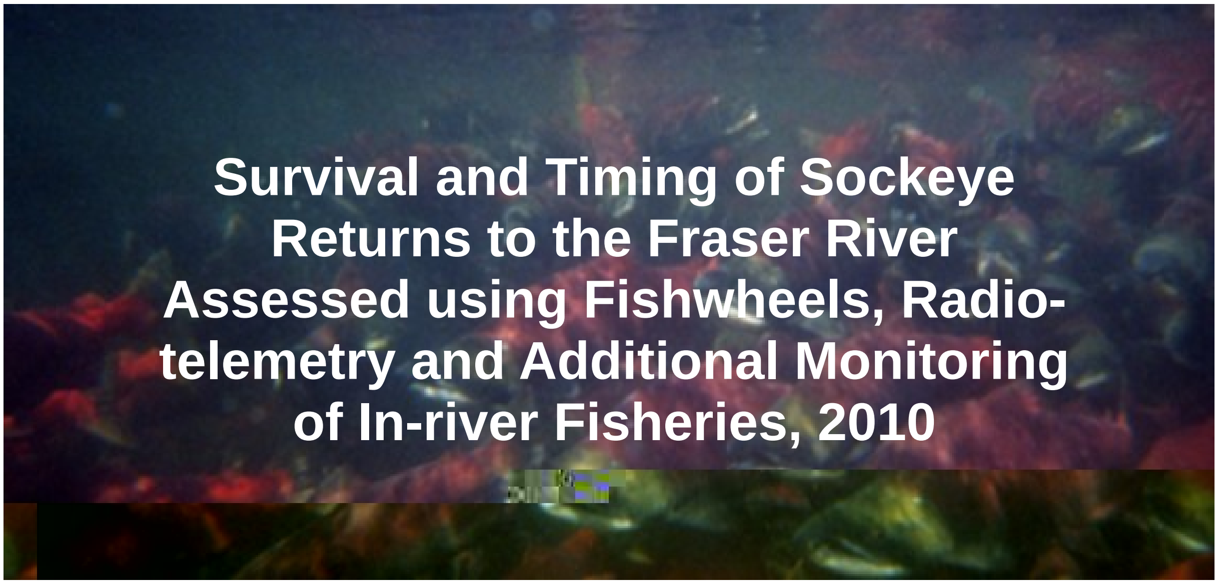

Survival and Timing of Sockeye Returns to the Fraser River Assessed using Fishwheels, Radio-telemetry and Additional Monitoring of In-river Fisheries, 2010

Final Report

Prepared for:

Pacific Salmon Foundation
Fraser Salmon and Watersheds Program
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and

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26 April 2011

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Survival and Timing of Sockeye Returns to the Fraser River Assessed using Fishwheels, Radio-telemetry and Additional Monitoring of In-river Fisheries, 2010

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EXECUTIVE SUMMARY

Recently, there have been large discrepancies between the estimates of abundance derived from the Mission hydroacoustic surveys, and those made on the spawning grounds for some Fraser River sockeye stocks. Also recently, large proportions of Late-run Fraser River sockeye salmon have died in fresh water before reaching their spawning grounds. Early river entry has been associated with increased levels of pre-spawn mortality for this stock. In 2010, a large scale radio-telemetry study was conducted to provide estimates of river entry timing, in-river survival, migration rates and the impact of fisheries on the survival of all run-timing groups of Fraser River sockeye salmon.

In 2010, 728 sockeye were radio-tagged, including 67 at the Crescent Island fishwheels, 303 at the Juan de Fuca reef-nets, and 358 on the Johnstone Strait troll boat near Crescent Island. Each radio-tagged fish was also measured and spaghetti-tagged, and a small adipose tissue sample was taken for microsatellite stock identification. Radio-tagged fish were tracked using 28 fixed-station receivers in 27 locations along the Fraser River and within major tributaries. Fifty-two percent of the radio-tagged sockeye were detected at least once after release, and 46% were known to pass Mission. In all, 9% of tags were returned from marine and in-river fisheries, and 24% were tracked to the vicinity of stock-specific spawning areas. The majority (43%) of radio-tagged sockeye were identified to Late-run stocks. Adequate tags were successfully applied in proportion to the run for Early Stuart and late-run sockeye, but the other two run timing groups were under-tagged and tagging events did not line-up with the peaks of these runs.

Early Summer and Summer-run sockeye had a median travel time to Mission of 3.9 d from Lummi Island, and 9.1 d from Johnstone Strait (range 8.0-11.3 d for the tagging periods). For late-run sockeye that entered after the Early Summer and Summer-run stocks, the median travel time from release to Mission was 20 d for Lummi releases and 20-30 d for Johnstone Strait releases. Delay periods for these delayed-entry fish ranged from 11.2-22.3 d. The portion of Late-run sockeye in each release group that co-migrated with Early Summer/Summer-run sockeye was 82% for the July and early August releases near Lummi Island and much lower (0-29%) for the last four tagging periods in Johnstone Strait (mid-August to early September).

Within the Fraser River, Early Stuart, Early Summer and Summer-run sockeye exhibited median travel times that were faster than those for Late-run sockeye. The fastest migration rates were for Early Stuart sockeye (53 km/d) along the Fraser mainstem between the Thompson and Quesnel junctions. The comparable median migration rate for Summer-run sockeye was 43 km/d.

'After-harvest' survival to spawning areas was significantly higher for Late-run sockeye than for all other run timing groups. There is good confidence in the survival estimates for Early Stuart (52.6%) and Late-run (84.3%) sockeye, but confidence for Early Summer (46.3%) and Summer-run (70.8%) estimates were lower, given that tags were applied in low numbers and not in proportion to the run. The highest rate of en-route loss for Early Stuart and Summer-run sockeye was observed in the reach between Hell's Gate and Kelly Creek, and for Thompson-bound stocks between Hell's Gate and Ashcroft.

As observed in 2002, 2003 and 2006, Late-run sockeye in-river survival rates increased over the course of the study period. For Late-run fish that passed Mission during the first two passage periods in August, survival was near zero. For the remaining passage periods in August and

September, Late-run survival rates fell close to or between the survival curves fit to the 2002 and 2003 in-river survival estimates for Late-run sockeye. The consistency in the results across the four study years provides strong evidence that few, if any, of the Late-run sockeye that pass Mission in the first half of August survive to spawn.

In addition to the telemetry component of this study, two fishwheels were operated from late June to early October in a relatively fast-flowing section of the Fraser River near Crescent Island. The goal was to collect data from fishwheels to estimate species composition for near-shore areas of the river channel. In conjunction with 'centre-channel' species composition data from the Whonnock gillnet test fishery, the acoustic signals recorded at the Mission hydroacoustic site can be partitioned among species. At the fishwheels, all captured fish were identified to species, and species composition was calculated daily. Including jacks, 7,346 sockeye (*Oncorhynchus nerka*), 1,094 steelhead (*O. mykiss*), 1,079 coho (*O. kisutch*), 616 Chinook (*O. tshawytscha*), 81 chum (*O. keta*), and 5 pink (*O. gorbuscha*) salmon were captured at the fishwheels, along with 14 other species.

The PSC Mission hydroacoustic estimates were split into near-shore (<50 m from shore) and off-shore strata. The species composition of the Crescent Island fishwheels and the Whonnock gillnets were applied to the near-shore and off-shore counts, respectively, to derive daily estimates of the number of sockeye passing Mission which were consistent with the PSC's 'best judgement' in-season sockeye abundance estimates.

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INTRODUCTION

The management of the Fraser River salmon fisheries is complex. Five species of salmon migrate through the Fraser toward hundreds of terminal spawning areas (Roos 1991). Chinook (*Oncorhynchus tshawytscha*) populations are divided into five major age-timing groups for management and analysis purposes (Pacific Salmon Commission 2002; English et al. 2007). There are more than 30 separate populations of Fraser sockeye (*O. nerka*) that spawn throughout the watershed (Roos 1991), and which are managed as four separate run-timing groups (Pacific Salmon Commission 1989). In addition, there are numerous populations of coho (*O. kisutch*), pink (*O. gorbuscha*) and chum (*O. keta*) salmon that co-migrate and are harvested in mixed-stock ocean and in-river fisheries. Salmon start running in the Fraser River in early April and continue well into October each year.

Decisions to open and close fisheries are based on a combination of pre-season and in-season estimates of run timing, stock composition, and abundance. Pre-season forecasts are based on the size of the return in the brood year, estimates of spawning success, fry-to-smolt survival, and historic spawner-recruit relationships. In-season abundance estimates result from test-fishing in near-shore marine waters, gillnetting in the lower Fraser, and hydroacoustic monitoring at Mission (Woodey 1987). Reliable and timely information on returning abundance and in-river survival of salmon and steelhead (*O. mykiss*) populations is required to manage the expanding harvests in Fraser River fisheries.

The reliability of in-season estimates of spawner escapement goals has been questioned in several recent years because sockeye salmon appeared to experience unexpectedly high pre-spawning mortality rates. For example, spawning ground surveys in 2004 could only account for 6%, 9% and 20% of the Mission in-season hydroacoustic estimate (less catches that occurred upstream of Mission) for Early Stuart, Early Summer-run and Summer-run stocks, respectively (Williams 2005). There is a need to determine whether the discrepancies between the Mission and spawning ground estimates are due to biases in estimation or due to en-route losses. If the discrepancies are primarily due to en-route losses, it is critical to determine whether these losses are likely the result of in-river fisheries or non-fishery related factors (e.g., elevated water temperature, river flow, parasites, etc.). One of the goals of this project was to identify the magnitude, timing and location of in-river losses, and attribute them both to fisheries and non-fishery related causes.

Since the late 1990's, high rates of pre-spawn mortality have recently been observed for Late-run sockeye stocks. Recent studies have shown the link between early river entry timing and pre-spawn mortality rates (Cooke et al. 2004). Prior to 1996, most Late-run fish accumulated in schools off the mouth of the Fraser River for three to six weeks before moving upstream in mid-September through late October. From 1996 to 2001, the portion of the Late-run stocks that entered the Fraser River with little or no delay has increased along with the pre-spawning mortality rate. It has been hypothesized that the relatively high pre-spawning mortality observed in freshwater was due to longer freshwater residence times before spawning, during which a myxosporan parasite, *Parvicapsula minibicornis*, contracted upon river entry, induces additional mortality via renal failure before spawning occurs (St-Hilaire et al. 2002). Given a link between mortality rates and river-entry timing for Late-run Fraser River sockeye salmon, a second goal of this project was to examine the timing of river entry in relation to survival for Late-run sockeye stocks.

A third goal of the 2010 study was to collect species composition data from two fishwheels operated from late June to early October in a relatively fast-flowing section of the Fraser River near Crescent Island. Species composition data are important for decision makers, and are used to manage marine and freshwater fisheries in-season. The Mission hydroacoustic program estimates the daily passage of all salmon species migrating upstream. The total salmon estimated from acoustic backscatter is then partitioned into species (and into stocks) based on the species (and stock) composition of the test-fishing sets that occur nearby at Whonnock. Last year, Robichaud et al (2010) described an approach to estimating Mission species composition, in which acoustic signals were partitioned into 'near-shore' and 'centre-channel' areas, and species compositions data from near-shore test-fishing gear (fishwheels) and centre-channel test-fishing gear (Whonnock gillnet test fishery) applied to each partition, respectively. This year, we apply that method again, to test its effects in an even-numbered year with virtually no Fraser pink salmon (but some other species) co-migrating with the sockeye.

The primary objectives for the 2010 project were to:

- use fishwheels to estimate near-shore species and stock composition throughout the Mission hydroacoustic monitoring period;
- capture, sample and radio-tag all run timing groups of Fraser sockeye;
- use radio-telemetry to provide a reliable estimates of river-entry timing and in-river survival rates, and to determine the portion of the en-route losses that can be reliably attributed to in-river fisheries and non-fishery related factors; and
- determine whether any discrepancy between the Mission hydroacoustic and spawning area escapement estimates for each sockeye run-timing group can be explained by en-route losses.

The fishwheels were also used to provide a continuous source of salmon for the biological sampling needs of management agencies. Specifically, DFO scientists used fishwheel-caught salmon (and those caught in marine waters) for a genomics project, and the PSC staff requested length data for all species, and DNA and scale samples from sockeye, to assess species and stock composition, and for size and age-composition analyses. The radio-tracking receivers that were used for this study were also used for several independent UBC and Carleton University radio-tracking research projects. The results of these other projects are reported elsewhere.

MATERIALS AND METHODS

Study area

The main study area extended from the Johnstone and Juan de Fuca straits, to the upper reaches of the Fraser River (Figure 1). Tracking effort was focused on areas upstream of the Mission hydroacoustic site. Sockeye were captured, tagged and released at three locations, including two marine locations (Lummi Island in Juan de Fuca Strait; and Discovery Passage in Johnstone Strait) and at one in-river location (about 10 km downstream of Mission, near Crescent Island).

Fixed-station receivers were deployed at 27 sites along the Fraser mainstem, at major tributary confluences, and within major sockeye tributaries (Figure 1). A pair of receivers was deployed at Mission to detect time at which the tagged fish moved upstream past the hydroacoustic site and into the main tracking area. A fixed-station receiver was deployed downstream of the main tracking area (about 1 km downstream of the fishwheel location) to detect any fish that were tagged at the fishwheels, and the dropped-back downriver after release.

Study design

The basic components of the proposed study were:

1. to continuously operate one large and one small fishwheel in a relatively fast-flowing section of the Fraser River near Crescent Island, with efforts timed to coincide with the operations of the PSC hydroacoustic site near Mission;
2. to collect species composition data from the fishwheels daily throughout the study period;
3. to take adipose tissue and scale samples from a random subsample of the sockeye salmon captured in the fishwheels for the PSC (for stock-composition and ageing analysis);
4. to apply radio tags to the Early Stuart run-timing group of sockeye, captured using fishwheels in the lower Fraser River;
5. to apply radio tags to the other run-timing groups of Fraser sockeye salmon, captured using reef nets near Lummi Island and troll gear in Johnstone Strait;
6. to attach radio tags to adequate numbers of fish in order to assess their migratory behaviour and spawning success with reasonable certainty;
7. to take gill tissue samples from a subset of the radio-tagged sockeye for a DFO genomics study;
8. to relocate radio-tagged fish using mobile tracking and fixed-station receivers deployed at strategic positions throughout the Fraser River drainage; and
9. to recover the majority of tags that were caught in recreational, commercial and First Nation fisheries, using a lottery-based rewards system.

The initial goal for radio-tagging operations was to apply radio tags to sockeye salmon throughout the migration period for Fraser sockeye. The number of tags allocated to the Early Stuart group (< 30 tags/week) was lower than that for the other run-timing groups because of the lower abundance and expected lower fishing pressure on Early Stuart sockeye. A tagging target of 100 tags per week was initially set for each of the six anticipated marine tagging weeks with the marine tagging location to be determined by the sockeye diversion rate. Tagging was to be conducted at the Lummi Island site in the US Gulf Islands when the majority of the sockeye were migrating through Juan de Fuca Strait (i.e., when the "diversion rate" was low). The diversion rate typically increases in early August, and by mid to late August the majority of the sockeye are typically migrating through Johnstone Strait. In 2010, we applied tags for three week at the Lummi Island, and then moved to Johnstone Strait for tagging sessions starting 11 August. In 2010, the marine tagging period was extended into early September (one week longer than planned) because of the larger than expected return and more protracted duration of the migration (Table 1; Figure 2).

The fixed-station tracking involved the deployment of antennas and receivers at strategic locations along the Fraser River to provide data on study-area entry times, in-river movement patterns, and spawning destinations. The mobile tracking in the Harrison, Quesnel, Little River, Adams, Seymour, Shuswap, and along the Thompson River around Kamloops Lake were conducted to determine the fate of the fish last detected at fixed-station receivers adjacent to these areas.

Environmental data

Hydrometric data from a station located at Mission (#08MH024) on the Fraser River were obtained from Environment Canada (Environment Canada 2010). The Mission station is located on the north bank of the Fraser River immediately downstream of the Mission Railway Bridge (drainage area = 228,000 km^2). Water temperature of the Fraser River at the fishwheel site was recorded daily using a boat-mounted sonar equipped with a temperature sensor.

Fishwheel operations

Fishwheel deployment and operation

In 2010, one small fishwheel and one large fishwheel were operated on the left bank of the Fraser River approximately 3 km upstream from Crescent Island. The small fishwheel was similar in design to those that have operated on the Nass River, BC since 1992 (Link and English 1996; Alexander and Bocking 2004) and on the Copper River in Alaska since 2001 (Smith et al. 2005). The small fishwheel had two welded-aluminum pontoons (11.6 m long × 0.9 m wide × 0.5 m deep) that were comprised of seven independent, pressure-tested compartments. It had three baskets (3.4 m long × 3.0 m wide × 2.1 m deep) that were framed with aluminum tubing (3.8 cm square) and lined with white, knotless, nylon mesh (6.4 cm stretch). The baskets were attached to a 3.7 m axle and designed to fish up to 3 m below the water surface. Hand winches and a tower (6.1 m high) and boom assembly (4.9 m long) were used to raise and lower the baskets. An aluminum tank (4.3 m long × 0.6 m wide × 1.5 m deep) for holding captured fish was fitted inside each pontoon. The bottom of each holding tank was fitted with windows of extruded aluminum mesh to allow for ample water circulation. As the river's current propels the rotating baskets, upstream-migrating fish are captured and directed down plywood chutes and into the holding tanks on either side of the fishwheel.

Pontoons for the large fishwheel were similar in width and depth to those of the regular fishwheel but were 17.7 m long. The large fishwheel baskets (6.1 m long × 4.3 m wide × 3 m deep) were framed with same aluminum tubing and lined with the same nylon mesh as the small fishwheel. The baskets were attached to an axle (5.2 m long) and designed to fish 5.8 m below the water surface. The two holding tanks had the same dimensions as tanks in the small fishwheel. Square aluminum tubing (15.2 cm square) was used to build the tower (5.2 m high) and boom arms (7.0 m long) of the large fishwheel. The boom arms were braced along their lengths with an additional piece of 15.2 cm square tubing. Additional bracing (10.2 cm square tubing) between the tower uprights, and between the tops of the tower uprights and boom arms, further supported the structure. Two hoists (Warn DC3000LF with 1,363 kg rating) powered by 12 V batteries were mounted on 20.3 cm square steel beams (4 m long) that were welded to each pontoon at the stern of the fishwheel. The hoists were used to tilt the tower and boom arm backwards towards the stern of the fishwheel, while simultaneously lifting the basket assembly up and out of the water.

Field mobilization began in late June 2010 with the installation of a log boom assembly designed to hold the fishwheels in place at the fishing site (rather than using steel pilings) and to deflect floating debris away from the path of the fishwheels (Figure 3). River current pushing against three "swifter" logs, as well as the use of a spar log, kept the entire log boom assembly from grounding-out on the river bank. As water levels dropped over the season, adjustments were made to increase the angle of the swifter logs against the current.

As in 2008 and 2009, a floating shoreline abutment was used at the Crescent Island site in 2010 which served three main functions: 1) it held the fishwheels offshore in water deep enough to turn their baskets; 2) it allowed the fishwheels to be shifted inshore or offshore as water levels changed so that the baskets could be fished as close to the river bottom as possible; and 3) it supported a fish guidance weir along the downstream side which deterred fish from passing upstream between the small fishwheel and shore. The abutment was constructed of two steel pontoons (6.1 m long × 76 cm dia. pipe) and two steel stretcher pipes (8.2 m long × 32 cm dia.). The weir had a triangular aluminum frame (7.6 m base × 3.7 m high) and vertical aluminum rails (1.9 cm dia. tubing).

The floating shoreline abutment and two fishwheels were towed to the Crescent site (Catherwood Towing, Mission) from a location near Hatzic Slough (4.5 km upstream from the Mission Railway Bridge) where they were stored over the winter. The abutment was secured to two pilings and a tree using wire (1.3 cm dia.) and polypropylene rope (1.9 cm dia.). Two spar logs were used to keep the abutment from grounding-out on the river bank. The small fishwheel was placed alongside the abutment and offset slightly downstream to increase the likelihood that fish guided offshore by the weir would be captured in the fishwheels. The large fishwheel was then placed alongside the outside pontoon of the small fishwheel. Polypropylene rope (1.9 cm dia) was used to secure the small fishwheel to a steel piling located 50 m upstream, and to secure the large fishwheel to a cross-member of the log boom assembly. Logs and tires were placed between the fishwheels and abutment to prevent abrasion.

A power-assist unit was used on the small fishwheel in an effort to maintain the rotation rate at 2 revolutions per minute (RPM) during periods of the tidal cycle when river currents were too low to turn the baskets. The power-assist unit consisted of a gas-powered hydraulic motor, hydraulic hoses filled with environmentally friendly vegetable oil, and a reducer unit that was connected to the fishwheel axle.

Fishwheel effort

The fishwheels were operated 24 h per day except for stoppages to re-position or repair the fishwheels. As in 2009, the fishwheels were not stopped during in-river fisheries in 2010 (they had been stopped in 2007 and 2008). Fishwheel speed (RPM) was determined one or more times each day by measuring the time required for the fishwheel baskets to complete three revolutions.

Daily fishing effort of the fishwheels was calculated in two ways. First, total effort was calculated as the number of hours that a fishwheel operated on a given calendar day from midnight to midnight. Total effort indicated the amount of down time (i.e., non-operational time) associated with each day. Second, the effort used to determine catch per unit effort (CPUE, fish/h) was calculated as the number of hours that a fishwheel fished between sampling sessions. For example, if fishwheel operated continuously for several days without stoppage, the daily fishing effort on each of those days would be 24 h. Notwithstanding, the catch could have been examined at 1200 hours on day t and at 1000 hours on day t+1, thus the effort used to calculate CPUE on day t+1 would be 22 h. Note that effort for calculating CPUE on day t+1 could exceed 24 h if the sampling session on day t was earlier in the day than the sampling session on day t+1. To calculate CPUE, the total number of fish captured during visits on a given calendar day was divided by that day’s fishing effort.

The fishwheels were visited one or more times each day. During each visit, all fish were removed using a dip net, identified to species, counted, sampled (if applicable) and released back into the river. A subset (~30 individuals per species per fishwheel per day) was measured (cm FL), and those lengths 30 cm or greater were recorded (at the request of the PSC hydroacoustic analysts). A small tissue (adipose) and scale sample was taken from a subset of sockeye for stock composition and ageing analysis (also at the request of the PSC). In July, some sockeye salmon were also radio-tagged (see below).

Fishwheel harvest

As in 2009, the Matsqui First Nation harvested a portion of the salmon caught at the fishwheels in 2010 for food, social, and ceremonial (FSC) purposes. An Aboriginal Communal Fishing License was issued by DFO which specified the species and number of fish allowed to be harvested. Typically, the license allowed for harvesting during periods that overlapped with other in-river FSC fishery openings. Fish harvested under this license, as well as any mortalities found in the fishwheel holding tanks, were distributed to members of the Matsqui First Nation. The harvest date, species, and number of fish were recorded.

Fishwheel size selectivity

The degree of fishwheel size selectivity was assessed by comparing the size distribution of sockeye caught in fishwheels with those of sockeye caught in two PSC test fisheries: the Whonnock and Cottonwood variable-mesh gillnet fishery. At Cottonwood, the length data were collected as fork lengths, but at Whonnock, postorbital fork length (POF) were transformed to fork lengths (FL) using sex-specific relationships (PSC unpublished data):

$$FL = (1.133\ POF) - 2.1044 \qquad \text{for males; and}$$

$$FL = (1.1015\ POF) + 1.0022 \qquad \text{for females.}$$

The FL distributions for the sockeye caught in the fishwheels and in the two PSC test fisheries were plotted, and the means were compared using ANOVA.

Fishwheel species composition

Every individual caught in both fishwheels was counted and identified to species. For salmon, species composition was calculated every day and for both fishwheels. Species composition was expressed as the percentage of each salmon species comprising the total catch of salmon (based upon the number of individuals caught). Species composition data from the fishwheels were compared to those from the Whonnock gillnet test fishery (PSC unpublished data).

Species composition proportions from the fishwheels were applied to the PSC hydroacoustic counts in order to estimate abundances of sockeye salmon. Similarly, sockeye abundances were calculated using the species composition from the Whonnock test fishery. These abundances were compared to those estimated using a combination of both species composition datasets. As in 2009, the PSC provided hydroacoustic counts that were partitioned into 5 m intervals across the river channel. These counts were summed for two spatial strata; a near-shore stratum (within 50 m of each shoreline) and an off-shore stratum (counts for all other intervals). The species composition estimates from fishwheel catches were applied to the near-shore stratum, and those of the Whonnock test fishery was applied to the off-shore stratum. The same stratified approach was used to derive daily estimates of the number of Chinook salmon passing the Mission hydroacoustic site.

Radio-telemetry methods

Radio-transmitters

Two types of radio transmitters were used during this study. In 2010, 59% of the tags were manufactured by Lotek Wireless, Inc. (Newmarket, Ontario). The remainder of the transmitters used in 2010 were manufactured by Sigma Eight Inc. (Newmarket, Ontario). Each tag transmitted on one of seven different frequencies (320, 360, 460, 480, 500, 600 and 800 kHz) within the 150 MHz band. Within each frequency, three different pulse intervals (4.5, 5.0, and 5.5 s) were used to reduce the incidence of signal collisions when several transmitters were present at the same location at the same time. All transmitters were programmed to stop transmitting after 154 d to minimize interference with other studies.

The Lotek tags were of the same model that has been used in previous years: model MCFT-3A micro-coded fish transmitters. These tags measured 16 mm in diameter, 46 mm long, and had a 460 mm antenna. The Lotek transmitters were powered by 3 V batteries, with an expected life of 761 days. Many (37%) of the Lotek tags were manufactured in 2010, but most (63%) were manufactured in 2009. Although some of the tags that were manufactured in 2009 were being used for the first time in 2010, some were used in 2009 and were being re-used in 2010.

The Sigma Eight tags measured nominally 15.5 mm in diameter, 50 mm long, and had a 400 mm antenna. These transmitters were powered by 3 V batteries, with an expected life of 5.7 to 6.8 years.

Tracking systems

Radio-tagged salmon were monitored using fixed stations and mobile tracking. Both monitoring systems used SRX400 or SRX400A radio receivers manufactured by Lotek Wireless. Fixed stations used 3-element or 4-element Yagi antennas manufactured by Maxrad, Inc. (Hanover Park, Illinois) or Grant Systems Engineering Inc. (King City, Ontario). For mobile tracking, an H-antenna (Lotek Model AN-ADH-150) was used. At the Qualark Site, underwater antennas were monitored using broadband Orion receivers manufactured by Grant Systems Engineering.

Fixed stations

The fixed-station tracking involved the deployment of antennas and receivers at strategic locations along the Fraser River to provide data on study-area entry times, in-river movement patterns, and coarse spawning destinations.

Twenty-eight fixed-station receivers similar to those described by English et al. (2004) were deployed at 27 locations along the Fraser River and within major tributaries (Figure 1) to monitor radio-tagged fish movements towards spawning areas. Specific locations were chosen to monitor the arrival of radio-tagged fish into the study area, to document departures from the mainstem of the Fraser River into s

Each fixed station consisted of two or three antennas (see Appendix Table A1), antenna switching hardware, a receiver, a 12 V battery, an enclosure to protect the equipment, and a solar panel to charge the battery. Antennas were placed more than 10 m above the water level in a tree. Antennas were aimed to detect radio-tagged fish that were present downstream of the station, upstream of the station, and up a tributary (if present). Since each fish detection is associated with a particular antenna, sequential detection data can be used to determine the direction of a fish's movements.

The detection range of each fixed station was tested in the upstream and downstream direction of the mainstem, and up the tributary. Ranges were tested by drifting a radio tag, at 2 m depth, at one-half and three-fourths of the channel width. In each case, adjustments were made to the antenna position and signal gain to ensure that tags were detectable across most of the river channel, and that there was good separation among antennas in the areas covered. At Mission, the antennas at the two fixed stations were aimed in different directions to minimize the possibility of local noise events (from CB radios, etc) simultaneously affecting all antennas on both receivers. At most fixed-station receiver sites, the antenna adjustments and detection range tests were performed in 2005 (as part of a previous study; see Robichaud and English 2006), the antennas were not removed after the 2005 study, and were, following annual range testing, used again in each subsequent year.

Plots of the daily detections of radio-tagged fish and noise levels recorded by each receiver (Appendix Figure A1) were used to assess the effect of signal collisions and environmental noise on the ability to detect radio-tagged fish, and to identify any gaps in the monitoring period. Details of receiver performance are provided in Appendix Table A2.

<u>Mobile tracking</u>

Mobile tracking was conducted to confirm the fates of radio-tagged fish, distinguish between tags located in the river and those out of the water (based on signal strength), and determine more precise final locations for en-route losses. Mobile tracking included some areas that were not monitored by fixed stations, such as Scotch Creek.

Helicopter (CC Helicopters Ltd., Lillooet) and boat tracking were based out of Lillooet, BC, and were conducted in conjunction with regularly scheduled DFO catch monitoring surveys. For helicopter tracking, an H-antenna was mounted vertically to the nose of the helicopter and connected to a single SRX receiver that was operated by an LGL biologist. Helicopter tracking was conducted on 12-13 August, 25 August, and 2 September. Survey coverage included the mainstem Fraser River between Hope and Kelly Creek and the Thompson River from the mouth upstream to Ashcroft. Mobile tracking by boat was conducted on 6 August (Lytton to Bridge River) and 11 August (Boston Bar to Lytton). Mobile tracking by truck (and on foot) in key fishing areas was also conducted opportunistically from 5 August to 1 September. For truck surveys, a 2-element antenna was mounted on a 1 m long mast that was secured to the side of the bed and connected to a single SRX receiver in the cab of the truck.

Additional mobile-tracking surveys, conducted around the upper-Thompson spawning areas were conducted on 9 October (by foot) and on 11 November (by helicopter).

During all tracking surveys a hand-held GPS unit was used to record a waypoint every 3 s along the survey route. The time on the SRX receiver and GPS unit were synchronized so that the specific location of each radio-tagged fish detected could be determined. All radio-tagged fish detected during mobile surveys were assigned to specific stream reaches. Mobile survey methods, effort, and tag locations are provided in Appendix Table B1.

Fish capture procedures

Marine

Marine tagging occurred in six intervals. The first two tagging sessions occurred in Juan de Fuca Strait from 21 to 28 July and from 4 to 6 August. Tagging was then moved to Johnstone Strait, where four tagging sessions occurred: 11 to 13 August, 17 to 19 August, 25 to 26 August, and 2 to 3 September (Table 1).

In Juan de Fuca Strait, sockeye for tagging were caught using reef net gear located in Legoe Bay at the south end of Lummi Island, WA (Area 5; Figure 1). Reef nets in Area 5 are used as a test fishery by the PSC and to commercially harvest sockeye and other salmon species. Reef nets are fixed in place and only catch migrating adult salmon that swim through the gear. They typically consist of two floating platforms, a net, large concrete anchors, and a lead made from small-diameter rope and ribbons. On an incoming tide, salmon are led into the shallow laid net. The net is then lifted using winches and the captured fish are directed into holding tanks on one of the floating platforms. Fish are not gilled in the net, nor are they directly handled when shunted into the holding tanks, so they were typically in excellent condition for sampling. Sockeye that quickly righted themselves were transferred from the holding tank into a tagging trough using a long-handled dipnet. Fish that were ≥ 52 cm in nose-fork length were tagged and released.

In Johnstone Strait, sockeye for tagging were captured in Area 13 (Figure 1) using a chartered troll vessel ("Skully") owned by Tom Forge (Campbell River, BC). Fish were captured as far north as Chatham Point and Howe Island and as far south as The Bluffs near Deepwater Bay. Pink hoochies with single barbless hooks were used exclusively. When the crew noticed that a fish had been hooked they hauled in the line, lifted the fish out of the water using a dip net, removed the hook, and then placed the fish into a holding tank with circulating water. Fish that were noticeably bleeding, injured (e.g., hook in the eye) or lethargic were immediately released. Others were transferred from the holding tank into a tagging trough using a hand-held dip net. Fish that were not injured by the capture process and which were ≥ 52 cm in nose-fork length were tagged and released.

In-river

Two fishwheels were operated near-continuously in a location about 1 km upstream of Crescent Island from 27 June to 3 October. The goal was to target the Early Stuart run-timing group by tagging three days per week for three weeks in July (Table 1). On the morning of each tagging day, the sockeye that had been captured overnight were selected haphazardly from the holding tanks, and transferred into a tagging trough using a long-handled dip net. Fish that were ≥ 55 cm in nose-fork length were tagged and released.

Fish tagging procedures

The initial goal was to apply 650 radio tags to sockeye salmon distributed across all the run-timing groups. As indicated above, the application of these tags was distributed between three different tagging locations. The fishwheels were used to capture and tag the Early Stuart component of the run in late June and early July when water temperatures were less than 18 °C (and prior to the onset of any marine test fisheries). The tagging operation moved to the reef-nets when river temperatures increased, when the reef-net test fishery was expected to open, and while the diversion rate (i.e., the % of run returning through Johnstone Strait) was less than 50%. Once the diversion rate reached 50%, the tagging operation was moved to the troll vessel in Area 13.

For all three capture methods (fishwheels, reef nets, troll vessel), sockeye selected for tagging were placed in a V-shaped tagging trough filled with a constant supply of water (using a bucket or bilge pump). Fish were measured (nose-fork length), and we tagged those that were greater than the threshold minimum size, and which had no significant injuries due to capture.

For fish that were radio-tagged, a tissue sample was taken from the adipose fin (for DNA analysis), scales were taken (for ageing) from the "preferred area" (along the diagonal connecting the back of the dorsal fin with the front of the anal fin, and 2-3 rows above the lateral line), a colored spaghetti tag was threaded through the dorsal musculature adjacent to the dorsal fin (and tied with an overhand knot), and the radio tag was orally inserted into the stomach of the fish using a plastic tag applicator. The species, fork length, radio tag number, spaghetti tag number, amount of descaling, duration of the tagging procedure, and release time were recorded for all radio-tagged fish. For a related genomics study, a small tissue sample was taken from the gills of a subset of the radio-tagged sockeye. All fish were released immediately after tagging.

At the fishwheels, PIT tags were applied to white sturgeon (*Acipenser transmontanus*) and, for one day, radio tags were applied to Pacific lamprey (*Lampetra tridentata*). All other species were counted and released. A sub-sample of the bycatch species were measured to establish species-specific length distributions.

Effects of genomic sampling

The effects of gill-clipping on the survival of sockeye were examined by comparing the success of the clipped fish to that of fish that were not clipped. Success was measured as the proportion of sockeye that survived to be detected in their stock-specific spawning areas. A chi-square contingency analysis was performed, where the dependent variable (success = yes / no) was modeled as a function of sampling type (clipped vs. not).

Catch monitoring

Past telemetry studies identified specific locations (and times) where a substantial number of radio-tagged sockeye salmon pre-maturely ended their upstream migration. Several of these tracking locations (e.g., Hope to Sawmill Creek, Lillooet area, lower Chilcotin River, lower Thompson River) were associated with major in-river fisheries and/or natural stressors (high flow or temperature). In 2010, additional fixed-station receiver sites were added, and catch monitoring efforts and mobile tracking surveys (discussed in a previous section) were conducted to determine the fate of all radio-tagged sockeye salmon entering these key areas.

In 2010, four fixed-station receiver sites were deployed that were not used during the 2009 study. Fixed stations were deployed in the Thompson River near Ashcroft (downstream of the outlet of Kamloops Lake) and in the North Thompson River near the mouth. These two stations helped to identify the fates of radio-tagged fish that may have been last detected at the Spence's Bridge station in previous years (e.g., 2006 study year). Fixed stations were also deployed on the Fraser River near the Bridge River and Kelly Creek confluences, which were areas of intense fishing effort and high water velocities. In addition, a fixed station was deployed in the lower Chilcotin River just upstream of the Farwell Canyon fishery.

DFO has a well-established catch monitoring program for First Nation fisheries in the Mid and Upper Fraser River. In 2010, project biologists liaised with DFO and several First Nations to raise awareness of the tagging program among catch monitors and harvesters, and to facilitate the recovery of all captured radio-tagged fish. Tag-recovery notices were posted at First Nation band offices and strategic locations along the river where people would be most likely to see them (access points to fishing areas, boat launches). Catch monitoring was also conducted to obtain accurate mark-rate estimates (i.e., catch and tag recovery data) in all of the major in-river fishing areas where significant numbers of tagged fish were last detected in previous study years (Hope-Sawmill, Seton-Kelly Creek, Chilcotin Junction-Farwell Canyon, and Thompson Junction-Ashcroft).

Telemetry data management

Data from fixed stations were downloaded at regular intervals, which depended on the number of radio-tagged fish passing the location and the accessibility of the station. Most stations were downloaded every 7 d. Some remote stations in low noise environments, with few fish expected to pass, were downloaded as infrequently as once per month. For each download, a diagnostic program was run before erasing the internal memory in the receiver, to ensure that all data had been transferred, the file was readable, and the receiver and antennas had been operating properly.

The downloaded data were processed and analyzed using LGL's custom database software, "*Telemetry Manager*." *Telemetry Manager* facilitates data organization, record validation, and analysis through the systematic application of user-defined criteria. Raw data were archived so that the temporal or spatial resolution, or noise filtering criteria could be changed by the user at any time without altering the raw data. An important aspect of radio-telemetry is the removal of false records in receiver files, for example, those that arise from electronic noise. In this study, the following criteria were set for records to be considered valid: 1) power levels had to be greater than 30 (on a 1 to 232 scale); 2) detections had to be paired within a single zone, and recorded within 20 minutes of each other (single records, or records separated by more than 20 minutes were rejected); 3) detections had to be recorded at zones that were geographically located between the locations of previous and subsequent valid detections; and 4) detections requiring unrealistic travel times were removed. Once false records were removed, *Telemetry Manager* created a compressed database of sequential detections for each fish. Each record included the tag number, location, the first and last time and date for sequential detections in that location, and the maximum power for all detections in that interval. The compressed database was used to determine when each fish entered the study area, residence times at each fixed-station or spawning area, rates of movement between detection sites, and sites of last detection.

Detection efficiency of receivers

Detection efficiencies for each fixed-station receiver site were estimated by dividing the total number of unique radio-tagged fish detected at the site by the total number of unique radio-tagged fish known to have passed. The number of fish detected at each site included only fish moving in the upstream direction (detection efficiencies would be artificially inflated if they included fish that were missed as they passed a receiver in the upstream direction, but which were subsequently detected as they dropped back past the receiver in a downstream direction). The total number known to have passed each receiver included all those radio-tagged fish detected at that site, or at any site located farther upstream.

Passage event interpolation

For fish that were not detected by a receiver, but were known to have passed it (i.e., that were detected upstream of it), we estimated their date and time of passage by interpolating between upstream and downstream detections, assuming a constant travel speed. Interpolated passage times were not used for analyses of migration times or speeds. They were only used to assign fish to Mission Passage Periods, or for analyses regarding the availability of fish to reach-specific harvest.

River entry timing

Mission Passage Timing was used as a surrogate for River Entry Timing. River Entry Timing was determined for all radio-tagged fish that passed Mission, whether or not they were detected when moving past the Mission site. For those fish that were detected, the first detection at the Mission fixed-station receivers was used as the Mission Passage Timing. For those that were not detected passing Mission, but were detected farther upstream, Mission Passage Timing was interpolated from the timing of detections at adjacent fixed-station sites (see above).

Delay behaviour of Late-run sockeye

The amount of time that Late-run sockeye held in Georgia Strait before entering the Fraser River is not precisely known because radio-tagged fish cannot be tracked in brackish and saline waters at the river mouth. An index of delay behaviour was developed by examining the distribution of travel time between marine release sites and Mission for Early Summer/ Summer-run sockeye, as compared to that of Late-run fish. Late-run fish were divided into two groups: those that entered the Fraser River with the same timing as Summer-run fish (termed “co-migrant” group), and those that entered after the Summr-run fish d Su

DNA analysis of their tissue sample (as per Beacham et al. 2004). Together, these data were required to determine stock-specific movement rates.

Since tissue samples were analyzed for all sockeye, including those tracked to spawning destinations, differences between the DNA-based stock assignments and the fish's final spawning area could be assessed. The differences could be interpreted either as 'straying' or as DNA analysis inaccuracy, but the two effects cannot be teased apart.

In-river movements

Travel times (and travel speeds) for each individual radio-tagged fish were calculated based on the timing between detections at the various fixed-station receivers along the river. Travel time between two receivers was calculated as the time between the first detection at the downstream receiver and that at the upstream receiver. Migration rates were calculated by dividing the distance (in km) between receivers by the travel time. Median travel times and migration rates were compared among run-timing groups and among stocks using the Kruskal-Wallis test. Interpolated passage times were excluded from these analyses.

