Prepared in cooperation with the U.S. Fish and Wildlife Service

Composition and Relative Abundance of Fish Species in the Lower White Salmon River, Washington, Prior to the Removal of Condit Dam

Open-File Report 2011-1087

U.S. Department of the Interior
U.S. Geological Survey

Cover:

Photograph showing rotary screw trap collecting fish (*background*) and Carrie Munz preparing to remove fish from the rotary screw trap (*foreground*) in the White Salmon River, Washington. Photograph by Brady Allen, USGS, WFRC, Columbia River Research Laboratory.

Top Inset: Salmonid fry collected by a rotary screw trap in the White Salmon River, Washington. Photograph by Brady Allen, USGS, WFRC, Columbia River Research Laboratory.

Bottom Inset: Wild fall Chinook salmon fry stained with Bismarck brown (top), wild fall Chinook salmon (middle), and hatchery fall Chinook salmon (bottom) stained with Bismarck brown. Photograph by Brady Allen, USGS, WFRC, Columbia River Research Laboratory.

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Conversion Factors

Multiply	By	To obtain
	Length	
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
yard (yd)	0.9144	meter (m)
	Volume	
ounce, fluid (fl. oz)	0.02957	liter (L)
pint (pt)	0.4732	liter (L)
quart (qt)	0.9464	liter (L)
gallon (gal)	3.785	liter (L)
cubic inch (in^3)	0.01639	liter (L)
	Flow rate	
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
	Mass	
ounce, avoirdupois (oz)	28.35	gram (g)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:
°F=(1.8×°C)+32
Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as follows:
°C=(°F-32)/1.8

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Composition and Relative Abundance of Fish Species in the Lower White Salmon River, Washington, Prior to the Removal of Condit Dam

By M. Brady Allen and Patrick J. Connolly

Abstract

Information about the composition and relative abundance of fish species was collected by a rotary screw trap and backpack electrofishing in the lower White Salmon River, Washington. The information was collected downstream of Condit Dam, which is at river kilometer (rkm) 5.2, and is proposed for removal in October 2011. A rotary screw trap was installed in the White Salmon River at rkm 1.5 and operated from March through June during 2006–09. All captured fish were identified to species and enumerated. Daily subsets of fish were weighed, measured, and fin clipped for a genetic analysis by the U.S. Fish and Wildlife Service.

- Fall Chinook salmon (*Oncorhynchus tshawytscha)* were captured in the highest numbers (n=18, 640), and were composed of two stocks: tule and upriver bright. Almost all captured fall Chinook salmon were age-0, with only 16 (0.09 percent) being age-1 or older.
- Tule fall Chinook salmon, the native stock, generally out-migrated from mid-March through early April. The tule stock was the more abundant fall Chinook salmon subspecies, comprising 85 percent of those captured in the trap.
- Upriver bright fall Chinook salmon comprised 15 percent of the Chinook salmon catch and generally out-migrated from late May to early June.
- Coho salmon (*O. kisutch)* and steelhead trout (*O. mykiss)* were captured by the rotary screw trap in all years. Coho salmon were caught in low numbers (n=661) and 69 percent were age-0 fish. Steelhead were slightly more abundant (n=679) than coho salmon and 84 percent were age-1 or older fish.

Trap efficiency estimates varied widely (range, 0-10 percent) by species, fish size, and time of year. However, if we use only the estimates from efficiency tests where more than 300 wild age-0 Chinook salmon were released, there was a mean trapping efficiency of 1.4 percent (n=4, median, 1.3 percent, range, 0.3–2.4 percent) during the tule out-migration period, and a mean trapping efficiency of 0.8 percent (n=2, range, 0.3–1.2 percent) during the upriver bright fall Chinook salmon out-migration period.

When water levels in the White Salmon River declined in late summer, we electrofished the river margins in 2006–09 along three sites at rkm 1.5, 2.3, and 4.2. Age-0 steelhead were the most abundant fish captured (n=565, 62 percent), followed by age-0 coho salmon (n=222, 24 percent). In autumn, age-0 Chinook salmon were collected while electrofishing (n=40, 4 percent). This suggests that there may be a migration in the autumn as age-0 Chinook salmon or in the spring as age-1 Chinook salmon, since the Chinook salmon that migrate as age-0 fish in the spring departed several months

earlier (the typical life history for fall Chinook salmon). The only age-1 salmonids captured while electrofishing were steelhead (n=84, 9 percent). Fish distribution and abundance will likely change when Condit Dam is removed and anadromous fish gain access to their historical spawning and rearing areas in the White Salmon River. These findings should provide a baseline with which to compare juvenile fish species composition and relative abundance after Condit Dam is removed.

Introduction

The completion of Condit Dam in 1913 blocked anadromous fish runs at river kilometer (rkm) 5.1 of the White Salmon River in southern Washington. When this study was initiated, Condit Dam was scheduled for removal in October 2009 by PacifiCorp, the owner and operator of the dam. Condit Dam is scheduled for removal in October 2011. Because it had been more than 20 years since there had been juvenile salmonid sampling efforts, the species composition and amount of juvenile salmonid production occurring in the White Salmon River downstream of Condit Dam were unknown. The last evaluation of juvenile production in the White Salmon River was conducted by Seiler and Neuhauser in 1984 with an incline plane trap. By collecting new information about natural production, species composition, distribution, and genetic information of fish species within the White Salmon River, we will be more able to predict and track the effects that dam removal could have on important fish species such as Chinook salmon (*Oncorhynchus tshawytscha)*, coho salmon (*Oncorhynchus kisutch)*, steelhead/rainbow trout (*Oncorhynchus mykiss)* (hereafter referred to as steelhead), Pacific lamprey (*Lampetra tridentata)*, bull trout (*Salvelinus confluentus)*, and sea-run cutthroat trout (*Oncorhynchus clarki clarki)*.

Dams disrupt longitudinal habitat connectivity for migratory fish species, such as salmonids (Hall and others, 2010). Dams without fish passage, like Condit Dam, physically block access for fish, but even with fish passage, dams can degrade fish habitat by altering physical processes. Dams in rivers modify the aquatic habitat by altering sediment transport, nutrient transport, hydrologic regime, and temperature (Heinz Center, 2002). Dams can cause extirpation of salmonid species that tend to spawn higher in watersheds, such as summer steelhead and spring Chinook salmon, by blocking access to their historical spawning areas. They also can alter the spawning distribution and success of fish that tend to spawn in the lower portions of watersheds, such as fall Chinook salmon. Dams may degrade downstream spawning and rearing habitat by reducing sediment transport and altering the flow regime, which can reduce spawning gravel availability and result in an armoring of the streambed (Allan and Castillo, 2007). The loss of habitat connectivity and aquatic habitat can lead to species decline and extirpation.

It has largely been assumed and predicted by modeling efforts (Normandeau, 2004; Allen and Connolly, 2005) that reconnecting the upper White Salmon River to the Columbia River will result in increased natural production of several anadromous fish species. Although this may be a reasonable assumption, a large question remains as to which natural stocks would be most likely to succeed by natural recolonization, and which stocks would be available to be incorporated into hatchery-based reintroduction. Before considering hatchery reintroductions, managers needed to know what species and stocks were present, what their genetic relatedness was to hatchery stocks, and what the abundance of those species were in order to recognize needs and opportunities for fisheries restoration in the White Salmon River system.

Determination of whether natural-origin (wild) fall Chinook salmon in the lower White Salmon River (downstream of Condit Dam) were genetically distinct from hatchery stocks of fall Chinook salmon that stray and spawn in the White Salmon River was a key decision factor in U.S. Fish and Wildlife Service's (USFWS) restoration strategy. Both tule and upriver bright (URB) fall Chinook salmon were known to spawn in the White Salmon River (Normandeau, 2004). Tule fall Chinook salmon typically spawned earlier (late September) than URB fall Chinook salmon (November). Based on recovery of coded wire tags from carcasses, hatchery-origin tule fall Chinook salmon from USFWS's Spring Creek National Fish Hatchery (NFH), URBs from the Little White Salmon NFH, and tule and URB fall Chinook salmon from Bonneville Hatchery (Oregon Department of Fish and Wildlife) were spawning in the White Salmon River (Pastor, 2004). Carson-stock spring Chinook salmon from the Little White Salmon NFH or Carson NFH also may have been spawning in low numbers in the White Salmon River. For more than 100 years, the Spring Creek NFH, located 1.8 km downstream of the confluence of the White Salmon and Columbia Rivers, has raised the tule stock of fall Chinook salmon that is native to the White Salmon River. From 1901 to 1964, a nearly uninterrupted collection of adult tule fall Chinook salmon occurred from the lower White Salmon River for spawning at Spring Creek NFH. The stock collected from White Salmon River was developed over many generations and has been identified by the Columbia Basin Fish and Wildlife Authority and regional fishery biologists for reintroduction into the White Salmon River after Condit Dam removal. Because of the impending dam removal, the results of the genetic relatedness between wild spawning Chinook salmon populations in the White Salmon River and USFWS hatchery facilities was deemed a high priority of the USFWS and the organization provided internal funding for this genetic analysis.

We intended to take advantage of the unique opportunity that exists to link the dam removal efforts proposed in the White Salmon River with efforts in the Elwha River. Two Elwha River dams, which are similar in size to Condit Dam, were slated for removal in approximately the same time frame as Condit Dam. To adequately compare and contrast fish response to dam removal in these two systems, a concerted effort was expended to characterize fish use, using similar methodology as used in the Elwha River (Connolly and Brenkman, 2008), before the dams are removed. This approach was intended to fill an information gap at a low cost considering the logistical difficulties of sampling the lower White Salmon River, due to the difficult access, river size, and high water velocity in the lower river. When tributary habitat and mainstem habitat are available to fish after Condit Dam removal, it is expected that the success of some fish species would change, which would possibly alter the species distribution, age composition, and growth conditions. Therefore, we characterized the existing fish populations in the margins of the mainstem White Salmon River downstream of Condit Dam to provide a baseline from which to compare that change.

The objectives of the work were to:

- Determine the fish assemblage and relative abundance of fish in the lower White Salmon River as one index of productivity.
- Determine the relatedness of Chinook salmon collected in the White Salmon River compared with those returning to Spring Creek NFH.
- Assess whether hybridization was occurring between URB Chinook salmon and tule Chinook salmon.

The results of the USFWS's genetic analysis will be used to guide Chinook salmon reintroduction plans for the White Salmon River. The results of this study will help maximize learning about fish response to dam removal.

Study Area

The study area was from the mouth of the White Salmon River to the base of Condit Dam at rkm 5.2 (fig. 1). Bonneville Dam, at rkm 234 on the Columbia River, was completed in 1938 and inundates the lower White Salmon River creating slack water 1.5 rkm upstream of its confluence with the Columbia River. Base water flow and temperature in the lower White Salmon River are maintained by groundwater, glacial melting from Mount Adams, and Condit Dam operations. At Condit Dam, which creates a run-of-the-river reservoir (Northwestern Lake), most river flow is bypassed for 1.9 km downstream to a powerhouse located at rkm 3.2, where it rejoins the rest of the river flow. The bypass section can have flows as low as 30 ft^3/s (Normandeau and Associates, 2004). There is a USGS streamflow gaging station (Underwood, gage# 14123500) about 200 m downstream of the bypass section and powerhouse at rkm 3.0 (fig. 2). The release site for testing trap efficiency was at rkm 2.3, where a road accessed USFWS rearing ponds and the White Salmon River. The rotary screw trap was installed at rkm 1.5, which was about 20 m upstream of the most downstream riffle in the White Salmon River. The closest gage to measure the Bonneville pool level was in Stevenson (gage # 14128600), which was located 8 km upstream of Bonneville Dam, and 29 km downstream of the White Salmon River confluence with the Columbia River (fig. 2). Water depth and velocity at the trap location were variable due to operations at both Condit and Bonneville Dams. Bonneville pool elevation fluctuated up to a meter within a few hours. The location of the trap was inundated when Bonneville pool elevations were high. The discharge in the White Salmon River fluctuated rapidly due to power generation at Condit Dam. This rapid change in discharge altered the depth and velocity of water at the trap location.

The lower White Salmon River below Condit Dam is within the Columbia River Gorge National Scenic Area and is sparsely developed with limited access. Limited information exists on fish stocks in the White Salmon River below Condit Dam, but the White Salmon River Subbasin Plan (Normandeau and Associates, 2004) indicates that coho salmon, tule fall Chinook salmon, upriver bright fall Chinook salmon, resident and anadromous *O. mykiss,* chum salmon *O. keta*, spring Chinook salmon, pink salmon *O. gorbuscha,* and sea-run cutthroat may use the lower White Salmon River, with the latter four species dwindling or sporadic in number.

