Detection of PIT-Tagged Juvenile Salmonids in the Columbia River Estuary using Pair Trawls, 2003 and 2004

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EXECUTIVE SUMMARY

In 2003 and 2004, we continued to detect juvenile Pacific salmonids *Oncorhynchus* spp. implanted with passive integrated transponder (PIT) tags using surface pair-trawls fitted with PIT-tag detection antennas. Two areas in the Columbia River estuary were sampled. The primary sampling site was an upper, freshwater reach near Jones Beach, at river kilometer (rkm) 61-83. A secondary site (sampled in 2004 only) was in the brackish-water portion of the lower estuary (rkm 8-24).

During 2003 and 2004, spring river flows were slightly lower than the previous 10-year average, but considerably higher than flows recorded during the drought year of 2001. We report detection data and compare these data to detections in previous years for fish under these differing flow conditions.

Several large annual release-groups of spring migrant PIT-tagged fish were targeted during our sampling. In the Snake River basin, about 153,000 fish were released for a transportation study and about 303,000 were released for a comparative survival study of hatchery fish. In the Upper Columbia River basin, several large studies made releases of PIT tagged fish: during 2003-2004, and over 1.5 million Chinook salmon and over 600,000 steelhead *O. mykiss* were tagged and released. We recorded detections in the estuary of fish from many other releases; overall, more than 4.2 million PIT-tagged fish were released for migration during 2003 and 2004.

Our first goal in sampling was to compare migration timing and relative survival to the estuary between inriver migrant and transported juvenile Chinook salmon *O. tshawytscha* and steelhead. A second goal was to provide estuarine passage dates to allow survival comparisons between adult fish groups that entered the ocean as juveniles at similar times. These comparisons of smolt-to-adult return ratios have been made possible with the successful installation of PIT-tag readers for adult fish passing upstream at Bonneville and other dams.

From the total detections of 2003 and 2004 respectively, the species composition included 14,554 and 11,725 yearling Chinook salmon; 1,554 and 695 subyearling Chinook salmon; 231 and 362 coho salmon *O. kisutch*; 4,035 and 3,586 steelhead; 46 and 85 sockeye salmon *O. nerka*; and 9 and 5 sea-run cutthroat trout *O. clarki clarki*.

In both years, the PIT-tagged fish we detected originated from two primary sources: the Snake River (47 and 39% in 2003 and 2004 respectively) and the upper-Columbia River (50 and 57% in 2003 and 2004). Fish from both of these sources were subject to transportation at Lower Granite, Little Goose, or Lower Monumental Dams on the Snake River or McNary Dam on the Columbia River. The remaining detection percentages in both years were composed of fish released downstream from McNary Dam, and therefore not subject to transportation.

Fish that had been transported and released downstream from Bonneville Dam made up 23% of our detections in 2003 and 30% in 2004. Fish that had been detected previously in the juvenile bypass system at Bonneville Dam made up 14% of our total detections in 2003 and 6% in 2004. The majority of the remaining fish had passed Bonneville Dam via spill or other routes lacking PIT-tag interrogation capability. Less than 4% of the total trawl detections each year were fish released at or downstream from Bonneville Dam.

In the upper estuary, the large-trawl detection system consisted of the same antenna developed in 2001 (2 coils; 86-cm diameter × 2-m long, operating at 134.2-kHz). We sampled for over 1,500 h during both years combined. We conducted nearly continuous day- and night-time sampling throughout much of the yearling salmonid migration period. Minimal sampling occurred each day between 1200 and 1800 PDT because these hours were characterized by high winds and difficult sampling conditions. Thus we used these hours to change crews, re-fuel, and perform maintenance.

Sample sizes of wild and hatchery yearling Chinook salmon and steelhead were sufficient in most instances to conclude that diel trends among rearing-types were similar for both species. Thus we pooled wild and hatchery detection data for the analyses and summaries.

During the two-crew sampling period in 2003, we averaged 13 detections/h of yearling Chinook salmon during daylight and 33 detections/h during darkness ($P = 0.001$). For steelhead in 2003, the intensive sample periods yielded an average 5 detections/hr, irrespective of time of day ($P = 0.622$). During two-crew sampling in 2004, we averaged 12 yearling Chinook salmon detections/h during daylight and 20 detections/h during darkness ($P = 0.002$), as well as 5 steelhead detections/h in daylight and 4 detections/h in darkness hours ($P = 0.688$).

During two-crew sampling in 2003 and 2004, we detected about 2.5% of the yearling Chinook salmon and 1.6% of the steelhead that had previously been detected at Bonneville Dam; a rough estimate of detection efficiency. We detected 2.1% of more than 160,000 yearling Chinook salmon and 1.6% of more than 40,000 steelhead transported in 2003. In 2004, slightly fewer fish were transported, and we detected 2.9% of the 134,000 transported yearling Chinook salmon and 2.1% of the 29,000 transported steelhead. Overall, we believe the trawl detection system detected over 95% of all PIT-tagged fish that passed through the antenna.

The rate of travel for PIT-tagged fish to the estuary was measured using the time of transport-barge release below Bonneville Dam or time of detection at Bonneville Dam. In 2003, travel time for Chinook salmon and steelhead was about 85 km/d; in the same year, radio-tagged Chinook salmon traveled 63 km/d and steelhead, 86 km/d. In 2004, PIT-tagged yearling Chinook salmon and steelhead traveled 80 and 77 km/d, respectively, while radio-tagged Chinook salmon traveled 80 km/d.

Weekly average survival for Snake River yearling Chinook salmon from the tailrace of McNary Dam to the tailrace of Bonneville Dam was 73% in 2003 and 59% in 2004. For Snake River steelhead, weekly average survival from the tailrace of McNary Dam to the tailrace of Bonneville Dam was 52% in 2003. In 2004, the numbers of steelhead detections at Bonneville Dam were insufficient for weekly survival estimates.

For mid-Columbia River yearling Chinook salmon, weekly average survival from the tailrace of McNary Dam to the tailrace of Bonneville Dam was 77% in 2003 and 62% in 2004. Weekly average survival for mid-Columbia River steelhead from the tailrace of McNary Dam to the tailrace of Bonneville Dam was 70% in 2003 and 50% in 2004.

The smaller surface pair-trawl system, originally developed for use in the lower estuary in 2002, was not used in 2003 except briefly during May when we deployed it directly in front of the large trawl system at Jones Beach. We detected 42 Chinook and 24 steelhead with the small trawl system: 11 of those fish were subsequently detected on the larger trawl system between 9 and 51 min later (median was 18 min, similar to travel times between trawls observed in 2002). During May and June of 2004, we operated the small trawl system for 126 h in the lower estuary and detected 16 yearling Chinook salmon and 108 steelhead.

Finally, in 2004, we modified a PIT-tag detection system originally used along the shoreline in the Snake River for use at Jones Beach. Although we did not detect any fish using this system, we were able to tag and release several groups of Chinook salmon from an on-site beach seine effort to assess detection efficiency and fish passage.

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INTRODUCTION

In 2003 and 2004, we continued detections of juvenile Pacific salmonids *Oncorhynchus* spp. implanted with passive integrated transponder (PIT) tags using surface pair-trawls fitted with PIT-tag detection antennas. Two areas of the Columbia River estuary were sampled. The primary sampling site was in the upper, freshwater reach of the estuary near Jones Beach, from river kilometer (rkm) 61 to 83. A secondary site was sampled in 2004 only, and was located in the brackish-water portion of the lower estuary from rkm 8 to 24 (Ledgerwood et al. 1997, 2000, 2003, 2004b).

During 2003 and 2004, river flows were slightly lower than the previous 10-year springtime average, but considerably higher than flows recorded during the drought year of 2001. We report detection data and compare these data to detections in previous years under differing flow conditions.

Several large annual release groups of spring migrant PIT-tagged fish were targeted for sampling in the estuary. For 2003 and 2004 combined, about 200,000 fish were released for a Snake River transportation study, about 180,000 released for a survival study of Snake River hatchery fish, and about 200,000 from a survival study of Upper Columbia hatchery fish. Estuary detections from many other release groups of PIT-tagged fish were also recorded. Over 4.2 million PIT-tagged juvenile salmonids were released into the Columbia River Basin for migration between 2003 and 2004. These fish were also monitored during downstream migration using detectors installed by the National Marine Fisheries Service and the U.S. Army Corps of Engineers (USACE) at hydroelectric dams throughout the basin (Prentice et al. 1990a,b,c).

To store and disseminate records containing individual fish release and detection times and locations, as well as species, origin, and migration history, we used the *PIT-Tag Information System for the Columbia River Basin* (PTAGIS) database was used (PSMFC 2003).

In addition to bypassing fish around the dams, fishery managers have the option to transport and release fish downstream from Bonneville Dam, the lowermost dam in the Columbia River basin (rkm 234). Over 400,000 PIT-tagged fish were transported in 2003 and 2004.

The goal of trawling efforts in the estuary was to monitor timing and survival of PIT-tagged juvenile Chinook salmon *O. tshawytscha* and steelhead *O. mykiss* that have either migrated in the river and through the hydropower system to the estuary or have been transported by truck or barge to a release site below Bonneville Dam. These data also provide estuarine passage dates that will allow later adult survival comparisons between fish groups that enter the ocean as juveniles at similar times. These temporal comparisons of smolt-to-adult return ratios are possible with the recent installation of adult interrogation systems at Bonneville and other dams.

We collected detection data from pair-trawl sampling with the following objectives:

1) Compare migration timing and relative survival to the estuary between inriver migrant and transported juvenile yearling Chinook salmon and steelhead during the spring migration period.

2) Assess migration timing to the estuary for fish detected at Bonneville Dam and contribute data to estimates of passage-route survival.

3) Estimate in-river survival from McNary and Lower Granite Dams to Bonneville Dam for major groups of yearling salmonids.

4) Compare migration timing between radio- or acoustic-tagged and PIT-tagged juvenile salmonids.

5) Compare migration timing to the estuary between inriver migrant and transported subyearling fall Chinook salmon during late June through July. Sampling for this objective was cancelled because there were insufficient numbers of fish tagged in 2003 and 2004.

6) Compare migration timing of individual salmonids between the upper and lower estuary using a brackish-water tolerant PIT-tag detection system.

METHODS

Study Fish

In 2003 and 2004, we continued to focus detection effort on large groups of PIT-tagged fish released upstream from Jones Beach from April through July. These groups included over 141,000 fish released to the Snake and Columbia River in 2003 and over 67,000 released in 2004 for transportation studies by the National Marine Fisheries Service (NMFS; Marsh et al. 2004, 2005). A second major release of PIT-tagged fish to the Snake River was the Comparative Survival Study, which released 151,706 fish in 2003 and 152,265 in 2004 (Berggren et al. 2005; T. Berggren, Fish Passage Center, personal communication). Records from PTAGIS for these years included over 1.6 million Chinook salmon and 617,000 steelhead released in the Upper Columbia River.

These releases provided large groups of PIT-tagged migrants with known release locations and times that could be coordinated with trawl system operations. For example, after being collected in the juvenile bypass system at Lower Granite Dam (rkm 695), transportation study fish were tagged and released either to raceways for subsequent loading aboard transportation barges or to the tailrace to continue migration in the Snake River. A portion of the inriver migrants were subsequently diverted to transportation barges at Little Goose (rkm 635), Lower Monumental (rkm 589), and McNary (rkm 470) Dams for eventual release downstream from Bonneville Dam.

We included all PIT-tagged fish diverted to barges in our analyses, including hatchery fish and others not specifically tagged for the transportation study. Records of PIT-tagged fish detected at Bonneville Dam were also downloaded from PTAGIS for comparison with our detections (PSMFC 2003). An independent database (Microsoft Access[1]) of detection information was maintained to facilitate data management and analysis. Records of PIT-tagged fish determined from PTAGIS to have been diverted to transportation barges were included. Fish were intentionally diverted to barges using the separation-by-code slide gates at specific dams (Stein et al. 2001).

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[1] Reference to trade name does not imply endorsement by NOAA Fisheries Service.

Diversion to transportation barges, both intentional and otherwise (i.e. fish missed by slide gates) was confirmed by identifying PTAGIS records of fish whose last upriver detection was on a route that ended only at a transport raceway or barge. We worked with the USACE to obtain accurate barge loading dates and times. This allowed us to identify which specific transport barge a fish was loaded onto by matching its detection date and time with the next available barge at that facility (Scott Dunmire, USACE, Walla Walla, personal communication). This method has allowed assignment of nearly 1.7 million fish to our transported-fish database; some dating back to 1987 when PIT-tagged fish were initially released into the basin.

In addition to these major tagging studies, there were several other studies in the Columbia River basin that released spring-migrating, PIT-tagged salmonids. In this report, we focus our analyses on the more numerous yearling spring/summer Chinook salmon and juvenile steelhead; however, detections of PIT-tagged coho *O. kisutch*, sockeye *O. nerka*, and subyearling fall Chinook salmon, as well as sea-run cutthroat trout *O. clarki clarki* were also recorded.

Study Sites

We operated the large-trawl system from Eagle Cliff, near rkm 83, to the west end of Puget Island, near rkm 61 (Figure 1). This is a freshwater reach characterized by frequent ship traffic, occasional severe weather, and river currents often exceeding 1.5 m/s. Tides in this area are semi-diurnal with about 7 h of ebb and 4.5 h of flood. During the spring freshet period (April-June), little or no flow reversal occurred at this site during flood tides: this was particularly true during 2003, when river flows were slightly higher than in 2004. The net was deployed adjacent to a 200-m-wide navigation channel which is maintained at a depth of 14 m.

In 1998, while testing the large-trawl system near rkm 10, it became apparent that sampling in the lower estuary would be possible only by using a smaller trawl. Deployment and retrieval of the large trawl requires ample room for maneuverability, and this was not generally available in the lower estuary. Currents are stronger in the lower estuary, than at Jones Beach, often exceeding 2 m/s (4 knots). Lower estuary currents are also bi-directional, with strong daily ebb and flood tides. Thus there are few, if any,

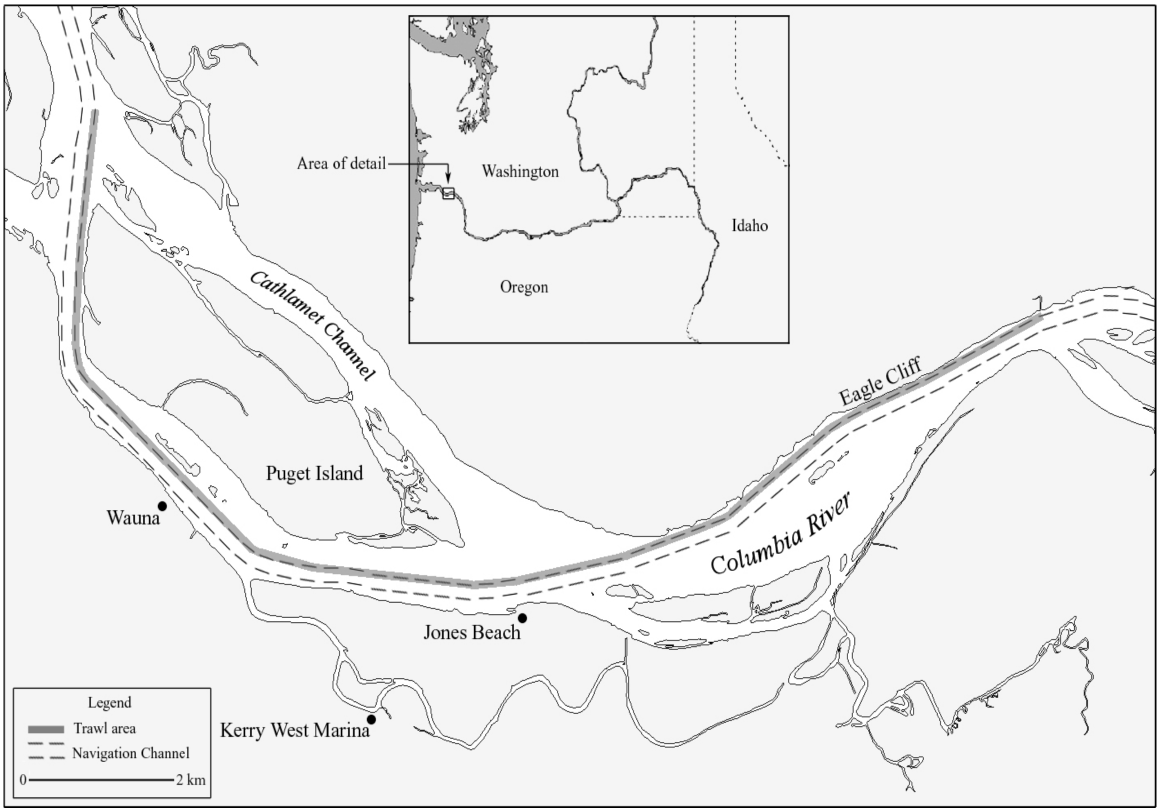


Figure 1. Primary trawling area adjacent to the navigation channel in the upper Columbia River estuary near Jones Beach at Columbia River Kilometer 75.

unobstructed areas that would allow for the undirected drift of vessels required for deployment and retrieval of nets from the large-trawl system.

In 2001 and 2002, we tested a smaller prototype trawl system designed for use in brackish water (Ledgerwood et al. 2004b). Our goal for the small trawl system was to sample PIT-tagged fish in areas inaccessible to the large vessel trawl. A particular objective was to monitor fish previously detected in the upper estuary with the large trawl system. During May 2004, we again deployed the small trawl system in the brackish-water region of the lower estuary. We operated from near the river mouth at rkm 10 to area near the Astoria-Megler Bridge at rkm 16 (Figure 2). Sampling in the lower estuary was cancelled in 2003; however, on a few dates in 2003, we deployed the small directly in front of the large trawl at Jones Beach to evaluate timing of PIT-tagged fish between systems.

In 2004, we also modified a third PIT-tag detection system, which was originally used along the shoreline in 2003 in the Snake River (Regan McNatt, project leader). We deployed this system along the shoreline at Jones Beach (rkm 75).

Trawls and System Designs

Large Trawl System

The large-trawl components are described below, and their basic configuration remained fairly constant throughout the 2003-2004 study periods (Ledgerwood et al. 2004a; Figure 3). To prevent turbulence on the net from the tow vessels, 73-m-long tow lines were used. The upstream end of each wing of the trawl initiated with a 3-m-long spreader bar, which was shackled to the wing section. The end of each wing was attached to the 14-m-long trawl body, which was connected to a 2.7 m antenna-attachment sleeve, for a total length of 108.2 m along each side of the trawl. The mouth of the trawl body opened 9 m between the wings and from the surface to a depth of 6 m. The floor extended 9 m forward from the mouth; double the distance used in previous years.

The detection antenna (Figure 4) was centered at a depth of 2.5 m, and the trawl wings tapered upward from a sample depth of 6 m at the floor of the trawl body to 3 m at the tow bridle. In previous years, drag on the trawl body when under tow had tended to

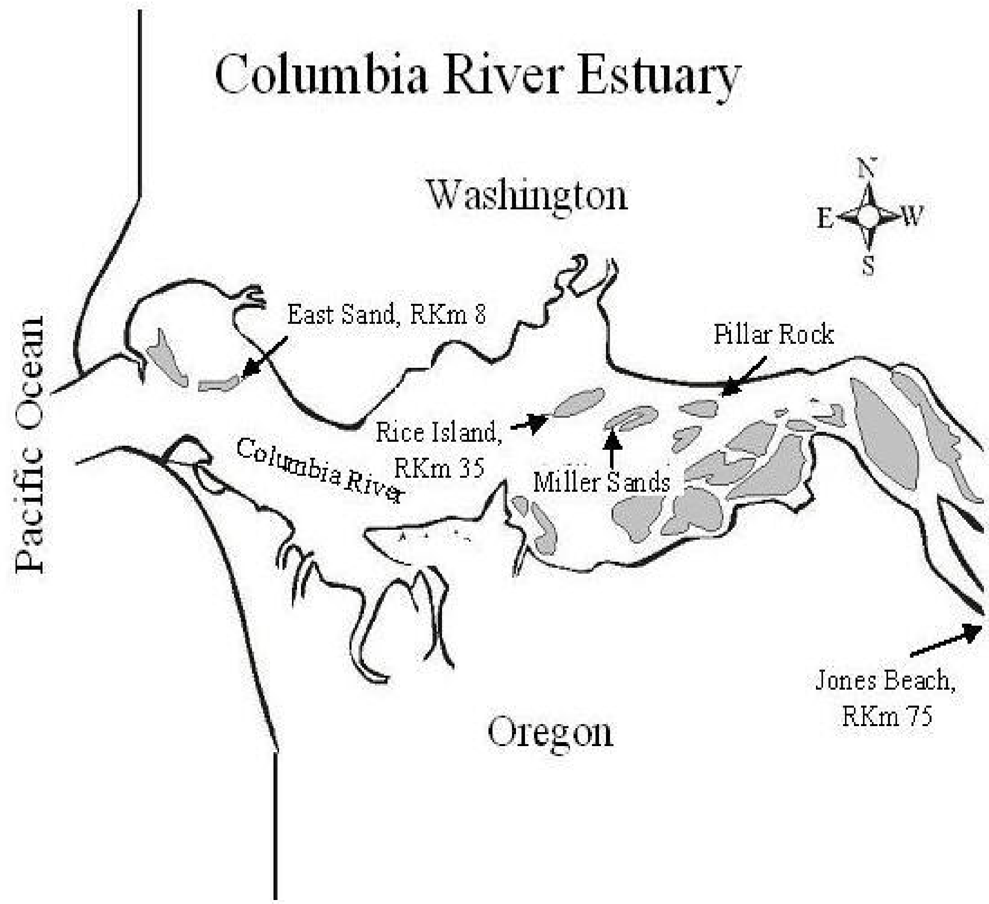


Figure 2. Map of the lower estuary showing relative locations of the small and large trawl sampling areas.

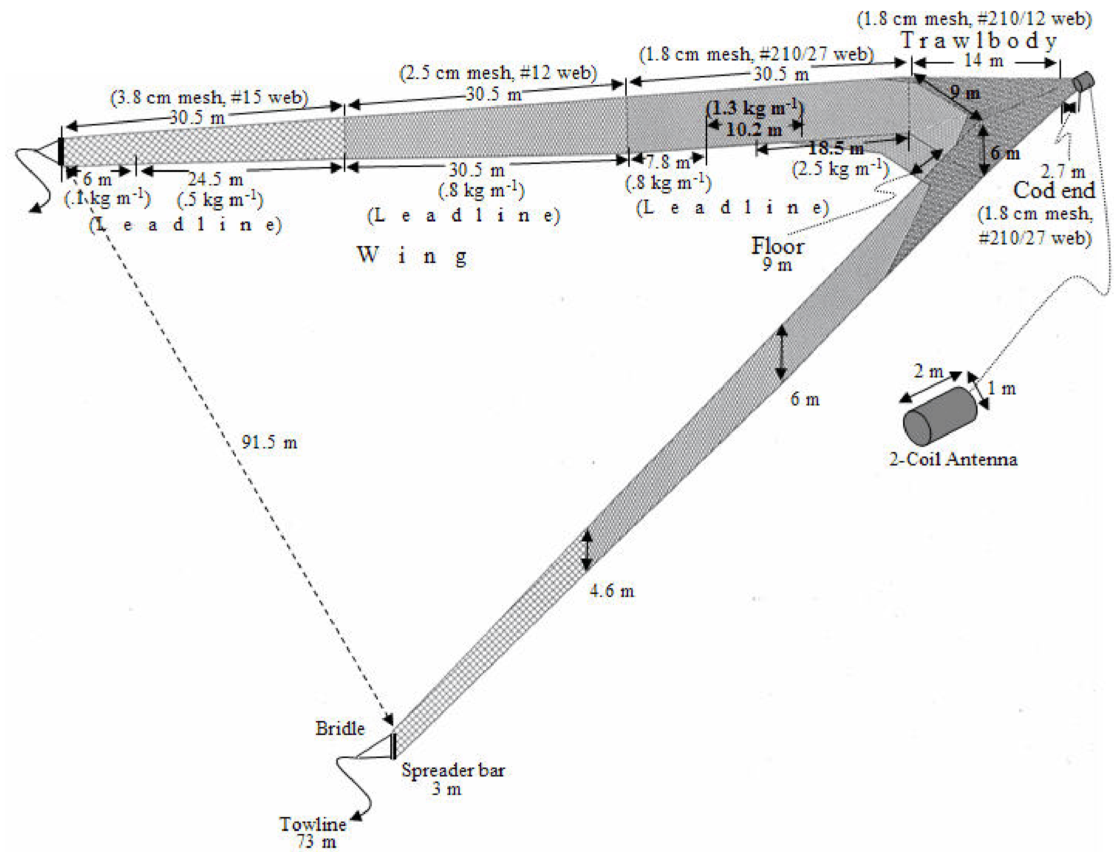


Figure 3. Basic design of the large surface pair trawl used to sample PIT-tagged juvenile salmonids in the upper, freshwater portion of the Columbia River estuary, rkm 61-83, 2003 and 2004.

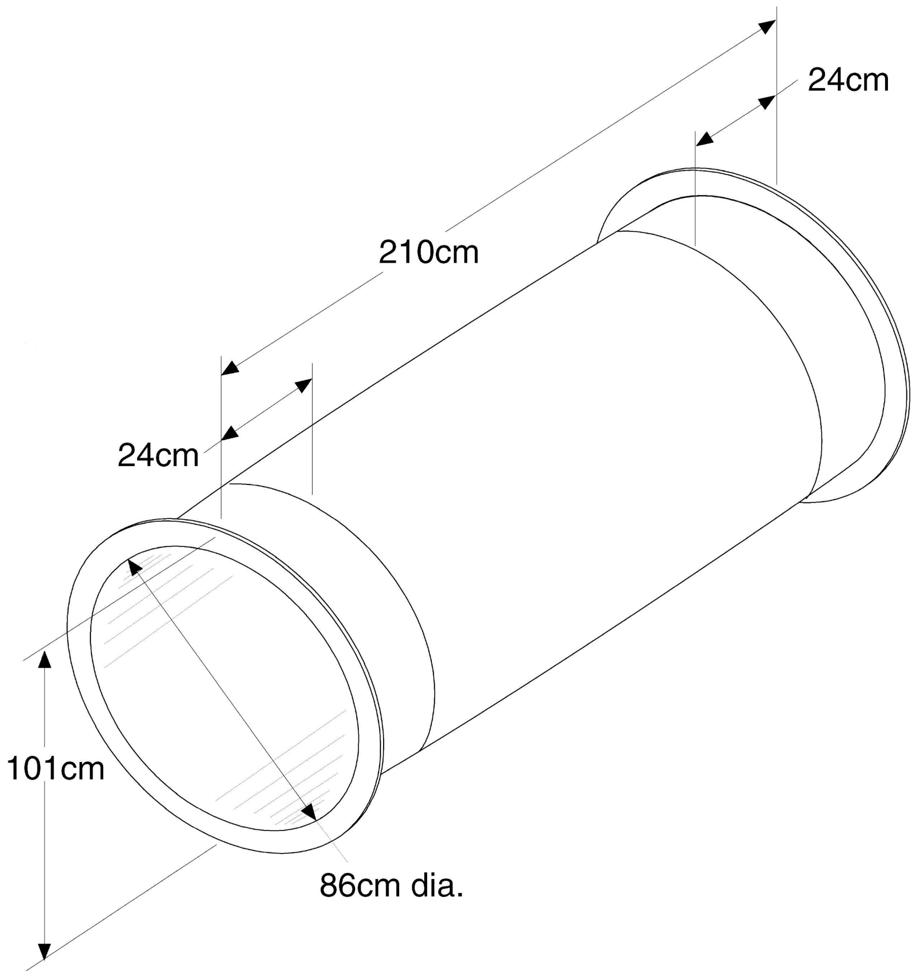


Figure 4. Basic design of antenna used in 2003 and 2004 with a surface pair-trawl to sample PIT-tagged juvenile salmonid in the Columbia River estuary at Jones Beach, rkm 75.

align the net components to the same depth, raising the trawl floor and causing curvature of the wing walls. This reduced the sample depth to 3.5 m. To compensate for the lift and curvature, we attached an additional lead line to the perimeter of the trawl. Beginning in 2000, adaptation of a detector antenna suitable for 134.2 KHz PIT-tags allowed for a larger opening through the antenna; this further reduced drag and lift, thus increasing sample depth of the trawl under tow to 4.9 m.

During a typical deployment of the large trawl equipment at Jones Beach, the net is towed upstream facing into the current, with a spread of about 91 m between the wings of the trawl. Fish that enter between the wings are guided to the trawl body and exit through the antenna where the cod end is normally located. During net retrieval, the antenna is removed and then the net is inverted in the current to flush debris and release fish from between the small-mesh wings. The deployment/retrieval process of the large trawl requires about 20 min, during which time the vessels and net are adrift in tidal and river currents often exceeding 1.5 m/s (3 kts).

Small Trawl System

The design of the small trawl was based upon that of the large surface pair trawl, but there were some basic alterations required to allow for safe operations in the high-current and confined areas of the lower estuary (Figure 5). We initially deployed and tested the equipment in July 2001 near Chinook, WA, (rkm 10) where adequate net handling procedures and electronic components were developed (Ledgerwood et al. 2004b).