Harvest and tag return rate

<u>Downstream of Mission</u>

The number of radio tags that were caught in the Fraser River downstream of Mission (c) was estimated from daily harvest rates of freshwater fisheries downstream of Mission (HR_term_d), and the daily number of radio-tagged sockeye from Juan de Fuca and Johnstone Strait that passed the Mission detection site (e_JDF_d, e_JS_d):

$$c = \left[\sum_d \left(\left(\frac{e\_JDF_d}{1 - HR\_term_d} \right) - e\_JDF_d \right) \right] + \left[\sum_d \left(\frac{e\_JS_d}{1 - HR\_term_d} - e\_JS_d \right) \right]$$

The daily number of tags that passed the Mission detection site (e_JDF_d, e_JS_d) was known mainly from telemetric detection data. However, some fish passed Mission without being detected; for these individuals, the date of Mission Passage was interpolated from detections at adjacent arrays. The daily harvest rates of fisheries downstream of Mission were calculated from three-day averages of daily escapement and daily catch as:

$$HR\_term_d = \sum_{i=-1}^{1} C\_term_{d+i} \Big/ \sum_{i=-1}^{1} \left(E_{d+i} + C\_term_{d+i} \right) \qquad \text{where } i \in \{-1, 0, +1\}$$

where C_term_d is the daily catch in Area 29 and in the Fraser River downstream of Mission, and E_d is the daily Mission escapement.

The tag return rate for river-fisheries downstream of Mission (tags returned / c) was applied to the number of tags caught in marine areas to estimate overall marine harvest of tags.

<u>Upstream of Mission</u>

The number of radio tags expected to be caught in fisheries above Mission (*ABFR*) was calculated using a harvest-rate method similar to that used in previous years (e.g., Robichaud et al. 2008). *ABFR* was the product of fishery harvest rates (HR_{fd}) and the number of radio tagged sockeye known to be in the vicinity of active fisheries (T_{fd}), summed over the *f* fisheries and the *d* days of the study period:

$$ABFR = \sum_f \sum_d \left(HR_{fd} \cdot T_{fd} \right).$$

Harvest data, specifically in-river catches in First Nations and recreational fisheries, were provided by Fisheries and Oceans Canada (DFO). Sockeye harvests were divided up into eight fisheries: 1) Mission to Vedder; 2) Vedder to Hope; 3) Hope to Sawmill; 4) Sawmill to Texas; 5) the Thompson watershed; 6) Texas to Deadman; 7) the Chilcotin watershed; and 8) all areas upstream of Deadman. The PSC compiled the sockeye catch estimates from DFO, and estimated stock-specific escapement past Mission on a daily basis (J. Gable, PSC, pers. comm.). Daily harvest rates (HR_{fd}) were estimated for each of the first three fisheries, using running three-day averages of catch and escapement:

$$HR_{fd} = \sum_{i=-1}^{1} C_{fd+i} \Big/ \sum_{i=-1}^{1} E_{fd+i} \qquad \text{where } i \in \{-1, 0, +1\} \text{ and } f \in \{1, 2, 3\}$$

where E_{fd+i} was the sockeye escapement into fishery *f* on day $d+i$, and C_{fd+i} was the total sockeye catch in fishery *f* on day $d+i$. Daily estimates of stock-specific sockeye escapement past Mission were used as E_d for the first fishery, and the survivors of a given fishery became the escapement for the subsequent one:

$$E_{fd} = E_{f-1d} - C_{f-1d}$$

Harvest rate calculation for the sockeye fishery above Sawmill was more complex, as fish were exposed to fishing pressure for more extended periods. Fish were expected to move through the Sawmill to Texas fishery in two days ($m = 2$), thus, on any given day, the sum of two daily escapements would be available to be caught in the fishery. Fish were expected to move through the Texas to Deadman fishery in four days ($m = 4$), and the remaining fisheries in 7 days ($m = 7$). In any of these complex fisheries, the survival of an escapement cohort entering the fishery on day *d* would be:

$$S_d = 1 - (C_d \Big/ \sum_{j=0}^{m-1} E_{d-j})$$

The harvest rate for a cohort entering the "the Sawmill to Texas" fishery on day *d* would be:

$$HR_{fd} = 1 - \prod_{j=0}^{m-1} S_{d+j} \qquad \text{where } f \in \{4, 5, 6, 7, 8\}.$$

Since fixed station receivers operated near the boundaries of each of the four fisheries (the Rosedale station was used as a proxy for Vedder; the Thompson station for Texas; and the Chilcotin station for Deadman), the daily number of radio-tagged fish that entered each fishery (T_{fd}) was known. Assuming that fish were exposed to each of the three lower fisheries for one day, the Sawmill to Texas fishery for two days, the Texas to Deadman fishery for four days, and the remaining fisheries for seven days (based on median travel times measured in previous years; English et al. 2004), it was possible to estimate the daily number of radio-tagged fish that should have been caught, (i.e., *ABFR*, the expected number of radio tags removed).

Radio tag returns (*ABTR*) were solicited through flyers and meetings with user groups. All radio-tagged fish were marked near their dorsal fin with a yellow or green spaghetti tag in order to increase the probability that the fish be scrutinized, and the radio tag noticed. A toll-free phone number, an Internet URL, and a mailing address were included on the label of the radio tags. Fishers that visited the webpage or called the toll-free number were given directions on how to arrange for a courier to pick up the tag from their home, free of charge to the fisher. Moreover, each time a fisher returned a radio tag to LGL (along with the date and location of capture), they were entered into a draw for $1000. For each tag returned, a letter was mailed to the fisher describing where and when the fish had been tagged, and where it had been tracked to date.

The radio tag reporting rate was not calculated on a daily basis, since estimates would be too noisy. Data were pooled into 13 approximately week-long blocks. Each of the blocks, called "Mission Passage Periods," corresponded to a week during which fish traveled past Mission. The radio tag reporting rate (*RR*) for Mission passage period *p* was calculated as:

$$RR_p = \sum_f \sum_d ABTR_{fd} \Big/ \sum_f \sum_d ABFR_{fd}$$

where *d* includes all days in Mission Passage Period *p*.

Escapements (and hence harvest rates) and expected fishery returns were calculated separately for each sockeye run-timing group.

Terminal detection zones

Each radio-tagged fish was assigned a terminal detection zone based on its farthest upriver movement into the river or tributary in which it was last detected. For example, a fish that entered the Adams, but which subsequently drifted out and was last detected in Little Shuswap Lake would have the Adams as its terminal zone.

Survival estimation

Sockeye survival rates were calculated from Mission to spawning areas both before accounting for harvest (S') and after harvest (S). Survival rates from Mission to the spawning areas were computed for each Mission Passage Period, and were computed separately for each sockeye run-timing group. Fixed-station and mobile tracking data were used to determine the fate for each radio-tagged sockeye that moved upstream past Mission. Sockeye were assumed to have survived to spawning areas if their terminal detections were at fixed stations (or during mobile tracks) adjacent to their stock-specific spawning locations. Adams and Lower-Shuswap sockeye that were last detected at Little River during the spawning period (after Sept 25) were considered as successful spawners.

Survival rates were derived by dividing the number of sockeye detected in spawning terminal areas by the number of radio-tagged sockeye that remained after accounting for tagging-related losses, and, for the calculation of S, estimated fishery removals:

$$S'_v = \frac{O_v}{E_v - L_v} \quad \text{and} \quad S_v = \frac{O_v}{E_v - C_v - L_v}$$

$$\sigma(S'_v) = \sqrt{\frac{S'_v(1-S'_v)}{E_v - L_v - 1}} \quad \text{and} \quad \sigma(S_v) = \sqrt{\frac{S_v(1-S_v)}{E_v - C_v - L_v - 1}}$$

where E_v is the number of sockeye in group v that were detected at Mission, C_v is the number of sockeye in group v that were caught upstream of Mission, L_v is the number of sockeye in group v that were lost due to tagging-related effects[1], and O_v is the number of sockeye in group v that had a stock-specific spawning location as their terminal zone of detection. The groups denoted by v could be defined in any way, but in this report, survival was examined by: 1) run-timing group; and 2) by run-timing group *and* Mission Passage Period. The standard deviation equation is the formula for proportions based on high sampling fractions (Cochran 1977).

Effect of river entry timing on survival of Late-run sockeye

In 2002 and 2003, procedures developed by Schnute and Richards (1990) were used to fit a family of six curves to data describing the relationship between survival of Late-run sockeye and their river entry date. Similar likelihood estimates were derived for each of the six curve shapes. The two curves with the best fit included one sigmoid curve and one cut-off curve (English et al. 2003), with no statistical difference between the two curves. Sigmoid curves are “S” shaped curves where survival rates asymptote towards 0% and 100% and remain between these values over the entire range of possible river entry dates. Cut-off curves are curves with an X-intercept that defines the date when survival is estimated to be nil for all fish that enter the river on or before that date.

The 2002-03 curves were plotted along with the weekly survival data (estimates of the survival to spawning areas for sockeye that passed Mission each week) from 2006 and 2010.

For the 2010 survival data, seven weekly Late-run survival estimates (from Mission to spawning areas) were plotted. Although most of these data-points represented weekly survival estimates, one was generated by pooling two consecutive weeks that each had relatively low sample sizes.

RESULTS

Environmental data

Fraser River water levels at Mission ranged from 0.17 to 3.95 m between 1 June and 31 October 2010 (Figure 4). As water levels dropped below 3 m in mid-July, daily fluctuations in water level increased as a result of tidal influence. Fraser River discharge at Mission peaked at 7,562 m^3s^{-1} in late June (Figure 5).

Water temperature at the Crescent fishwheel site ranged from 12.0 °C to 18.0 °C (mean = 15.2 °C) from 6 July to 3 October (Figure 6).

PSC Mission escapement estimates

In this report, the PSC estimates of the number of sockeye passing the Mission hydroacoustic site were used for comparison with the daily fishwheel catch-rates and the migration timing of the radio-tagged sockeye. In even-numbered years, these PSC estimates are usually derived by applying the species composition proportions from the Whonnock gillnet test fishery to the

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[1] All tags that were last detected on the Fraser mainstem downstream of Sawmill Creek, other than those that were countable as fishery removals, were classified as tagging-related losses.

Mission hydroacoustic counts from their split-beam system. In 2009 and 2010, shore-based DIDSON hydroacoustic systems were used to count fish targets within 60 m of each shore because of concerns that the counts from the split-beam systems were significant underestimates during periods of high fish abundance. In 2010, estimates of the daily abundance of sockeye passing the Qualark hydroacoustic site were used to adjust the Mission estimates during periods when PSC biologists were concerned that the Mission boat-based hydroacoustic counts were missing fish due to boat avoidance behaviour (M. Lapointe, PSC, pers. comm.).

Fishwheel operations

Fishwheel deployment and operation

The large fishwheel operated for 2,274 h (97% of the time) from 27 June to 3 October (Figure 7, Appendix Table D1). Fishwheel speed averaged 1.1 RPM and ranged from 0.4 RPM (26 August, 1 September) to 2.0 RPM (29 and 30 June). The large fishwheel was stopped on several occasions to repair damage to basket tubing or replace missing bolts. On 29 September, the crew arrived at the large fishwheel and noticed that someone had stopped the fishwheel overnight.

The small fishwheel operated for 2,330 h (99% of the time) from 27 June to 3 October (Figure 7; Appendix Table D1). Fishwheel speed averaged 1.4 RPM and ranged from 0.3 RPM (18 August) to 2.7 RPM (28 June). A power-assist unit was used to turn the small fishwheel during portions of each day starting on 27 August.

Fishwheel performance

Including jacks, 7,346 sockeye, 1,094 steelhead, 1,079 coho, 616 Chinook, 81 chum and 5 pink salmon were captured at the fishwheels (Table 2). Fifteen other fish species including 10 white sturgeon, and three harbour seals (*Phoca vitulina*) were also captured and released. Daily catches of sockeye, Chinook and coho salmon are shown in Figure 8.

Of the 7,346 sockeye captured at the fishwheels from 27 June to 3 October, 7,316 (99.6%) were adults (Appendix Table D2) and 30 (0.4%) were jacks. The large fishwheel caught nearly 9.5 times as many adult sockeye (6,615; peak daily = 380) as the small fishwheel (701; peak daily = 68; Figure 9). Sockeye catches occurred in three main pulses: a relatively small but steady pulse from late June to mid-late July, a large pulse from late July to late August, and a moderate but prolonged pulse through September (Figure 9). Daily CPUE averaged 2.9 fish/h (peak daily = 17.0 fish/h) at the large fishwheel and 0.3 fish/h (peak daily = 3.0 fish/h) at the small fishwheel (Figure 10; Appendix Table D2).

Of the 616 Chinook captured at the fishwheels from 27 June to 3 October, 370 (60.1%) were 143 TmOf the 6y to late A

Fishwheel harvest

From 10 July to 19 September, 743 adult sockeye, 56 adult Chinook, 34 jack Chinook, and 1 coho salmon were harvested by the Matsqui First Nation from the Crescent Island fishwheels (Table 3).

Fishwheel size selectivity

The size distribution of sockeye varied significantly among sites and gear-types ($F_{2,5272} = 148.8$, $P < 0.0001$). On average, the fishwheels caught the smallest fish (mean = 57.9 cm), compared to the variable mesh gillnet test fisheries. The fork length of fish measured in the Cottonwood test fishery (mean = 59.1 cm) was significantly smaller than that estimated in the Whonnock test fishery (mean = 59.9 cm; Figure 13).

Since smaller fish are likely to have slower burst swim speeds (Bainbridge 1958), the bias towards smaller fish makes sense: they may be less likely to avoid capture and more likely to be entrained by the rotating baskets. Additionally, smaller fish may be forced to swim closer to shore, in areas of greater drag (and thus slower water velocities), which would also result in a greater 'small fish' capture rate in the near-shore fishwheel gear relative to offshore and mid-channel test fisheries.

Fishwheel species composition

Species composition estimates from the Crescent Island fishwheels were compared to those from the Whonnock gillnet test fishery each day between 27 June and 3 October 2010 (Figure 14). From late June to late July, when Fraser River water levels were high and some adult Chinook salmon were present in the river, adult sockeye represented a larger portion of the fish caught in the near-shore fishwheel samples compared to the mid-channel gillnet test fishery. During low water in September, adult sockeye represented a smaller portion of the fish caught in the fishwheel samples than in the gillnet test fishery. The general similarity between the species composition measured using the fishwheels and Whonnock test fishery data throughout the 2010 sockeye migration resulted in similar estimates of the daily sockeye migration past Mission regardless of the source of the species composition data. All of the estimates based solely on Mission hydroacoustic data, underestimated the PSC "best estimate" during peak migration periods because Qualark data was used to expand the Mission counts during these periods (Figure 15). It is interesting to note that during two of these peak migration periods (20-23 August and 21-25 September), the estimates deived by combining the Whonnock and fishwheel species composition estimates produced an estimate that was closer to the PSC "best estimate" than the estimate based solely on the Whonnock test fishery data.

Radio-telemetry results

Reef-net effort and catch

Reef-netting occurred in two intervals, from 21 to 28 July, and from 4 to 6 Aug. The daily tagging quotas ranged from 19 to 51 fish, and fishing effort ranged from 0.25 to 5.6 h per day. The total fishing effort for the two fishing sessions was 23.6 hours.

Troll boat effort and catch

Trolling occurred in four intervals, 11 to 13 August, 17 to 19 August, 25 to 26 August, and 2 to 3 September. The daily tagging quotas ranged from 19 to 49 fish, and daily trolling effort ranged from 80.5 to 422 hook-hours. The total fishing effort for the four fishing sessions was 2358 hook hours.

Radio tag releases

In all, 728 sockeye were radio-tagged, including 67 at the Crescent Island fishwheels, 303 at the Juan de Fuca reef-nets, and 358 on the Johnstone Strait troll boat (Table 1; Figure 2). At the Crescent Island fishwheel location, almost all of the radio-tagged fish were caught in the large fishwheel (66 sockeye; compared to one fish in the small fishwheel).

Of the 728 radio-tagged sockeye, 278 were gill-clipped for a related genomics study. Processing time (from the time the fish was placed in the tagging trough to the time it was released into the river) was significantly shorter (mean 1.2 minutes) for the simple procedure than for the gill-clipped sockeye (mean 2.0 minutes; $t_{719} = 21.4$; $P < 0.0001$).

Of the four sockeye run-timing groups, Late-run stocks made up the largest component (42.4%) of the radio-tagged sample (Figure 2). At the fishwheels, 79.1% of the radio-tagged sockeye were identified as Early Stuart fish, whereas no Early Stuart fish were tagged in marine areas. Early Summer, Summer-run and Late-run stocks were tagged over a wide range of dates, with Late-run fish dominating numerically starting the week of 9 August. At least for the radio-tagged sockeye, there was no apparent difference in run-timing between Early Summer and Summer-run stocks.

Comparison of the PSC estimates of sockeye abundance at Mission with the detections of radio-tagged sockeye at Mission, confirmed that radio-tagged sockeye were distributed over the entire sockeye migration from early July through late September 2010 (Figure 16). As expected, the application of roughly 100 tags per week in marine areas did not result in tag application being proportional to the abundance estimated at the Mission site. Overall, a disproportionally large number of fish were tagged until about mid-August, and then a disproportionally small number were tagged until the latter part of September. For individual run-timing groups, the migration of radio-tags past Mission was roughly proportional to the run for Early Stuart and Late-run stocks but not for the other two timing groups (Figure 17). The later half of the Early Summer and Summer-run groups were under-represented by radio-tags because the Late-run sockeye dominated the stock composition in the marine tagging areas during the last four tagging periods (i.e., the later half of the migration of summer-run stocks).

The radio-tagged Summer-run sockeye that passed Mission were predominantly Chilko fish until 28 August, after which Quesnel dominated (Figure 18). Summer-run fish bound for Stuart passed Mission during a two week period from 25 July to 7 August.

In terms of the radio-tagged Late-run sockeye that passed Mission, fish bound for Harrison passed Mission relatively early (25 July to 14 Aug). The Lower Shuswap and Adams stocks passed Mission over a protracted period, but peaked in the latter parts of the study (Figure 19).

Effects of genomic sampling

Of the 728 sockeye radio-tagged, 721 were identified to a stock. Of the 721 sockeye, 358 were gill-clipped. Of these, 79 survived to stock-specific spawning areas (22%). The survival of the 363 non-clipped sockeye was 23% (84 fish). The difference in survival was not statistically significant ($\chi_1^2 = 0.12$; $P = 0.73$). Other similar analyses were run, with comparable results. Survival from release to Sawmill was 37% for gill-clipped, and 39% for non-clipped fish ($\chi_1^2 =$

0.21; $P = 0.65$). Survival from Mission to spawning was 49% for gill-clipped fish and 48% for non-clipped fish ($\chi_1^2 = 0.04$; $P = 0.84$). No survival differences were found between gill-clipped and non-clipped sockeye when analyses were restricted to any of the four run-timing groups. Consequently, subsequent analyses of migration and survival patterns were conducted using all radio-tagged sockeye, without distinguishing those that were gill-clipped from those that were not.

Fixed-station detection efficiencies

Detection efficiencies in 2010 (Table 4) were similar to those estimated in previous years (English et al. 2004; Robichaud and English 2006, 2007; Robichaud et al. 2008, 2010; Smith et al. 2009). The receivers at Sawmill and Hell's Gate detected > 99% of the passing fish. The receivers at the Thompson junction, at Ashcroft and at Little River all had sockeye detection efficiencies greater than 90%. The receiver at Rosedale performed particularly badly (16.3%) in 2010. Apparently, the river channel shifted over the winter from a configuration in which the majority of the fish passed through the fixed-station's detection range, to one in which the main channel was far from the receiver site so most fish were missed. The relatively low detection efficiency of the Fraser-Harrison confluence (24.4%) was not surprising, as the station was set up to detect fish migrating up the Harrison River and was therefore expected to miss a portion of the fish migrating in the Fraser mainstem.

The detection efficiency of the Seton fixed-station (54.4%) was low in 2010. Although a solar panel problem resulted in a three-day period of down-time in early August (Appendix Table A2), tagged fish were missed at this station throughout the study period, thus other factors must have contributed the problems at this site.

The detection efficiency of the Chilcotin fixed station (63.2%) was lower than normal because it had large period of inactivity (Appendix Table A2). The receiver was installed after seven tags had passed (on 18 July). A crew error resulted in the station being down from 1 to 22 August (10 tagged fish passed). Then, haze from a forest fire caused solar panel ineffectiveness, the station battery was dead from 29 August to 2 September (4 tagged fish passed). During periods of receiver activity, the receiver detection efficiency was 91.4% (43 of 47 tags detected).

Daily detections of radio-tagged fish and corresponding receiver noise levels recorded by each fixed-station receiver are given in Appendix Figure A1.

Tracking histories

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Of the 336 radio-tagged sockeye that passed Mission, at least 26 were harvested (i.e., reported). In addition, 327 were identified as being part of stock groups for which tracking systems were installed in terminal spawning areas, and of these 163 were tracked to these spawning areas (Table 5). The remaining fish were lost en-route between Mission and their spawning locations (some of these may have been unreported fishery removals, see below). A more detailed description of the patterns of en-route losses (and expected fishery recaptures) are provided later.

DNA stock assignments and straying

Prior to the arrival of radio-tagged sockeye in known stock spawning areas, DNA micro-satellite analyses provided estimates of stock origins for all but 3 of the radio-tagged sockeye. Radio-tracking provided additional insight to the stock-classifications. In total, 160 radio-tagged sockeye with DNA-based stock assignments were tracked as far as, or were captured from spawning destinations or their tributaries. These final stock assignments were compared to the *a priori* DNA-based stock assignments to assess the discrepancy rate.

The radio-tracking data and the DNA analysis assigned radio-tagged sockeye to the same run-timing group 95.0% of the time (Table 6). A more difficult task was the assignment of fish to a specific stock, and percent correct ranged from 100% (for Early Stuart assignments) to 78.7% for Late-run assignments (Table 6).

Disagreements between radio-tracking and DNA analysis could represent either inaccuracies in the DNA stock-assignment algorithms, or straying of sockeye to non-natal spawning areas.

Entry timing and delay behaviour

Early Summer and Summer-run sockeye moved steadily and consistently between the release sites and Mission throughout the season (Figure 20): the periodicity of the tagging events could clearly be seen in the pattern of arrival times at Mission. Each cohort of tags largely remained together, showing little variation in delay behaviour among individuals. For Late-run stocks, river entry timing was different than the release timing (Figure 21), showing considerably more mixture of the release-groups by the time they reached Mission.

The amount of time that Late-run sockeye held in Georgia Strait before entering the Fraser River is not precisely known because radio-tagged fish cannot be tracked in brackish and saline waters at the river mouth. Nevertheless, delay duration could be inferred using travel time from release to Mission (Figure 22), with the assumption being that travel times within the river would not vary markedly among individuals such that any observed difference in travel time could be attributed to a delay in the river mouth. In 2010, Early Summer and Summer-run sockeye had a median travel time to Mission of 3.9 d from Lummi Island, and 9.1 d from Johnstone Strait (range 8.0-11.3 d for the tagging periods, Table 7). For Late-run sockeye that entered after the Early Summer and Summer-run stocks, the median travel time from release to Mission was 20 d for Lummi releases and 20-30 d for Johnstone Strait releases. Delay periods for delayed-entry fish ranged from 11.2-22.3 d (Table 7). The portion of Late-run sockeye in each release group that co-migrated with Early Summer/Summer-run sockeye was 82% for the July and early August releases near Lummi Island and much lower (0-29%) for the last four tagging period in Johnstone Strait (mid-August to early September).

In-river migration rates

Early Stuart sockeye exhibited median travel times (Mission to Thompson: 37.9 km/d) that were significantly faster than those of Early Summer (30.1 km/d), Summer-run (29.6 km/d) and Late-run (24.8 km/d) sockeye in the Fraser mainstem ($\chi_3^2 = 57.8$; $P < 0.0001$; Table 8; Table 9; Figure 23). The fastest migration rates were for Early Stuart sockeye (52.9 km/d) along the Fraser mainstem between the Thompson and Quesnel junctions. The comparable median migration rate for Summer-run stocks sockeye was 43.0 km/d (Table 8).

Early Summer travel speeds were significantly faster than those of Late-run sockeye ($\chi_1^2 = 12.4$; $P = 0.0004$). Travel speeds in the Thompson drainage were slower than in the Fraser mainstem (Table 8; Table 9; Figure 23). As in the mainstem, median travel speeds of Early Summer sockeye (Thompson to Spence's Bridge: 25.0 km/d) were significantly faster than those of Late-run sockeye (18.4 km/d; $\chi_1^2 = 20.3$; $P < 0.0001$).

Catch monitoring

A total of 37,322 sockeye salmon were reported to DFO and First Nation catch monitors during complete interviews (i.e., expandable for CPUE calculations, ≥ 15 min duration) conducted in the Mid and Upper Fraser River from 1 August to 30 September (Appendix Table E1; Cynthia Breau, DFO, personal communication). Of these, 30,825 (82.6%) were hailed in by fishermen and 6,497 (17.4%) were physically observed by catch monitors. None of the hailed or observed sockeye salmon were reported as having a radio tag deployed during this study. Only a single radio-tagged sockeye was reported from fisheries in the Thompson drainage (e.g., Northern Shuswap Tribal Council, Lytton Band, Shuswap Band). Unfortunately, catch monitoring data for the lower Fraser (Hope-Yale) and Chilcotin rivers was not available in time to be included in this report (April 2011).

Late-run sockeye salmon were harvested in three demonstration commercial fisheries conducted by the Shuswap Nation in 2010 (Appendix Figure E1; Aaron Gillespie, Shuswap Nation, personal communication). From 8 August to 9 September, 583 sockeye salmon were landed in a gillnet fishery in Kamloops Lake, of which none were reported tagged. From 11 September to 1 October, 106,588 sockeye salmon were landed in a purse seine fishery in Kamloops Lake and none of the fish were reported tagged. During a beach seine fishery in the Thompson River (1 km downstream from Kamloops Lake) from 20 September to 1 October, a total of 17,036 sockeye salmon were landed in a total of 76 sets (4-8 sets per day). Of these, one fish landed on 29 September was radio-tagged (this fish was tagged on 26 August in Johnstone Strait).

Six radio-tagged sockeye salmon were detected out of the water during mobile tracking (by truck/foot). Of these, 2 tags were subsequently reported by the fisher as harvested, and 4 tags remained unreported, but were clearly located in residential areas (2 in Lillooet area, 2 in Kanaka Bar).

Mobile tracking surveys identified the upstream-most locations of 15 sockeye along the mainstem Fraser between Agassiz and Kelly Creek that would otherwise have been last-detected at the nearest downstream fixed-station receiver (Appendix Figure B1). The precise location of these mobile detections provided some additional information on the fate for these tagged fish. Three of these tags (Tags 42, 51 and 62) were tracked to residences along the river. Five other tags (Tags 116, 235, 254, 351, 442), last tracked at locations between Nahatlatch and Kanaka Bar, were likely either harvested or were mortalities associated with fisheries in these areas. Tag

119 was tracked during an aerial survey a long distance from the Fraser River and was likely a fishery recovery. The other six tagged sockeye were last tracked during mobile surveys along the Fraser mainstem, and likely died close to where they were last detected; the reasons for their demise remains unknown.

Fishery recoveries

Downstream of Mission

It is estimated that about 100 of the marine-applied tags were removed prior to Mission passage. In all, 45 tags were estimated to have been removed in marine areas (19 returned), and 55 in the Fraser River downstream of Mission (22 returned). The number of tags accounted for (harvest + detections) is shown for each release group in Table 10. The proportion of tags that was accounted for varied from 32% (tagged early in study period at Lummi Island) to 77% (tagged late in study period in Johnstone Strait).

Upstream of Mission

Of the radio-tagged sockeye that were identified as being part of one of the four main run-timing groups, a total of 329 were detected at or above Mission (Table 5). Of these, 28.3 were estimated (using the harvest-rate method described above) to have been removed in fisheries upstream of Mission (Table 11). In all, 26 tags were returned (91.9% return rate). Return rates were higher in the fisheries between Mission and Sawmill (94.0%) compared to those upstream of Mission (89.5%). Due to low sample sizes, and the fact that returns must be reported as units, passage-period-specific return rates were unrealistic.

The numbers of radio-tagged sockeye that were available to be caught in eight Fraser River fisheries are shown in Figure 24. These data show that most of the fisheries below Texas Creek occurred after the Early Stuart sockeye had passed and before the bulk of the Late-run stocks had arrived. Fisheries above Texas Creek occurred at times when they only has access to Summer-run stocks. Given the relatively low numbers of tags applied to Summer-run stocks, it was not surprising that there were very few tag recoveries from the fisheries above Texas Creek. Most of the recoveries of tags applied to Late-run stocks occurred within the Thompson River during peak fishing periods in the later half of September when large numbers of tagged sockeye were migrating through this fishery.

En-route loss

The extent of en-route losses between Mission and Sawmill ranged from 4 to 10% of the sockeye that passed Mission, depending on the run-timing group (Table 12). These values represent the difference between the expected numbers of tags passing Sawmill, and those that actually passed the monitoring station at Sawmill Creek. For Early Stuart sockeye, tagged 10 km downstream of Mission, en-route losses (10%) also include latent post-tagging effects. Other stocks were tagged in marine areas, and fish that reached Mission are assumed to be fully recovered from stressors associated with tagging.

In previous years, Early Summer, Summer-run, and Late-run stocks have been tagged in river, and relatively large rates of en-route loss have been observed (e.g., Robichaud et al. 2010). The fact that 4-10% en-route losses were observed for these stocks in 2010 (despite being tagged in marine areas) suggests that 'Mission to Sawmill' losses in previous years should not have been fully attributed to tagging effects.

In previous years, tagging-related effects of fish tagged in the river have been assessed by comparing reach-specific survival of sockeye that dropped back to Crescent Island before re-ascending to Mission with that of fish that proceeded directly past Mission after tagging. This year, a comparison between marine- and river-tagged sockeye was imagined, but was not possible using only LGL-tagged fish, as there was no temporal overlap between the two groups. Instead, the reach-specific survival of sockeye tagged in-river by UBC/Carleton researchers was compared to that of LGL's marine-tagged sockeye (Figure 25). Reach-specific survival of river-tagged fish was initially lower than that observed for co-migrating marine-tagged fish, and the survival pattern suggested that latent tagging-related effects were manifest until the fish reached Sawmill. These results are similar to what was observed when tags were applied in marine and freshwater areas in 2006 (Robichaud and English 2007).

Survival estimates

Sockeye were assumed to have survived to their spawning areas if their last detections were at fixed stations (or during mobile tracks) adjacent to their stock-specific spawning tributaries (see shaded areas in Table 5). Survival from Mission to spawning area was estimated for each run-timing group two ways: 1) including fishery removals; and 2) excluding fishery removals (Table 13).

Survival rates (after harvest) varied among run-timing groups (Table 13). The shaded portions of the survival rate tables for each run-timing group indicate periods when samples sizes were not sufficient to derive a period-specific survival rate estimate. These periods were generally at the beginning or end of the migration for each run-timing group. The only exception was the peak of Summer-run, where low sample sizes required that the survival estimate for period seven be calculated as the average of that for the two adjacent periods. Survival of Late-run sockeye (84.3%) was significantly higher than that of Early Stuart (52.6%) and Early Summer (46.3%) sockeye ($Z \geq 4.2$, $P < 0.0001$; Figure 26), and was higher than that of Summer-run sockeye (70.8%), though this latter difference was not statistically significant after the Bonferroni correction was applied ($Z = 2.1$, $P = 0.037$, adj $\alpha = 0.0083$). For this analysis, survival of Summer run was significantly greater than that of Early Summer sockeye ($Z = 3.0$, $P = 0.003$), but both these survival values should be interpreted with caution given that the later half of each run was represented by less than 25 tags passing the Mission monitoring site.

Because of the temporal variability in fishery openings, harvesting effort was not spread evenly among the run-timing groups, hence the Mission-to-spawning survival rates should be interpreted with caution (Figure 26).

Fate of radio-tagged sockeye

The fates of radio-tagged sockeye are shown by last detection location and by run timing group in Figure 27. The highest incidence of en-route loss was observed in the reach between Hell's Gate and Thompson (17 fish, 14.5% of en-route losses). However, when total distance of reach was considered, the highest rate of en-route loss occurred in the area between Little River and the Adams mouth (4 fish; 6 km; 0.67 fish/km; Table 14). The rate of en-route loss in the Hell's Gate to Thompson reach was second highest (17 fish; 56 km, 0.3 fish/km).

For Early Summer, Summer-run and Late-run groups, 278 sockeye reached Mission, of which 140 reached stock-specific spawning areas, and 138 were either captured or lost en-route. Nineteen of the unsuccessful sockeye were last detected between Hell's Gate and the Thompson Junction. Of these 19 sockeye, three (16%) had travel times that were longer than 95% of the successful fish (Figure 28).

Effect of river entry timing on survival of Late-run sockeye

Survival of Late-run sockeye was affected by river-entry timing. No Thompson-bound Late-run sockeye that passed Mission before 30 August survived to a spawning area (Figure 29).

Late-run sockeye in-river survival rates increased over the course of the study period (Figure 30). For late-run fish that passed Mission during the first two passage periods in August, survival was near zero. For the remaining passage periods in August and September, Late-run survival rates fell close to or between the survival curves fit to the 2002 and 2003 data (Figure 30). The consistency in the results across the four study years provides strong evidence that few, if any, of the Late-run sockeye that pass Mission in the first half of August survive to spawn.

DISCUSSION

Fishwheel performance

Catch rates of adult sockeye salmon at the Crescent Island fishwheels in 2010 (7,316 fish) were 2.2 times higher than catch rates in 2009 (3,394 fish; Figure 31). Fishwheel catches of adult sockeye from 27 June to 3 October 2010 represented 0.04% of the 16,298,700 sockeye counted at the Mission hydroacoustic site over the same period. Individually, the large fishwheel caught 0.04% of the run and the small fishwheel caught 0.004% of the run. The Crescent Island fishwheels caught 0.31% of the run in 2009 (when both fishwheels were operational; Robichaud et al. 2010) and 0.07% of the run in 2008 (Smith et al. 2009). In comparison, catch rates for sockeye salmon at six fishwheels operated on the Nass River ranged from 0.9-7.1% of the run per fishwheel (mean = 2.8% for all fishwheels) from 1994 to 2009 (Alexander et al. 2010).

As in 2009, the combination of relatively high Fraser River water levels and minor tidal influences likely contributed to a period of high catch efficiences for sockeye at the Crescent Island fishwheels in the first half of July 2010 (Figure 32). Under these conditions, fish were likely bank- and bottom-oriented as they tried to avoid faster-flowing water offshore. Catch efficiencies decreased as water levels dropped and tidal influences increased through late September. At the end of September, water levels rose and there was a concurrent increase in sockeye catch efficiencies.

Species Composition at Mission

The 2010 sockeye return to the Fraser River was the largest since the 1913 Hell's Gate slide, and the total sockeye abundance estimated at Mission was the largest recorded at this site. This large abundance of sockeye dwarfed the numbers of other co-migrating species. As a result, sockeye represented the lion's share (usual > 85%) of the salmon captured by the fishwheels and Whonnock gillnet test fishery. Consequently, these two test fisheries produced very similar stock composition estimates for most of the sockeye migration period. The fishwheel estimates of the percent sockeye were higher than the Whonnock estimates during the first three weeks of the sockeye migration when the Whonnock test fishery caught proportionately more Chinook

(Figure 14). The short-term divergences between the two estimates in September were the result of major reductions in sockeye abundance and steadily increasing abundances of coho adults and jacks that were more readily caught by the fishwheels than the gillnet test fishery (Figure 8 and Figure 14).

Effects of tagging

In past years, when tags have been applied in-river, there has been evidence that the effects of tagging were fully manifest by the time Sawmill was reached (Robichaud and English 2006; 2007). In those years, losses of tagged fish that occurred upstream of Sawmill were called 'en-route' losses, whereas those that occurred downstream of Sawmill were attributed to 'tagging effects'. In 2010, the extent of losses of marine-tagged fish between Mission and Sawmill ranged from 4 to 10%, depending on the run-timing group (Table 12). Since tagging was in marine areas, the fish that reached Mission were presumed to be fully recovered from the acute handling stressors. The fact that losses were non-zero suggests that 'Mission to Sawmill' losses in previous years should not have been fully attributed to tagging effects. Nevertheless, tagging and handling effects were certainly not zero, as shown in the comparison of reach-specific survival of sockeye tagged in-river by UBC/Carleton researchers with that of LGL's marine-tagged sockeye (Figure 25). Robichaud et al. (2010) and Martins et al. (in prep) have argued that the effects of handling are exacerbated when the tagged fish experience elevated river-temperatures.

Fishery removals

One of the tasks for the 2010 study was to increase the catch monitoring and mobile tracking efforts associated with specific fishing areas where sockeye catches or en-route losses have been large in previous years. The two primary purposes for this increased monitoring effort were: 1) to produce an estimate of the number of tags removed by fisheries that was independent of the Mission abundance estimate; and 2) determine the fate of the tags last tracked in each of these specific fishing areas. Study team members worked with First Nation catch monitoring technicians on multiple (> 6) occasions to increase the awareness of the need to sample sockeye catches for the presence of tagged fish. Unfortunately, the large abundance of sockeye and very few tagged fish available for recapture in the fisheries above Sawmill Creek resulted in no tags observed in the 37,322 sockeye caught by interviewed fishers.

En-route losses

In past years, concerns have been expressed that some portion of the en-route losses may be due to delayed effects of the tagging and handling process. These concerns combined with high water temperatures at the lower Fraser tagging sites resulted in the changes to the 2010 study design and the return to marine tagging sites. The proportion of the tags last tracked in the areas between Mission and Sawmill was 12% (32 of 272 tags that passed Mission) for the 2010 marine releases compared to 38% to 63% for the sockeye tagged in 2007-2009 in the lower Fraser River (2007: 134 of 325; 2008: 57 of 91; 2009: 103 of 270; Robichaud et al. 2008, 2010, Smith et al. 2009). This observation was consistent with the expectation that virtually all of the losses associated with the capture, handling and tagging process would occur before the marine-tagged fish arrived at Mission. Therefore, the location of en-route losses above Sawmill in 2010 could be used to validate or refute the observations from the recent sockeye radio-telemetry studies. Comparison of the en-route loss locations and proportions with those for the 2005-2009 studies reveals a strong consistency between years for the major Early Summer, Summer-run and Late-run stocks (see Robichaud et al. 2010). The persistent pattern of en-route loss is cause for concern, especially for radio-tagged Summer-run sockeye in the areas from Hell's Gate to Kelly Creek; and for Thompson sockeye (both Early Summer and Late-run stocks) in locations between Spence's Bridge to Little River. The data compiled from 2005-10 provide compelling evidence that cumulative effects of elevated water temperature, in-river fisheries and difficult passage points (Robichaud et al. 2010) are consistent with the timing and location of en-route losses.

Survival estimates by timing group

Survival estimates derived from radio-telemetry data were compared with the Difference Between Estimates (DBEs) derived from the Mission and spawning ground estimates. The previous observed pattern, of telemetry-based survival estimates being lower than those derived from the DBEs, continued in 2010. The telemetry data indicated that the survival rates were lowest for Early Stuart (53% ±14%) and Early Summer (46% ±12%) while DBEs suggested survival rates of 61% for both of these timing groups. The DBE for Summer-run stocks suggests a rather unbelievable survival rate of 108% compared to the radio-telemetry estimate of 71% ±12%. The DBE for Late-run Shuswap stocks (89%) was reasonably close to the comparable and most precise of the radio-telemetry estimates (84% ±6%). The distribution of the tags relative to the abundance measured at Mission was clearly better for the Early Stuart and Late-run components than for the other two run-timing groups (Figure 17), and the telemetry-derived survival estimates are probably much more reliable for these two run-timing groups. The poor representation of the latter half of the Early Summer and Summer-run migrations could have contributed to the underestimation of survival rates for these run-timing groups, especially if in-river survival tended to increase as water temperatures declined.

Plans for 2011

Building on the understanding and information obtained from recent efforts (2007-2010), specific applications of fishwheels and radio-telemetry have been proposed for 2011. Three conceptual proposals were submitted to potential funding agencies. The first project would include the operation of the two Crescent Island fishwheels from early August through early-September 2011 to provide daily in-season estimates of near-shore species composition. These data would then be combined with off-shore species composition estimates from the Whonnock gillnet test fishery and the Mission hydroacoustic counts to derive reliable estimates of escapement past Mission for sockeye, pink and Chinook salmon.