Methods

In early March of each year, 2006–09, a 5-foot rotary screw trap (E.G. Solutions, Corvallis, Oregon) was installed and operated in the White Salmon River at rkm 1.5 (fig. 1). Because much of the limited amount of spawning gravel occurred near or below the lowermost portion of flowing water, the rotary screw trap was installed as close to the inundated portion of the White Salmon River as possible to collect salmonids produced from that area. During the 4 years of operation, the date of installation and number of days that the trap operated varied (table 1). The trap was operated 5 days per week in 2006, 2008, and 2009. In 2007, the trap was operated 7 days per week. When operating, the trap was checked daily for fish. The cone of the trap was raised, rendering it inoperable, for about 1 week each year when hatchery fish were released upstream of our trap by the State of Washington (10,000 summer steelhead and 10,000 winter steelhead smolts per year). In 2006, 2008, and 2009, the cone was raised after the fish were collected on Fridays and then lowered back into the sampling position on Monday mornings. Trap efficiency tests were conducted two times in 2006, daily in 2007, and three times each in 2008 and 2009. The trap was operated for at least 11 consecutive days after all efficiency tests to maintain equal likelihood of recapture. In 2007, 2008, and 2009, trap operation continued until the last week of June or until less than 10 Chinook salmon were captured in the trap for 7 consecutive days.

The methods for installing and operating the rotary screw trap generally followed those described in Volkhardt and others (2007). Each sampling day, prior to checking the live box in the rotary screw trap, the number of cone revolutions per minute, weather conditions, sampling time, water clarity, and water depth at the trap were recorded. Debris was removed from the live box, and captured fish were netted into buckets and transported to shore. After the fish were transported to shore, as many as 60 fish of each species were anesthetized per day with 50 mg/L tricaine methanesulfonate (MS-222), measured for fork length (FL) to the nearest millimeter, weighed to the nearest 0.1 g, examined for external parasites and diseases, and scored for smolt condition (1 = parr, 2 = intermediate, and 3 = smolt). All additional fish that were collected each day were identified to species, origin (absence of an adipose fin indicated the fish was of hatchery origin), and counted. To estimate the proportion of tule Chinook salmon versus URB Chinook salmon, fin clips were submitted to the USFWS Abernathy Fish Technology Center (AFTC) for genetic analysis. To ensure reasonable sample size for the genetic analysis, fin clips were collected and preserved in 100 percent ethanol from as many as 30 fish of each species per day [fry (< 80 mm FL) and smolts (≥ 80 mm FL) were considered separately], but no more than 60 genetic samples per species each week. Fin clips from most other non-hatchery origin salmonids also were collected and preserved for potential future analysis. Incidental fish mortalities were put on ice and delivered to the USFWS's Lower Columbia River Fish Health Center (LCRFHC) to provide a thorough disease profile as part of the USFWS's National Wild Fish Health Survey. In 2009, 60 Chinook salmon fry were submitted for a disease profile early in the trapping season, and 60 more were submitted late in the trapping season to ensure adequate sample size for disease profile. The fish provided to the LCRFHC were given a rigorous inspection for disease by testing or microscopic observation. Disease screening included bacterial (bacterial kidney disease, coldwater disease, columnaris, emphysematous putrefactive disease, furunculosis, enteric redmouth), viral (infectious pancreatic necrosis, infectious hematopoietic necrosis, viral hemorrhagic septicemia), and parasitic agents (whirling disease, Ceratomyxa, digenetic trematodes, *Myxobolus kisutchi*, *Myxidium minteri*, Hexamita, Gyrodactulus, Scyphidia, Heteropolaria).

Efficiency tests were conducted to estimate the fraction of salmonids outmigrating from the White Salmon River that were captured in the trap. In 2006, the pilot year, an efficiency test was done early and another one late in the sampling season to test the logistics and ensure the feasibility of estimating capture efficiency. To test the trap efficiency, salmonids were marked with 16 mg/L Bismarck Brown Y biological stain (Sigma Chemical Company, St. Louis, Missouri) for the duration of time it took to transport them to the release location (about 35–45 minutes). Fish were transported by boat from the screw trap location to a nearby vehicle, which then took the fish to an access point at the USFWS raceway at rkm 2.3, where they were released (fig. 1). From March 7 through April 27, 2007, fish were transported for efficiency tests daily. In 2008 and 2009, about 500 hatchery Chinook salmon, which were the same subspecies and similar in size as the wild Chinook salmon, were used to boost the sample size of the efficiency tests. We used hatchery Chinook salmon as surrogates to increase our sample size in 2008 and 2009 because a low proportion of fish that were transported for efficiency tests in 2007 were recaptured (10 of 914 fish). Efficiency tests were conducted using 500 hatchery Chinook salmon on each of three occasions in each year. During the peak tule fall Chinook salmon outmigration, 500 tule fall Chinook salmon from USFWS's Spring Creek NFH were marked with Bismarck Brown and adipose fin clips before being released upstream of the trap in 2008 and 2009. During the period between the peak tule and peak URB outmigration, another 500 tule fall Chinook salmon fry were similarly marked and released for an efficiency test in 2008 and 2009. During the peak URB outmigration period, 500 URB fry from the USFWS's Little White Salmon NFH were similarly marked and released as an efficiency test. During each efficiency release in 2008 and 2009, all fish captured at the trap also were marked with Bismarck Brown Y and released upstream in addition to the hatchery releases to increase the sample size of potential recaptures, and to compare the wild and hatchery fish recapture rates.

Capture efficiency, defined as the percentage of fish passing the trap that were captured (Thedinga and others, 1994), needs to be estimated if an estimate of the total number of fish migrating is desired. Trap efficiency estimates were calculated by the use of the equation:

$$E = R / M, \qquad (1)$$

where E is the estimated trap efficiency, R is the number of marked fish recaptured, and M is the number of marked fish released. Fish production estimates were calculated by use of the equation:

$$A = \mathrm{C} / E, \qquad (2)$$

where A is the estimated abundance, and C is the total catch for the period (Thedinga and others, 1994).

Similar to methods implemented in the Elwha River system (Connolly and Brenkman, 2008), backpack electrofishing was conducted in the White Salmon River at three accessible and wadeable locations (rkm 1.5, 2.3, and 4.2), all of which were downstream of Condit Dam (at rkm 5.1). At each location, the electrofishing was done as a single upstream pass within a 4.5 m swath of the wadeable margin of the river left bank (when looking downstream) in accessible mainstem pools and non-pools. The area and proportion of the habitat unit that was electrofished was measured. All salmonids, as well as a representative subsample of other fish species encountered, were collected. The percentage of area of the 4.5 m swath that was too fast or too deep to effectively electrofish was subtracted from the total for each habitat unit. At least two consecutive habitat types, pools and non-pools, were sampled at each site. Attempts were made to keep the sampling effort as consistent as possible between sites and years. The method used in the Elwha River included side channels as separate habitat types, however, there were no side channels in the White Salmon River downstream of Condit Dam to include for this survey. The river margins served as index areas to document juvenile fish assemblage and relative abundance.

Results

There was a bi-modal distribution in Chinook salmon fry abundance captured in the trap in all years of sampling (fig. 2). Of the two periods of increased abundance, the first peak was the largest in 2006, 2008, and 2009 and occurred in mid-March through early April (fig. 2, table 1). After this initial peak, low numbers of Chinook salmon were captured (generally from the third week in April through late May), but another peak in Chinook salmon fry abundance occurred in late May to early June (fig. 2, table 1). In 2007, much lower numbers of fish were captured during the first out-migration peak than in other years, but the second peak was similar to other years.

Age-0 Chinook salmon were the numerically dominant salmonid captured at the trap in all years of operation. Although the trap was fished in the same location, the total number of fish captured in the screw trap varied nine-fold between years (table 1). Fewer Chinook salmon were captured in 2007 (n=1,070) than the other years of trap operation. However in 2007, we captured the highest number of steelhead (n=54) and coho salmon (n=195) fry. The greatest number of Chinook salmon fry (n=9,986) were captured in 2009, with more than double the next highest year’s catch. Chinook salmon averaged 39 mm FL, with lengths less than 32 mm and visible yolk-sacks were captured during both the early and late peaks in out-migration in 2006–09. Chinook salmon as small as 37 mm were captured in May (ordinal week 21), indicating that they were still hatching during this period.

Yearling Chinook salmon were rarely captured at the trap (table 2). Eleven or fewer yearling Chinook salmon were captured annually, with no apparent pattern in timing (fig. 3). Fork lengths of yearling Chinook ranged from 80 to 190 mm. In 2006, smolting coho salmon with little or no parr marks and highly eroded anal fins were incorrectly identified as yearling Chinook salmon. Tissue samples were collected from these fish, and genetic analysis identified them as coho salmon. Fish biologists working in adjacent watersheds corroborated that these coho salmon were likely hatchery fish released in nearby tributaries that strayed into the White Salmon River, where no hatchery coho salmon were released (J. Zendt, Yakama Nation fisheries biologist, oral commun., 2007).

Few age-0 steelhead were captured throughout the trap operations, with an average of 0– 4 fish per day per week in late May and early June (fig. 4), and a maximum of 13 fish in a single day. Naturally produced (adipose fin present) age-1 or older steelhead were captured in low numbers (ranging from 0 to 8 fish per day per week), with a peak in numbers from late April through mid-May (fig. 5). Steelhead were the most common age-1 or older salmonid (table 2). Trap operation was halted each year for about 1 week in early April or late May to allow 20,000 hatchery steelhead (adipose fin removed), released by Washington Department of Fish and Wildlife upstream of our trap, to out-migrate without overwhelming the trap. However, an increase in the captured number of hatchery steelhead occurred for several weeks (ordinal weeks 19–23) after release in each year of trap operation (table 2).

Age-0 coho salmon were captured at the trap in low numbers, with an average of 0–10 fish captured per day per week (fig. 6) and a maximum of 26 fish captured in single day. They were typically captured from mid-March to mid-June. Coho salmon less than 40 mm were captured in the trap throughout the sampling period, indicating a wide range in emergence times (table 1, fig. 6). Age-1 coho salmon were occasionally captured in the trap. We believe that most of the age-1 coho salmon captured in 2006 were unmarked (adipose fin present) hatchery fish. Age-1 coho salmon were not captured in 2007, 18 were captured in 2008, and 15 were captured in 2009. The proportion of wild versus hatchery coho salmon was not certain because hatchery coho salmon were not adipose fin clipped. However, some of the coho salmon captured in 2006 and 2009 were captured after hatchery releases in nearby watersheds and were pale with eroded fins, indicating that they were likely of hatchery origin (table 2, fig. 7).

The period that the rotary screw trap operated and the number of days fished each year varied (tables 1 and 3). In the pilot year (2006), the trap began operating March 27 and operated 5 days per week until May 18. Trap operations were halted on May 20, 2009, because the number of Chinook salmon captured was approaching our permitted number to handle. A modification to increase the allowed take was permitted on May 29, 2009, and trap operation resumed. A total of 492 fin clips were collected for genetic analysis (table 3). Fin clips collected for genetic analysis were largely limited to 2006, 2007, and 2008. Chinook salmon was the focus of the genetic analysis and more than 1,500 tissue samples were submitted to the USFWS (table 3). Additional tissue samples, taken from steelhead and coho salmon, were archived for potential future analysis.

A variety of species other than salmonids were captured in the trap in all years of operation (table 4). Lamprey were the most common of the non-salmonids in the trap in most years. Many of the lamprey were gravid females less than 120 mm in length, which were likely brook lamprey (*Lampetra richardsoni)*, but many others of similar size were immature, with no developed eyes. Sculpin (*Cottus spp.)* were the next most common species captured in the trap. The largescale sucker (*Catastomus macrocheilus)* that were captured typically were large adults (greater than 400 mm). One fry collected on March 29, 2006, was identified as a pink salmon, however, the specimen was very small (37 mm FL), and the species identification was tentative. Fish that were of unknown identity were either fry that were too undeveloped to identify (often with the egg yolk still evident), or mortalities that were too degraded to identify (often regurgitated from the captured salmonid smolts or sculpin).

