Distribution, Migration Behavior, Habitat Use, and Species Interactions of Fall-Released Juvenile Hatchery Spring Chinook Salmon in the Deschutes River, Oregon, 2003

Annual Report for 2003

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Annual report for 2003

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Executive Summary

In a review of National Fish Hatcheries (NFH), the U.S. Fish and Wildlife Service (USFWS) identified the need to assess the fate of hatchery-reared fish and their potential effect on the aquatic community (USFWS 1998). Additionally, the National Marine Fisheries Service (NMFS) recommended monitoring and evaluating ecological interactions between hatchery and wild fish (NMFS 1999; Columbia River Biological Opinion). In 2003, a study was designed to investigate the fate of hatchery-reared fish and to assess habitat use and fish interactions in the Deschutes River, Oregon.

In this study, we used biotelemetry to examine the distribution and behavior of fall-released juvenile hatchery spring Chinook salmon in the Deschutes River. From 17 October to 22 December 2003, we radio tagged and tracked 77 fish. Fish were surgically implanted with radio transmitters and released downstream of a migrant trap on the Warm Springs River. Five telemetry fixed sites were established along the lower Warm Springs and Deschutes rivers and two telemetry fixed sites were used on the Columbia River to monitor fish movement after leaving the Deschutes River. Based on data obtained from fish implanted with radio tags, we found that 5% (4 of 75) of the radio-tagged fish left the Deschutes River and 95% (71 of 75) remained in the Deschutes River. Fish that left the Deschutes River migrated quickly and exited the 135 km study area at a median travel rate of 0.88 km/h and median travel time of 118.4 h (4.94 d). Three of the fish that left the Deschutes River were detected downstream in the Columbia River.

From 10 October through 11 December 2003, personnel from the Confederated Tribes of the Warm Springs Reservation of Oregon (CTWSRO) and U.S. Geological Survey (USGS) mobile tracked radio-tagged juvenile Chinook salmon in the Deschutes River. We were able to collect multiple contacts on fish that remained in the river and determine holding areas. All radio-tagged fish remaining in the Deschutes River held in the upper portion of the study area above Oak Springs. Once a fish stopped migrating downstream, it remained in that general location for the remainder of the study period. Macrohabitat assessments were conducted by CTWSRO and USFWS personnel at locations where radio-tagged fish were holding. Thirty-two fish were determined to be “holding” in the Deschutes River in 2003. In 2004, 32 random points were generated along the Deschutes River using a GIS to collect macrohabitat data independent of where fish were ‘holding” in 2003. According to the graphical distribution, juvenile Chinook

salmon were staging in slow water refuges in the Deschutes River. Even though there was less slow water habitat (pools and eddies) available, the majority of the radio-tagged fish were located in this habitat. Conversely, about two-thirds of the available habitat was comprised of fast water habitat (runs and riffles), but contained only one-third of the holding fish. Fish also appeared to select seam-lines, areas between differing water velocities or directions. The dominant riparian vegetation in the lower Deschutes River was grass. Undercut banks and overhanging grass was an important type of cover used by fish, followed by woody cover (alder, willow, and oak).

ATPase activity was measured as an indicator to better understand the physiological development of fish that left the Warm Springs National Fish Hatchery during the fall volitional release. Thirty fish were sampled from each of nine volitional release ponds. ATPase levels were not related to size at the hatchery ($R^2 = 0.0006$). Samples were not taken in 2003 at the migrant trap due to a lack of available fish.

Introduction

The U.S. Fish and Wildlife Service's (USFWS) review of National Fish Hatchery (NFH) practices identified a need to assess the fate of hatchery-reared fish and their potential effect on the aquatic community (USFWS 1998). Additionally, the National Marine Fisheries Service (NMFS) recommended monitoring and evaluating ecological interactions between hatchery and wild fish (NMFS 1999; Columbia River Biological Opinion). In response to these recommendations, the U.S. Geological Survey (USGS) conducted a pilot study in 2000, in cooperation with USFWS and the Confederated Tribes of the Warm Springs Reservation of Oregon (CTWSRO). The study was designed to investigate the potential effect of hatchery-reared fish released from the Warm Springs NFH on the aquatic community in the Deschutes River (Wardell 2002). Results of the study indicated that this type of investigation was feasible and prompted interest in funding additional research. In 2002, we designed a study to further investigate the fate of hatchery-reared fish and assess habitat use and fish interactions (Reagan 2004). Due to a limitation of fish that were of adequate size in 2002, we were not able to address our objectives. The study conducted in 2003 was designed to address study objectives that were not met in 2002, as well as investigate new technologies that may help to assess the fate of hatchery-reared fish.

Warm Springs NFH is a unique program in the Columbia River Basin. The operation of the hatchery is considered pivotal for enhancing salmon stocks to meet tribal trust responsibilities and is managed to preserve the genetic integrity and characteristics of hatchery and wild fish. Managers are concerned about fall releases of juvenile spring Chinook salmon *Oncorhynchus tshawytscha* because hatchery fish that over-winter in the Warm Springs and Deschutes rivers may interact with wild fish. However, quantifying the freshwater fate of juvenile Chinook salmon released in the fall from Warm Springs NFH has been problematic (Olson et al. 1995). Typically, about 10% of the hatchery production volitionally exit in the fall (30,000 to 75,000 fish). In the past, this fall emigration (early October - early November) included a mixture of sizes, ranging from 70 mm to 229 mm, with the majority of fish being 140 mm or larger (USFWS 1999). Most fish released in the spring reach the Columbia River estuary within 3-4 weeks of release, whereas the destination of fish volitionally released in the fall was not clear. Cates (1992) reported that fish from the fall release survive and contribute to adult production. Sampling in the lower Deschutes River, at Bonneville Dam, and in the Columbia River estuary indicated that fish released in the fall can exit the Deschutes River during the fall,

winter, or spring periods. Recent scale analysis has shown that most fall-released fish surviving to adulthood have over-wintered in freshwater before migrating to the ocean in the spring (J. Fryer, Columbia River Inter-Tribal Fish Commission, personal communication). Although the fall volitional release strategy has been successful in contributing to adult returns (Olson 1998), managers are concerned that large numbers of hatchery fish rearing in the Deschutes River may negatively affect the freshwater aquatic community. These over-wintering hatchery salmon could displace or compete with wild fish in the Deschutes River.

In 2000, we conducted a pilot study to determine the distribution of fall-released fish in the Deschutes River and investigate methods to assess habitat use. Fifty-four fish were implanted with radio transmitters and tracked for 45-75 d. Over the study period, we found that 65% of the radio-tagged fish remained in the Deschutes River, indicating that there were a substantial number of fish remaining over the winter. In a study conducted in 2002, we intended to expand the work done in 2000 and further develop the habitat and ecological interactions assessment. The study focused on determining the migration behavior and distribution of fall-released hatchery spring Chinook salmon, assessing microhabitat, addressing potential interactions within the fish community in the Deschutes River, and assessing possible ways of quantifying habitat. Twenty-four fish were implanted with radio transmitters and tracked for 9-90 days, depending on the type of tags used. Over the study period, we found that 63% (5 of 8) of the 90 d radio-tagged fish remained in the Deschutes River. Although the sample size was small, it was consistent with 2000 data and indicated that a substantial number of fish were remaining over the winter. With the majority of fall-released hatchery fish remaining in the Deschutes River, there could be a potential impact on wild juvenile spring Chinook salmon, bull trout (*Salvelinus confluentus*), steelhead, rainbow trout (*Oncorhynchus mykiss*), and other resident fish. Habitat assessments conducted during the pilot study at sites where radio-tagged fish were found indicated that these fish select discrete microhabitat. If there is interspecies overlap in microhabitat use and potential antagonistic behavior caused by hatchery-released fish, then managers may need to review current practices. However, if there are low levels of interaction or overlap in microhabitat use, the hatchery-released fish may be able to coexist in the Deschutes River.

Our work in 2003 was intended to expand the work conducted in 2000 and 2002, and further develop the habitat and ecological interactions assessment. The objectives of this study were to: 1) Determine the over-wintering behavior and distribution of fall volitional releases of

juvenile hatchery spring Chinook salmon from Warm Springs National Fish Hatchery; 2) Determine the migration behavior of fish that leave the Deschutes River watershed and enter the Columbia River; and 3) Determine the feasibility of using underwater acoustic cameras to determine diel movements of juvenile fish from the hatchery and document predation effects. As part of our first objective, USFWS led a habitat evaluation. The primary goal of the habitat evaluation of the fall volitional release at Warm Springs National Fish Hatchery was to determine over-wintering macrohabitat selection in the Deschutes River of the juvenile spring Chinook that left the hatchery. The results of this study, along with future studies, will help fisheries managers determine the potential impact of hatchery release strategies on the aquatic community within the Lower Deschutes River watershed.

Methods

Study Site

Warm Springs National Fish Hatchery is operated by the U.S. Fish and Wildlife Service (USFWS) and is located on the Warm Springs River, within the Warm Springs Indian Reservation of Oregon. The Warm Springs River is a major tributary to the lower Deschutes River in north central Oregon and enters the Deschutes River at river kilometer 135. The Deschutes River enters the Columbia River 330 km from the Pacific Ocean (Figure 1).

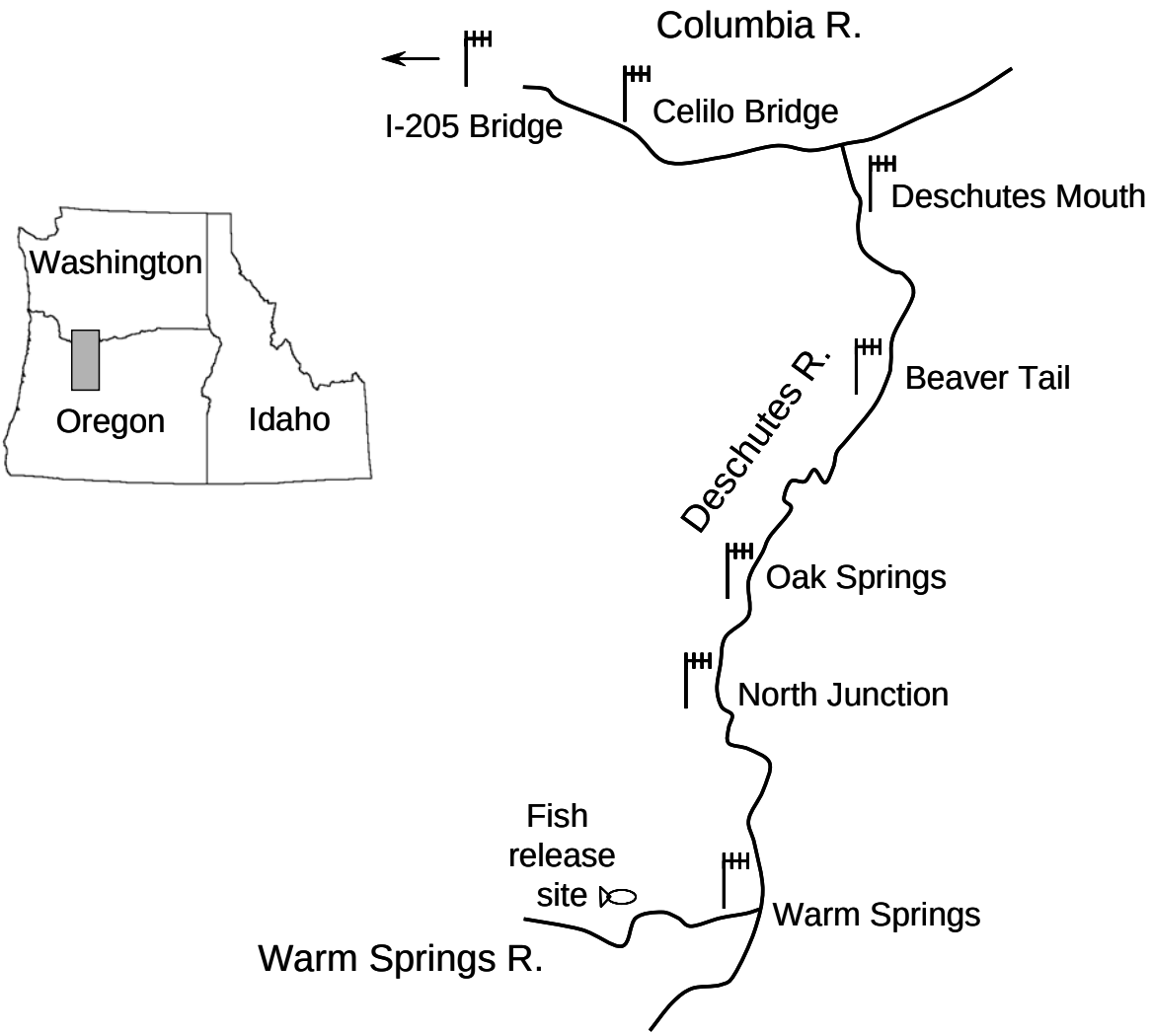

Figure 1.—Map of lower Deschutes River, Oregon, showing 2003 study area, fixed monitoring telemetry sites (antennas), and release site of radio-tagged juvenile Chinook salmon.