In the lower estuary, it was not possible to invert the trawl to release trapped fish prior to retrieving the net. Therefore, we eliminated small mesh in the outer net wing sections, which could entrap fish if the wings were collapsed for retrieval without being inverted. A larger mesh size in the outer sections also helped reduce drag, facilitating the use of smaller vessels. Field observations in 1997 at Jones Beach indicated that if the wings of the trawl were not held perpendicular to the current (i.e. spread too wide), a 33-cm stretch-mesh would guide salmonids into the trawl body (Ledgerwood et al. 2000).

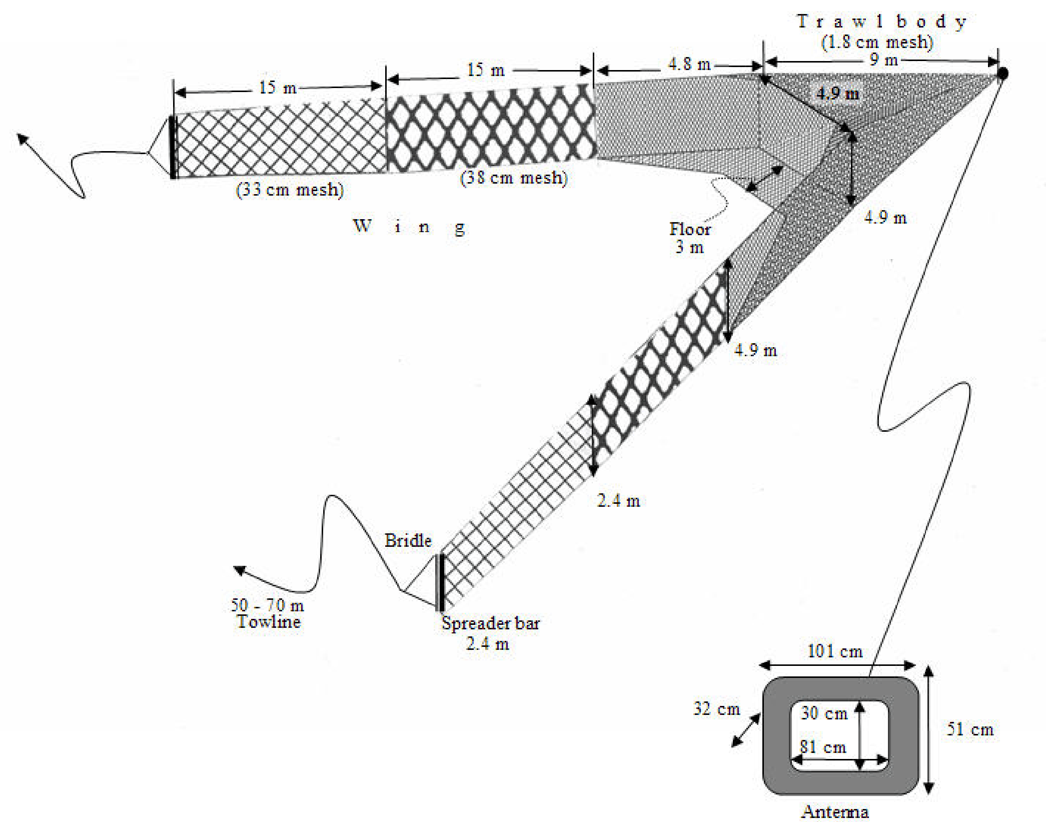


Figure 5. Basic design of the small surface pair used to sample PIT-tagged juvenile salmonids in the brackish-water portion of the lower Columbia River estuary, rkm 10-16, 2004.

To further reduce drag and thus facilitate the use of smaller vessels, we also designed a smaller trawl body. To simplify construction, we decided on a symmetrical design, 4.9-m tall by 4.9-m wide at the entrance to the trawl body, tapering evenly to the antenna attachment centered 2.4-m beneath the surface. The small trawl, consisted of a 9-m long symmetrical trawl body with a floored section with 4.8-m-long wings. Both the trawl and inner wing sections were 1.8 cm (small) mesh.

An additional 30 m of large-mesh (33 cm mesh) wing extended forward and attached to spreader bars and towing bridles used to hold the wings at full sample depth, similar to the large trawl system. We used 70-m-long tow lines to minimize the influence of prop wash from the towing vessels on the net. Under tow, we maintained a distance of about 23 m between the wings. Thus the effective sample depth was about 3.3 m at the center of the floor.

Shoreline System

Our shoreline PIT-tag detection system consisted of a variable-length net wing leading between one side of a 2.4-m square opening trawl body and the shore, with a second 15-m-long wing leading between the trawl body and an off-shore fixed anchor. The trawl body was 5 m long and positioned at an appropriate depth (about 3.5 m) off shore by positioning the offshore anchor. The 0.9-m-diameter antenna was supported on a buoy similar to that of our other trawls.

Generally, we deployed this system near high tide and sampled during ebb currents. Current velocities varied from 0 to about 1.5 knots at maximum ebb. A video camera was mounted within the antenna and used to monitor fish passage. Using a line to shore from the tip of the wing, we developed a method to “flush” the net for cleaning and to encourage fish to exit downstream through the antenna, similar to methods used with the pair trawl system.

Electronic Equipment and Operation

In 2003 and 2004, we used essentially the same electronic components and procedures for the large trawl system as in 2001 and 2002. A 10-m-long pontoon barge was towed near the exit of the trawl. A gasoline generator powered all electronic equipment. Two Whit-Patten transceivers and associated PIT-tag detection electronics were mounted in the cabin of the barge, and cables led underwater to a tuner port on each of two detection antenna coils. A video camera mounted inside the antenna tunnel was used to monitor fish passage on a VCR/TV housed in the barge. The antenna was 2.1-m long, weighed 200 kg (in air), and had an 86-cm-diameter fish-passage opening with a detection coil on each end.

Once the antenna was energized, a computer software program (MULTIMON.EXE) automatically recorded time, date, detection data and Global-positioning-system (GPS) coordinates (Downing et al. 2001). GPS positions were recorded in the datafile every 15 min with every fish detection, but the analogue transceivers did not provide annotated diagnostic or status reports. We did maintain written logs for each sampling cruise, noting the time and duration of net deployment, total detections, the number of impinged or injured fish observed, and net-flushing periods (5-min periods were the wings are brought together to minimized holding behavior of fish in the trawl).

The electronic PIT-tag recording system used with the small trawl was somewhat different than that used with the large trawl. After small trawl sampling was finished in 2004, we adapted its detection system for use with the shoreline sampler and a freshwater antenna. Electronic components were contained in a water-tight box (0.8 × 0.5 × 0.3 m) mounted on a pontoon raft (1.9 × 1.2 m; Ledgerwood et al. 2004b). A DC-powered Destron-Fearing model FS-1001A PIT-tag transceiver was used to power the underwater antenna and interrogate tagged fish.

The FS1001A transceiver was designed for permanent installation and was typical of the transceivers used at hydroelectric facilities on the Columbia and Snake Rivers. The unit included a serial-maintenance and high-speed serial ports for connection to a computer to monitor the status of the installation and for logging of individual PIT tags.

We used a wireless connection to transmit data and status reports in real-time to a portable computer mounted in a tow vessel. GPS positions were included in these status and diagnostic reports every 15-min and with every fish detection. Two 12-volt deep-cycle batteries provided power to the transceiver and a wireless modem, with one battery mounted on each pontoon for added stability. Fully-charged batteries provided sufficient power for at least a 10-h daily sample period. A 15-m long cable connected the transceiver to the underwater antenna. The antenna was strapped to the cod end of the trawl and suspended on a buoy to a depth of 2.4 m (on center) beneath the surface. A strain-relief line, wrapped with the cable and bridled to the raft and the antenna, served to tow the raft and detection electronics with the trawl.

The small trawl and shoreline detection systems utilized PIT-tag detection and transceiver status monitoring software (MULTIMON.EXE) for recording purposes. In addition to the date, time, GPS position of the tow vessel, and tag code of PIT-tagged fish, the software also recorded internal transceiver, diagnostic, and status reports. These reports were generated and recorded every 2 min on the computer as part of the standard Multimon data files. During unplanned power outages or computer failures, the internal buffering capability of the FS-1001A transceiver provided backup PIT-tag detection records, but the date and time of detection and the status and diagnostic reports for the transceiver were lost.

Raw data files were submitted to PTAGIS and also added to our independent database for correlated with non-MULTIMON data. Various sampling activities were recorded in a hand-written log, including date and time of trawl deployment and retrieval, net flushes, GPS coordinates, salinity, temperature, diver observations, and impacts to fish (numbers of all fish species trapped or killed in the trawls or shoreline sampler).

Salinity, temperature, and depth were recorded by a YSI model 6920 probe at 5-s intervals during most deployments of the small trawl in the lower estuary. The instrument was mounted on the top of the trawl body about 1 m forward of the antenna. We had attempted to mount the unit directly on the antenna but discovered that it created unacceptable electronic interference with PIT-tag recording equipment.

PIT-tag detection data files for both large and small trawl systems were periodically (about weekly) uploaded to PTAGIS using standard methods described in the *PIT-tag Specification Document* (Stein et al. 2001). The specification document, PTAGIS operating software, and user manuals are available via the Internet (PSMFC 2002). Large trawl detections were identified in the PTAGIS database by the site code TWX (towed array-experimental) and small trawl detections by site code ESX (estuary salt-water experimental). Small trawl data from sampling conducted at Jones Beach are also listed under site code TWX but as the secondary recorder (coil F1) and the large trawl as the primary recorder (coils 00 and 01). Only test fish released were recorded with the shoreline sampler (coil A1) thus those data were not submitted to PTAGIS.

Detection Efficiency Tests

To evaluate efficiency of the trawl systems, we used a procedure that did not require the release of test fish (Ledgerwood et al 2004b). A 2.5-cm-diameter PVC pipe with a small plastic funnel on each end was positioned through the center of the antennae (both freshwater and brackish-water antenna systems were tested about weekly). The pipe extended past each end of the antenna beyond detection range of the electronic field (about 0.5 m). We evaluated detection efficiency by measuring the detections of 50 PIT tags attached at known intervals (and orientations) on a vinyl-coated tape measure (Appendix Table 1). We chose densities and orientations along the tape such that not all tags could be decoded; the relative consistency of tag detection helped validate electronic tune and identify possible problems with the electronics.

During tests, we suspended the antenna underwater and pulled the PIT-tagged tape back and forth several times through the PVC pipe. The start time of each pass was recorded in a logbook, and we used standard PIT-tag software to record detections. Efficiency was calculated as the total number of unique tags decoded during each pass divided by the total tags passed through the antenna.

Impacts on Fish

We used nearly continuous video monitoring of fish exiting the antenna (large trawl) and periodic diver observations to assess impacts of trawling on fish. When debris accumulations or other problems were observed near the antenna on the video monitor, tow speed was reduced, and the cod-end and antenna were pulled to the surface for cleaning. The large-mesh wings of the small trawl allowed us to retrieve the net directly onto a tow vessel without having to invert the trawl to release fish. One drawback of this design was the occasional accumulation of significant quantities of debris while trawling. Since the net was not inverted for retrieval, debris had to be removed by hand, either during the retrieval process, which required longer drifts, or back at the dock. During debris-removal activities and net-collection and redeployment procedures for either trawl system, we recorded impinged or trapped fish as mortalities in operation log books.

Sample Period

Sampling with the large trawl system began at Jones Beach in mid-April and continued through late June, coincident with the passage of PIT-tagged yearling Chinook salmon and steelhead from the Snake River transportation study. Sampling effort was increased from a single daily sampling crew to two daily crews from 30 April through 9 June 2003, and from 21 April through 23 June 2004.

Daily shut-down periods generally occurred between 1400 and 1800 PDT, when strong winds often made sampling difficult, and again between 0200 and 0500, when we changed crews. From 4 May through 7 June 2004, we also sampled intensively with the small trawl system in the brackish-water portion of the lower estuary. When the small trawl electronic equipment became available in June, we adapted it for use with the shoreline system, which was deployed on 4, 8, 9, and 22 June and 8 July 2004.

During the peak of the spring migration of 2003 and 2004, we conducted nearly continuous day and night-time sampling. We often used an extra vessel to transport relief crews so that retrieval and redeployment could be avoided during crew changes. Sampling was nearly continuous during these dates except for brief periods of net cleaning or when it was necessary to retrieve the net and move back upstream.

Transportation of Snake River fall Chinook salmon (subyearling migrants) is new, and little information on behavior and timing of these fish following release is available. Summer spill programs are also being considered as a management action for these fish. In 2003 and 2004, we cancelled sampling cruised planned for July because insufficient numbers of subyearlings were PIT-tagged. Limited sampling in July 2002 suggested that using a single crew during low summertime river flow conditions, we could attain adequate detection rates to evaluate timing and behavior differences in the estuary among transported and inriver migrants.

Statistical Analyses

We used one-way ANOVA (Zar 1999) to examine diel detection patterns for yearling Chinook salmon and steelhead using the number of fish detected during daylight vs. darkness hours. There were too few detections of other species for a meaningful analysis. The number of detections and the minutes within each hour that the detector was energized during two-crew daily sample periods were separated into daylight and darkness hour categories, and mean hourly detection rates for wild vs. hatchery rearing types were compared using ANOVA. Diel detection rates for yearling Chinook salmon vs. steelhead were also compared based on the average number of fish detected each hour. Detection rates for hatchery and wild fish were examined on separate scales for better visual resolution. In addition, because sampling was limited during the hours when crews were changing (1400-1700 PDT in 2003 and 1400-1800 in 2004), we used pooled mean values for these hours.

We plotted travel-time distributions and compared estuary detection rates for subsets of yearling Chinook salmon and steelhead tagged at Lower Granite Dam and released to migrate in the river or loaded to barges and released just downstream from Bonneville Dam. These plots represent the seasonal duration of availability in the estuary for the respective migration-history groups. Periods of availability in the estuary for various subsets of data were compared using analyses of travel-time distributions. Travel time (in days) to the estuary was calculated for each fish by subtracting date and time of release, barge release, or detection at Bonneville Dam from date and time of detection at Jones Beach.

Multiple linear regression was used to evaluate differences in travel speed to Jones Beach between inriver migrants and transported fish each year. Factors used in the regression models of travel speed included Julian date, flow, migration history (inriver migrant vs. transported), and two-way interaction among terms for these three main effects. Flow data were daily average discharge rates at Bonneville Dam ($ft^{3/}s$). When interaction terms for Julian date and flow were not significant, they were removed from the models. Travel speed data are presented showing daily mean values, but all regression analyses were performed using data from individual fish.

Estuarine detection rates of PIT-tagged yearling salmonids released from barges were compared with those of yearlings previously detected at Bonneville Dam (inriver migrants) using logistic regression analysis (Hosmer and Lemeshow 1989). Daily detection data collected using the pair-trawl was compared between the years 2003 and 2004. Treatment groups (barge release or inriver migrant) were defined based on barge release dates, and were treated as "cohorts" rather than individually. This was necessary because barge releases early in the season often occurred before inriver migrant fish had arrived at Bonneville Dam. Recovery percentages for both groups are shown for the entire season, but were not used for analysis except when both groups were present on the same date. For these analyses, data were adequate in both years for yearling Chinook salmon, but were not adequate for steelhead.

Components of the logistic regression model were treatment as a factor and date as a covariant. The model estimated the log odds of the detection rate of the daily cohorts (i.e., $\ln[p/(1-p)]$) as a linear function of the components, assuming a binomial distribution for the errors. All analyses in this report are preliminary.

A stepwise procedure was used to determine the appropriate model. First, the model containing interaction between treatment (e.g., inriver migrant or barge release) and date was fitted. If the interaction term was not statistically significant (> 0.05), the reduced model (without the interaction term) was fitted. The model was further reduced depending on the significance of treatment and date. Various diagnostic plots (e.g., Delta deviance vs. estimated probability and Leverage vs. original values) were examined to assess the appropriateness of the model. Extreme or highly influential outliers were identified and included in, or excluded from, the analyses on an individual basis depending on the particular aspects of each "data situation."

Daily transported and inriver-migrant groups had similar distributions of availability in the sampling area, and presumably passed the sample area at similar times. We thus assumed that they were subject to the same sampling biases (sample effort). If this assumption was correct, differences in relative detection rates among these groups would reflect differences in survival from the area of release (near or at Bonneville Dam) to the estuary.

To test the assumption that transported and inriver migrant groups passed the sample area with similar diel timing, we divided total estuary detections for each group into 1-h intervals, based on the time they were detected. Detection proportions per interval were then compared using a contingency table, and average differences were found for each hour by subtracting the inriver migrant proportion from the barged proportion of detections. If there was no difference in detection proportions between groups in an interval, similar proportions of barged and inriver fish passed during that hour. A positive difference indicated higher proportions of transported fish passed, and a negative difference indicated a higher proportion of inriver migrants passed during that hour. These data are preliminary and were not weighed by date and number.

Detection data from the estuary are also essential to estimate survival of juvenile salmonids to Bonneville Dam, the last dam encountered by seaward migrants (Muir et al. 2001; Williams et al. 2001; Zabel et al. 2002). The probability of survival through an individual river reach was estimated from PIT-tag detection data using a multiple-recapture model for single release groups (Cormack 1964; Jolly 1965; Seber 1965; Skalski et al. 1998). This model requires detection probability estimates for the lowest downstream detection site (i.e., Bonneville Dam), and these estimates are calculated using detections below this site.

RESULTS

Large Trawl System

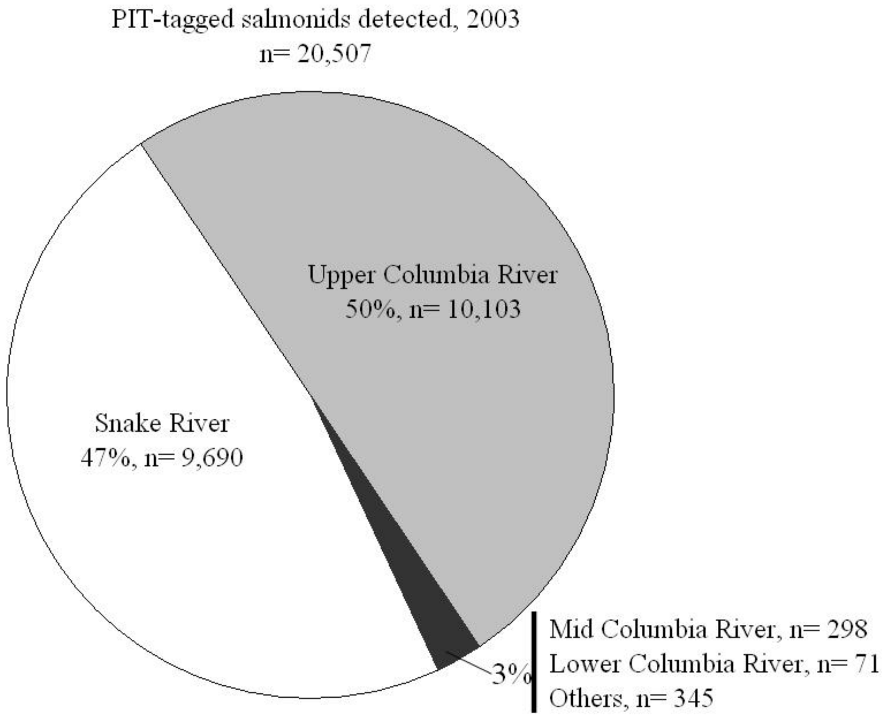
For all species, runs, and rearing types combined, we detected a total of 20,507 juvenile salmonids in 2003 and 16,492 in 2004 using the large surface pair-trawl at Jones Beach (Appendix Tables 2 and 3). However, not all stocks and rearing types were equally represented in these annual detection totals. For example, in 2003 78% of the total detections were Chinook salmon, 20% were steelhead, and the remaining 2% were other salmonid species. In 2004 the species distribution was similar, with 75% Chinook, 22% steelhead, and 3% other species (Table 1).

In both years, 13% of the total detections were wild fish, with the remainder hatchery-reared. Contributions of PIT-tagged fish to the estuary from the different river basins and with different migration histories (inriver migration or transported) are shown in Figures 6 and 7. These variations in catch composition resulted primarily from differences in PIT-tagging strategies between years and complicate multi-year comparisons among species and run or rearing types.

We also compared detection data between fish migrating under different flow conditions. Springtime river flows in 2003 and 2004 were low compared to the 10-year average from 1991 to 2000, though not as low as the near-record drought year of 2001 (Figure 8). Equipment was energized and under tow for 794 h in 2003 and 872 h in 2004 (Figure 9). There were approximately 21% fewer PIT-tagged fish released into the basin in 2004 than in 2003 (PSMFC 2004), which was consistent with our having detected about 20% less fish in 2004 than in 2003.

Table 1. Species composition and rearing-type history for PIT-tagged fish detected in the large pair-trawl at Jones Beach, 2003 and 2004.

	2003			
Species/run	Hatchery	Wild	Unknown	Total
Spring/summer Chinook salmon	13,245	1,743	1	14,989
Fall Chinook salmon	1,090	7	9	1,106
Coho salmon	224	1	6	231
Steelhead	3,159	844	0	4,000
Sockeye salmon	39	7	0	46
Other	0	8	127	135
Grand total	17,754	2,610	143	20,507
	2004			
Species/run	Hatchery	Wild	Unknown	Total
Spring/summer Chinook salmon	10,296	1,337	92	11,725
Fall Chinook salmon	254	4	437	695
Coho salmon	356	0	6	362
Steelhead	2,862	721	3	3,586
Sockeye salmon	50	35	0	85
Other	0	5	34	39
Grand total	13,818	2,102	572	16,492



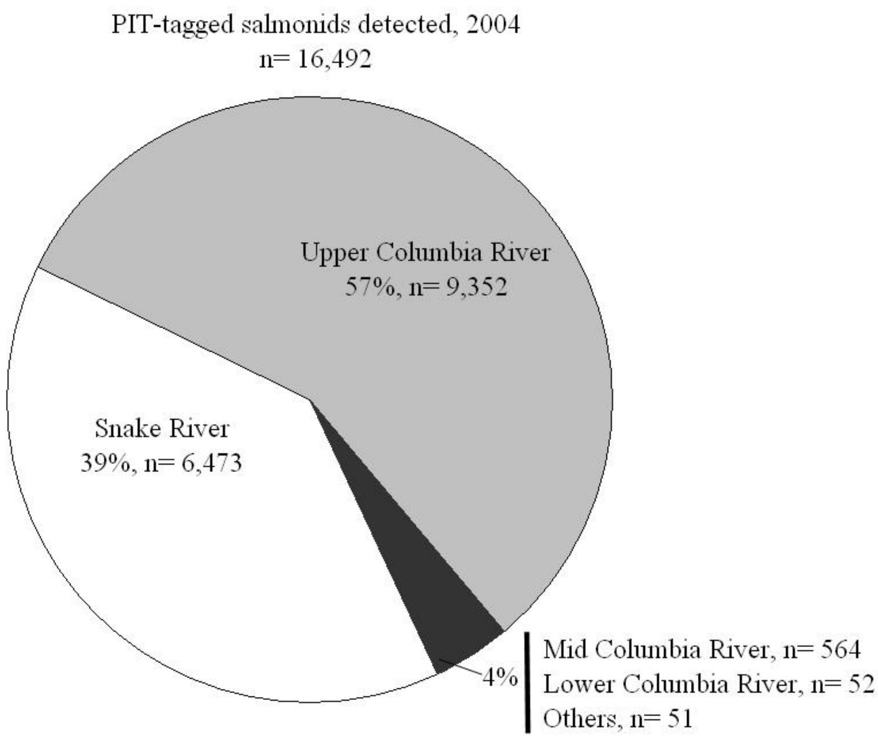
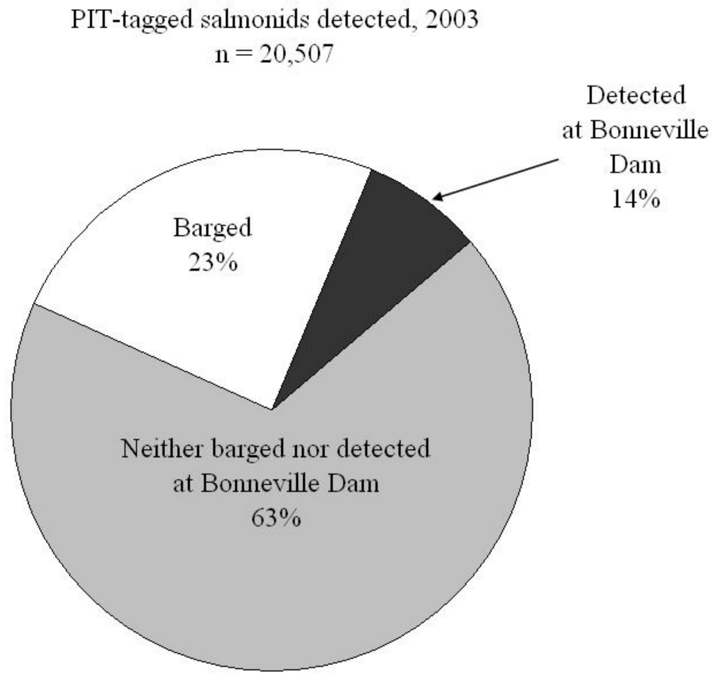


Figure 6. River basin sources of PIT-tagged fish detected in the Columbia River estuary at Jones Beach, rkm 75, using a surface pair-trawl in 2003 and 2004.



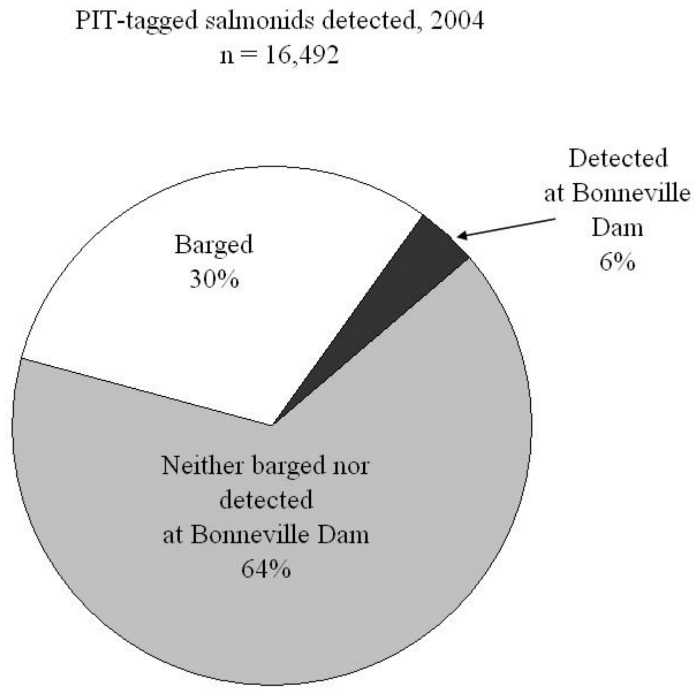


Figure 7. Migration history of PIT-tagged fish detected in the estuary, 2003 and 2004. In 2004, the installation of a new corner collector at Bonneville Dam which lacked PIT-tag detection capability, dramatically lowered the number of detections there. Less than 2% of all detections were released downstream of Bonneville Dam in both years.

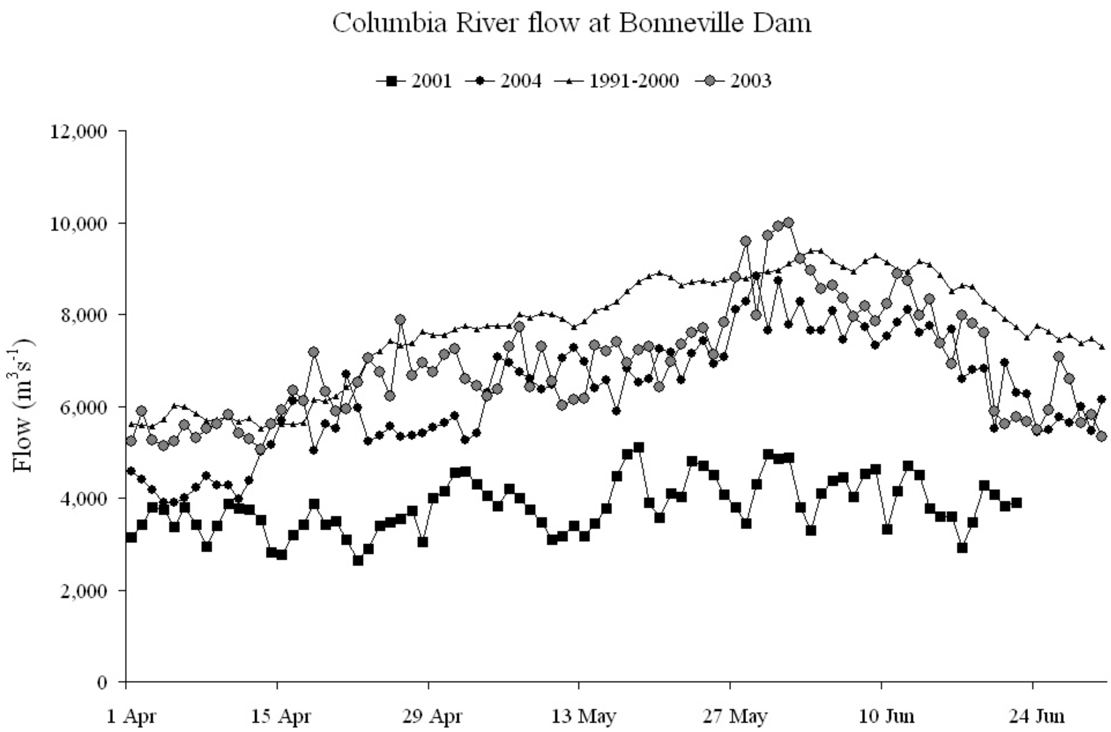


Figure 8. Columbia River flow at Bonneville Dam during the study periods of 2003 and 2004 compared to drought year 2001 and the average flow from 1991-2000.

