

**Abundance Estimates for Fraser  
River Sockeye and Pink Salmon  
based on Mission Hydroacoustic  
Data and Species Composition  
Estimates from the Whonnock  
Gillnet Test Fishery and Lower  
Fraser Fishwheels, 2009-2015**

**Final Report**

*Prepared for:*

Pacific Salmon Commission

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**Abundance Estimates for Fraser River Sockeye and Pink Salmon based on Mission Hydroacoustic Data and Species Composition Estimates from the Whonnock Gillnet Test Fishery and Lower Fraser Fishwheels, 2009-2015**

**Final Report**

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## **EXECUTIVE SUMMARY**

One of the significant challenges in implementing the Mission hydroacoustic program is to partition acoustic targets among salmon species. While most of the salmon migrating upstream during even-numbered years are Sockeye salmon (*Oncorhynchus nerka*), there is a substantial migration of Pink salmon (*Oncorhynchus gorbuscha*) during odd-numbered years. Test fishing data can be used to help partition targets among species, but the existing gillnet test fisheries tend to overestimate Sockeye proportions because they are unable to operate in the near-shore areas where Pink salmon are more concentrated. As a consequence, Pacific Salmon Commission (PSC) staff developed Sockeye estimation methods that involved expanding catch per effort data, and estimation of other species abundances using expert judgement. One of the objectives of the 2009 study and the primary objective of the 2011, 2013, and 2015 fishwheel projects was to determine whether a stratified approach to estimating species composition could provide an alternative to existing methods. The proposed approach used data from fishwheels to estimate species composition for near-shore areas, and used similar data from the existing Whonnock test-fishery to represent the species composition for off-shore areas. Two fishwheels were continuously operated from early July to mid-September 2009 and in August of 2011, 2013, and 2015 in a relatively fast-flowing section of the Fraser River near Crescent Island. All captured fish were identified to species, and species composition was calculated daily. 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. The follow points summarize our findings:

- Spatially stratified hydroacoustic counts can be combined with species composition data from the fishwheel data, dual-frequency imaging sonar (DIDSON) length-based methods, and Whonnock test fisheries to produce estimates of the number of Sockeye and Pink salmon that pass the Mission hydroacoustic site in odd-number years.
- The fishwheel data and DIDSON length-based method strongly support other observations of major differences in the species composition between near-shore and off-shore waters in the lower Fraser River. When Pink salmon are present in the Fraser River, they are a larger portion of the salmon in near-shore areas than in off-shore areas.
- Substantial differences have been observed between the DIDSON length-based species composition estimates and those derived from fishwheel samples for near-shore waters.
- A more detailed examination of the differences between the near-shore species composition estimates derived from the fishwheel and DIDSON length-based methods is required to identify the most scientifically defensible method for estimating near-shore species composition in August, in years with high Pink salmon abundance.
- The need to understand the potential causes of the discrepancies between DIDSON and fishwheel based species proportions has led to the development of a proposal for a detail examination of any differences observed between the length-based and fishwheel estimates in 2017.

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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). 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.

The Mission abundance estimates are an important source of data 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. In 2005 and 2006, the Mission hydroacoustic program has generated substantial over and underestimates of Sockeye salmon (*Oncorhynchus nerka*) passage during the in-season period. In 2005, the errors were attributed primarily to incorrect species composition estimates, which resulted in incorrect partitioning of the acoustics signals among species (PSC 2009). Determining the correct species composition is difficult since it varies across the river channel, and since the available test-fishing gear types have catchabilities that also vary across the river channel (Smith et al. 2009). For example, the Whonnock test-fishery samples less efficiently near shore than it does in the central part of the channel, thus it is likely to underestimate the relative abundance of groups that swim closer to shore (such as Pink salmon (*Oncorhynchus gorbuscha*) or jack Chinook salmon (*Oncorhynchus tshawytscha*); Robichaud et al. 2008). The species-partitioning problem is paramount in odd-numbered years, when substantial numbers of Pink salmon migrate upstream past the Mission hydroacoustic site. In past years, this issue mainly affected Sockeye estimates in September (thus mostly affecting the estimates of Late-run Sockeye passage), but in more recent years Pink salmon have initiated earlier upstream migration, potentially also affecting abundance estimation in August (thus affecting both Summer-run and Late-run Sockeye estimates). Moreover, in recent years the abundance of Chinook migrating past Mission in August has increased substantially, and this combined with low abundance years for Summer-run Sockeye (e.g., 2008 and 2009) may be creating further species-composition issues for the Mission hydroacoustic site. One objective of this report is to describe how a stratified approach to estimating species composition may improve the accuracy of acoustic signal partitioning. Specifically we explored methods of combining data collected from efficient near-shore capture devices (i.e., from two fishwheels operating near Crescent Island), with off-shore data from the Whonnock test-fishery to try to determine how best to partition acoustic signals from the Mission acoustic site. In 2013 and 2015, a dual-frequency imaging sonar (DIDSON) length-based mixture model was used to derived species composition estimates for near-shore areas from early August when Sockeye are the dominate species to late August when Pink are dominant in odd-numbered years.