Migrant Trap

An eight-foot rotary screw trap was installed near the mouth of the Warm Springs River, about 10 km downstream of the Warm Springs NFH. CTWSRO staff used the trap to monitor wild and hatchery spring Chinook salmon movement. The trap was typically operated 24 h/d, Monday through Friday, from 1 September to 15 December 2003. Fish caught in the trap were identified and enumerated. A sub-sample of up to 20 each steelhead/rainbow trout, bull trout, wild Chinook salmon, hatchery Chinook salmon, and lamprey was measured per day. CTWSRO staff marked bull trout, steelhead/rainbow trout, wild spring Chinook salmon, and hatchery spring Chinook salmon with a fin clip to the upper or lower caudal to perform population abundance estimates. CTWSRO produced population estimates and calculated trap efficiencies based on trap data.

Radio Tagging & Transmitters

Juvenile Chinook salmon used in our study were collected in the downstream migrant trap in the Warm Springs River operated by CTWSRO. Fish were collected by CTWSRO personnel and held in containers (127 L) in the river for at least 24 h prior to tagging. Fish were surgically implanted with microprocessor coded radio transmitters using procedures described by Adams et al. (1998). Biological measurements including fork length, weight, and overall condition were recorded for all radio-tagged fish.

Fish 17 g and larger were implanted with a 0.85 g digitally-coded radio transmitter (Lotek Engineering; model NTC-3-1). Transmitters emitted a signal every 7 s and had a battery life of 26 d. Each transmitter had a unique channel-code combination so that we could distinguish individual fish. A minimum fish weight criterion (17 g) was established so that the weight of the tag would not exceed 5% of the weight of the fish. Immediately after tagging, fish were placed in a 127 L recovery container and supplied with a constant flow of river water and bottled oxygen. Fish were allowed to recover for about 30 min, then transferred to holding containers and held for 24 h in the Warm Springs River before release. Immediately before release, transmitters were checked to ensure that they were functioning properly.

Fixed-Site Monitoring

Five telemetry fixed sites were established along the lower Deschutes River and two on the Columbia River (Figure 1). Sites were set up at the following locations: 1) near the mouth of the Warm Springs River, allowing us to monitor when fish migrated out of the Warm Spring River and entered the Deschutes River (rkm 135); 2) at North Junction (rkm 115), the first site after fish entered the Deschutes River, 3) near Oak Springs Fish Hatchery (rkm 76), serving as a midway point between the Warm Springs River and the mouth of the Deschutes River; 4) at Beaver Tail (rkm 51), downstream of the Oak Springs site, and 5) near the mouth of the Deschutes River (rkm 2), to monitor fish as they left the Deschutes River system and entered the Columbia River. Fixed stations consisted of two four-element Yagi (aerial) antennas mounted on a 6 m mast and connected to two Lotek SRX 400 data-logging receivers (Lotek Wireless, Ontario, Canada). Each station was powered by 12 V deep-cycle batteries connected to solar powered chargers. To minimize the time required to monitor channel-code combinations, four channels were chosen. To ensure sufficient time for the receivers to recognize and log the signal, each channel (frequency) was monitored for 8 s by each receiver before moving to the next channel. This resulted in a 24 s scan time per receiver. The scan time was reduced by half by programming the two receivers to scan on alternate frequencies, increasing the probability of detecting tags. Data were collected on telemetry receivers continuously. Sites were maintained and data downloaded to a hand-held or laptop computer on a weekly basis.

Two existing USGS telemetry receiving arrays were also used along the lower Columbia River, allowing us to monitor fish that left the Deschutes River and migrated downstream. The first array, located on the Celilo train bridge (rkm 324), was an array of antennas spanning across the Columbia River. The second array consisted of 70 antennas, spanning across the Interstate-205 bridge near Portland, Oregon (rkm 181). Sites were maintained and data downloaded to a hand-held or laptop computer on a weekly basis.

Mobile Tracking

To determine the location and spatial distribution of radio-tagged juvenile Chinook salmon, as well as to verify data from fixed sites, mobile tracking was conducted in the lower 135 km stretch of the Deschutes River on a weekly basis. CTWSRO and USGS personnel mobile tracked radio-tagged fish between 0800 and 1600 hours using vehicles equipped with a telemetry antenna and receiver. When a radio-tagged fish was located, a Global Positioning

System (GPS) was used to geo-reference the position. Fish locations were also marked on a map, along with the time and a written description of the general area. Once a fish was found repeatedly in a discrete location for more than two weeks, we considered that fish to be holding.

Radio Telemetry Data Management and Analysis

Data monitoring began on 17 October 2003 and continued until 22 December 2003 when the life expectancy of the transmitters was surpassed. Data were incorporated into statistical analysis software (SAS version 8.1) and automatically proofed. Automated proofing was followed by manual proofing to ensure the quality of all data. All fish records were scrutinized to determine fish presence at each fixed site.

We calculated the travel times and travel rates of fish between detections at the fixed sites. Travel times were calculated as the time taken to travel from one site to the next downstream site. Travel rates were calculated by dividing the distance traveled by the travel time. Travel times and rates were investigated relative to fish length, weight, and condition factor. All statistical tests were conducted at the 5% probability level.

Habitat Assessments

Seventy-seven fish were radio tagged and released in the fall of 2003 by USGS personnel and radio tracked by CTWSRO, USFWS and USGS personnel. Radio tagged fish were tracked in the lower Warm Springs River and throughout the lower Deschutes River using fixed and mobile telemetry receivers. Fish were located by turning down the gain on the mobile receivers until the fish location could be determined to within a few meters, if possible. Our ability to accurately pinpoint the fish location was determined by the physical characteristics of the river and bank. Steep banks and/or a wide river channel often made it difficult to accurately determine the fish location. For the purpose of this study, however, it was more important to identify the type of habitat the fish was located in (ie. pool, riffle, etc.) and less important to determine the exact location of the fish. GPS coordinates were recorded with every fish location. If fish were located in the same area for two weeks or more, macrohabitat characteristics were recorded for that individual.

General macrohabitat characteristics were recorded for each fish in each designated holding area. The macrohabitat designations were characterized in a similar manner as DiStefano et al. (2003). However, the macrohabitat that DiStefano et al. called a backwater, we

call an eddy. We believed that the eddy designation more closely described what we were observing. The observer determined the habitat characteristics for the cross section of the river where the fish was located. The dominant river habitat, river section, and associated bank habitat was recorded for each individual fish (Callahan, USGS, pers. comm.). Bank habitat designations were defined as grass, alder, willow, oak, and rocky rip rap. The river habitat designations and subsequent criteria were defined as follows: 1) riffle: notable surface disturbance, 2) run: minimal surface disturbance, 3) pool: no surface disturbance, and 4) eddy: surface moving opposite of general flow. Riffles and runs were classified as fast water, whereas pools and eddies were classified as slow water.

When fish held in a section of river comprised of multiple habitat characteristics, the percentage of each characteristic was estimated. For example, a fish holding area may have been comprised of 70% riffle with eddies on each bank occupying the remaining 30% of the cross section. Composition was estimated in 5% increments and was solely the judgment of the data collector. The difference between riffles and runs could be difficult to determine at times and, again, was left to the discretion of the sampler. Digital photos were also taken to visually record the macrohabitat characteristics.

Thirty-two fish were determined to be "holding" in the Deschutes River in 2003 and macrohabitat data were collected on all of these fish. In 2004, 32 random points were generated along the Deschutes River using a GIS to collect macrohabitat data independent of where fish were 'holding" in 2003 (Figure 2). A sampler navigated to the points and recorded macrohabitat characteristics in the same manner as in 2003. One of the points generated was inaccessible so data was only collected on 31 cross-sections. Since there were no fish associated with each point, both banks were included in the habitat determination instead of just the one closest to the fish. This is not a true use/non-use situation because it is not known if any hatchery fish were present at the time of sampling, but it should provide representative availability. The results of habitat associations were analyzed by examining differences between proportions from the random survey in 2004 and biotelemetry results in 2003 (Zar 1974). Significance of statistical analyses were reported at the $p < 0.05$ level.

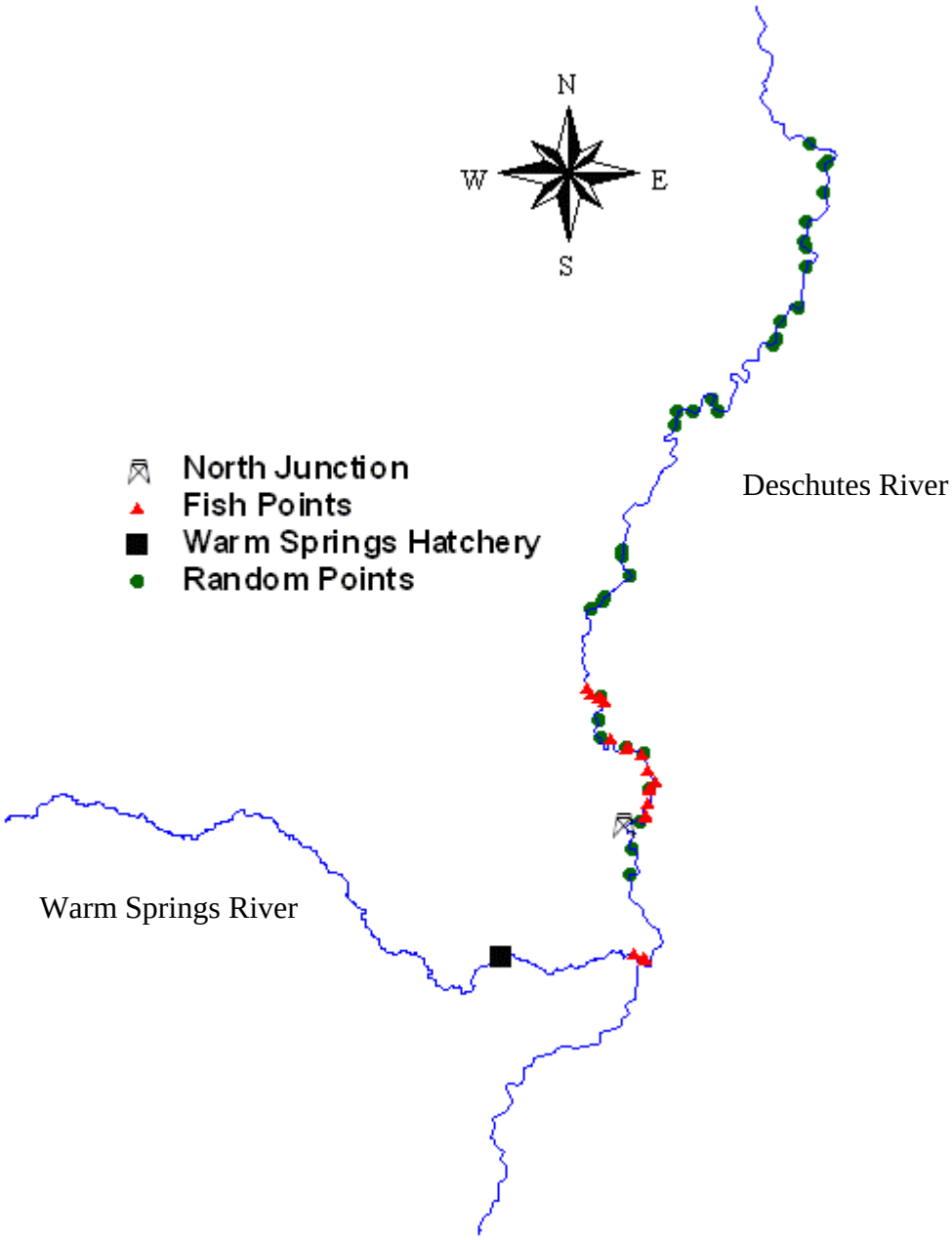

Figure 2.— Locations of fish and randomly selected points where macrohabitat data was collected along the Warm Springs and Deschutes rivers, fall 2003-2004.