The second proposed project would include the operation of one fishwheel at a site located upstream of the Qualark hydroacoustic site (as in 1998-2000) from early August through mid-September 2011 to provide daily in-season estimates of near-shore species composition. These data would then be combined with off-shore species composition estimates from the Qualark gillnet test fishery and the Qualark hydroacoustic counts to derive reliable estimates of escapement past Qualark for sockeye, pink, Chinook and coho salmon.

The purpose of the third proposed project would be to deploy and maintain 10-12 fixed-station receivers at strategic locations along the Fraser mainstem and in key tributaries to monitor the migration of radio-tags released from NSERC experiments planned by UBC and Carleton University researchers.

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TABLES

Table 1. Summary of the 2010 radio tag releases by tagging period, and capture method. The two fishwheels are labelled "Lar

Table 2. Total catch of fish, by species, from two fishwheels operated near Crescent Island in the lower Fraser River, 2010.

		Fishwheel		
Common Name	Latin Name	Large	Small	Total
Chinook Salmon[a]	*Oncorhynchus tshawytscha*	514	102	616
Chum Salmon	*Oncorhynchus keta*	67	14	81
Coho Salmon[a]	*Oncorhynchus kisutch*	784	295	1,079
Pink Salmon	*Oncorhynchus gorbuscha*	2	3	5
Sockeye Salmon[a]	*Oncorhynchus nerka*	6,632	714	7,346
Steelhead[a]	*Oncorhynchus mykiss*	730	364	1,094
Smolts	*Oncorhynchus spp.*	72	23	95
American Shad	*Alosa sapidissima*	7	2	9
Black Crappie	*Pomoxis nigromaculatus*	2	0	2
Bull Trout	*Salvelinus confluentus*	6	4	10
Carp	*Cyprinus carpio*	1	2	3
Eulachon	*Thaleichthys pacificus*	1	0	1
Largescale Sucker	*Catostomus macrocheilus*	170	79	249
Mountain Whitefish	*Prosopium williamsoni*	4	1	5
Northern Pikeminnow	*Ptychocheilus oregonensis*	1,413	927	2,340
Pacific Lamprey	*Lampetra tridentata*	206	14	220
Peamouth Chub	*Mylocheilus caurinus*	6,476	2,209	8,685
Pumpkinseed Sunfish	*Lepomis gibbosus*	0	3	3
Redside Shiner	*Richardsonius balteatus*	80	26	106
Smallmouth Bass	*Micropterus dolomieui*	15	17	32
White Sturgeon	*Acipenser transmontanus*	10	0	10
Total		17,192	4,799	21,991

[a] Includes catches of jacks

Table 3. Number of salmon harvested at the Crescent Island fishwheels by the Matsqui First Nation, 10 July to 19 September 2010. Harvest includes fish caught for FSC purposes under Aboriginal Fishing Licences issued by DFO and mortalities found in the fishwheel holding tanks.

		Chinook			
Date	Sockeye	Adult	Jack	Coho	Total
10-Jul		1			1
11-Jul		1			1
17-Jul		11	2		13
18-Jul		1	3		4
21-Jul		2			2
22-Jul		1			1
24-Jul		8	7		15
25-Jul		2	3		5
27-Jul		3			3
31-Jul	79	2	6		87
1-Aug	71	2	8	1	82
4-Aug		2			2
5-Aug	2				2
7-Aug	183	9	2		194
8-Aug	17		1		18
9-Aug	1				1
14-Aug	100	1			101
15-Aug	100	7			107
20-Aug			1		1
21-Aug	105		1		106
22-Aug	83	3			86
19-Sep	2				2
Total	743	56	34	1	834

Table 4. Numbers of radio-tagged fish that passed and that were detected passing each fixed-station receiver site. The detection efficiency (the detected/passed ratio) of each receiver is also shown. No terminal zones are included as detection efficiencies for these sites cannot be computed (there are no upstream detection zones).

Fixed-station Site	Passed	Detected	Detection Efficiency
Mission Hydroacoustic Site	336	250	74.4%
Harrison-Fraser Confluence	319	77	24.1%
Rosedale	301	49	16.3%
Hope	292	248	84.9%
Qualark	287	238	82.9%
Sawmill	284	283	99.6%
Hell's Gate	280	278	99.3%
Thompson-Fraser Confluence	255	236	92.5%
Spences Bridge	152	125	82.2%
Ashcroft	147	135	91.8%
Kamloops	127	95	74.8%
Little River	117	111	94.9%
Seton-Fraser Confluence	90	49	54.4%
Bridge-Fraser Confluence	88	79	89.8%
Kelly-Fraser Confluence	78	55	70.5%
Chilcotin-Fraser Confluence	68	43	63.2%
Quesnel-Fraser Confluence	46	33	71.7%
Nechako-Fraser Confluence	35	35	100.0%

Table 5. Terminal detection zone for radio-tagged sockeye, by stock. For each stock, fish are considered to have escaped to a spawning area if their last detection zone was one of those that are shaded in the table. Numbers in stock names correspond to run-timing groups.

	Stocks																								Run-timing			
Terminal Detection Zone	1-Stuart	2-Bowron	2-Chilliwack	2-Eagle	2-Fennell	2-Gates	2-Nadina	2-Pitt	2-Raft	2-Scotch	2-Seymour	3-Chilko	3-Quesnel	3-Stuart	3-Stellako	4-Adams	4-Eagle	4-Lower Shu	4-Little River	4-Shuswap	4-Portage	4-Harrison	4-Weaver	5-Birkenhead	Early Stuart	Early Summer	Summer-run	Late-run
Release Site	1			1	3	2	5	1		70	23	57	6	8	14	40	5	23	12	30	6	30	2	4	1	105	85	148
Crescent Island FS	1									1		1				1									1	1	1	1
Mission FS	1		1				2			3		2										1			1	6	2	1
Harrison Confluence FS *	1											1				1						4		4	1	0	1	5
Weaver FS																							1		0	0	0	1
Weaver Mobile																							2		0	0	0	2
Rosedale FS	2											2										1			2	0	2	1
Below Hope Mobile												1													0	0	1	0
Hope FS	1										1					1				1					1	1	0	2
Qualark FS1							1							2											0	1	2	0
Sawmill FS										1		1				1		1							0	1	1	2
Hell's Gate FS	1						1			3	2	1		1		1		2		2					1	6	2	5
Below Thompson Mobile										3		3													0	3	3	0
Thompson Confluence FS										1		1				1	1	1		1	1				0	1	1	5
Spences Bridge FS									1	2						1		1							0	3	0	2
Ashcroft FS					1					5	1					2	1	2	1	6					0	7	0	12
Kamloops FS											5									2					0	5	0	2
South Thompson Mobile											1					1	1								0	1	0	2
Little River FS										12	5			1		10	4	1	2	4					0	17	1	21
Little River Mobile																			1						0	0	0	1
Adams River FS																31									0	0	0	31
Adams River Mobile																5									0	0	0	5
Scotch Creek Mobile										6															0	6	0	0
Shuswap Lake Mobile											2						1								0	2	0	1
Seymour River Mobile											1														0	1	0	0
Lower Shuswap FS																		24		7					0	0	0	31
Thompson to Seton Mobile							1																		0	1	0	0
Seton Confluence FS												1													0	0	1	0
Bridge River FS	3	1										1													3	1	1	0
Bridge to Kelly Mobile	2						1																		2	1	0	0
Kelly Creek FS	4											3	1	1							1				4	0	5	1
Chilcotin Confluence FS	5											2													5	0	2	0
Farwell Canyon FS												8													0	0	8	0
Chilko FS												10													0	0	10	0
Quesnel Confluence FS	3																								3	0	0	0
Likely FS													5												0	0	5	0
Nechako Confluence FS	3													1	1										3	0	2	0
Stuart Confluence FS	22						1							1	3										22	1	4	0
Nadina or Stellako Mobile	1						1							1											1	1	1	0
Fisheries																												
Commercial Fishery Area 12-13										1	1	3	1		1	1				1	1				0	2	5	3
U.S. Marine Commercial Fishery										2	2	3				1				1					0	4	3	2
Freshwater Commercial Fishery										3		1	1			6	1		2	2		1			0	3	2	12
FN Fishery - In River D/S Mission										2	1				1							1			0	3	1	1
FN Fishery - Mission to Sawmill										2	2					2		1	1	1		1			0	4	0	6
FN Fishery - In River U/S Sawmill							1			1		5	1					1							0	2	6	1
Sport Fishery - Mission to Sawmill										1		2								2					0	1	2	2
Possible fishery recovery	2																								2	0	0	0
Totals																												
Total Below Mission	2	0	0	1	3	2	5	1	0	79	27	65	8	8	16	49	6	23	14	34	7	32	2	4	2	118	97	167
Total at or Above Mission	51	1	1	0	1	0	9	0	1	40	20	44	7	8	4	57	8	34	5	26	2	7	3	4	51	73	63	142
Fates																												
Above Mission Fisheries	2	0	0	0	0	0	1	0	0	4	2	7	1	0	0	2	0	2	1	3	0	1	0	0	2	7	8	9
Escapement to Spawning Grounds	23	0	1	0	na	0	2	na	na	18	8	20	5	2	3	36	5	24	3	7	0	3	3	na	23	29	30	81
Other Fate (Above Mission)	26	1	0	0	1	0	6	0	1	18	10	17	1	6	1	19	3	8	1	16	2	3	0	4	26	37	25	52

na – no survey effort in spawning area

* one 4-Harrison fish with terminal zone at Harrison confluence was last detected drifting downstream, too early in year to have spawned

Table 6. DNA classification accuracy for Fraser sockeye. Upper panel: run-timing group agreement between DNA classification and final destination. Lower panel: stock agreement between DNA classification and final destination.

	Final Run-timing Group				
DNA Assignment	Early Stuart	Early Summer	Summer	Late	% correct
Early Stuart	21	0	0	0	100.0%
Early Summer	0	28	0	4	87.5%
Summer	1	0	29	2	90.6%
Late	0	0	1	74	98.7%
Overall	95.5%	100.0%	96.7%	92.5%	95.0%

DNA Assignment	Assigned to Correct Stock	Mis-assigned	% correct
Early Stuart	21	0	100.0%
Early Summer	28	4	87.5%
Summer	29	3	90.6%
Late-run	59	16	78.7%

Table 7. Estimates of median travel times to Mission and holding periods in Georgia Strait for Late-run sockeye, by 'entry timing' group' and release group. Late-run sockeye either entered the river with the same timing as co-migrating Summer-run sockeye, or delayed river entry until after the majority of the Summer-run sockeye had entered.

Release	Median travel time (d)			Sample Size		
Group	Entry with Summers	Entry after Summers	Delay (d)	Entry with Summers	Entry after Summers	% Entering with Summers
JDF1-3	4.9	20.7	15.7	18	4	82%
JS1	8.0	30.3	22.3	6	15	29%
JS2	11.3	25.9	14.6	6	19	24%
JS3	8.7	19.9	11.2	1	36	3%
JS4	x	20.4	x	0	37	0%

Table 8. Travel speeds for radio-tagged sockeye, by run-timing group, for certain river reaches in 2010.

	Sockeye Run Timing Groups			
River Reach	Early Stuart	Early Summer	Summer-run	Late-run
Travel speed (km/d)				
Mission - Hope	41.5	37.7	39.2	29.7
Mission - Hell's Gate	38.2	32.3	32.2	26.4
Mission - Thompson Junction	37.9	30.1	29.6	24.8
Mission - Chilcotin	42.5		29.7	
Mission - Quesnel	45.7		32.2	
Thompson Junction - Spence's Bridge		25.0		18.4
Thompson Junction - Kamloops		26.1		23.0
Thompson Junction - Little River		27.8		24.5
Thompson Junction - Seton	52.4	34.2	35.3	
Thompson Junction - Chilcotin	49.3		41.0	
Thompson Junction - Quesnel	52.9		43.0	
Sample Size (n)				
Mission - Hope	26	38	30	100
Mission - Hell's Gate	30	40	31	106
Mission - Thompson Junction	26	31	26	99
Mission - Chilcotin	18	1	5	0
Mission - Quesnel	12	1	9	0
Thompson Junction - Spence's Bridge	0	32	1	80
Thompson Junction - Kamloops	0	20	1	73
Thompson Junction - Little River	0	15	1	84
Thompson Junction - Seton	20	5	23	0
Thompson Junction - Chilcotin	26	1	15	0
Thompson Junction - Quesnel	17	1	14	0

Table 9. Travel speeds for radio-tagged sockeye, by run-timing group, for sequential river reaches in 2010.

	Sockeye Run Timing Groups			
River Reach	Early Stuart	Early Summer	Summer-run	Late-run
Travel speed (km/d)				
FW - Mission	22.6	4.5		
JDF - Mission		34.1	34.6	26.4
JS - Mission		39.4	40.5	12.8
Mission - Rosedale	38.5	37.3	40.8	28.0
Rosedale - Hope	52.1	36.6	44.7	36.8
Hope - Qualark	35.0	24.9	24.0	17.9
Qualark - Sawmill	27.6	26.9	21.4	18.7
Sawmill - Hell's Gate	44.6	31.3	38.1	23.3
Hell's Gate - Thompson Junction	36.8	27.8	27.5	25.9
Thompson Junction - Spence's Bridge		23.0		18.4
Spence's Bridge - Ashcroft		82.3		24.0
Ashcroft - Kamloops		32.9		27.0
Kamloops - Little River		13.7		37.5
Thompson Junction - Seton	34.0	22.2	26.8	
Seton - Bridge	178.3	174.9	51.0	
Bridge - Kelly	103.2	72.3	54.3	
Kelly - Chilcotin	21.3		18.2	
Chilcotin - Quesnel	21.1		50.5	
Quesnel - Nechako	3.8		3.0	
Sample Size (n)				
FW - Mission	35	6	0	0
JDF - Mission	0	40	28	16
JS - Mission	0	4	12	104
Mission - Rosedale	11	3	4	25
Rosedale - Hope	10	3	3	24
Hope - Qualark	31	33	43	97
Qualark - Sawmill	37	39	49	109
Sawmill - Hell's Gate	46	60	52	118
Hell's Gate - Thompson Junction	42	41	44	108
Thompson Junction - Spence's Bridge	0	32	1	80
Spence's Bridge - Ashcroft	0	29	1	82
Ashcroft - Kamloops	0	16	1	73
Kamloops - Little River	0	12	1	69
Thompson Junction - Seton	20	5	23	0
Seton - Bridge	18	5	22	0
Bridge - Kelly	27	2	24	1
Kelly - Chilcotin	24	1	4	0
Chilcotin - Quesnel	15	1	8	0
Quesnel - Nechako	14	1	7	0

Table 10. Summary of reported and estimated fishery recoveries in marine areas and in the Fraser downstream of Mission. Also shown is the number of tags detected within the Fraser watershed and the percent of the tags that have been 'accounted for' for each marine tagging period, 2010.

	Marine Tagging Periods							
	Juan de Fuca			Johnstone St.				
	1	2	3	1	2	3	4	Total
Tags applied	115	85	103	101	100	80	77	661
Reported fishery recoveries below Mission								
Marine								
Canada				3	6	1		10
US	1	1	6				1	9
Fraser River Below Mission								
First Nations Fishery			2	3	5	5	2	17
Commercial Fishery	1	1	3					5
Sub-total Marine	1	1	6	3	6	1	1	19
Sub-total FW	1	1	5	3	5	5	2	22
Estimated fishery recoveries below Mission								
Marine	1.4	2.2	8.0	11.6	16.4	2.8	2.8	45.2
Fraser below Mission	1.4	2.2	6.6	11.6	13.6	14.0	5.7	55.2
Detections at or above Mission	34	34	47	36	37	45	39	272
Detections Crescent Is		1	1		1			3
Tags accounted for	36.7	39.5	62.6	59.2	68.0	61.8	47.5	375.4
% of tags applied accounted for	32%	46%	61%	59%	68%	77%	62%	57%

Table 11. Summary of reported and estimated sockeye fishery recoveries, and reporting (return) rates for fisheries between Mission and Sawmill and upstream of Sawmill, by Mission Passage Period and run-timing group, 2010.

Early Stuart

	Mission-Sawmill Fishery			Above Sawmill		
Mission Passage Period	Tags Returned	Est. Tags Caught	Return Rate	Tags Returned	Est. Tags Caught	Return Rate
1	0.0	0.1	0.0%	0.0	0.1	0.0%
2	0.0	0.1	0.0%	0.0	0.3	0.0%
3	0.0	0.0	0.0%	2.0	0.2	1321.6%
4	0.0	0.0		0.0	0.0	
5	0.0	0.0		0.0	0.0	
6	0.0	0.0		0.0	0.0	
7	0.0	0.0		0.0	0.0	
8	0.0	0.0		0.0	0.0	
9	0.0	0.0		0.0	0.0	
10	0.0	0.0		0.0	0.0	
11	0.0	0.0		0.0	0.0	
12	0.0	0.0		0.0	0.0	
13	0.0	0.0		0.0	0.0	
Total	0.0	0.2	0.0%	2.0	0.6	323.7%

Summer-run

	Mission-Sawmill Fishery			Above Sawmill		
Mission Passage Period	Tags Returned	Est. Tags Caught	Return Rate	Tags Returned	Est. Tags Caught	Return Rate
1	0.0	0.0		0.0	0.0	
2	0.0	0.0		0.0	0.0	
3	0.0	0.0	0.0%	0.0	0.2	0.0%
4	0.0	1.3	0.0%	1.0	0.9	111.2%
5	0.0	0.6	0.0%	2.0	0.6	346.0%
6	1.0	1.0	103.9%	1.0	0.8	123.4%
7	0.0	0.4	0.0%	1.0	0.1	908.2%
8	1.0	0.3	336.1%	0.0	0.5	0.0%
9	0.0	0.6		1.0	0.4	241.0%
10	0.0	0.2		0.0	0.1	0.0%
11	0.0	0.0		0.0	0.0	
12	0.0	0.0		0.0	0.0	
13	0.0	0.0		0.0	0.0	
Total	2.0	4.4	45.5%	6.0	3.5	171.2%

Early Summer

	Mission-Sawmill Fishery			Above Sawmill		
Mission Passage Period	Tags Returned	Est. Tags Caught	Return Rate	Tags Returned	Est. Tags Caught	Return Rate
1	0.0	0.0		0.0	0.0	
2	0.0	0.0	0.0%	0.0	0.0	-
3	0.0	0.1	0.0%	0.0	0.4	0.0%
4	1.0	2.0	51.0%	0.0	0.8	0.0%
5	0.0	0.9	0.0%	2.0	0.4	465.4%
6	1.0	0.8	124.4%	0.0	0.2	0.0%
7	0.0	0.4	0.0%	0.0	0.1	0.0%
8	2.0	0.3	667.3%	0.0	0.0	-
9	0.0	0.1	0.0%	1.0	0.0	-
10	0.0	0.0		0.0	0.0	
11	0.0	0.0		0.0	0.0	
12	0.0	0.0		0.0	0.0	
13	0.0	0.0		0.0	0.0	
Total	4.0	4.5	88.2%	3.0	2.0	149.7%

Late-run

	Mission-Sawmill Fishery			Above Sawmill		
Mission Passage Period	Tags Returned	Est. Tags Caught	Return Rate	Tags Returned	Est. Tags Caught	Return Rate
1	0.0	0.0		0.0	0.0	
2	0.0	0.0		0.0	0.0	
3	0.0	0.0		0.0	0.0	
4	0.0	0.2	0.0%	0.0	0.1	0.0%
5	1.0	0.1	769.0%	0.0	0.1	0.0%
6	1.0	0.7	134.6%	0.0	0.2	0.0%
7	3.0	0.5	612.4%	0.0	0.1	0.0%
8	0.0	0.2	0.0%	0.0	0.0	-
9	1.0	1.2	80.2%	0.0	0.2	0.0%
10	0.0	0.9	0.0%	0.0	0.6	0.0%
11	2.0	1.5	130.1%	1.0	1.7	59.4%
12	0.0	0.1	0.0%	0.0	3.1	0.0%
13	0.0	0.2	0.0%	0.0	1.3	0.0%
Total	8.0	5.8	137.8%	1.0	7.3	13.7%

Table 12. En-route loss between Mission and Sawmill, by sockeye run-timing group and Mission Passage Period, 2010. Estimated catch of tags between Mission and Sawmill is the larger of the reported vs. estimated season-wide sockeye fishery recoveries; the Mission-passage-period specific values of 'estimated catch' are drawn from Table 11.

Early Stuart

	Estimation of Tagging Effects (Mission to Sawmill)						
Mission Passage Period	Tags Passing Mission	Est. Catch of Tags	Pooled HR for Miss-Saw	Tags at Sawmill Pred.	Obs.	Diff.	En-route Loss
1	16	0.1	0.4%	15.9	16	-0.1	0%
2	25	0.1	0.2%	24.9	21	3.9	16%
3	10	0.0	0.4%	10.0	9	1.0	10%
4	0	0.0		0.0	0	0.0	
5	0	0.0		0.0	0	0.0	
6	0	0.0		0.0	0	0.0	
7	0	0.0		0.0	0	0.0	
8	0	0.0		0.0	0	0.0	
9	0	0.0		0.0	0	0.0	
10	0	0.0		0.0	0	0.0	
11	0	0.0		0.0	0	0.0	
12	0	0.0		0.0	0	0.0	
13	0	0.0		0.0	0	0.0	
Total	51	0.2	0.3%	50.8	46	4.8	10%

Summer-run

	Estimation of Tagging Effects (Mission to Sawmill)						
Mission Passage Period	Tags Passing Mission	Est. Catch of Tags	Pooled HR for Miss-Saw	Tags at Sawmill Pred.	Obs.	Diff.	En-route Loss
1	0	0.0		0.0	0	0.0	
2	0	0.0		0.0	0	0.0	
3	1	0.0	0.4%	1.0	1	0.0	0%
4	15	1.3	8.9%	13.7	11	2.7	18%
5	11	0.6	5.2%	10.4	9	1.4	13%
6	14	1.0	6.9%	13.0	12	1.0	7%
7	5	0.4	7.6%	4.6	4	0.6	12%
8	8	0.3	3.7%	7.7	7	0.7	9%
9	6	0.6	10.0%	5.4	6	-0.6	-10%
10	3	0.2	8.0%	2.8	3	-0.2	-8%
11	0	0.0		0.0	0	0.0	
12	0	0.0		0.0	0	0.0	
13	0	0.0		0.0	0	0.0	
Total	63	4.4	7.0%	58.6	53	5.6	9%

Early Summer

	Estimation of Tagging Effects (Mission to Sawmill)						
Mission Passage Period	Tags Passing Mission	Est. Catch of Tags	Pooled HR for Miss-Saw	Tags at Sawmill Pred.	Obs.	Diff.	En-route Loss
1	0	0.0		0.0	0	0.0	
2	2	0.0	0.4%	2.0	2	0.0	0%
3	11	0.1	0.7%	10.9	9	1.9	17%
4	24	2.0	8.2%	22.0	19	3.0	13%
5	15	0.9	6.0%	14.1	14	0.1	1%
6	11	0.8	7.3%	10.2	9	1.2	11%
7	5	0.4	8.4%	4.6	5	-0.4	-8%
8	4	0.3	7.5%	3.7	2	1.7	43%
9	1	0.1	6.0%	0.9	1	-0.1	-6%
10	0	0.0		0.0	0	0.0	
11	0	0.0		0.0	0	0.0	
12	0	0.0		0.0	0	0.0	
13	0	0.0		0.0	0	0.0	
Total	73	4.5	6.2%	68.5	61	7.5	10%

Late-run

	Estimation of Tagging Effects (Mission to Sawmill)						
Mission Passage Period	Tags Passing Mission	Est. Catch of Tags	Pooled HR for Miss-Saw	Tags at Sawmill +Harrison Pred.	Obs.	Diff.	En-route Loss
1	0	0.0		0.0	0	0.0	
2	0	0.0		0.0	0	0.0	
3	0	0.0		0.0	0	0.0	
4	4	0.0	0.0%	4.0	2	2.0	50%
5	3	1.0	33.3%	2.0	2	0.0	0%
6	11	1.0	9.1%	10.0	10	0.0	0%
7	8	3.0	37.5%	5.0	3	2.0	25%
8	2	0.0	0.0%	2.0	2	0.0	0%
9	13	1.0	7.7%	12.0	11	1.0	8%
10	18	0.0	0.0%	18.0	18	0.0	0%
11	43	2.0	4.7%	41.0	41	0.0	0%
12	31	0.0	0.0%	31.0	31	0.0	0%
13	9	0.0	0.0%	9.0	9	0.0	0%
Total	142	8.0	5.6%	134.0	129	5.0	4%

Table 13. Survival of radio-tagged sockeye to spawning areas, by run-timing group and by Mission passage period. Shaded Passage Periods were not included in the survival calculations.

Early Stuart

Mission Passage Periods		Radio Tagged Sockeye							Sockeye		
Number	Dates	Tags Past Mission	Tag Loss	Harvest	Tags after Harvest	Tags in Spawning Areas	Survival (Miss-Spawn)	Survival (after harvest)	Abundance at Mission	Abundance After Harvest	Est. Fish in Spawning Areas
1	4 Jul to 10 Jul	16	-0.1	0.2	15.9	9	56.0%	56.7%	38,267	37,780	21,440
2	11 Jul to 17 Jul	25	3.9	0.4	20.7	12	57.0%	58.0%	38,468	37,773	21,925
3	18 Jul to 24 Jul	10	1.0	0.2	8.8	2	22.1%	22.6%	12,455	12,198	2,757
4	25 Jul to 31 Jul	0	0.0	0.0	0.0	0	-	-	1,866	-	?
5	1 Aug to 7 Aug	0	0.0	0.0	0.0	0	-	-	786	-	?
6	8 Aug to 14 Aug	0	0.0	0.0	0.0	0	-	-	145	-	?
7	15 Aug to 21 Aug	0	0.0	0.0	0.0	0	-	-	0	-	0
8	22 Aug to 28 Aug	0	0.0	0.0	0.0	0	-	-	0	-	0
9	29 Aug to 4 Sep	0	0.0	0.0	0.0	0	-	-	0	-	0
10	5 Sep to 11 Sep	0	0.0	0.0	0.0	0	-	-	0	-	0
11	12 Sep to 18 Sep	0	0.0	0.0	0.0	0	-	-	0	-	0
12	19 Sep to 25 Sep	0	0.0	0.0	0.0	0	-	-	0	-	0
13	26 Sep to 2 Oct	0	0.0	0.0	0.0	0	-	-	0	-	0
Totals (excluding shaded cells)		51	4.8	0.8	45.4	23			89,190	87,752	46,122
Weighted Average							51.7%	52.6%			

Early Summer

Mission Passage Periods		Radio Tagged Sockeye							Sockeye		
Number	Dates	Tags Past Mission	Tag Loss	Harvest	Tags after Harvest	Tags in Spawning Areas	Survival (Miss-Spawn)	Survival (after harvest)	Abundance at Mission	Abundance After Harvest	Est. Fish in Spawning Areas
1	4 Jul to 10 Jul	0	0.0	0.0	0.0	0	-	-	1,493	-	?
2	11 Jul to 17 Jul	2	0.0	0.0	2.0	1	49.8%	51.0%	9,848	9,624	4,906
3	18 Jul to 24 Jul	11	1.9	0.5	8.6	6	66.1%	70.0%	45,788	43,253	30,263
4	25 Jul to 31 Jul	24	3.0	2.8	18.2	10	47.7%	55.0%	281,775	244,583	134,423
5	1 Aug to 7 Aug	15	0.1	1.3	13.6	5	33.5%	36.8%	596,723	543,328	200,190
6	8 Aug to 14 Aug	11	1.2	1.0	8.8	5	51.0%	56.7%	520,178	467,884	265,293
7	15 Aug to 21 Aug	5	-0.4	0.5	4.9	2	36.9%	40.7%	569,265	516,349	210,018
8	22 Aug to 28 Aug	4	1.7	0.3	2.0	0	0.0%	0.0%	414,501	-	0
9	29 Aug to 4 Sep	1	-0.1	0.1	1.0	0	0.0%	0.0%	133,582	-	0
10	5 Sep to 11 Sep	0	0.0	0.0	0.0	0	-	-	41,637	-	?
11	12 Sep to 18 Sep	0	0.0	0.0	0.0	0	-	-	0	-	0
12	19 Sep to 25 Sep	0	0.0	0.0	0.0	0	-	-	0	-	0
13	26 Sep to 2 Oct	0	0.0	0.0	0.0	0	-	-	0	-	0
Totals (excluding shaded cells)		68	5.8	6.1	56.0	29			2,023,577	1,825,021	845,094
Weighted Average							41.8%	46.3%			

..continued

Table 13 continued.

Summer-run

Mission Passage Periods		Radio Tagged Sockeye							Sockeye		
Number	Dates	Tags Past Mission	Tag Loss	Harvest	Tags after Harvest	Tags in Spawning Areas	Survival (Miss-Spawn)	Survival (after harvest)	Abundance at Mission	Abundance After Harvest	Est. Fish in Spawning Areas
1	4 Jul to 10 Jul	0	0.0	0.0	0.0	0	-	-	6	-	?
2	11 Jul to 17 Jul	0	0.0	0.0	0.0	0	-	-	1,650	-	?
3	18 Jul to 24 Jul	1	0.0	0.2	0.8	1	99.6%	117.8%	14,557	12,313	14,501
4	25 Jul to 31 Jul	15	2.7	2.2	10.1	6	48.6%	59.4%	150,488	123,172	73,168
5	1 Aug to 7 Aug	11	1.4	1.2	8.4	2	20.9%	23.7%	462,901	407,171	96,692
6	8 Aug to 14 Aug	14	1.0	1.8	11.2	8	61.7%	71.5%	495,382	427,639	305,741
7	15 Aug to 21 Aug *	5	0.6	0.5	3.9	1	72.0%	81.6%	932,896	823,232	671,394
8	22 Aug to 28 Aug	8	0.7	0.7	6.5	6	82.2%	91.6%	569,510	511,095	468,248
9	29 Aug to 4 Sep	6	-0.6	1.0	5.6	4	60.6%	71.6%	410,622	347,412	248,815
10	5 Sep to 11 Sep	3	-0.2	0.3	2.9	2	61.7%	68.7%	98,901	88,845	61,044
11	12 Sep to 18 Sep	0	0.0	0.0	0.0	0	-	-	2,407	-	?
12	19 Sep to 25 Sep	0	0.0	0.0	0.0	0	-	-	9,126	-	?
13	26 Sep to 2 Oct	0	0.0	0.0	0.0	0	-	-	0	-	0
Totals (excluding shaded cells)		63	5.6	7.9	49.5	30			3,135,257	2,740,878	1,939,603
Weighted Average							61.9%	70.8%			

* Survival estimate for period 7 is the average of those for period 6 and 8 due to small sample size in week 7

Late-run

Mission Passage Periods		Radio Tagged Sockeye							Sockeye		
Number	Dates	Tags Past Mission	Tag Loss	Harvest	Tags after Harvest	Tags in Spawning Areas	Survival (Miss-Spawn)	Survival (after harvest)	Abundance at Mission	Abundance After Harvest	Est. Fish in Spawning Areas
1	4 Jul to 10 Jul	0	0.0	0.0	0.0	0	-	-	429	-	?
2	11 Jul to 17 Jul	0	0.0	0.0	0.0	0	-	-	5,184	-	?
3	18 Jul to 24 Jul	0	0.0	0.0	0.0	0	-	-	26,556	-	?
4	25 Jul to 31 Jul	4	1.8	0.3	1.9	0	0.0%	0.0%	166,008	-	0
5	1 Aug to 7 Aug	3	0.9	0.2	1.9	0	0.0%	0.0%	343,862	-	0
6	8 Aug to 14 Aug *	11	0.3	0.9	9.8	1	9.3%	10.2%	395,096	361,455	36,777
7	15 Aug to 21 Aug	8	4.5	0.5	2.9	0	0.0%	0.0%	486,232	-	0
8	22 Aug to 28 Aug	2	-0.2	0.2	2.0	0	0.0%	0.0%	336,693	-	0
9	29 Aug to 4 Sep	13	0.8	1.5	10.8	7	57.2%	65.1%	1,250,240	1,097,749	714,648
10	5 Sep to 11 Sep	18	-0.9	1.5	17.4	16	84.6%	91.7%	1,758,903	1,621,576	1,487,160
11	12 Sep to 18 Sep	43	0.5	3.2	39.3	34	79.9%	86.5%	2,982,500	2,756,548	2,383,879
12	19 Sep to 25 Sep	31	-0.1	3.2	27.9	29	93.2%	104.0%	2,061,374	1,847,684	1,921,498
13	26 Sep to 2 Oct	9	-0.2	1.5	7.7	5	54.4%	64.9%	402,700	337,790	219,140
Totals (excluding shaded cells)		142	7.2	13.1	121.7	92			10,183,608	8,022,801	6,763,102
Weighted Average							66.4%	84.3%			

* the only tag detected in a spawning area for period 6 was a Harrison sockeye that was last detected at the Harrison junction on Aug 12th, fate unknown.

Table 14. Locations of en-route losses for radio-tagged sockeye, 2010.

River Reach	Early Stuart	Early Summer	Summer-run	Late-run	Total En-route loss	distance (km)	loss per km	Rank
Mission-Harrison	0	5	0	1	6	32	0.18	6
Harrison-Rosedale	0	0	1	1	2	13	0.15	8
Rosedale-Hope	0	0	3	1	4	38	0.11	12
Hope-Qualark	0	1	0	2	3	15	0.20	5
Qualark-Sawmill	0	0	2	0	2	14	0.14	9
Sawmill-Hell's Gate	0	1	0	2	3	22	0.14	10
Hell's Gate-Thompson	0	9	3	5	17	56	0.30	2
Thompson-Spence's Bridge/Seton	0	2	2	4	8	94	0.09	14
Spence's Bridge-Ashcroft		3		2	5	42	0.12	11
Ashcroft-North Thompson		7		6	13	81	0.16	7
North Thompson-Kamloops		0		0	0	24	0.00	19
Kamloops-Little River		5		4	9	39	0.23	4
Little River-Adams		0		4	4	6	0.67	1
Adams-Lower Shuswap		0		0	0	79	0.00	19
Seton-Bridge	0	0	1		1	11	0.09	13
Bridge-Kelly	4	2	1	1	8	34	0.24	3
Kelly-Chilcotin	4	0	5		9	108	0.08	15
Chilcotin-Quesnel	5	0	0		5	160	0.03	17
Quesnel-Nechako	3	0	0		3	151	0.02	18
Nechako-Stuart	3	0	2		5	90	0.06	16

FIGURES

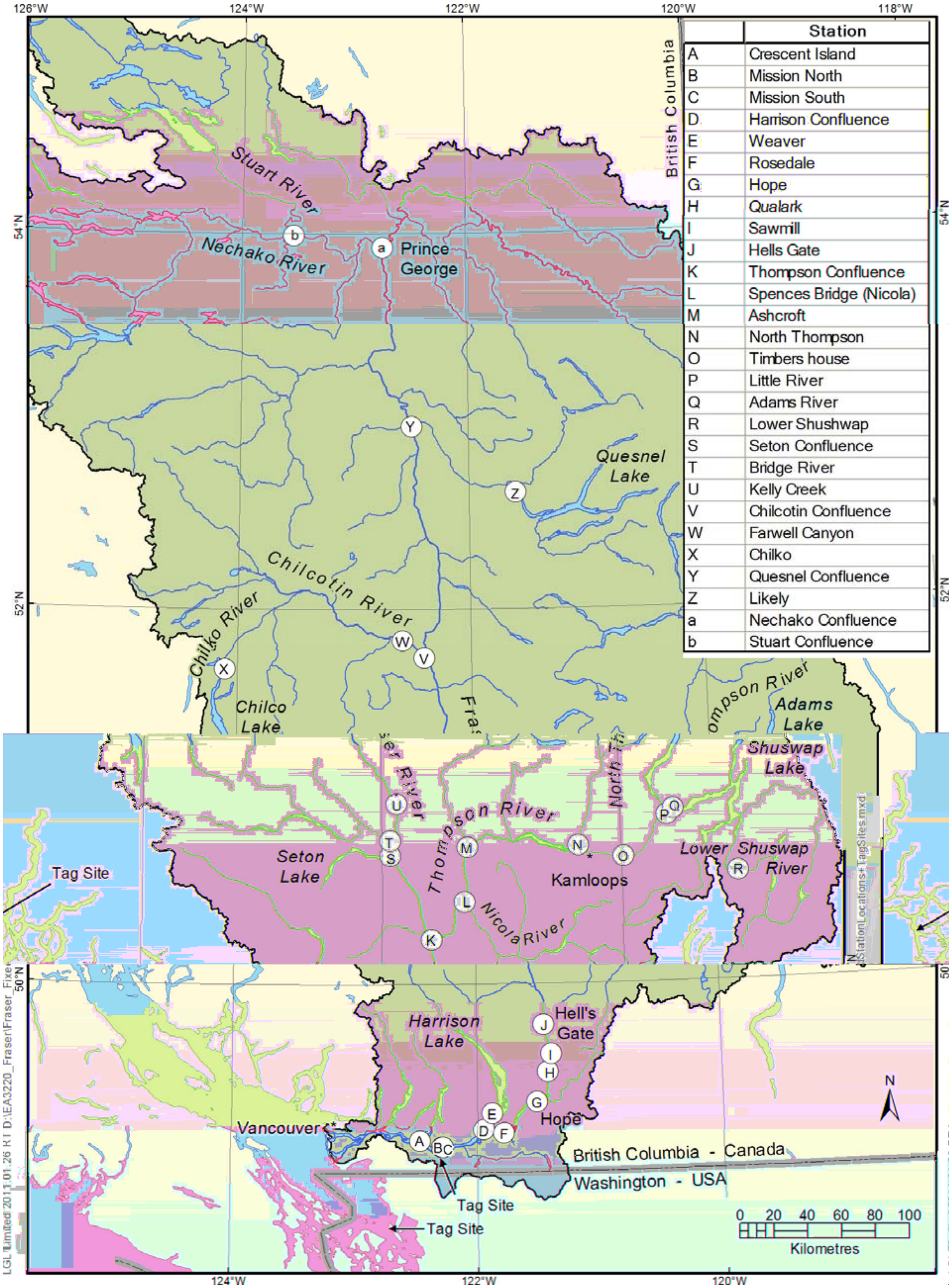


Figure 1. **Location of fixed-station sites for the 2010 radio-telemetry study.**

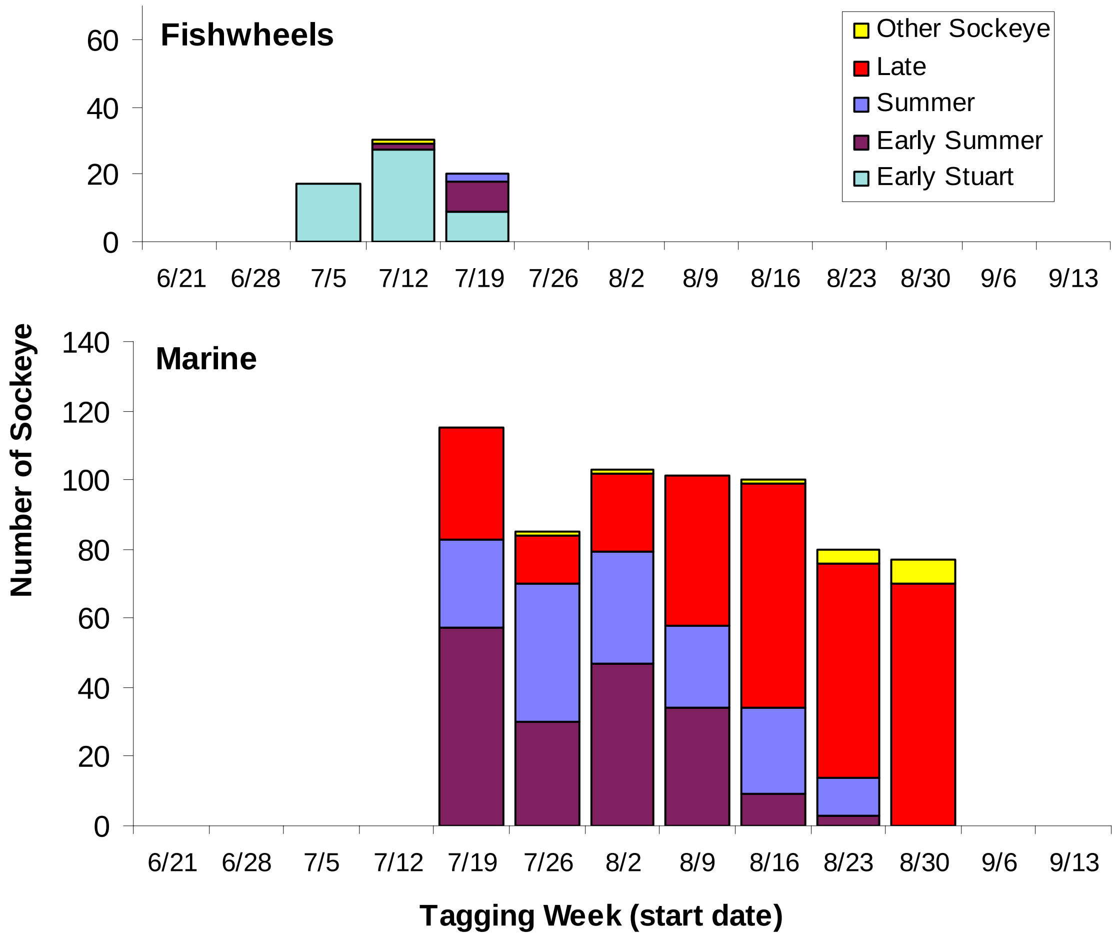


Figure 2. **Stock composition of sockeye radio-tagged at the fishwheels (near Crescent Island) and in marine areas (Juan de Fuca and Johnstone straits) in 2010, by tagging week. "Other sockeye" includes Birkenhead sockeye, and sockeye that were not identified to a stock.**