The fishwheels were also used to provide a continuous source of salmon for the biological sampling needs of management agencies. Specifically, Fisheries and Oceans Canada (DFO) scientists used fishwheel-caught salmon for a genomics project, and the Pacific Salmon Commission (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 results of the biosampling data collected from fish captured by the fishwheels are reported elsewhere (e.g., Robichaud et al. 2010).

## **MATERIALS AND METHODS**

### **Study Area**

The study area locations included the Whonnock gillnet test fishery (rkm 56), the fishwheel site upstream from Crescent Island (rkm 71) and the Mission hydroacoustic site (rkm 81). The time required for Sockeye and Pink salmon to traverse the distance from the Whonnock test fishery to the hydroacoustic site is less than one day (24 hours).

### **Study Design**

In 2009, Fraser fishwheel and radio-telemetry project was the first odd-numbered year (Pink salmon year) when species composition data was collected using fishwheels deployed near Crescent Island in the lower Fraser River. The results from the 2009 study indicated that fishwheels could be an effective tool for monitoring near-shore species composition which was significantly different from the off-shore species composition estimates from the Whonnock gillnet test fishery (Robichaud et al. 2010). Consequently, funding was provided for operating the fishwheels at the Crescent Island site in 2011, 2013, and 2015.

The primary objectives for these later Fraser fishwheel studies were:

1. to continuously operate one large and one small fishwheel in a relatively fast-flowing section of the Fraser River near Crescent Island during the period of run-timing overlap between Sockeye and Pink salmon;
2. to collect species composition data from the fishwheels daily throughout the study period; and
3. provide fork-length measurements for a sample of the Sockeye and Pink salmon caught and all other fish that were greater than 50 cm in fork-length.

### **Fishwheel Deployment and Operation**

In each year, 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 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 1). 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.

A floating shoreline abutment was used at the Crescent Island site which served three main functions: 1) it held the fishwheels off-shore in water deep enough to turn their baskets; 2) it allowed the fishwheels to be shifted inshore or off-shore 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 off-shore 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.

In 2009, 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 was not used in 2011-2015. 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 Species Composition**

Every fish 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). The report on the 2009 study provides a comparison of the species composition data from the fishwheels with those from the Whonnock gillnet test fishery for 1 July to 20 September 2009 (Robichaud et al. 2010). However, in all subsequent years the August was the only month when fishwheels were only consistently operated to assess the transition near-shore species composition from mostly Sockeye in early August to mostly Pink salmon by the end of August. The period selected for this comparison was 4-31 August each year.