River Conditions

Daily stream flow data were obtained from USGS gauging stations along the lower Deschutes River at Moody (rkm 2.5) and on the Warm Springs River at Kahneeta (rkm 10). Temperature data were also obtained from Portland General Electric (PGE) thermographs on the lower Deschutes River at Ferry Canyon (rkm 40; site 32) and Kaskela (rkm 127; site 29).

ATPase Sampling and Analysis

We measured ATPase activity as an indicator to better understand the physiological development of fish that leave the Warm Springs National Fish Hatchery during the fall volitional release. Na^+, K^+-ATPase (hereafter referred to as ATPase) activity has commonly been used as an indicator of physiological development of anadromous salmonids during the parr-smolt transformation (Ewing 1984) and for smolt condition assessment (Folmar 1980; Dickhoff 1995; Beckman et al. 1999). Elevated levels of ATPase are typically correlated with seaward migration of Chinook salmon (Hart et al. 1981). Fish size is usually positively correlated with ATPase activities (Folmar 1981). Because the sizes of fish leaving the hatchery during the fall volitional release are substantially larger than the fish remaining at the hatchery (Cates, U.S. Fish and Wildlife, unpublished data), we hypothesized that fish that leave volitionally should have higher ATPase levels than smaller fish that remain in the hatchery. ATPase samples were to be collected from fish prior to release from the Warm Springs National Fish Hatchery on 2 October 2003, and at the migrant trap during migration of the fall volitional releases.

Pre-release ATPase sampling was conducted during the annual fish health screening at Warm Springs National Fish Hatchery. We collected gill clips and recorded fish length and weight. We sampled 30 fish from each of six volitional release ponds: ponds three and four (Spring/Fall Erythromycin treated), ponds seven and eight (Spring Erythromycin treated), and ponds nine and ten (control), for a total of 180 samples. ATPase analysis was conducted using procedures described by Schrock et al. (1994). Condition factor was also calculated and ATPase activity was compared to fish fork length.

The study design included sampling hatchery fish collected in the downstream migrant trap. ATPase samples would be collected during the fall migration and coincide with our radio tagging of juvenile Chinook salmon. Fish that were to be sampled for ATPase would not be implanted with radio tags. Sampling at the trap would include non-lethal sampling of 30-60 fish

in size ranges similar to radio-tagged fish. This sampling design would allow us to determine the physiological condition of migrating fish.

Underwater acoustic camera

Previous investigations using underwater video have shown that predation of juvenile fish occurs during the daytime where the outlet from the hatchery empties into the Deschutes River. Video records show predatory birds, fish, and otter consuming juvenile fish as they exit the hatchery release pipe. Because video does not work well in dark environments, our objective was to evaluate the diel movement of out-migrating fish and determine if predation was occurring during the night.

To meet this objective, we used an underwater acoustic camera (also known as a dual-frequency identification sonar, hereafter referred to as DIDSON). The DIDSON was originally developed at the University of Washington's Applied Physics Laboratory for military use in harbor surveillance. It forms near-video-quality images by simultaneously transmitting and receiving acoustic beams. In its high-frequency mode (1.8Mhz), images, or frames, are constructed from 96 beams 0.3^{o} apart from each other in the horizontal plane. At this frequency, images can be formed to a range of 12 m, and resolution ranges from 3 mm at a distance of 1.5 m to 24 mm at a distance of 12 m from the DIDSON. The field of view is 29^{o} in the horizontal plane and 8.5^{o} in the vertical plane. Images can be formed at a rate of 4-12 frames/s. The camera is 30 cm x 17.5 cm x 20.5 cm, weighs 5.5 kg in air, and is nearly neutrally buoyant in water. Data from the DIDSON is sent via a cable to a topside breakout box where images can be output to video equipment or to a laptop computer using an Ethernet connection. The DIDSON has the advantage of being able to image in zero-visibility water making it ideal for use during nighttime conditions. Entrained air, however, can have a large effect on the clarity of the image. The original proposed site, at the hatchery release pipe exit, contained a lot of entrained air from water flowing over the barrier dam immediately upstream of the outlet pipe. This prevented us from getting a clear image of the area with the DIDSON camera. As an alternative, the camera was deployed in one of the hatchery holding raceways to evaluate when juvenile fish left the hatchery.

The DIDSON was deployed in the southeast corner of pond two from 23 October to 10 November 2003 (Figure 3). The camera was positioned to optimize the view of the volitional release outflow, which was an 8" drainpipe. The camera recorded 6 frames per second and

sampled data for 3 to 5 min every hour. Data were automatically logged to a laptop PC with an external hard drive, which was downloaded every 2 to 5 days. The data were broken up into hourly files, each containing the 3 to 5 minutes sampled during a particular hour. Using SAS, we randomly chose 120 files distributed evenly by time of day. Because each file varied from 3 to 5 minutes in length, the files chosen were also weighted so that 22 minutes of DIDSON footage from each hour of the day were analyzed. We randomly selected one still frame per minute of recorded data for a total of 528 still frames in the analysis. The number of fish present on screen was counted for each still frame. This allowed us to calculate an average number of fish present near the volitional outflow pipe for each hour of the day.

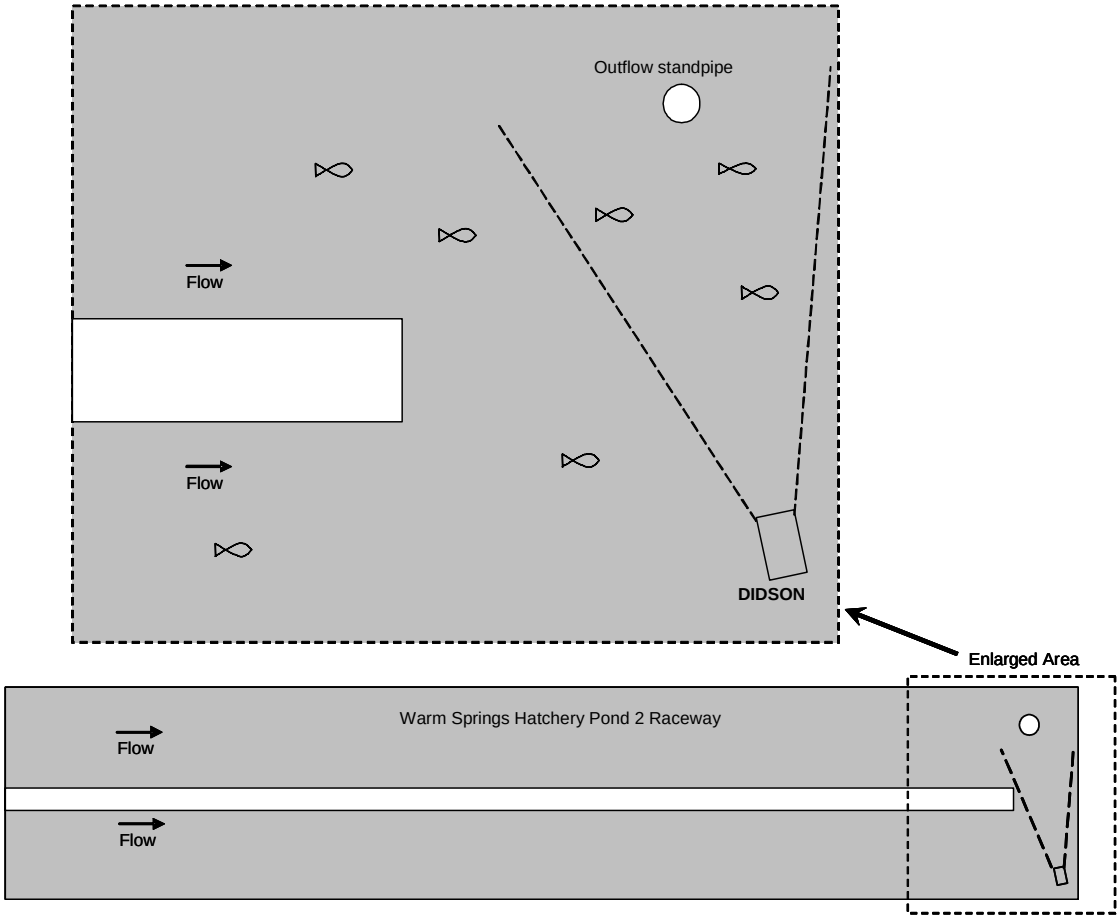

Figure 3—Schematic of pond two raceway at Warm Springs National Fish hatchery, 2003, showing location of DIDSON in relation to raceway and outflow standpipe.

Results

River Conditions

The Deschutes River is a relatively stable river (Deschutes River Subbasin Summary, 2001), because the Pelton/Round Butte complex regulates daily outflow. Mean daily discharge during the study ranged from 4,050 to 6,210 cfs on the Deschutes River and from 215 to 645 cfs on the Warm Springs River (Figure 4). Flows remained relatively low through the season, with one higher flow event in December. Temperatures on the Deschutes River decreased from about 18.5 ^{o}C in early October to 4 ^{o}C in late December (Figure5).

Migrant Trap

Hatchery fish collected at the migrant trap between 11 September and 5 December 2003 were larger than their wild counterparts (Figure 6). The mean size of hatchery juvenile Chinook salmon at the trap was 112 mm and ranged from 78 to 176 mm. In comparison, the mean size of wild juvenile Chinook salmon was 87.1 mm and ranged from 55 to 110 mm. Hatchery fish that met the size criteria for radio tag implantation represented the upper 34% of the population.

Radio Tagging

During fall 2003 (17 October - 21 November), we radio tagged 79 juvenile Chinook salmon (Table 1; Appendix 1). Two fish died during the 24 h post-tag holding period. Due to the low number of fish available in the required size range, we were only able to tag and release 77 fish of the 100 intended for the study.