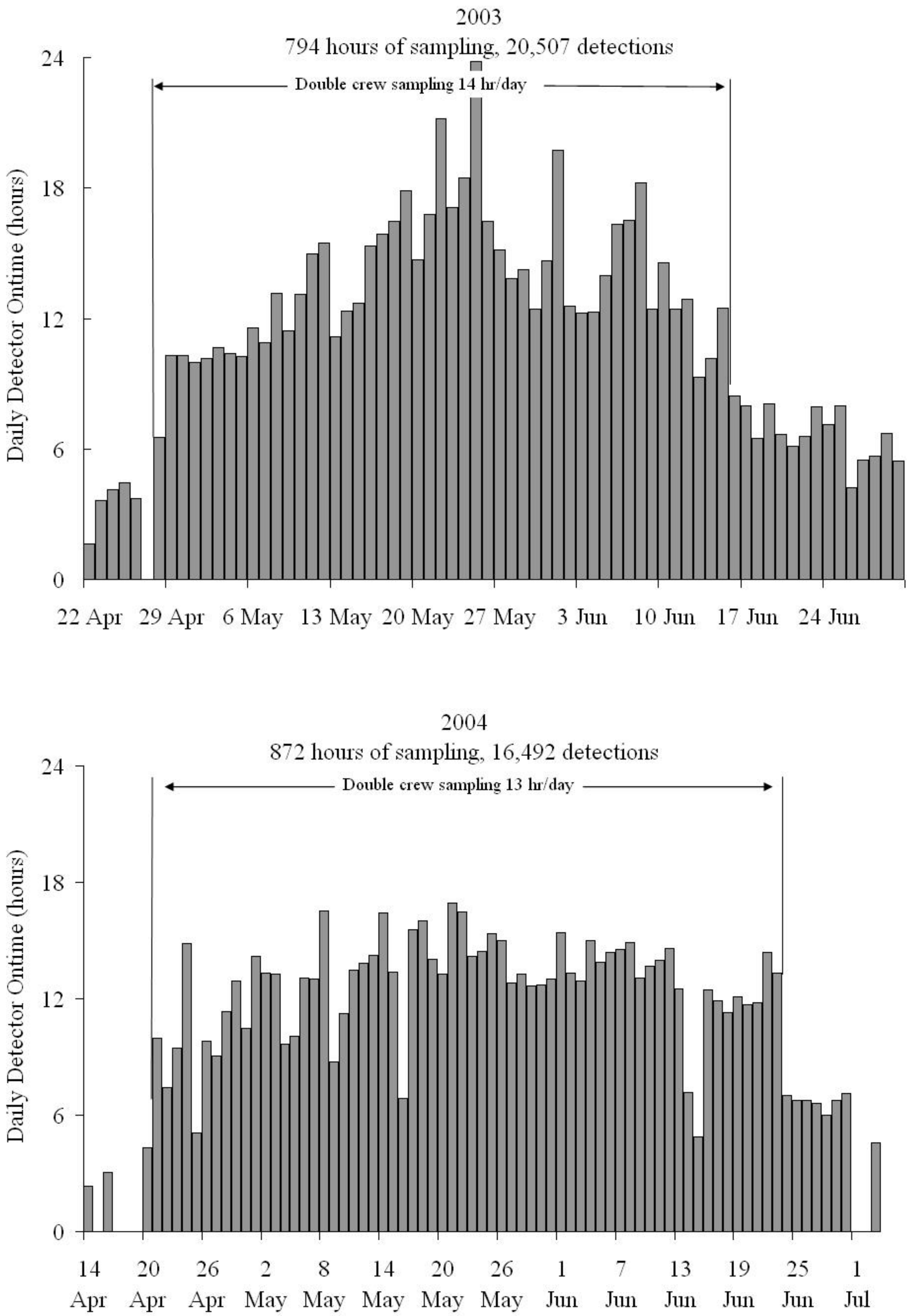


Figure 9. Sampling times during 2003 and 2004 study periods using a PIT-tag detector surface pair trawl in the Columbia River estuary at Jones Beach, rkm 75.

Small Trawl System

In 2004, we sampled for 126 h with the small trawl in the lower estuary and detected 127 fish (Figure 10). We sampled on the south side of the river along the shipping channel between Buoy 10 and the Astoria-Megler Bridge (Figure 11). There was a strong bias towards detection of steelhead in the small trawl relative to the large trawl, with steelhead comprising 86% of detections in the small trawl compared to about 22% during the same date period in the large trawl (Appendix Table 4). This suggested that the small trawl primarily samples fish passing in surface waters.

The 3.3-m sampling depth, large-mesh wings, and relatively short floor in this trawl may not effectively guide juvenile salmonids into the net and through the antenna. In late June 2002, when the net was deployed at Jones Beach, divers observed that subyearling Chinook salmon within the trawl body would not volitionally exit through the antenna (Earl Dawley, National Marine Fisheries Service, Ret. personal communication)

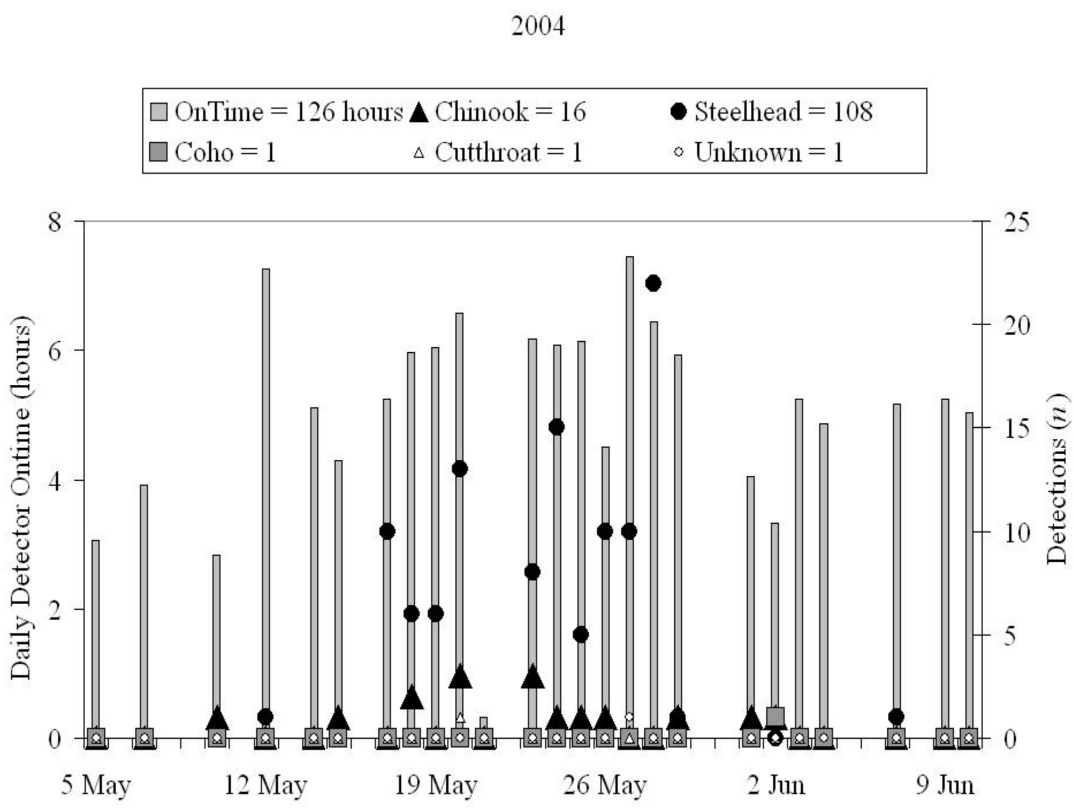


Figure 10. Daily sampling effort ("on time") and detection numbers obtained using a small surface pair-trawl in the brackish-water portion of the lower Columbia River estuary, 2004.

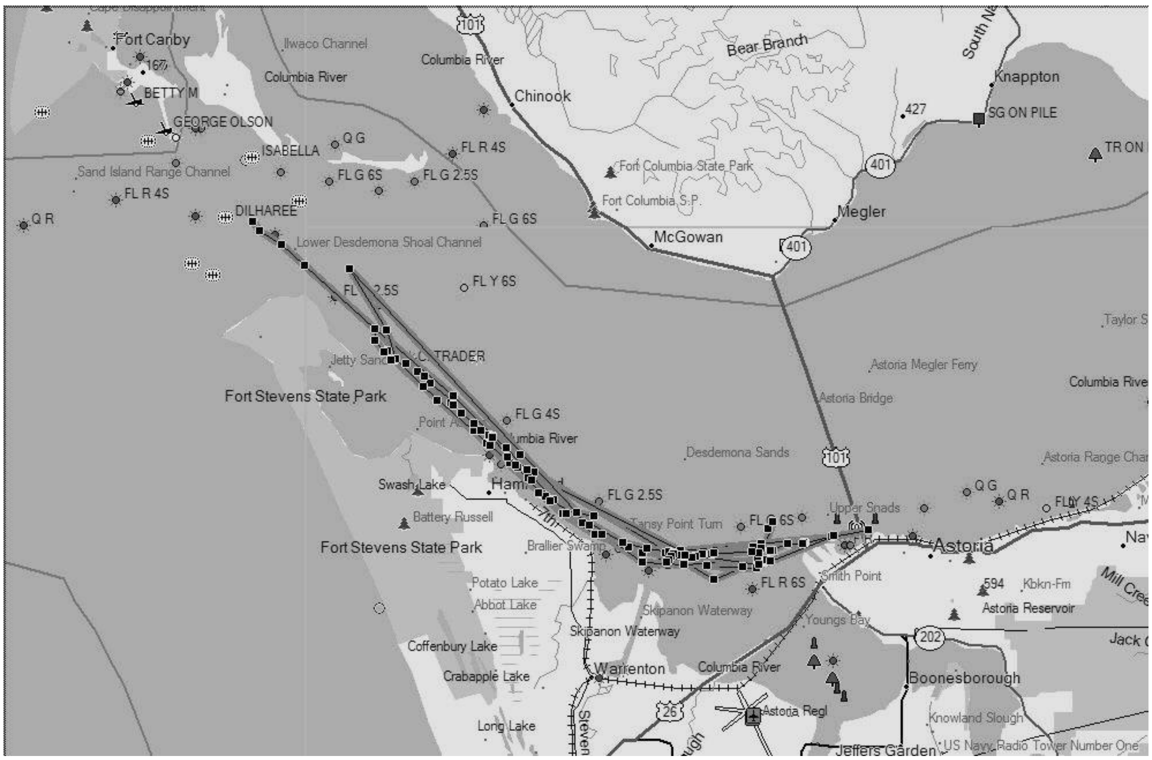


Figure 11. Sample routes of the small trawl in the lower estuary, 2004. Waypoints of the small trawl are indicated by black squares.

Shoreline System

We sampled ebb tides for 20.5 h over 6 d with the shoreline sampler but detected no PIT-tagged fish. On 27 June we PIT-tagged 53 subyearling Chinook salmon captured in beach seines at Jones Beach (Curtis Roegner, NMFS, Project Leader) and released them, with other untagged fish, just in front of the head rope on the shoreline sampler. We detected 27 of the released fish (51%), and most detections came within 3 min after release. Video observations revealed that many fish continued to swim easily against a strong shoreline current (over 1 knot) directly in front of the camera for over 30 min. It is possible that the flushing action of the net caused them to swim forward and escape rather than moving downstream through the antenna. It was rare to get a detection more than 5 min after a test release. We detected no river-run PIT-tagged fish, and few were observed entering the trawl during these deployments.

Detection Efficiency

For the freshwater (large trawl) system, tag-reading efficiencies improved in 2004, when most researchers started tagging fish with "super" PIT-tags, which allow a longer reading range. For example, in 2003, when properly tuned, our detection system read about 46% of test tags spaced 30 cm apart and perpendicular (0°) to the electronic field. The system read about 26% of similarly spaced tags oriented at 45° (Figure 12 top). In 2004, using "super" tags, the system read 58% of tags spaced 30-cm apart at 0° and 43% at 45° (Figure 12 middle).

When spacing between tags was increased to 61 cm, detection efficiency increased from 78 to 81% for perpendicular tags and 37 to 75% for 45° tags. When the same tags were passed within about 20 cm of the antenna wall rather than through the center of the antenna, detection rates increased to 98% in both years, regardless of tag spacing or orientation. For the small trawl system, the smaller dimension salt-water antenna in 2004 read about 89% of all tags on a similar test tape, regardless of spacing or orientation; however, most of these tests were conducted in low-salinity waters (Figure 12 bottom).

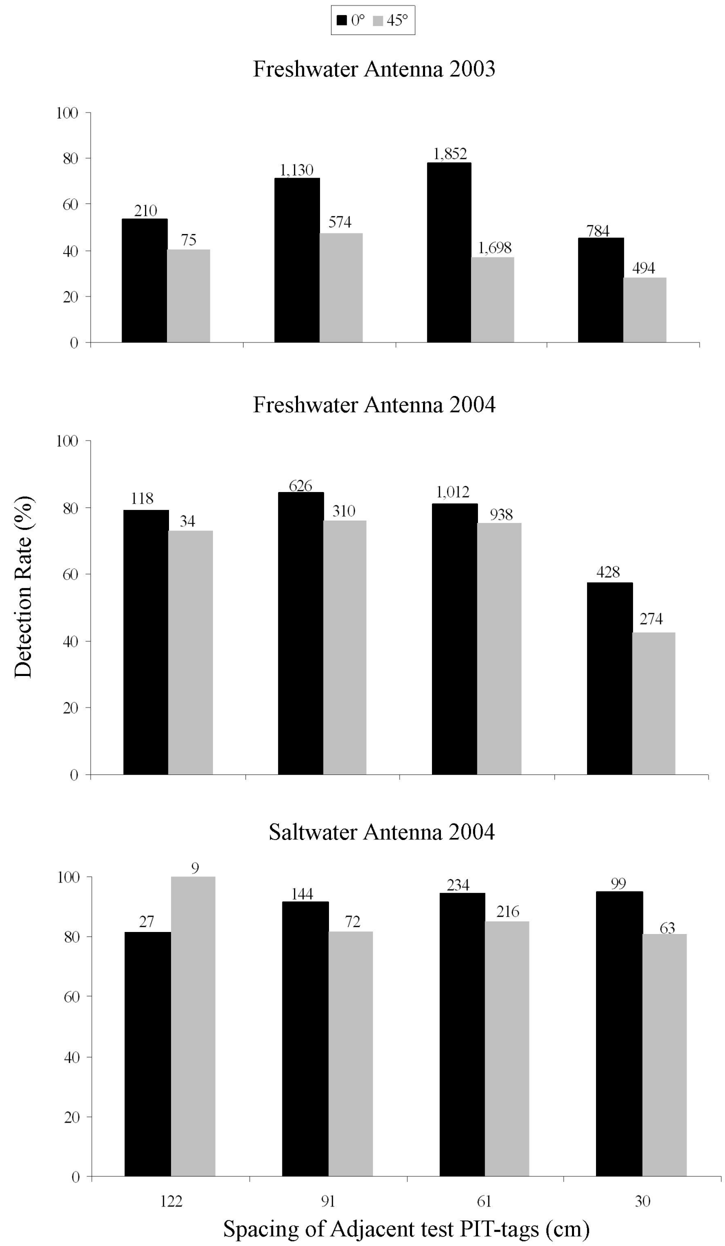
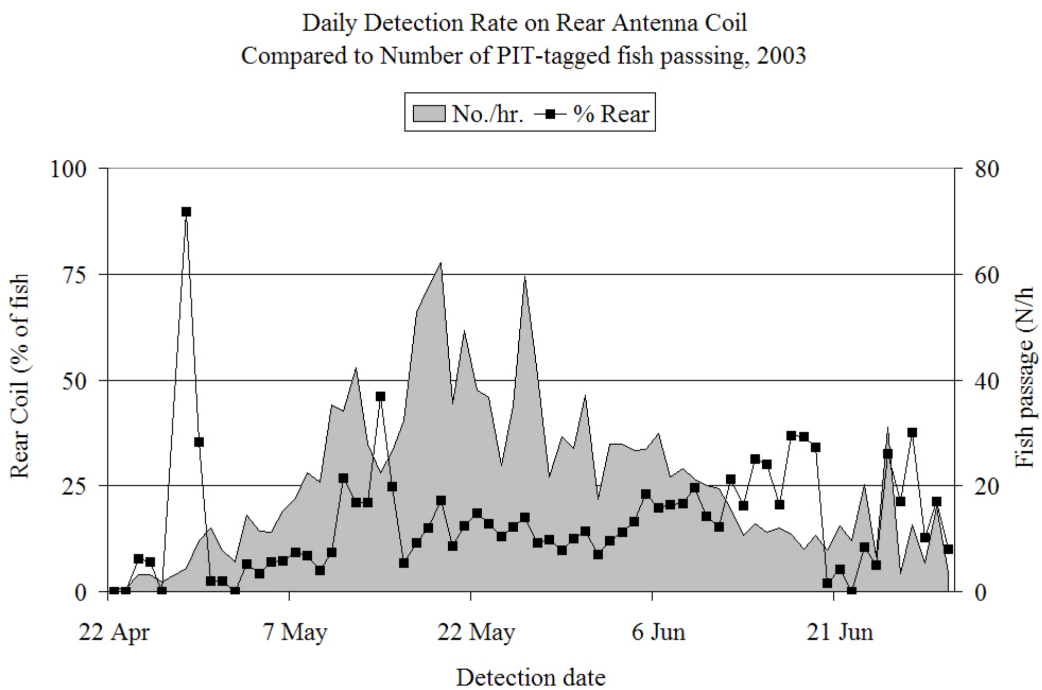


Figure 12. Detection efficiency evaluation using 132.4 kHz PIT-tags attached to vinyl tape measures. Efficiency of the freshwater antenna is shown for "super" tags in 2004 and regular tags in 2003. "Super" tags were used with the saltwater antenna in 2004. Various spacing between tags and orientation to the electronic field were used (0° or 45°), but all tape configurations were identical. Tags were passed through the antenna repeatedly on different dates (total potential tags list above the bars). The saltwater antenna decoded nearly 100% of Super tags, regardless of spacing or orientation.

Detection efficiency was also evaluated by comparing the number of tags first detected on the front (upstream) antenna coil and subsequently detected on the rear (downstream) coil (Figure 13). In 2003, 17% percent of all individual detections were recorded on the rear coil only (missed by the front coil), but in 2004, only 9% of the fish were missed by the front coil. Unlike in previous years, the miss-rate of the front coil did not seem strongly correlated with the numbers of PIT-tagged fish passing, as one might expect, given the increased likelihood of electronic collision of tag codes (Downing et al. 2003). Rather, increased 'miss rates' occurred when the electronic components were not properly tuned.

We used daily front/rear fish detection proportions to help optimize use of system components. For example, of the system's two transceivers (one each for the front and rear antennas), we used the better performing transceiver with the rear coil antenna. This maximized the chance of detection because after fish entered the antenna and were swept downstream toward the rear coil, their tag orientation tended to improve. After entering the antenna, their tendency was to position themselves headfirst into the current, which should have positioned their tags perpendicular to the electronic field (at the optimal reading angle).

Median time between detection on the front and rear coils was 4 s. Of 8,625 individual fish detected on the front coil, only 641 (7%) were not also detected on the rear coil. An unknown number of fish could have avoided detection on the rear coil by swimming forward and escaping the trawl. We believe that for the large trawl system, the combined detection rate of the front and rear coils exceeded 95% for all PIT-tagged fish passing through the antenna.



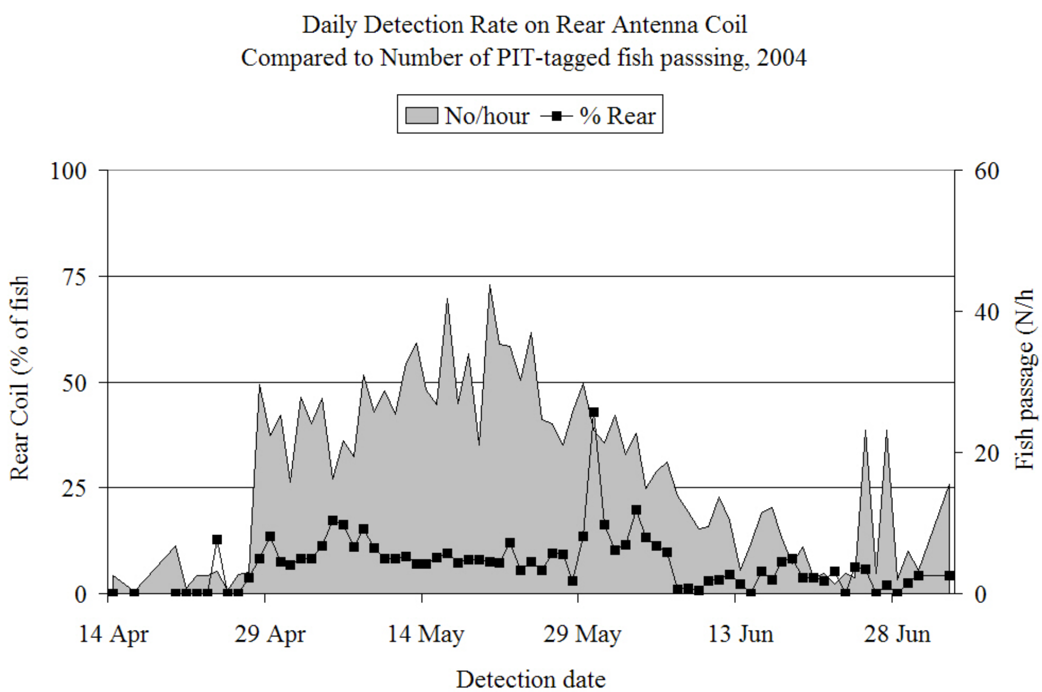


Figure 13. Proportion of PIT-tagged fish detected only on the rear antenna coil of the large trawl compared to daily fish passage, 2003 and 2004.

Impacts on Fish

We used continuous daytime video observation and periodic diver observations to visually assess impacts to fish in the large trawl. We adjusted sampling operations immediately when sources of potential injury to fish were observed. For example, when debris accumulations or other problems were observed, we reduced tow speed and pulled the detection antenna to the surface to clean the cod end of the net. To clean debris in extreme conditions, we disconnected the electronics and inverted the entire net. With the small trawl system, tow durations were relatively short, and the net was cleaned during retrieval.

We recovered 278 impinged, gilled, or otherwise injured juvenile salmonids in the netting during the trawl inspections or upon retrieval of the net in the large trawl during 2003 and 2004 combined (Appendix Tables 5 and 6). It is possible that other mortalities and injuries were not observed. This could have occurred during inversions of the large trawl or during the gentle shaking of the small trawl to encourage fish to exit through the antenna. However, divers inspected the trawl and wing areas of the nets and reported they rarely observed fish swimming close to the webbing, except near the antennas. Rather, fish tended to linger near the entrance of the trawl body and directly in front of the antenna.

In previous years, we eliminated web size and color transitions in the trawl body and cod end that appeared to provide an area where fish might delay passage out of the net. We minimized holding behavior in the trawl by flushing the net every 15 min. While volitional passage through the antenna occurred, the majority of fish were detected during the 5-min net-flushing periods.

The median time between front (first) and rear (last) coil detections was 4 s in 2003 and 5 s in 2004. Generally, fish were detected on the front coil and detected again on the rear coil within about 3 s. However, included in the median values were those of a few fish detected repeatedly over extended periods (Tables 2 and 3). For example, on 1 May 2004 a yearling Chinook salmon (3D9.1BF19DB2D0) was detected once on the front coil and 220 times on the rear coil over a 2.3-h period. On 26 May 2004, a steelhead (3D9.1BF199579A) was detected 73 times on the front coil over a 0.9-h period and was never detected on the rear coil. These multiple detections of a single fish were relatively rare, and only 85 fish in 2003 and 53 fish in 2004 had over 20 detections (0.3% of the total detections in both years).

Table 2. Dates and PIT-tag codes of individual salmonids detected more than 20 times during passage through the large trawl detection system, 2003. Species codes are 1 for Chinook salmon and 3 for steelhead. F indicates detection on front coil only, R indicates detection on rear coil only.

Detection date	Species code	Tag_ID	Detection records (n)	Duration (h)	Coil
23 Apr 03	3	3D9.1BF180611F	124	0.93	F
29 Apr 03	3	3D9.1BF15A15D5	40	1.32	both
10 May 03	1	3D9.1BF1866A35	32	1.17	both
11 May 03	1	3D9.1BF19545FA	37	1.46	both
11 May 03	3	3D9.1BF1BE5C8A	65	1.87	both
11 May 03	1	3D9.1BF18164CA	111	2.84	both
11 May 03	1	3D9.1BF1801797	45	0.61	R
11 May 03	1	3D9.1BF17F44C3	123	1.97	both
11 May 03	1	3D9.1BF1765C17	24	0.98	R
11 May 03	1	3D9.1BF16A16A1	29	1.14	both
11 May 03	1	3D9.1BF15A3A58	66	0.37	R
11 May 03	3	3D9.1BF1C36F4C	30	3.18	both
12 May 03	1	3D9.1BF177CC16	83	1.47	both
12 May 03	1	3D9.1BF17C4132	29	0.33	F
12 May 03	1	3D9.1BF1C02DFF	41	1.24	both
12 May 03	1	3D9.1BF1953E0B	68	1.67	both
12 May 03	1	3D9.1BF19534BF	126	0.9	both
12 May 03	1	3D9.1BF1906F16	66	1.50	both
12 May 03	1	3D9.1BF181F3AF	97	0.45	R
12 May 03	1	3D9.1BF17F4D38	66	1.77	both
12 May 03	1	3D9.1BF1754F6A	162	2.09	both
12 May 03	1	3D9.1BF14FA93D	76	0.8	R
12 May 03	1	3D9.1BF173316D	32	1.34	both
12 May 03	1	3D9.1BF171A624	22	2.39	both
12 May 03	1	3D9.1BF16E4E06	68	0.54	F
12 May 03	1	3D9.1BF163B3C7	28	1.20	both
12 May 03	1	3D9.1BF163A8B2	43	0.32	F
12 May 03	1	3D9.1BF163314D	33	0.29	R
12 May 03	1	3D9.1BF17CDED0	31	1.37	both
13 May 03	1	3D9.1BF14FE121	65	3.45	both
13 May 03	1	3D9.1BF17F482A	32	2.78	both
13 May 03	1	3D9.1BF17CD8C3	47	1.21	both
13 May 03	1	3D9.1BF176D67F	23	0.15	R
13 May 03	1	3D9.1BF1743E06	38	1.96	both
13 May 03	1	3D9.1BF171A624	21	2.39	both
13 May 03	1	3D9.1BF1689B72	109	0.88	F
13 May 03	1	3D9.1BF163F3DA	75	0.72	F
13 May 03	1	3D9.1BF1626A58	71	0.31	R
13 May 03	1	3D9.1BF1503B3A	49	1.44	both
13 May 03	1	3D9.1BF1BE744F	26	1.24	both
13 May 03	1	3D9.1BF1100919	137	1.15	F

Table 2. Continued.

Detection date	Species code	Tag_ID	Detection records (n)	Duration (h)	Coil
13 May 03	1	3D9.1BF1B14E99	92	0.68	R
13 May 03	1	3D9.1BF15B6AD1	119	0.59	F
13 May 03	1	3D9.1BF1BFD3EA	24	1.95	both
13 May 03	1	3D9.1BF1C05AC9	51	1.60	both
13 May 03	1	3D9.1BF1C08D17	80	4.96	both
13 May 03	3	3D9.1BF1510A8E	23	1.02	both
13 May 03	3	3D9.1BF1510A8E	23	1.60	both
13 May 03	1	3D9.1BF197D4E0	91	1.66	both
14 May 03	1	3D9.1BF18531D1	41	0.37	R
14 May 03	3	3D9.1BF1759846	22	0.35	F
14 May 03	3	3D9.1BF162CF5B	31	3.37	F
14 May 03	1	3D9.1BF184F9D4	26	0.81	R
14 May 03	1	3D9.1BF1762AB6	22	0.08	R
14 May 03	1	3D9.1BF14FE121	48	3.45	both
14 May 03	3	3D9.1BF163B718	103	4.51	both
15 May 03	1	3D9.1BF1761C10	29	1.44	both
15 May 03	1	3D9.1BF17AF297	24	3.22	both
15 May 03	1	3D9.1BF183678B	36	2.45	both
15 May 03	3	3D9.1BF163B718	122	4.51	both
17 May 03	1	3D9.1BF1905F12	30	1.22	both
18 May 03	3	3D9.1BF15B7DA5	23	3.08	both
19 May 03	1	3D9.1BF1915977	180	1.89	F
20 May 03	1	3D9.1BF1C00F96	23	1.09	both
21 May 03	3	3D9.1BF17FD949	99	1.40	both
21 May 03	1	3D9.1BF1783422	29	1.10	both
22 May 03	1	3D9.1BF191D06C	42	4.96	both
22 May 03	1	3D9.1BF1965E6F	25	1.79	both
22 May 03	1	3D9.1BF196BBE5	38	1.83	both
22 May 03	1	3D9.1BF1AB818D	33	2.9	F
24 May 03	1	3D9.1BF1C0CAC4	97	1.83	both
24 May 03	3	3D9.1BF1716041	46	1.65	both
26 May 03	1	3D9.1BF1AC5D59	37	5.05	both
28 May 03	1	3D9.1BF1A46C6E	61	2.35	both
29 May 03	1	3D9.1BF1A46C6E	46	2.35	both
31 May 03	1	3D9.1BF197F8C8	225	2.28	F
02 Jun 03	3	3D9.1BF161DC6C	31	1.18	both
04 Jun 03	3	3D9.1BF175A438	29	1.10	both
06 Jun 03	3	3D9.1BF17FD4F5	578	1.67	F
06 Jun 03	3	3D9.1BF1B608CF	62	1.3	R
07 Jun 03	3	3D9.1BF15F8636	21	1.13	both
09 Jun 03	3	3D9.1BF15CA4C9	39	0.18	R
11 Jun 03	1	3D9.1BF1BCA418	26	0.15	both
12 Jun 03	1	3D9.1BF1ACBC46	35	0.8	R
12 Jun 03	1	3D9.1BF1B15BB7	34	1.50	both
25 Jun 03	3	3D9.1BF1855505	55	1.77	both

Table 3. Dates and PIT-tag codes of individual salmonids detected more than 20 times during passage through the large trawl detection system, 2004. Species codes are 1 for Chinook salmon and 3 for steelhead. F indicates detection on front coil only, R indicates detection on rear coil only.