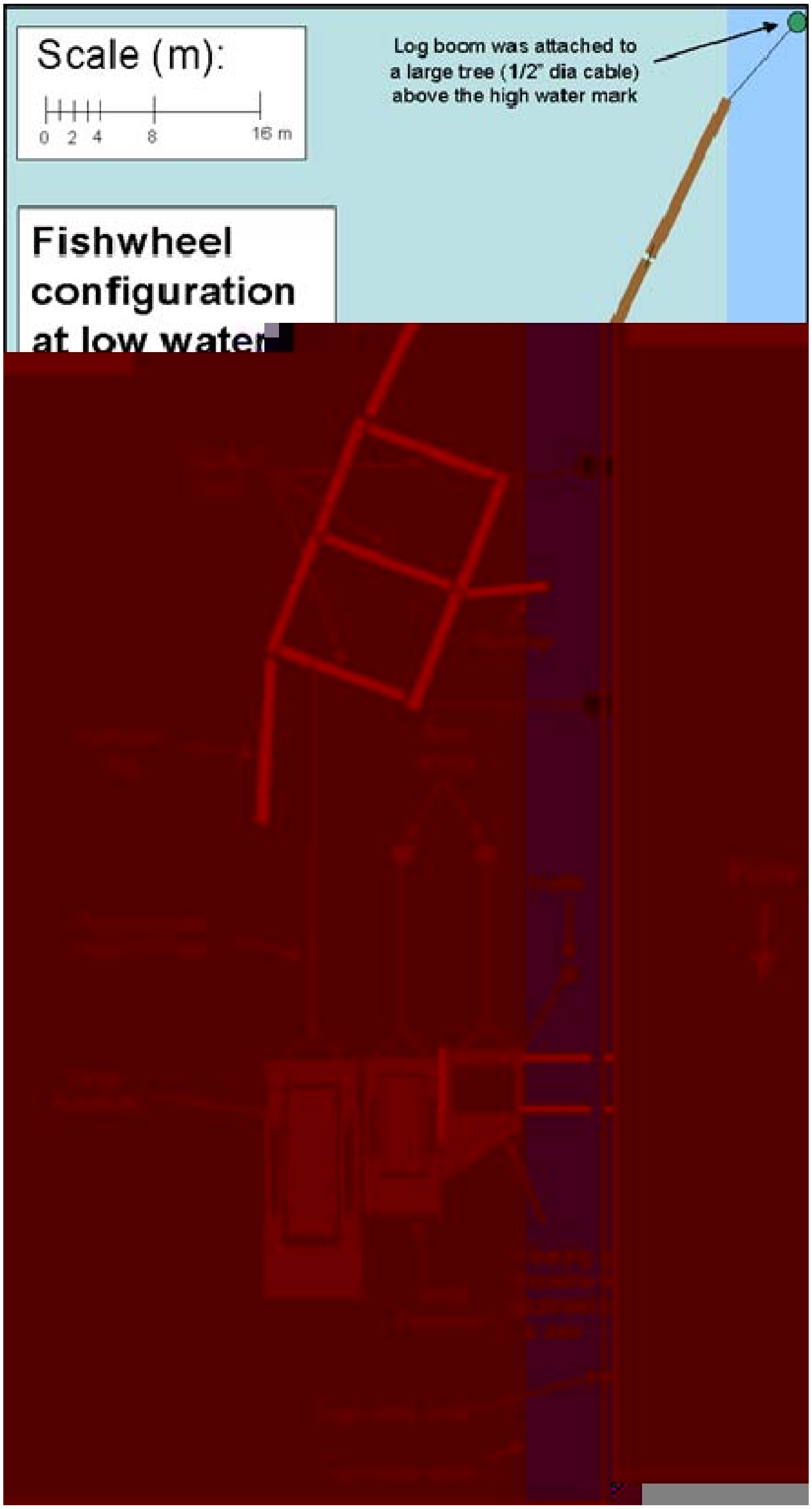


Figure 3. **Schematic of the Crescent site showing the location of the log boom assembly, steel pilings, fishwheels and floating shoreline abutment, 2010.**

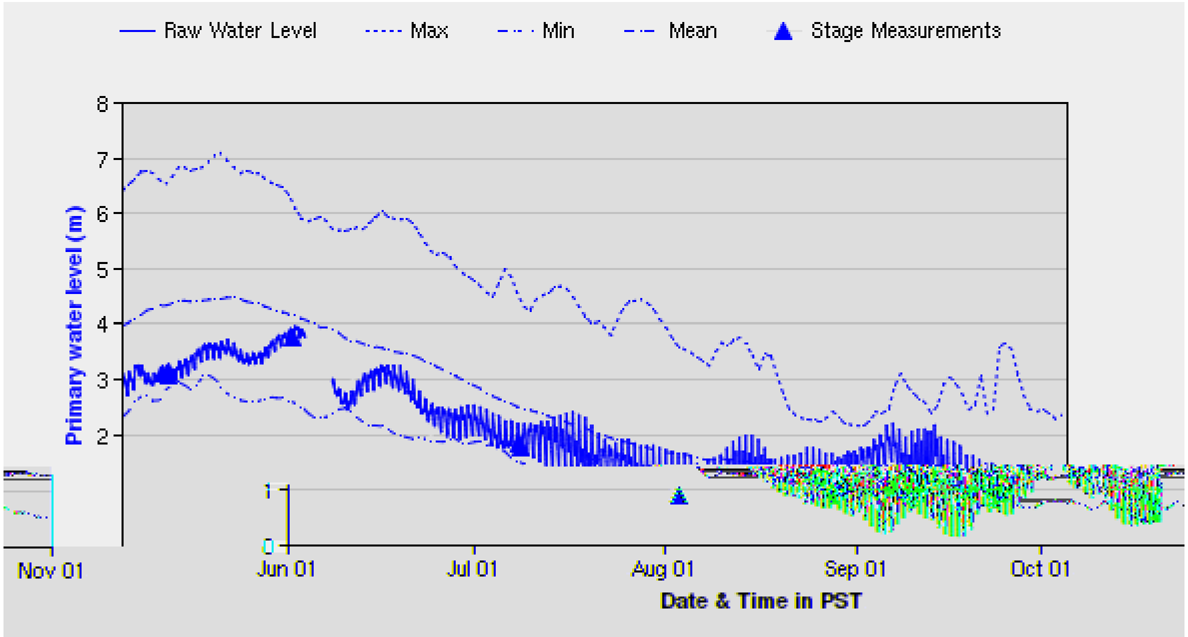


Figure 4. **Fraser River water level (m) measured at a hydrometric station (08MH024) in Mission, BC, from 1 June to 31 October 2010 (Environment Canada 2010).**

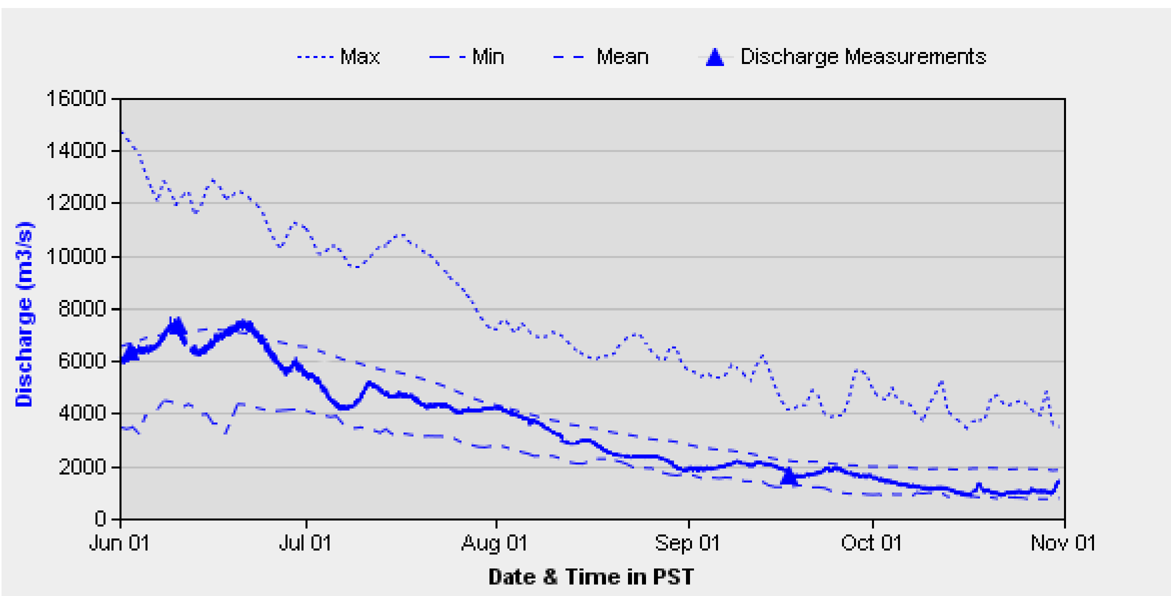


Figure 5. **Fraser River discharge (m^3s^{-1}) measured at a hydrometric station (08MH024) in Mission, BC, from 1 June to 31 October 2010 (Environment Canada 2010).**

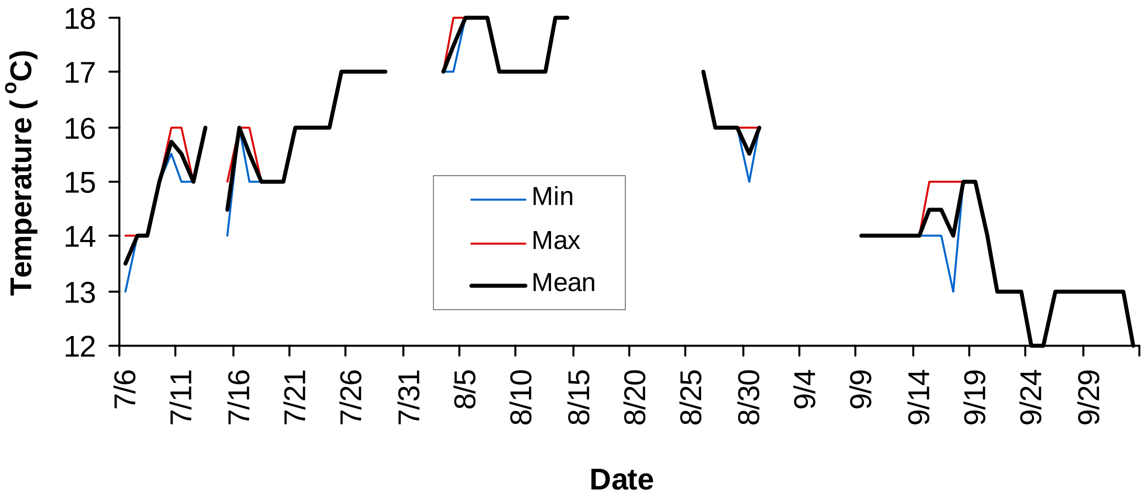


Figure 6. Fraser River water temperature (°C) measured at the Crescent Island fishwheels, 6 July to 3 October 2010. A boat-mounted temperature sensor was used to measure temperature (daily min, max, and mean shown).

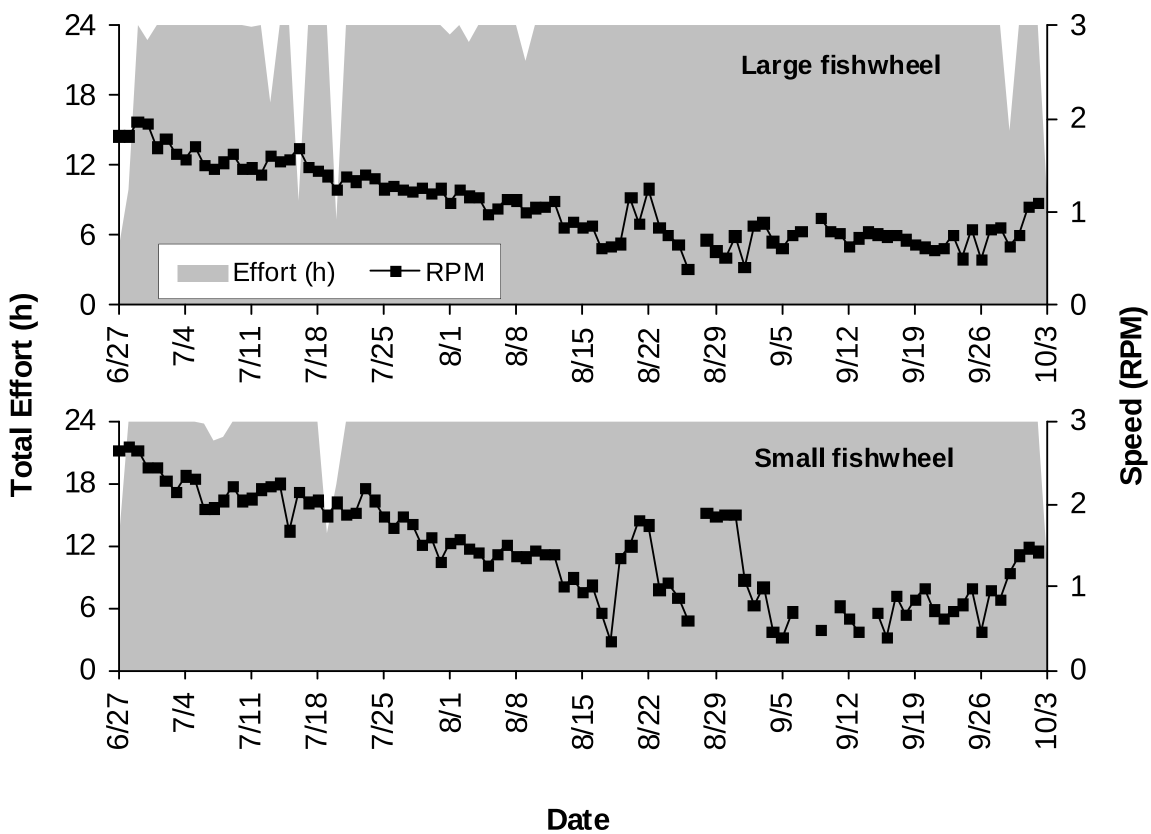
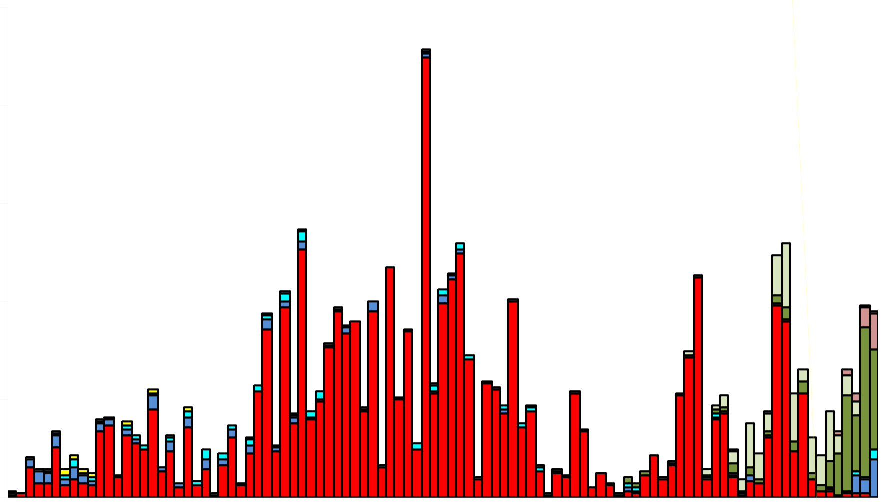


Figure 7. Total effort (h) and speed (RPM) for the Crescent Island fishwheels, 27 June to 3 October 2010.



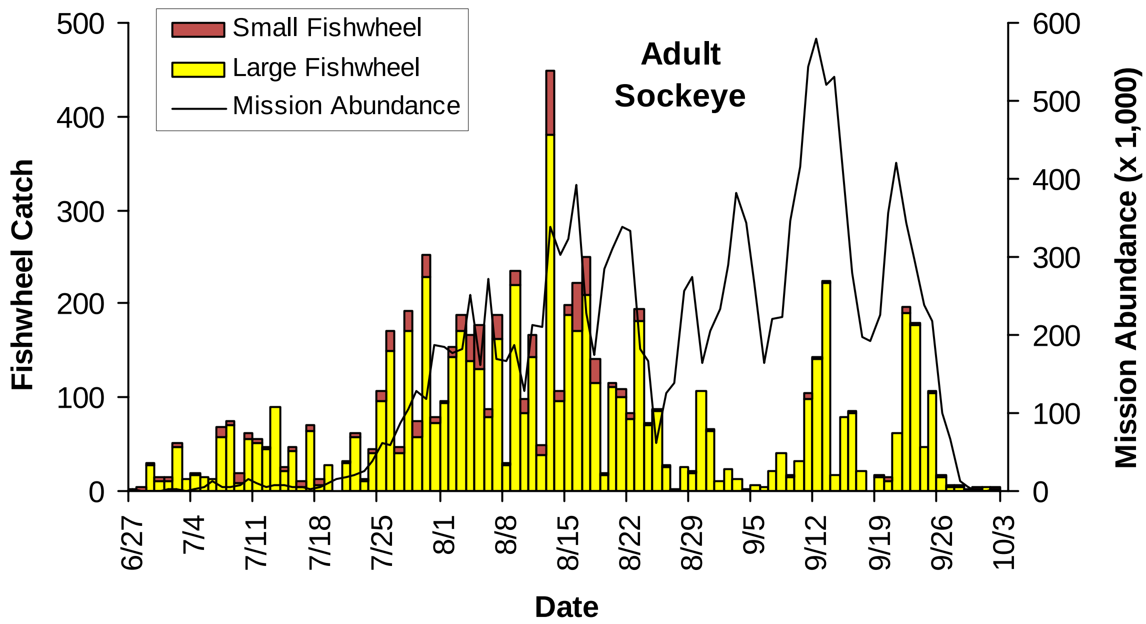


Figure 9. **Daily sockeye abundance estimates at the Mission hydroacoustic site and catches at the Crescent Island fishwheels, 27 June to 3 October 2010.**

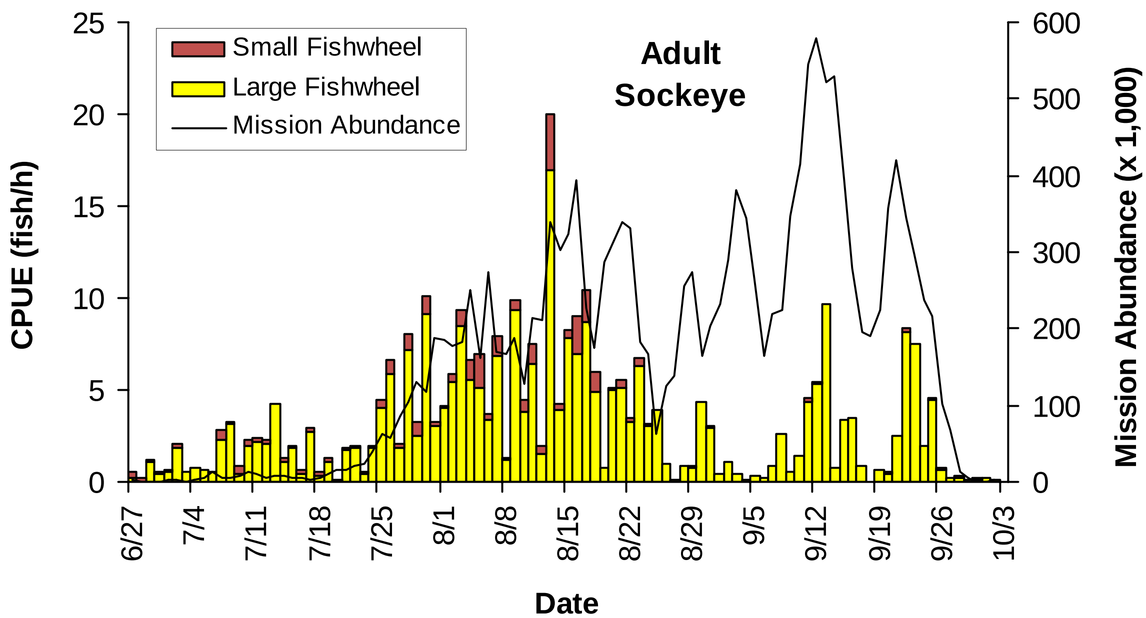


Figure 10. **Daily sockeye abundance estimates at the Mission hydroacoustic site and catch per unit effort (CPUE) at the Crescent Island fishwheels, 27 June to 3 October 2010.**

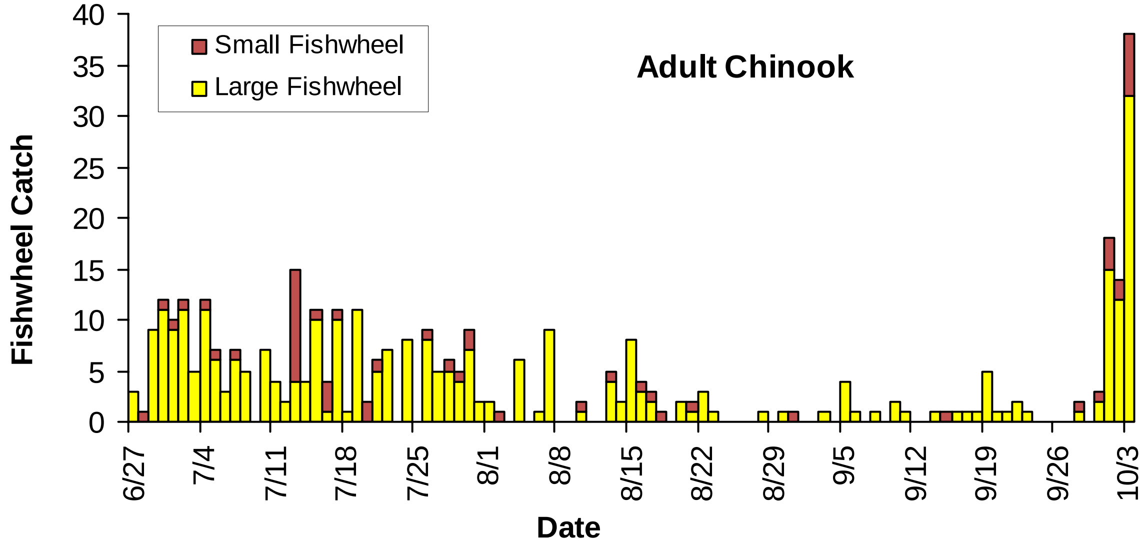


Figure 11. **Daily adult Chinook abundance estimates at the Mission hydroacoustic site and catches at the Crescent Island fishwheels, 27 June to 3 October 2010.**

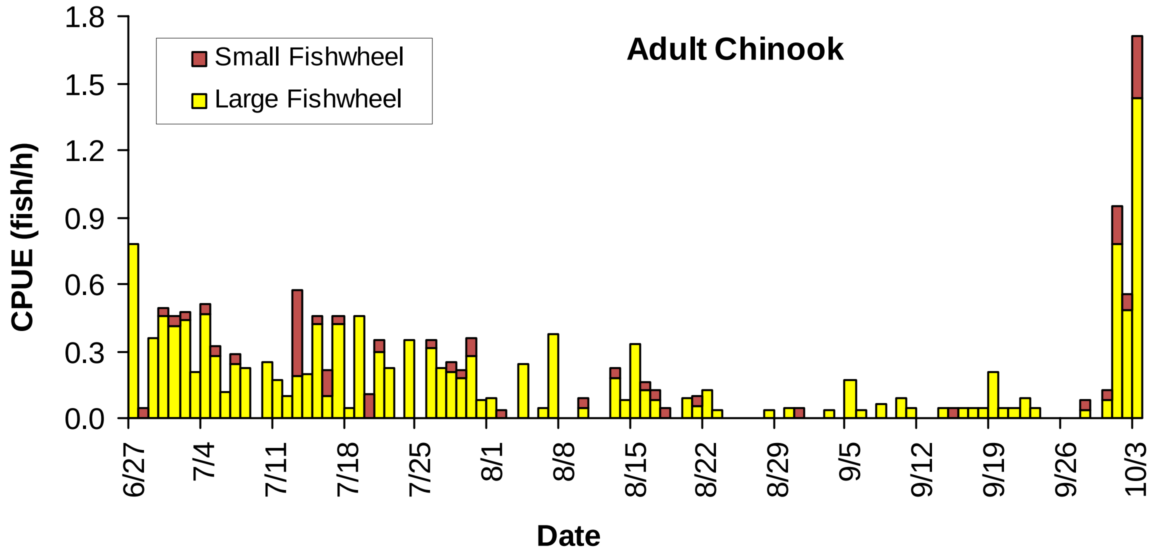


Figure 12. **Daily adult Chinook abundance estimates at the Mission hydroacoustic site and catch per unit effort (CPUE) at the Crescent Island fishwheels, 27 June to 3 October 2010.**

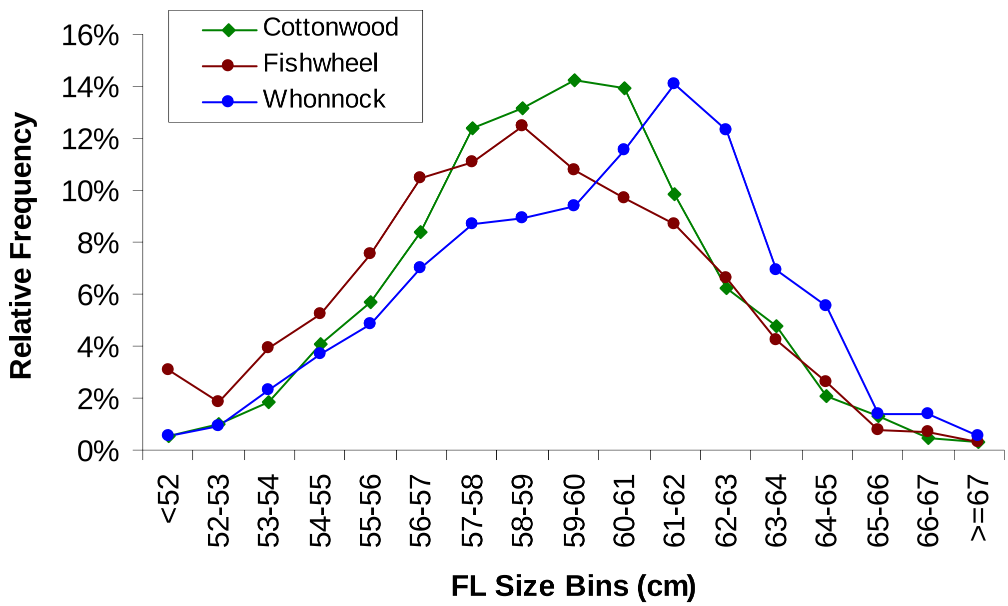


Figure 13. **The relative length frequency distribution of sockeye salmon caught in fishwheels, and in the Cottonwood and Whonnock gillnet test fisheries. Data are for all sockeye caught by each gear (i.e., not stock specific). Whonnock length data were measured as post-orbital fork (POF) length, and transformed to fork length (FL) for this comparison.**

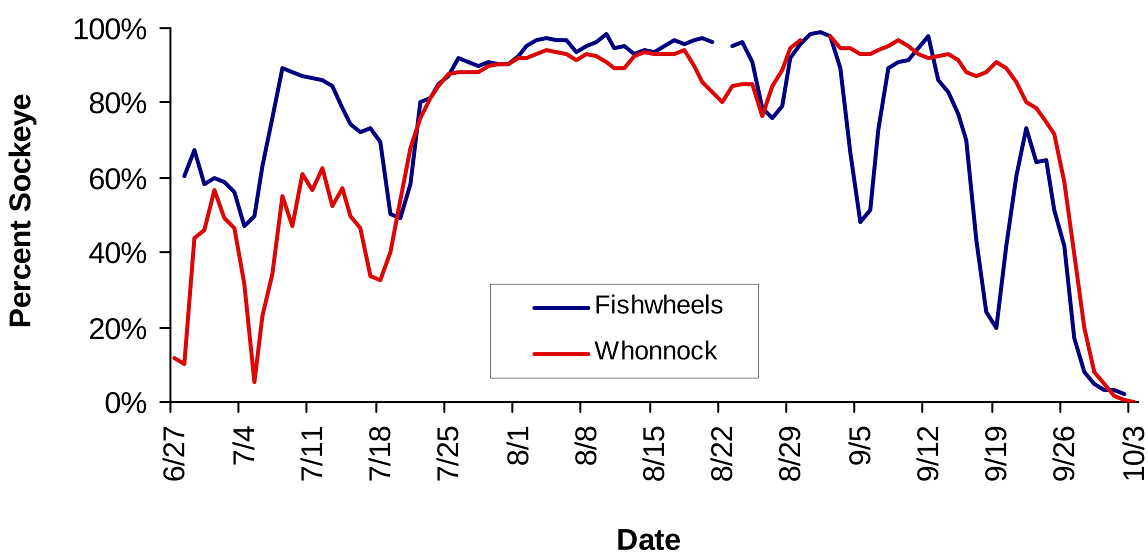


Figure 14. **Percentage of daily catch (3 d moving average) that was comprised of adult sockeye salmon at the Crescent Island fishwheels and in the Whonnock gillnet test fishery, 28 June to 2 October 2010.**

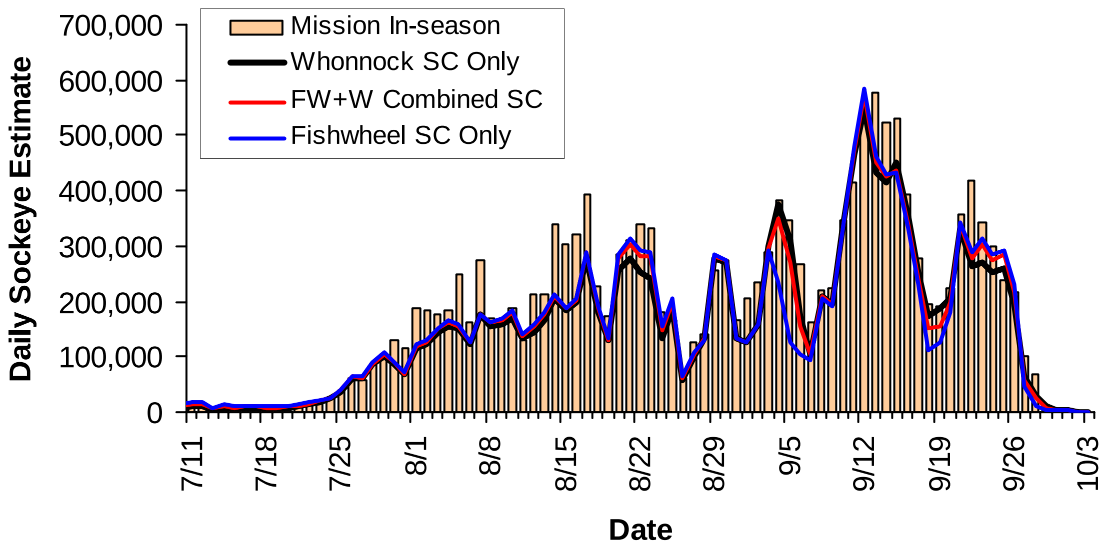


Figure 15. Comparison of the 2010 PSC in-season estimates of daily sockeye passage with those estimated using the total Mission hydroacoustic counts and three alternative species composition (SC) estimates: 1) Whonnock SC only, 2) fishwheel SC only and 3) Whonnock SC for off-shore and fishwheel SC for near-shore.

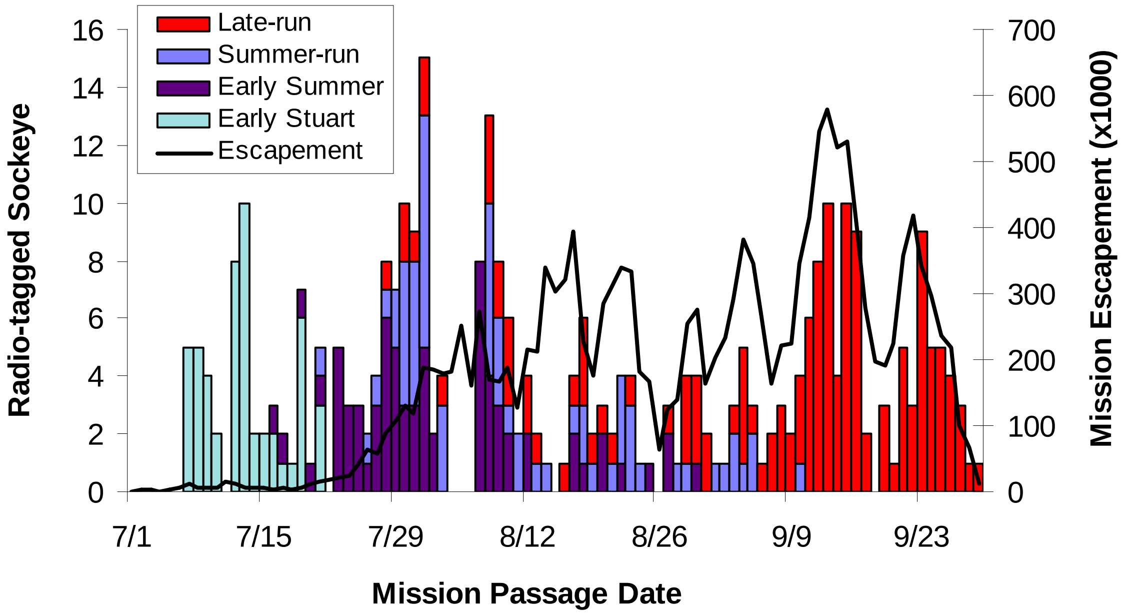


Figure 16. The number of radio-tagged sockeye the passed Mission, by date and run-timing group (bars), and the daily sockeye escapement estimates from the Mission hydroacoustic site (line).

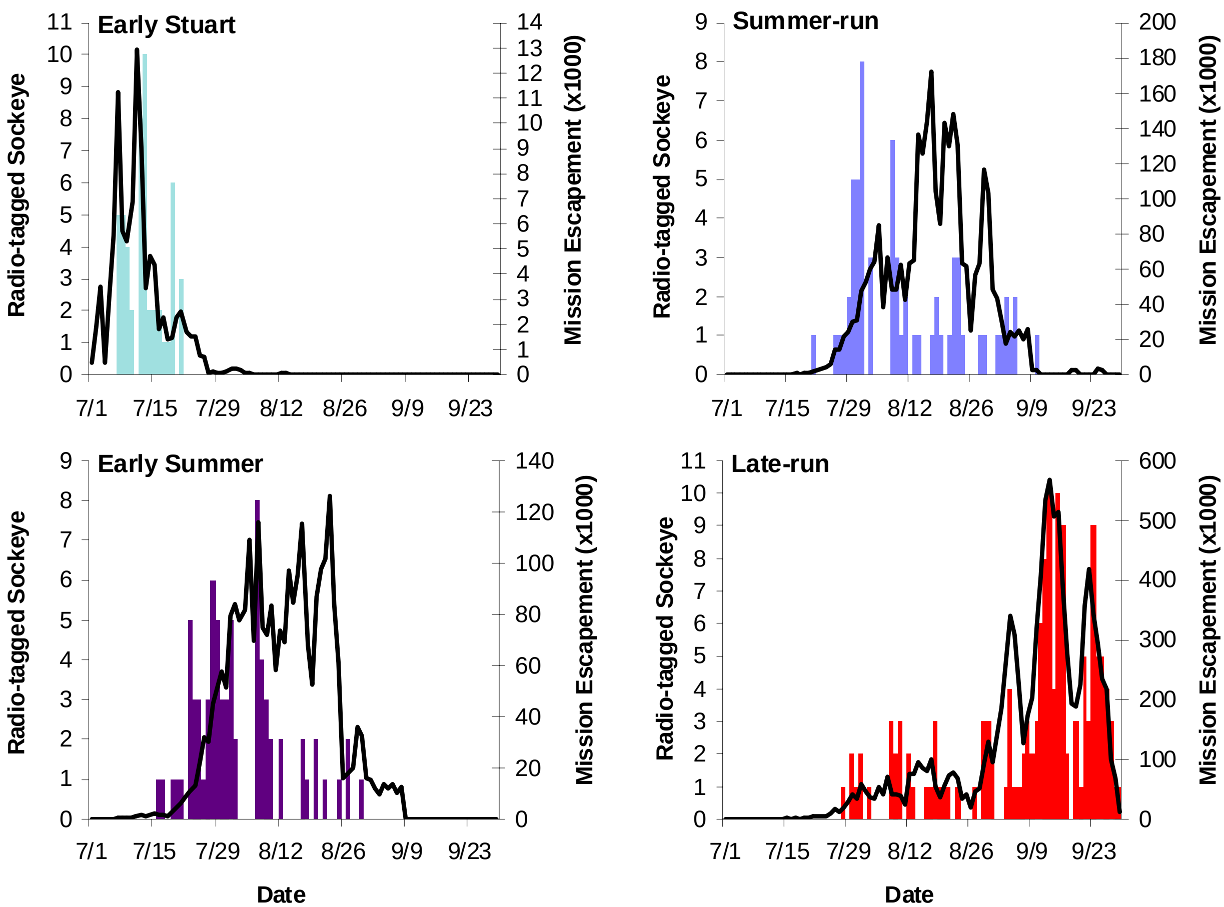


Figure 17. The number of radio-tagged sockeye the passed Mission, by date, shown separately for each run timing group. The lines show run-timing-group-specific daily sockeye escapement estimates from the Mission hydroacoustic site.

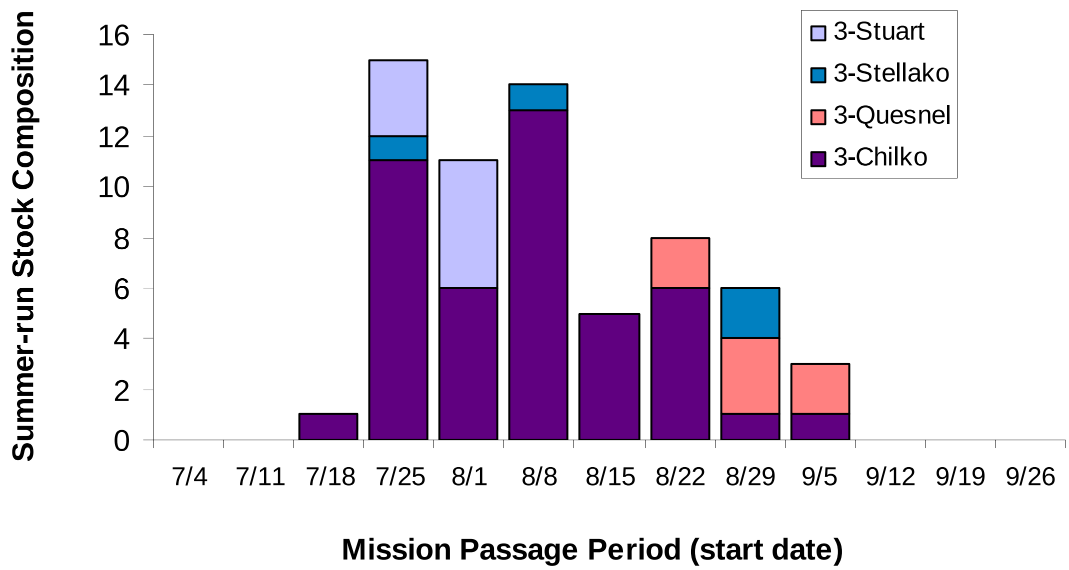


Figure 18. Stock composition of Summer-run sockeye radio-tagged in 2010, by Mission Passage Period.