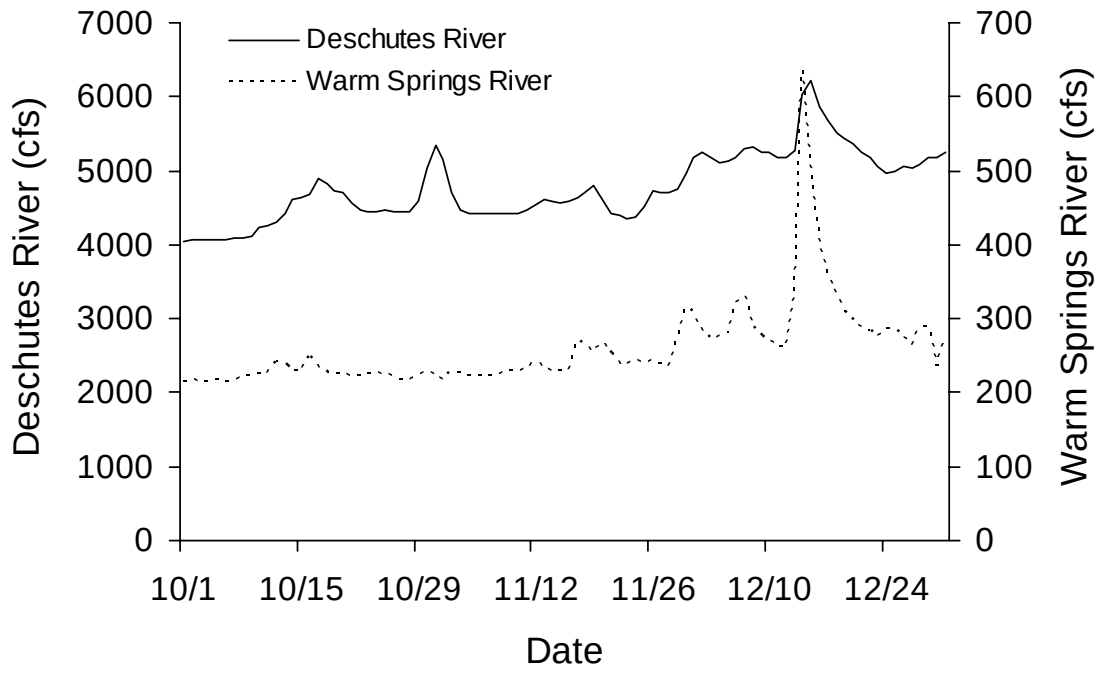

Figure 4—Mean daily discharge, in cubic feet per second (cfs), for the Deschutes and Warm Springs rivers from 1 October through 31 December 2003. Data received in February 2004 from the USGS website: http://waterdata.usgs.gov. The USGS station ID for the Deschutes River is 14103000 and for the Warm Springs River 14097100.

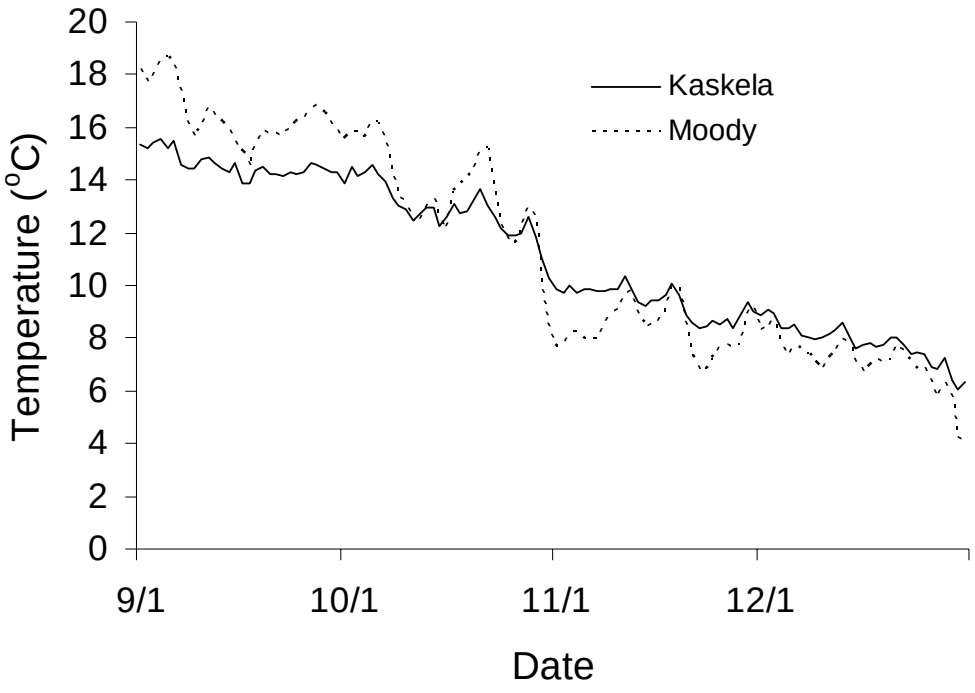

Figure 5—Mean daily river temperature (ºC) of the Lower Deschutes River between 1 October 2003 and 1 January 2004. Sample locations were at Kaskela (rkm 127; site 29) and Moody (rkm 4; site 33). Data collected by Portland General Electric.

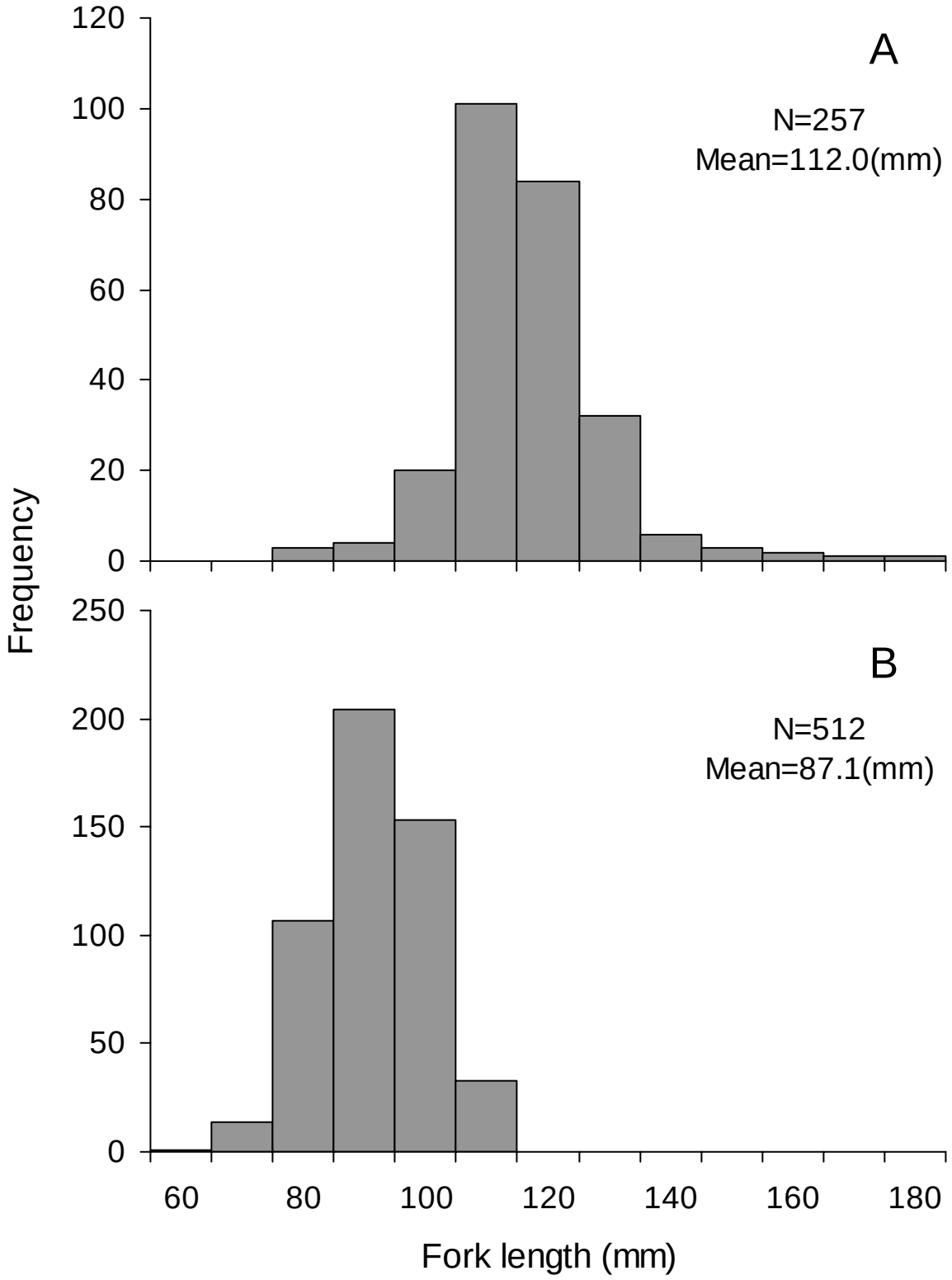

Figure 6—Size distribution of (A) hatchery and (B) wild juvenile Chinook salmon captured at the downstream migrant trap between 11 September and 5 December 2003. Note the difference in scale on the y-axes.

Table 1.—Descriptive statistics, including fork length, in millimeters (mm), and weight, in grams (g), for radio-tagged juvenile Chinook salmon released in the Deschutes River, fall 2003. Minimum and maximum values are also listed for each release.

Release	Date	N	Fork Length (mm)			Weight (g)		
			Mean	Min	Max	Mean	Min	Max
1	10/18	2	126.0	116	136	23.9	18.8	29.0
2	10/19	9	118.1	113	129	19.5	17.1	26.4
3	10/26	4	119.8	116	123	20.2	17.9	21.7
4	10/29	8	118.5	116	124	19.5	18.0	21.8
5	10/31	5	123.4	119	128	21.9	19.5	24.7
6	11/01	9	129.9	117	162	25.6	19.6	48.8
7	11/02	12	125.4	118	153	23.6	18.3	42.1
8	11/05	8	128.3	116	176	25.7	18.0	61.7
9	11/06	6	124.0	118	142	23.7	18.9	34.9
10	11/07	2	122.0	120	124	20.9	20.6	21.2
11	11/08	3	117.0	116	167	18.3	17.5	19.8
12	11/09	2	126.0	126	126	24.7	23.0	26.4
13	11/10	2	121.0	117	125	21.2	19.2	23.2
14	11/13	3	122.7	116	127	21.4	17.4	24.1
15	11/21	2	127.0	118	136	23.9	17.4	30.4
Overall		77	123.3	113	176	22.3	17.1	61.7

Migration Behavior and Mobile tracking

Using data from fixed sites and mobile tracking, we were able to contact 75 of the 77 fish released into the Warm Springs River. Two fish were never contacted after release. We found that 5% (4 of 75) of the radio-tagged fish left the Deschutes River and 95% (71 of 75) remained in the Deschutes or Warm Springs rivers over the study period. This was the first year that we documented fish remaining in the Warm Springs River and not entering the Deschutes River.

Our fixed site stations performed well in 2003, contacting 89% (69 of 77) of the released radio-tagged juvenile spring Chinook salmon. Of those contacted, 99% (68 of 69) were detected at the mouth of the Warm Springs River, 59% (41 of 69) were contacted downstream at North Junction, 7% (5 of 69) were contacted at both the Oak Springs and Beaver Tail sites, and 6% (4 of 69) were documented leaving the Deschutes River and entering the Columbia River (Table 2).

Travel rates and travel times were highly variable (Tables 2, 3, 4). Fish migrated past the North Junction site with a median travel time of 39.3 h (1.64 d), with individual travel times ranging from 8.7-751.7 h (0.36-31.32 d). The median travel rate from Warm Springs to North Junction was 1.10 km/h, with rates ranging from 0.03 to 7.64 km/h. Fish that left the Deschutes River and exited the 135-km study site also had variable travel times. The median travel time was 118.4 h (4.94 d) and ranged from 32.9-462.5 h (1.37-19.27 d). The median travel rate for fish to exit the Deschutes River was 0.88 km/h. Once fish left the Deschutes River, most (3 of 4) were detected downstream at the Celilo Bridge site, but none were contacted farther downstream at the I-205 bridge site.