A number of methods were used to estimate capture efficiency of the screw trap. In 2006, there were two attempts at estimating trap efficiency using fish captured at the trap (table 5). In 2007, when fish were transported upstream for efficiency tests every day and the trap was fished 7 days per week, no steelhead smolts and 9 Chinook salmon fry were recaptured. This was after 708 Chinook salmon and 134 steelhead smolts were transported in 43 consecutive efficiency releases. Because of the low numbers of recaptured fish in 2007, the efficiency estimates were lumped into an early estimate (1.3 percent for fry, 0 percent for smolts) and a late estimate (1.2 percent for fry, 0 percent for smolts, table 5). The transportation of fish for daily efficiency estimates ceased on April 27, 2007, because too few fish were being captured in the trap to be transported for efficiency testing, and only nine fish had been recaptured during the entire season. After April 27, 2007, the trap was operated 5 days per week until June 28, 2007. In 2008 and 2009, hatchery fall Chinook salmon from the USFWS's Spring Creek NFH, and Little White Salmon NFH were used on three occasions in each year for tests of trap efficiency (table 5). In 2008 and 2009, the estimates of capture efficiency of hatchery and wild caught fish were calculated separately (table 5). In April 2008, 10.6 percent of the hatchery Chinook salmon and 2.4 percent of the wild Chinook salmon were recaptured when released in similar numbers upstream on the same day (table 5). In early June 2009, 3.6 percent of hatchery Chinook salmon and 0.3 percent of wild Chinook salmon were recaptured when released upstream on the same day (table 5). Although fish were consistently captured in the trap, occasionally in high numbers, our tests indicate that the efficiency of the trap was low and inconsistent. The efficiency estimate ranged from 0 to 11 percent, and it was different based on fish size, species, origin (hatchery or wild), and the date of the test (table 5). However, when we restricted the use of efficiency tests to only those times when more than 300 wild age-0 Chinook salmon were released, there was a mean trapping efficiency of 1.4 percent (n=4, range=0.3–2.4 percent, median=1.3 percent) during the earlier tule Chinook salmon out-migration and a mean trapping efficiency of 0.8 percent (n=2, range=0.3–1.2) during the later URB Chinook salmon out-migration (table 5). When we restrict the use of efficiency tests to only those when more than 500 hatchery Chinook salmon were released, there was a mean trapping efficiency of 5.9 percent (n=2, range=1.2–10.6 percent) during the tule Chinook salmon out-migration, and 2.7 percent (n=2, range=1.7–3.6 percent) during the URB Chinook salmon out-migration (table 5). Using an efficiency estimate of 1.4 percent, we calculated the wild tule Chinook salmon escapement during the days the trap operated to range from 42,760 to 578,062 fish (table 6). Using an efficiency estimate of 0.7 percent, we calculated the wild URB Chinook salmon escapement during the days the trap operated to range from 58,991 to 218,111 fish. Escapement, calculated using efficiencies from hatchery releases, was about one-quarter of the escapement calculated using efficiency tests from wild fish releases (table 6). Because of the variability in efficiency estimates, and confounding factors relating to those estimates, we did not calculate a variance for these estimates, nor did we extrapolate to total escapement over the entire out-migration period.

Electrofishing surveys, conducted in the autumn of each year (2006–09), indicated that steelhead and coho salmon were the numerically dominant salmonids in the margins of the White Salmon River downstream of Condit Dam at this time of year (table 7). We captured 649 steelhead, 222 coho salmon, and 40 Chinook salmon. Steelhead typically were captured in higher abundance in all years and at all three electrofishing sites. Coho salmon were captured at all electrofishing locations, but with high variability in abundance within sites among years. Most of the Chinook salmon (n=38) were captured at rkm 2.3; 78 percent of which were captured in 2009. These were likely age-0 fish, which averaged 82 mm FL (median=80, mode=90, range=60–105). Chinook salmon were not captured at rkm 1.5, and only two were captured at rkm 4.2.

Length-frequency analysis of steelhead and coho salmon indicated that all fish captured at rkm 1.5 were age-0 (figs. 8–11). Too few Chinook salmon were collected during electrofishing to conduct a length-frequency analysis. In 2007, the electrofishing effort was reduced to shallow riffle habitat at rkm 1.5, which was a subset of the area that was electrofished in 2006, 2008, and 2009. This was because of a large number of spawning or holding tule fall Chinook salmon adults in the larger area that was electrofished in 2006, 2008, and 2009. Age-1 steelhead (FL > 105 mm) were captured at rkm 2.3 and 4.1 (table 7, figs. 8–11). Age-1 coho salmon were not captured at any site. The range in the lengths of steelhead (28–155 mm in 2009, fig. 11) was wider at rkm 2.3 and rkm 4.3 compared with rkm 1.5 (38–70 mm FL in 2009, fig. 11) in all years of sampling (figs. 8–11). The habitat at rkm 1.5 had smaller substrate and slower velocity than the other electrofishing sites, which might influence the fish use and electrofishing efficiency when compared with the other sites. Age-0 coho salmon (46–100 mm FL) were consistently captured at all electrofishing sites and were on average larger than the age-0 steelhead (25–105 mm, figs. 8–11).

The greatest variety of fish species were collected at rkm 1.5, with lamprey, sculpin, longnose dace (*Rhinichthys cataractae),* and three-spined stickleback (*Gasterosteus aculeatus)* adding to the species composition (table 7). Sculpin were consistently the most abundant non-salmonid at all electrofishing sites. Lamprey were collected at rkm 1.5 and rkm 2.3 and averaged 137 mm long. Of the eight captured, six were mature with eyes, and two were ammocetes with undeveloped eyes.

A total of 156 fish were submitted to the USFWS's LCRFHC for disease analysis (table 8). Most (92 percent) of the fish submitted for disease analysis were fry collected in the spring by the screw trap, but five of the fish submitted were collected in the autumn when electrofishing. No disease agents were detected other than *Epistylis* in a single 141 mm FL steelhead that was collected while electrofishing (table 8). Overall, fish in the lower White Salmon River were nearly free of disease.

Discussion

Two distinct pulses of Chinook salmon were observed to out-migrate from the White Salmon River. The first pulse was from March to late April, and the second pulse was from mid-May to early June, with a transitional period during the first 2 weeks of May (fig. 2). The genetics analysis, conducted by USFWS, concluded that the early hatching and out-migrating fall Chinook salmon were tule fall Chinook salmon, which were closely related to Chinook salmon from Spring Creek NFH (Smith and others, 2009). Because Spring Creek NFH collected their Chinook salmon broodstock from the White Salmon River from 1901 to 1964, and because stray hatchery tule fall Chinook salmon were known to spawn in the lower White Salmon River (more than 30 to 86 percent of the tule Chinook salmon spawners in some years; Normandeau, 2004, p. 82), the genetic relatedness of the two stocks was not surprising. The later hatching and out-migrating Chinook salmon were URB stock that were genetically similar to fall Chinook salmon from the middle and upper Columbia River, as well as to the stock raised at USFWS's Little White Salmon NFH (Smith and others, 2009). This genetic divergence between stocks was substantial, indicating very little interbreeding between the tule and URB stocks, or low survival of tule-URB hybrids.

Tule fall Chinook salmon were the most abundant age-0 salmonid out-migrating from the lower White Salmon River. However, the adult URB Chinook salmon were the more abundant stock counted during spawning surveys in most years (Normandeau 2004, p. 75). Spawning URB Chinook salmon were five-fold more abundant than spawning tule Chinook salmon in 2006 (2007 age-0 out-migration), and nearly equal to that of tule spawner estimates in 2007 and 2008 (2008 and 2009 age-0 out-migration respectively, Washington Department of Fish and Wildlife, 2011). Prior to this study, the extent that the November spawning URB Chinook salmon affected egg-to-fry survival by superimposing on the redds of the earlier spawning (late September) tule Chinook salmon was unknown. Because spawning habitat was limited downstream of Condit Dam (Normandeau, 2004, p. 97), some amount of redd superimposition was thought to occur. If redd superimposition did occur downstream of Condit Dam, it did not affect tule Chinook salmon egg to fry survival such that the URB fry outnumbered the tule Chinook salmon fry (fig. 2). One possible reason for higher numbers of age-0 tule Chinook salmon being captured at the rotary trap is that the native stock (tule) were better adapted to conditions in the White Salmon River and had higher egg-to-fry survival when compared to the URBs.

Relatively few tule fall Chinook salmon fry were captured in 2007 when compared with other years of trap operation (fig. 2). A high-flow event in November 2006 likely reduced the survival of the tule Chinook salmon eggs that had recently been laid. Some coho salmon and URB Chinook salmon spawned after the flow event and steelhead spawn in the spring, so the November 2006 flow event would not have affected their egg survival to the same extent. The low abundance of age-0 tule fall Chinook salmon in 2007 was therefore considered to be atypical.

Similar to our findings, Chinook salmon were the most abundant salmonid captured in an incline plane scoop trap operated in the lower White Salmon River in 1983 and 1984 (Seiler and Neuhauser, 1985). This trap was operated in about the same location as ours in 1983, but in 1984, it was installed farther upstream at the location of our efficiency releases (rkm 2.3). In 1983, the capture was 4,057 Chinook salmon (hatchery and wild), 1,669 coho salmon, 92 wild steelhead smolts, 128 subyearling steelhead, and 12 steelhead fry. In 1984, the capture was 6,000 wild Chinook salmon, 4,463 coho salmon, 619 age-1 steelhead, and 42 steelhead fry. During the same years, the USFWS raceways at rkm 2.3 were raising Chinook salmon and 1 million coho salmon were stocked upstream of Condit Dam as part of a pilot project. Therefore, the coho salmon and Chinook salmon relative capture rates were confounded by unmarked hatchery fish and were not comparable. However, the hatchery steelhead that were released upstream of the trap were fin-clipped and could be differentiated from wild production. The findings of Seiler and Neuhauser (1985) were similar to ours in terms of the relative abundance of each species, but the trap they used was an incline plane and not a rotary screw trap, their catch rates were confounded by other releases and the release of unmarked hatchery fish, and there was substantial variability in species abundance between years.

There were many variables affecting the accuracy of trap efficiency estimates. Our estimates of trap efficiency were highly variable (range 0–10.6 percent), with too few age-1 or older fish released and/or recaptured to estimate trap efficiency for that age class. Trap efficiency generally was low for tests with wild Chinook salmon fry (range 0.3–2.4 percent). Only two of six of those tests recaptured more than five fish. Schwarz and Taylor (1998) suggest that there may be bias in tests with so few recaptures. Therefore, we recognize that the estimates are likely biased. The Bismarck Brown Y staining method appeared to work well, with stained fish easily identified at least 1 week after marking. However, marked fish may have migrated past the trap well after being released. This biological dye has been reported to fade after about 2 weeks post immersion, but temperature and other environmental factors may alter dye retention (Ewing and others, 1990). Another factor affecting trap efficiency estimates was that the fry captured at the trap were not necessarily migrating, and may have been simply drifting downstream to find rearing habitat in slower water (Quinn, 2005). If this was the case, the fry that were transported upstream may have found rearing habitat prior to reaching the trap, which violates the assumption that fish transported upstream were actively migrating (Volkhardt and others, 2007).

Because so few fish were recaptured when conducting daily efficiency tests in 2007, we used hatchery Chinook salmon as surrogates for wild caught fish in 2008 and 2009. While releasing hatchery fish did increase our sample size, in all but one occasion the estimates were not similar between hatchery and wild Chinook salmon. Hatchery Chinook salmon were recaptured at 4 times the rate of wild Chinook salmon in April 2008, and 10 times the rate of wild Chinook salmon in June 2009. Roper and Scarneccia (1996) found that hatchery age-0 Chinook salmon were captured with far less efficiency than wild Chinook salmon, the opposite of our finding. Ricker (1975) suggests that one assumption when testing trap efficiency is that the test groups should have similar behavior. Similar capture rates among species or age classes would be unlikely because different species exhibit different migratory behavior (Quinn, 2005). Therefore, we did not combine coho salmon or steelhead in our Chinook salmon efficiency estimates. To show the range in the number of Chinook salmon being produced in the White Salmon River, we calculated escapement of Chinook salmon using wild and hatchery Chinook salmon efficiency estimates (table 6). Because of our inconsistent efficiency estimates for age-1 fish, we do not believe that this information should be used to estimate total escapement for age-1 fish of any species.

There was likely high temporal variability in trap efficiency over multiple time scales due to rapidly changing White Salmon River flow from dam operations as well as weather events and snow melt, and due to the influence of a rapidly changing Bonneville pool elevation (fig. 2). The river width and depth and water velocity at the trap site varied unpredictably due to the interaction between Bonneville and Condit dam operations. This affected the spin rate of the rotary trap and likely affected fish behavior and trap efficiency. Therefore, an expanded effort to estimate trap efficiency would be needed to accurately calculate escapement, and we recommend that the trap be placed above potential Bonneville pool influence.