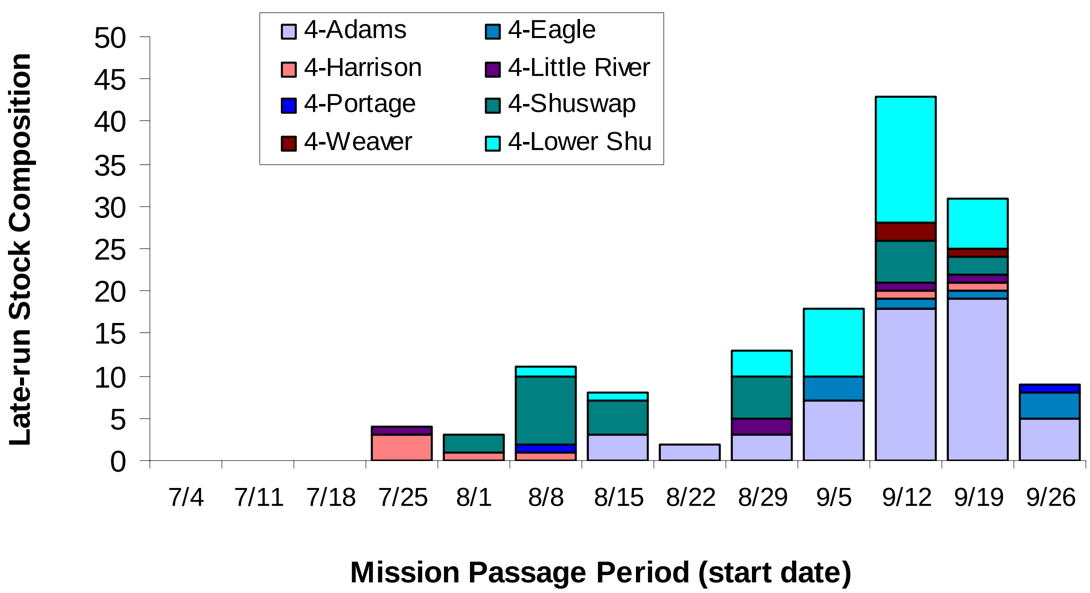
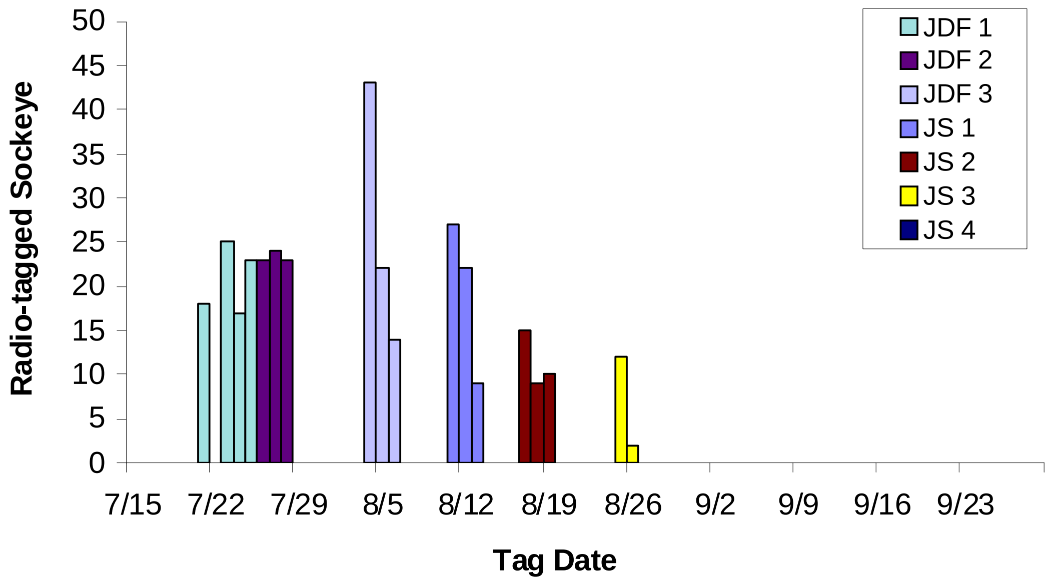


Figure 19. Stock composition of Late-run sockeye radio-tagged in 2010, by Mission Passage Period.



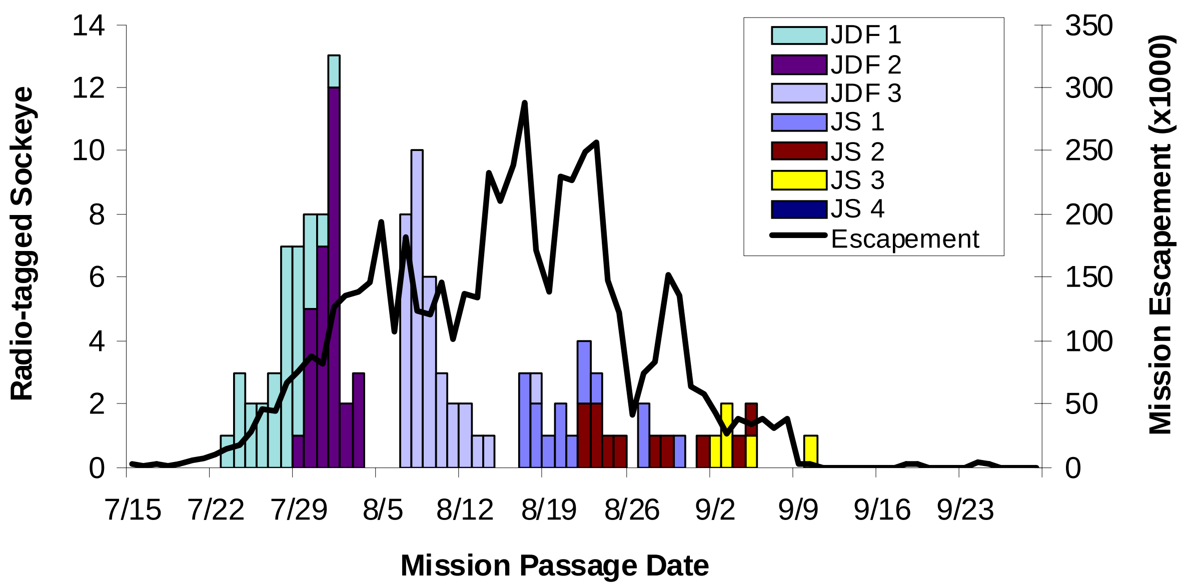
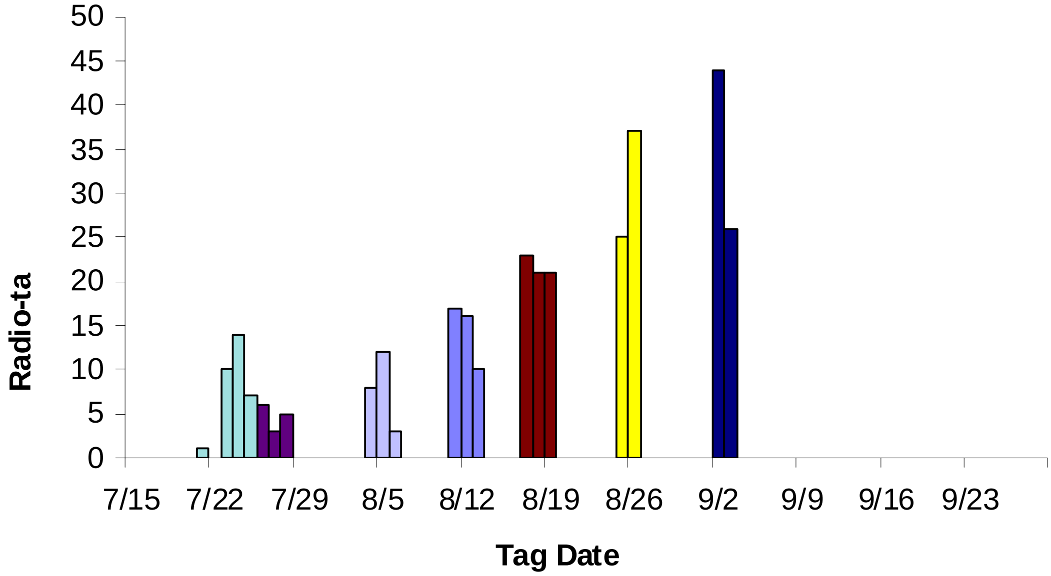


Figure 20. **Number of Early Summer and Summer-run sockeye released (upper panel), and detected at Mission (lower panel) by date and release group. Also on lower panel: Daily escapement estimates for Early Summer and Summer-run sockeye at the Mission hydroacoustic site.**


50
45
40
35
30
25
20
15
10
5
0
Radio-ta
7/15
7/22
7/29
8/5
8/12
8/19
8/26
9/2
9/9
9/16
9/23
Tag Date

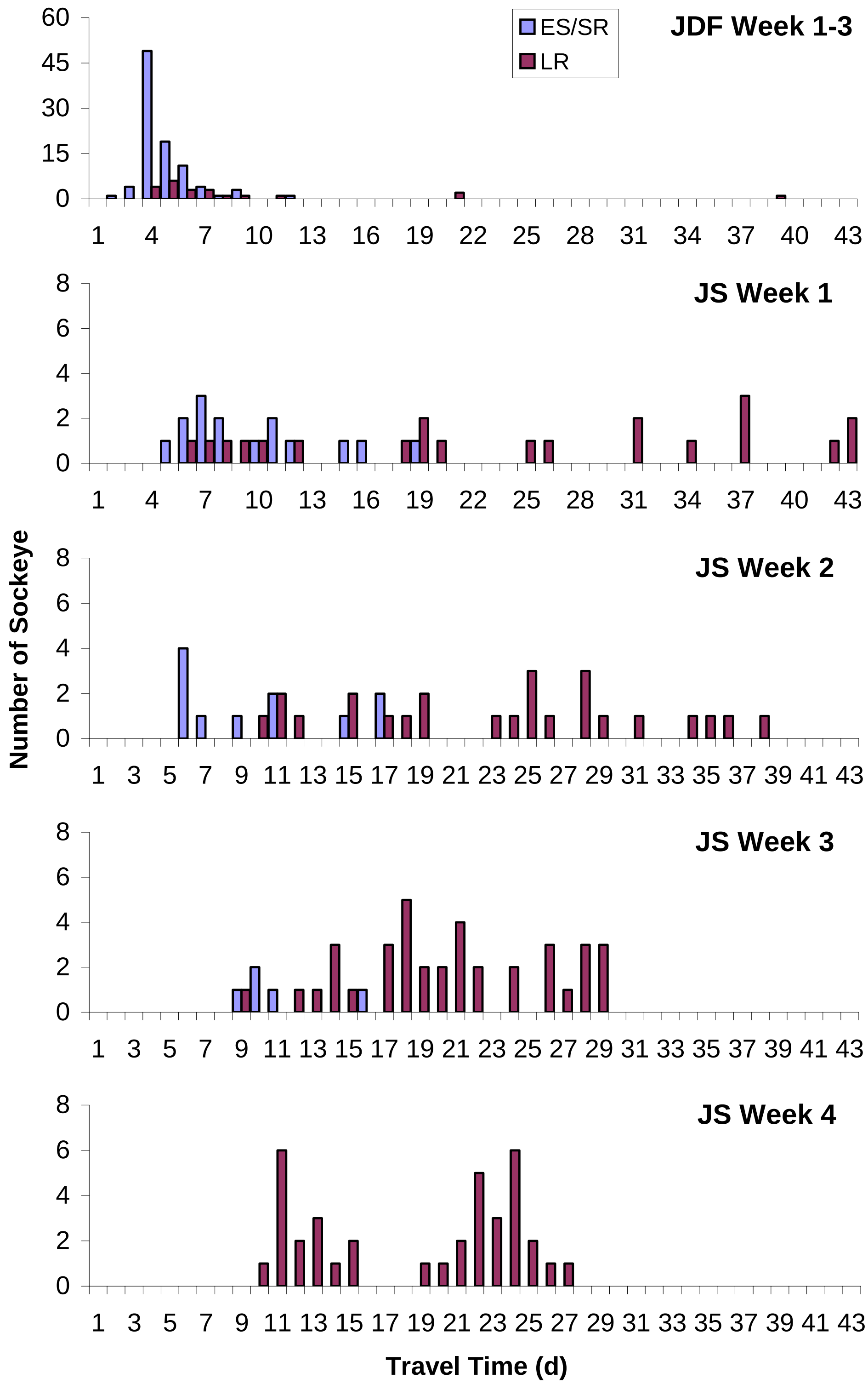


Figure 22. **Frequency distribution of travel times (days) from release to Mission for radio-tagged Early Summer, Summer-run and Late-run sockeye, released during three tagging intervals in Juan de Fuca Strait, and during four subsequent tagging intervals in Johnstone Strait.**

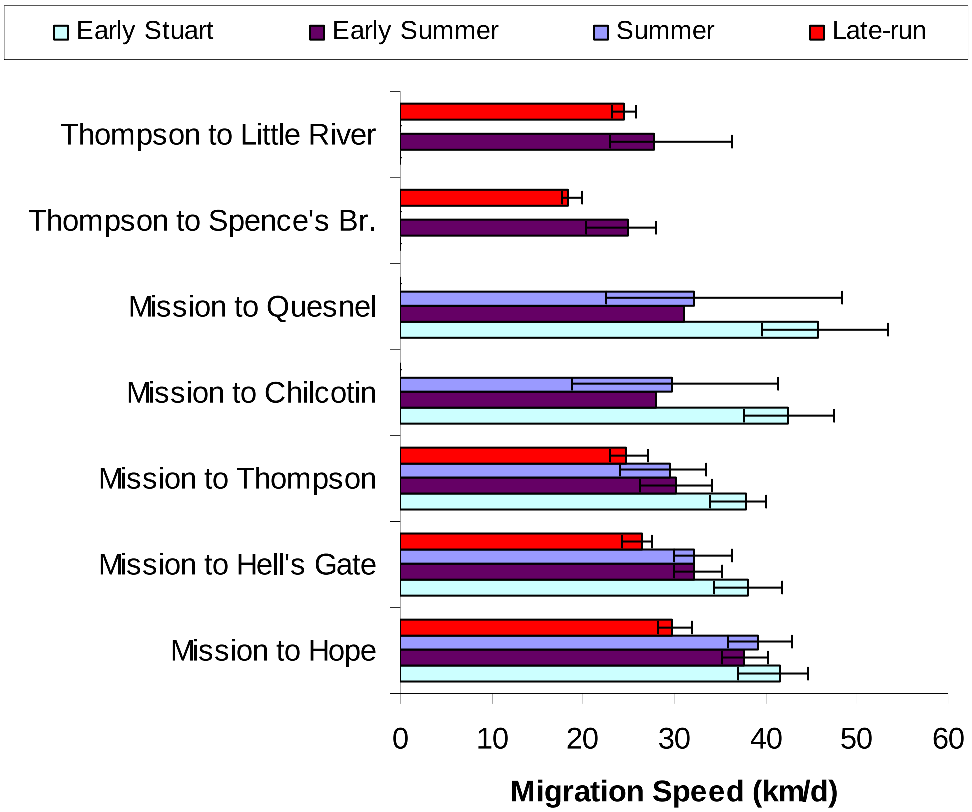


Figure 23. **Migration speeds from Mission to several Fraser River destinations for radio-tagged sockeye, by run-timing group in 2010. Error bars represent 95% confidence in the median value (generated using the method recommended in Zar, 1984). Statistical comparisons (see text) were done using non-parametric Kruskal Wallis tests; overlapping error bars do not preclude statistical significance.**

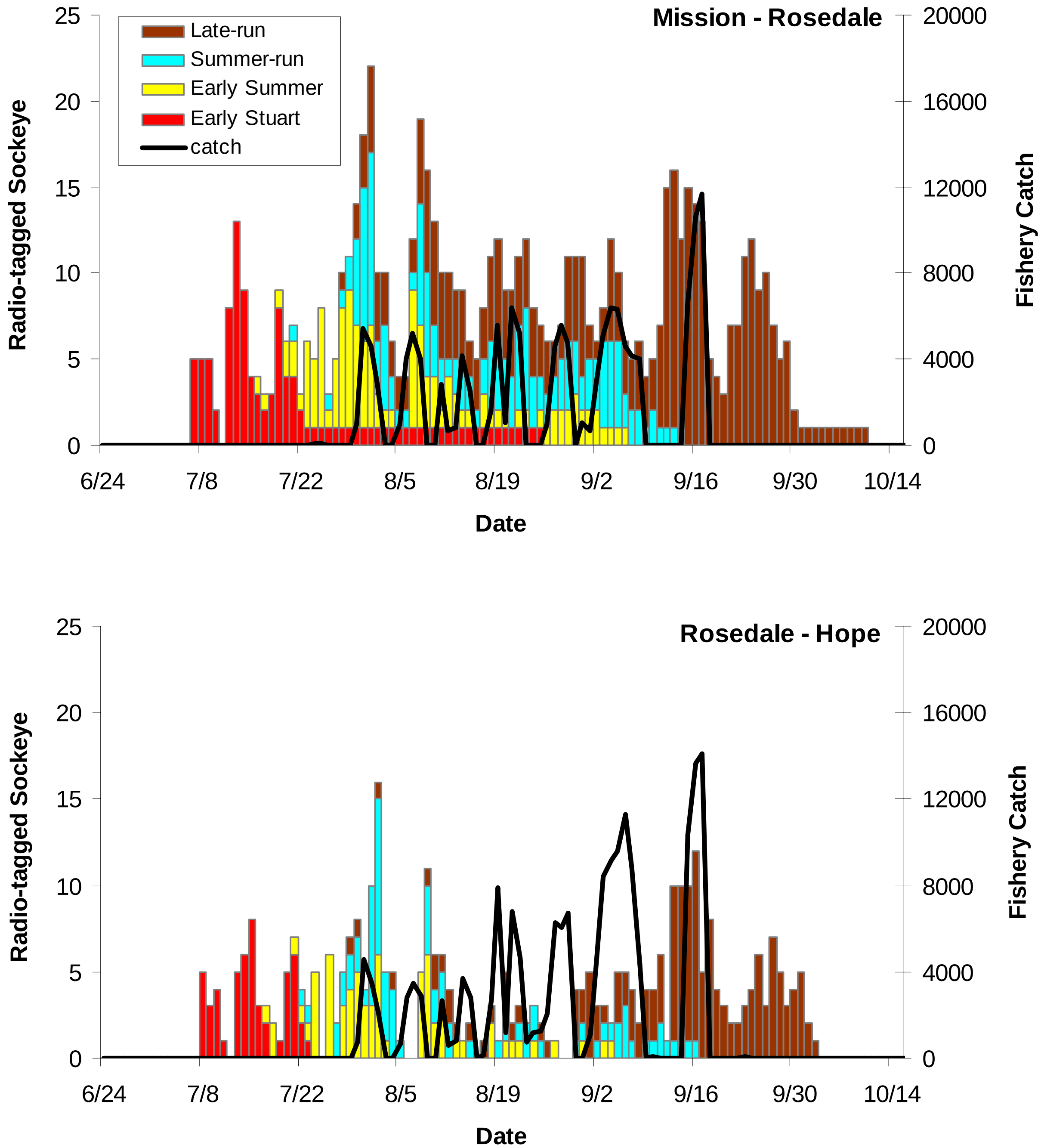
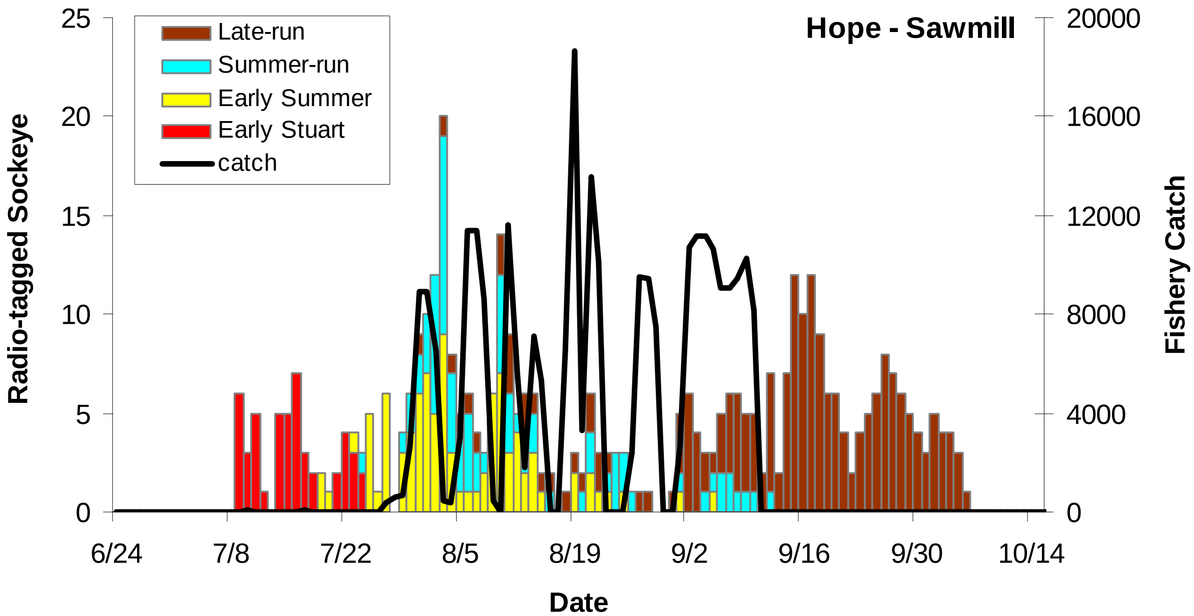
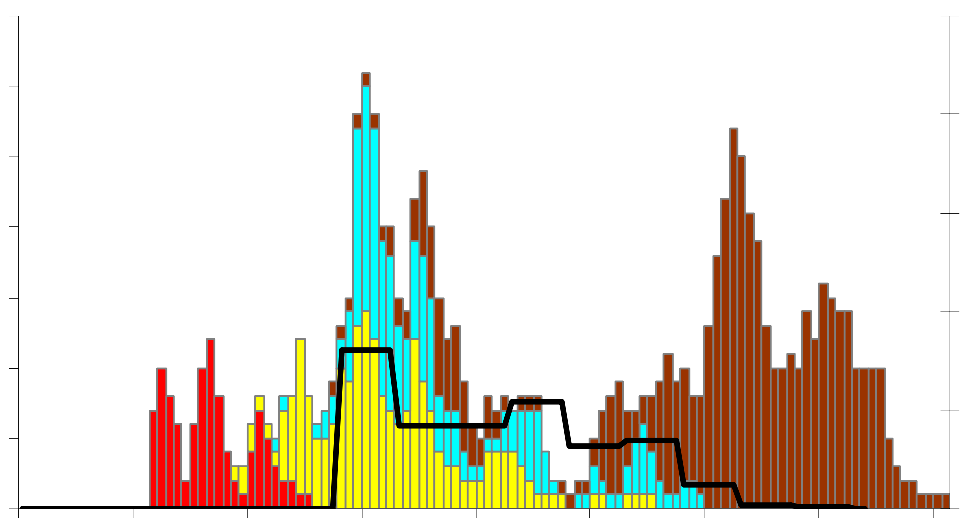
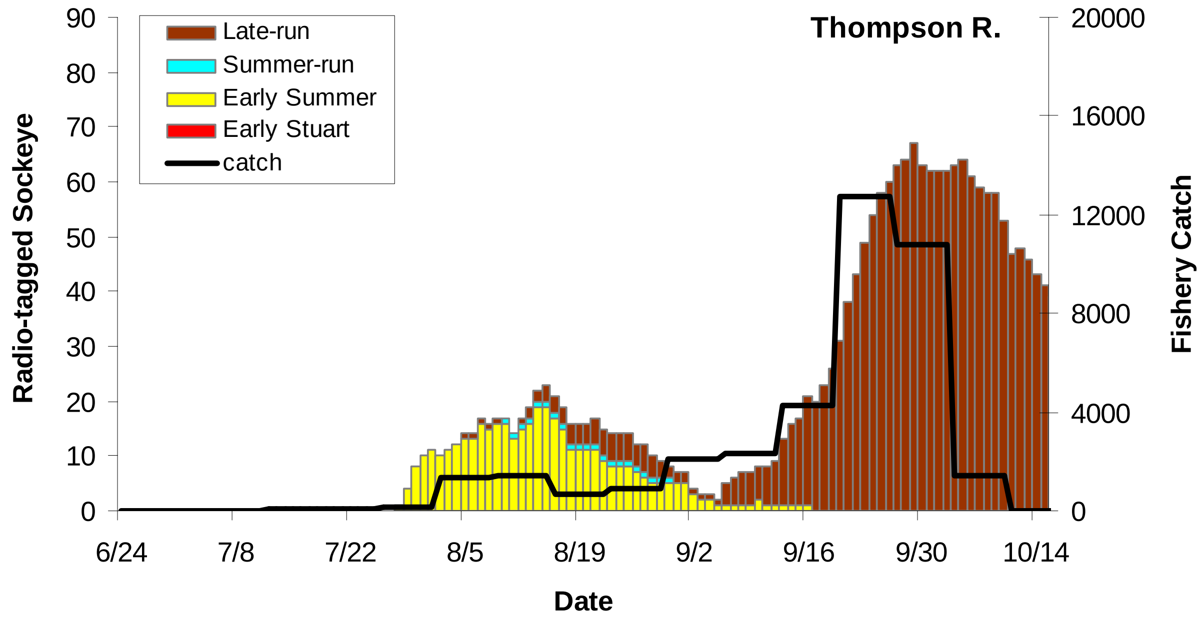


Figure 24. **The number of radio-tagged sockeye present in a fishery location, by date and run-timing group, and the daily number of sockeye caught there (from DFO). The eight panels show data for eight Fraser fisheries: a) Mission to Rosedale; b) Rosedale to Hope; c) Hope to Sawmill; d) Sawmill to Texas; e) Thompson River; f) Texas to Deadman; g) Chilcotin River; and h) upstream of Deadman. Radio-tagged fish were considered to have been "available" for capture in al fishery from the time of their first detection in a given fishing location until the time of their first detection elsewhere. Fish that "disappeared" within a fishing area were considered "unavailable" after 3 days of their last detection.**


Hope - Sawmill
Late-run
Summer-run
Early Summer
Early Stuart
catch
Radio-tagged Sockeye
Fishery Catch
Date
25
20
15
10
5
0
20000
16000
12000
8000
4000
0
6/24
7/8
7/22
8/5
8/19
9/2
9/16
9/30
10/14





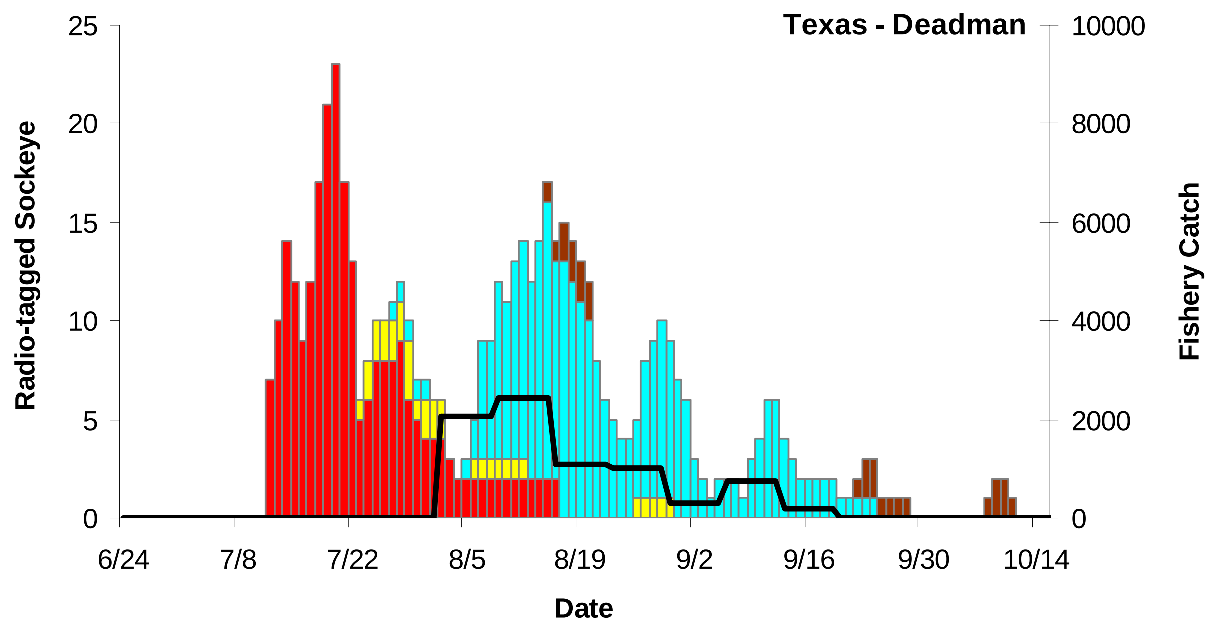
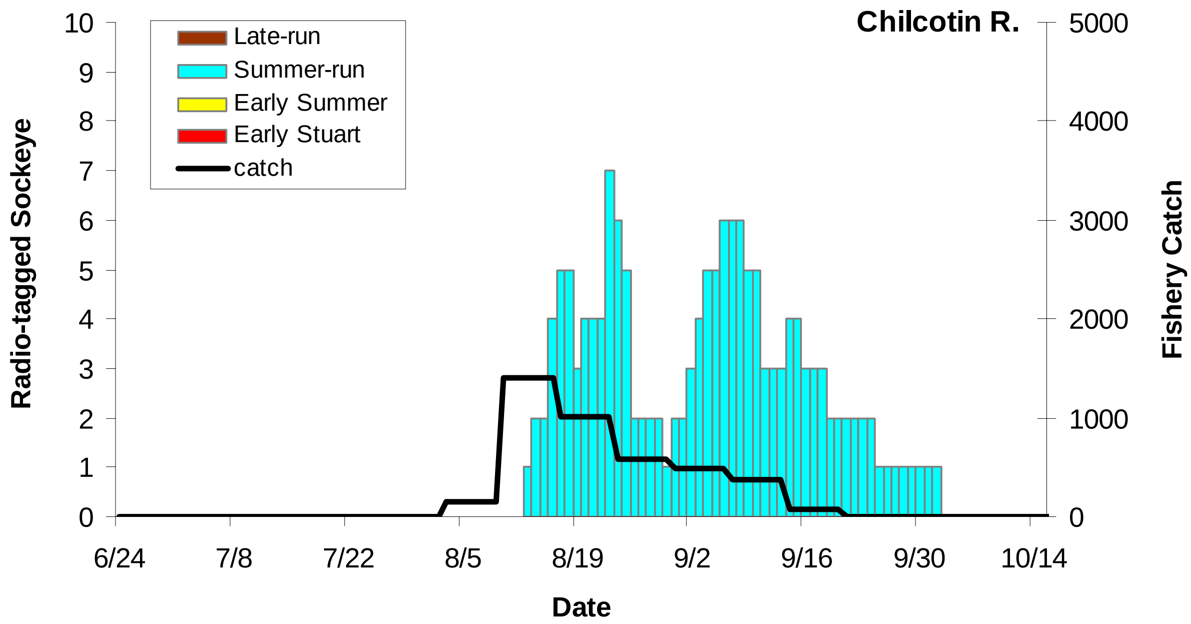


Figure 24 continued.



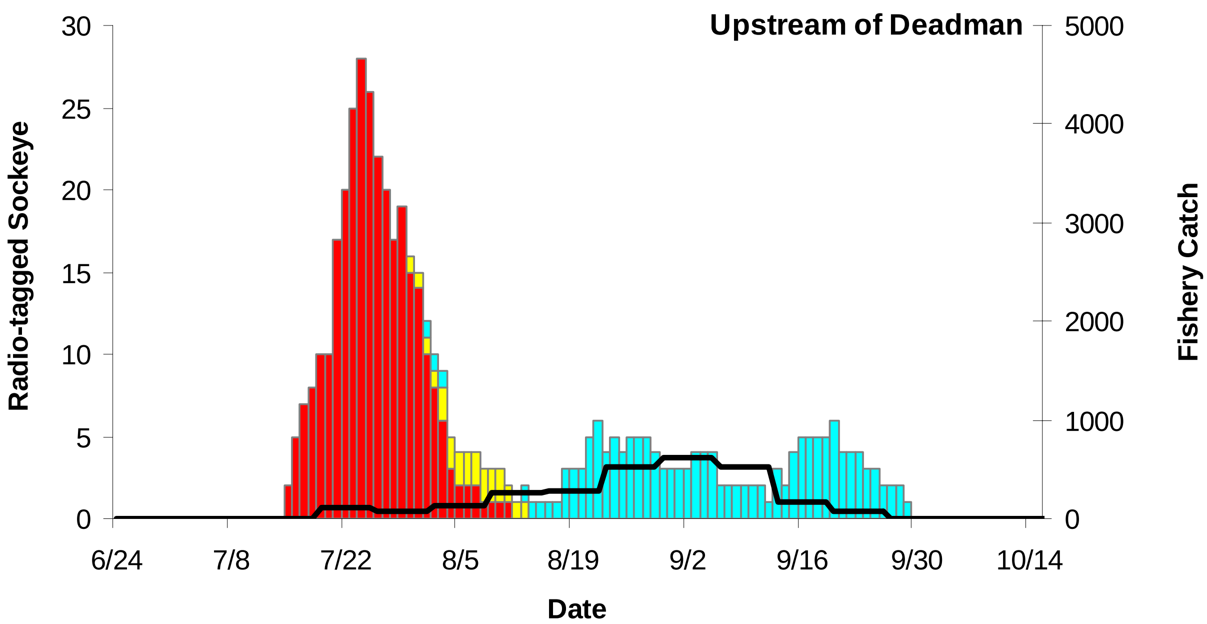


Figure 24 continued.

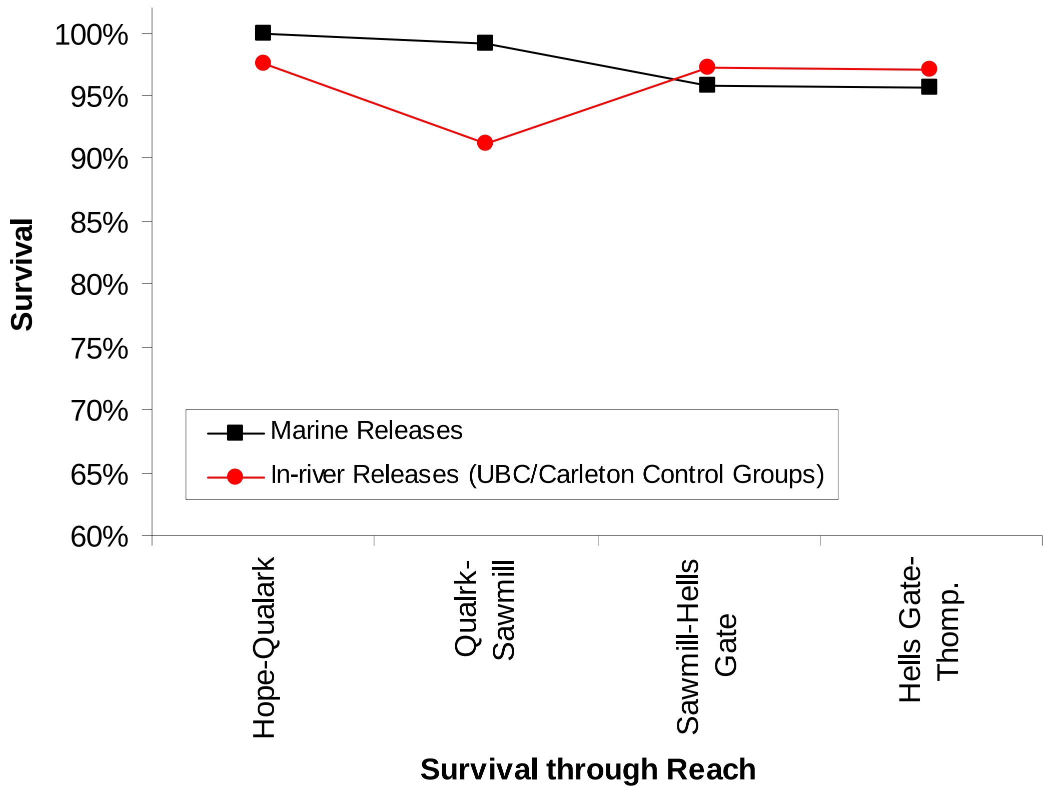
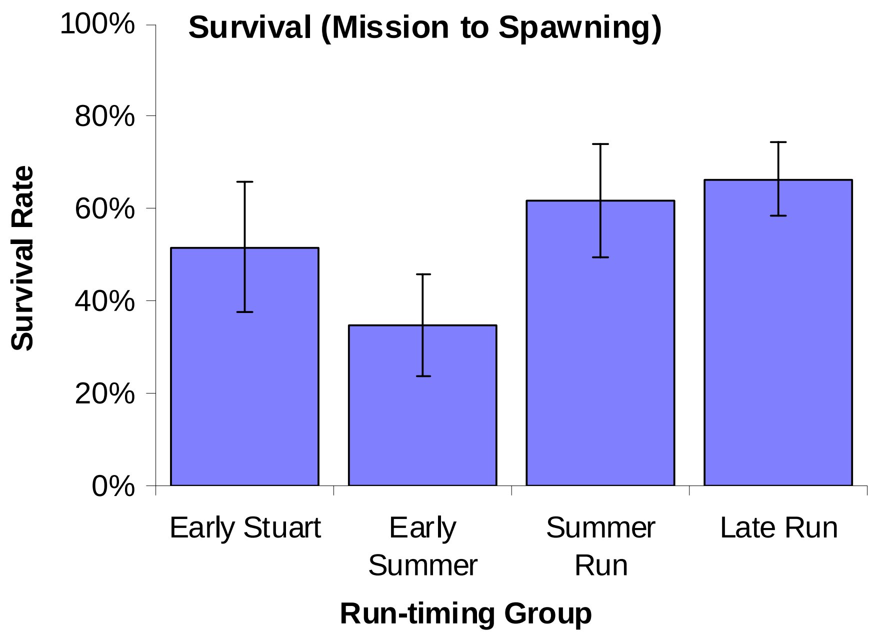


Figure 25. Reach-specific survival rates for sockeye, comparing the fish that were tagged in marine areas by LGL with the 'control group' sockeye tagged in-river by UBC and Carleton affiliates. Data are restricted to two periods during which fish from both tagging sources were in the river simultaneously (Hope passage dates: 10-29 August, 15-21 Sept). Reach-specific survival rates were calculated as the proportion of fish passing the downstream reach boundary that subsequently passed the upstream reach boundary



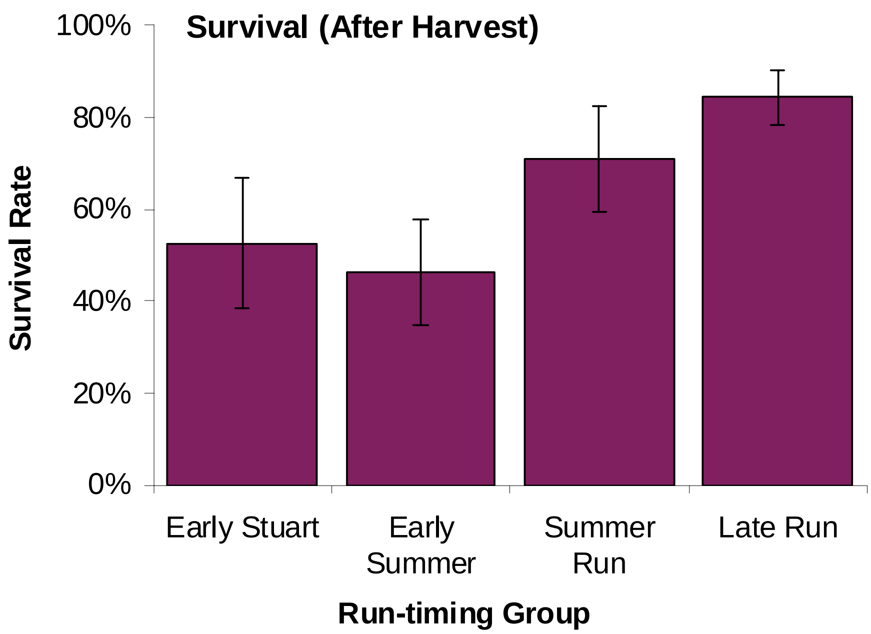


Figure 26. Survival estimates for radio-tagged sockeye by run-timing group. Top panel: survival estimates are based on the proportion of radio-tagged sockeye that passed Mission that were subsequently in spawning areas. Bottom Panel: survival estimates are based on the proportion of radio-tagged fish that survived mainstem fisheries that were subsequently detected in spawning areas. Error bars represent 95% confidence where standard errors follow the binomial distribution.