Detection date	Species code	Tag_ID	Detection records (n)	Duration (h)	Coil
28 Apr 04	1	3D9.1BF1A5CB33	33	1.34	both
29 Apr 04	3	3D9.1BF1FDAC2D	214	1.33	both
01 May 04	1	3D9.1BF19DB2D0	221	2.31	both
01 May 04	1	3D9.1BF1A5A4F4	24	0.83	F
04 May 04	3	3D9.1BF1AACF15	28	1.37	both
07 May 04	1	3D9.1BF1E9238B	23	1.04	both
10 May 04	1	3D9.1BF1AA4374	30	1.19	both
11 May 04	1	3D9.1BF19B22A2	40	1.51	both
11 May 04	3	3D9.1BF1CF6E92	21	1.27	both
13 May 04	1	3D9.1BF193D010	27	0.43	R
13 May 04	1	3D9.1BF19B18B1	29	1.25	both
13 May 04	1	3D9.1BF1B41740	27	1.18	F
16 May 04	1	3D9.1BF1AD1D6C	96	1.45	both
16 May 04	1	3D9.1BF1CCF051	29	1.39	both
16 May 04	1	3D9.1BF1E9BE7A	29	2.33	both
17 May 04	1	3D9.1BF19A68EC	29	1.41	both
17 May 04	1	3D9.1BF1B56029	25	1.23	both
17 May 04	1	3D9.1BF1DA28AB	61	1.32	both
18 May 04	1	3D9.1BF1AF3D4F	28	1.27	both
18 May 04	1	3D9.1BF1AF500F	22	1.29	both
18 May 04	3	3D9.1BF1A1CBE8	57	1.34	both
19 May 04	3	3D9.1BF1C1DEAB	27	1.62	both
19 May 04	3	3D9.1BF1D62792	44	0.36	both
20 May 04	3	3D9.1BF192B375	28	2.58	both
21 May 04	3	3D9.1BF1945FD5	22	1.13	both
21 May 04	1	3D9.1BF19E9513	30	1.34	both
21 May 04	3	3D9.1BF1D6FF89	36	1.37	both

Table 3. Continued.

Detection date	Species code	Tag_ID	Detection records (n)	Duration (h)	Coil
28 May 04	3	3D9.1BF1E73A9B	25	1.15	both
29 May 04	3	3D9.1BF1946DBF	91	1.79	F
30 May 04	3	3D9.1BF19459A0	52	1.43	both
30 May 04	3	3D9.1BF1A65635	28	0.17	R
31 May 04	3	3D9.1BF19AC558	38	1.38	both
31 May 04	3	3D9.1BF1D7FA03	54	2.33	both
01 Jun 04	1	3D9.1BF1DAFBA4	22	2.70	both
02 Jun 04	3	3D9.1BF19B6421	46	1.34	both
09 Jun 04	1	3D9.1BF1AC37D5	49	2.69	F
09 Jun 04	1	3D9.1BF1E6912F	37	1.16	F
11 Jun 04	1	3D9.1BF1CC5187	271	1.80	F
21 May 04	3	3D9.1BF192833E	52	1.40	both
22 May 04	2	3D9.1BF1A1BFCD	24	1.42	both
22 May 04	3	3D9.1BF1AD748A	103	1.61	both
22 May 04	3	3D9.1BF1C2A605	73	1.37	both
23 May 04	1	3D9.1BF19B00CE	44	1.38	both
23 May 04	1	3D9.1BF1AEEDBB	45	0.35	R
23 May 04	1	3D9.1BF1E8ABE0	45	2.05	both
23 May 04	3	3D9.1BF199969F	35	3.24	F
23 May 04	3	3D9.1BF19D489E	29	2.82	both
23 May 04	3	3D9.1BF1BE5719	33	0.39	R
23 May 04	3	3D9.1BF1D64604	42	2.38	both
24 May 04	3	3D9.1BF19B48AE	50	1.42	both
25 May 04	3	3D9.1BF1A16641	28	1.35	both
26 May 04	1	3D9.1BF1ADB623	35	1.74	both
26 May 04	3	3D9.1BF199579A	73	0.94	F
28 May 04	1	3D9.1BF1DB322C	63	2.10	both

Diel Detection Patterns

As mentioned previously, sampling operations were often halted between 1400 and 1800 daily due to high winds; refueling, crew changes, and maintenance were performed during these periods. In 2004, sampling was also limited between 0200 and 0500 because we lacked a backup net-reel and crew-transport vessel in that year. However, sample sizes of wild and hatchery yearling Chinook salmon and steelhead were sufficient in most instances to conclude that diel trends within species and among rearing types were similar. Therefore we were able to pool these data for analysis (Appendix Table 7, Figure 14).

During the two-crew sampling period in 2003, we averaged 13 detections/h of yearling Chinook during daylight and 33/h during darkness hours ($P = 0.001$), as well as 5 steelhead detections/h, irrespective of time of day ($P = 0.622$). In 2004, we averaged 12 and 20 yearling Chinook salmon during daylight and darkness hours, respectively ($P = 0.002$), and averaged 5 and 4 steelhead, during daylight and darkness hours, respectively ($P = 0.688$, Appendix Table 8, Figure 15).

Overall detection rates during darkness hours in 2004 were no doubt somewhat lower than the previous year due to the reduced sampling from 1400 to 1700. This period was characterized by high detection numbers in 2003. In years past, similar daylight/darkness distributions were noted for yearling Chinook salmon, whereas detection rates for steelhead were typically higher during daylight than during darkness (Ledgerwood et al. 1991, 2004b). Overall detection numbers for steelhead were probably reduced by the afternoon shut-down of sampling in both years.

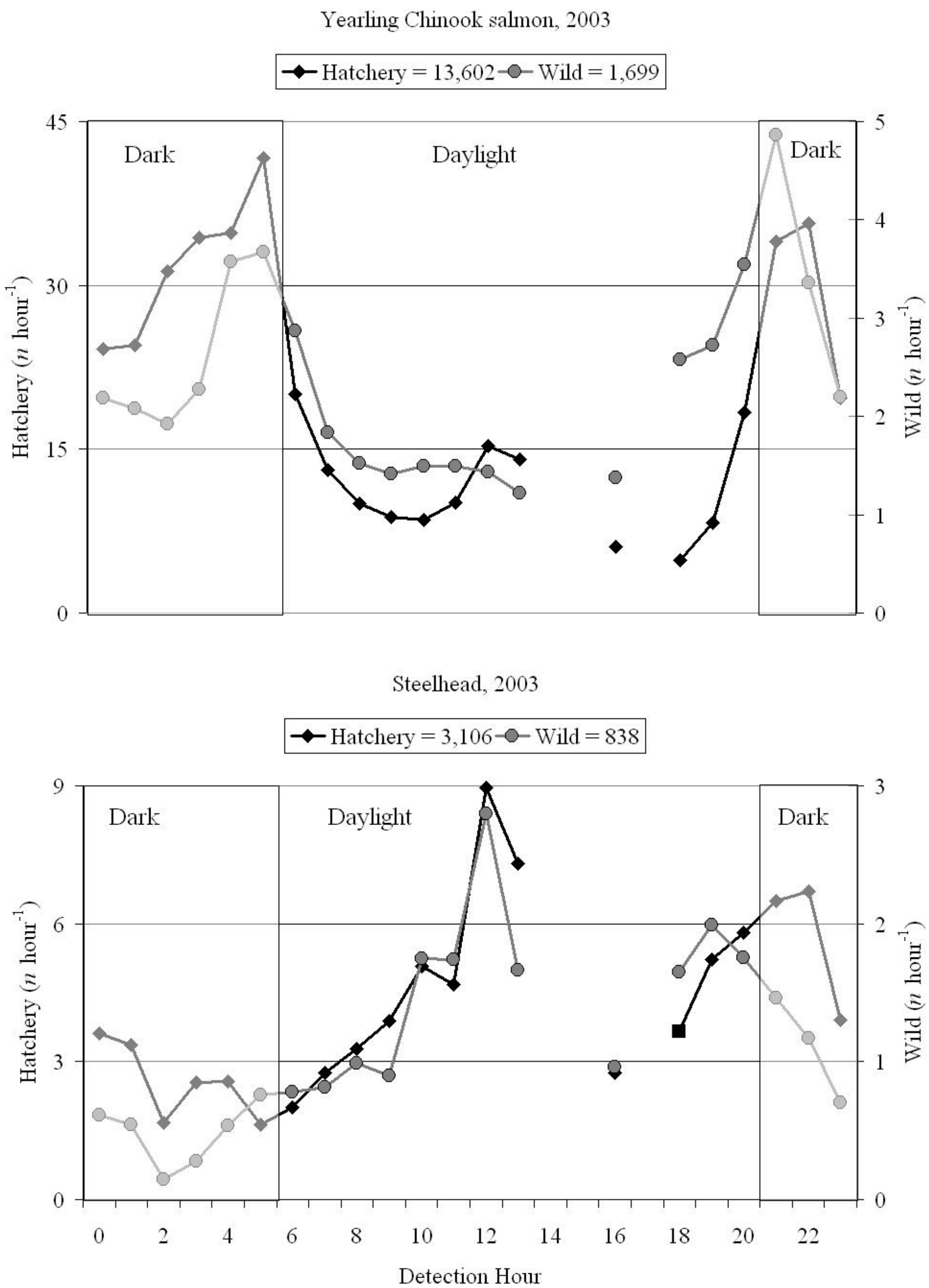


Figure 14. Average hourly detection rates of yearling Chinook salmon and steelhead in the Columbia River estuary at Jones Beach, rkm 75, 2003. Detections for hatchery and wild fish were plotted on separate scales. Data from 1400 to 1700 were pooled due to low sampling effort during that period.

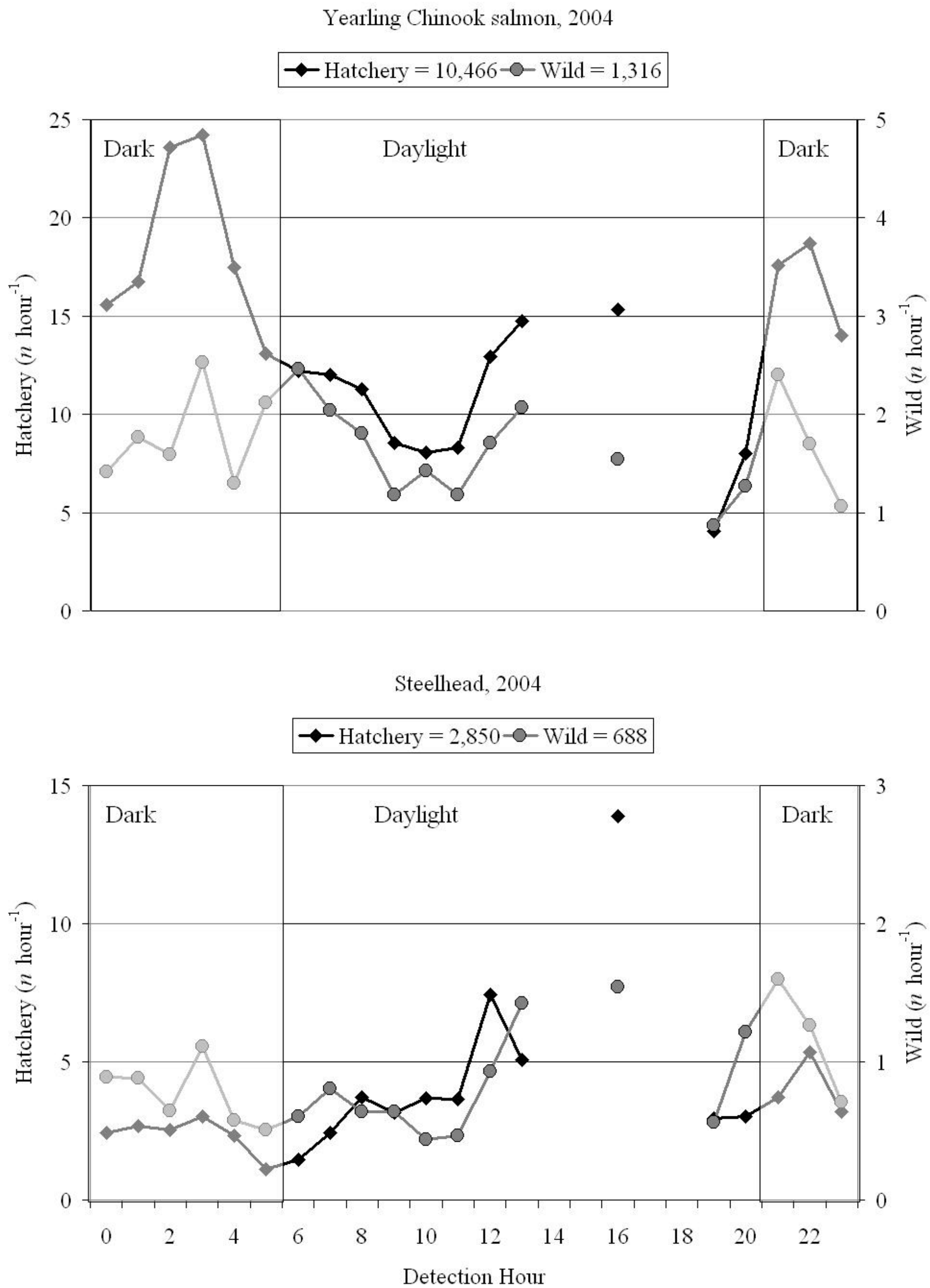


Figure 15. Average hourly detection rates of yearling Chinook salmon and steelhead in the Columbia River estuary at Jones Beach, rkm 75, 2004. Detections for hatchery and wild fish were plotted on separate scales. Data from 1400 to 1800 were pooled due to low sampling effort during that period.

Timing and Migration History Comparisons

Yearling Salmonids (Spring Migration)

For both yearling Chinook salmon and steelhead, travel times for inriver migrating fish from the tailrace of Lower Granite Dam to Jones Beach were similar under the average flow conditions of 2003 and 2004. Median travel time for yearling Chinook salmon and steelhead was about 17 d for both species in both years (Table 4). This was almost twice as fast as the 33-d median recorded for yearling Chinook during the near-record low-flow drought year of 2001, and substantially faster than the 29-d median recorded for steelhead in the same year (Ledgerwood et al. 2004).

Table 4. Median travel time between release at Lower Granite Dam (inriver migration), detection at Bonneville Dam, or release from fish transportation barges to Jones Beach (rkm 75) for yearling Chinook salmon and steelhead, 2003 and 2004.[a]

Yearling Chinook salmon				Steelhead			
2003		2004		2003		2004	
Travel time (d)	Sample (n)	Travel time (d)	Sample (n)	Travel time (d)	Sample (n)	Travel time (d)	Sample (n)
Release at Lower Granite Dam tailrace[b] (rkm 695)							
17.0	563	16.6	867	16.5	95	16.6	153
Detection at Bonneville Dam bypass system[b] (rkm 234)							
1.8	1,721	1.9	672	1.7	567	2.0	110
Release from fish transportation barge[b] (rkm 225)							
2.1	2,382	2.2	2,997	1.7	435	1.9	333

[a] Between 15 April and 7 June, the median flow volume at Bonneville Dam in 2003 was 8% higher than in 2004 (7,140 and 6,597 m^3s^{-1}, respectively).

[b] Fish released downstream from McNary Dam or detected at Jones Beach after 9 June were excluded.

Median travel times to the estuary following detection at Bonneville Dam were also similar between species and years. For yearling Chinook salmon, travel time over this reach was 1.8 d in 2003 and 1.9 d in 2004. Transported yearling Chinook were slightly slower, passing from the barge release site to the estuary in 2.1 d in 2003 and 2.2 d in 2004. For steelhead, median travel times to the estuary were almost identical for fish detected at Bonneville Dam (1.7 d) vs. those released from barges (1.9 d). In contrast, during the drought year of 2001, median travel times were 2.3 d for yearling Chinook and 2.5 d for steelhead detected at Bonneville Dam. For fish transported in 2001, travel time was 3.0 d for yearling chinook and 1.9 d for steelhead.

Travel times from detection in the upper estuary to detection in the lower estuary in 2004 fit within the range of similar observations obtained in 2002 using trawls simultaneously in both regions (Table 5a). We were unable to confirm the routes of passage through the estuary for the 4 yearling Chinook salmon and 5 steelhead detected in both the upper and lower estuary. However, the variation in travel times of these fish to the lower estuary, (range 16 to 41 h), corresponded to encounters with one, two and three flood tides respectively.

In 2002 and 2003, we also deployed the small trawl directly in front of the large trawl at Jones Beach (Table 5b). Ten yearling Chinook salmon and 7 steelhead were detected with both systems, and the median time from detection in the small trawl to detection in the large trawl following detection in the small trawl was 18 min (range 9 to 51 min).

We compared the daily differences in travel speed of PIT-, radio-, and acoustic-tagged fish to the estuary based on migration history (fish either released from barges or inriver migrants detected at Bonneville Dam) and river flow. All changes in daily mean travel speed of PIT-tagged fish appeared highly correlated with changes in river flow, as one might expect (Figures 16 and 17). This is a variable in travel speed not well defined by about weekly releases of radio- or acoustic-tagged fish in these years. Fish released from barges, regardless of tag type, generally traveled to the estuary slower than those detected or released at Bonneville Dam on the same date (i.e., compared with fish thought to have migrated to the estuary from Bonneville Dam under similar conditions).

Table 5a. Lapse time between detections of PIT-tagged fish detected on large and small trawl detection systems located in the upper and lower estuary, respectively, in 2002 and 2004. NA indicates data were not available.

Tag code/ Species code	Detection date/time large trawl (upstream)	rkm	Detection date/time small trawl (downstream)	rkm	Distance between trawls (km)	Lapse time (h)	No. flood tides between detections
2002							
3D9.1BF145F0DD/1	21 May/1957	74	23 May/1251	15	56	41	3
3D9.1BF15779BC/1	22 May/0706	71	23 May/1215	15	54	29	2
3D9.1BF11FF94D/1	29 May/1713	69	30 May/0918	23	45	16	1
2004							
3D9.1BF1AAD862/3	17 May/0826	75	18 May/0721*	NA	NA	23	1
3D9.1BF1DAAE17/3	17 May/1221	72	18 May/0721*	NA	NA	19	1
3D9.1BF1D568D4/3	17 May/1312	74	18 May/0721*	NA	NA	18	1
3D9.1BF19457EA/3	23 May/1122	72	24 May/1058	15	55	24	2
3D9.1BF1D56C72/3	25 May/2223	74	27 May/0716	19	55	33	3
3D9.1BF1AD077D/1	28 May/0547	68	29 May/0621	12	57	25	2

* Detection time and geographic position data lost, position and time estimated using log book.

Table 5b. Lapse time between detections of PIT-tagged fish decoded on large and small trawl detection systems with both trawls located in the upper estuary in 2002 and 2003.

Tag code	Species code	Small trawl (upstream)	Large trawl (downstream)	Lapse time (min)
2002				
3D9.1BF0E4221B	1	08 May/0535	08 May/0556	21
3D9.1BF1570E2D	1	08 May/0618	08 May/0649	31
3D9.1BF112C618	3	14 May/0727	14 May/0744	18
3D9.1BF14444C0	1	18 May/0525	18 May/0543	18
3D9.1BF12F50D6	1	18 May/0548	18 May/0603	14
3D9.1BF144CA2B	1	18 May/0639	18 May/0654	15
2003				
3D9.1BF1864460	1	27 May/2105	27 May/2130	25
3D9.1BF1C0450D	1	27 May/2113	27 May/2130	17
3D9.1BF1BF98C7	1	27 May/2127	27 May/2153	26
3D9.1BF15EDCAE	3	27 May/2148	27 May/2224	36
3D9.1BF1B34AB7	3	29 May/2009	29 May/2018	9
3D9.1BF187B725	3	29 May/2005	29 May/2018	13
3D9.1BF1602758	3	29 May/2135	29 May/2147	13
3D9.1BF18751AE	3	29 May/2057	29 May/2148	51
3D9.1BF1568B24	3	29 May/2146	29 May/2156	9
3D9.1BF186BF79	1	29 May/2144	29 May/2216	32
3D9.1BF1771ADB	1	29 May/2159	29 May/2216	17

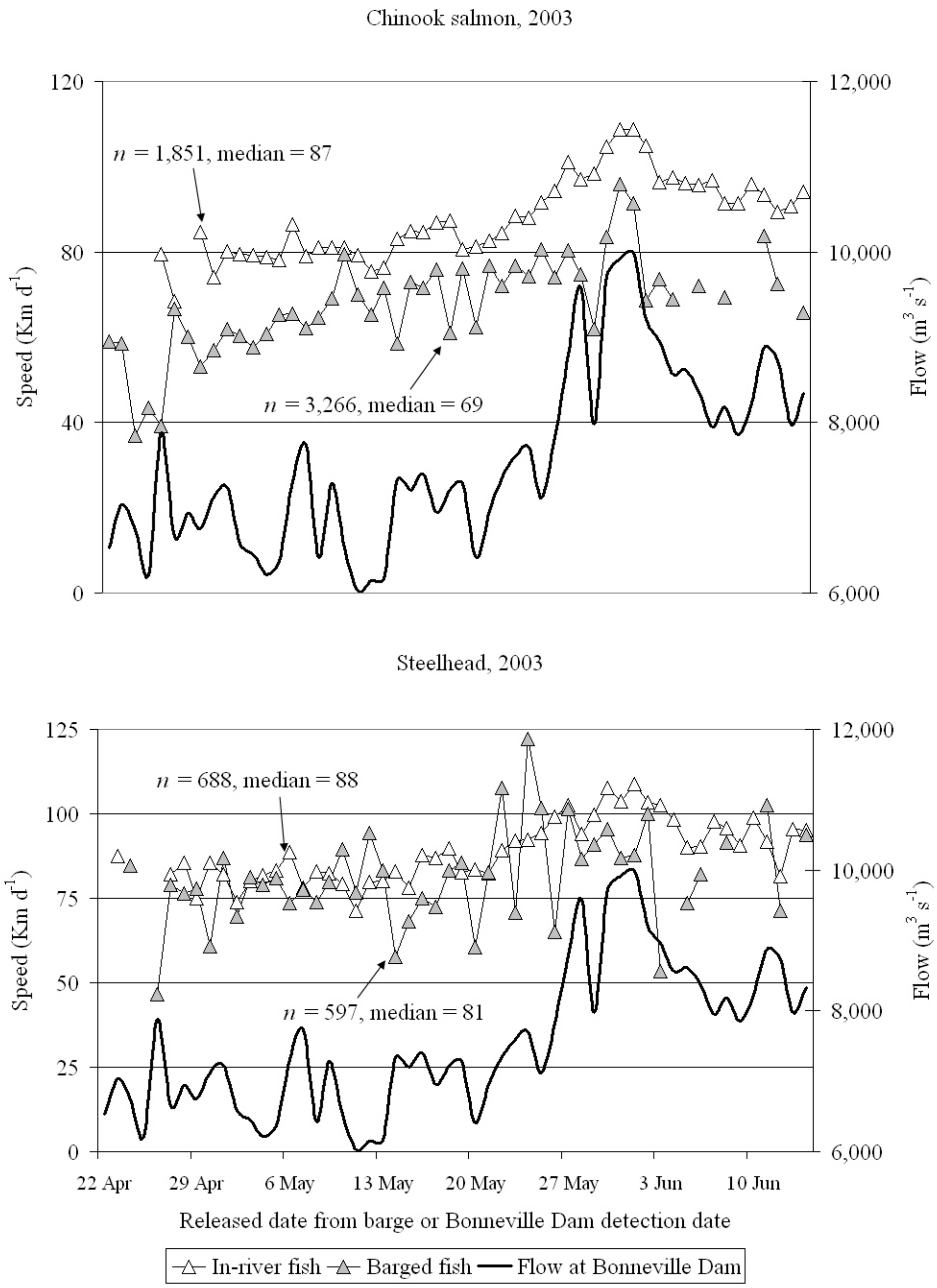


Figure 16. Daily mean travel speed from detection at Bonneville Dam or barge release to detection in the estuary (near rkm 75) using the large trawl system for yearling Chinook salmon and steelhead, 2003.

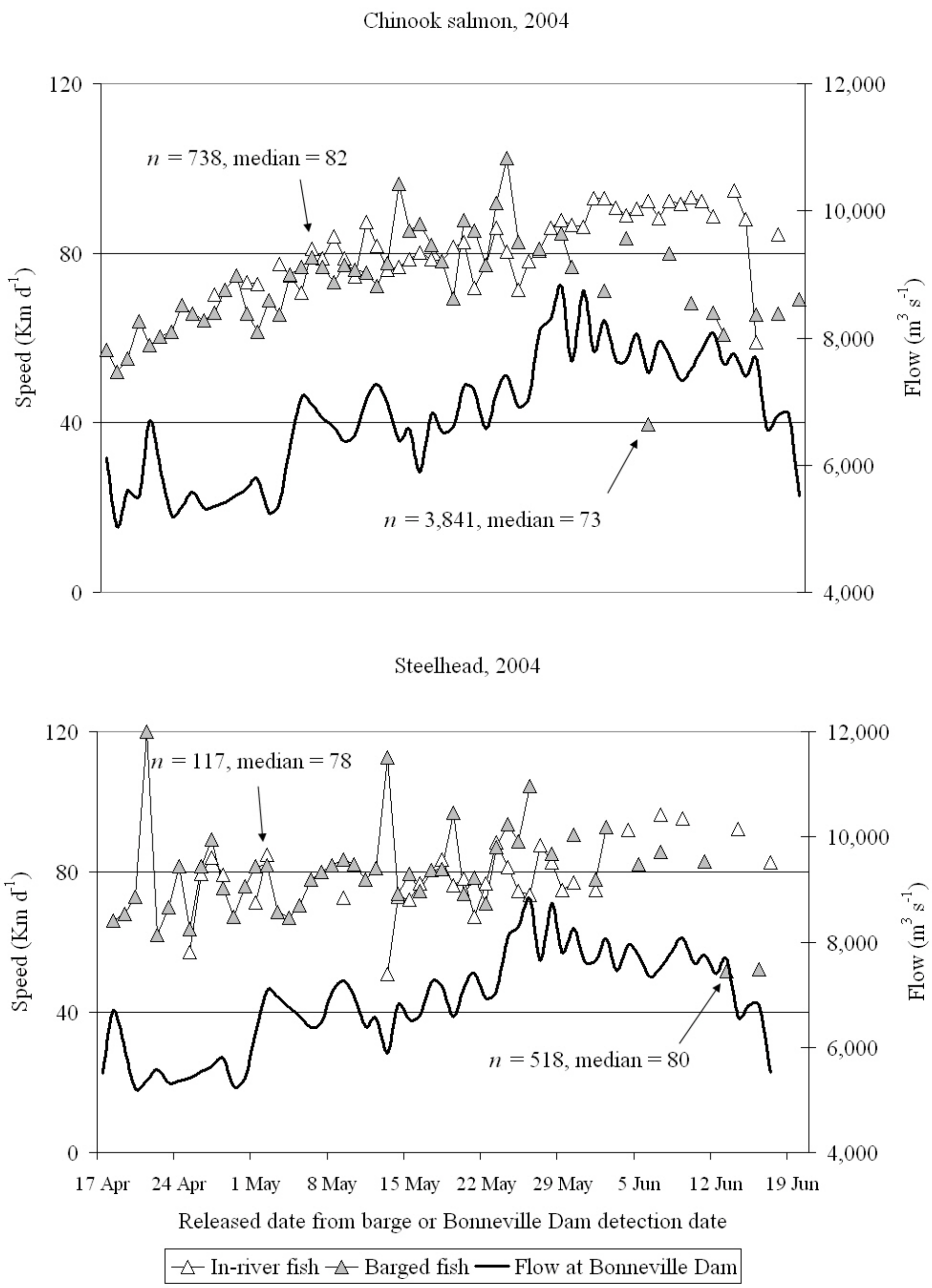


Figure 17. Daily mean travel speed from detection at Bonneville Dam or barge release to detection in the estuary (near rkm 75) using the large trawl system for yearling Chinook salmon and steelhead, 2004.