Steelhead were the most common fish collected when electrofishing the margins of the White Salmon River downstream of Condit Dam at all three sites sampled. Coho salmon were regularly captured, and in 2008 at our lower site (rkm 1.5), they outnumbered steelhead. At rkm 1.5, much of the habitat was shallow and had smaller substrate and slower water velocity than the other sites. Chinook salmon comprised only 4 percent of the catch while electrofishing, with most (95 percent) of them captured at rkm 2.3. Because our electrofishing sampling was in the late summer, we would expect that fall Chinook salmon would have already migrated out of the area.

The results from this study helped guide the fish salvage and reintroduction plans in the White Salmon River during and after the removal of Condit Dam. The White Salmon River Working Group was formed in February 2007 to share information and identify and prioritize the salvage and reintroduction efforts for each native salmonid species. This was done in anticipation of the restoration of fish passage after dam removal. The group consisted of representatives from USGS, USFWS, Yakama Nation, PacifiCorp, National Marine Fisheries Service, Washington Department of Fish and Wildlife, and the U.S. Forest Service. Because of the high number of tule Chinook salmon fry found in this study, the group decided that there was a wild spawning population worth salvaging in the year of removal. A salvage effort is planned because the sediment released from the reservoir upstream of Condit Dam will likely smother all redds, resulting in the loss of that year's Chinook salmon production.

Several other rivers in the Pacific Northwest have large dams that are scheduled for removal or have recently been removed. The methods for dam removal and the strategy for dealing with the sediment retained behind it typically are unique to each structure (Magirl and others, 2010). The biological response after dam removal also likely will be unique to each river and removal method (Heinz Center, 2002). Dams on the Rogue River, Oregon (Savage Rapids Dam removed in 2009), Sandy River, Oregon (Marmot Dam removed in 2007), and Trout Creek of the Wind River, Washington (Hemlock Dam removed in 2009) all had fish passage, so the fish reintroduction questions are not similar to the White Salmon and Elwha Rivers. The Elwha River has two dams scheduled for removal beginning in 2011, and similar to Condit Dam on the White Salmon River, these dams have blocked fish for a century. However, the methods for removal and sediment management are quite different, with progressive notching and sediment stabilization over several years proposed in the Elwha River and rapid sluicing of the sediment proposed in the White Salmon River (Magirl and others, 2010). Much work has been conducted on the Elwha River to characterize the sediment, riparian, and aquatic community upstream and downstream of the dams along with efforts to predict the changes after removal (Duda and others, 2008). The removal of dams on the Elwha and White Salmon Rivers provide an opportunity to learn about fish response to newly available habitat. These dam removals provide an opportunity to learn about short-term response of fish to a large disturbance (dam removal). The removals also provide an opportunity to learn about the long-term response of fish to the redistribution of sediments, nutrients, wood, and aquatic communities after a century of blockage.

We expect the species composition, migration timing, and length frequencies of anadromous species to change after the removal of Condit Dam, currently scheduled for October 2011. The historically accessible habitats will likely have a higher diversity of temperatures and feeding opportunities than what was available downstream of Condit Dam. As spring Chinook salmon, fall Chinook salmon, coho salmon, steelhead, lamprey, and possibly chum salmon recolonize their historical habitat, there will likely be a change in the number and size of the juveniles of those species. It was our intent that the electrofishing and rotary trapping results from this project provide a baseline of information, which can be contrasted with information collected after the dam is removed and anadromous fish return to their historical habitats.

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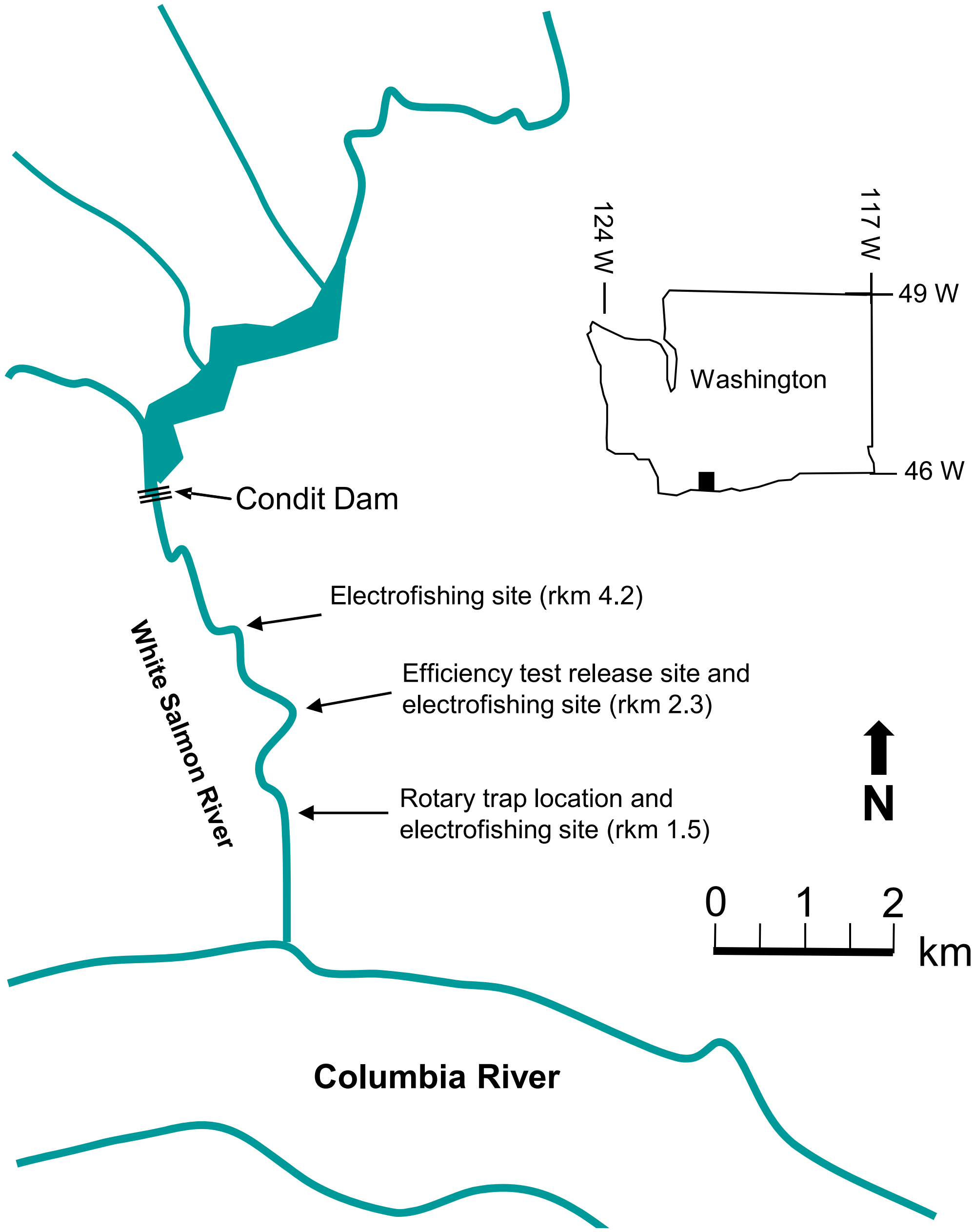

Figure 1. Map of the lower White Salmon River highlighting the location where the rotary screw trap was installed from March through June 2006–09, and the location of efficiency releases upstream of the trap at river kilometer (rkm) 2.3. The sites at rkm 1.5, 2.3, and 4.2 were electrofished in the late summer 2006–09.

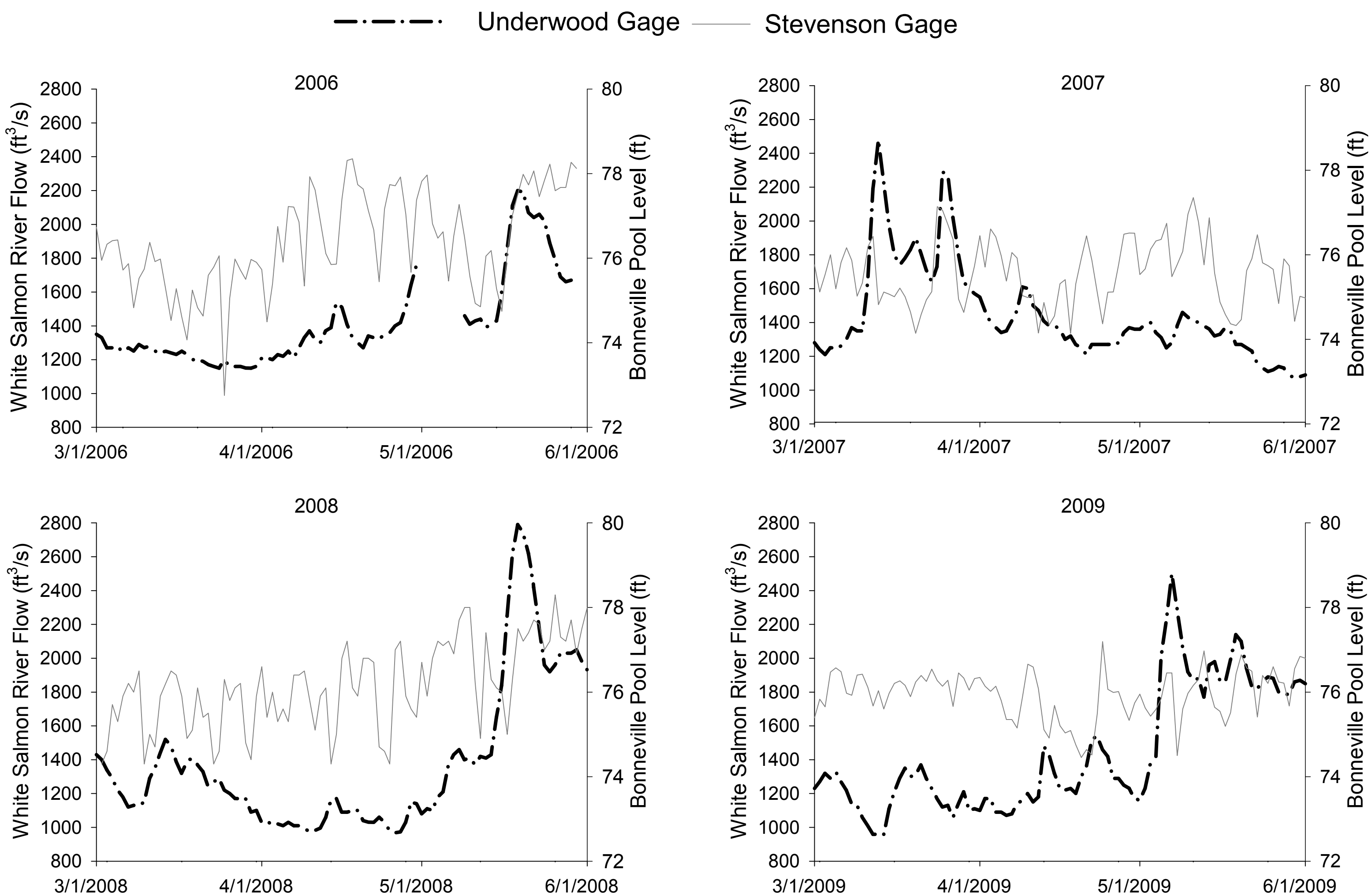

Figure 2. Daily average White salmon River flow (ft³/s) during the period of trap operation from USGS gage number 14123500 at river kilometer 3.1 and Bonneville Pool level (ft above sea level) measured at USGS gage number 14128600 at river kilometer 244 of the Columbia River .