Mobile tracking was used to verify fish location. Mobile tracking allowed us to ground-truth our fixed data, document holding behavior, and determine fish locations for habitat assessments. From 10 October through 11 December 2003, CTWSRO and USGS personnel radio-tracked juvenile Chinook salmon in the Deschutes River. Mobile tracking was conducted by vehicle on a weekly basis by CTWSRO and USGS personnel. The majority of fish were contacted in the upper sections of our study area (Figure 7) by CTWSRO personnel. The GPS could not be used in some areas due to interference caused by the steep canyon. In those cases, fish positions were marked on a map. During the two weeks following their release, fish movement varied greatly, with some fish moving little and others traveling great distances. After about two weeks, fish held in the river and most were still holding in the upper sections of our study area when the study ended (Figure 8).

On average, fish that left the Deschutes River system had a larger average fork length (133 mm) than fish that remained in the Deschutes River (123 mm). However, these differences were not statistically significant.

Table 2.—Travel times, in hours (and days), from release site to each fixed site station on the Deschutes River for radio-tagged juvenile Chinook salmon, fall 2003.

Travel Reach	N	Median	Mean	Minimum	Maximum
Warm Springs R.	68	11.1 (0.46)	76.0 (3.17)	0.4 (0.02)	817.4 (34.06)
North Junction	41	39.3 (1.64)	148.5 (6.19)	8.7 (0.36)	751.7 (31.32)
Oak Springs	5	61.3 (2.55)	246.0 (10.25)	19.0 (0.79)	667.8 (27.83)
Beaver Tail	5	66.5 (2.77)	262.5 (10.93)	24.8 (1.03)	713.2 (29.71)
Mouth Deschutes R.	4	118.4 (4.94)	183.1 (7.63)	32.9 (1.37)	462.5 (19.27)
Celilo Bridge	3	203.1 (8.46)	236.9 (9.87)	36.6 (1.53)	471.0 (19.62)

Table 3.—Travel times, in hours (and days), of radio-tagged juvenile Chinook salmon between fixed site stations on the Deschutes River, fall 2003.

Travel Reach	N	Median	Mean	Minimum	Maximum
Warm Springs to North Junction	40	18.5 (0.77)	105.1 (4.38)	2.6 (0.11)	629.2 (26.22)
North Junction to Oak Springs	5	19.0 (0.79)	18.9 (0.79)	6.4 (0.27)	34.5 (1.44)
Oak Springs to Beaver Tail	5	5.8 (0.24)	16.5 (0.69)	4.6 (0.19)	45.3 (1.89)
Beaver Tail to mouth Deschutes R.	4	12.5 (0.52)	33.3 (1.39)	8.1 (0.34)	100.0 (4.17)
mouth Deschutes R. to Celilo Bridge	3	8.5 (0.36)	16.3 (0.68)	3.7 (0.15)	36.6 (1.53)

Table 4.—Travel rates, in km/h (and km/d) of radio-tagged juvenile Chinook salmon from detection at each fixed site station to the next station on the Deschutes and Columbia rivers, fall 2003.

Travel Reach	N	Median	Mean	Minimum	Maximum
Warm Springs to North Junction	40	1.10 (26.3)	1.88 (45.0)	0.03 (0.8)	7.64 (183.4)
North Junction to Oak Springs	5	2.05 (49.3)	2.79 (66.9)	1.13 (27.2)	6.11 (146.6)
Oak Springs to Beaver Tail	5	4.34 (104.2)	3.27 (78.5)	0.55 (13.2)	5.47 (131.2)
Beaver Tail to mouth Deschutes R.	4	4.47 (107.2)	3.86 (92.7)	0.49 (11.8)	6.03 (144.6)
mouth Deschutes R. to Celilo Bridge	3	3.52 (84.4)	4.15 (99.5)	0.82 (19.7)	8.10 (194.4)

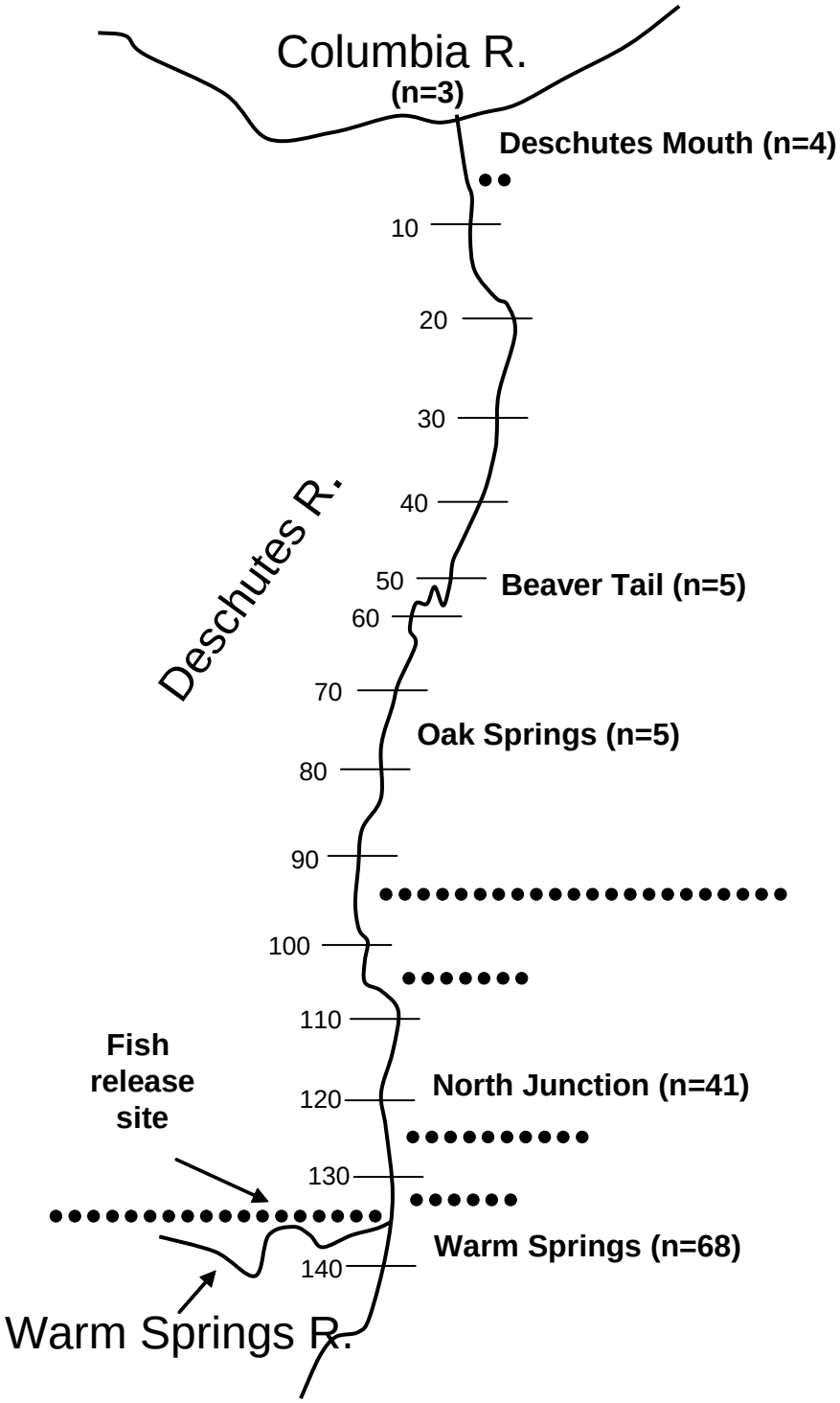

Figure 7.—Mobile detections (•) in 10 km reaches and number of contacts at fixed site stations of radio-tagged juvenile Chinook salmon in the Deschutes and Warm Springs rivers, Oregon, fall 2003. Detections represent individual contacts of all types of radio tags, therefore showing multiple hits in cases where fish were contacted multiple times in the same reach.

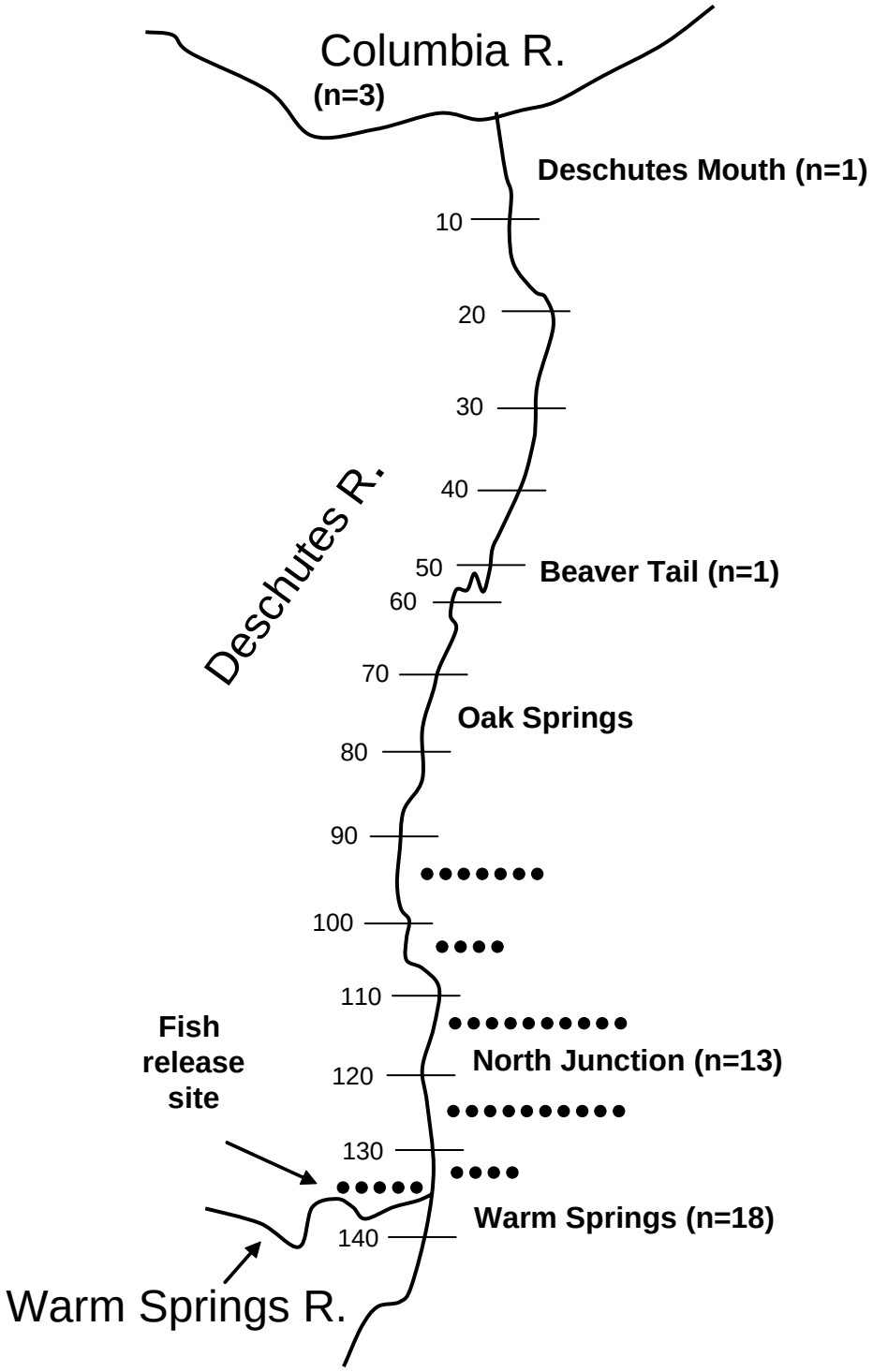

Figure 8.—Last individual contact of radio-tagged juvenile Chinook salmon in the Deschutes and Warm Springs rivers, Oregon, fall 2003. Number of last individual contacts by mobile tracking is represented by •, separated into 10 km reaches.