Subyearling Fall Chinook Salmon (Summer Migration)

We did not extend sampling beyond June in either 2003 or 2004, and unlike in 2002, we have only limited information regarding the late spring and summer migration of subyearling fall Chinook salmon. We did detect 1,106 juvenile subyearling Chinook salmon in 2003 and 695 in 2004 (i.e., Chinook salmon designated as run-code 3 in the PTAGIS database). The majority of these fish had been released in the Snake or Columbia River and were generally expected to migrate to sea as subyearlings. However, 16 of these detections in 2003 and 4 in 2004, were actually yearling fish that had been released the previous year in the Snake River and had overwintered in the Columbia River basin.

In addition, 171 of the run-code 3 detections in 2003 and 81 in 2004 were Chinook salmon released prior to mid-April and thus, were yearlings (tagged in April with fork lengths >120 mm). The remaining run-code 3 Chinook salmon were subyearling migrants released after mid-May with fork lengths <120 mm. The majority had been released in either the Snake River or Upper-Columbia River. In both years, over 70% of the subyearling Chinook salmon we detected had been transported and released downstream from Bonneville Dam. This high proportion of transported fish is due in part to the fact that we did not extend sampling into July and August when the majority of the inriver migrants enter the estuary.

The daily average travel speed of PIT-tagged subyearling fall Chinook salmon decreased with river flow volume and, in 2003, was similar to averages of the four release groups of radio-tagged fish released at Bonneville Dam between mid-June and mid-July in 2003, as well as the three such groups that were transported and released below Bonneville Dam (Figure 18). In 2004, there were no radio-tagged subyearling Chinook salmon released at Bonneville Dam or from barges for comparison to PIT-tagged fish (radio-tagged fish travel time data from, Ben Clemens, Oregon State University Fisheries Cooperative Unit, personal communication).

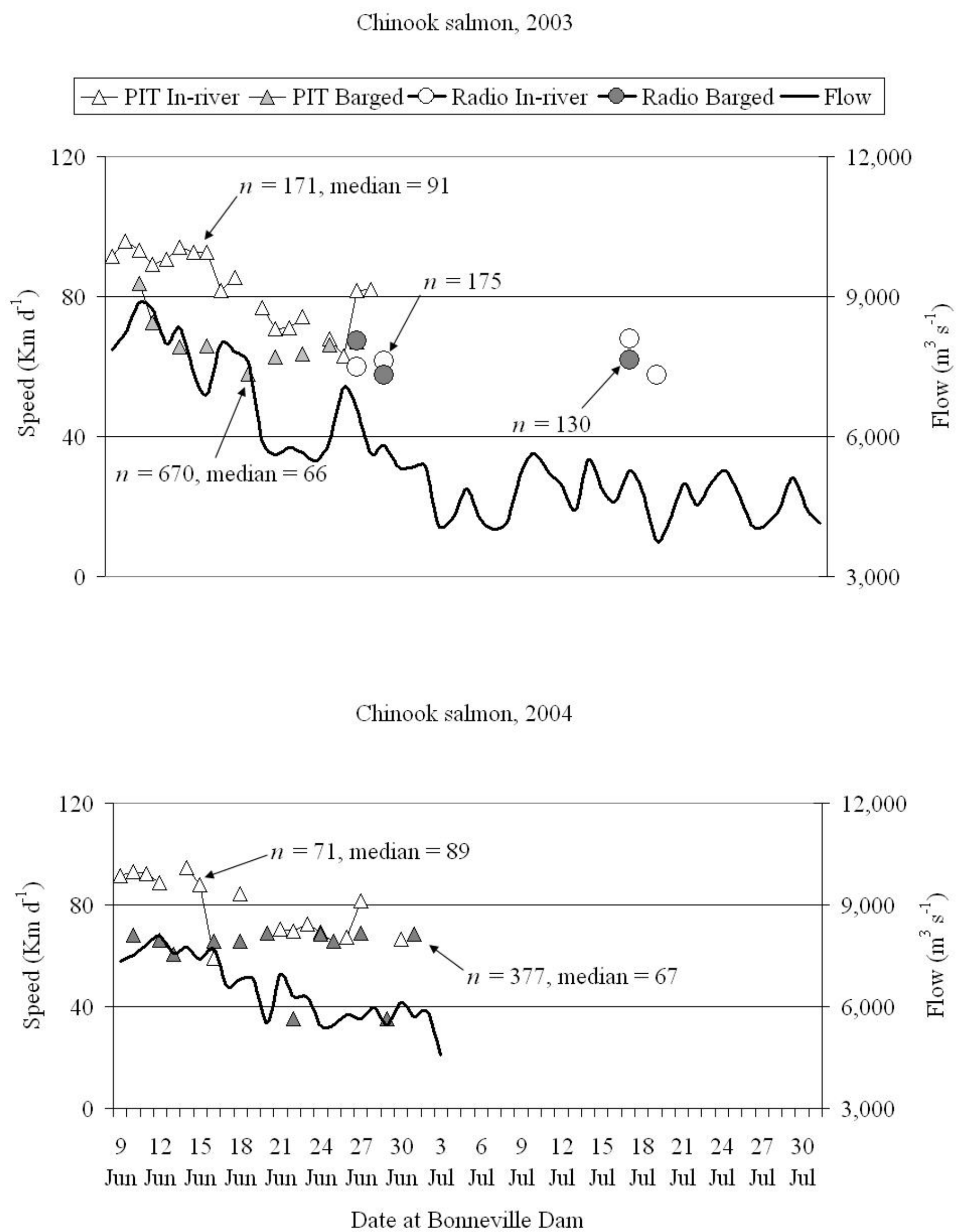


Figure 18. Daily mean travel speed for subyearling Chinook salmon following detection at Bonneville Dam or barge release to detection in the estuary (near rkm 75), 2003 and 2004. Similar travel speed data for radio-tagged fish are shown for 2003.

Transportation Evaluation

In 2003 and 2004 combined, 355,439 yearling and subyearling Chinook salmon and 71,219 steelhead were diverted by PIT-tag code to transportation barges at dams on the Snake and Columbia Rivers. These fish were subsequently released downstream from Bonneville Dam near rkm 224. Of those, we detected 8,199 yearling and subyearling Chinook and 1,286 steelhead in the estuary at rkm 75 (Appendix Tables 9-12). During the same two-year period, 122,196 Chinook and 51,541 steelhead migrants were detected in the juvenile bypass system at Bonneville Dam (rkm 230). Of those we detected 2,748 yearling and subyearling Chinook salmon and 852 steelhead (Appendix Table 13 and 14).

Daily totals of transport and inriver migrants are listed in appendices , i.e., numbers released from barges or detected at Bonneville Dam and numbers detected in the estuary. For transported fish, daily totals are further subdivided by transportation dam. A portion of both barged and inriver migrant fish passed through the estuary both before and after our trawl sampling period. These fish were excluded from the analysis of relative estuarine detection rates presented below. There were about 17% fewer PIT-tagged fish released in 2004 than in 2003, but it should also be noted that there were about 75% fewer fish detected at Bonneville Dam in 2004 than in 2003.

The major contributor to reduced detections at Bonneville Dam in 2004 was the successful operation of the new corner-collector bypass route at the Second Powerhouse, which lacks detection capability. The corner-collector passes fish directly from the forebay at the Second Powerhouse; an exit flume returns them to the river downstream from PIT-tag detection antennas at the juvenile bypass facility. The proportion of migrants estimated passing via the corner collector during spring and summer 2004 was 39% for yearling Chinook, 74% for steelhead, and 39% for subyearling Chinook salmon.[2] Remaining proportions exited the forebay either via turbine or the juvenile bypass system.

We used logistic regression analysis to compare daily detection percentages of transported fish to those of fish detected at Bonneville Dam during the period of our two-crew sampling effort each year. For analyses, we further selected the Bonneville Dam detections for fish originating upstream from McNary Dam (rkm 470), i.e., fish groups subject to transportation but which had remained in the river. We also used logistic regression to model the daily detection rates of fish released from the same daily transport barge but loaded at different dams.

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[2] Passage estimates based on radio-tagged fish, personal communication, Blaine Ebberts, U.S. Army Corps of Engineers, Portland District, Portland, OR. September 2005.

Detections of Transported vs. Inriver Migrant Fish

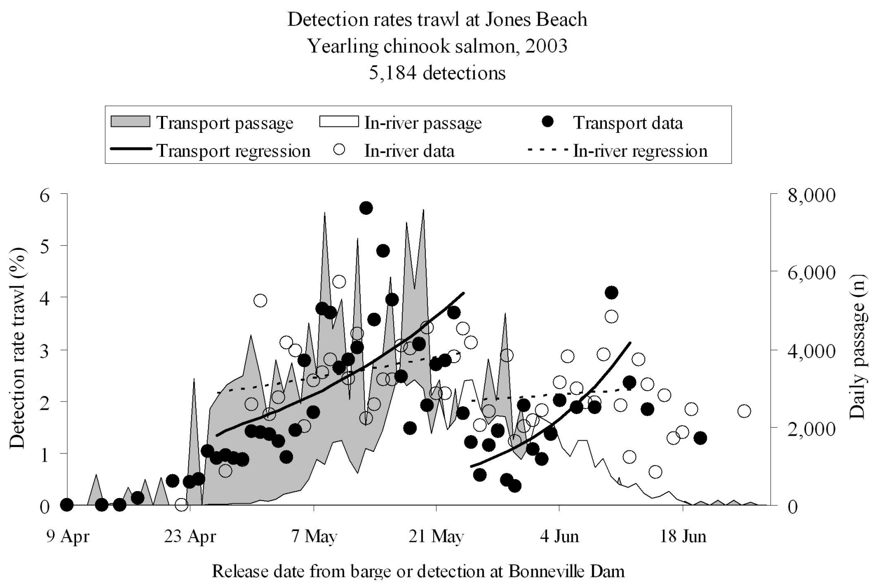
2003--There was significant interaction between migration history (barge vs. inriver) and date at Bonneville Dam for yearling Chinook salmon in 2003 (P <0.001). Detection percentages increased for both groups from late April thru mid-May, but the estimated increase for transported Chinook was much larger (1 to 4%) than for inriver migrants (2 to 3%; Figure 19). Detection rates for both groups declined rapidly at around 25 May; this decline was probably related to increased river flow and temperature and slightly decreased sampling effort. However, after 25 May, estimated detection rates for transported Chinook increased sharply (from 1 to 3%) while remaining fairly constant for inriver migrants (around 2%).

Note that we chose ad hoc to break the logistic regression model into two pieces around the 25 May date based on visual inspection of the data. Detection rate was modeled as a monotonic function of the regression factors (i.e. date), which in this specific case was inappropriate over the entire date range. Also, we were not specifically interested in the absolute detection rate through time, but the relative rates of transported vs. inriver-migrating groups.

There was significant interaction between migration history and date at Bonneville Dam for steelhead (P <0.001). Detection rates for barged steelhead declined from 3 to about 1% from late April through mid-June, whereas detection rates for inriver migrants increased from less than 1 to over 2.5% in the same period.

2004–In 2004, we found mild but significant interaction in estimated detection rates between barged and inriver-migrating yearling Chinook salmon (P = 0.040). The estimated detection rate of transported yearling Chinook was initially quite high (almost 4%) and then declined to about 2% from late April through mid-June (Figure 20). Detection rates for inriver migrant yearling Chinook declined as well, but not as sharply (3 to 2.5%). Caution should be exercised in any inference comparing barged and inriver-migrant yearling Chinook salmon due to the lack of inriver-migrant fish, particularly during the first two weeks of full sampling. No inriver group was released for the NMFS transportation study in 2004.

There was no significant interaction in estimate detection rates between barged and inriver-migrant steelhead in 2004 (P = 0.040). Detection rates for barged steelhead declined from nearly 3 to 2% from late April to mid-June. Detection rates for inriver migrant steelhead were significantly lower (P < 0.001), declining from 2 to 1% during the same period. Too few detections of inriver fish were available for strong inference from this analysis. This was due to efficient operation of the corner collector at Bonneville Dam Second Powerhouse, which passes fish without the opportunity for PIT-tag detection. Additionally, the day with maximum transported steelhead, 21 April, fell outside the full sampling window at Jones Beach.



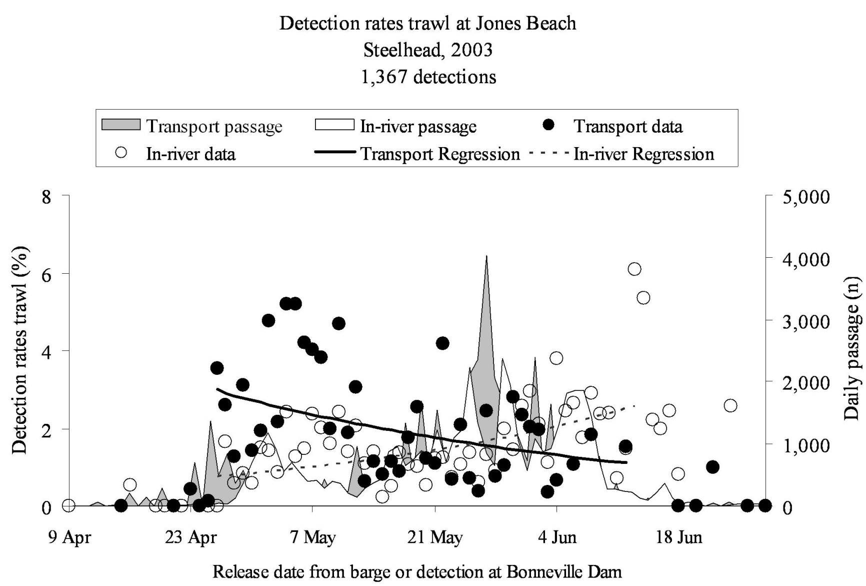
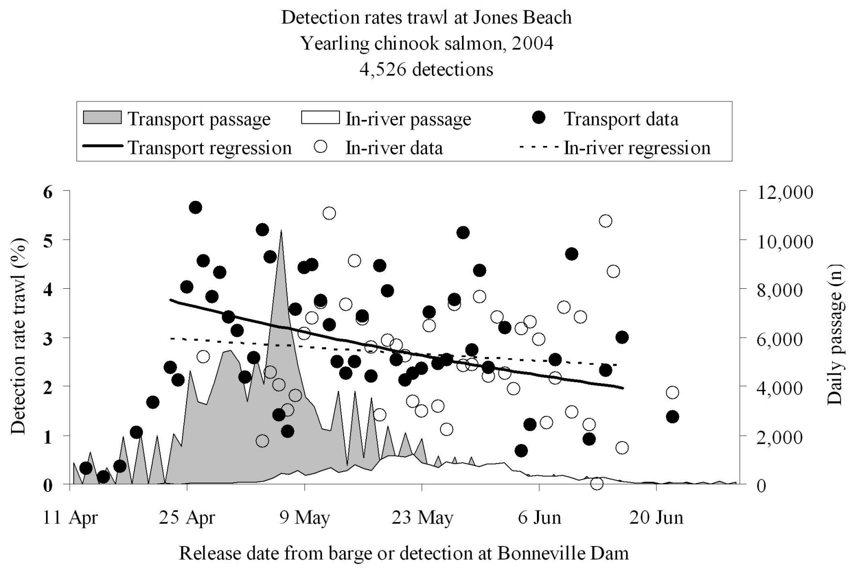


Figure 19. Logistic regression analysis for daily detection percentages of barge-transported vs. inriver-migrating Chinook salmon and steelhead detected at Bonneville Dam, 2003.



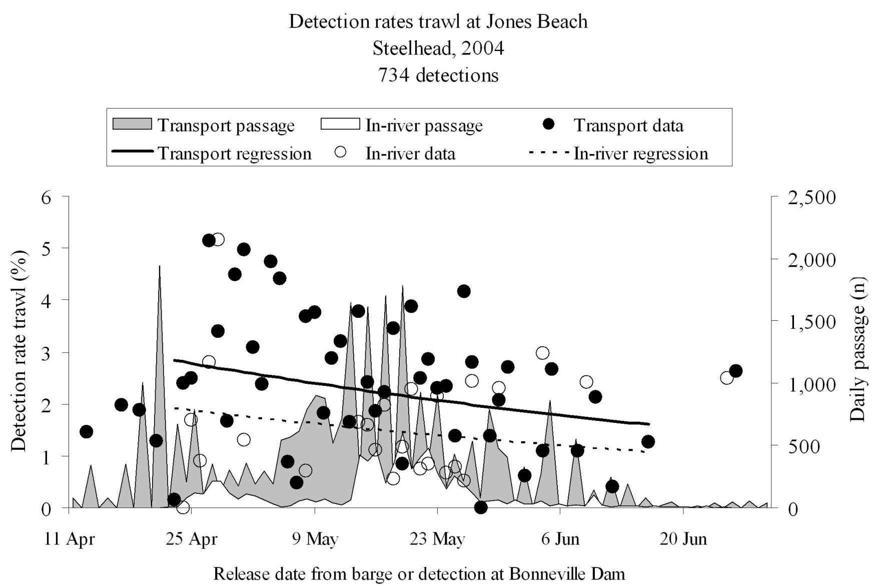


Figure 20. Logistic regression analysis of the daily detection percentages of barge-transported and inriver migrant Chinook salmon and steelhead detected at Bonneville Dam, 2004.

Mixing Assessment: Transported vs. Inriver-Migrant Detections

Comparisons of relative estuary detection rates between barged and inriver migrants rely on the assumption that fish released from barges or detected at Bonneville Dam on the same date had equal probabilities of detection in the estuary. To test this assumption, we calculated the hourly differences in diel detection distributions between the two groups for each sample year since 2000 (Figure 21). Average hourly differences in diel distributions for yearling Chinook salmon varied from 0 to 4% (5-year average 2000-2004). There did not appear to be strong diel detection trends in the difference for either group of yearling Chinook salmon, indicating that groups were well mixed during their passage through the estuary. The extreme values in most years represented intervals with low sampling effort (shift change time periods) and perhaps low detection numbers for one group or another during the time of year that those time slots were sampled. In 2001, diel variation was highest of all 5 years (range -9 to 7%, with more inriver fish at 1400 PST and more barged fish detected at 2100).

Average hourly differences in diel distributions for steelhead during the same 5-year period varied from 0 to 3%. While individual years indicated possible patterns, when analyzed together, there did not appear to be strong diel trends in the difference for either group, which also supports a conclusion that the two groupings of steelhead were well mixed during their passage through the estuary. For example, data from 2000 suggested that higher proportions of barged fish are sampled during mid-day and lower proportions in the evening, while data from 2001 suggested the opposite. Ranges of difference were higher in 2000 and 2001 than in the other years with larger sample sizes of steelhead.

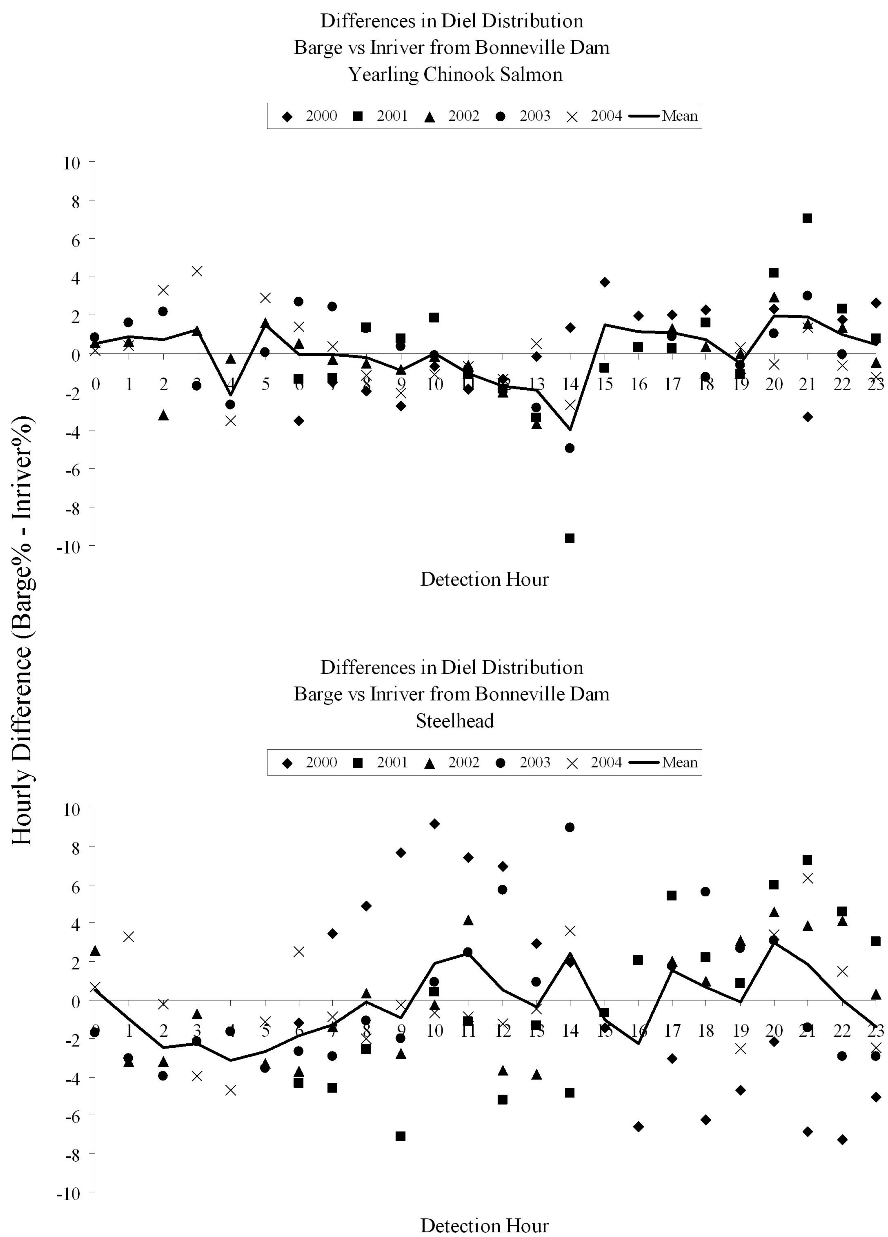


Figure 21. Hourly difference in estuarine detection percentages of barge-release fish compared to those fish previously detected at Bonneville Dam, 2-crew sampling periods, 2000-2004. The pooled mean difference is plotted, and a mean difference greater than 0 indicates that a higher proportion of barged fish were detected during those hours and vice versa.

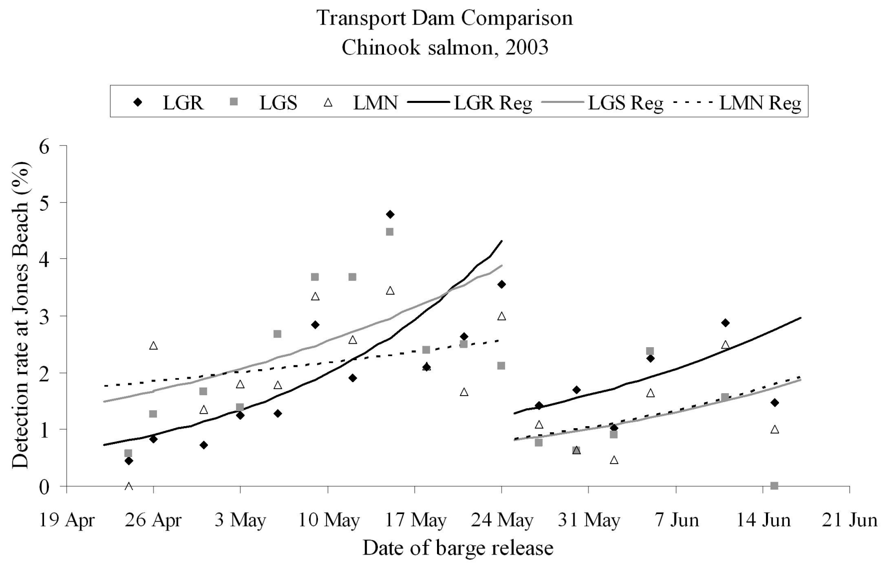
Transport Dam Assessment

2003--In 2003, there was significant interaction between Snake River transport dam and barge release date for yearling Chinook salmon (P <0.001). From late April to mid-May, estimated proportions of yearling Chinook detected in the estuary increased for fish transported from Lower Granite Dam (from 1 to about 4%) and from Little Goose Dam (1.5 to 4%), but increased only slightly (from 2 to 2.5%) for fish transported from Lower Monumental Dam (Figure 22).

A sudden drop in detection rates to around 1% occurred around 25 May for fish from all three Snake River collector dams. After this drop, estimated detection rates rose again to nearly 3% for Lower Granite Dam transports, but to less than 2% for both Little Goose and Lower Monumental Dam transports, again indicating a significant interaction between Snake River collector dam and barge release date (P < 0.001). See the discussion above regarding breaking the data set into two groups based on 25 May.

Though not presented in the figure, we also compared pooled detection data for fish transported from all three Snake River collector dams to detection data for fish loaded at McNary Dam in 2003. In this comparison, we found no significant interaction between transport dam and barge release date for yearling Chinook salmon (P = 0.616) early in the migration season. Estimated estuary detection rates increased from about 1% in late April to above 4% by mid-May for fish transported from both pooled Snake River Dams and McNary Dam, with yearling Chinook salmon loaded at McNary Dam about 0.3% higher (P = 0.009). A sudden drop in detection rates to less than 1% occurred by 25 May (see discussion above) followed by sharply increasing rates to over 2 or 4% by mid-June for fish transported from Snake River and McNary Dams, respectively. The sharper increase for McNary Dam was significant (P < 0.001).

There was no significant interaction between Snake River transport dam and barge release date for steelhead in 2003 (P = 0.216). Estimated estuarine detection rates for transported steelhead loaded at Little Goose Dam decreased from 5% in early May to about 2% by early June, which was slightly higher than for steelhead loaded at Lower Monumental Dam, and was significantly higher (P = 0.016) from 4 to 1% at Lower Granite Dam. Note the difference from Lower Monumental to Lower Granite Dam was not quite significant (P = 0.120). Detections rates for steelhead loaded at McNary Dam were significantly lower than for Snake River fish (about 1.2% through the entire season, not presented in the figure).



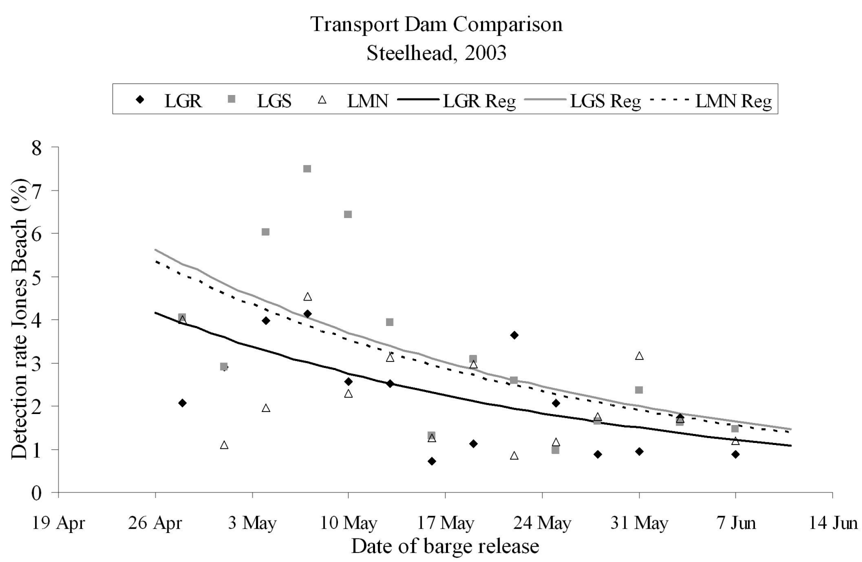
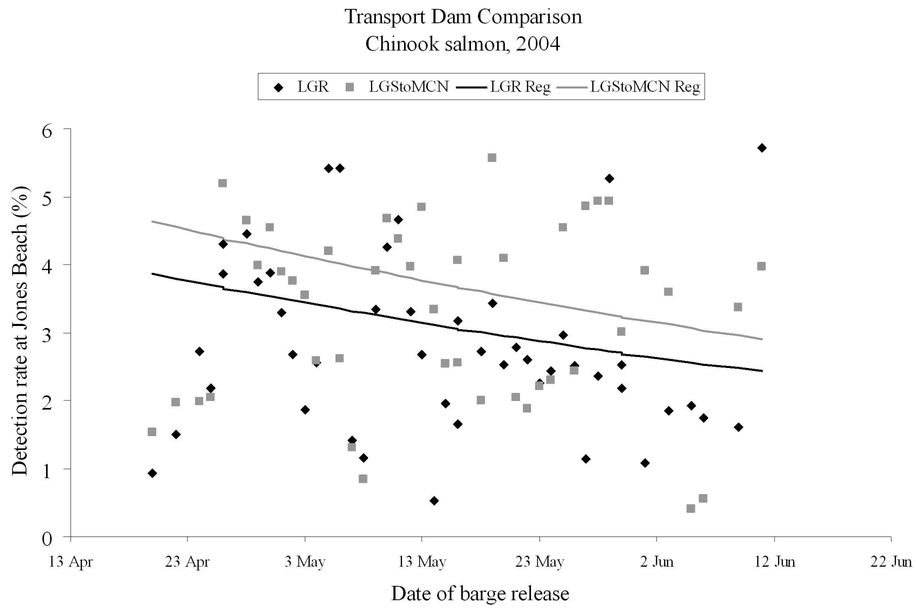


Figure 22. Estuary detection rates of yearling Chinook salmon and steelhead released from barges loaded at Lower Granite (LGR) or downstream dams (LGS, Little Goose Dam or LMN, Lower Monumental Dam), 2003.