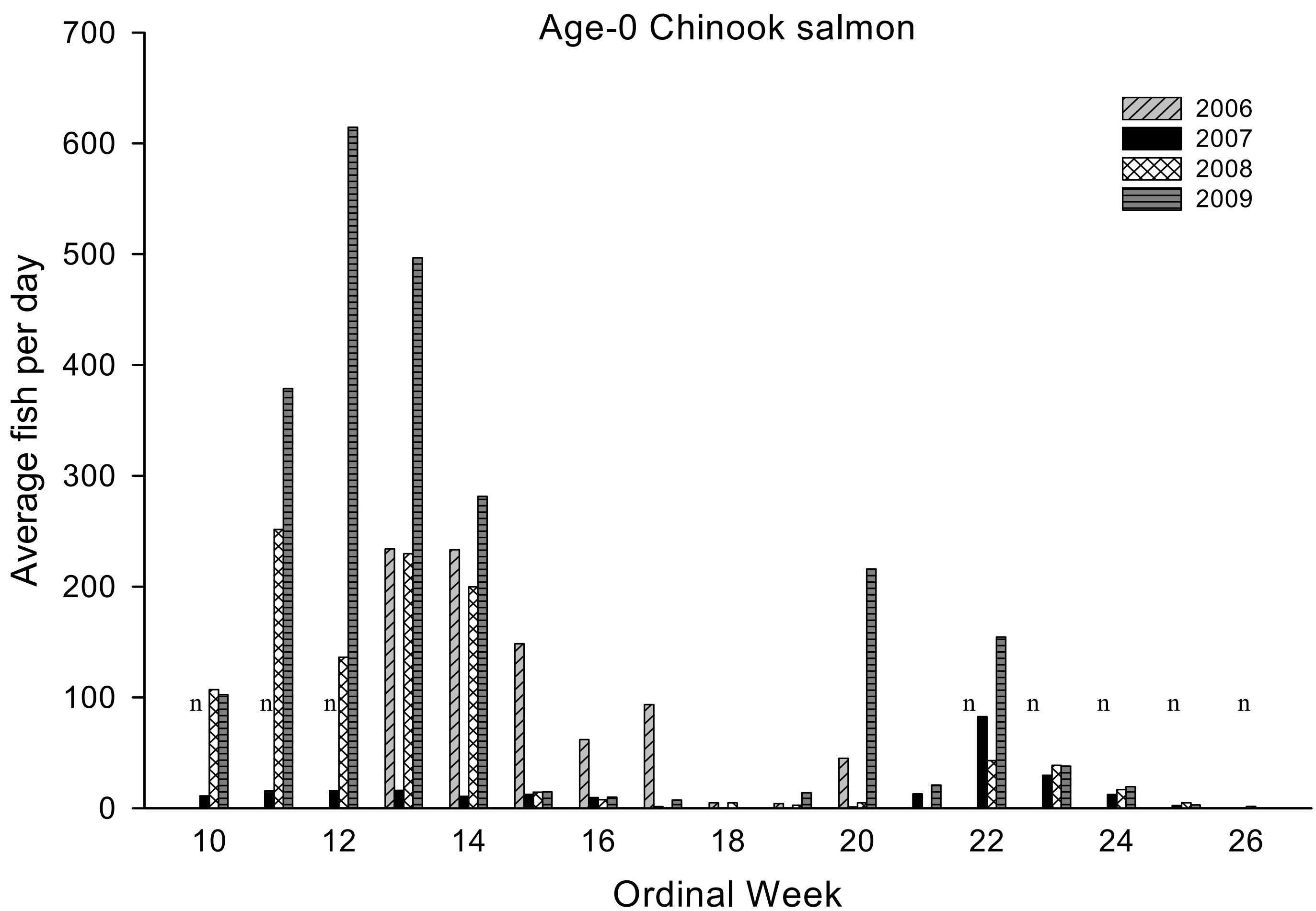

Figure 3. Average number of age-0 Chinook salmon (not including hatchery released fish) captured per day by the rotary screw trap for each year of operation at river kilometer 1.5 of the White Salmon River, Washington, March–June, 2006-09. n, not sampled.

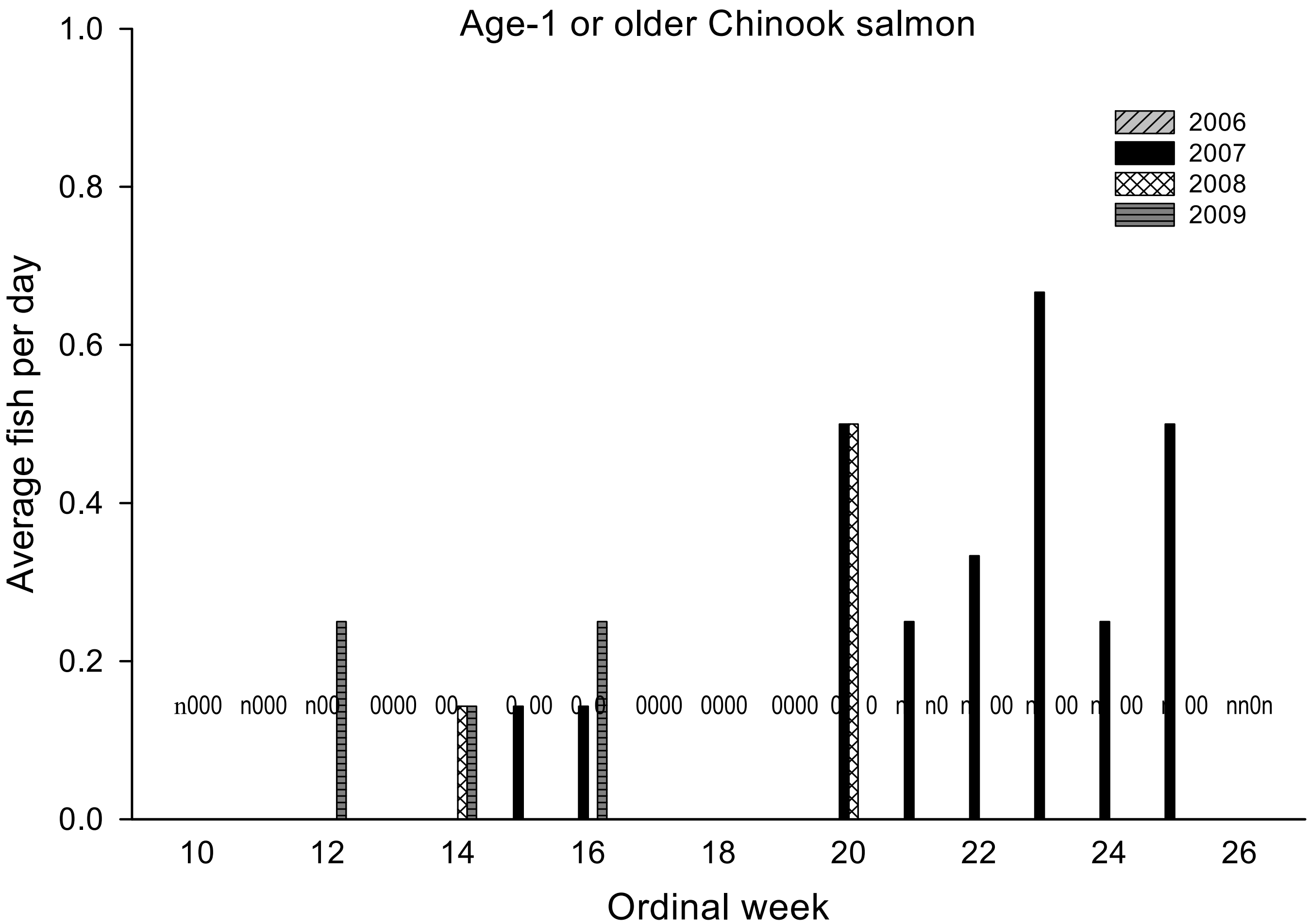

Figure 4. Average number of age-1 or older Chinook salmon captured per day by the rotary screw trap for each year of operation at river kilometer 1.5 of the White Salmon River, Washington, March–June 2006–09. n, not sampled; 0, none captured.

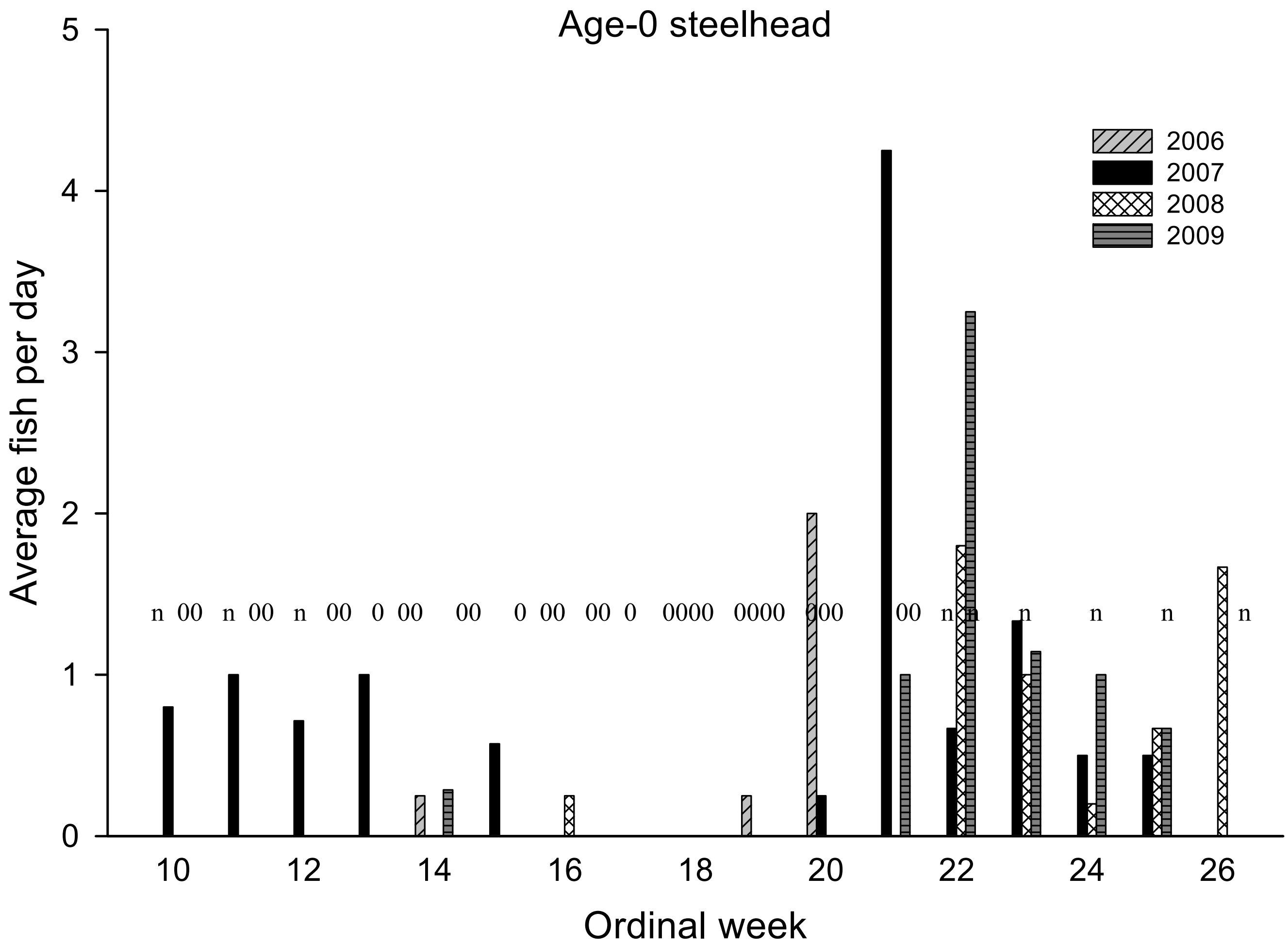

Figure 5. Average number of age-0 steelhead captured per day by the rotary screw trap for each year of operation at river kilometer 1.5 of the White Salmon River, Washington, March–June, 2006–09. n, not sampled; 0, none captured.

Figure 6. Average number of age-1 or older steelhead (not including hatchery fish) captured per day by the rotary screw trap for each year of operation at river kilometer 1.5 of the White Salmon River, Washington, March–June, 2006–09. n, not sampled; 0, none captured.