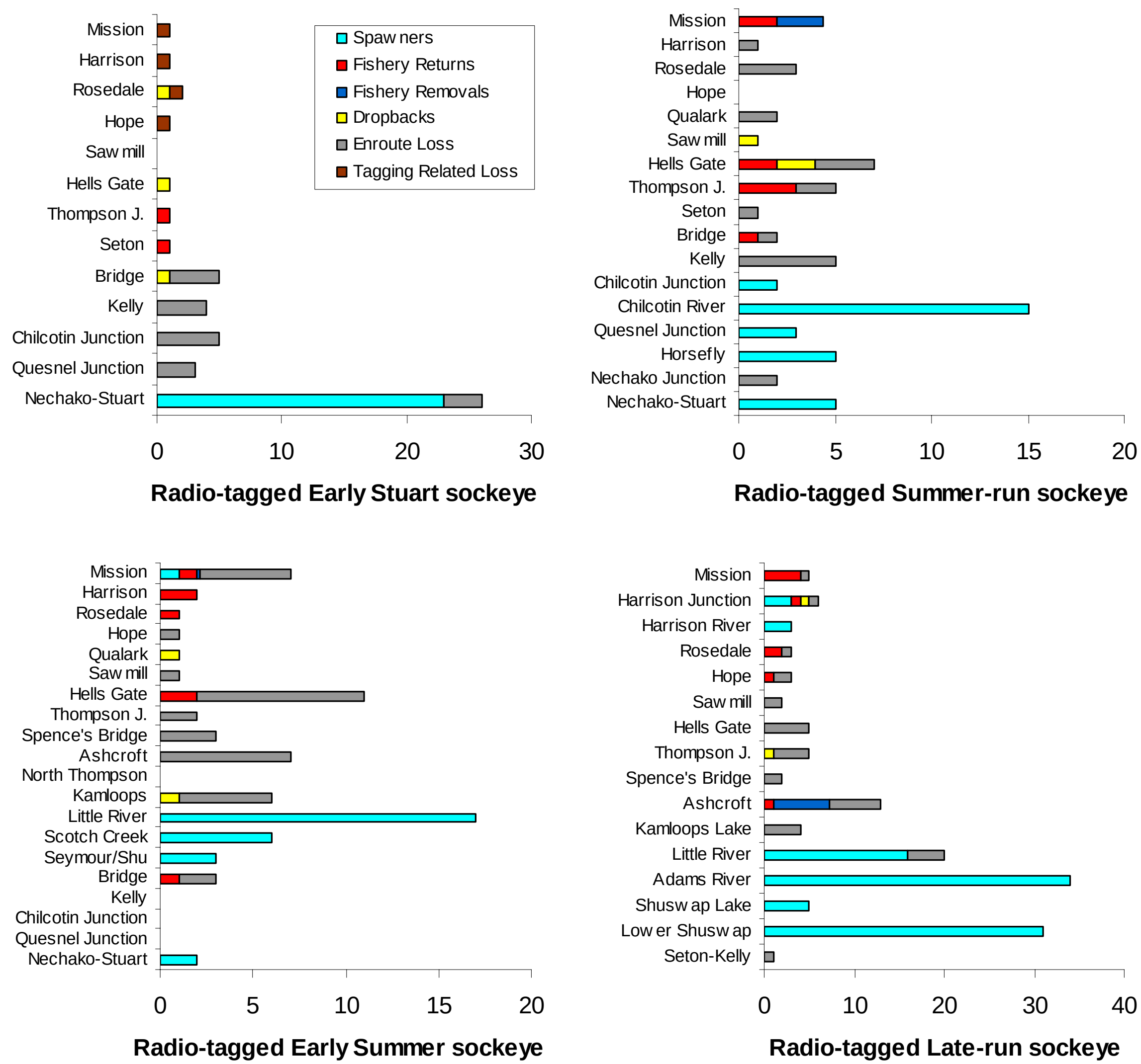


Figure 27. Fate of radio-tagged sockeye, by zone of last detection and by run-timing group, 2010. Fishery removals were assigned to zones proportionally to fishery returns. For Early Stuart fish, tagging related losses were assigned to zones proportionally to last (non-fishery) detections below Sawmill.

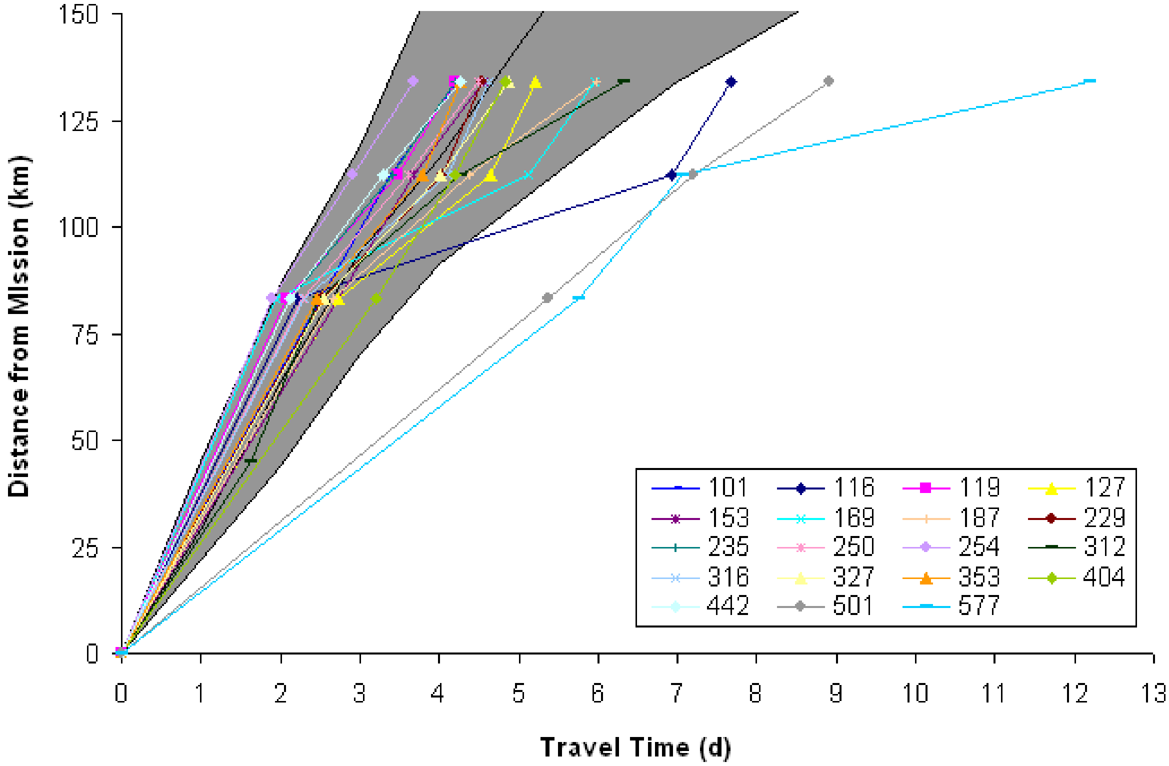
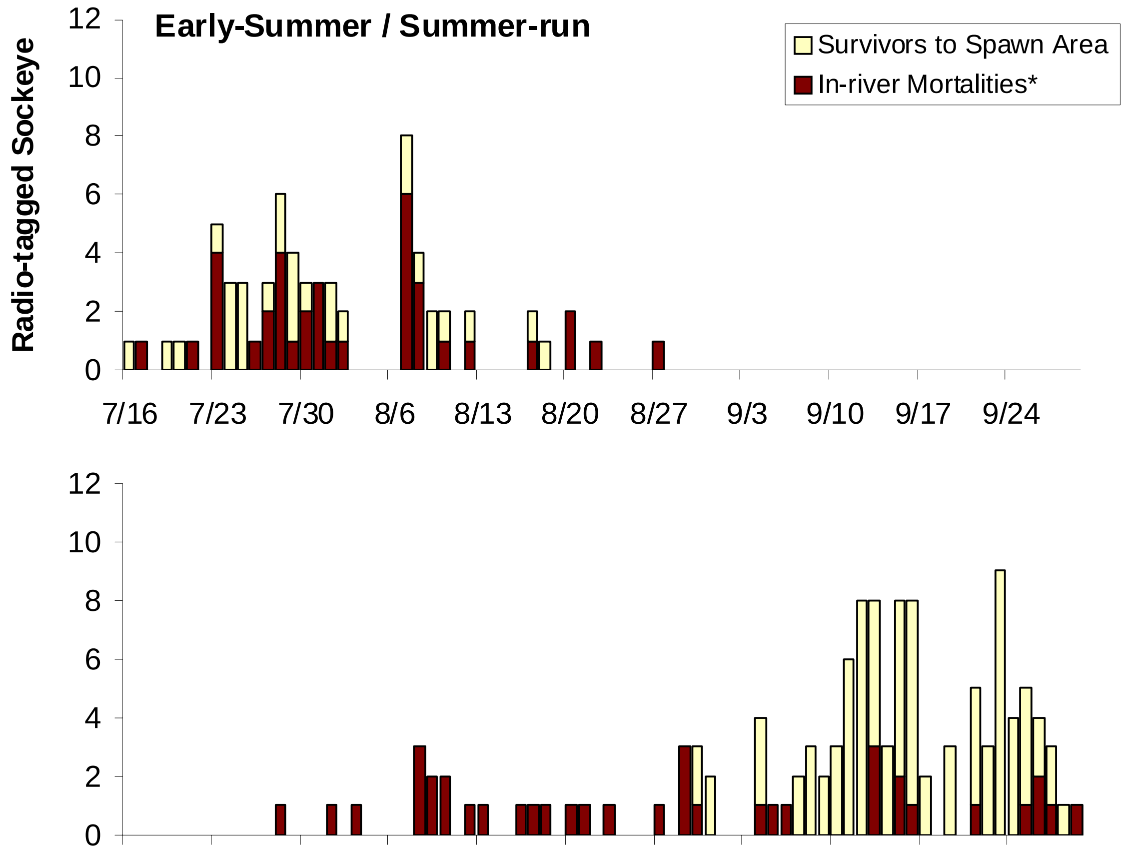


Figure 28. **Times for radio-tagged sockeye (Early Summer, Summer-run and Late-run) to travel from Mission to various fixed-station receivers along the Fraser Mainstem. The shaded area delimits the central 90% of the observed travel times for sockeye that successfully migrated to spawning areas (the central line shows the median). The series show 19 individual fish that did not reach spawning areas and were last detected between Hell's Gate and Thompson. Series that lie within the shaded areas traveled at rates similar to those observed for successful fish.**


Early-Summer / Summer-run
Survivors to Spawn Area
In-river Mortalities*
Radio-tagged Sockeye
12
10
8
6
4
2
0
7/16
7/23
7/30
8/6
8/13
8/20
8/27
9/3
9/10
9/17
9/24
12
10
8
6
4
2
0

[redacted]

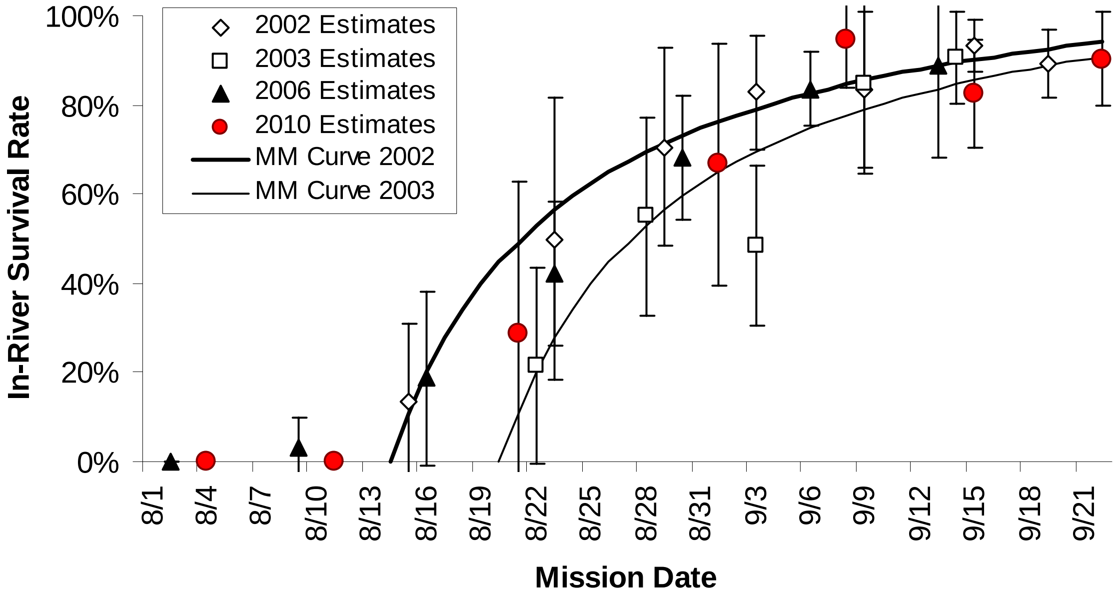


Figure 30. Relationship between the timing of Late-run sockeye passing Mission and in-river survival, excluding fishery removals. Survival rate estimates for 2002 and 2003 are for consecutive periods 5-day periods and estimates for 2006 and 2010 are for consecutive 7-day periods, except the point in the second half of August 2010 which combines the data for two consecutive weeks. Error bars show 2 SE. Curves are Michaelis-Menten (MM) cut-off curves fit to the 2002 and 2003 survival estimates (from English et al. 2005)

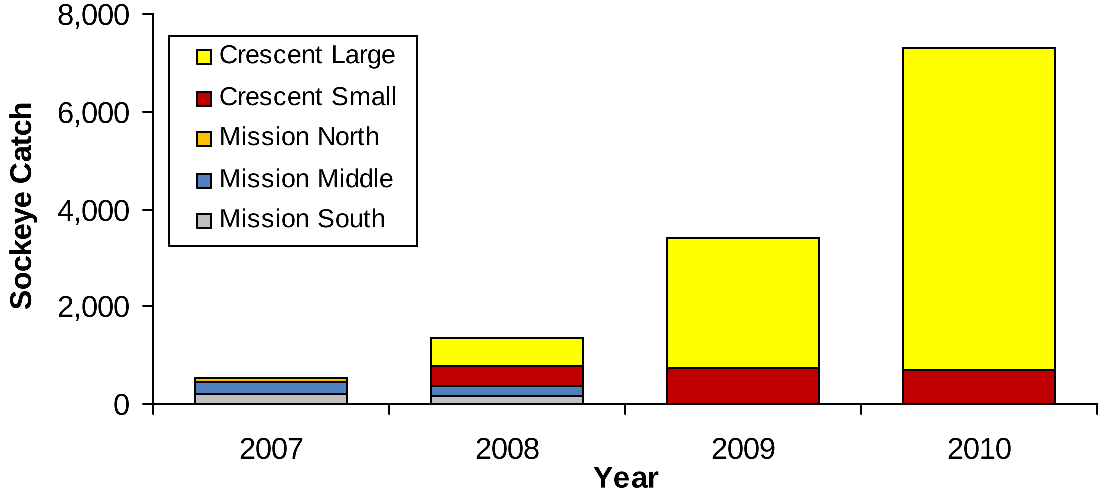


Figure 31. Sockeye catch by fishwheel and year. The Mission South and Mission Middle fishwheels were operated in 2007 and 2008. The Mission North fishwheel was only operated in 2007. The Crescent Small fishwheel was operated in 2008 and 2009. The Crescent Large fishwheel was operated from 28 July to 23 October 2008, and for the entire study period in 2009 and 2010.

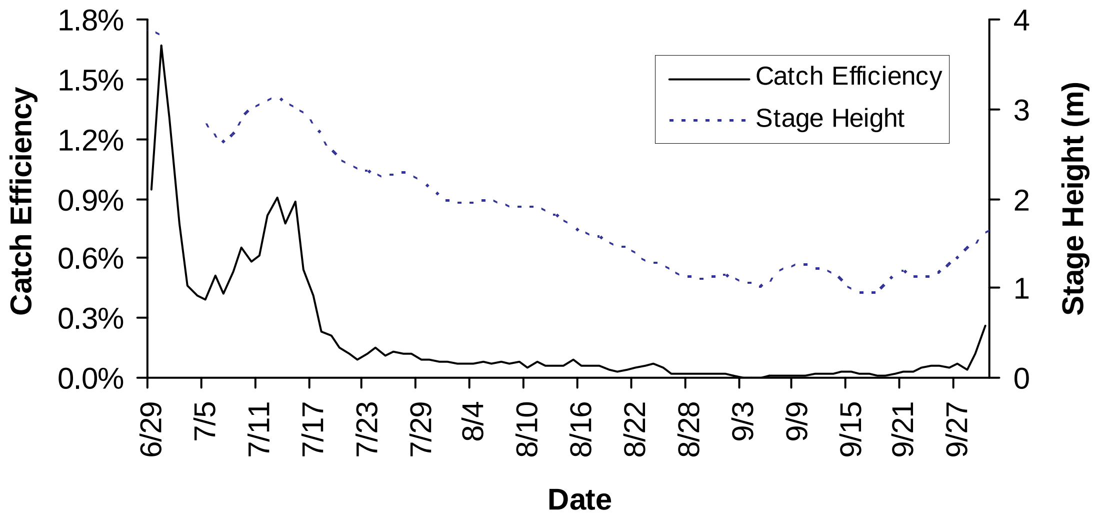


Figure 32. Catch efficiency (5 d moving average) for sockeye salmon at the Crescent Island fishwheels, 2010. Catch efficiency was calculated by dividing cumulative fishwheel catch (large and small fishwheels combined) by salmon abundance at the Mission hydroacoustic site. Mission hydroacoustic estimates were lagged by 1 d to account for the travel time of fish between the two locations.

APPENDICIES

APPENDIX A

Fixed-station Receiver Setup and Performance

Appendix Table A1. Orientation of each antenna at each fixed-station receiver site, 2010.

Receiver Site	Antenna	Antenna Orientation
Cresent Island	1	Downstream Main Channel
Cresent Island	2	Downstream Back Channel
Cresent Island	3	Upstream Main Channel
Cresent Island	4	Upstream Back Channel
Mission North	1	Downstream
Mission North	2	Upstream
Mission South	1	Downstream
Mission South	2	Upstream
Harrison Confluence	1	Downstream Fraser
Harrison Confluence	2	Upstream Harrison River
Harrison Confluence	3	Upstream Fraser
Weaver	1	Downstream
Weaver	2	Upstream
Rosedale	1	Downstream
Rosedale	2	Upstream
Hope	1	Downstream
Hope	2	Upstream
Sawmill	1	Downstream
Sawmill	2	Upstream
Qualark Orion Near Bank	1	cross bank
Qualark Orion Far Bank	1	cross bank
Qualark Lotek Near Bank	1	Downstream
Qualark Lotek Near Bank	2	Upstream
Hells Gate	1	Downstream
Hells Gate	2	Downstream
Hells Gate	3	Upstream
Hells Gate	4	Upstream
Thompson Confluence	1	Downstream Fraser
Thompson Confluence	2	Upstream Thompson River
Thompson Confluence	3	Upstream Fraser
Spences Bridge	1	Downstream Thompson River
Spences Bridge	2	Upstream Nicola River
Spences Bridge	3	Upstream Thompson River
Ashcroft	1	Downstream
Ashcroft	2	Upstream
North Thompson	1	Downstream
North Thompson	2	Upstream

continued to right…

Receiver Site	Antenna	Antenna Orientation
Kamloops Lake	1	Downstream
Kamloops Lake	2	Upstream
Little River	1	Downstream
Little River	2	Upstream
Adams River	1	Downstream Main Channel
Adams River	2	Downstream Back Channel
Adams River	3	Upstream Main Channel
Adams River	4	Upstream Back Channel
Lower Shuswap	1	Downstream
Lower Shuswap	2	Upstream
Seton	1	Downstream Fraser
Seton	2	Upstream Seton River
Seton	3	Upstream Fraser
Bridge River	1	Downstream
Bridge River	2	Upstream
Kelly Creek	1	Downstream
Kelly Creek	2	Upstream
Chilcotin Confluence	1	Downstream Fraser
Chilcotin Confluence	2	Upstream Chilcotin River
Chilcotin Confluence	3	Upstream Fraser
Farwell Canyon	1	Downstream
Farwell Canyon	2	Upstream
Chilko	1	Downstream
Chilko	2	Upstream
Likely	1	Downstream
Likely	2	Upstream
Quesnel	1	Downstream Fraser
Quesnel	2	Upstream Quesnel River
Quesnel	3	Upstream Fraser
Nechako	1	Downstream
Nechako	2	Upstream
Stuart Confluence	1	Downstream Nechako
Stuart Confluence	2	Upstream Stuart River
Stuart Confluence	3	Upstream Nechako

Appendix Table A2. **Fixed station monitoring efficiency (percent operational) by week for all sites monitored between 13 June and 5 December, 2010.**

	Fixed-Station Receiver Site								
Week Start Date	Crescent Island	Mission North	Mission South	Harrison Conf.	Weaver	Rosedale	Hope	Qualark	Sawmill
13 Jun									
20 Jun	100%		100%						
27 Jun	100%	100%	100%	100%					
4 Jul	64%	100%	100%	100%		100%	100%	100%	100%
11 Jul	100%	100%	100%	100%		100%	100%	100%	100%
18 Jul	100%	100%	23%	100%		100%	100%	100%	100%
25 Jul	99%	100%	76%	100%		58%	100%	99%	100%
1 Aug	100%	100%	100%	100%		48%	100%	100%	100%
8 Aug	100%	100%	100%	100%		99%	96%	100%	100%
15 Aug	100%	100%	100%	100%		100%	100%	100%	99%
22 Aug	100%	100%	100%	100%		100%	100%	99%	100%
29 Aug	100%	24%	100%	100%		100%	100%	100%	100%
5 Sep	95%	75%	100%	100%		100%	100%	99%	98%
12 Sep	100%	100%	100%	100%		100%	100%	99%	100%
19 Sep	98%	100%	100%	100%	100%	100%	100%	100%	100%
26 Sep	100%	100%	100%	100%	100%	100%	100%	100%	100%
3 Oct		100%	100%	100%	100%	100%	100%	100%	100%
10 Oct		100%		100%	100%	100%	100%		100%
17 Oct				100%	100%		100%		100%
24 Oct				100%	100%		100%		100%
31 Oct				100%	100%				
7 Nov									
14 Nov									
21 Nov									
28 Nov									
5 Dec									
Overall	**97%**	**93%**	**93%**	**100%**	**100%**	**93%**	**100%**	**100%**	**100%**

continued…

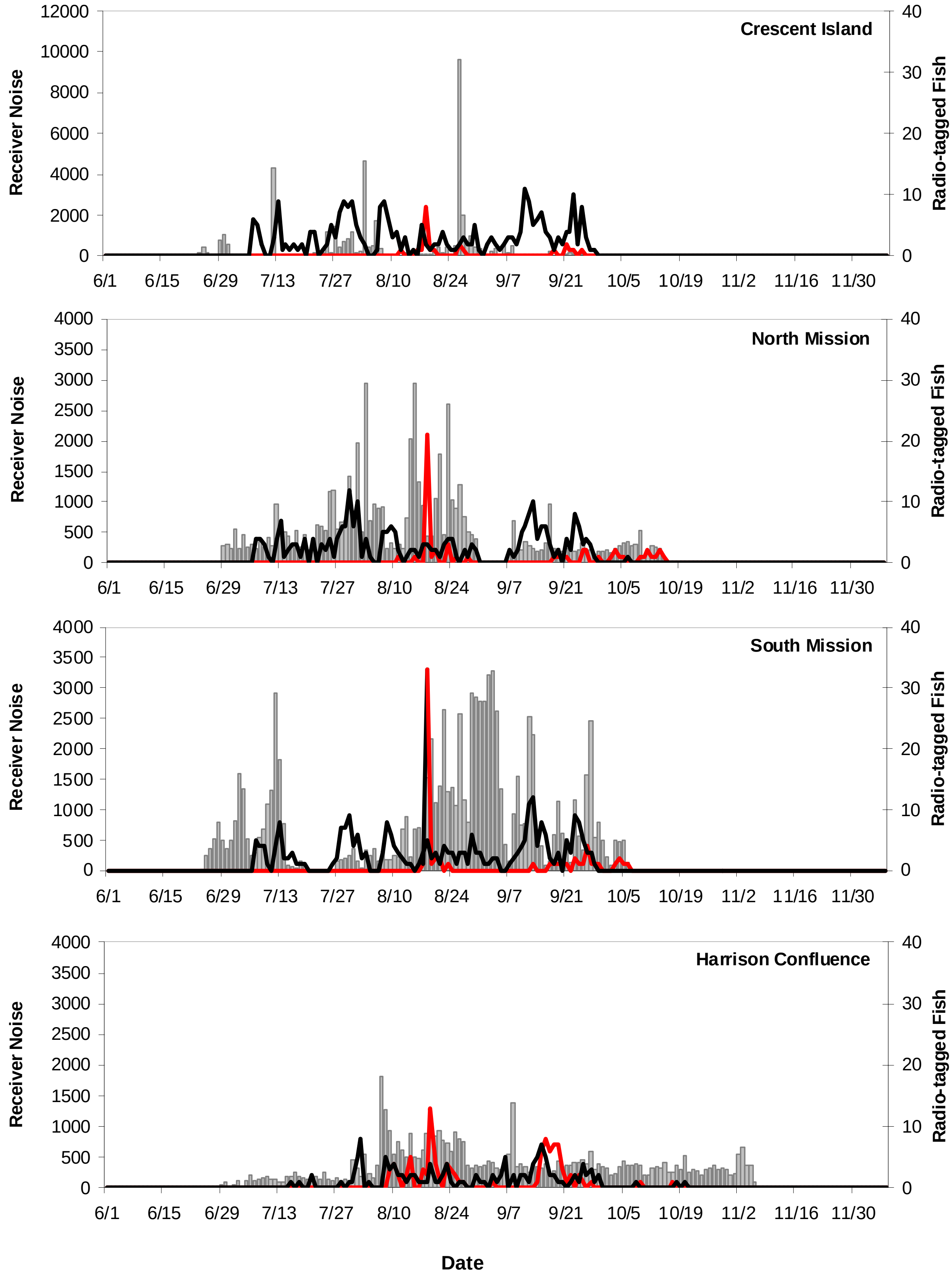
Appendix Table A2 continued.

Week Start Date	Fixed-Station Receiver Site: Hell's Gate	Thompson Conf.	Spence's Bridge	Ashcroft	North Thompson	Kamloops Lake	Little River	Adams River	Lower Shuswap
13 Jun			100%						
20 Jun			100%						
27 Jun	100%	100%	100%						
4 Jul	100%	100%	100%						
11 Jul	100%	100%	100%						
18 Jul	100%	99%	100%						
25 Jul	100%	100%	100%						
1 Aug	100%	100%	98%	100%	100%	100%	100%		
8 Aug	100%	100%	100%	100%	100%	100%	100%		
15 Aug	100%	100%	100%	100%	100%	100%	40%		
22 Aug	100%	100%	100%	100%	100%	100%	61%		
29 Aug	100%	100%	100%	100%	100%	100%	100%	100%	100%
5 Sep	100%	100%	100%	100%	100%	100%	100%	100%	100%
12 Sep	100%	100%	100%	97%	100%	100%	100%	100%	100%
19 Sep	97%	100%	100%	100%	100%	100%	100%	100%	100%
26 Sep	100%	100%	63%	100%	100%	100%	100%	100%	100%
3 Oct	100%	99%	35%	99%	100%	100%	100%	100%	99%
10 Oct	100%	99%	100%	100%	100%	100%	100%	92%	95%
17 Oct	100%	100%	28%	100%	100%	100%	100%	91%	76%
24 Oct	100%	100%	100%	100%	100%	100%	100%	27%	100%
31 Oct	100%	100%	100%	100%	100%	100%	100%	92%	100%
7 Nov	100%		100%	100%	100%	100%	100%	77%	100%
14 Nov							100%	100%	
21 Nov							100%		
28 Nov							100%		
5 Dec									
Overall	**100%**	**100%**	**92%**	**100%**	**100%**	**100%**	**94%**	**89%**	**97%**

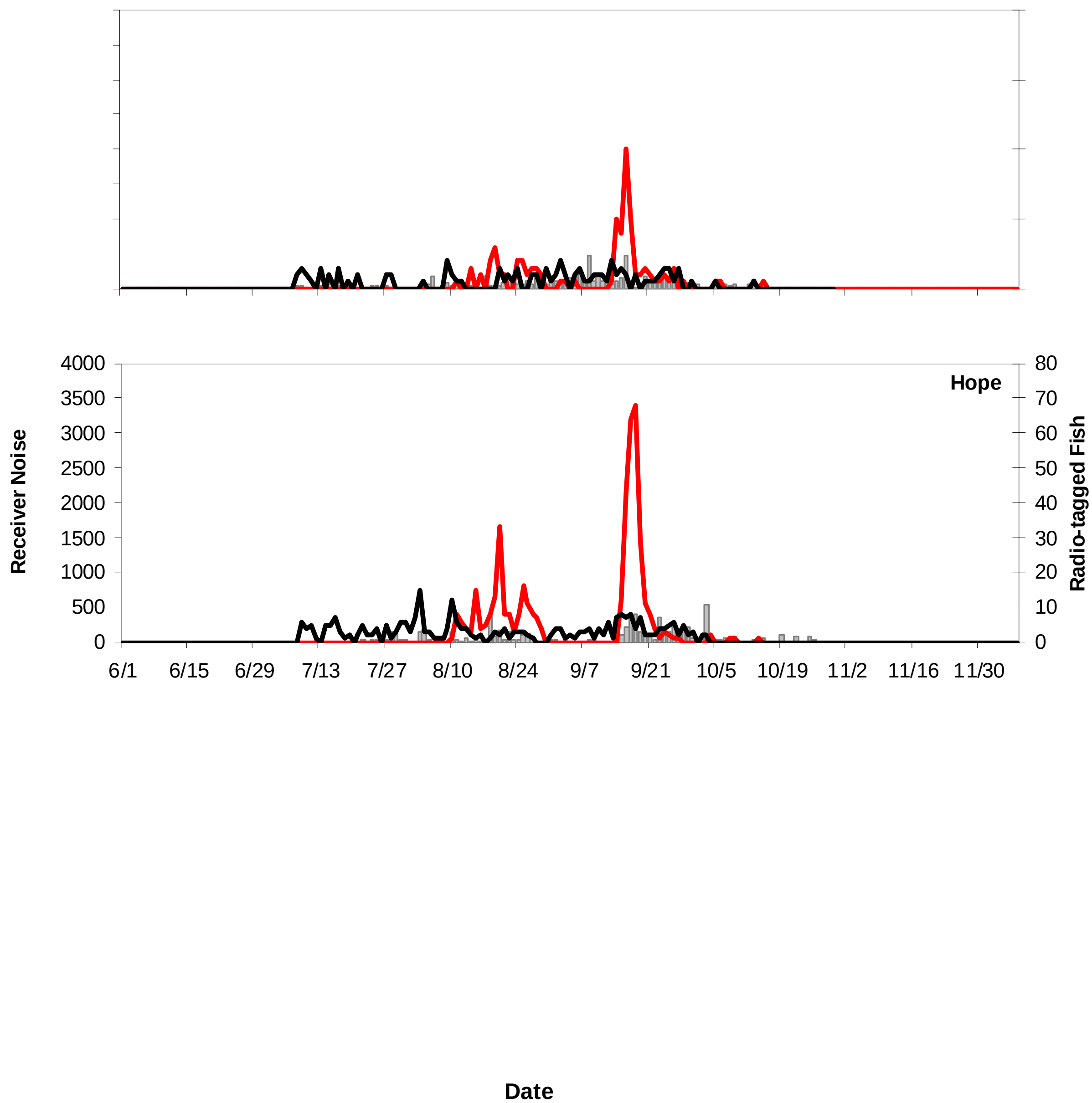
continued…

Appendix Table A2 continued.

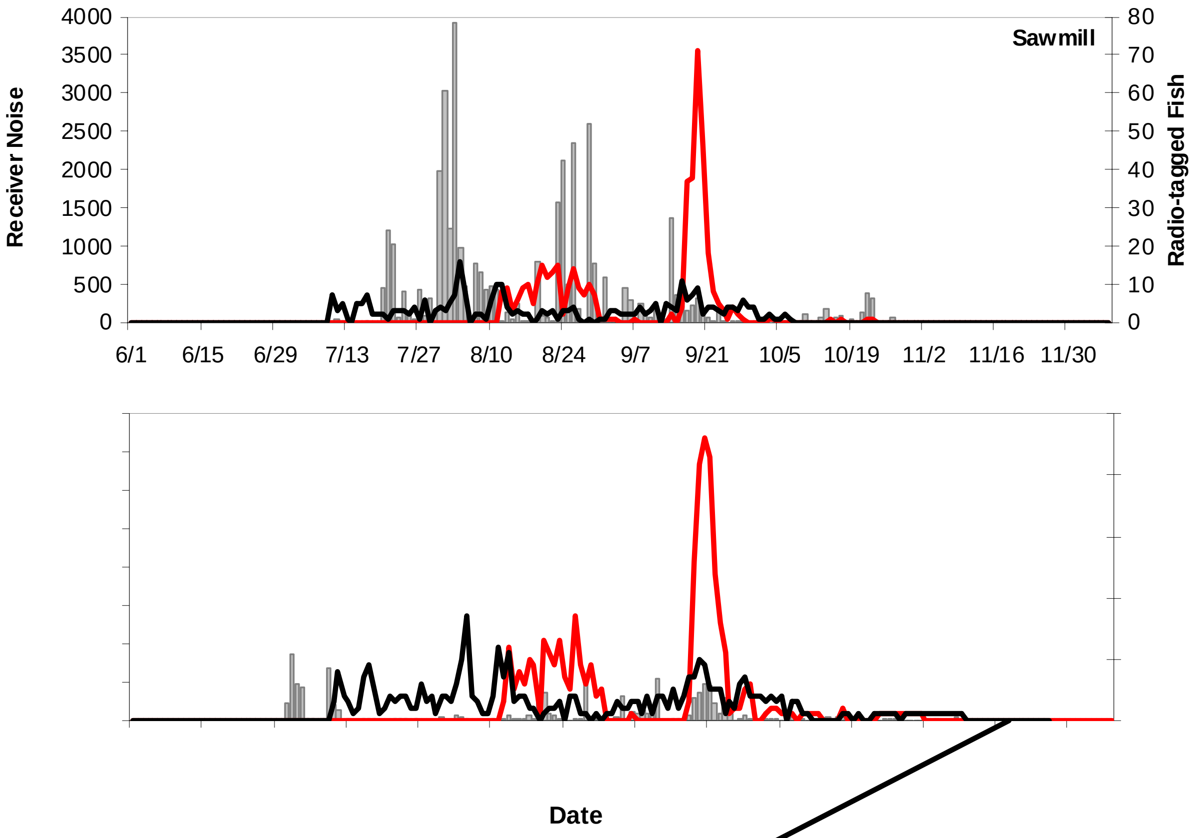
Week Start Date	Fixed-Station Receiver Site: Seton	Bridge River Rapids	Kelly Creek	Chilcotin Conf.	Farwell	Chilko	Quesnel	Likely	Nechako	Stuart Conf.
13 Jun									100%	100%
20 Jun									100%	100%
27 Jun	100%	100%							100%	100%
4 Jul	100%	100%							100%	100%
11 Jul	99%	46%							100%	100%
18 Jul	100%	100%	100%	100%	100%		100%	100%	100%	100%
25 Jul	99%	100%	100%	100%	93%	100%	100%	100%	100%	100%
1 Aug	68%	100%	27%	8%	0%	100%	36%	38%	100%	100%
8 Aug	100%	100%	66%	0%	62%	100%	0%	0%	100%	100%
15 Aug	100%	100%	100%	1%	100%	100%	79%	93%	100%	100%
22 Aug	100%	97%	100%	90%	100%	100%	100%	100%	100%	100%
29 Aug	100%	100%	90%	43%	84%	98%	100%	100%	100%	100%
5 Sep	100%	100%		100%	100%	100%	100%	100%	100%	100%
12 Sep	100%	100%		100%	88%	100%	100%	100%	100%	100%
19 Sep	100%	100%		100%	34%	100%	100%	100%	100%	100%
26 Sep	100%	100%		85%		100%	100%	100%	100%	100%
3 Oct	100%	100%		100%		100%	100%	100%	100%	100%
10 Oct									100%	100%
17 Oct										100%
24 Oct										100%
31 Oct										100%
7 Nov										100%
14 Nov										
21 Nov										
28 Nov										
5 Dec										
Overall	**98%**	**96%**	**83%**	**68%**	**80%**	**100%**	**84%**	**85%**	**100%**	**100%**



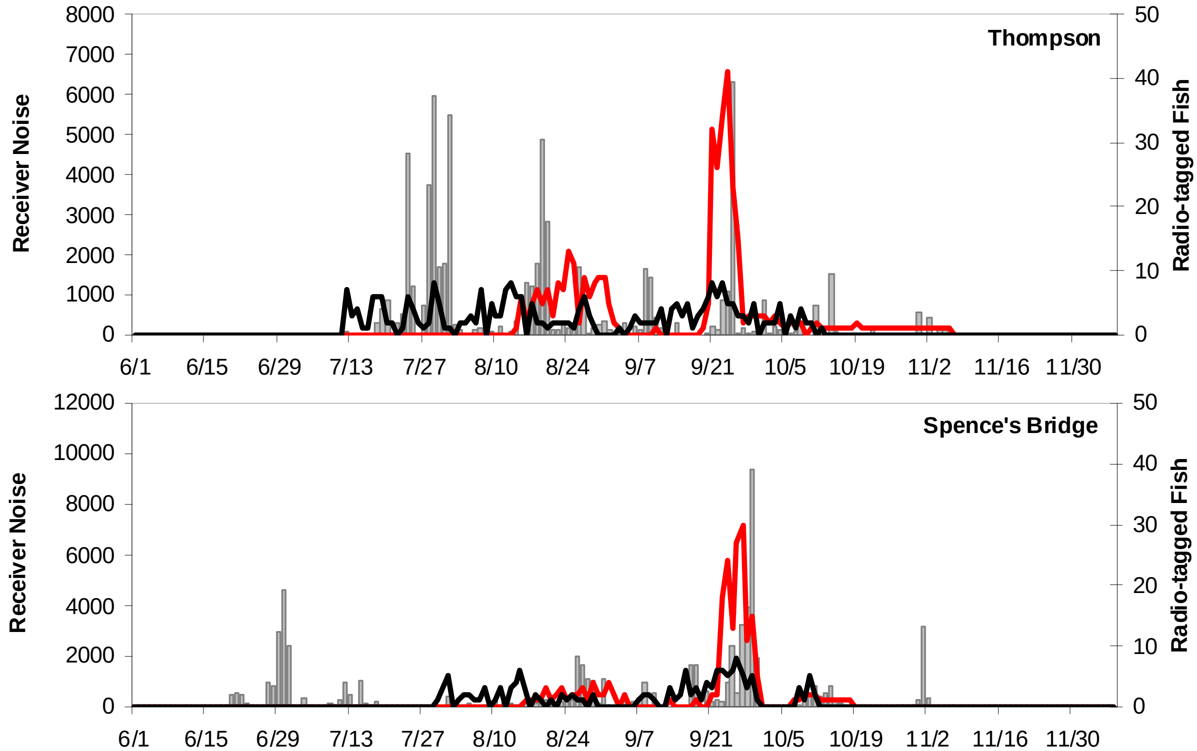
Appendix Figure A1. **Receiver noise/collisions (bars) and total number of fish detected (LGL tags: black line; other tags: red line) by day from 1 June to 5 December, 2010.**