2004--In 2004, there was no significant interaction between Snake River transport dam and barge release date for yearling Chinook salmon ($P = 0.341$; Figure 23). Estuarine detection rates for fish loaded at Lower Granite Dam were consistently about 1% lower than pooled detection rates for fish those loaded at Little Goose and Lower Monumental Dams (pooled due to low numbers at Lower Monumental Dam). Detection rates for fish transported from the two lower dams declined through the migration season from about 5% in early May to 4% by mid-June. Detections rates for yearling Chinook salmon loaded at McNary Dam (not shown in the figure) declined similarly to pooled detection rates for fish loaded at Snake River Dams but were about 0.33% higher through the period (significant, $P = 0.33\%$). This trend of higher detection rates for fish loaded at McNary Dam was opposite that observed in 2003, but differences in both years were small.

There was no significant interaction in the estimated estuarine detection rate between Snake River transport dam and barge release date for steelhead ($P = 0.925$) in 2004 and no significant difference between fish transported from Lower Granite Dam versus the pooled rate from Little Goose and Lower Monumental Dams ($P = 0.609$).

Overall the estimated detection rates declined from around 4% in early May to less than 3% by mid-June. Data from the lower two dams were pooled due to low numbers of steelhead. Estimated estuarine detection rates for transported steelhead from McNary Dam during the same period (not shown in figure) increased about 1 to 2% but there was a significant interaction ($P = 0.008$) between transport dam and released date from barge for this comparison. The trend of lower detection rates for steelhead loaded at McNary Dam compared to pooled Snake River Dams also occurred in 2003.



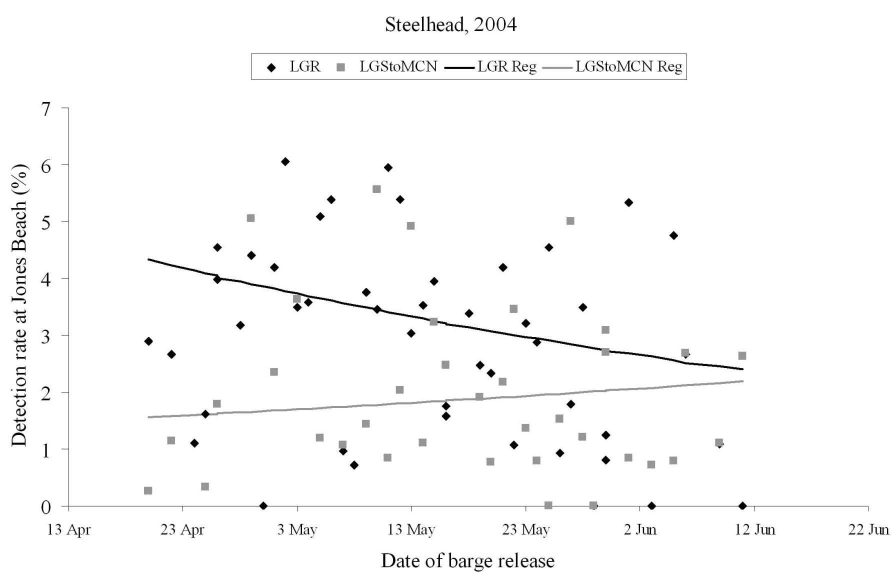


Figure 23. Estuary detection rates of yearling Chinook salmon and steelhead released from barges loaded at Lower Granite (LGR) or other downstream dams (LGS, Little Goose Dam or MCN, McNary Dam), 2004.

Survival Estimates of Inriver Migrants to the Tailrace of Bonneville Dam

Detection data from the trawl are essential for calculating survival probabilities for juvenile salmonids to the tailrace of Bonneville Dam, the last dam encountered by seaward migrants (Muir et al. 2001; Williams et al. 2001; Zabel et al. 2002). Detections of yearling Chinook salmon and steelhead arriving at McNary Dam were pooled weekly, and survival probabilities of fish released in the Snake and mid-Columbia Rivers were estimated from McNary to John Day, John Day to Bonneville, and McNary to Bonneville Dams (Tables 6 and 7). Estimated survival probabilities were lower in 2004 than 2003 (Ledgerwood et al. 2003) in every instance where sample sizes were adequate for an estimate.

For Snake River yearling Chinook salmon, survival estimates from McNary Dam to Bonneville Dam were 72.8% in 2003 and 59.4% in 2004. Survival through the same reach was estimated at 51.8% for Snake River steelhead in 2003. For mid-Columbia River stocks, survival of yearling Chinook salmon from McNary to Bonneville Dam was estimated at 76.7 in 2003 and 62.2% in 2004, and survival for steelhead was estimated at 69.5 in 2003 and 49.6% in 2004. Sample sizes were insufficient for survival estimates of other stocks, reaches or species.

Seasonal average survival of inriver migrants from the tailrace of Lower Granite Dam to the tailrace of Bonneville Dam was 53.2 and 39.5% for yearling Chinook salmon, in 2003 and 2004, respectively, and 30.9% for steelhead in 2003 (Table 8). Survival probabilities for both species through the entire hydropower system in 2003 were similar to those from 1998-2000 and 2002, when seasonal average river flow was comparable.

Survival probabilities in 2001, a year characterized by extremely low river flow due to the regional drought, was about half the survival of the other years (27.6%). In 2004, also a year with lower-than-average river flows, the survival probability for yearling Chinook salmon was lower than the average (but not as low as in 2001). We could not calculate a survival probability for steelhead due to insufficient detections at Bonneville Dam.

Table 6. Weekly average survival percentages from the tailrace of McNary Dam to the tailrace of Bonneville Dam for yearling Chinook salmon and steelhead, 2003. Total fish used in the survival estimates, weighted average survivals, and standard errors for each species and water basin are presented.

Week	*n*	McNary to John Day Dam		John Day to Bonneville Dam		McNary to Bonneville Dam	
		%	SE	%	SE	%	SE
	Snake River Yearling Chinook salmon						
20 Apr-26 Apr	1,463	88.0	9.3	90.4	27.4	79.5	22.6
27 Apr-03 May	9,538	88.8	4.1	102.0	16.1	90.6	13.7
04 May-10 May	16,748	86.7	3.6	76.7	8.3	66.5	6.7
11 May-17 May	19,814	93.1	3.1	73.7	7.2	68.6	6.3
18 May-24 May	15,423	83.0	2.6	86.9	10.9	72.2	8.8
25 May-31 May	6,172	92.1	3.1	83.5	16.5	76.9	15.0
01 Jun-07 Jun	2,188	95.3	4.7	82.7	15.8	78.8	14.5
Wt. Avg.	71,346	89.3	1.7	81.8	3.6	72.8	3.0
	Snake River steelhead						
27 Apr-03 May	483	104.6	26.7	44.4	22.4	46.5	20.2
04 May-10 May	363	92.8	35.9	0.0	0.0	0.0	0.0
11 May-17 May	506	103.8	41.6	39.9	27.9	41.4	23.7
18 May-24 May	1,091	96.9	14.7	51.5	17.3	49.9	15.0
25 May-31 May	2,596	85.6	6.3	62.8	13.7	53.8	11.0
01 Jun-07 Jun	782	81.4	11.6	83.3	25.0	67.8	18.0
Wt. Avg.	5,821	87.9	3.2	63.0	6.6	51.8	1.5
	Mid-Columbia River Yearling Chinook salmon						
27 Apr-03 May	4,835	79.6	5.0	98.6	23.0	78.5	17.7
04 May-10 May	7,764	92.1	5.3	110.4	22.6	101.6	20.0
11 May-17 May	8,975	91.0	3.3	89.3	13.2	81.3	11.6
18 May-24 May	7,354	89.6	3.3	81.2	14.7	72.8	12.9
25 May-31 May	7,672	89.1	2.1	93.2	16.8	83.1	14.8
01 Jun-07 Jun	1,872	113.9	8.9	43.2	8.0	49.2	8.2
Wt. Avg.	38,472	90.2	2.5	84.8	9.1	76.7	6.9
	Mid-Columbia River Steelhead						
04 May-10 May	1,218	82.3	10.1	76.4	38.9	62.9	31.0
11 May-17 May	2,445	127.0	16.0	28.2	7.8	35.8	8.7
18 May-24 May	4,492	98.5	6.5	86.8	28.3	85.5	27.3
25 May-31 May	4,421	99.4	5.1	101.2	31.4	100.6	30.8
01 Jun-07 Jun	3,971	87.2	4.8	97.0	18.0	84.6	15.0
08 Jun-14 Jun	908	70.3	13.9	58.0	19.8	40.8	11.4
Wt. Avg.	17,455	95.4	4.7	78.6	11.9	69.5	10.8

Table 7. Weekly average survival percentages from the tailrace of McNary Dam to the tailrace of Bonneville Dam for yearling Chinook salmon and steelhead, 2004. Total fish used in the survival estimates, weighted average survivals, and standard errors for each species and water basin are presented.

		McNary to John Day Dam		John Day to Bonneville Dam		McNary to Bonneville Dam	
Week	*n*	%	SE	%	SE	%	SE
		Snake River Yearling Chinook salmon					
20 Apr-26 Apr		67.8	14.4	56.7	24.8	38.4	14.7
27 Apr-03 May		77.2	8.9	149.8	66.8	115.5	49.8
04 May-10 May		87.5	7.5	106.0	33.0	92.8	27.7
11 May-17 May		85.4	6.7	53.1	11.1	45.4	8.7
18 May-24 May		67.0	12.1	95.2	63.9	63.8	41.2
25 May-31 May		79.7	13.9	72.8	27.6	58.0	19.5
01 Jun-07 Jun		63.1	17.0	113.7	79.7	71.9	46.5
01 Jun-07 Jun		78.8	16.7	81.7	54.6	64.3	40.8
08 Jun-14 Jun		67.3	13.8	68.5	44.9	46.1	28.7
Wt. Avg.		80.9	2.8	73.5	9.2	59.4	7.4
		Snake River steelhead					
27 Apr-03 May	206	31.6	27.3	--	--	--	--
04 May-10 May	676	38.2	13.2	--	--	--	--
11 May-17 May	1,107	96.7	52.1	--	--	--	--
18 May-24 May	395	48.6	22.2	--	--	--	--
25 May-31 May	1,001	36.9	9.4	94.0	91.9	34.7	32.8
01 Jun-07 Jun	730	57.5	26.0	--	--	--	--
Wt. Avg.		46.5	7.8	--	--	--	--
		Mid-Columbia River Yearling Chinook salmon					
20 Apr-26 Apr	2,101	85.3	20.7	142.7	143.1	121.7	118.5
27 Apr-03 May	6,328	72.4	8.3	92.4	34.6	66.9	23.9
04 May-10 May	4,350	81.9	9.0	71.0	26.1	58.2	20.4
11 May-17 May	7,463	68.2	4.2	84.6	20.5	57.7	13.5
18 May-24 May	4,166	97.0	13.2	49.5	14.6	48.0	12.5
25 May-31 May	2,148	68.3	9.8	138.9	60.8	94.9	39.2
01 Jun-07 Jun	764	60.4	19.8	124.2	90.2	75.0	48.7
Wt. Avg.	27,320	74.1	3.8	84.0	11.1	62.2	6.3

Table 7. Continued.

		McNary to John Day Dam		John Day to Bonneville Dam		McNary to Bonneville Dam	
Week	*n*	%	SE	%	SE	%	SE
		Mid-Columbia River Steelhead					
13 Apr-19 Apr	975	83.3	1`7.2	0.0	0.0	0.0	0.0
20 Apr-26 Apr	3,463	106.6	18.8	45.1	18.1	43.5	16.5
27 Apr-03 May	786	80.7	42.8	2-week pools to Bonneville			
04 May-10 May	1,423	78.6	18.4	0.0	0.0	0.0	0.0
11 May-17 May	5,587	75.1	9.1	100.6	57.3	78.0	43.6
18 May-24 May	2,244	78.5	14.5	0.0	0.0	0.0	0.0
25 May-31 May	809	48.7	11.1	56.8	39.1	28.6	18.8
01 Jun-07 Jun	831	54.4	19.2	0.0	0.0	0.0	0.0
Wt. Avg.	16,118	78.6	5.9	62.3	16.8	49.6	12.4

Table 8. Estimated survival probabilities from the tailrace of Lower Granite Dam to Bonneville Dam for yearling Chinook salmon and steelhead, 1998-2004. SE = standard error, and 95% confidence limits for the respective means.

	Survival estimates					
Migration	Yearling Chinook salmon			Steelhead		
year	(%)	SE	95% CI	(%)	SE	95% CI
1998	53.8	4.6	44.8-62.8	50.0	5.4	39.4-60.6
1999	55.7	4.6	46.7-64.7	44.0	1.8	40.5-47.5
2000	48.6	9.3	30.4-66.8	39.3	3.4	32.6-46.0
2001	27.6	1.6	24.5-30.7	4.2	0.3	3.6-4.8
2002	57.8	6.0	46.0-69.6	26.2	5.0	16.4-36.0
2003	53.2	2.3	48.7-57.7	30.9	1.1	28.7-33.1
2004*	39.5	5.0	29.7-49.3			

* In 2004, detection rates of steelhead at Bonneville Dam were too low for useful survival estimates.

DISCUSSION

Deployment of the large pair trawl PIT-tag detection system in 2003 and 2004 represented a continuing effort to improve collection efficiency of migrating juvenile salmonids while decreasing impacts to fish. Originally deployed in 1995, modifications of the mobile underwater PIT-tag detection system have generally involved changes in trawl design and enlargement of fish passage tunnels (detection antennas) utilized by collected fish to exit the trawl.

In 2000, researchers in the Columbia River Basin switched to 134.2-KHz tags, which allowed longer read ranges than the previously used 400-KHz PIT-tags. Also in 2000, we were able to enlarge the fish-passage opening of our antenna to 86 cm. The following year, we added a second detection coil and spacer between the coils. This created an antenna that was 2.1-m long, and was used through 2004. This antenna improved tag-reading efficiency by allowing redundant reads of PIT-tagged fish, and its longer length appeared to improve orientation of fish within the electronic fields and reduce delay of fish at the entrance to the antenna.

In 2004, we also began utilization of a new pair-trawl having a longer floor extending forward of the head rope. This longer floor was designed to reduce the number of fish (primarily Chinook salmon) that may sound at the head-rope and swim along the floor to escape under the trawl. As a result of these modifications and utilization of two daily sampling crews during the peak of the spring migration, detection efficiency in the estuary has increase to over 2% of all surviving juvenile salmonids. An efficiency generally sufficient to provide weekly estimates of survival from McNary Dam to the tailrace of Bonneville Dam for inriver migrants and daily survival comparisons between fish groups released from transportation barges to those detected passing Bonneville Dam. In 2004, there was a major, if temporary, change in overall PIT-tag detection efficiency for juvenile salmonids passing Bonneville Dam with the operation of a corner-collector-bypass system (lacking PIT-tag capability). Detection numbers at Bonneville Dam dropped to about 40,000 in 2004 compared to about 140,000 in 2003. This reduction in efficiency at Bonneville Dam adversely effected our ability to make survival estimates due to the reduced sample-size of fish passing Bonneville Dam.

The numbers of PIT-tagged fish released into the Columbia River Basin each year of our sampling have not been constant. In 2000 and 2001, about 1 million PIT-tagged fish were released and numbers increased to about 2 million per year in subsequent years. The number of PIT-tags we detected each year ranged from a low of about 5,500 in 2001 to over 20,000 in 2003. However, by use of two daily sampling crews during the spring migration period, our detection efficiency in the estuary each year ranged from 2 and 3% of all PIT-tagged fish surviving to reach the estuary. This estimate of sample efficiency of the trawl system was based on detection rates of fish previously detected at Bonneville Dam, and assumes 100% survival between Bonneville Dam and the sampling area (a conservative estimate). We believe this estimate for inriver fish is reasonably extrapolated for detection rates of all other PIT-tagged fish, including barged fish.

Seasonal mean survival rates for PIT-tagged fish from the tailrace of Lower Granite Dam to the tailrace of Bonneville Dam were positively correlated to river flow in the years from 2000 through 2004. In 2004, survival was lower than in 2003 but higher than in the drought year 2001, whereas, survival in 2003 was similar to the other average to above average flow years 2000 and 2002. In 2004, weekly survival probabilities estimated for fish from McNary Dam to Bonneville Dam were consistently lower than in 2003 and thus additional support for a conclusion that seasonal trends in survival for non-transported migrants are related to river flow volume and possibly directly linked to longer travel times through the reservoirs.

To offset high expected mortality for inriver migrants due to drought and low river flow conditions, fishery managers typically increase the proportion of fish transported by barge. In 2004, NMFS transport study did not release any inriver migrant groups. Similarly, the proportion of transported fish we detected in the estuary increased from 23% in 2003 to 30% in 2004 (compares to 31% in 2001).

In 2003, we could not equate the change in detection rates for yearling Chinook salmon on 25 May with any change in the source of fish. There was a 26% decline in sampling effort after 25 May 2003, with 5-d averages of 19 h before 25 May and 14 h after. There was also a 15% increase in flow volume, with 5-d average flows of 7,205 m^3/sec prior to 25 May and 8,261 m^3/sec after. This drop in sampling time, combined with increased flows, may account for the decline in detection rates.

It is possible that barge loading densities or other factors also effected post-transport survival of yearling Chinook salmon during this period in 2003. The decline in detection rates of transported steelhead through the season may have been a function of water temperature. As temperature approaches 11-13°C, steelhead begin to revert to parr and may stop moving downstream (Gene Matthews, NMFS, personal communication). Temperatures in the estuarine sampling area typically reach 13°C by early June.

By comparing detection percentages of barge-transported fish to those detected passing Bonneville Dam, we assumed that the sample distributions in the area were similar. Visual inspection of travel-time distribution plots supported this assumption, although additional analyses of these distributions is warranted. We also evaluated the 5-year average differences in diel detection distributions between the two groups and saw little evidence that the two groups were not uniformly mixed in the sample area. Therefore we assume that when both barged and inriver groups were present in the estuary on a given day, they were subject to the same sampling procedures and river conditions. This assumption also applies to comparisons of daily detection percentages of fish loaded at various dams and released from the same barge.

Comparison of daily detection rates for fish released from barges with those of selected upriver released fish detected at Bonneville Dam should properly reflect differences in daily survival to the estuary. We suspect much of the observed variability in daily detection rates observed for transported fish are associated with specifics of barge loading, such as species composition, loading densities, and loading site. However, release information currently available for barged fish does not enable distinction between even individual barges released on the same day (often two barge-loads are released on one tug boat trip) or from which barge holes, thus these detection data should be considered preliminary.

Differences in relative survival may reflect the degree of delayed mortality experienced by fish following transportation. It is possible that for yearling Chinook salmon transported early in the 2003 migration season, there was considerable delayed mortality between release from a barge and arrival in the estuary, but that this pattern disappeared later in the season. The pattern was not evident for steelhead in 2003 nor for yearling Chinook salmon or steelhead in 2004–though the 2004 evaluations were compromised due to low detection numbers at Bonneville Dam associated with operation of the corner collector. Bonneville Dam and other dams now have adult detection systems designed for monitoring 134.2-kHz PIT tags. Detections of adult fish at these sites will facilitate comparison of smolt-to-adult return ratios by date or place of transport and release.

Sampling results in the lower estuary were disappointing given the few fish detected in 2004. Strong tidal and river currents challenged, but did not impede our ability to sample, and we developed routine net-handling procedures for the area. Salinity was recorded continuously and ranged from less than 1 to 9 ppt near the depth of the antenna. In situ testing of PIT-tag detection equipment indicated acceptable performance in brackish water.

Precise travel times for fish detected in the upper estuary and again in the lower estuary suggested rapid downstream movement through the estuary, with the timing of individual fish highly correlated with tidal movement times. In other words, fish first detected in the upper estuary near low tide took considerably longer to reach the lower estuary than fish first detected near high tide. Presumably, encountering one or more flood tides slowed the migration of these fish.

These few observations of individual fish movement through the estuary were consistent with the trends observed for marked groups of fish in the late 1970s and early 1980s (Dawley et al. 1986). Using beach and purse seines Dawley et al. (1986) recovered groups of branded and coded-wire tagged yearling fish released upstream from Jones Beach. In their estimates of travel time, they reported no slowing of movement during passage through the estuary and into the ocean plume relative to travel speeds to the estuary. However, the confidence bands on these estimates were wide, and much of the variation in travel time remained unexplained.

Using PIT-tag technology to study individual fish movement rates, we have confirmed that movement from the upper to the lower estuary is indeed rapid, and we believe much of the variability in estimates from the earlier study was related to tidal movement associated with arrival timing in the upper estuary for individual fish.

We were able to efficiently deploy and operate the shoreline PIT-tag detection system through the full range of ebb tide currents at Jones Beach. However, flow reversal along the shoreline precluded use of the shoreline system during flood tides. We detected no river-run PIT-tagged fish along the shoreline, and generally observed few fish on the antenna-mounted camera. While all electronics systems performed satisfactorily, releases of test fish, both tagged and untagged, indicated that subyearling Chinook salmon can hold position in the current for extended periods and perhaps escape the trawl body without passing through the antenna. Use of a larger diameter antenna should improve passage and reduce delay of fish in the net. Adaptation of a wireless video-link from the antenna to shore matching the wireless data transfer procedure would improve the system.

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APPENDIX

Appendix Table 1. Sample list of the PIT-tags taped to at vinyl tape measure at specific spacings and orientations. Tape was passed through the center of antennas and validate antenna performance in 2003 and 2004.

Position on tape measure (ft)	Orientation (°)	Distance from previous tag (ft)[a]	PIT-tag code[b]
117	0	0	3D9.1BF1011386
119	0	2	3D9.1BF100AB32
121	0	2	3D9.1BF101042C
123	45	2	3D9.1BF10091B6
125	45	2	3D9.1BF1011C76
128	0	3	3D9.1BF1008FBA
131	0	3	3D9.1BF1011AC3
134	0	3	3D9.1BF1010462
137	45	3	3D9.1BF100A707
140	45	3	3D9.1BF100BE5A
143	45	3	3D9.1BF1009593
145	0	2	3D9.1BF100A42E
147	0	2	3D9.1BF1011111
149	0	2	3D9.1BF1014524
150	0	3	3D9.1BF100971D
151	0	1	3D9.1BF10077C4
152	0	1	3D9.1BF100A8A6
155	0	3	3D9.1BF1009533
158	0	3	3D9.1BF1010A92
159	0	1	3D9.1BF10091EA
162	0	3	3D9.1BF1012045
163	0	1	3D9.1BF1009552
166	0	3	3D9.1BF10098C1
169	45	3	3D9.1BF1007D30
170	45	1	3D9.1BF100950A
172	0	2	3D9.1BF1008D28
173	0	1	3D9.1BF100A25D
175	0	2	3D9.1BF100A4E7
177	0	2	3D9.1BF100A0E8
181	0	4	3D9.1BF100A239

Appendix Table 1. Continued.

Position on tape measure (ft)	Orientation (°)	Distance from previous tag (ft)[a]	PIT-tag code[b]
183	0	2	3D9.1BF1009D7A
185	0	2	3D9.1BF10089A6
188	45	3	3D9.1BF1008A24
189	45	1	3D9.1BF100AA57
191	45	2	3D9.1BF10093E6
192	45	1	3D9.1BF100795B
194	45	2	3D9.1BF100A286
196	45	2	3D9.1BF1008738
200	45	4	3D9.1BF1007FC1
202	45	2	3D9.1BF100911E
204	45	2	3D9.1BF1007D3E
206	0	2	3D9.1BF10092EB
208	0	2	3D9.1BF100A865
210	0	2	3D9.1BF1009F26
212	0	2	3D9.1BF1008EB9
214	45	2	3D9.1BF1009B08
216	45	2	3D9.1BF101074D
218	45	2	3D9.1BF1009A75
220	45	2	3D9.1BF1009A8A
225	0	5	3D9.1BF1009EAB

a. Distance from previous tag as measured in the direction from 117 to 225 ft.
b PIT-tags were tested after each antenna evaluation with a hand held reader and replaced as needed.

Appendix Table 2. Daily total PIT-tag detections for each salmonid species at Jones Beach using a pair-trawl, 2003.

Detection date	Hours[a]	Unknown	Chinook salmon	Coho salmon	Steelhead	Sockeye salmon	Sea-run Cutthroat trout	Total
22 Apr 03	1.6		1					1
23 Apr 03	3.6		1		1			2
24 Apr 03	4.1		11		2			13
25 Apr 03	4.4	1	5		8			14
26 Apr 03	3.7		6		1			7
28 Apr 03	6.5		21		8			29
29 Apr 03	10.3	1	50		48			99
30 Apr 03	10.3	2	64		58			124
01 May 03	10.0		16		63			79
02 May 03	10.2		29		29			58
03 May 03	10.7	3	77		73		1	154
04 May 03	10.4	4	78		37			119
05 May 03	10.2	2	80		33			115
06 May 03	11.6		120		57			177
07 May 03	10.9	1	151		40			192
08 May 03	13.2	2	261		33			296
09 May 03	11.4	1	193		42			236
10 May 03	13.1		439		24			463
11 May 03	15.0		472		36		1	509
12 May 03	15.5	2	609		41		2	654
13 May 03	11.2	1	290		21			312
14 May 03	12.4	2	242	1	32			277
15 May 03	12.7	1	310	2	23			336
16 May 03	15.4	3	467	1	23			494
17 May 03	15.9	3	806		29			838
18 May 03	16.4	4	900		41			945
19 May 03	17.9	7	1,035	1	70			1,113
20 May 03	14.7	3	473	1	44			521
21 May 03	16.8	6	725	1	97			829
22 May 03	21.2	1	734	1	71			807
23 May 03	17.1	3	531		93			627
24 May 03	18.4	5	368		68		1	442
25 May 03	23.8	4	695	2	133			834
26 May 03	16.5	5	848	2	125			980
27 May 03	15.2	3	437		180			620

Appendix Table 2. Continued.

Detection date	Hours[a]	Unknown	Chinook salmon	Coho salmon	Steelhead	Sockeye salmon	Sea-run Cutthroat trout	Total
28 May 03	13.8	1	240	1	58			300
29 May 03	14.2	1	233		183	1		418
30 May 03	12.4	1	230	2	102		1	336
31 May 03	14.6	5	319	8	211	1		544
01 Jun 03	19.8	4	173	4	162	2	1	346
02 Jun 03	12.6	4	229	9	103	4	1	350
03 Jun 03	12.2	6	213	4	117	2		342
04 Jun 03	12.3	4	174	12	137	1		328
05 Jun 03	14.0	1	267	18	84	6		376
06 Jun 03	16.3	4	245	13	220	5		487
07 Jun 03	16.5	1	185	6	159	5		356
08 Jun 03	18.2	8	193	8	209	8		426
09 Jun 03	12.4	2	150	12	97	3		264
10 Jun 03	14.6	2	145	10	133	1		291
11 Jun 03	12.4	3	155	16	67	1		242
12 Jun 03	12.9		154	12	32	2		200
13 Jun 03	9.3		75	5	19			99
14 Jun 03	10.2	1	106	5	19			131
15 Jun 03	12.5	1	88	14	37			140
16 Jun 03	8.4	2	60	8	31	1		102
17 Jun 03	8.0	1	56	9	20	1		87
18 Jun 03	6.5		26	8	18			52
19 Jun 03	8.1		46	6	33			85
20 Jun 03	6.6	1	24	5	21	1		52
21 Jun 03	6.1		66	2	8			76
22 Jun 03	6.6		43	10	10			63
23 Jun 03	7.9		150	3	7	1		161
24 Jun 03	7.1		39	4	4			47
25 Jun 03	8.0		239	2	7			248
26 Jun 03	4.2		12	1	1			14
27 Jun 03	5.5		66	1	2			69
28 Jun 03	5.7		28	1	2			31
29 Jun 03	6.7	3	104		1			108
30 Jun 03	5.4	1	17		2			20
Totals	794	127	16,095	231	4,000	46	8	20,507

Appendix Table 3. Daily total PIT-tag detections for each salmonid species at Jones Beach using a pair-trawl, 2004.

Detection date	Hours[a]	Unknown	Chinook salmon	Coho salmon	Steelhead	Sockeye salmon	Sea-run Cutthroat trout	Total
14 Apr 04	2.3				6			6
16 Apr 04	3.0		1					1
20 Apr 04	4.3		3		26			29
21 Apr 04	10.0		7		1			8
22 Apr 04	7.4		14		5			19
23 Apr 04	9.4		12		11			24
24 Apr 04	14.9	1	32		14			47
25 Apr 04	5.1		2					2
26 Apr 04	9.8		24		3			27
27 Apr 04	9.0		17		10			27
28 Apr 04	11.3		275		60	1		336
29 Apr 04	12.9		185		104			289
30 Apr 04	10.5		173		90		2	265
01 May 04	14.2	14	182		27	1		224
02 May 04	13.3	3	348		20			371
03 May 04	13.2	2	278		38			318
04 May 04	9.6	2	226		39			267
05 May 04	10.1		135		28			163
06 May 04	13.0		258		24	1		283
07 May 04	13.0		231		21			252
08 May 04	16.5		498		15			513
09 May 04	8.8		210		15			225
10 May 04	11.2		291		32			323
11 May 04	13.5	1	275	1	66			343
12 May 04	13.8		392	2	56	1		451
13 May 04	14.3		454	1	48	3		506
14 May 04	16.4		407		66	2		475
15 May 04	13.4	1	289		68	1		359
16 May 04	6.9		224	1	61	1		287
17 May 04	15.6		274	2	142	1		419
18 May 04	16.0	2	380	1	157	4		544
19 May 04	14.0		220	1	73	1		295
20 May 04	13.2		417	1	160	1		579
21 May 04	16.9	1	424	1	172	1		599
22 May 04	16.5	1	427	5	140	3	1	577
23 May 04	14.2		265	1	160	2	1	429
24 May 04	14.4	1	287	4	239	4		535
25 May 04	15.3		228	3	145	2		378
26 May 04	15.0	1	212	6	139	2		360

Appendix Table 3. Continued.