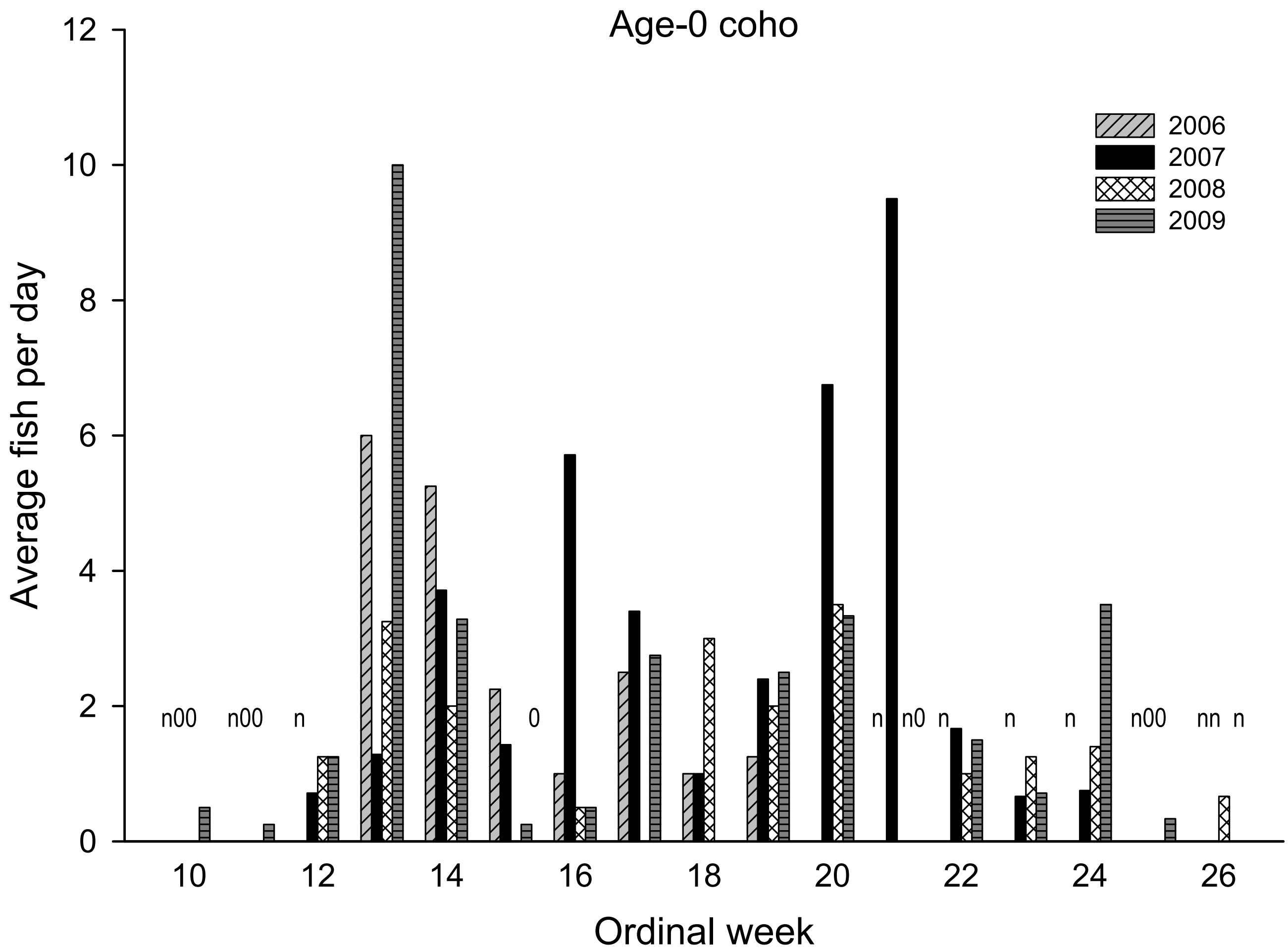

Figure 7. Average number of age-0 coho salmon captured per day by the rotary screw trap for each year of operation at river kilometer 1.5 of the White Salmon River, Washington, March–June 2006–09. n, not sampled; 0, none captured.

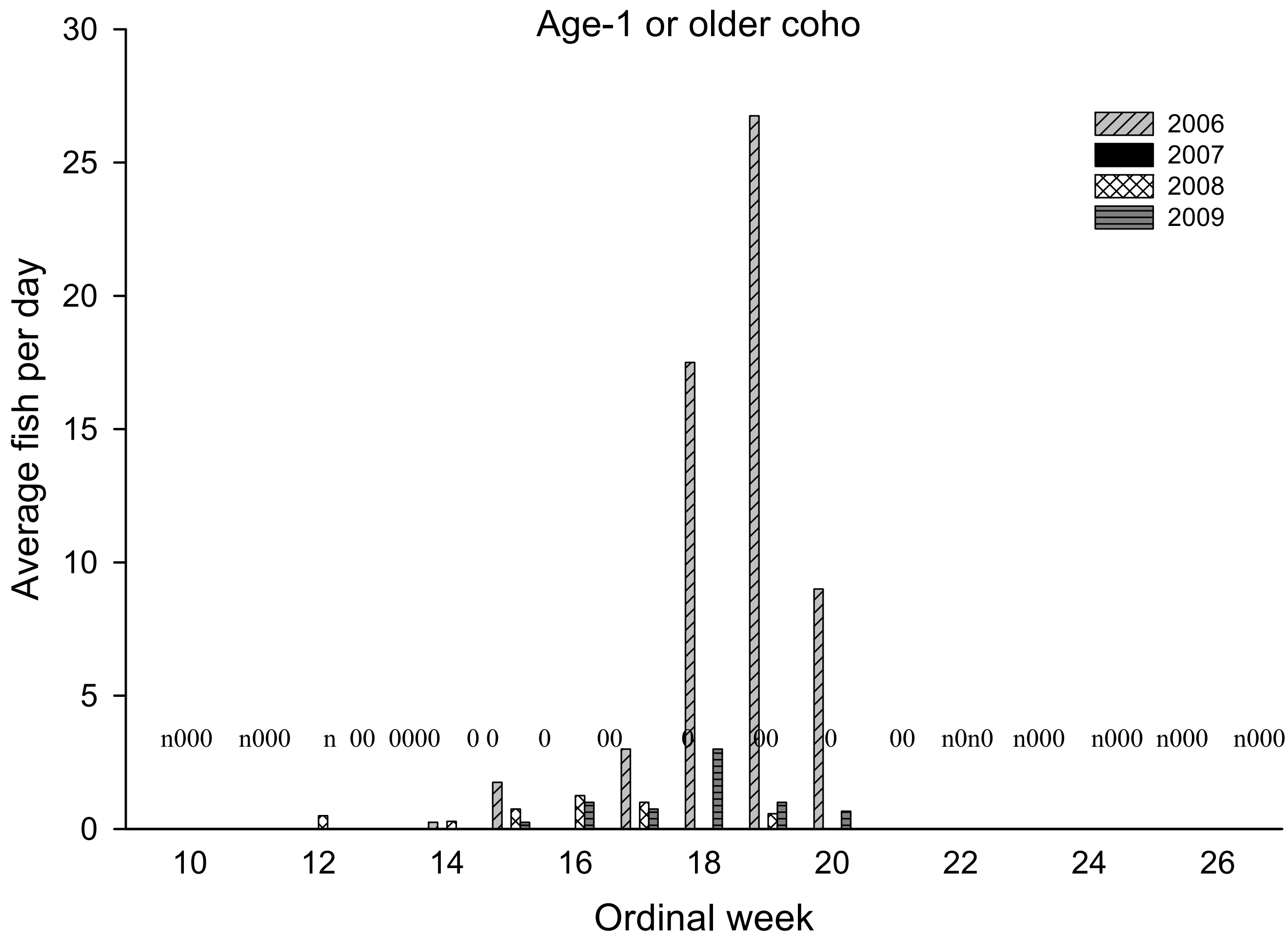

Figure 8. Average number of age-1 or older coho salmon captured per day by the rotary screw trap for each year of operation at river kilometer 1.5 of the White Salmon River, Washington, March–June 2006–09. No age-1 or older coho salmon were captured in 2007. n, not sampled; 0, none captured.

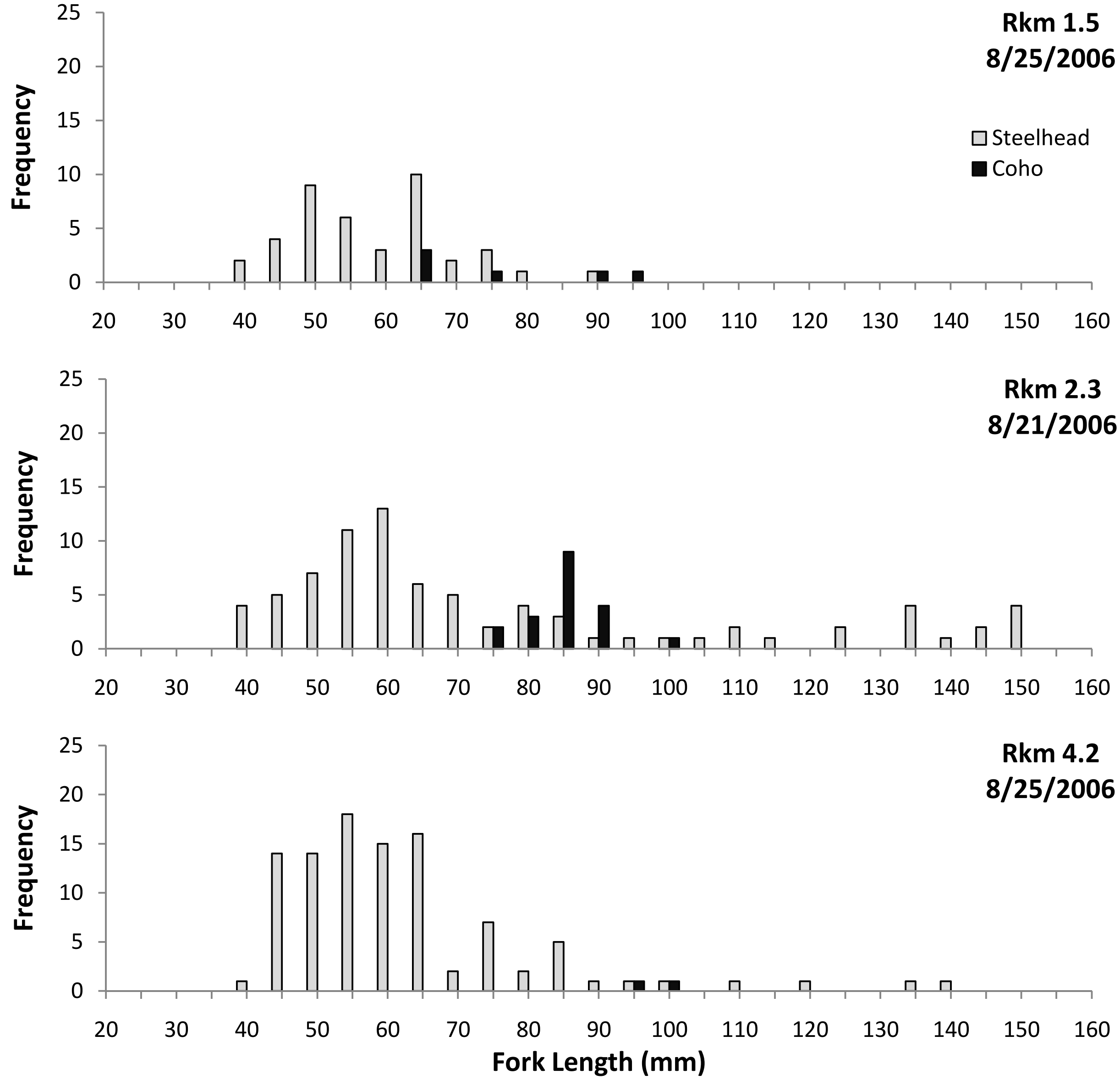

Figure 9. Length-frequency histograms of coho salmon and steelhead collected by electrofishing a 4.5-m swath of the left margin of the White Salmon River, at river kilometers (rkm) 1.5, 2.3, and 4.2, Washington, 2006.