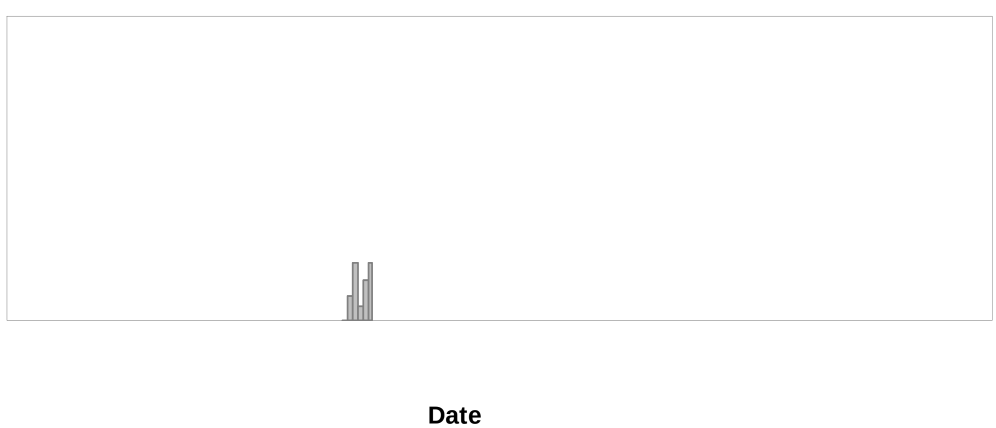


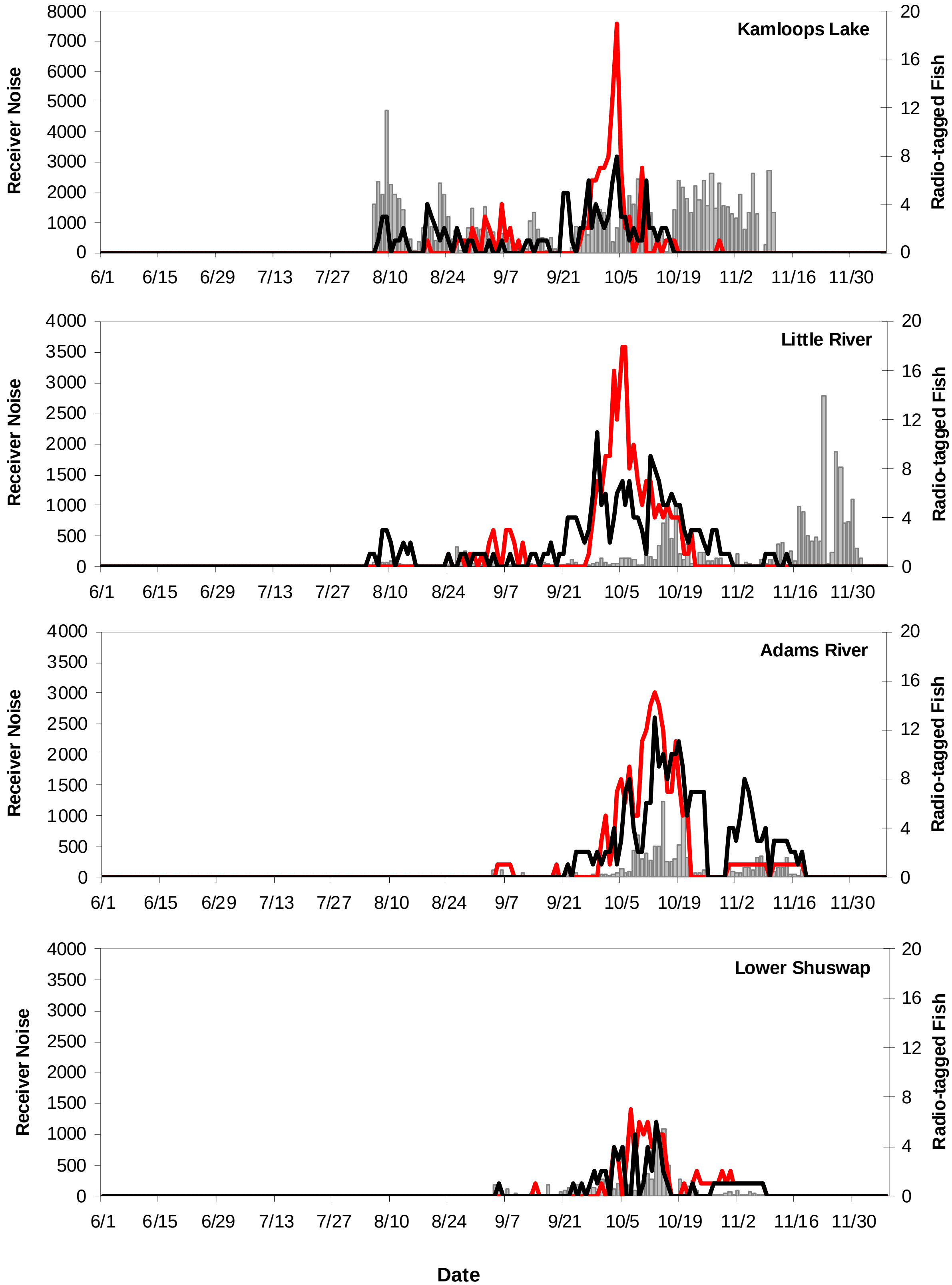
4000
3500
3000
2500
2000
1500
1000
500
0
Receiver Noise
Hope
80
70
60
50
40
30
20
10
0
Radio-tagged Fish
6/1
6/15
6/29
7/13
7/27
8/10
8/24
9/7
9/21
10/5
10/19
11/2
11/16
11/30
Date



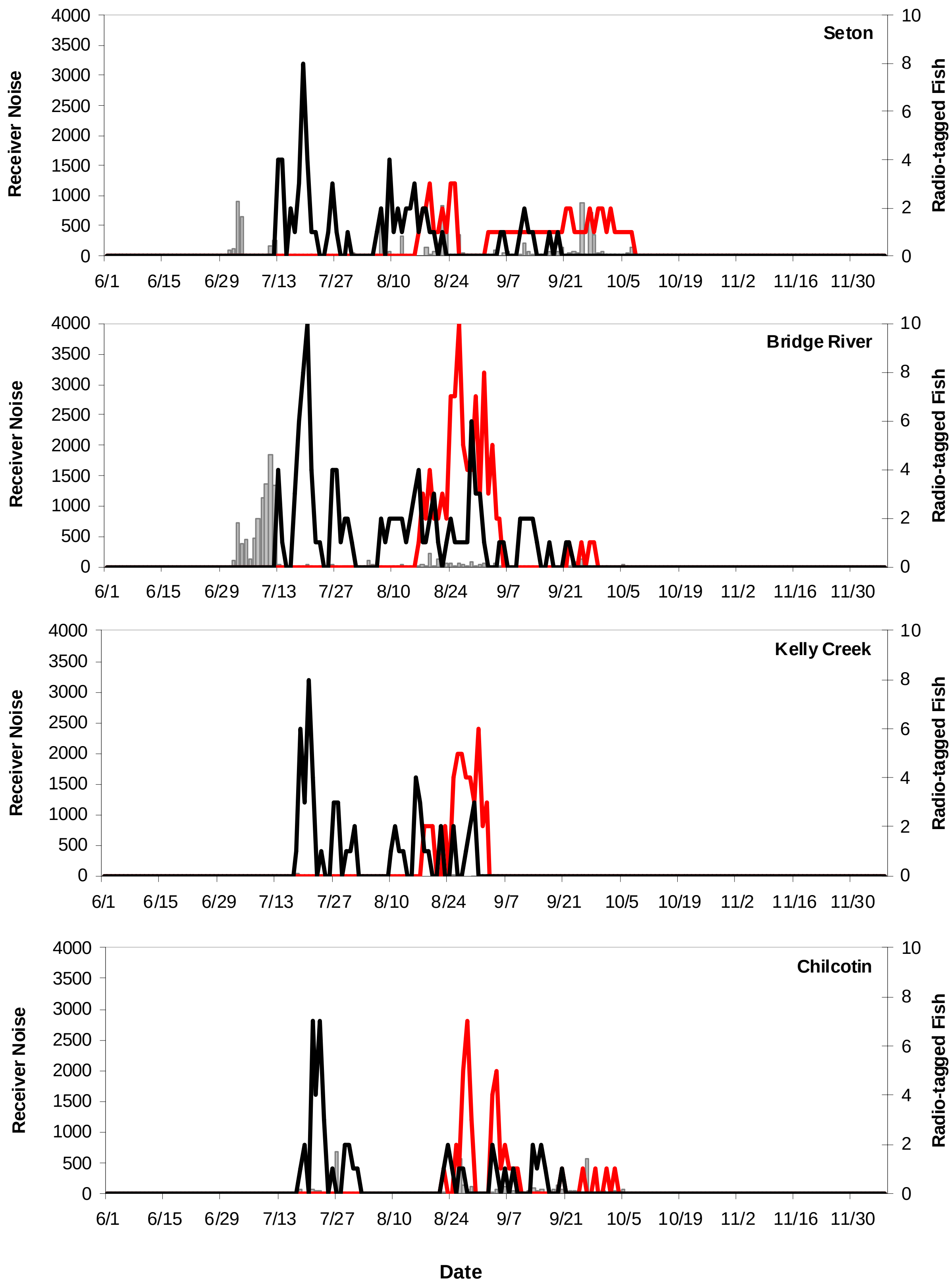
Sawmill
Receiver Noise
Radio-tagged Fish
4000
3500
3000
2500
2000
1500
1000
500
0
80
70
60
50
40
30
20
10
0
6/1
6/15
6/29
7/13
7/27
8/10
8/24
9/7
9/21
10/5
10/19
11/2
11/16
11/30
Date


Thompson
Receiver Noise
Radio-tagged Fish
0
1000
2000
3000
4000
5000
6000
7000
8000
0
10
20
30
40
50
6/1
6/15
6/29
7/13
7/27
8/10
8/24
9/7
9/21
10/5
10/19
11/2
11/16
11/30
Spence's Bridge
Receiver Noise
Radio-tagged Fish
0
2000
4000
6000
8000
10000
12000
0
10
20
30
40
50
6/1
6/15
6/29
7/13
7/27
8/10
8/24
9/7
9/21
10/5
10/19
11/2
11/16
11/30

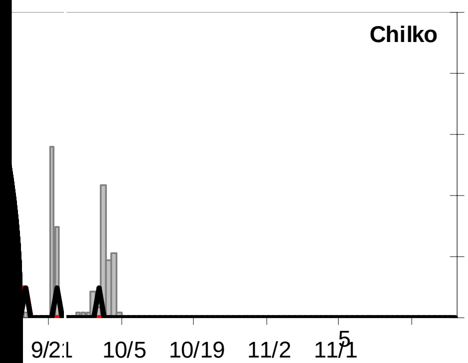

Date

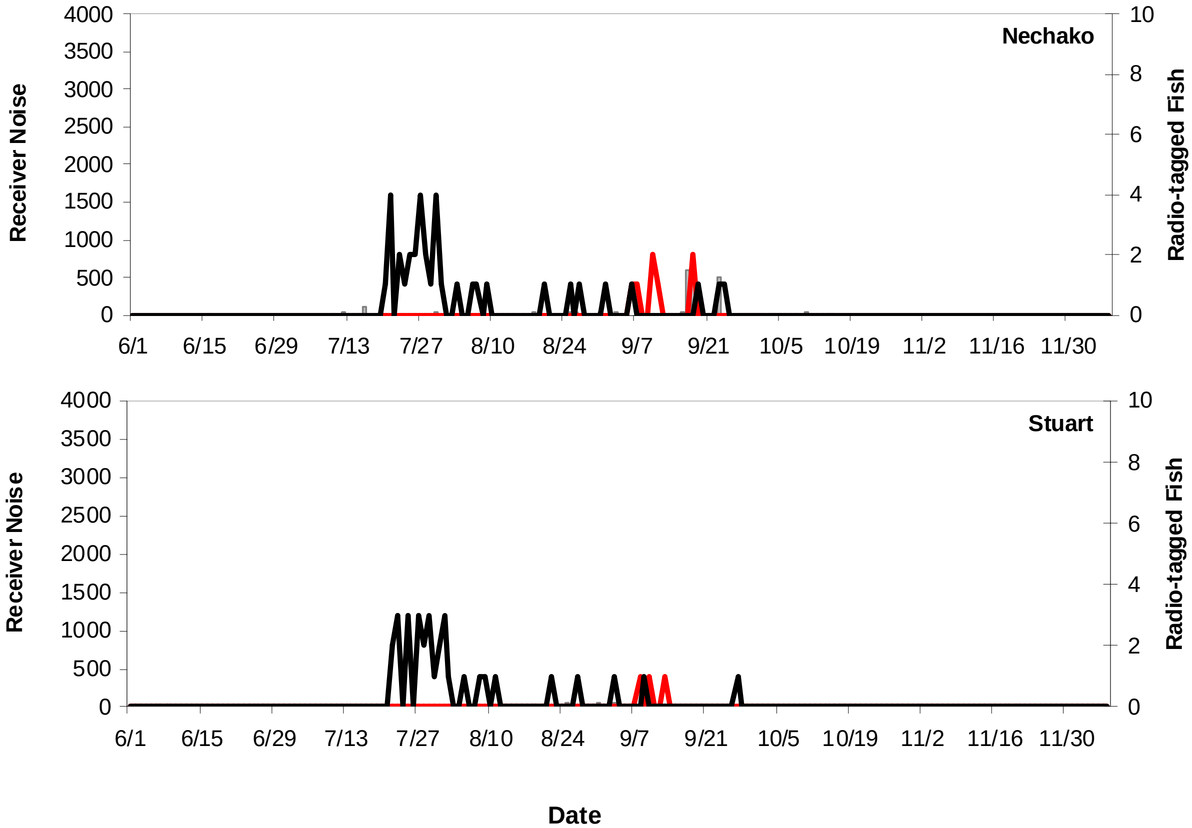


Appendix Figure A1 continued.



Appendix Figure A1 continued.


Chilko
9/21
10/5
10/19
11/2
11/15



Appendix Figure A1 continued.

APPENDIX B

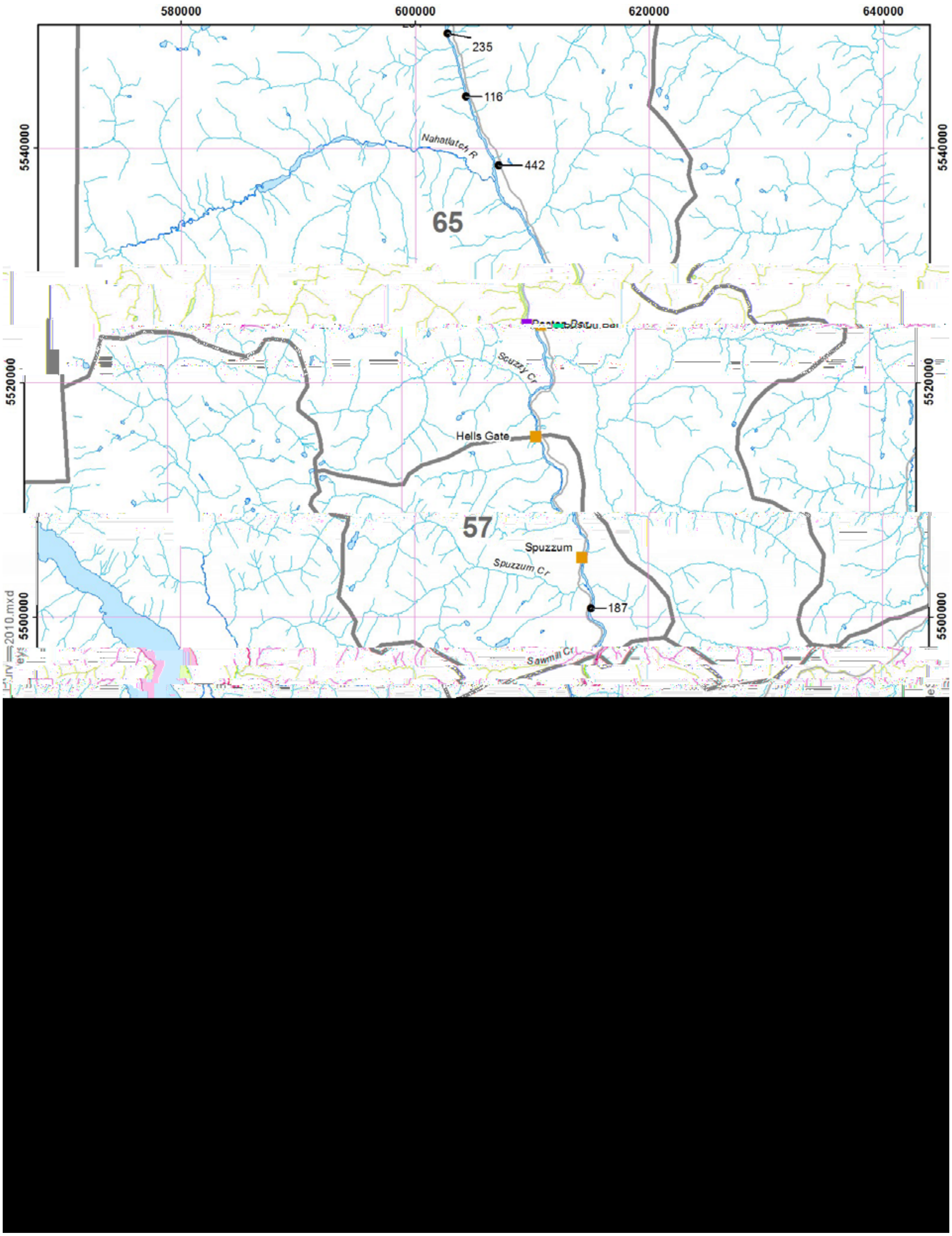
Mobile Surveys and Detections

Appendix Table B1. **Dates, locations and survey types ([B]oat, [F]oot, [H]elicopter, [T]ruck) for mobile tracking surveys conducted in 2010.**

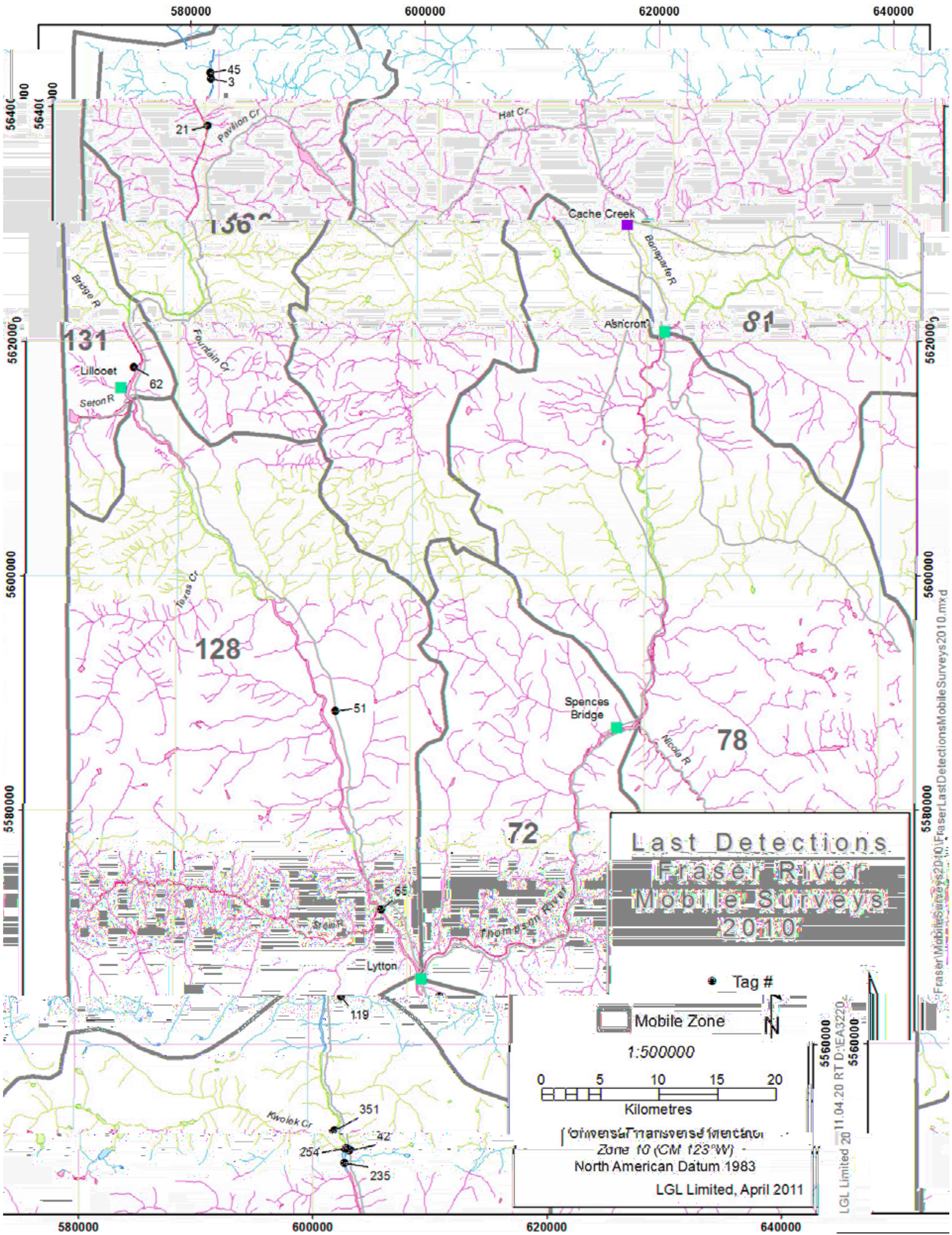
	Date (m/d)																	
Method/Location	8/5	8/6	8/7	8/8	8/10	8/11	8/12	8/13	8/14	8/15	8/16	8/19	8/25	8/26	9/1	9/2	10/9	11/11
<u>Boat/Helicopter/Truck Surveys</u>																		
Rosedale to Hope									T									
Hope to Boston Bar				T			H			T	T		H	T		H		
Boston Bar to Lytton				T		B	H			T	T		H	T		H		
Lytton to Seton River		B					H				T		H	T		H		
Seton R to Bridge River	T	B					H						H	T		H		
Bridge River to Kelly Creek							H	H					H			H		
Lytton to Spence's Bridge										T						H		
Spence's Bridge to Ashcroft										T						H		
Spot Checks (by truck/foot)																		
Cheam FN village (Rosedale)									T									
Town of Hope									T		T				T			
Town of Yale										T	T	T		T	T			
Yale fishing area (in Yale)										T	T	T		T	T			
Yale fishing area (3 km u/s Yale)										T	T	T		T	T			
Siska FN village										T	T	T		T				
Town of Lytton										T	T	T		T				
City of Lillooet	T				F					T	T	T		T				
Bridge River fishing area	F		F		F						T	T		T				
Bridge River FN village			F								T			T				
Fountain FN village										T								
<u>Upper-Thompson Spawning Areas</u>																		
Adams River																	F	H
Kamloops to Shuswap Lake																		H

Appendix Table B2. Radio tags detected during mobile tracking surveys conducted in 2010.

Date	Location	Survey Type	Tags Detected
5 Aug	Seton To Bridge River, Lillooet	Truck/Foot	none
6 Aug	Lytton to Bridge River	Boat	none
7 Aug	Bridge River fishing area and village	Foot	none
8 Aug	Hope to Thompson mouth	Foot	201
10 Aug	Bridge River fishing area and Lillooet	Foot	none
11 Aug	Hells Gate to Seton	Boat	42, 65, 156, 187, 205, 215, 254, 547
12 Aug	Sawmill Creek to Kelly Creek	Helicopter	21, 42, 45, 51, 62, 65, 116, 127, 156, 205, 215, 235, 257, 269, 271, 278, 285, 291, 293, 300, 312, 315
13 Aug	Hells Gate to Thompson mouth	Helicopter	21, 45
14 Aug	Rosedale to Hope	Truck	231, 246
15 Aug	Hells Gate to Thompson mouth, Spences Bridge to Ashcroft	Truck	42, 271, 368, 652, 668
16 Aug	Hells Gate to Bridge River	Truck	42, 51, 273, 274, 324, 368, 652, 668
19 Aug	Yale to Bridge River	Truck	none
25 Aug	Sawmill to Kelly Creek	Helicopter	21, 116, 119, 187, 302, 335, 351, 422, 429, 442, 445, 472
26 Aug	Hope to Sawmill, Hells Gate to Thompson, Seton to Bridge River	Truck	117, 429, 673
1 Sep	Hope to Yale	Truck	none
2 Sep	Sawmill to Thompson, Seton to Kelly Creek, Thompson to Ashcroft	Helicopter	3, 21, 116, 254, 450, 565
9 Oct	Lower Adams River	Foot	400, 485, 491
11 Nov	Kamloops to Adams River Mouth, lower portion of Shuswap Lake around Scotch Creek, Adams River to Adams Lake	Helicopter	72, 83, 88, 284, 285, 313, 341, 350, 447, 458, 485, 487, 491, 546, 562, 579, 581, 605, 641, 659, 662, 667, 668, 683, 690, 692, 721, 723



Appendix Figure B1. **Two maps showing last known positions for 15 fish that were last detected during mobile tracking survey efforts between 12 Aug and 11 November, 2010. Respectively: lower Fraser River mainstem, and upper Fraser River mainstem.**



Appendix Figure B1 continued.

APPENDIX C

Spawning Area Recoveries, and Fishery Returns

Appendix Table C1. Radio tags recovered from fisheries and reported before 31 December, 2010.

Tag No.	Release Date	Run-timng Group	Recovery Date	Zone	Recovery Location
96	23 Jul	Late-run	27 Jul	U.S. Marine Commercial Fishery	Lummi Island, Legoe Bay
268	4 Aug	Early Summer	4 Aug	U.S. Marine Commercial Fishery	Lummi Island, Legoe Bay
287	4 Aug	Early Summer	4 Aug	U.S. Marine Commercial Fishery	Lummi Island, Legoe Bay
128	24 Jul	Late-run	2 Aug	FN Fishery - Mission to Sawmill	Fraser River near Chilliwack
140	24 Jul	Late-run	27 Jul	FN Fishery - In River D/S Mission	Stat Area 29-13 or 29-14
170	25 Jul	Early Summer	31 Jul	FN Fishery - Mission to Sawmill	Fraser River just below Fraser Bridge near Hope
247	28 Jul	Early Summer	31 Jul	FN Fishery - In River D/S Mission	Golden Ears Bridge - near Pitt Meadows
297	4 Aug	Summer-run	9 Aug	Sport Fishery - Mission to Sawmill	Rosedale area
323	5 Aug	Early Summer	7 Aug	FN Fishery - In River D/S Mission	South Fraser Arm - near Steveston
337	5 Aug	Early Summer	10 Aug	Freshwater Commercial Fishery	Maple Ridge at Albion
345	5 Aug	Summer-run	7 Aug	U.S. Marine Commercial Fishery	Between Blaine and Point Roberts
356	6 Aug	Late-run	12 Aug	Sport Fishery - Mission to Sawmill	Seabird Island
357	6 Aug	Summer-run	8 Aug	U.S. Marine Commercial Fishery	Area 7A - US near Point Roberts
364	6 Aug	Early Summer	7 Aug	U.S. Marine Commercial Fishery	Point Roberts outside Harbour
398	11 Aug	Summer-run	11 Aug	Commercial Fishery Area 12-13	Area 12
42	13 Jul	Undetermined	16 Aug	Possible fishery recovery	
51	19 Jul	Early Stuart	16 Aug	Possible fishery recovery	
62	21 Jul	Early Stuart	16 Aug	Possible fishery recovery	
201	26 Jul	Early Summer	9 Aug	FN Fishery - In River U/S Sawmill	Siska - below reserve on westside
252	28 Jul	Summer-run	9 Aug	FN Fishery - In River U/S Sawmill	Thompson, 1 mi up from Junction of Fraser
386	11 Aug	Early Summer	17 Aug	Commercial Fishery Area 12-13	Robson Bight
457	13 Aug	Late-run	17 Aug	Freshwater Commercial Fishery	mouth of Fraser - Bedwell
505	17 Aug	Late-run	18 Aug	Commercial Fishery Area 12-13	Granite Bay - JS - Campbell River
249	28 Jul	Early Summer	12 Aug	FN Fishery - In River U/S Sawmill	Fountain, 6 mile (Bridge River Rapids, RL)
259	28 Jul	Summer-run	12 Aug	FN Fishery - In River U/S Sawmill	Bridge River Rapids - D11
427	12 Aug	Late-run	21 Aug	Sport Fishery - Mission to Sawmill	near Hope
499	17 Aug	Summer-run	23 Aug	Sport Fishery - Mission to Sawmill	Grassy Bar - Chilliwack
260	28 Jul	Late-run	22 Aug	FN Fishery - Mission to Sawmill	Strawberry Island
477	17 Aug	Early Summer	27 Aug	Sport Fishery - Mission to Sawmill	above Herrling Island
540	19 Aug	Late-run	21 Aug	Commercial Fishery Area 12-13	Area 12 commercial fishery
107	23 Jul	Summer-run	1 Aug	FN Fishery - In River U/S Sawmill	Chi[illegible]ltin
206	26 Jul	Early Summer	14 S J		

Appendix Table C1 continued.

Tag No.	Release Date	Run-timng Group	Recovery Date	Zone	Recovery Location
399	11 Aug	Early Summer	17 Aug	Commercial Fishery Area 12-13	Johnson Strait Windy Point Area 12-1
409	11 Aug	Late-run	22 Aug	FN Fishery - Mission to Sawmill	near Hope
433	12 Aug	Early Summer	6 Sep	FN Fishery - Mission to Sawmill	North Side of Agassiz near Rosedale Bridge
500	17 Aug	Summer-run	23 Aug	Commercial Fishery Area 12-13	Area 13-8 - McMullen Point
563	19 Aug	Late-run	30 Aug	Freshwater Commercial Fishery	Dease Island near Steveston
564	19 Aug	Early Summer	1 Sep	Freshwater Commercial Fishery	South Arm Fraser Cottonwoods upriver 4 miles
566	19 Aug	Late-run	5 Sep	FN Fishery - Mission to Sawmill	1 mile below Agassiz Bridge
585	25 Aug	Summer-run	10 Sep	Freshwater Commercial Fishery	Prince Rupert from Area 29 gillnet fishery
594	25 Aug	Late-run	26 Aug	Commercial Fishery Area 12-13	validator found tag in Delta - from Area 12(2/3)
639	26 Aug	Summer-run	3 Sep	Freshwater Commercial Fishery	Area 29
681	2 Sep	Late-run	9 Sep	Freshwater Commercial Fishery	Area 29 - Canadian fishing company processing plant
494	17 Aug	Late-run	8 Sep	Freshwater Commercial Fishery	found at the Canadian Fishing Company - Prince Rupert
635	26 Aug	Late-run	13 Sep	Freshwater Commercial Fishery	from Area 29 commercial fishery
715	3 Sep	Late-run	8 Sep	Freshwater Commercial Fishery	came from an Area 29 packer
530	18 Aug	Summer-run	4 Sep	Commercial Fishery Area 12-13	recovered at process plant in Prince Rupert
615	26 Aug	Late-run	9 Sep	Freshwater Commercial Fishery	Area 29 commercial fishery
638	26 Aug	Late-run	29 Sep	FN Fishery - In River U/S Sawmill	Thompson River near Kamloops Lake
685	2 Sep	Late-run	15 Sep	U.S. Marine Commercial Fishery	Homeport Seafoods, Bellingham
314	4 Aug	Early Summer	15 Aug	FN Fishery - In River D/S Mission	Katzie (between Barnston and Golden Ears Bridge)
335	5 Aug	Summer-run	15 Aug	FN Fishery - In River D/S Mission	bought fish from FN fisher at UBC
358	6 Aug	Late-run	10 Aug	Freshwater Commercial Fishery	Fort Langley
370	6 Aug	Early Summer	15 Aug	FN Fishery - Mission to Sawmill	unknown - tracked to Harrison, so likely above that
403	11 Aug	Late-run	25 Aug	Freshwater Commercial Fishery	from Area 29 gillnet
302	4 Aug	Summer-run	15 Aug	FN Fishery - In River U/S Sawmill	Lytton
422	12 Aug	Summer-run	24 Aug	FN Fishery - In River U/S Sawmill	Skuppah
513	18 Aug	Summer-run	25 Aug	Commercial Fishery Area 12-13	Campbell River -Kamish Bay
565	19 Aug	Summer-run	7 Sep	FN Fishery - In River U/S Sawmill	Texas Creek to Lillooet - near old Bridge
630	26 Aug	Late-run	17 Sep	FN Fishery - Mission to Sawmill	Cheam Beach
717	3 Sep	Late-run	16 Sep	FN Fishery - Mission to Sawmill	below Sawmill ?
498	17 Aug	Summer-run	19 Aug	Commercial Fishery Area 12-13	Area 13
451	12 Aug	Early Summer	15 Sep	Freshwater Commercial Fishery	Area 29 packer
525	18 Aug	Late-run	15 Sep	Freshwater Commercial Fishery	Area 29 packer
571	19 Aug	Late-run	30 Aug	Freshwater Commercial Fishery	Area 29 packer
582	25 Aug	Late-run	30 Aug	Freshwater Commercial Fishery	Alex Fraser Bridge

Appendix Table C2. Sockeye radio tags recovered from spawning areas, 2010.

Tag No.	Release Date	Run-timng Group	Recovery Date	Zone	Recovery Location
164	25 Jul	Early Summer	8 Sep	Shuswap Lake Mobile	Anstey Beach Marine Park - Shuswap Lake
65	21 Jul	Early Summer	21 Aug	Thompson to Seton Mobile	found near the confluence of Stein River and Fraser
246	28 Jul	Summer-run	28 Aug	Below Hope Mobile	found tag near Jones Lake and Laidlaw
461	13 Aug	Late-run	8 Sep	On a Beach	Rathtrevor Beach Found Tag - No fish
561	19 Aug	Late-run	17 Oct	Weaver Mobile	Weaver Creek Spawning Channel
699	2 Sep	Late-run	26 Oct	Weaver Mobile	Weaver Creek Spawning Channel
2	7 Jul	Early Stuart	3 Aug	Nadina or Stellako Mobile	Narrows Creek (Stuart)
74	21 Jul	Summer-run	22 Aug	Chilko River Mobile	Chilko River
315	4 Aug	Early Summer	12 Sep	Seymour River Mobile	Seymour River
278	4 Aug	Early Summer	8 Sep	Scotch Creek Mobile	Scotch Creek
317	4 Aug	Summer-run	19 Sep	Chilko River Mobile	Chilko River
588	25 Aug	Summer-run	5 Oct	Mitchell River Mobile	Mitchell River (Quesnel)
257	28 Jul	Summer-run	7 Oct	Nadina or Stellako Mobile	Stellako
40	13 Jul	Early Summer	25 Sep	Nadina or Stellako Mobile	Stellako
714	3 Sep	Late-run	27 Oct	Adams River Mobile	Adams River
633	26 Aug	Late-run	16 Oct	Lower Shuswap Mobile	Lower Shuswap River
389	11 Aug	Late-run	21 Oct	Lower Shuswap Mobile	Bessette Creek (South Thompson)
707	3 Sep	Late-run	22 Oct	Lower Shuswap Mobile	Lower Shuswap River
702	3 Sep	Late-run	27 Oct	Lower Shuswap Mobile	Lower Shuswap River
692	2 Sep	Late-run	11 Nov	Little Shuswap Lake Mobile	Little Shuswap Lake
447	12 Aug	Late-run	14 Nov	Shuswap Lake Mobile	Shuswap Lake
458	13 Aug	Late-run	14 Nov	Shuswap Lake Mobile	Shuswap Lake

APPENDIX D

Fishwheel Effort and Catch

Appendix Table D1. Total effort, effort used to calculate CPUE, and average daily fishwheel speed (RPM) for the Crescent Island fishwheels, 2010.

	Large Fishwheel			Small Fishwheel		
Date	Total effort (h)	CPUE effort (h)	RPM	Total effort (h)	CPUE effort (h)	RPM
27-Jun	5.0	3.8	1.8	12.8	4.2	2.6
28-Jun	10.0	0.0	1.8	24.0	22.9	2.7
29-Jun	24.0	25.4	2.0	24.0	25.3	2.6
30-Jun	22.8	24.2	2.0	24.0	25.5	2.4
1-Jul	24.0	22.0	1.7	24.0	22.1	2.4
2-Jul	24.0	25.1	1.8	24.0	25.1	2.3
3-Jul	24.0	24.2	1.6	24.0	24.3	2.1
4-Jul	24.0	23.6	1.6	24.0	23.6	2.3
5-Jul	24.0	21.6	1.7	24.0	21.0	2.3
6-Jul	24.0	26.0	1.5	23.8	26.1	1.9
7-Jul	24.0	24.7	1.5	22.1	21.8	2.0
8-Jul	24.0	22.4	1.5	22.5	21.5	2.0
9-Jul	24.0	23.4	1.6	24.0	23.9	2.2
10-Jul	24.0	27.9	1.5	24.0	28.2	2.0
11-Jul	23.9	23.2	1.5	24.0	22.4	2.1
12-Jul	24.0	21.2	1.4	24.0	21.3	2.2
13-Jul	17.4	21.2	1.6	24.0	28.6	2.2
14-Jul	24.0	20.0	1.5	24.0	19.3	2.3
15-Jul	24.0	24.0	1.6	24.0	24.0	1.7
16-Jul	9.0	10.0	1.7	24.0	25.6	2.1
17-Jul	24.0	24.0	1.5	24.0	23.3	2.0
18-Jul	24.0	24.2	1.4	24.0	24.2	2.0
19-Jul	24.0	24.2	1.4	13.3	4.3	1.9
20-Jul	7.3	0.3	1.2	18.0	18.1	2.0
21-Jul	24.0	16.9	1.4	24.0	19.2	1.9
22-Jul	24.0	31.0	1.3	24.0	30.3	1.9
23-Jul	24.0	22.8	1.4	24.0	23.0	2.2
24-Jul	24.0	22.8	1.4	24.0	22.8	2.0
25-Jul	24.0	24.1	1.3	24.0	24.1	1.8
26-Jul	24.0	25.8	1.3	24.0	25.8	1.7
27-Jul	24.0	22.2	1.2	24.0	22.2	1.9
28-Jul	24.0	23.9	1.2	24.0	24.0	1.8
29-Jul	24.0	22.9	1.3	24.0	23.2	1.5
30-Jul	24.0	25.0	1.2	24.0	24.7	1.6
31-Jul	24.0	24.2	1.3	24.0	24.2	1.3
1-Aug	23.3	23.3	1.1	24.0	24.3	1.5
2-Aug	24.0	26.1	1.2	24.0	26.0	1.6
3-Aug	22.7	20.1	1.2	24.0	21.4	1.5
4-Aug	24.0	25.1	1.2	24.0	24.6	1.4
5-Aug	24.0	25.3	1.0	24.0	25.6	1.3
6-Aug	24.0	23.4	1.0	24.0	23.9	1.4
7-Aug	24.0	23.9	1.1	24.0	23.8	1.5
8-Aug	24.0	23.7	1.1	24.0	23.6	1.4
9-Aug	21.0	23.7	1.0	24.0	26.8	1.4
10-Aug	24.0	22.2	1.0	24.0	22.2	1.4

Appendix Table D1 continued.

	Large Fishwheel			Small Fishwheel		
	Total	CPUE		Total	CPUE	
Date	effort (h)	effort (h)	RPM	effort (h)	effort (h)	RPM
11-Aug	24.0	22.1	1.1	24.0	22.0	1.4
12-Aug	24.0	25.1	1.1	24.0	25.1	1.4
13-Aug	24.0	22.4	0.8	24.0	22.4	1.0
14-Aug	24.0	25.0	0.9	24.0	25.2	1.1
15-Aug	24.0	24.1	0.8	24.0	24.0	0.9
16-Aug	24.0	24.5	0.9	24.0	24.5	1.0
17-Aug	24.0	24.0	0.6	24.0	24.0	0.7
18-Aug	24.0	23.4	0.6	24.0	23.5	0.3
19-Aug	24.0	25.3	0.7	24.0	25.2	1.3
20-Aug	24.0	22.6	1.2	24.0	22.6	1.5
21-Aug	24.0	19.7	0.9	24.0	20.1	1.8
22-Aug	24.0	23.8	1.3	24.0	23.7	1.7
23-Aug	24.0	28.8	0.8	24.0	28.5	1.0
24-Aug	24.0	23.2	0.7	24.0	22.8	1.1
25-Aug	24.0	22.1	0.6	24.0	22.5	0.9
26-Aug	24.0	26.4	0.4	24.0	26.4	0.6
27-Aug	24.0	18.7		24.0	18.8	
28-Aug	24.0	29.3	0.7	24.0	29.2	1.9
29-Aug	24.0	24.0	0.6	24.0	24.0	1.9
30-Aug	24.0	24.4	0.5	24.0	24.1	1.9
31-Aug	24.0	22.1	0.7	24.0	22.0	1.9
1-Sep	24.0	25.5	0.4	24.0	25.9	1.1
2-Sep	24.0	22.9	0.9	24.0	22.8	0.8
3-Sep	24.0	26.9	0.9	24.0	26.8	1.0
4-Sep	24.0	23.1	0.7	24.0	23.2	0.5
5-Sep	24.0	23.4	0.6	24.0	23.3	0.4
6-Sep	24.0	26.2	0.8	24.0	26.2	0.7
7-Sep	24.0	23.9	0.8	24.0	24.0	
8-Sep	24.0	15.6		24.0	16.5	
9-Sep	24.0	32.0	0.9	24.0	31.0	0.5
10-Sep	24.0	22.9	0.8	24.0	23.2	
11-Sep	24.0	22.8	0.8	24.0	22.6	0.8
12-Sep	24.0	26.4	0.6	24.0	26.1	0.6
13-Sep	24.0	23.1	0.7	24.0	23.4	0.5
14-Sep	24.0	23.2	0.8	24.0	23.1	
15-Sep	24.0	23.6	0.8	24.0	23.6	0.7
16-Sep	24.0	24.4	0.7	24.0	24.4	0.4
17-Sep	24.0	23.6	0.8	24.0	23.6	0.9
18-Sep	24.0	24.0	0.7	24.0	24.3	0.7
19-Sep	24.0	24.6	0.7	24.0	24.0	0.9
20-Sep	24.0	24.2	0.6	24.0	24.4	1.0
21-Sep	24.0	24.5	0.6	24.0	24.5	0.7
22-Sep	24.0	23.3	0.6	24.0	23.1	0.6
23-Sep	24.0	23.9	0.7	24.0	23.8	0.7
24-Sep	24.0	24.0	0.5	24.0	24.2	0.8

Appendix Table D1 continued.