Detection date	Hours[a]	Unknown	Chinook salmon	Coho salmon	Steelhead	Sockeye salmon	Sea-run Cutthroat trout	Total
27 May 04	12.8		125	17	127	1		270
28 May 04	13.2		253	9	72	7		341
29 May 04	12.7		274	10	87	6		377
30 May 04	12.7		234	6	53	1		294
31 May 04	13.0		206	8	63		1	278
01 Jun 04	15.4	1	297	12	76	4		390
02 Jun 04	13.3		212	10	40	1		263
03 Jun 04	12.9		211	13	68	1		293
04 Jun 04	15.0	2	193	5	23	1		224
05 Jun 04	13.9		165	27	46	2		240
06 Jun 04	14.4		155	47	64	3		269
07 Jun 04	14.5		135	15	49	1		200
08 Jun 04	14.9		97	18	55	3		173
09 Jun 04	13.1		91	9	19			119
10 Jun 04	13.7		77	9	38	5		129
11 Jun 04	14.0		115	15	60	1		191
12 Jun 04	14.6		67	19	60	6		152
13 Jun 04	12.5		34	1	6	1		42
14 Jun 04	7.2		38	10	1	1		50
15 Jun 04	4.9		43	5	7	1		56
16 Jun 04	12.5		110	14	24	4		152
17 Jun 04	11.9		73	15	6			94
18 Jun 04	11.3		34	5	7	2		48
19 Jun 04	12.1		53	10	17	1		81
20 Jun 04	11.7		18	4	4			26
21 Jun 04	11.8		14	9	11			34
22 Jun 04	14.4		13	1	5			19
23 Jun 04	13.3		34	1	4			39
24 Jun 04	7.0		16					16
25 Jun 04	6.8		152	3	2			157
26 Jun 04	6.8		14	4	1			19
27 Jun 04	6.6		149		4			153
28 Jun 04	6.0		10	1	1			12
29 Jun 04	6.8		38		3			41
30 Jun 04	7.1		23		1			24
03 Jul 04	4.6		70		1			71
Totals	872	33	12,420	362	3,586	85	5	16,492

Appendix Table 4. Daily total PIT-tag detections for each salmonid species at Hammond using the small pair-trawl, 2004.

Detection date	Hours[a]	Unknown	Chinook salmon	Coho salmon	Steelhead	Sockeye salmon	Sea-run Cutthroat trout	Total
05 May 04	3.1	0	0	0	0	0	0	0
07 May 04	3.9	0	0	0	0	0	0	0
10 May 04	2.8	0	1	0	0	0	0	1
12 May 04	7.3	0	0	0	1	0	0	1
14 May 04	5.1	0	0	0	0	0	0	0
15 May 04	4.3	0	1	0	0	0	0	1
17 May 04	5.3	0	0	0	10	0	0	10
18 May 04	6.0	0	2	0	6	0	0	8
19 May 04	6.1	0	0	0	6	0	0	6
20 May 04	6.6	0	3	0	13	0	1	17
21 May 04	0.3	0	0	0	0	0	0	0
23 May 04	6.2	0	3	0	8	0	0	11
24 May 04	6.1	0	1	0	15	0	0	16
25 May 04	6.1	0	1	0	5	0	0	6
26 May 04	4.5	0	1	0	10	0	0	11
27 May 04	7.5	1	0	0	10	0	0	11
28 May 04	6.5	0	0	0	22	0	0	22
29 May 04	5.9	0	1	0	1	0	0	2
01 Jun 04	4.1	0	1	0	0	0	0	1
02 Jun 04	3.3	0	1	1	0	0	0	2
03 Jun 04	5.3	0	0	0	0	0	0	0
04 Jun 04	4.9	0	0	0	0	0		0
07 Jun 04	5.2	0	0	0	1	0	0	1
09 Jun 04	5.3	0	0	0	0	0	0	0
10 Jun 04	5.0	0	0	0	0	0	0	0
Totals	126.3	1	16	1	108	0	1	127

Appendix Table 5. Daily total of impinged fish at using a PIT-tag detector trawl at Jones Beach, Columbia River kilometer 75, 2003.

Date	Chinook salmon Yearling	Chinook salmon Sub-yearling	Coho salmon	Steelhead	Sockeye salmon	Non-salmonid (quantity/ species)
22 Apr 03	0	0	0	0	0	0
23 Apr 03	0	0	0	0	0	0
24 Apr 03	0	0	0	0	0	0
25 Apr 03	0	0	0	0	0	0
26 Apr 03	0	0	0	0	0	1 flatfish
27 Apr 03	0	0	0	0	0	0
28 Apr 03	0	0	0	0	0	0
29 Apr 03	0	0	0	0	0	0
30 Apr 03	0	0	0	0	0	0
01 May 03	1	1	1	1	0	0
02 May 03	0	0	0	0	0	0
03 May 03	0	0	0	0	0	0
04 May 03	0	0	0	0	0	0
05 May 03	0	0	0	0	0	0
06 May 03	0	0	0	0	0	0
07 May 03	2	1	1	1	1	0
08 May 03	0	0	0	0	0	0
09 May 03	0	0	0	0	0	0
10 May 03	0	0	0	0	0	0
11 May 03	0	0	0	0	0	0
12 May 03	1	0	0	0	0	0
13 May 03	0	0	0	0	0	0
14 May 03	1	1	1	1	0	1 stickleback
15 May 03	1	1	1	0	0	0
16 May 03	4	2	2	1	1	0
17 May 03	0	0	0	0	0	0
18 May 03	1	0	0	0	0	0
19 May 03	1	1	1	0	0	0
20 May 03	10	6	5	4	3	0
21 May 03	1	0	0	0	0	0
22 May 03	0	0	0	0	0	0
23 May 03	2	1	1	1	1	3 shad
24 May 03	5	3	3	2	2	12 shad
25 May 03	1	1	1	1	0	5 shad
26 May 03	1	0	0	0	0	1 shad
27 May 03	3	2	2	1	1	0

Appendix Table 5. Continued.

Date	Chinook salmon Yearling	Chinook salmon Sub-yearling	Coho salmon	Steelhead	Sockeye salmon	Non-salmonid (quantity/ species)
28 May 03	4	3	2	2	1	0
29 May 03	0	0	0	0	0	0
30 May 03	0	0	0	0	0	0
31 May 03	2	1	1	1	1	0
01 Jun 03	0	0	0	0	0	0
02 Jun 03	0	0	0	0	0	0
03 Jun 03	1	0	0	0	0	0
04 Jun 03	0	0	0	0	0	0
05 Jun 03	0	0	0	0	0	0
06 Jun 03	0	0	0	0	0	0
07 Jun 03	0	0	0	0	0	0
08 Jun 03	0	0	0	0	0	0
09 Jun 03	0	0	0	0	0	0
10 Jun 03	0	0	0	0	0	0
11 Jun 03	0	0	0	0	0	0
12 Jun 03	0	0	0	0	0	0
13 Jun 03	0	0	0	0	0	0
14 Jun 03	0	0	0	0	0	0
15 Jun 03	0	0	0	0	0	0
16 Jun 03	0	0	0	0	0	0
17 Jun 03	0	0	0	0	0	0
18 Jun 03	0	0	0	0	0	0
19 Jun 03	0	0	0	0	0	0
20 Jun 03	0	0	0	0	0	0
21 Jun 03	0	0	0	0	0	0
22 Jun 03	0	0	0	0	0	0
23 Jun 03	0	0	0	0	0	0
24 Jun 03	0	0	0	0	0	0
25 Jun 03	0	0	0	0	0	0
26 Jun 03	0	0	0	0	0	0
27 Jun 03	0	0	0	0	0	0
28 Jun 03	0	0	0	0	0	0
29 Jun 03	0	0	0	0	0	0
30 Jun 03	0	0	0	0	0	0
Totals	43	27	22	17	13	23

Appendix Table 6. Daily total of impinged fish at using a PIT-tag detector trawl at Jones Beach, Columbia River kilometer 75, 2004.

	Chinook salmon					
Date	Yearling	Sub-yearling	Coho salmon	Steelhead	Sockeye salmon	Non-salmonid (quantity/ species)
15 Apr 04	0	0	0	0	0	0
16 Apr 04	0	0	0	0	0	0
17 Apr 04	0	0	0	0	0	0
18 Apr 04	0	0	0	0	0	0
19 Apr 04	0	0	0	0	0	0
20 Apr 04	0	0	0	0	0	0
21 Apr 04	0	0	0	0	0	0
22 Apr 04	0	0	0	0	0	0
23 Apr 04	0	0	0	0	0	0
24 Apr 04	0	0	0	0	0	0
25 Apr 04	0	0	0	0	0	0
26 Apr 04	0	0	0	0	0	0
27 Apr 04	0	0	0	0	0	0
28 Apr 04	0	0	0	0	0	0
29 Apr 04	0	0	0	0	0	0
30 Apr 04	1	0	0	1	0	0
01 May 04	0	0	0	0	0	0
02 May 04	11	4	4	7	1	0
03 May 04	1	0	0	1	0	0
04 May 04	5	2	2	3	1	0
05 May 04	0	0	0	0	0	0
06 May 04	21	7	7	13	3	0
07 May 04	8	3	3	5	1	0
08 May 04	0	0	0	0	0	100
09 May 04	3	1	1	2	0	0
10 May 04	0	0	0	0	0	0
11 May 04	0	0	0	0	0	100
12 May 04	0	0	0	0	0	0
13 May 04	1	0	0	1	0	0
14 May 04	1	0	0	1	0	0
15 May 04	0	0	0	0	0	50
16 May 04	0	0	0	0	0	150
17 May 04	0	0	0	0	0	0
18 May 04	0	0	0	0	0	100

Appendix Table 6. Continued.

Date	Chinook salmon Yearling	Chinook salmon Sub-yearling	Coho salmon	Steelhead	Sockeye salmon	Non-salmonid (quantity/ species)
19 May 04	0	0	0	0	0	10
20 May 04	2	1	1	1	1	200
21 May 04	0	0	0	0	0	150
22 May 04	0	0	0	0	0	0
23 May 04	0	0	0	0	0	0
24 May 04	0	0	0	0	0	60
25 May 04	0	0	0	0	0	0
26 May 04	0	0	0	0	0	150
27 May 04	0	0	0	0	0	10
28 May 04	0	0	0	0	0	10
29 May 04	0	0	0	0	0	15
30 May 04	0	0	0	0	0	0
31 May 04	0	0	0	0	0	0
01 Jun 04	0	0	0	0	0	0
02 Jun 04	0	0	0	0	0	25
03 Jun 04	0	0	0	0	0	25
04 Jun 04	0	0	0	0	0	10
05 Jun 04	0	0	0	0	0	15
06 Jun 04	0	0	0	0	0	0
07 Jun 04	1	0	0	1	0	0
08 Jun 04	0	0	0	0	0	0
09 Jun 04	0	0	0	0	0	150
10 Jun 04	3	1	1	2	0	40
11 Jun 04	0	0	0	0	0	0
12 Jun 04	0	0	0	0	0	0
13 Jun 04	0	0	0	0	0	0
14 Jun 04	0	0	0	0	0	0
15 Jun 04	0	0	0	0	0	0
16 Jun 04	0	0	0	0	0	0
17 Jun 04	0	0	0	0	0	0
18 Jun 04	0	0	0	0	0	0
19 Jun 04	0	0	0	0	0	0
20 Jun 04	0	0	0	0	0	0
21 Jun 04	0	0	0	0	0	0

Appendix Table 6. Continued.

Date	Chinook salmon		Coho salmon	Steelhead	Sockeye salmon	Non-salmonid (quantity/ species)
	Yearling	Sub-yearling				
22 Jun 04	0	0	0	0	0	0
23 Jun 04	0	0	0	0	0	0
24 Jun 04	0	0	0	0	0	0
25 Jun 04	0	0	0	0	0	0
26 Jun 04	0	0	0	0	0	0
27 Jun 04	0	0	0	0	0	0
28 Jun 04	0	0	0	0	0	0
29 Jun 04	0	0	0	0	0	0
30 Jun 04	0	0	0	0	0	0
01 Jul 04	0	0	0	0	0	0
02 Jul 04	0	0	0	0	0	0
03 Jul 04	0	0	0	0	0	0
Totals	63	22	22	40	9	1,370

Appendix Table 7. Diel sampling of yearling Chinook salmon and steelhead using a PIT-tag detector surface pair-trawl at Jones Beach, Columbia River kilometer 75, 2003.

Diel Period: 28 April-20 June									
		Yearling Chinook salmon				Steelhead			
		n		*n*/hour		*n*		*n*/hour	
Hour	Effort[a]	H	W	H	W	H	W	H	W
0	34.3	829	75	24.2	2.2	124	21	3.6	0.6
1	31.3	766	65	24.5	2.1	105	17	3.4	0.5
2	20.3	635	39	31.3	1.9	34	3	1.7	0.1
3	18.0	619	41	34.4	2.3	46	5	2.6	0.3
4	16.8	585	60	34.8	3.6	43	9	2.6	0.5
5	18.5	770	68	41.6	3.7	30	14	1.6	0.8
6	41.1	822	118	20.0	2.9	82	32	2.0	0.8
7	51.7	676	95	13.1	1.8	143	42	2.8	0.8
8	51.8	518	79	10.0	1.5	170	51	3.3	1.0
9	52.4	459	74	8.8	1.4	204	47	3.9	0.9
10	51.4	437	77	8.5	1.5	261	90	5.1	1.8
11	44.8	454	67	10.1	1.5	210	78	4.7	1.7
12	26.5	405	38	15.3	1.4	237	74	9.0	2.8
13	15.6	220	19	14.1	1.2	114	26	7.3	1.7
14	5.3	72	11	13.6	2.1	33	14	6.2	2.6
15	2.3	9	0	3.9	0.0	4	0	1.7	0.0
16	2.0	0	0	0.0	0.0	0	0	0.0	0.0
17	5.0	7	9	1.4	1.8	3	0	0.6	0.0
18	14.0	67	36	4.8	2.6	51	23	3.7	1.6
19	27.2	225	74	8.3	2.7	142	54	5.2	2.0
20	46.8	858	166	18.3	3.5	272	82	5.8	1.8
21	48.5	1,649	236	34.0	4.9	315	71	6.5	1.5
22	47.9	1,706	161	35.6	3.4	321	56	6.7	1.2
23	41.4	814	91	19.7	2.2	162	29	3.9	0.7
Totals	714.7	13,602	1,699	19.0	2.4	3,106	838	4.3	1.2

Appendix Table 7. Continued.

Season Total: 20 April-30 June									
		Yearling Chinook salmon				Steelhead			
		n		*n*/hour		*n*		*n*/hour	
Hour	Effort[a]	H	W	H	W	H	W	H	W
0	34.3	829	75	24.2	2.2	124	21	3.6	0.6
1	31.3	766	65	24.5	2.1	105	17	3.4	0.5
2	20.3	635	39	31.3	1.9	34	3	1.7	0.1
3	18.0	619	41	34.4	2.3	46	5	2.6	0.3
4	16.8	585	60	34.8	3.6	43	9	2.6	0.5
5	21.2	803	72	37.9	3.4	30	14	1.4	0.7
6	49.1	966	126	19.7	2.6	88	33	1.8	0.7
7	61.7	818	103	13.3	1.7	149	43	2.4	0.7
8	62.0	629	84	10.1	1.4	179	51	2.9	0.8
9	65.1	558	79	8.6	1.2	212	48	3.3	0.7
10	64.1	517	85	8.1	1.3	267	90	4.2	1.4
11	55.8	523	74	9.4	1.3	215	79	3.9	1.4
12	32.9	449	42	13.7	1.3	241	74	7.3	2.3
13	17.0	227	19	13.4	1.1	114	26	6.7	1.5
14	7.3	72	11	9.9	1.5	34	15	4.7	2.1
15	3.7	9	1	2.4	0.3	4	0	1.1	--
16	3.0	2	0	0.7	--	1	0	0.3	--
17	6.0	7	10	1.2	1.7	5	1	0.8	0.2
18	14.3	69	36	4.8	2.5	53	23	3.7	1.6
19	27.2	225	74	8.3	2.7	142	54	5.2	2.0
20	46.8	858	166	18.3	3.5	272	82	5.8	1.8
21	48.5	1,649	236	34.0	4.9	315	71	6.5	1.5
22	47.9	1,706	161	35.6	3.4	321	56	6.7	1.2
23	41.4	814	91	19.7	2.2	162	29	3.9	0.7
Totals	795.4	14,335	1,750	18.0	2.2	3,156	844	4.0	1.1

a Effort, rounded to the nearest tenth, is presented as a decimal hour.

Appendix Table 8. Diel sampling of yearling Chinook salmon and steelhead using a PIT-tag detector surface pair-trawl at Jones Beach, Columbia River kilometer 75, 2004.

		Diel Period: 21 April-23 June							
		Yearling Chinook salmon				Steelhead			
		n		*n*/hour		*n*		*n*/hour	
Hour	Effort[a]	H	W	H	W	H	W	H	W
0	55.0	857	78	15.6	1.4	134	49	3.3	2.4
1	46.4	778	82	16.7	1.8	124	41	3.6	2.7
2	26.4	623	42	23.6	1.6	67	17	3.2	2.5
3	9.9	240	25	24.2	2.5	30	11	4.1	3.0
4	6.9	121	9	17.5	1.3	16	4	2.9	2.3
5	9.9	130	21	13.1	2.1	11	5	1.6	1.1
6	41.5	507	102	12.2	2.5	60	25	2.0	1.4
7	58.4	703	119	12.0	2.0	141	47	3.2	2.4
8	60.9	686	110	11.3	1.8	227	39	4.4	3.7
9	60.9	520	72	8.5	1.2	193	39	3.8	3.2
10	61.6	497	88	8.1	1.4	227	27	4.1	3.7
11	60.3	501	71	8.3	1.2	220	28	4.1	3.6
12	34.5	446	59	12.9	1.7	256	32	8.4	7.4
13	14.0	207	29	14.8	2.1	71	20	6.5	5.1
14	4.2	74	6	17.5	1.4	53	8	14.4	12.5
15	1.0	19	4	19.0	4.0	46	2	48.0	46.0
16	0.0	4	1	240.0	60.0	0	0	0.0	0.0
17	0.2	0	0	0.0	0.0	1	0	4.6	4.6
18	2.3	22	1	9.6	0.4	8	2	4.3	3.5
19	23.1	94	20	4.1	0.9	68	13	3.5	2.9
20	54.4	434	69	8.0	1.3	165	66	4.3	3.0
21	59.5	1,047	143	17.6	2.4	222	95	5.3	3.7
22	60.0	1,122	102	18.7	1.7	320	76	6.6	5.3
23	59.4	834	63	14.0	1.1	190	42	3.9	3.2
Total	810.9	10,466	1,316	12.9	1.6	2,850	688	3.5	.8

Appendix Table 8. Continued.

		Season Total: 14 April-3 July							
		Yearling Chinook salmon				Steelhead			
		n		*n*/hour		*n*		*n*/hour	
Hour	Effort[a]	H	W	H	W	H	W	H	W
0	55.0	857	78	15.6	1.4	134	49	2.4	0.9
1	46.7	778	82	16.6	1.8	124	41	2.7	0.9
2	26.4	623	42	23.6	1.6	67	17	2.5	0.6
3	9.9	240	25	24.2	2.5	30	11	3.0	1.1
4	6.9	121	9	17.5	1.3	16	4	2.3	0.6
5	12.4	137	22	11.1	1.8	11	5	0.9	0.4
6	48.7	523	108	10.7	2.2	60	27	1.2	0.6
7	66.6	717	122	10.8	1.8	142	47	2.1	0.7
8	69.9	700	115	10.0	1.6	228	44	3.3	0.6
9	70.2	531	78	7.6	1.1	198	48	2.8	0.7
10	72.4	502	90	6.9	1.2	229	34	3.2	0.5
11	70.2	512	73	7.3	1.0	222	37	3.2	0.5
12	38.1	452	59	11.9	1.5	257	33	6.7	0.9
13	14.2	207	29	14.6	2.0	71	20	5.0	1.4
14	4.2	74	6	17.5	1.4	53	8	12.5	1.9
15	1.0	19	4	19.0	4.0	46	2	46.0	2.0
16	0.0	4	1	240.0	60.0	0	0	0.0	0.0
17	0.2	0	0	0.0	0.0	1	0	4.6	0.0
18	2.3	22	1	9.6	0.4	8	2	3.5	0.9
19	23.1	94	20	4.1	0.9	68	13	2.9	0.6
20	54.4	434	69	8.0	1.3	165	66	3.0	1.2
21	59.5	1,047	143	17.6	2.4	222	95	3.7	1.6
22	60.0	1,122	102	18.7	1.7	320	76	5.3	1.3
23	59.4	834	63	14.0	1.1	190	42	3.2	0.7
Total	871.8	10,550	1,341	12.1	1.5	2,862	721	3.3	.8

a Effort, rounded to the nearest tenth, is presented as a decimal hour.

Appendix Table 9. Number of PIT-tagged yearling Chinook loaded at each of four dams and number and rate of fish detected in the estuary at Jones Beach, 2003. Dams: LGR, Lower Granite; LGO, Little Goose; LMN, Lower Monumental; MCN, McNary. Transport dates 9 April-18 Aug; trawl sampling 22 Apr-30 Jun; Two-crew sampling 28 Apr-15 Jun. Totals for the entire season are shown.

2003 release	Yearling Chinook loaded*				Totals	Jones Beach detection (%)				Totals	
date and time	LGR	LGO	LMN	MCN	(n)	LGR	LGO	LMN	MCN	(n)	(%)
9 Apr 18:35	52	11	3	0	66	0.0	0.0	0.0	--	0	0.0
11 Apr 16:00	7	2	0	0	9	0.0	0.0	--	--	0	0.0
13 Apr 16:10	204	3	2	0	209	0.0	0.0	0.0	--	0	0.0
15 Apr 19:35	83	52	3	0	138	0.0	0.0	0.0	--	0	0.0
17 Apr 17:15	65	198	29	0	292	0.0	0.0	0.0	--	0	0.0
22 Apr 2:10	361	288	49	0	698	0.0	0.0	0.0	--	0	0.0
24 Apr 1:00	226	298	30	821	1,375	0.0	0.0	0.0	0.7	6	0.4
25 Apr 1:10	156	299	36	0	491	0.0	0.0	0.0	--	0	0.0
25 Apr 23:45	131	116	34	567	848	0.0	0.0	0.0	0.2	1	0.1
26 Apr 1:50	107	178	35	46	366	2.8	3.9	5.7	2.2	13	3.6
28 Apr 0:40	124	189	18	248	579	2.4	5.3	5.6	0.4	15	2.6
28 Apr 20:10	109	103	22	0	234	0.9	1.9	0.0	--	3	1.3
30 Apr 0:50	109	60	33	153	355	5.5	5.0	0.0	1.3	11	3.1
30 Apr 23:50	93	87	29	0	209	1.1	1.1	3.4	--	3	1.4
2 May 3:10	143	26	29	165	363	2.1	3.8	0.0	1.8	7	1.9
2 May 23:30	72	65	31	0	168	1.4	9.2	3.2	--	8	4.8
4 May 0:15	67	50	12	102	231	1.5	8.0	0.0	0.0	5	2.2
4 May 21:45	62	84	8	0	154	9.7	2.4	0.0	--	8	5.2
6 May 0:45	56	70	15	109	250	7.1	7.1	13.3	1.8	13	5.2
6 May 22:45	47	51	21	0	119	2.1	7.8	0.0	--	5	4.2
8 May 1:00	66	93	8	256	423	3.0	7.5	0.0	3.1	17	4.0
8 May 20:25	70	80	33	0	183	1.4	5.0	6.1	--	7	3.8
10 May 1:30	89	45	17	0	151	2.2	2.2	0.0	--	3	2.0
10 May 22:30	152	46	37	0	235	3.3	13.0	0.0	--	11	4.7
12 May 1:15	61	40	41	811	953	3.3	7.5	4.9	1.4	18	1.9
12 May 21:00	181	67	13	0	261	2.8	4.5	0.0	--	8	3.1
14 May 0:55	36	46	10	217	309	0.0	0.0	0.0	0.9	2	0.6
14 May 20:30	46	198	15	0	259	0.0	1.5	0.0	--	3	1.2
16 May 0:45	138	137	31	304	610	1.4	0.7	0.0	0.7	5	0.8
17 May 0:30	95	46	34	0	175	0.0	2.2	2.9	--	2	1.1

Appendix Table 9. Continued.

2003 release date and time	Yearling Chinook loaded*				Totals	Jones Beach detection (%)				Totals	
	LGR	LGO	LMN	MCN	(n)	LGR	LGO	LMN	MCN	(n)	(%)
18 May 1:00	218	264	56	798	1,336	2.3	1.1	0.0	0.5	12	0.9
18 May 21:20	227	239	48	0	514	0.4	2.9	2.1	--	9	1.8
20 May 4:30	274	311	99	1,009	1,693	0.7	4.8	5.1	2.1	43	2.5
20 May 21:30	123	328	36	0	487	2.4	0.9	0.0	--	6	1.2
22 May 2:10	88	311	26	1,114	1,539	2.3	3.5	0.0	0.4	17	1.1
22 May 19:30	450	95	55	0	600	4.2	5.3	1.8	--	25	4.2
24 May 1:00	75	47	89	789	1,000	2.7	2.1	1.1	0.4	7	0.7
24 May 20:35	292	117	21	0	430	2.7	0.9	0.0	--	9	2.1
26 May 0:40	310	660	61	1,092	2,123	1.3	0.9	1.6	0.4	15	0.7
26 May 23:55	218	1,804	339	0	2,361	0.5	0.3	0.9	--	9	0.4
27 May 23:40	234	1,998	574	1,226	4,032	2.1	3.3	3.1	0.8	99	2.5
28 May 23:55	349	1,045	678	0	2,072	0.3	0.8	1.0	--	16	0.8
30 May 1:25	239	386	241	845	1,711	0.4	1.3	2.5	0.7	18	1.1
30 May 21:30	41	1,072	238	0	1,351	0.0	2.8	3.4	--	38	2.8
31 May 23:40	146	484	151	326	1,107	2.1	2.3	4.0	1.8	26	2.3
1 Jun 20:30	103	459	177	0	739	1.0	2.4	1.7	--	15	2.0
3 Jun 0:25	102	407	112	1,766	2,387	3.9	1.7	3.6	1.8	47	2.0
3 Jun 20:30	83	367	120	0	570	0.0	0.5	0.0	--	2	0.4
5 Jun 0:10	18	128	68	1,428	1,642	0.0	0.8	1.5	0.6	11	0.7
6 Jun 22:40	180	277	55	425	937	0.6	0.7	1.8	1.4	10	1.1
8 Jun 22:45	26	464	72	95	657	3.8	1.7	0.0	3.2	12	1.8
11 Jun 0:01	117	362	140	174	793	0.9	1.9	1.4	0.6	11	1.4
12 Jun 22:15	20	103	116	127	366	0.0	1.0	0.9	0.8	3	0.8
14 Jun 23:25	20	15	17	156	208	0.0	0.0	5.9	3.8	7	3.4
16 Jun 22:08	15	6	5	105	131	6.7	16.7	0.0	1.9	4	3.1
19 Jun 0:30	6	3	1	81	91	0.0	0.0	0.0	0.0	0	0.0
21 Jun 0:40	10	0	0	11	21	0.0	--	--	0.0	0	0.0
23 Jun 0:20	1	2	2	40	45	0.0	0.0	0.0	0.0	0	0.0
25 Jun 3:20	5	4	0	43	52	0.0	0.0	--	2.3	1	1.9
27 Jun 3:45	2	4	1	56	63	0.0	0.0	0.0	0.0	0	0.0
29 Jun-18 Aug	2,824	2,897	1,674	2,184	9,579	0.0	0.0	0.0	0.0	0	0.0
Totals/means	91,275	57,030	12,841	38,186	199,332	1.9	2.1	1.4	2.3	3,952	2.0

* Beginning in mid-June most PIT-tagged Chinook salmon detected in the estuary were subyearling migrants tagged in the Upper Columbia River or the Snake River.

Appendix Table 10. Number of PIT-tagged steelhead loaded at each of four dams and number and rate of fish detected in the estuary at Jones Beach, 2003. LGR, Lower Granite; LGO, Little Goose; LMN, Lower Monumental; MCN, McNary. *Fish transportation occurred between 9 April and 18 August, trawl sampling in the estuary occurred between 15 April and 30 July, with two-crew daily sampling between 30 April and 9 June. Season totals are shown.