Habitat Assessments

Of the 32 fish determined to be "holding" in the Deschutes River in the fall of 2003, 21 fish were found in slow water (17 in eddies and 4 in pools) and 11 fish were found in fast water (10 in runs and 1 in a large riffle that stretched from bank-to-bank). Fish were found to use a general area as opposed to a specific point in which to hold. For example, a fish could be tracked moving around a large eddy. There was very little instream cover found other than boulders and seams between areas of differing water velocities or directions. The fish were typically found near these seam-lines.

The habitat survey of randomly selected transects in the Deschutes River found that there was more fast water than slow water habitat available; this was an inverse relationship as compared to where the fish were found (Figure 9). The majority of fish (66%) were found in slow water habitat, even though it only comprised 12% of the water type available. The proportion of habitat found in the random transects was significantly different than where the fish were found ($Z = 4.41$, $P < 0.001$).

Grass was the dominant bank habitat followed by alder in both the randomly selected transects and in transects where fish were found (Figure 10). Woody cover of willow and oak were also found in transects where fish were located but absent in the randomly selected transects; whereas, rocky riprap was absent from transects where fish were found.

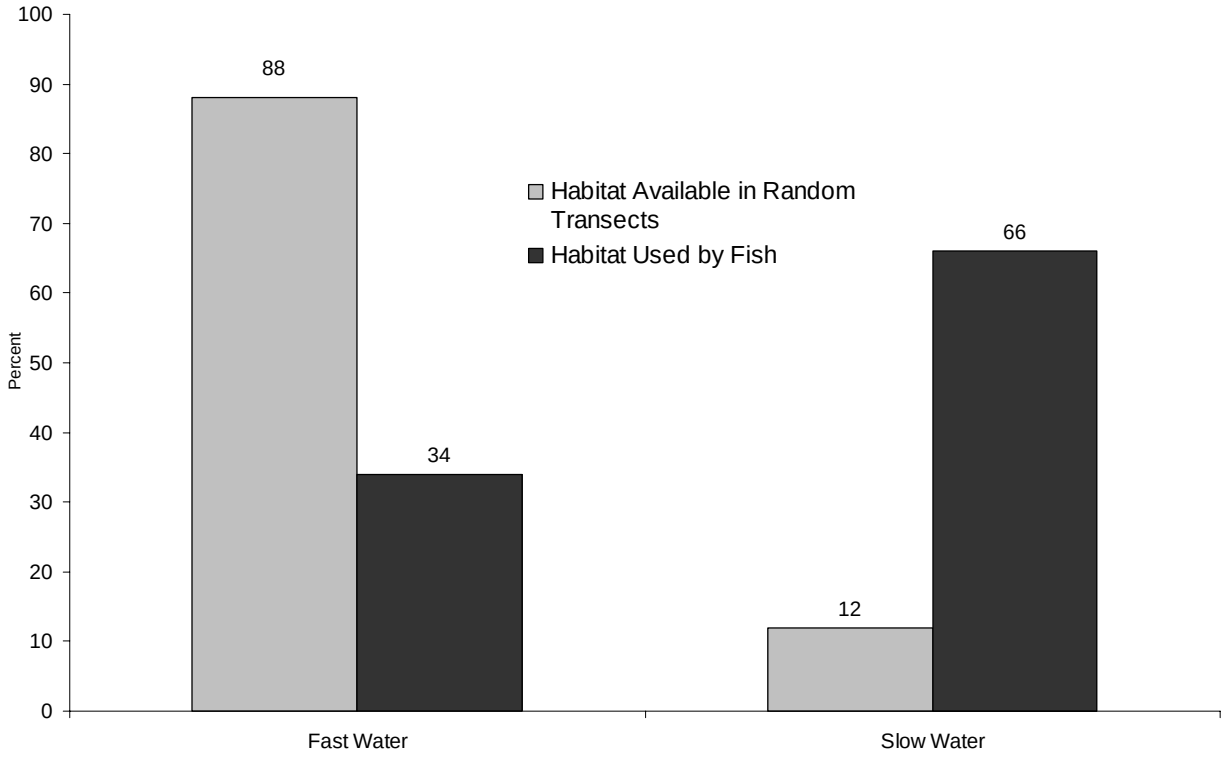

Figure 9.—Percent of habitat available in random transects and used by juvenile hatchery spring Chinook salmon in the Deschutes River, OR fall 2003 and 2004.

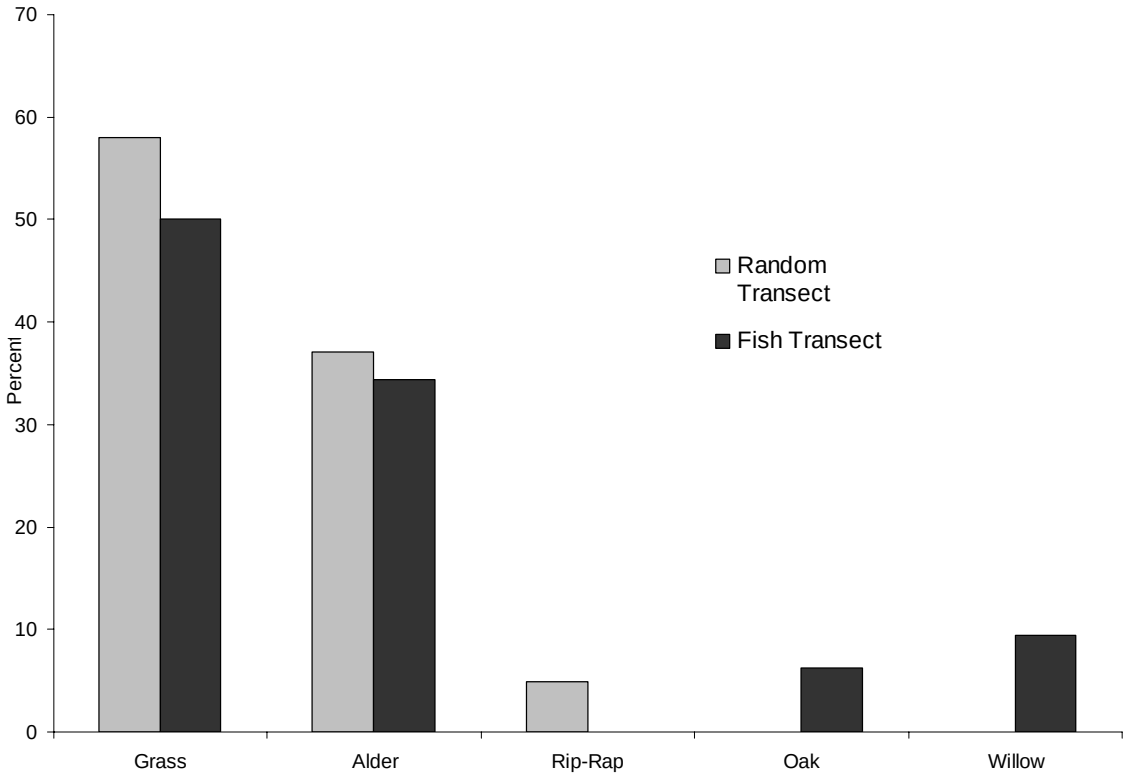

Figure 10.—Percent bank cover of random and fish transects in the Deschutes River, OR, fall 2003-2004.

ATPase

Samples taken at the hatchery had low detectable ATPase levels. Mean ATPase activity of fish sampled at Warm Springs National Fish Hatchery was 1.8 μmoles ATP hydrolyzed/mg protein per hour (Table 5). The mean was below our detection level for this assay. Lengths of fish ranged from 77 mm to 134 mm, with a mean of 106.7 mm. Mean weight was 14.3 g and the mean condition factor (Fulton's K) was 1.2. The ATPase, condition factor, fork length, and weight were not different between ponds ($P>0.05$), therefore ATPase data was pooled. ATPase levels were not related to size at the hatchery ($R^2 = 0.0006$), (Figure 11). ATPase samples were not taken in 2003 at the migrant trap due to a lack of available fish.

Table 5. Na^+, K^+-stimulated ATPase activity (μmol P_i·mg protein^{-1}·h^{-1}), condition factor (Fulton's K), fork length, and weight of juvenile Chinook salmon sampled at the Warm Springs National Fish Hatchery on 2 October 2003.

		ATPase		Condition Factor		Fork Length (mm)		Weight (g)	
Pond	N	Mean	STD	Mean	STD	Mean	STD	Mean	STD
3	30	1.7	0.8	1.2	0.1	105.0	9.8	14.0	3.8
4	29	1.5	0.8	1.1	0.2	108.5	9.3	14.7	3.9
7	29	1.4	0.6	1.1	0.1	105.6	10.4	13.7	3.9
8	30	2.0	1.1	1.1	0.1	106.5	8.8	14.1	3.5
9	30	2.3	1.4	1.2	0.1	107.7	9.9	15.0	4.4
10	30	1.8	0.9	1.1	0.1	107.0	8.3	14.1	3.4
Overall	178	1.8	1.0	1.2	0.1	106.7	9.4	14.3	3.8

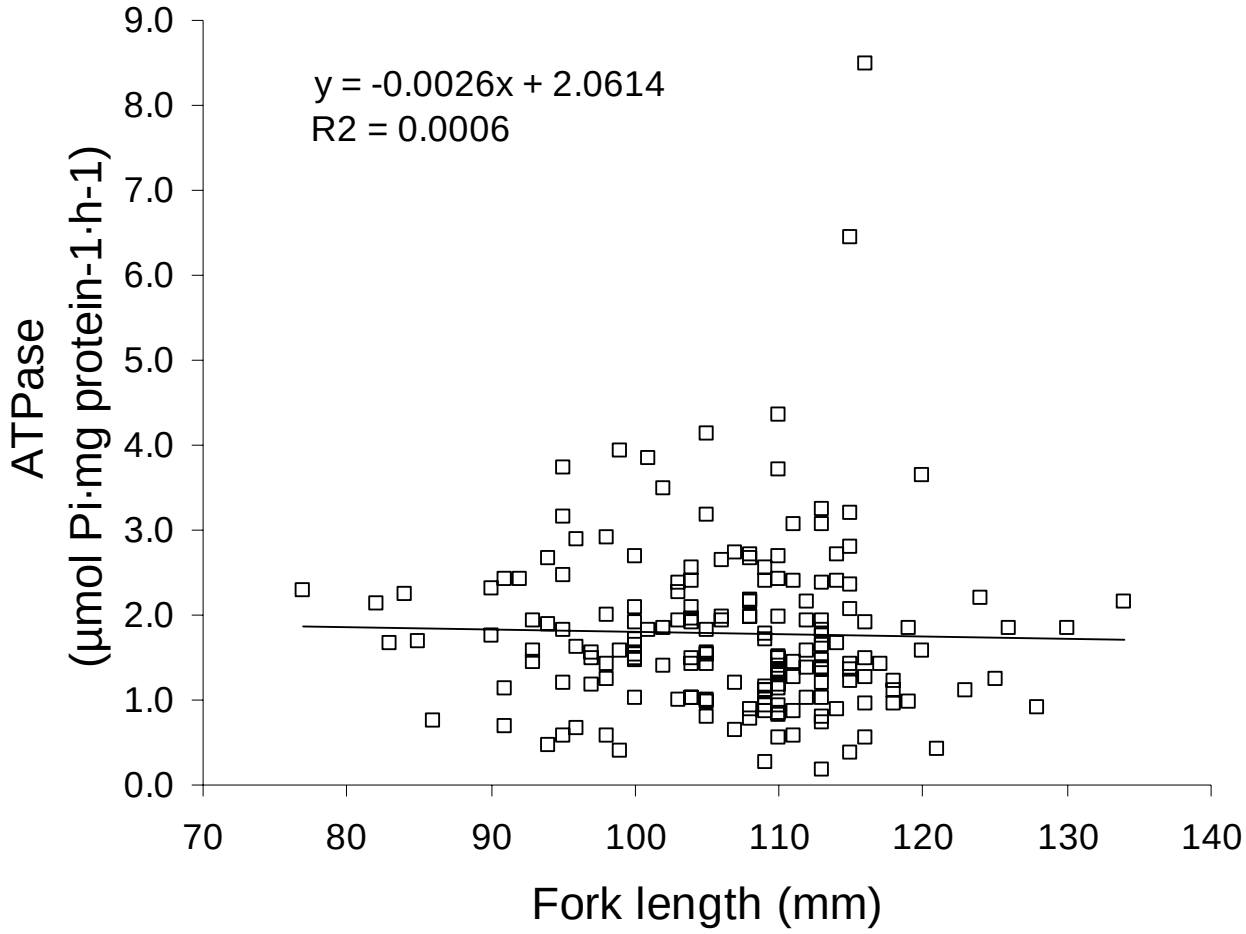

Figure 11.—ATPase of juvenile Chinook salmon collected at the Warm Springs National Fish Hatchery on 2 October 2003.