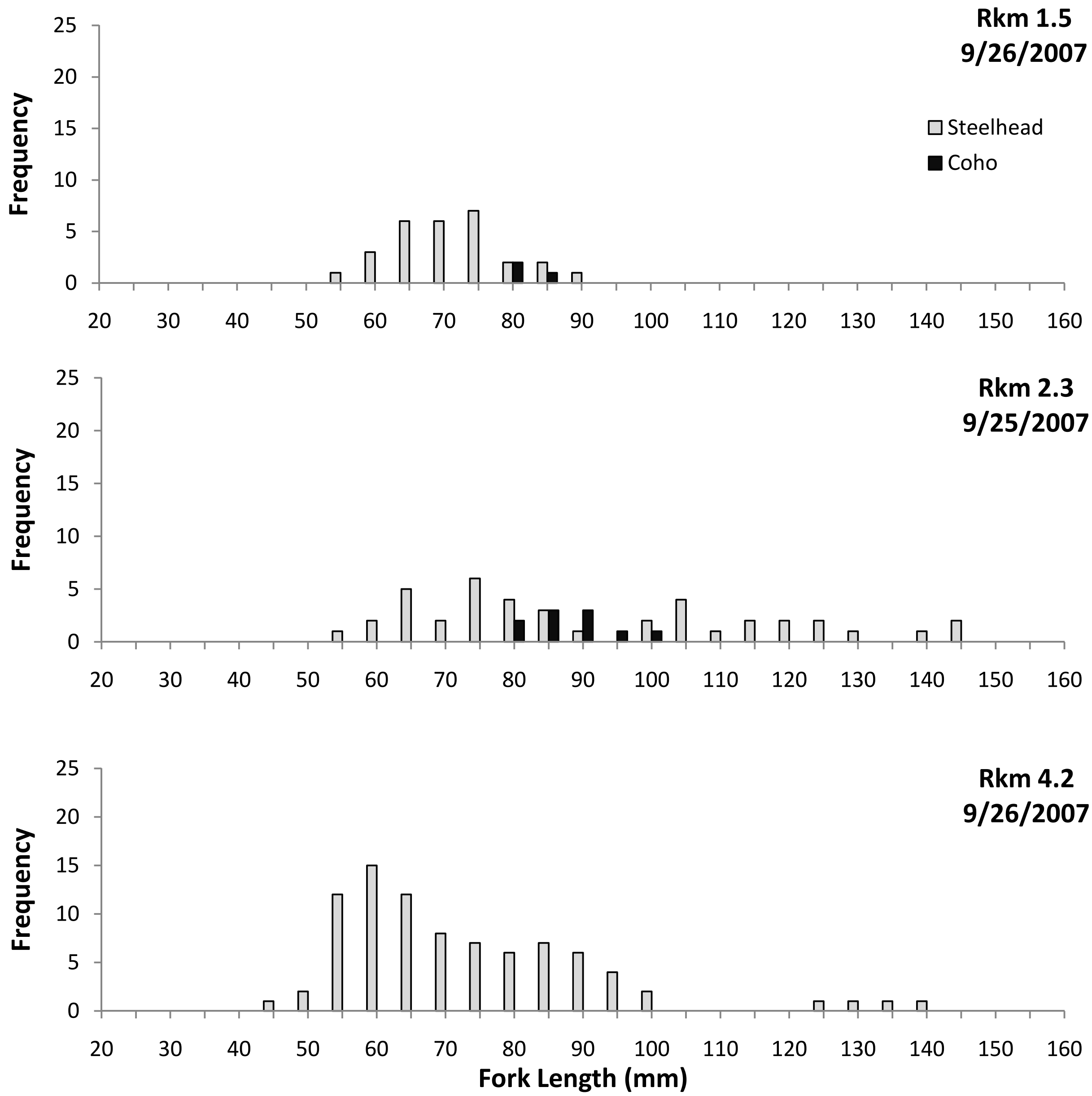

Figure 10. Length-frequency histograms of coho salmon and steelhead collected by electrofishing a 4.5-m swath of the left margin of the White Salmon River at river kilometers (rkm) 1.5, 2.3, and 4.2, Washington, 2007.

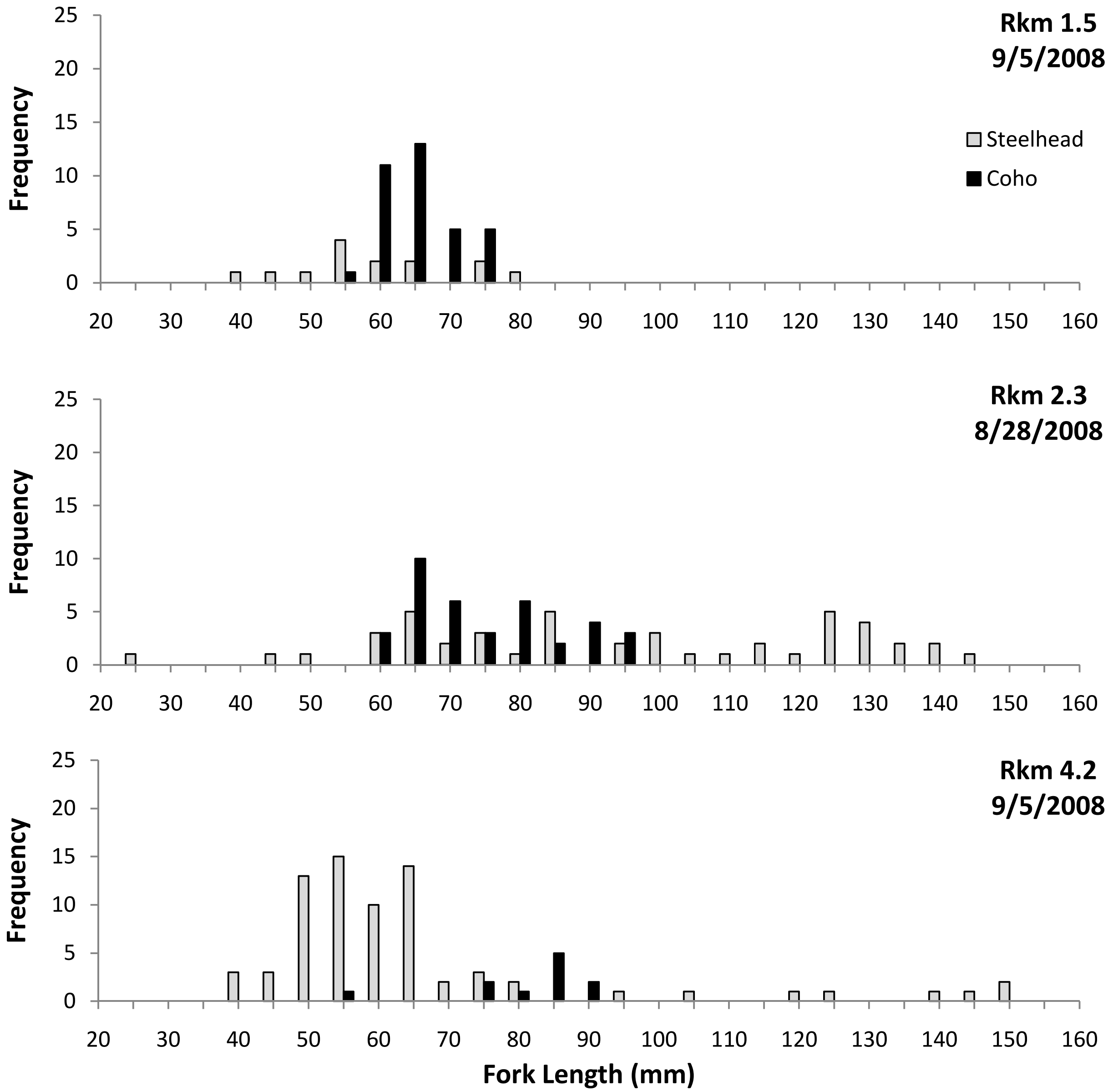

Figure 11. Length-frequency histograms of coho salmon and steelhead collected by electrofishing a 4.5-m swath of the left margin of the White Salmon River at river kilometer (rkm) 1.5, 2.3, and 4.2, Washington, 2008.

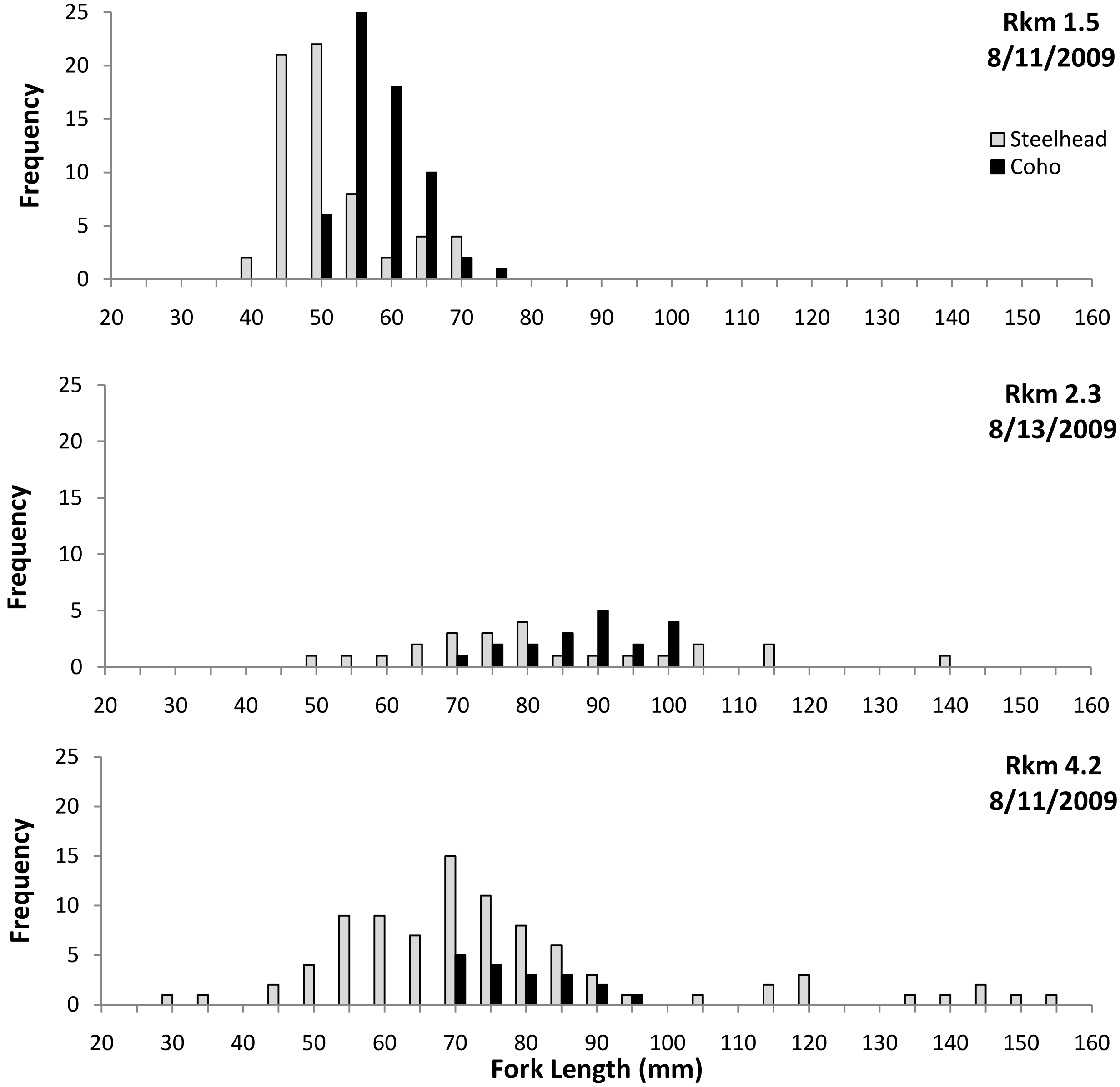

Figure 12. Length-frequency histograms of coho salmon and steelhead collected by electrofishing a 4.5-m swath of the left margin of the White Salmon River at river kilometer (rkm) 1.5, 2.3, and 4.2, Washington, 2009.

Table 1. Weekly total number of age-0 Chinook salmon, steelhead, and coho salmon captured at the rotary screw trap at river kilometer 1.5 in the White Salmon River, Washington, March–June 2006–09.

[Week number indicates ordinal week with week 10 starting on March 5 of each year. Number in parenthesis indicates the number of fish missing an adipose fin, which indicates hatchery origin. NS, not sampled]

	Sampling days				Chinook				Steelhead				Coho			
Week	**2006**	**2007**	**2008**	**2009**	**2006**	**2007**	**2008**	**2009**	**2006**	**2007**	**2008**	**2009**	**2006**	**2007**	**2008**	**2009**
10	0	5	4	2	NS	56	428	205	NS	4	0	0	NS	0	0	1
11	0	6	4	4	NS	95	1,006	1,515	NS	6	0	0	NS	0	0	1
12	0	7	4	4	NS	111	545	2,458	NS	5	0	0	NS	5	5	5
13	3	7	4	4	702	113	919	1,993(6)	0	7	0	0	18	9	13	40
14	4	7	7	7	933	75	1,451(53)	1,970	1	0	0	2	21	26	14	23
15	4	7	4	4	594	88	58	59	0	4	0	0	9	10	0	1
16	2	7	4	4	124	68	31	70(30)	0	0	1	0	2	40	2	2
17	2	5	4	4	187	7	2	30	0	0	0	0	5	17	0	11
18	2	1	1	1	10	1	5	0	0	0	0	0	2	1	3	0
19	4	5	7	2	17	2	19	28	1	0	0	0	5	12	14	5
20	1	4	2	3	45	5	10	648	2	1	0	0	0	27	7	10
21	0	4	0	1	NS	52	NS	21	NS	17	NS	1	NS	38	NS	0
22	0	3	5	4	NS	248	215	636(18)	NS	2	9	13	NS	5	5	6
23	0	3	4	7	NS	89	155	266	NS	4	4	8	NS	2	5	5
24	0	4	5	4	NS	50	93(9)	78	NS	2	1	4	NS	3	7	14
25	0	4	6	4	NS	10	30	9	NS	2	4	2	NS	0	0	1
26	0	0	3	0	NS	NS	5	NS	NS	NS	5	NS	NS	NS	2	NS
Sum	**22**	**79**	**68**	**59**	**2,612**	**1,070**	**4,972(62)**	**9,986(54)**	**4**	**54**	**24**	**30**	**62**	**195**	**77**	**125**

Table 2. Weekly total number of age-1 or older Chinook salmon, steelhead, and coho salmon captured at the rotary screw trap at river kilometer 1.5 in the White Salmon River, Washington, March–June 2006–09.