	Large Fishwheel			Small Fishwheel		
Date	Total effort (h)	CPUE effort (h)	RPM	Total effort (h)	CPUE effort (h)	RPM
25-Sep	24.0	23.4	0.8	24.0	23.6	1.0
26-Sep	24.0	23.2	0.5	24.0	23.1	0.5
27-Sep	24.0	24.7	0.8	24.0	25.7	1.0
28-Sep	24.0	25.2	0.8	24.0	24.7	0.8
29-Sep	15.0	13.8	0.6	24.0	22.8	1.2
30-Sep	24.0	24.2	0.8	24.0	24.3	1.4
1-Oct	24.0	19.2	1.1	24.0	18.0	1.5
2-Oct	24.0	25.0	1.1	24.0	27.3	1.4
3-Oct	9.0	22.3		10.0	22.0	
Total effort (h)	2,274			2,330		
% operational	97.1%			99.1%		

Appendix Table D2. Catch and catch per unit effort (CPUE, fish per hour) for adult sockeye and Chinook salmon at the Crescent Island fishwheels, 2010.

	Sockeye Salmon[a]				Chinook Salmon[a]			
	Large FW		Small FW		Large FW		Small FW	
Date	Catch	CPUE	Catch	CPUE	Catch	CPUE	Catch	CPUE
27 Jun	1	0.26	1	0.24	3	0.78	0	0.00
28 Jun	0		4	0.17	0		1	0.04
29 Jun	27	1.06	3	0.12	9	0.35	0	0.00
30 Jun	10	0.41	4	0.16	11	0.45	1	0.04
1 Jul	11	0.50	4	0.18	9	0.41	1	0.05
2 Jul	46	1.83	6	0.24	11	0.44	1	0.04
3 Jul	13	0.54	0	0.00	5	0.21	0	0.00
4 Jul	17	0.72	2	0.08	11	0.47	1	0.04
5 Jul	15	0.70	0	0.00	6	0.28	1	0.05
6 Jul	13	0.50	0	0.00	3	0.12	0	0.00
7 Jul	57	2.31	11	0.51	6	0.24	1	0.05
8 Jul	70	3.12	4	0.19	5	0.22	0	0.00
9 Jul	9	0.39	11	0.46	0	0.00	0	0.00
10 Jul	56	2.00	7	0.25	7	0.25	0	0.00
11 Jul	51	2.20	5	0.22	4	0.17	0	0.00
12 Jul	44	2.08	4	0.19	2	0.09	0	0.00
13 Jul	89	4.19	0	0.00	4	0.19	11	0.38
14 Jul	21	1.05	5	0.26	4	0.20	0	0.00
15 Jul	43	1.79	3	0.12	10	0.42	1	0.04
16 Jul	4	0.40	6	0.23	1	0.10	3	0.12
17 Jul	64	2.67	7	0.30	10	0.42	1	0.04
18 Jul	7	0.29	5	0.21	1	0.04	0	0.00
19 Jul	27	1.11	1	0.23	11	0.45	0	0.00
20 Jul	0	0.00	1	0.06	0	0.00	2	0.11
21 Jul	29	1.72	3	0.16	5	0.30	1	0.05
22 Jul	58	1.87	4	0.13	7	0.23	0	0.00
23 Jul	11	0.48	1	0.04	0	0.00	0	0.00
24 Jul	41	1.80	3	0.13	8	0.35	0	0.00
25 Jul	97	4.03	10	0.42	0	0.00	0	0.00
26 Jul	150	5.83	22	0.85	8	0.31	1	0.04
27 Jul	41	1.85	5	0.23	5	0.23	0	0.00
28 Jul	172	7.21	20	0.84	5	0.21	1	0.04
29 Jul	58	2.53	16	0.69	4	0.17	1	0.04
30 Jul	229	9.16	23	0.93	7	0.28	2	0.08
31 Jul	73	3.02	5	0.21	2	0.08	0	0.00
1 Aug	94	4.04	3	0.12	2	0.09	0	0.00
2 Aug	143	5.48	11	0.42	0	0.00	1	0.04
3 Aug	170	8.48	19	0.89	0	0.00	0	0.00
4 Aug	139	5.54	28	1.14	6	0.24	0	0.00
5 Aug	130	5.13	48	1.88	0	0.00	0	0.00
6 Aug	80	3.42	7	0.29	1	0.04	0	0.00
7 Aug	163	6.82	26	1.09	9	0.38	0	0.00
8 Aug	28	1.18	2	0.08	0	0.00	0	0.00
9 Aug	221	9.32	14	0.52	0	0.00	0	0.00

Appendix Table D2 continued.

	Sockeye Salmon[a]				Chinook Salmon[a]			
	Large FW		Small FW		Large FW		Small FW	
Date	Catch	CPUE	Catch	CPUE	Catch	CPUE	Catch	CPUE
10 Aug	84	3.79	15	0.68	1	0.05	1	0.05
11 Aug	143	6.46	24	1.09	0	0.00	0	0.00
12 Aug	38	1.51	11	0.44	0	0.00	0	0.00
13 Aug	380	16.95	68	3.04	4	0.18	1	0.04
14 Aug	97	3.88	10	0.40	2	0.08	0	0.00
15 Aug	188	7.80	10	0.42	8	0.33	0	0.00
16 Aug	171	6.97	51	2.08	3	0.12	1	0.04
17 Aug	209	8.70	41	1.71	2	0.08	1	0.04
18 Aug	115	4.93	25	1.06	0	0.00	1	0.04
19 Aug	18	0.71	1	0.04	0	0.00	0	0.00
20 Aug	112	4.97	4	0.18	2	0.09	0	0.00
21 Aug	100	5.08	9	0.45	1	0.05	1	0.05
22 Aug	77	3.24	6	0.25	3	0.13	0	0.00
23 Aug	182	6.32	13	0.46	1	0.03	0	0.00
24 Aug	70	3.02	2	0.09	0	0.00	0	0.00
25 Aug	86	3.89	1	0.04	0	0.00	0	0.00
26 Aug	25	0.95	2	0.08	0	0.00	0	0.00
27 Aug	3	0.16	0	0.00	0	0.00	0	0.00
28 Aug	25	0.85	0	0.00	1	0.03	0	0.00
29 Aug	19	0.79	2	0.08	0	0.00	0	0.00
30 Aug	106	4.35	1	0.04	1	0.04	0	0.00
31 Aug	65	2.95	2	0.09	0	0.00	1	0.05
1 Sep	10	0.39	0	0.00	0	0.00	0	0.00
2 Sep	24	1.05	0	0.00	0	0.00	0	0.00
3 Sep	13	0.48	0	0.00	1	0.04	0	0.00
4 Sep	3	0.13	0	0.00	0	0.00	0	0.00
5 Sep	7	0.30	0	0.00	4	0.17	0	0.00
6 Sep	5	0.19	0	0.00	1	0.04	0	0.00
7 Sep	21	0.88	1	0.04	0	0.00	0	0.00
8 Sep	41	2.63	0	0.00	1	0.06	0	0.00
9 Sep	16	0.50	1	0.03	0	0.00	0	0.00
10 Sep	32	1.40	1	0.04	2	0.09	0	0.00
11 Sep	99	4.35	6	0.27	1	0.04	0	0.00
12 Sep	140	5.31	3	0.11	0	0.00	0	0.00
13 Sep	223	9.64	1	0.04	0	0.00	0	0.00
14 Sep	18	0.78	0	0.00	1	0.04	0	0.00
15 Sep	79	3.34	1	0.04	0	0.00	1	0.04
16 Sep	84	3.45	1	0.04	1	0.04	0	0.00
17 Sep	21	0.89	0	0.00	1	0.04	0	0.00
18 Sep	1	0.04	0	0.00	1	0.04	0	0.00
19 Sep	16	0.65	1	0.04	5	0.20	0	0.00
20 Sep	11	0.46	3	0.12	1	0.04	0	0.00
21 Sep	61	2.49	1	0.04	1	0.04	0	0.00
22 Sep	191	8.20	5	0.22	2	0.09	0	0.00

Appendix Table D2 continued.

	Sockeye Salmon[a]				Chinook Salmon[a]			
	Large FW		Small FW		Large FW		Small FW	
Date	Catch	CPUE	Catch	CPUE	Catch	CPUE	Catch	CPUE
23 Sep	178	7.46	2	0.08	1	0.04	0	0.00
24 Sep	46	1.91	0	0.00	0	0.00	0	0.00
25 Sep	105	4.48	1	0.04	0	0.00	0	0.00
26 Sep	14	0.60	4	0.17	0	0.00	0	0.00
27 Sep	5	0.20	1	0.04	0	0.00	0	0.00
28 Sep	5	0.20	2	0.08	1	0.04	1	0.04
29 Sep	1	0.07	1	0.04	0	0.00	0	0.00
30 Sep	3	0.12	1	0.04	2	0.08	1	0.04
1 Oct	4	0.21	0	0.00	15	0.78	3	0.17
2 Oct	3	0.12	1	0.04	12	0.48	2	0.07
3 Oct	0	0.00	1	0.05	32	1.44	6	0.27
Total	6,615		701		317		53	

[a] Sockeye and Chinook jacks captured at the fishwheels were not included in this table.

Appendix Table D3. **Final version of the in-season 'Mission Fishwheel Activity Summary' Table that was produced daily and posted on the PSC webpage during the study period, 2010.**

Fraser Daily Catch Summary 2010 (phone: 1-866-221-3444) **Data to:**

Capture Method	Date	Rotation Speed (RPM)R

Appendix Table D3 continued.

Fraser Daily Catch Summary 2010 (phone: 1-866-221-3444) **Data to: October 3, 2010**

Capture Method	Date	Rotation Speed (RPM)	Hours Operating	SockeyeAdultCaught	SockeyeAdultRadioTag	SockeyeJackCaught	SockeyeRecaptures	ChinookAdultCaught	ChinookJackCaught	PinkAdultCaught	CohoAdultCaught	CohoJackCaught	SteelheadAdultCaught	ChumAdultCaught	SturgeonCaught	SturgeonPITTagApplied	OtherSpeciesCaught
	7/21/10	1.4	24.0	29	9	0	0	5	4	0	0	0	0	0	0	0	17
	7/22/10	1.3	24.0	58	0	0	0	7	4	0	0	0	0	0	0	0	39
	7/23/10	1.4	24.0	11	0	0	0	0	1	0	0	0	0	0	0	0	33
	7/24/10	1.4	24.0	41	0	1	0	8	7	0	0	0	1	0	0	0	15
	7/25/10	1.3	24.0	97	0	0	0	0	5	0	0	0	0	0	0	0	29
	7/26/10	1.3	24.0	150	0	0	0	8	4	0	0	0	1	0	0	0	70
	7/27/10	1.2	24.0	41	0	1	0	5	1	0	0	0	0	0	0	0	43
	7/28/10	1.2	24.0	172	0	1	0	5	8	0	0	0	1	0	0	0	40
	7/29/10	1.3	24.0	58	0	0	0	4	2	0	0	0	0	0	0	0	66
	7/30/10	1.2	24.0	229	0	1	0	7	9	0	0	0	0	0	0	0	77
	7/31/10	1.3	24.0	73	0	1	0	2	5	0	0	0	0	0	0	0	79
	8/01/10	1.1	23.3	94	0	1	0	2	7	0	0	0	0	0	2	0	76
	8/02/10	1.2	24.0	143	0	0	0	0	0	0	0	0	1	0	1	1	100
	8/03/10	1.2	22.7	170	0	0	0	0	0	0	0	0	0	0	0	0	100
	8/04/10	1.2	24.0	139	0	0	0	6	1	0	0	0	1	0	0	0	49
	8/05/10	1.0	24.0	130	0	1	0	0	0	0	0	0	0	0	1	0	113
	8/6/2010*	1.0	24.0	80	0	1	0	1	3	0	0	0	0	0	0	0	56
	8/07/10	1.1	24.0	163	0	0	0	9	2	0	0	0	0	0	0	0	51
	8/08/10	1.1	24.0	28	0	1	0	0	2	1	0	0	0	0	0	0	46
	8/09/10	1.0	21.0	221	0	0	0	0	0	0	0	0	0	0	0	0	59
	8/10/10	1.0	24.0	84	0	0	0	1	0	0	0	0	0	0	0	0	64
	8/11/10	1.1	24.0	143	0	0	0	0	1	0	0	0	0	0	0	0	103
	8/12/10	1.1	24.0	38	0	0	0	0	6	0	0	0	0	0	0	0	219
	8/13/10	0.8	24.0	380	0	0	0	4	2	0	0	0	0	0	0	0	258

Appendix Table D3 continued.

Fraser Daily Catch Summary 2010 (phone: 1-866-221-3444) **Data to:** **October 3, 2010**

Capture Method	Date	Rotation Speed (RPM)	Hours Operating	SockeyeAdultCaught	SockeyeAdultRadioTag	SockeyeJackCaught	SockeyeRecaptures	ChinookAdultCaught	ChinookJackCaught	PinkAdultCaught	CohoAdultCaught	CohoJackCaught	SteelheadAdultCaught	ChumAdultCaught	SturgeonCaught	SturgeonPITTagApplied	OtherSpeciesCaught
	8/14/10	0.9	24.0	97	0	0	0	2	3	0	0	0	1	0	0	0	351
	8/15/10	0.8	24.0	188	0	0	0	8	6	0	0	0	0	0	0	0	171
	8/16/10	0.9	24.0	171	0	0	0	3	0	0	0	0	0	0	1	0	281
	8/17/10	0.6	24.0	209	0	0	0	2	3	0	0	0	0	0	0	0	171
	8/18/10	0.6	24.0	115	0	0	1	0	2	0	0	0	0	0	0	0	154
	8/19/10	0.7	24.0	18	0	0	0	0	0	0	0	0	1	0	0	0	154
	8/20/10	1.2	24.0	112	0	0	0	2	0	0	0	0	0	0	0	0	117
	8/21/10	0.9	24.0	100	0	0	0	1	0	0	0	0	0	0	0	0	166
	8/22/10	1.3	24.0	77	0	2	0	3	4	0	0	0	1	0	0	0	213
	8/23/10	0.8	24.0	182	0	3	0	1	1	0	0	0	0	0	0	0	122
	8/24/10	0.7	24.0	70	0	0	0	0	3	0	0	0	0	0	0	0	111
	8/25/10	0.6	24.0	86	0	1	0	0	3	0	0	0	1	0	0	0	262
	8/26/10	0.4	24.0	25	0	0	0	0	3	1	1	0	0	0	0	0	115
	8/27/10		24.0	3	0	0	0	0	1	0	0	0	0	0	0	0	109
	8/28/10	0.7	24.0	25	0	0	0	1	1	0	2	0	0	0	0	0	257
	8/29/10	0.6	24.0	19	0	0	0	0	1	0	1	0	0	0	0	0	188
	8/30/10	0.5	24.0	106	0	0	0	1	0	0	0	0	0	0	0	0	249
	8/31/10	0.7	24.0	65	0	0	0	0	0	0	0	0	0	0	0	0	275
	9/01/10	0.4	24.0	10	0	0	0	0	0	0	0	0	0	0	0	0	194
	9/02/10	0.9	24.0	24	0	0	0	0	0	0	0	0	0	0	0	0	227
	9/03/10	0.9	24.0	13	0	0	0	1	0	0	0	0	0	0	0	0	265
	9/04/10	0.7	24.0	3	0	0	0	0	0	0	0	0	0	0	0	0	179
	9/05/10	0.6	24.0	7	0	0	0	4	2	0	4	0	0	0	1	0	185
	9/06/10	0.8	24.0	5	0	0	0	1	4	0	3	0	0	0	0	0	180

Appendix Table D3 continued.

Fraser Daily Catch Summary 2010 (phone: 1-866-221-3444) **Data to: October 3, 2010**

Capture Method	Date	Rotation Speed (RPM)	Hours Operating	SockeyeAdultCaught	SockeyeAdultRadioTag	SockeyeJackCaught	SockeyeRecaptures	ChinookAdultCaught	ChinookJackCaught	PinkAdultCaught	CohoAdultCaught	CohoJackCaught	SteelheadAdultCaught	ChumAdultCaught	SturgeonCaught	SturgeonPITTagApplied	OtherSpeciesCaught
	9/07/10	0.8	24.0	21	0	0	0	0	0	0	3	0	0	0	0	0	68
	9/08/10		24.0	41	0	1	0	1	0	0	0	0	0	0	0	0	11
	9/09/10	0.9	24.0	16	0	0	0	0	0	0	1	2	0	0	0	0	137
	9/10/10	0.8	24.0	32	0	0	0	2	2	0	0	0	0	0	0	0	5
	9/11/10	0.8	24.0	99	0	0	0	1	0	0	0	0	0	0	0	0	36
	9/12/2010*	0.6	24.0	140	0	0	0	0	0	0	2	3	0	0	0	0	21
	9/13/10	0.7	24.0	223	0	0	0	0	1	0	0	1	0	0	0	0	53
	9/14/10	0.8	24.0	18	0	0	0	1	1	0	1	5	0	0	0	0	25
	9/15/10	0.8	24.0	79	0	0	0	0	4	0	3	2	0	0	0	0	58
	9/16/10	0.7	24.0	84	0	0	0	1	2	0	3	10	0	0	0	0	23
	9/17/10	0.8	24.0	21	0	0	0	1	3	0	8	9	0	1	0	0	44
	9/18/2010*	0.7	24.0	1	0	0	0	1	0	0	2	6	0	0	0	0	35
	9/19/10	0.7	24.0	16	0	0	0	5	0	0	6	22	0	1	0	0	24
	9/20/10	0.6	24.0	11	0	0	0	1	0	0	2	19	1	0	0	0	23
	9/21/10	0.6	24.0	61	0	0	0	1	0	0	3	11	1	0	0	0	45
	9/22/10	0.6	24.0	191	0	0	0	2	0	0	6	20	0	0	0	0	43
	9/23/10	0.7	24.0	178	0	0	1	1	1	0	8	51	0	1	0	0	26
	9/24/10	0.5	24.0	46	0	0	0	0	0	0	10	42	0	1	0	0	12
	9/25/10	0.8	24.0	105	0	0	0	0	0	0	9	8	0	0	0	0	6
	9/26/10	0.5	24.0	14	0	0	0	0	1	0	5	20	0	0	0	0	11
	9/27/10	0.8	24.0	5	0	0	0	0	0	0	6	24	0	0	0	0	19
	9/28/10	0.8	24.0	5	0	0	0	1	0	0	18	40	0	0	0	0	24
	9/29/10	0.6	15.0	1	0	0	0	0	0	0	26	15	1	0	0	0	9
	9/30/10	0.8	24.0	3	0	0	0	2	0	0	75	11	0	7	0	0	16

Appendix Table D3 continued.

Fraser Daily Catch Summary 2010 (phone: 1-866-221-3444) **Data to:** **October 3, 2010**

Capture Method	Date	Rotation Speed (RPM)	Hours Operating	SockeyeAdultCaught	SockeyeAdultRadioTag	SockeyeJackCaught	SockeyeRecaptures	ChinookAdultCaught	ChinookJackCaught	PinkAdultCaught	CohoAdultCaught	CohoJackCaught	SteelheadAdultCaught	ChumAdultCaught	SturgeonCaught	SturgeonPITTagApplied	OtherSpeciesCaught
	10/01/10	1.1	24.0	4	0	0	0	15	4	0	39	12	0	9	0	0	23
	10/02/10	1.1	24.0	3	0	1	0	12	1	0	128	0	1	17	0	0	11
	10/03/10		9.0	0	0	0	0	32	7	0	76	0	0	30	0	0	32
Large FW Total			**2,274**	**6,615**	**66**	**17**	**3**	**317**	**197**	**2**	**451**	**333**	**39**	**67**	**10**	**2**	**8,452**
Small Fishwheel	6/27/10	2.6	12.8	1	0	0	0	0	1	0	0	0	0	0	0	0	1
	6/28/10	2.7	24.0	4	0	0	0	1	0	0	0	0	0	0	0	0	5
	6/29/10	2.6	24.0	3	0	0	0	0	0	0	0	0	0	0	0	0	8
	6/30/10	2.4	24.0	4	0	0	0	1	0	0	0	0	2	0	0	0	5
	7/01/10	2.4	24.0	4	0	0	0	1	1	0	0	0	1	0	0	0	12
	7/02/10	2.3	24.0	6	0	0	0	1	0	0	0	0	1	0	0	0	11
	7/03/10	2.1	24.0	0	0	0	0	0	1	0	0	0	2	0	0	0	22
	7/04/10	2.3	24.0	2	0	0	0	1	0	0	0	0	2	0	0	0	28
	7/05/10	2.3	24.0	0	0	0	0	1	1	0	0	0	3	0	0	0	40
	7/06/10	1.9	23.8	0	0	0	0	0	1	0	0	0	1	0	0	0	91
	7/07/10	2.0	22.1	11	0	0	0	1	0	0	0	0	0	0	0	0	31
	7/08/10	2.0	22.5	4	0	0	0	0	0	0	0	0	1	0	0	0	20
	7/09/10	2.2	24.0	11	0	0	0	0	1	0	0	0	1	0	0	0	8
	7/10/10	2.0	24.0	7	0	0	0	0	1	0	0	0	1	0	0	0	15
	7/11/10	2.1	24.0	5	0	0	0	0	0	0	0	0	0	0	0	0	23
	7/12/10	2.2	24.0	4	0	0	0	0	1	0	0	0	0	0	0	0	8
	7/13/10	2.2	24.0	0	0	0	0	11	0	0	0	0	1	0	0	0	16
	7/14/10	2.3	24.0	5	0	0	0	0	0	0	0	0	1	0	0	0	3
	7/15/10	1.7	24.0	3	0	0	0	1	1	0	0	0	0	0	0	0	30

Appendix Table D3 continued.

Fraser Daily Catch Summary 2010 (phone: 1-866-221-3444) **Data to:** **October 3, 2010**

Capture Method	Date	Rotation Speed (RPM)	Hours Operating	SockeyeAdultCaught	SockeyeAdultRadioTag	SockeyeJackCaught	SockeyeRecaptures	ChinookAdultCaught	ChinookJackCaught	PinkAdultCaught	CohoAdultCaught	CohoJackCaught	SteelheadAdultCaught	ChumAdultCaught	SturgeonCaught	SturgeonPITTagApplied	OtherSpeciesCaught
	7/16/10	2.1	24.0	6	0	0	0	3	1	0	0	0	0	0	0	0	14
	7/17/10	2.0	24.0	7	0	0	0	1	0	0	0	0	2	0	0	0	26
	7/18/10	2.0	24.0	5	0	0	0	0	0	0	0	0	0	0	0	0	18
	7/19/10	1.9	13.3	1	0	0	0	0	0	0	0	0	0	0	0	0	13
	7/20/10	2.0	18.0	1	1	0	0	2	1	0	0	0	0	0	0	0	27
	7/21/10	1.9	24.0	3	0	0	0	1	3	0	0	0	0	0	0	0	13
	7/22/10	1.9	24.0	4	0	0	0	0	1	0	0	0	0	0	0	0	3
	7/23/10	2.2	24.0	1	0	0	0	0	0	0	0	0	1	0	0	0	11
	7/24/10	2.0	24.0	3	0	0	0	0	0	0	0	0	0	0	0	0	3
	7/25/10	1.8	24.0	10	0	2	0	0	0	0	0	0	0	0	0	0	2
	7/26/10	1.7	24.0	22	0	0	0	1	1	0	0	0	0	0	0	0	19
	7/27/10	1.9	24.0	5	0	0	0	0	0	0	0	0	0	0	0	0	7
	7/28/10	1.8	24.0	20	0	1	0	1	1	1	0	0	0	0	0	0	13
	7/29/10	1.5	24.0	16	0	2	0	1	1	0	0	0	1	0	0	0	10
	7/30/10	1.6	24.0	23	0	0	0	2	0	1	0	0	3	0	0	0	20
	7/31/10	1.3	24.0	5	0	0	0	0	1	0	0	0	1	0	0	0	12
	8/01/10	1.5	24.0	3	0	0	0	0	1	0	1	0	0	0	0	0	9
	8/02/10	1.6	24.0	11	0	0	0	1	0	0	0	0	1	0	0	0	13
	8/03/10	1.5	24.0	19	0	0	0	0	3	0	0	0	1	0	0	0	34
	8/04/10	1.4	24.0	28	0	0	0	0	0	0	0	0	1	0	0	0	18
	8/05/10	1.3	24.0	48	0	0	0	0	0	1	0	0	0	0	0	0	26
	8/06/10	1.4	24.0	7	0	0	0	0	0	0	0	0	0	0	0	0	20
	8/07/10	1.5	24.0	26	0	1	0	0	0	0	0	0	0	0	0	0	11
	8/08/10	1.4	24.0	2	0	0	0	0	0	0	0	0	0	0	0	0	1

Appendix Table D3 continued.

Fraser Daily Catch Summary 2010 (phone: 1-866-221-3444) **Data to: October 3, 2010**

Capture Method	Date	Rotation Speed (RPM)	Hours Operating	SockeyeAdultCaught	SockeyeAdultRadioTag	SockeyeJackCaught	SockeyeRecaptures	ChinookAdultCaught	ChinookJackCaught	PinkAdultCaught	CohoAdultCaught	CohoJackCaught	SteelheadAdultCaught	ChumAdultCaught	SturgeonCaught	SturgeonPITTagApplied	OtherSpeciesCaught
	8/09/10	1.4	24.0	14	0	0	0	0	0	0	0	0	0	0	0	0	15
	8/10/10	1.4	24.0	15	0	0	0	1	0	0	1	0	0	0	0	0	47
	8/11/10	1.4	24.0	24	0	2	0	0	1	0	0	0	1	0	0	0	47
	8/12/10	1.4	24.0	11	0	0	0	0	0	0	0	0	0	0	0	0	46
	8/13/10	1.0	24.0	68	0	0	0	1	0	0	0	0	2	0	0	0	84
	8/14/10	1.1	24.0	10	0	0	0	0	2	0	0	0	2	0	0	0	61
	8/15/10	0.9	24.0	10	0	0	0	0	1	0	0	0	0	0	0	0	26
	8/16/10	1.0	24.0	51	0	0	0	1	3	0	0	0	0	0	0	0	72
	8/17/10	0.7	24.0	41	0	0	0	1	3	0	0	0	1	0	0	0	45
	8/18/10	0.3	24.0	25	0	0	0	1	1	0	0	0	1	0	0	0	49
	8/19/10	1.3	24.0	1	0	0	0	0	0	0	0	0	0	0	0	0	35
	8/20/10	1.5	24.0	4	0	0	0	0	0	0	0	0	0	0	0	0	14
	8/21/10	1.8	24.0	9	0	1	0	1	0	0	0	0	0	0	0	0	30
	8/22/10	1.7	24.0	6	0	1	0	0	0	0	0	0	0	0	0	0	59
	8/23/10	1.0	24.0	13	0	2	0	0	1	0	0	0	0	0	0	0	104
	8/24/10	1.1	24.0	2	0	0	0	0	0	0	0	0	0	0	0	0	109
	8/25/10	0.9	24.0	1	0	0	0	0	1	0	0	0	0	0	0	0	94
	8/26/10	0.6	24.0	2	0	0	0	0	1	0	0	0	0	0	0	0	22
	8/27/10		24.0	0	0	0	0	0	0	0	1	0	0	0	0	0	38
	8/28/10	1.9	24.0	0	0	0	0	0	0	0	0	0	0	0	0	0	61
	8/29/10	1.9	24.0	2	0	0	0	0	0	0	0	0	0	0	0	0	109
	8/30/10	1.9	24.0	1	0	0	0	0	0	0	1	0	0	0	0	0	74
	8/31/10	1.9	24.0	2	0	0	0	1	0	0	1	0	0	0	0	0	93
	9/01/10	1.1	24.0	0	0	0	0	0	0	0	0	0	0	0	0	0	102

Appendix Table D3 continued.

Fraser Daily Catch Summary 2010 (phone: 1-866-221-3444) **Data to:** **October 3, 2010**

Capture Method	Date	Rotation Speed (RPM)	Hours Operating	SockeyeAdultCaught	SockeyeAdultRadioTag	SockeyeJackCaught	SockeyeRecaptures	ChinookAdultCaught	ChinookJackCaught	PinkAdultCaught	CohoAdultCaught	CohoJackCaught	SteelheadAdultCaught	ChumAdultCaught	SturgeonCaught	SturgeonPITTagApplied	OtherSpeciesCaught
	9/02/10	0.8	24.0	0	0	0	0	0	0	0	0	0	0	0	0	0	170
	9/03/10	1.0	24.0	0	0	0	0	0	0	0	0	0	0	0	0	0	183
	9/04/10	0.5	24.0	0	0	0	0	0	0	0	1	0	0	0	0	0	191
	9/05/10	0.4	24.0	0	0	0	0	0	2	0	2	0	0	0	0	0	102
	9/06/10	0.7	24.0	0	0	0	0	0	1	0	0	0	0	0	0	0	47
	9/07/10		24.0	1	0	0	0	0	0	0	1	0	0	0	0	0	65
	9/08/10		24.0	0	0	0	0	0	0	0	0	0	0	0	0	0	13
	9/09/10	0.5	24.0	1	0	1	0	0	0	0	0	0	0	0	0	0	46
	9/10/10		24.0	1	0	0	0	0	0	0	0	0	0	0	0	0	2
	9/11/10	0.8	24.0	6	0	0	0	0	0	0	0	0	0	0	0	0	35
	9/12/2010*	0.6	24.0	3	0	0	0	0	0	0	0	2	0	0	0	0	15
	9/13/10	0.5	24.0	1	0	0	0	0	0	0	1	0	0	0	0	0	7
	9/14/10		24.0	0	0	0	0	0	1	0	0	1	0	0	0	0	23
	9/15/10	0.7	24.0	1	0	0	0	1	1	0	1	1	0	0	0	0	37
	9/16/10	0.4	24.0	1	0	0	0	0	0	0	1	3	0	0	0	0	11
	9/17/10	0.9	24.0	0	0	0	0	0	0	0	1	4	0	0	0	0	8
	9/18/2010*	0.7	24.0	0	0	0	0	0	2	0	0	6	0	0	0	0	5
	9/19/10	0.9	24.0	1	0	0	0	0	0	0	3	22	0	0	0	0	4
	9/20/10	1.0	24.0	3	0	0	0	0	0	0	1	7	0	0	0	0	7
	9/21/10	0.7	24.0	1	0	0	0	0	1	0	0	8	0	0	0	0	17
	9/22/10	0.6	24.0	5	0	0	0	0	0	0	3	19	0	0	0	0	19
	9/23/10	0.7	24.0	2	0	0	0	0	0	0	3	15	0	0	0	0	7
	9/24/10	0.8	24.0	0	0	0	0	0	0	0	2	6	0	0	0	0	5
	9/25/10	1.0	24.0	1	0	0	0	0	0	0	4	3	0	0	0	0	4

Appendix Table D3 continued.

Fraser Daily Catch Summary 2010 (phone: 1-866-221-3444) **Data to:** **October 3, 2010**

Capture Method	Date	Rotation Speed (RPM)	Hours Operating	SockeyeAdultCaught	SockeyeAdultRadioTag	SockeyeJackCaught	SockeyeRecaptures	ChinookAdultCaught	ChinookJackCaught	PinkAdultCaught	CohoAdultCaught	CohoJackCaught	SteelheadAdultCaught	ChumAdultCaught	SturgeonCaught	SturgeonPITTagApplied	OtherSpeciesCaught
	9/26/10	0.5	24.0	4	0	0	0	0	0	0	0	18	0	0	0	0	3
	9/27/10	1.0	24.0	1	0	0	0	0	0	0	1	6	0	0	0	0	2
	9/28/10	0.8	24.0	2	0	0	0	1	1	0	9	11	0	0	0	0	9
	9/29/10	1.2	24.0	1	0	0	0	0	0	0	16	5	0	3	0	0	57
	9/30/10	1.4	24.0	1	0	0	0	1	0	0	23	8	0	0	0	0	9
	10/01/10	1.5	24.0	0	0	0	0	3	0	0	18	2	0	1	0	0	13
	10/02/10	1.4	24.0	1	0	0	0	2	0	0	25	0	0	4	0	0	16
	10/03/10		10.0	1	0	0	0	6	3	0	26	1	2	6	0	0	19
Small FW Total			**2,330**	**701**	**1**	**13**	**0**	**53**	**49**	**3**	**147**	**148**	**37**	**14**	**0**	**0**	**3,307**
FW Total			**4,605**	**7,316**	**67**	**30**	**3**	**370**	**246**	**5**	**598**	**481**	**76**	**81**	**10**	**2**	**11,759**

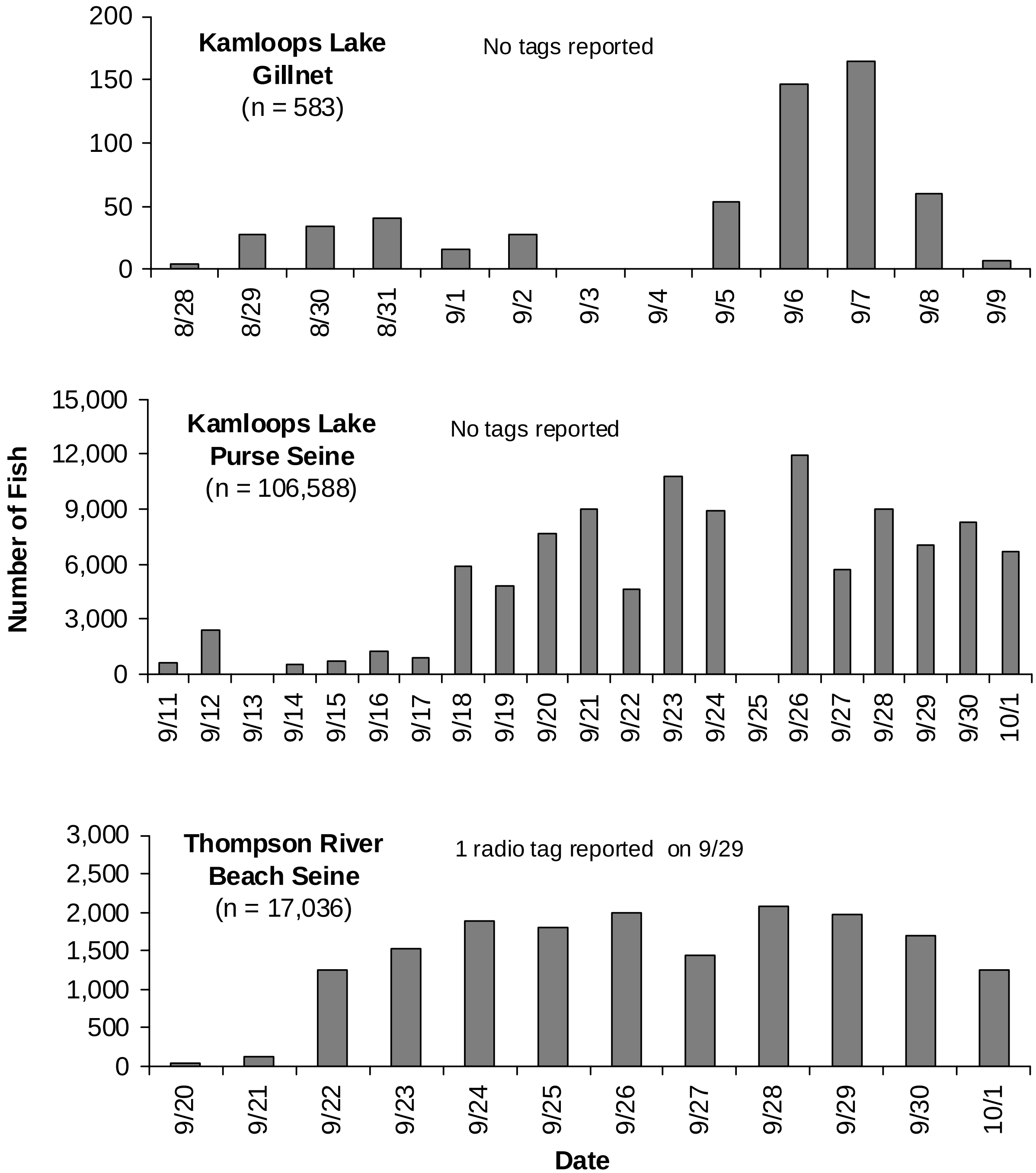
* Overnight catch data incomplete.

APPENDIX E

Catch Monitoring Information

Appendix Table E1. **Number of sockeye salmon reported (observed/hailed) by DFO/First Nation catch monitors in the Mid and Upper Fraser River, 2010 (Cynthia Breau, DFO, personal communication).**

	Management Unit												
	Sawmill Creek to Hell's Gate D-01	Hell's Gate to Sam Adams Indian Reserve D-02	Sam Adams IR to Siwash Creek D-03	Siwash Creek to Piglog Creek D-04	Piglog Creek to Pooeyelth Creek D-05	Pooeyelth Creek to Saw Creek D-06	Saw Creek to Thompson River D-07a	Thompson River confluence to Stein River D-07b	Stein River to Texas Creek D-08	Texas Creek to CN Rail Bridge, Lillooet D-09	CN Rail Bridge to Pavilion Creek D-11	Thompson River to Bonaparte confluence D-10	Total
Week	*Observed*												
31	0	0	0	0	0	0	0	0	0	0	0	0	0
32	10	28	110	43	56	49	4	5	18	53	496	6	878
33	21	0	185	0	17	0	51	6	0	25	496	82	883
34	0	46	0	48	15	52	8	0	1	18	426	404	1,018
35	14	180	38	145	23	4	0	0	11	31	795	177	1,418
36	0	181	10	97	10	20	17	21	35	73	80	137	681
37	5	78	0	15	0	8	0	2	9	43	0	302	462
38	37	29	0	38	0	0	23	0	0	31	212	375	745
39	22	0	0	0	0	0	0	0	0	0	0	275	297
40	0	0	0	0	0	0	0	0	0	0	0	115	115
Subtotal	109	542	343	386	121	133	103	34	74	274	2,505	1,873	6,497
Week	*Hailed*												
31	0	0	0	0	0	0	0	0	8	30	431	0	469
32	74	100	234	190	621	49	32	37	100	285	3,368	576	5,666
33	30	285	78	120	358	45	18	43	68	382	3,646	937	6,010
34	210	130	219	100	448	7	49	0	101	621	2,860	991	5,736
35	0	105	0	42	89	54	8	6	70	319	3,122	1,231	5,046
36	0	57	0	17	82	15	15	14	1	194	1,783	602	2,780
37	114	91	41	38	94	0	20	0	0	144	819	1,493	2,854
38	0	24	30	0	23	0	28	0	0	90	164	1,098	1,457
39	21	241	30	0	0	0	0	0	0	0	3	362	657
40	0	35	0	0	0	0	0	0	0	0	0	115	150
Subtotal	449	1,068	632	507	1,715	170	170	100	348	2,065	16,196	7,405	30,825
Total	558	1,610	975	893	1,836	303	273	134	422	2,339	18,701	9,278	37,322



Appendix Figure E1. **Number of sockeye salmon landed in Kamloops Lake gillnet (top), Kamloops Lake purse seine (middle), and Thompson River beach seine (bottom) demonstration commercial fisheries conducted by the Shuswap Nation, 2010 (Aaron Gillespie, Shuswap First Nation, personal communication).**