Underwater acoustic camera

The confluence of the hatchery outfall with the Warm Springs River was not deemed suitable for the DIDSON due to entrainment of air bubbles as water flowed over the barrier dam. However, the site at the outflow in the raceway was suitable and allowed us to determine diel movements of hatchery juvenile Chinook salmon. The DIDSON has the advantage of being able to image in zero-visibility water, making it ideal for use during nighttime conditions. The density of fish near the outflow was much higher during the evening compared to the daytime (Figures 12 and 13). Numbers were high between midnight and 0700 hours (more than 40 fish/frame), decreased during the daytime hours of 0700 to 1700 (1-5 fish/frame), and then began to increase again around dusk (1700).

An underwater camera (SeaViewer Sea-Drop 650 underwater color camera) operated by the USFWS was also used to examine fish behavior in the raceway. The underwater camera was set up at similar angle to the acoustic camera for one afternoon sampling period. In comparing the two technologies over the same time frame, we found similar results, showing similar numbers of fish.

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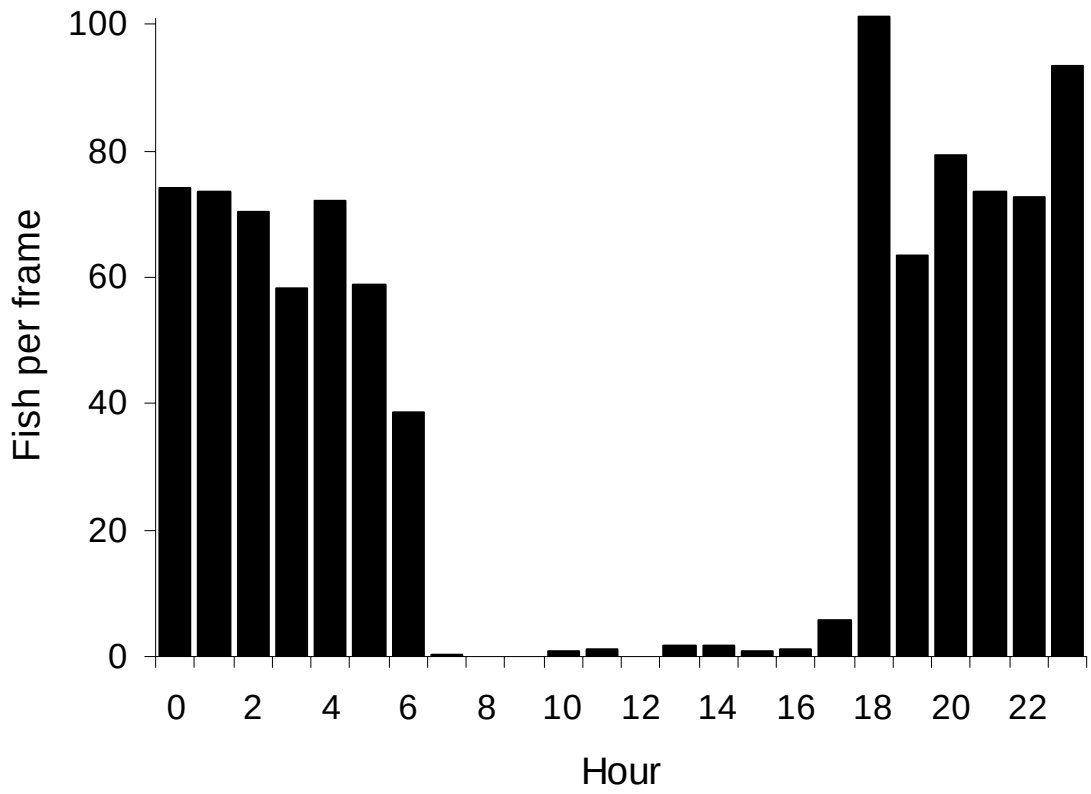

Figure 12.—Average number of fish per frame viewed from the DIDSON camera over a 24 h period. Numbers are based on hourly sub-samples from pond two at the Warm Springs National Fish Hatchery taken from 23 October to 10 November 2003.

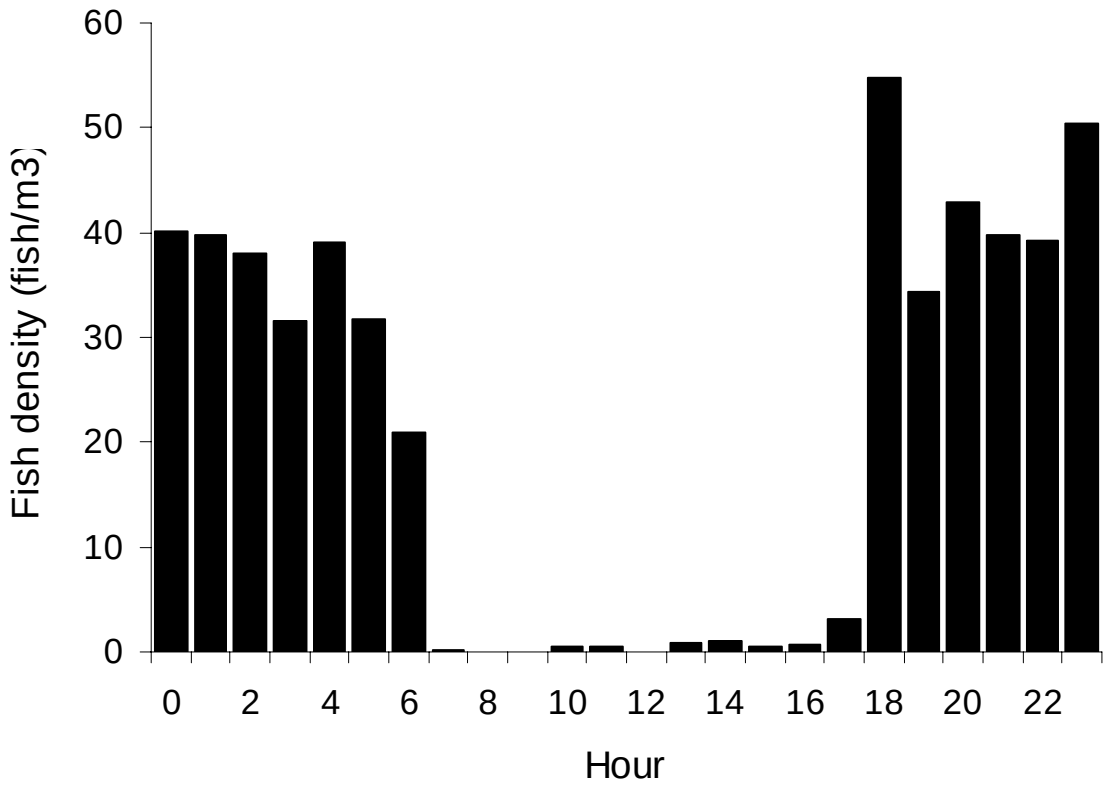

Figure 13.—Average density of fish (fish/m^3) near the outflow standpipe viewed from the DIDSON camera over a 24 h period. Average densities are based on hourly sub-samples from pond 2 at the Warm Springs National Fish Hatchery raceway taken from 23 October to 10 November 2003.

Discussion

Migration Behavior

We found variable migration behaviors in radio-tagged juvenile Chinook salmon once they left the Warm Springs River. Of the 75 radio-tagged fish released and later contacted by fixed or mobile receiver, 5% (4) migrated through the Deschutes River and entered the Columbia River. The remaining 95% (71) distributed in the Deschutes River and lower Warm Springs River until the end of the study period in late December. The proportion of fish remaining in the Deschutes and Warm Springs rivers was higher than in past studies, but consistent with the trend found in previous years where smaller fish tended to stay in the Deschutes River system and larger fish migrated through and exited the Deschutes River. A similar study conducted in 2000 showed that about 36% of the radio-tagged fish exited the system and 64% remained. However, tagged fish were larger in 2000 than those tagged in 2003. A similar trend was found in 2002. Although sample size was low in 2002, the data showed that about 7% (1 of 14) of the fish left the Deschutes River system shortly after release.

Although similar trends were found among study years (2000, 2002, 2003), the percentage of fish remaining in the Deschutes River increased. Part of this variability might be explained by the size of the fish at the hatchery prior to starting the volitional release. The size of the fish at the hatchery was progressively smaller across study years. If fish size was a factor in migration behavior, then a larger percentage of fish should have remained in the system as fish size decreased. Size-dependent migration behavior is supported by the findings of Beckman et al. (1998), who found that larger hatchery fish had a greater disposition to migrate. Although differences were not significant and there was some overlap, fish that left the system were on average larger (133 mm) than fish that did not (123 mm).

Median travel times of fish that exited the Deschutes River after migrating through the 135 k study area were slower than in previous years. Median travel time was 118.4 h (4.94 d) in 2003, 66.1 h (2.75 d) in 2002 and 38.4 h (1.60 d) in 2000. Low flows likely contributed to the increase in travel times.

Fish that remained in the Deschutes River system were found primarily in the upper portion of the study area above Oak Springs. Within 7 to 14 d after release, fish typically found an area and remained there throughout the study period. This was the first year that we found fish holding in the Warm Springs River, relatively close to the release site, for an extended time

period. Prior to this year, results had only shown fish residing in the Deschutes River. The impacts of hatchery fish on the aquatic community in the Warm Springs River may need to be investigated.

The battery life of the tag used in 2003 limited the duration of time we could gather data to 26 d and the size of the tag limited the size of the fish we could tag. However, data from 2000 and 2002 showed that fish leaving the Deschutes River did so within the first 7-14 d, well within the 26 d battery life of the tag used in 2003. The size of the tag limited the size of the fish we could tag to only the larger fish in the fall release. As a result, our data applies to the upper 34% of the hatchery fish size distribution. Migration behavior of the remaining 56% of the population remains unknown. Smaller radio tags or different methodologies (i.e. pit tags) would be needed to determine if size-dependent migration trends exist in this portion of the hatchery population.

We were able to contact radio-tagged fish after they migrated through the Deschutes River and entered the Columbia River. Three of the four fish that left the Deschutes River were contacted at the Celilo Bridge, downstream of the mouth of the Deschutes River. One of these fish was detected near the Celilo Bridge for 18 days. None of the fish that exited the Deschutes River were contacted at the I-205 bridge site. Sample size (3) was too small to adequately characterize the migration behavior of fish in the Columbia River.