[Week number indicates ordinal week with week 10 starting on March 5 of each year. Number in parenthesis indicates the number of fish missing an adipose fin, which indicates hatchery origin. NS, not sampled]

	Sampling days				Chinook				Steelhead				Coho			
Week	**2006**	**2007**	**2008**	**2009**	**[1]2006**	**2007**	**2008**	**2009**	**2006**	**2007**	**2008**	**2009**	**2006[a]**	**2007**	**2008**	**2009**
10	0	5	4	2	NS	0	0	0	NS	6(5)	1	0	NS	0	0	0
11	0	6	4	4	NS	0	0	0	NS	7(4)	2	1	NS	0	0	0
12	0	7	4	4	NS	0	0	1	NS	7(4)	0	0	NS	0	2	0
13	3	7	4	4	0	0	0	0	0	8(2)	0	0	0	0	0	0
14	4	7	7	7	0	0	1	1	3(1)	10(2)	4	2	1	0	2	0
15	4	7	4	4	0	1	0	0	3	20(4)	8	3	7	0	3	1
16	2	7	4	4	0	1	0	1	0	7	9	15	0	0	5	6(2)
17	2	5	4	4	0	0	0	0	1	20	29	8	6	0	4	3
18	2	1	1	1	0	0	0	0	30(23)	3	33(30)	89(81)	35	0	0	3
19	4	5	7	2	0	0	0	0	36(14)	61(52)	52(43)	6(2)	107	0	4	2
20	1	4	2	3	0	2	1	0	2	17(15)	9(7)	4(4)	9	0	0	2
21	0	4	0	1	NS	1	NS	0	NS	11(7)	NS	4(2)	NS	0	NS	0
22	0	3	5	4	NS	1	0	0	NS	10(5)	3	3(1)	NS	0	0	0
23	0	3	4	7	NS	2	0	0	NS	4(1)	4(1)	4(2)	NS	0	0	0
24	0	4	5	4	NS	1	0	0	NS	3(1)	1	0	NS	0	0	0
25	0	4	6	4	NS	2	0	0	NS	0	4(1)	0	NS	0	0	0
26	0	0	3	0	NS	NS	0	NS	NS	NS	0	NS	NS	NS	0	NS
Sum	**22**	**79**	**68**	**59**	**0**	**11**	**2**	**3**	**75(38)**	**194(102)**	**159(82)**	**139(92)**	**165**	**0**	**20**	**17(2)**

[1]Smolting coho salmon with adipose fins present, but highly eroded anal fins (likely hatchery released) were incorrectly identified in 2006 as spring Chinook salmon. Results from genetic analysis corrected this field identification error, and the data presented are the corrected information.

Table 3. Rotary screw trap installation date, number of days fished, and the number of genetic samples collected at river kilometer 1.5 of the White Salmon River, Washington, 2006–09.

Year	Installation date	End date	Total number of days fished/year	Genetic samples collected		
				Chinook	Steelhead	Coho
2006	Mar 27	May 18	23	427	17	48
2007	Mar 6	June 28	79	624	116	157
2008	Mar 4	June 27	68	644	2	0
2009	Mar 9	June 24	59	2	42	0

Table 4. Total number of fish and amphibian species, other than Chinook salmon, coho salmon, and steelhead, caught at a rotary screw trap at river kilometer 1.5 in the White Salmon River, Washington, for each year of operation, March–June 2006–09.

Species	Total fish caught in rotary screw trap			
	2006	2007	2008	2009
Lamprey *(Lampetra spp.)*	15	117	66	65
Longnose dace *(Rhinichthys cataractae)*	3	27	9	6
Mountain whitefish *(Prosopium williamsoni)*	0	3	0	1
Northern pikeminnow *(Ptychocheilus oregonensis)*	0	0	0	4
Peamouth *(Mylocheilus caurinus)*	0	1	0	0
Pink salmon *(Oncorhynchus gorbuscha)*	1	0	0	0
Sculpin *(Cottus* spp.*)*	6	16	12	6
Smallmouth bass *(Micropterus dolomieu)*	0	0	1	0
Largescale sucker *(Catostomus macrocheilus)*	1	2	2	3
Three-spined stickleback *(Gasterosteus aculeatus)*	19	1	2	2
Unknown fish	1	12	8	21
Pacific giant salamander *(Dicamptodon tenebrus)*	0	2	0	0

Table 5. Number of hatchery and wild Chinook salmon and steelhead that were released and recaptured to estimate trapping efficiency of a rotary screw trap at river kilometer 1.5 on the White Salmon River, Washington.

[Rotary trap was operated for at least 12 consecutive days after all efficiency releases. All age-0 fish used for efficiency releases were Chinook salmon and all age-1 or older fish used for efficiency releases were steelhead]

Age class	Year	Release dates	Number released		Number recaptured		Efficiency (%)	
			Hatchery	Wild	Hatchery	Wild	Hatchery	Wild
0	2006	April 4-7	--	499	--	3	--	0.6
		May 9	--	9	--	0	--	0.0
	2007	March 7 - April 24	--	300	--	4	--	1.3
		May 7 - June 14	--	408	--	5	--	1.2
	2008	April 1-5	500	532	53	13	10.6	2.4
		May 5-7	570	--	5	--	0.9	--
		June 16-17	532	--	9	--	1.7	--
	2009	March 31 - April 1	500	952	6	13	1.2	1.4
		April 20	500	0	30	--	6.0	--
		June 1 - June 4	500	312	18	1	3.6	0.3
1 or older	2006	May 9	33	--	2	--	6.1	--
	2007	March 7 - April 24	--	61	--	0	--	0.0
		May 7 - June 14	--	73	--	0	--	0.0
	2008	May 5-7	61	--	0	--	0.0	--

Table 6. Number of Chinook salmon captured at a rotary screw trap at river kilometer 1.5 and total escapement estimates of tule and upriver bright fall Chinook salmon during the days the trap operated in the White Salmon River, Washington.

[Efficiency estimates used to calculate escapement were the mean from tests when more than 300 wild Chinook salmon or 500 hatchery Chinook salmon were released upstream. n, number; URB, upriver bright]

Year	Total captured		Escapement estimate			
			Using mean wild fish efficiency		Using mean hatchery fish efficiency	
	Tule	URB	Tule (1.4 percent n=4)	URB (0.7 percent n=2)	Tule (5.9 percent n=2)	URB (2.7 percent n=2)
2006	2,550		177,586		43,220	
2007	614	456	42,760	58,991	10,407	17,208
2008	4,445	527	309,557	68,176	75,339	19,887
2009	8,300	1,686	578,026	218,111	140,678	63,623

Table 7. River kilometer (rkm), year, and number of fish by species and age class (age 0 salmonids were less than 105 millimeters fork length) that were collected during electrofishing surveys from three sites in the White Salmon River, Washington.

[No other fish species were captured while electrofishing. ≥, equal to or greater than]

		Number of fish									
		Steelhead		Chinook		Coho		Other			
Site (rkm)	Year	Age 0	Age≥1	Age 0	Age≥1	Age 0	Age≥1	Lamprey	Sculpin	Longnose dace	Stickleback
1.5	2006	41	0	0	0	6	0	4	6	0	8
	2007	28	0	0	0	3	0	2	3	1	3
	2008	14	0	0	0	35	0	0	0	1	0
	2009	63	0	0	0	62	0	0	0	2	0
	Sum	**146**	**0**	**0**	**0**	**106**	**0**	**6**	**9**	**4**	**11**
2.3	2006	64	17	1	0	19	0	0	15	2	0
	2007	30	11	2	0	10	0	0	9	0	0
	2008	26	21	5	0	37	0	1	10	0	0
	2009	20	5	30	0	19		1	17	0	0
	Sum	**140**	**54**	**38**	**0**	**85**	**0**	**2**	**51**	**2**	**0**
4.2	2006	97	4	0	0	2	0	0	2	0	0
	2007	82	5	1	0	0	0	0	0	0	0
	2008	66	8	1	0	11	0	0	7	0	0
	2009	77	13	0	0	18	0	0	9	0	0
	Sum	**322**	**30**	**2**	**0**	**31**	**0**	**0**	**18**	**0**	**0**

Table 8. Fish health report results from fish collected in the White Salmon River, Washington, and submitted to the U.S Fish and Wildlife Service's Lower Columbia River Fish Health Center, 2006–09.

[Species: CHN, Chinook salmon, URB, upriver bright. Age: Juv, juvenile. Disease: ND, None detected. Comments: USGS, U.S. Geological Survey; USFWS, U.S. Fish and Wildlife Service. mm, millimeter]

Date	Species	Number of fish	Mean fork length (mm)	Age	Disease	Comments
4/05/2006	steelhead	1	158	Juv	ND	
4/05/2006	fall CHN	4	40	Juv	ND	
4/05/2006	sculpin	1	182	Adult	ND	34 Chinook salmon fry in its stomach.
5/05/2006	spring CHN	4	132	Juv	ND	These fish were hatchery coho salmon that were incorrectly identified as yearling Chinook salmon by USFWS and by USGS; highly eroded anal fins.
8/21/2006	steelhead	1	87	Juv	*Epistylis*	Female. Fish had white patches throughout body surface. *Epistylis* (high levels) with a lot of mucous.
8/21/2006	coho	1	82	Juv	ND	–
3/13/2007	fall CHN	4	39	Juv	ND	Mortalities. Egg sack present
3/13/2007	sculpin	1	30	Juv	ND	–
3/13/2007	Pacific lamprey	1	105	Juv	ND	Mortality.
3/21/2007	steelhead	1	250	Juv	ND	Frayed fins. Right eye missing.
3/21/2007	fall CHN	1	40	Juv	ND	Mortality in trap.
3/26/2007	sculpin	1	35	Juv	ND	Big female with eggs. five Chinook salmon fry in its stomach.
3/28/2007	fall CHN	2	40	Juv	ND	–
4/03/2007	fall CHN	2	40	Juv	ND	–
4/04/2007	fall CHN	1	36	Juv	ND	Mortality in trap.
4/10/2007	steelhead	1	250	Juv	ND	Heavy descaling. Eroded dorsal fin.
4/11/2007	fall CHN	1	39	Juv	ND	–
4/22/2007	fall CHN	1	40	Juv	ND	–
4/24/2007	coho	1	35	Juv	ND	Mortality in trap.
4/25/2007	coho	1	36	Juv	ND	Mortality in trap.
5/09/2007	coho	1	38	Juv	ND	Mortality in trap.
9/26/2007	steelhead	1	70	Juv	ND	–
9/26/2007	steelhead	2	71, unknown	Juv	ND	–
3/11/2008	sculpin	1	152	Adult	ND	Big female with eggs. 21 fall Chinook salmon fry in stomach.
4/08/2008	sculpin	1	168	Adult	ND	Big female with eggs. 14 fall Chinook salmon fry in stomach.
4/01/2009	fall CHN (Tule)	30	38	Juv	ND	Fish appeared to be in good health.
4/07/2009	fall CHN (Tule)	30	40	Juv	ND	Fish appeared to be in good health.
5/19/2009	fall CHN (URB)	30	40	Juv	ND	Fish appeared to be in good health.
6/02/2009	fall CHN (URB)	30	40	Juv	ND	Fish appeared to be in good health.

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For more information concerning the research in this report, contact the
Director, Western Fisheries Research Center
U.S. Geological Survey
6505 NE 65th Street
Seattle, Washington 98115
http://wfrc.usgs.gov/

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