25/92-1/31/92	Dry Creek	26	2/21-3/19
C287	Yakima	111-114	10/22/91-12/04/91	12/4/91-12/10/91	Logy Creek	13	2/4-2/22

Appendix Table D.3. Continued.

Serial number	Holding location River name	RKm	Holding dates	Spawning drainage entry date	Spawning location River name	RKm	Spawning dates
C294	Yakima	111	10/22/91-01/06/92	1/6/92	Satus Creek	68	2/11-2/19
C295	Yakima	113-117	12/14/91-02/04/92	2/4/92-2/9/92	Logy Creek	3	03/10
C297	Yakima	<76		3/31/92-4/3/92	Rattlesnake Creek	>2	5/3-5/27
C301							
C302							
C305	Yakima	102-107	11/12/91-01/22/92	1/22/92-2/1/92	Satus Creek	39	2/11-3/9

[a]-Holding mortality.

Appendix Table D.4. Pre-spawning, winter holding, and spawning behavior of radio-tagged steelhead in the Yakima River Basin, 1992-93.

Serial number	Holding location River name	RKm	Holding dates	Spawning drainage entry date[a]	Spawning location River name	RKm	Spawning dates
C020				5/13/93			
C093				4/14/93[a]	Yakima	267-271	4/15-4/19
C113	Yakima	257-280	10/13/92-04/24/93	4/15/93	Teanaway	>0.3	4/15-4/24
C156				4/14/93[a]	Yakima	267-271	4/19-5/4
C164				5/16/93			
C174				5/11/93	Taneum	2.4	5/17-5/19
C235				5/6/93	West Fork Teanaway	0.2	5/17-5/19
C315					Yakima	274+	4/21-4/30

[a]-Entered Taneum Creek, however spawned in the mainstem Yakima River.