ATPase

Samples taken at the hatchery had low detectable ATPase levels and the mean was below our detection level for this assay. The variation in ATPase levels of fish taken at the hatchery was not explained by fish size in 2003 (R^2 =0.0006) and the results are consistent with findings from 2000 (R^2 =0.0246) and 2002 (R^2=0.0006). ATPase samples taken at the hatchery in all three years showed no relation between smoltification and fish size. Results reported in Zaugg (1985) and from observations of many other hatchery populations suggested that most anadromous salmonids in the Columbia River system do not develop maximum hypo-osmoregulatory capability (i.e. smoltification) while confined to the hatchery environment, but appear to require a period of active downstream migration to trigger this change. We do not know the ATPase levels of fish as they left the hatchery, so it is hard to determine if elevated ATPase caused fish to leave the hatchery or if their ATPase levels changed while in river. Beckman (1998) showed that there was a strong relation between fish size, growth rate and

advanced state of smoltification. This may result in a greater propensity of larger fish to move downstream when released into a natural system.

Since we did not sample at the trap in 2003, we do not know the ATPase activity of fish that migrated out of the hatchery or if there was a positive correlation between size and ATPase activity of in-river migrants, as seen in 2000. A positive relation between fish size of in-river migrants and ATPase may explain why larger fish exit the system. Several studies have shown that physiological smolt development and development of downstream migratory tendencies are correlated (Beckman 1998). Hart et al. (1981) found hatchery Chinook salmon with higher ATPase activities migrated out of rearing channels sooner than fish with lower ATPase activities. Beckman (1998) suggested that physiological change and migration behavior are temporally linked. The ATPase activity in fish at the time they left the hatchery is unknown. Once fish emigrated from the hatchery, they were exposed to a natural river flow. This change in conditions may cause an increase in ATPase activity, therefore prompting the fish to begin their migration downstream to the migrant trap. Sampling at the hatchery during the fall volitional release would provide further information to test this hypothesis.

Underwater acoustic camera

We were not able to deploy the DIDSON in the river outlet to the hatchery release pipe and could not evaluate nighttime predation as planned. However, the DIDSON was effective at monitoring diel behavior near the outflow pipe in the hatchery raceway. We found that fish congregated in higher densities at the outflow pipe during the evening, with minimum activity near the pipe during daytime hours (0700-1700). This may indicate that fish are more likely to leave the hatchery during the night. However, low numbers of fish at the outflow during the day could be attributed to environmental factors. During the day, the outflow pipe is in direct sunlight. This may have caused the fish to move to the other end of the raceway where it is shaded.

Study Constraints

Although we were able to radio-tag 77 of the 100 fish we planned to, obtaining study fish proved challenging. Fish captured at the migrant rotary screw trap in 2002 and 2003 were smaller than those captured in prior years. Comparing 2003 screw trap data to the migrant Humphrey trap data in 2000, we found that the mean size of juvenile spring Chinook salmon

(both hatchery and wild) was smaller in 2003. The mean size of hatchery spring Chinook salmon in 2002 was 112 mm, compared to 122 mm in 2000. Similarly, the size of wild spring Chinook salmon caught at the trap was also smaller. The mean size of wild spring Chinook salmon in 2003 was 87 mm, compared to 96 mm in 2000. The rate of rotation of the migrant trap might have contributed to the reduction in mean fish size captured in the trap. In 2003, the trap often rotated at less than one rotation per minute. Rate of rotation is directly related to flow and slower moving traps are not efficient at capturing large fish. In a study by Roper (1996), trap efficiencies for hatchery fish ranged from 1% to 26% and fish were captured at significantly lower rates when the trap was positioned in areas of lower-velocity water. When the trap rotates slowly, fish (especially larger fish) are able to swim out of the trap, thereby decreasing the overall number of fish collected and collecting disproportionately smaller sized fish.

Habitat Assessments

According to the graphical distribution, the juvenile spring Chinook salmon released from Warm Springs National Fish Hatchery during the fall were staging in slow water refuges of the Deschutes River. Even though there was less slow water habitat of pools and eddies available, the majority of the radio-tagged fish were located in this habitat. Conversely, approximately two-thirds of the available habitat was comprised of fast water habitat of runs and riffles, but contained only one-third of the holding fish. The fish also appear to select seam-lines between areas of differing water velocities or directions. For example, a seam-line of differing water directions is created on the edges of an eddy. Based on the results of this study, it was apparent that the juvenile hatchery spring Chinook salmon are choosing slow water areas for refuge and we suspect that these fish will likely over-winter in the Deschutes River.

Due to the desert ecology of the lower Deschutes River, it was not surprising that the dominant riparian vegetation was grass. The pattern of fish use followed the distribution of riparian habitat available, where undercut banks and overhanging grass was an important type of cover used by fish, followed by woody cover of alder, willow and oak.

Based on the data collected and analyzed, further study is warranted on quantifying the total area of slow water habitat available in the lower Deschutes River during the fall and winter period. The amount of slow water habitat needs to be quantified to help determine its over-winter carrying capacity and help fisheries managers determine if hatchery fish released from Warm Springs National Fish Hatchery in the fall are potentially competing with wild fish for this

habitat and to what extent. Alternatively, we may find that there is abundant slow water habitat available in the Deschutes River over winter and that the competition potential between hatchery and wild fish is minimal.

Conclusions

Based on our findings that 95% of tagged fish remained in the Deschutes and Warm Springs rivers, we estimate that 28,500-71,250 of the 30,000-75,000 hatchery fish volitionally released in the fall of 2003 overwintered in the lower Deschutes and Warm Springs rivers. Additional studies are needed to further examine annual variability, migration, fish distribution, carrying capacity, and potential interactions that may occur in the Deschutes River.

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Appendix A. Summary of individual radio-tagged Chinook salmon in 2003. Summary includes transmitter channel and code (ChCode), fish length, weight, K factor, release date, and last contact information. Last contact is shown as either the last fixed site contact (Warm Springs, North Junction, Oak Springs, Beaver Tail, mouth of the Deschutes, and Celilo Bridge) or river kilometer where the fish was last detected while mobile tracking.

ChCode	Fork Length (mm)	Weight (g)	K Factor	Release Date	Last Contact	
					Location	Date
5001	136	29.0	1.15	10/18	Warm Springs - mobile	11/12
5002	113	17.1	1.19	10/19	North Junction	11/06
5003	118	19.0	1.16	10/19	North Junction	11/19
5004	116	17.9	1.15	10/26	rkm 99	11/19
5005	119	18.0	1.07	10/29	rkm 129	11/05
5006	118	19.8	1.21	10/29	rkm 111	12/04
5007	128	22.5	1.07	10/31	Mouth of Deschutes	11/03
5008	162	48.8	1.15	11/01	Celilo Bridge	11/02
5009	130	25.5	1.16	11/01	rkm 113	12/04
5010	132	24.5	1.07	11/01	rkm 100	11/07
5011	134	27.1	1.13	11/02	North Junction	11/05
5012	127	24.6	1.20	11/02	North Junction	11/03
5013	118	18.3	1.11	11/02	North Junction	12/05
5014	128	23.2	1.11	11/05	rkm 128	11/12
5015	176	61.7	1.13	11/05	Warm Springs -fixed	11/06
5016	119	20.7	1.23	11/06	Warm Springs - trap	12/02
5017	124	20.6	1.08	11/07	Warm Springs - trap	12/02
5018	126	23.0	1.15	11/09	rkm 128	11/12
5019	125	23.2	1.19	11/10	Warm Springs - fixed	11/19
5020	118	17.4	1.06	11/22	rkm 111	12/05
6001	116	18.8	1.20	10/18	North Junction	11/13
6002	117	17.4	1.09	10/19	Warm Springs - mobile	11/05
6003	117	19.4	1.21	10/19	Warm Springs - fixed	11/10
6004	122	21.2	1.17	10/26	rkm 134	11/12
6005	117	19.3	1.21	10/29	rkm 112	11/07
6006	116	18.4	1.18	10/29	Warm Springs - mobile	11/05
6007	119	19.5	1.16	10/31	rkm 96	12/05
6008	133	25.0	1.06	11/01	Beaver Tail	12/01
6009	128	23.4	1.12	11/01	rkm 98	12/05
6010	123	21.2	1.14	11/02	rkm 130	11/05
6011	125	23.5	1.20	11/02	rkm 116	12/04
6012	119	20.0	1.19	11/02	rkm 132	11/12
6013	120	21.3	1.23	11/05	rkm 127	11/12
6014	118	20.2	1.23	11/05	No detections	
6015	118	20.5	1.25	11/06	North Junction	11/09
6016	142	34.9	1.22	11/06	North Junction	11/13
6017	120	21.2	1.23	11/07	North Junction	11/10
6018	126	26.4	1.32	11/09	rkm 105	12/11
6019	127	24.1	1.18	11/13	rkm 107	12/11

Appendix A (continued). Summary of individual radio-tagged Chinook salmon in 2003. Summary includes transmitter channel and code (ChCode), fish length, weight, K factor, release date, and last contact information. Last contact is shown as either the last fixed site contact (Warm Springs, North Junction, Oak Springs, Beaver Tail, mouth of the Deschutes, and Celilo Bridge) or river kilometer where the fish was last detected while mobile tracking.

ChCode	Fork Length (mm)	Weight (g)	K Factor	Release Date	Last Contact	
					Location	Date
6020	136	30.4	1.21	11/22	rkm 113	12/11
10001	129	26.4	1.23	10/19	rkm 132	11/12
10002	115	17.9	1.18	10/19	North Junction	11/22
10003	119	19.0	1.13	10/19	rkm 126	11/04
10004	123	21.7	1.17	10/26	rkm 117	11/04
10005	116	18.9	1.21	10/29	Warm Springs - fixed	12/06
10006	124	21.8	1.14	10/29	rkm 107	11/24
10007	123	23.3	1.25	10/31	Warm Springs - fixed	11/04
10008	125	21.6	1.11	11/01	North Junction	11/03
10009	117	19.6	1.22	11/01	rkm 129	11/12
10010	119	19.8	1.17	11/02	No detections	
10011	153	42.1	1.18	11/02	rkm 97	12/05
10012	119	19.9	1.18	11/02	North Junction	11/03
10013	123	20.9	1.12	11/05	Warm Springs - mobile	11/12
10014	121	19.8	1.12	11/05	rkm 100	12/11
10015	118	18.9	1.15	11/06	rkm 116	12/11
10016	125	24.7	1.26	11/06	rkm 128	11/12
10017	117	19.8	1.24	11/08	rkm 109	12/11
10018	117	19.2	1.20	11/10	rkm 98	12/11
10019	125	21.5	1.10	11/13	Celilo Bridge	11/21
11001	114	17.7	1.19	10/19	Warm Springs - mobile	11/12
11002	121	21.5	1.21	10/19	rkm 128	11/12
11003	118	20.1	1.22	10/26	Warm Springs - fixed	11/11
11004	118	19.3	1.17	10/29	Warm Springs - fixed	11/11
11005	120	20.3	1.17	10/29	Warm Springs - trap	12/02
11006	119	19.5	1.16	10/31	Warm Springs - fixed	11/01
11007	128	24.7	1.18	10/31	Warm Springs - fixed	12/07
11008	122	20.5	1.13	11/01	North Junction	11/19
11009	120	21.2	1.23	11/01	Warm Springs - fixed	11/02
11010	125	22.7	1.16	11/02	rkm 114	12/04
11011	122	22.8	1.26	11/02	rkm 134	11/12
11012	121	21.3	1.20	11/02	rkm 114	12/11
11013	116	18.0	1.15	11/05	Warm Springs - fixed	12/09
11014	124	20.6	1.08	11/05	rkm 127	11/12
11015	122	22.5	1.24	11/06	Warm Springs - fixed	12/13
11016	116	17.5	1.12	11/08	Celilo Bridge	12/15
11017	118	17.7	1.08	11/08	Warm Springs - fixed	12/12
11019	116	18.7	1.20	11/13	rkm 135	12/02