2003 release	Yearling Chinook loaded (n)				Totals	Jones Beach detection (%)				Totals	
date and time	LGR	LGO	LMN	MCN	(n)	LGR	LGO	LMN	MCN	(n)	(%)
9 Apr 18:35	52	11	3	0	66	0.0	0.0	0.0	--	0	0.0
11 Apr 16:00	7	2	0	0	9	0.0	0.0	--	--	0	0.0
13 Apr 16:10	204	3	2	0	209	0.0	0.0	0.0	--	0	0.0
15 Apr 19:35	83	52	3	0	138	0.0	0.0	0.0	--	0	0.0
17 Apr 17:15	65	198	29	0	292	0.0	0.0	0.0	--	0	0.0
22 Apr 2:10	361	288	49	0	698	0.0	0.0	0.0	--	0	0.0
24 Apr 1:00	226	298	30	821	1,375	0.0	0.0	0.0	0.7	6	0.4
25 Apr 1:10	156	299	36	0	491	0.0	0.0	0.0	--	0	0.0
25 Apr 23:45	131	116	34	567	848	0.0	0.0	0.0	0.2	1	0.1
26 Apr 1:50	107	178	35	46	366	2.8	3.9	5.7	2.2	13	3.6
28 Apr 0:40	124	189	18	248	579	2.4	5.3	5.6	0.4	15	2.6
28 Apr 20:10	109	103	22	0	234	0.9	1.9	0.0	--	3	1.3
30 Apr 0:50	109	60	33	153	355	5.5	5.0	0.0	1.3	11	3.1
30 Apr 23:50	93	87	29	0	209	1.1	1.1	3.4	--	3	1.4
2 May 3:10	143	26	29	165	363	2.1	3.8	0.0	1.8	7	1.9
2 May 23:30	72	65	31	0	168	1.4	9.2	3.2	--	8	4.8
4 May 0:15	67	50	12	102	231	1.5	8.0	0.0	0.0	5	2.2
4 May 21:45	62	84	8	0	154	9.7	2.4	0.0	--	8	5.2
6 May 0:45	56	70	15	109	250	7.1	7.1	13.3	1.8	13	5.2
6 May 22:45	47	51	21	0	119	2.1	7.8	0.0	--	5	4.2
8 May 1:00	66	93	8	256	423	3.0	7.5	0.0	3.1	17	4.0
8 May 20:25	70	80	33	0	183	1.4	5.0	6.1	--	7	3.8
10 May 1:30	89	45	17	0	151	2.2	2.2	0.0	--	3	2.0
10 May 22:30	152	46	37	0	235	3.3	13.0	0.0	--	11	4.7
12 May 1:15	61	40	41	811	953	3.3	7.5	4.9	1.4	18	1.9
12 May 21:00	181	67	13	0	261	2.8	4.5	0.0	--	8	3.1
14 May 0:55	36	46	10	217	309	0.0	0.0	0.0	0.9	2	0.6
14 May 20:30	46	198	15	0	259	0.0	1.5	0.0	--	3	1.2
16 May 0:45	138	137	31	304	610	1.4	0.7	0.0	0.7	5	0.8

Appendix Table 10. Continued.

2003 release date and time	Number of PIT-tagged yearling Chinook loaded				Totals	Jones Beach detection rate (%)				Totals	
	LGR	LGO	LMN	MCN	(n)	LGR	LGO	LMN	MCN	(n)	(%)
17 May 0:30	95	46	34	0	175	0.0	2.2	2.9	--	2	1.1
18 May 1:00	218	264	56	798	1,336	2.3	1.1	0.0	0.5	12	0.9
18 May 21:20	227	239	48	0	514	0.4	2.9	2.1	--	9	1.8
20 May 4:30	274	311	99	1,009	1,693	0.7	4.8	5.1	2.1	43	2.5
20 May 21:30	123	328	36	0	487	2.4	0.9	0.0	--	6	1.2
22 May 2:10	88	311	26	1,114	1,539	2.3	3.5	0.0	0.4	17	1.1
22 May 19:30	450	95	55	0	600	4.2	5.3	1.8	--	25	4.2
24 May 1:00	75	47	89	789	1,000	2.7	2.1	1.1	0.4	7	0.7
24 May 20:35	292	117	21	0	430	2.7	0.9	0.0	--	9	2.1
26 May 0:40	310	660	61	1,092	2,123	1.3	0.9	1.6	0.4	15	0.7
26 May 23:55	218	1,804	339	0	2,361	0.5	0.3	0.9	--	9	0.4
27 May 23:40	234	1,998	574	1,226	4,032	2.1	3.3	3.1	0.8	99	2.5
28 May 23:55	349	1,045	678	0	2,072	0.3	0.8	1.0	--	16	0.8
30 May 1:25	239	386	241	845	1,711	0.4	1.3	2.5	0.7	18	1.1
30 May 21:30	41	1,072	238	0	1,351	0.0	2.8	3.4	--	38	2.8
31 May 23:40	146	484	151	326	1,107	2.1	2.3	4.0	1.8	26	2.3
1 Jun 20:30	103	459	177	0	739	1.0	2.4	1.7	--	15	2.0
3 Jun 0:25	102	407	112	1,766	2,387	3.9	1.7	3.6	1.8	47	2.0
3 Jun 20:30	83	367	120	0	570	0.0	0.5	0.0	--	2	0.4
5 Jun 0:10	18	128	68	1,428	1,642	0.0	0.8	1.5	0.6	11	0.7
6 Jun 22:40	180	277	55	425	937	0.6	0.7	1.8	1.4	10	1.1
8 Jun 22:45	26	464	72	95	657	3.8	1.7	0.0	3.2	12	1.8
11 Jun 0:01	117	362	140	174	793	0.9	1.9	1.4	0.6	11	1.4
12 Jun 22:15	20	103	116	127	366	0.0	1.0	0.9	0.8	3	0.8
14 Jun 23:25	20	15	17	156	208	0.0	0.0	5.9	3.8	7	3.4
16 Jun 22:08	15	6	5	105	131	6.7	16.7	0.0	1.9	4	3.1
19 Jun 0:30	6	3	1	81	91	0.0	0.0	0.0	0.0	0	0.0
21 Jun 0:40	10	0	0	11	21	0.0	--	--	0.0	0	0.0
23 Jun 0:20	1	2	2	40	45	0.0	0.0	0.0	0.0	0	0.0
25 Jun 3:20	5	4	0	43	52	0.0	0.0	--	2.3	1	1.9
27 Jun 3:45	2	4	1	56	63	0.0	0.0	0.0	0.0	0	0.0
29 Jun-18 Aug	27	9	2	165	203	0.0	0.0	0.0	0.0	0	0.0
Totals/ means	7,227	14,799	4,728	15,670	41,974	1.6	2.0	1.9	1.0	646	1.5

Appendix Table 11. Number of PIT-tagged yearling Chinook loaded at each of four dams and number and rate of fish detected in the estuary at Jones Beach, 2004. Dams: LGR, Lower Granite; LGO, Little Goose; LMN, Lower Monumental; MCN, McNary. Transport 9 April-18 Aug; Trawl sampling 14 April-3 July; Intensive two-crew sampling 21 April-23 June. Totals for the entire season are shown.

2004 load,	Yearling Chinook loaded* (n)				Totals	Jones Beach detection (%)				Totals	
release?	LGR	LGO	LMN	MCN	(n)	LGR	LGO	LMN	MCN	(n)	(%)
11-Apr	852	11	1	0	864	0.0	0.0	0.0	--	0	0.0
13-Apr	1,260	34	4	0	1,298	0.3	0.0	0.0	--	4	0.3
16-Apr	602	74	18	0	694	0.2	0.0	0.0	--	1	0.1
18-Apr	1,736	100	119	5	1,960	0.3	1.0	1.7	0.0	8	0.4
20-Apr	1,724	199	180	16	2,119	0.9	2.5	0.6	0.0	22	1.0
22-Apr	1,343	431	179	61	2,014	1.3	1.6	2.8	1.6	30	1.5
24-Apr	1,113	430	346	195	2,084	1.9	0.7	1.4	1.0	31	1.5
25-Apr	830	355	381	0	1,566	1.3	1.7	0.5	--	19	1.2
26-Apr	3,576	3,234	547	698	8,055	4.1	5.4	7.1	2.9	380	4.7
28-Apr	1,557	747	132	826	3,262	4.4	5.0	5.3	4.2	148	4.5
29-Apr	2,786	1,241	147	0	4,174	3.7	3.9	4.8	--	159	3.8
30-Apr	1,834	2,008	94	1,489	5,425	3.9	4.9	5.3	3.9	234	4.3
01-May	4,458	999	39	0	5,496	3.3	3.9	2.6	--	187	3.4
02-May	2,918	716	44	1,300	4,978	2.7	4.2	6.8	3.4	155	3.1
03-May	2,742	647	6	0	3,395	1.9	3.6	0.0	--	74	2.2
04-May	1,883	1,554	5	1,778	5,220	2.5	3.2	0.0	2.1	134	2.6
05-May	3,329	740	2	0	4,071	5.4	4.2	0.0	--	211	5.2
06-May	5,208	788	3	1,241	7,240	5.4	5.3	0.0	0.9	335	4.6
07-May-04	9,154	964	13	254	10,385	1.4	1.5	0.0	0.8	145	1.4
08-May-04	4,905	830	16	1,082	6,833	1.2	1.1	0.0	0.6	74	1.1
09-May-04	2,912	1,959	14	0	4,885	3.3	3.9	7.1	--	174	3.6
10-May-04	2,252	1,268	42	0	3,562	4.3	4.8	0.0	--	157	4.4
11-May-04	1,138	658	58	1,333	3,187	4.7	4.6	5.2	4.4	145	4.5
12-May-04	817	399	13	1,053	2,282	3.3	2.8	0.0	4.7	87	3.8
13-May-04	1,610	569	10	0	2,189	2.7	4.9	0.0	--	71	3.2
14-May	1,135	559	13	2,106	3,813	0.5	2.5	0.0	3.7	97	2.5
15-May	358	393	2	0	753	2.0	2.5	0.0	--	17	2.3
16-May	1,056	622	28	3,159	4,865	2.7	3.1	7.1	2.8	137	2.8
18-May	921	187	35	2,369	3,512	2.7	4.3	5.7	2.0	83	2.4
19-May	408	352	25	0	785	3.4	5.4	8.0	--	35	4.5

Appendix Table 11. Continued.

2004 load,	Yearling Chinook loaded* (n)				Totals	Jones Beach detection (%)				Totals	
release?	LGR	LGO	LMN	MCN	(n)	LGR	LGO	LMN	MCN	(n)	(%)
20-May	237	206	32	1,916	2,391	2.5	3.9	9.4	4.4	102	4.3
21-May	611	264	29	0	904	2.8	2.3	0.0	--	23	2.5
22-May	652	165	42	1,226	2,085	2.6	2.4	11.9	1.8	48	2.3
23-May	840	203	70	0	1,113	2.3	1.5	4.3	--	25	2.2
24-May	905	102	38	819	1,864	2.4	3.9	2.6	2.4	47	2.5
25-May	203	60	51	0	314	3.0	5.0	3.9	--	11	3.5
26-May	278	69	38	756	1,141	2.5	2.9	5.3	3.3	36	3.2
27-May	174	83	20	0	277	1.1	3.6	10.0	--	7	2.5
28-May	508	141	16	453	1,118	2.4	4.3	6.2	6.0	46	4.1
29-May	114	64	17	0	195	5.3	6.2	0.0	--	10	5.1
30-May	604	89	239	582	1,514	2.3	2.2	6.3	3.1	49	3.2
01-Jun	277	71	22	471	841	1.1	5.6	4.5	2.8	21	2.5
03-Jun	108	99	20	244	471	1.9	5.1	10.0	2.9	16	3.4
05-Jun	52	41	21	189	303	1.9	0.0	4.8	0.0	2	0.7
06-Jun	266	56	10	117	449	1.9	0.0	0.0	0.9	6	1.3
09-Jun	237	122	23	82	464	1.3	3.3	0.0	6.1	12	2.6
11-Jun	123	95	64	41	323	5.7	3.2	4.7	4.9	15	4.6
13-Jun	485	81	40	19	625	0.8	0.0	0.0	0.0	4	0.6
15-Jun	269	87	72	10	438	1.5	1.1	5.6	0.0	9	2.1
17-Jun	256	610	598	5	1,469	1.6	2.5	1.5	0.0	28	1.9
19-Jun	714	450	518	2	1,684	1.3	0.4	1.2	0.0	17	1.0
20-Jun	317	468	257	3	1,045	0.9	2.8	0.8	0.0	18	1.7
23-Jun	421	2,611	165	0	3,197	1.7	4.6	4.8	--	134	4.2
25-Jun	44	1,547	254	104	1,949	6.8	4.5	3.5	1.0	83	4.3
27-Jun	545	966	254	178	1,943	7.0	1.2	2.0	1.1	57	2.9
29-Jun	555	3,776	312	251	4,894	0.9	0.0	0.0	0.4	7	0.1
01-Jul	55	2,060	265	237	2,617	1.8	1.9	1.5	3.0	52	2.0
03-Jul	495	1,233	673	161	2,562	1.6	0.0	0.0	0.0	8	0.3
5 Jul-18 Aug	627	3,587	1,438	1,299	6,951	0.0	0.0	0.0	0.0	0	0.0
Totals	77,389	42,474	8,114	28,130	156,107	2.7	2.9	2.2	2.7	4,247	2.7

* Beginning in mid-June most PIT-tagged Chinook salmon detected in the estuary were subyearling migrants tagged in the Upper Columbia River or Snake River.

Appendix Table 12. Number of PIT-tagged steelhead loaded at each of four dams and number and rate of fish detected in the estuary at Jones Beach, 2004. Dams: LGR, Lower Granite; LGO, Little Goose; LMN, Lower Monumental; MCN, McNary. Transport 9 Apr-18 Aug; Trawl sampling 14 Apr-3 Jul; Two-crew sampling 21 Apr-23 Jun. Totals for the entire season are shown.

	Steelhead loaded				Totals	Jones Beach detection (%)				Totals	
	LGR	LGO	LMN	MCN	(n)	LGR	LGO	LMN	MCN	(n)	(%)
11-Apr	69	2	5	0	76	0.0	0.0	0.0	--	0	0.0
13-Apr	336	1	5	0	342	1.5	0.0	0.0	--	5	1.5
16-Apr	66	11	4	0	81	0.0	0.0	0.0	--	0	0.0
18-Apr	272	51	6	24	353	0.7	7.8	16.7	0.0	7	2.0
20-Apr	623	43	26	318	1,010	2.9	2.3	0.0	0.0	19	1.9
22-Apr	188	27	48	1,678	1,941	2.7	3.7	0.0	1.1	24	1.2
24-Apr	91	9	31	540	671	1.1	0.0	0.0	0.0	1	0.1
25-Apr	186	8	14	0	208	1.6	0.0	0.0	--	3	1.4
26-Apr	270	109	16	491	886	2.6	4.6	12.5	0.8	18	2.0
28-Apr	63	67	10	210	350	3.2	0.0	0.0	0.0	18	5.1
29-Apr	68	43	7	0	118	4.4	11.6	0.0	--	4	3.4
30-Apr	38	24	6	233	301	0.0	0.0	16.7	0.0	5	1.7
01-May	143	28	7	0	178	4.2	0.0	28.6	--	8	4.5
02-May	165	33	7	157	362	6.1	6.1	0.0	0.0	19	5.2
03-May	172	15	8	0	195	3.5	13.3	0.0	--	6	3.1
04-May	140	15	4	135	294	3.6	0.0	0.0	0.0	9	3.1
05-May	177	8	5	0	190	5.1	0.0	0.0	--	9	4.7
06-May	409	31	2	103	545	5.4	0.0	0.0	0.0	24	4.4
07-May	514	14	3	35	566	1.0	14.3	0.0	0.0	5	0.9
08-May	417	27	14	156	614	0.7	0.0	0.0	0.0	3	0.5
09-May	638	113	38	0	789	3.8	0.0	0.0	--	29	3.7
10-May	780	107	19	0	906	3.5	3.7	5.3	--	34	3.8
11-May	168	53	14	643	878	6.0	13.2	0.0	0.0	17	1.9
12-May	130	47	9	336	522	5.4	2.1	0.0	1.8	16	3.1
13-May	659	50	11	0	720	3.0	2.0	0.0	--	23	3.2
14-May	369	59	24	1,192	1,644	3.5	3.4	4.2	0.0	32	1.9
15-May	203	43	19	0	265	3.9	2.3	0.0	--	10	3.8
16-May	405	87	28	1,466	1,986	1.7	2.3	0.0	0.0	49	2.5

Appendix Table 12. Continued.

	Steelhead loaded				Totals	Jones Beach detection (%)				Totals	
	LGR	LGO	LMN	MCN	(n)	LGR	LGO	LMN	MCN	(n)	(%)
18-May	473	10	29	1,192	1,704	3.4	40.0	3.4	3.1	38	2.2
19-May	121	13	11	0	145	2.5	0.0	0.0	--	5	3.4
20-May	86	25	21	1,650	1,782	2.3	0.0	4.8	1.3	15	0.8
21-May	238	34	12	0	284	4.2	0.0	16.7	--	11	3.9
22-May	373	13	48	490	924	1.1	7.7	0.0	2.4	23	2.5
23-May	312	34	39	0	385	3.2	2.9	0.0	--	11	2.9
24-May	659	13	18	224	914	2.9	7.7	5.6	7.6	22	2.4
25-May	88	25	58	0	171	4.5	0.0	1.7	--	4	2.3
26-May	108	59	52	216	435	0.9	0.0	0.0	1.4	6	1.4
27-May	56	60	100	0	216	1.8	0.0	0.0	--	9	4.2
28-May	372	34	29	102	537	3.5	2.9	10.3	1.0	15	2.8
29-May	53	10	20	0	83	0.0	30.0	25.0	--	0	0.0
30-May	816	72	219	167	1,274	1.0	1.4	0.0	0.6	21	1.6
01-Jun	169	28	49	161	407	5.3	0.0	0.0	0.0	12	2.9
03-Jun	55	51	76	149	331	0.0	2.0	10.5	2.7	2	0.6
05-Jun	21	31	60	164	276	4.8	0.0	0.0	0.0	3	1.1
06-Jun	675	25	37	124	861	2.7	0.0	0.0	2.4	23	2.7
09-Jun	368	21	39	120	548	1.1	0.0	2.6	0.8	9	1.6
11-Jun	27	26	60	28	141	0.0	0.0	1.7	3.6	3	2.1
13-Jun	124	12	18	92	246	0.8	8.3	11.1	2.2	1	0.4
15-Jun	139	4	13	32	188	0.0	0.0	7.7	12.5	1	0.5
17-Jun	25	4	9	41	79	4.0	50.0	11.1	0.0	1	1.3
19-Jun	2	4	6	14	26	0.0	0.0	0.0	0.0	0	0.0
20-Jun	7	3	28	7	45	0.0	0.0	0.0	14.3	1	2.2
23-Jun	9	6	1	0	16	0.0	0.0	0.0	--	0	0.0
25-Jun	5	9	4	23	41	20.0	0.0	0.0	0.0	3	7.3
27-Jun	3	9	8	29	49	33.3	0.0	0.0	3.4	3	6.1
29-Jun	6	5	2	42	55	0.0	0.0	0.0	0.0	0	0.0
01-Jul	1	1		34	36	0.0	0.0	--	0.0	1	2.8
03-Jul	4	3	2	10	19	0.0	33.3	0.0	10.0	0	0.0
05-31 Jul	14	11	5	6	36	0.0	0.0	0.0	0.0	0	0.0
Totals/means	13,168	1,780	1,463	12,834	29,245	2.7	3.2	2.6	1.5	640	2.2

Appendix Table 13. Detection rates of PIT-tagged juvenile Chinook salmon and steelhead previously detected at Bonneville Dam using a pair trawl in the Columbia River estuary at Jones Beach (rkm 75), 2003.

	Bonneville Dam detections		Jones Beach detections			
Detection at Bonneville Dam	Chinook salmon (*n*)	Steelhead (*n*)	Chinook salmon (*n*)	Steelhead (*n*)	Chinook salmon (%)	Steelhead (%)
12 Mar-19 Apr	410	48	0	0	0.0	0.0
20 Apr 03	185	18	2	0	1.1	0.0
21 Apr 03	118	27	0	0	0.0	0.0
22 Apr 03	130	44	4	0	3.1	0.0
23 Apr 03	139	15	0	1	0.0	6.7
24 Apr 03	133	43	1	0	0.8	0.0
25 Apr 03	121	35	0	0	0.0	0.0
26 Apr 03	139	137	1	0	0.7	0.0
27 Apr 03	135	368	2	6	1.5	1.6
28 Apr 03	142	675	1	4	0.7	0.6
29 Apr 03	214	947	4	8	1.9	0.8
30 Apr 03	206	1,186	4	7	1.9	0.6
01 May 03	275	936	6	14	2.2	1.5
02 May 03	414	571	6	8	1.4	1.4
03 May 03	497	706	10	6	2.0	0.8
04 May 03	506	545	16	13	3.2	2.4
05 May 03	798	409	20	6	2.5	1.5
06 May 03	1,365	420	20	7	1.5	1.7
07 May 03	1,213	301	28	7	2.3	2.3
08 May 03	1,828	409	47	8	2.6	2.0
09 May 03	1,894	376	50	6	2.6	1.6
10 May 03	1,295	213	51	6	3.9	2.8
11 May 03	928	146	22	2	2.4	1.4
12 May 03	1,559	295	51	6	3.3	2.0
13 May 03	1,478	375	24	5	1.6	1.3
14 May 03	2,023	443	40	7	2.0	1.6
15 May 03	2,770	887	69	2	2.5	0.2
16 May 03	3,488	958	84	5	2.4	0.5
17 May 03	3,139	661	97	9	3.1	1.4
18 May 03	3,339	758	100	8	3.0	1.1
19 May 03	3,101	901	93	9	3.0	1.0
20 May 03	1,902	767	65	4	3.4	0.5
21 May 03	2,804	1,240	60	15	2.1	1.2
22 May 03	1,993	722	42	9	2.1	1.2
23 May 03	2,232	1,103	63	9	2.8	0.8
24 May 03	3,225	1,231	109	13	3.4	1.1

Appendix Table 13. Continued.

Detection at Bonneville Dam	Bonneville Dam detections: Chinook salmon (*n*)	Steelhead (*n*)	Jones Beach detections: Chinook salmon (*n*)	Steelhead (*n*)	Chinook salmon (%)	Steelhead (%)
25 May 03	3,255	2,248	101	31	3.1	1.4
26 May 03	2,501	1,342	35	8	1.4	0.6
27 May 03	2,087	843	37	11	1.8	1.3
28 May 03	2,321	666	32	6	1.4	0.9
29 May 03	2,279	2,392	65	47	2.9	2.0
30 May 03	1,401	1,961	17	29	1.2	1.5
31 May 03	1,195	1,065	18	27	1.5	2.5
01 Jun 03	1,537	577	25	17	1.6	2.9
02 Jun 03	2,316	1,095	42	23	1.8	2.1
03 Jun 03	2,176	889	32	10	1.5	1.1
04 Jun 03	2,048	927	48	35	2.3	3.8
05 Jun 03	1,495	1,316	43	32	2.9	2.4
06 Jun 03	1,277	1,820	28	49	2.2	2.7
07 Jun 03	1,702	1,872	34	33	2.0	1.8
08 Jun 03	1,710	1,868	34	54	2.0	2.9
09 Jun 03	998	1,435	28	34	2.7	2.4
10 Jun 03	1,255	713	46	17	3.6	2.4
11 Jun 03	763	281	14	2	1.8	0.7
12 Jun 03	614	273	6	4	1.0	1.5
13 Jun 03	529	249	14	15	2.5	6.0
14 Jun 03	642	225	13	12	2.0	5.3
15 Jun 03	374	138	2	3	0.5	2.2
16 Jun 03	237	102	4	2	1.7	2.0
17 Jun 03	278	204	6	5	2.1	2.5
18 Jun 03	428	373	5	3	1.2	0.8
19 Jun 03	219	135	0	0	0.0	0.0
20 Jun 03	100	24	6	2	6.0	8.3
21 Jun 03	252	57	10	3	3.9	5.3
22 Jun 03	289	38	8	2	2.8	5.3
23 Jun 03	109	5	2	1	1.8	20.0
24 Jun 03	41	4	0	0	0.0	0.0
25 Jun 03	86		1	0	1.1	0.0
26 Jun 03	155	9	1	1	0.6	11.1
27 Jun 03	269	24	3	0	1.1	0.0
28 Jun 03	257	29	3	1	1.2	3.4
29 Jun-13 Oct	8,259	123	0	0	0.0	0.0
Totals	91,592	44,238	1,955	729	2.1	1.6

Appendix Table 14. Detection rates of PIT-tagged juvenile Chinook salmon and steelhead previously detected at Bonneville Dam using a pair trawl in the Columbia River estuary at Jones Beach (rkm 75), 2004.

	Bonneville Dam detections		Jones Beach detections			
Detection at Bonneville Dam	Chinook salmon (*n*)	Steelhead (*n*)	Chinook salmon (*n*)	Steelhead (*n*)	Chinook salmon (%)	Steelhead (%)
4 Mar-16 Apr	55	21	0	0	0.0	0.0
17 Apr 04	214	2	1	0	0.5	0.0
18 Apr 04	131	2	4	0	3.1	0.0
19 Apr 04	103	3	2	0	1.9	0.0
20 Apr 04	83	4	0	0	0.0	0.0
21 Apr 04	99	2	2	0	2.0	0.0
22 Apr 04	107	9	2	0	1.9	0.0
23 Apr 04	69	12	1	0	1.4	0.0
24 Apr 04	74	78	1	0	1.4	0.0
25 Apr 04	103	121	3	2	2.9	1.7
26 Apr 04	115	112	1	1	0.9	0.9
27 Apr 04	126	217	2	6	1.6	2.8
28 Apr 04	133	214	0	11	0.0	5.1
29 Apr 04	106	129	1	0	0.9	0.0
30 Apr 04	107	71	1	0	0.9	0.0
1 May 04	160	119	7	5	4.4	4.2
2 May 04	134	98	1	1	0.7	1.0
3 May 04	129	65	4	0	3.1	0.0
4 May 04	206	37	2	0	1.0	0.0
5 May 04	305	12	8	0	2.6	0.0
6 May 04	512	23	12	0	2.3	0.0
7 May 04	455	57	6	0	1.3	0.0
8 May 04	620	76	10	0	1.6	0.0
9 May 04	414	55	14	2	3.4	3.6
10 May 04	483	80	15	0	3.1	0.0
11 May 04	610	46	24	0	3.9	0.0
12 May 04	708	27	38	0	5.4	0.0
13 May 04	503	74	12	1	2.4	1.4
14 May 04	573	440	20	8	3.5	1.8
15 May 04	822	389	38	10	4.6	2.6
16 May 04	637	456	23	6	3.6	1.3
17 May 04	585	209	16	4	2.7	1.9
18 May 04	1,007	360	14	3	1.4	0.8
19 May 04	1,171	603	34	9	2.9	1.5
20 May 04	1,144	314	33	7	2.9	2.2
21 May 04	1,129	418	29	3	2.6	0.7
22 May 04	1,265	488	24	4	1.9	0.8
23 May 04	898	295	15	8	1.7	2.7
24 May 04	832	163	27	3	3.2	1.8

Appendix Table 14. Continued.

Detection at Bonneville Dam	Bonneville Dam detections: Chinook salmon (*n*)	Bonneville Dam detections: Steelhead (*n*)	Jones Beach detections: Chinook salmon (*n*)	Jones Beach detections: Steelhead (*n*)	Jones Beach detections: Chinook salmon (%)	Jones Beach detections: Steelhead (%)
25 May 04	702	268	12	2	1.7	0.7
26 May 04	924	211	12	1	1.3	0.5
27 May 04	853	133	34	4	4.0	3.0
28 May 04	874	56	24	2	2.7	3.6
29 May 04	791	61	22	3	2.8	4.9
30 May 04	739	64	30	2	4.1	3.1
31 May 04	829	39	22	0	2.7	0.0
1 Jun 04	858	64	33	2	3.8	3.1
2 Jun 04	890	29	21	0	2.4	0.0
3 Jun 04	569	33	13	0	2.3	0.0
4 Jun 04	526	59	17	5	3.2	8.5
5 Jun 04	313	19	10	0	3.2	0.0
6 Jun 04	341	33	10	0	2.9	0.0
7 Jun 04	327	18	6	1	1.8	5.6
8 Jun 04	331	27	7	0	2.1	0.0
9 Jun 04	365	17	13	4	3.6	23.5
10 Jun 04	277	110	4	0	1.4	0.0
11 Jun 04	177	24	6	0	3.4	0.0
12 Jun 04	252	9	3	0	1.2	0.0
13 Jun 04	259	13	0	0	0.0	0.0
14 Jun 04	281	14	17	1	6.0	7.1
15 Jun 04	243	14	9	0	3.7	0.0
16 Jun 04	179	6	2	0	1.1	0.0
17 Jun 04	123	16	0	1	0.0	6.3
18 Jun 04	98	10	1	0	1.0	0.0
19 Jun 04	72	11	0	0	0.0	0.0
20 Jun 04	74	7	0	0	0.0	0.0
21 Jun 04	74	6	3	0	4.1	0.0
22 Jun 04	79	3	3	0	3.8	0.0
23 Jun 04	123	13	4	0	3.3	0.0
24 Jun 04	87	1	4	0	4.6	0.0
25 Jun 04	63	5	0	1	0.0	20.0
26 Jun 04	58	0	2	0	3.4	0.0
27 Jun 04	74	1	1	0	1.4	0.0
28 Jun 04	58	1	0	0	0.0	0.0
29 Jun 04	50	1	0	0	0.0	0.0
30 Jun 04	40	2	1	0	2.5	0.0
1 Jul-12 Sep	503	4	0	0	0.0	0.0
Totals	30,404	7,303	793	123	2.6	1.7