### **PSC Mission Escapement Estimates**

In the report for the 2009 study, we compared our daily Sockeye abundance estimates, derived using the fishwheel and Whonnock species composition data in combination with the Mission hydroacoustic counts, to the daily Sockeye abundances estimated in-season by the PSC. Historically, Sockeye passage was estimated during periods of Pink salmon presence by using the Sockeye catch per unit effort (CPUE) from the Whonnock test fishery divided by a catchability coefficient that was obtained from a period prior to the migration of Pink salmon. While this method required an assumption that Sockeye catchability was constant before and after the Pink salmon upstream migration began, the method appeared to work fairly well prior to 2005, and any errors mainly affected Late-run Sockeye estimates in September. However, in 2005, the very early upstream migration of Fraser River Pink salmon coupled with the very late marine arrival and upstream migration of Fraser River Sockeye salmon meant that a much larger fraction of the Sockeye migration needed to be estimated while Pink salmon were co-migrating in the Fraser River. Lacking alternative sources of information, a decision was made in-season to apply the relative proportions of Sockeye and Pink salmon in the Whonnock test fishery catches to the daily total salmon migration estimated by hydroacoustics to estimate the abundances of Sockeye and Pink salmon through about mid-September. Following that period, the traditional method of estimating Sockeye by dividing the Whonnock Sockeye CPUE by a catchability coefficient was used. This in-season method led to a large overestimate of Sockeye passage that caused PSC staff to compare a number of alternative methods for estimating species composition in a post-season review (PSC 2009; see Appendix J). This review concluded that the in-season estimate likely overestimated the abundance of Sockeye salmon by nearly 2.8M fish and that the best method for generating post-season estimates of Sockeye passage was based on a method that generated species proportion estimates from the marine purse seine test fishery CPUE for each species. These CPUE values were parsed out to Fraser Sockeye based on stock composition samples, expanded to abundances based on historical catchability and then adjusted for travel times between the purse seine test fishery sites and Mission (PSC 2009). This post-season review, and the continuing early upstream migration of Fraser Pink salmon led to the monitoring of several alternative methods for estimating species proportions. These methods were focused on generating accurate estimates of Sockeye salmon, because it was acknowledged that the application of available technologies likely led to underestimates of total salmon and Pink salmon in particular. Prior to the migration of Pink, the in-season hydroacoustic signals at Mission were partitioned using species composition data from the Whonnock gillnet test fishery. After the beginning of the Pink migration, a variety of methods have been used to estimate

species composition. The selection of the data source and methods for estimating species composition was based on managers' best judgement as to which was most reliable for that period of time.

The time series of species proportions (% Sockeye) estimates used to generate the species-specific fish abundance estimates at Mission in 2009 along with 'time-line symbols' indicating which data sources were used are shown in Figure 2(PSC, unpublished data). The data sources resulting from the application of expert judgement in 2009 were as follows:

1. From 25 June to 5 August, the species composition data from the Whonnock gillnet test-fishery were used to partition the hydroacoustic signals at Mission among species. During periods of low Sockeye catch in the Whonnock gillnets, the species composition data were interpolated or assumed to be 50% Sockeye (see Figure 2);
2. From 6-19 August, an assumed number of Pink salmon (increasing from 0 to 30,000) was subtracted from the total hydroacoustic count before using the Whonnock test fishery data to partition these counts between Sockeye and Chinook salmon;
3. During the period from 20-25 August, species composition data from the marine test fisheries were used to partition the Mission hydroacoustic counts between Sockeye, Chinook and Pink salmon;
4. From 26 August until the end of the study period, the hydroacoustic data at Mission were ignored for in-season analysis, and the Mission escapement estimates for Sockeye were calculated by multiplying the daily Sockeye catch in the Whonnock test fishery by a fixed expansion factor. This expansion factor was derived by comparing the Whonnock Sockeye catches with the "best estimate" of Mission Sockeye escapement during the 10 day period prior to the arrival of Pink salmon.

During 2009 season, DIDSON acoustic sampling devices were deployed on both shores (within 20 m of the south bank and within 10 m of the north bank) during the Pink salmon migration period. These DIDSON data was processed post-season and comparisons were made between the DIDSON hydroacoustic counts and those derived from the standard split-beam system for near-shore areas covered by both systems. These comparisons confirmed previous observations that the split-beam systems substantially underestimated salmon counts during the peak of the Pink migration period. Total counts derived using the DIDSON technology were 2-6 times those from the split-beam system from 1-27 September 2009<sup>1</sup>. The revised post-season hydroacoustic estimates were combined with the Whonnock and fishwheel species composition data to derive the daily Sockeye, Chinook, and Pink salmon abundance estimates presented in Robichaud et al. (2010).

The deployment DIDSON technology at Mission has a number of consequences. First, the capacity DIDSON technology to monitor much higher densities than conventional split-beam acoustics technology, meant that it could generate credible estimates of total salmon in the near shore areas where Pink salmon migration was concentrated. This meant that accurate estimates of Fraser River Pink salmon were now possible, which had been unavailable since the mark-

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<sup>1</sup> The estimation of total salmon abundance in September during Pink years is the subject of ongoing research by the Hydroacoustics Group of the Pacific Salmon Commission. The working estimates provided to LGL Limited on 7 April 2010 are preliminary and subject to change.

recapture program had been discontinued after the 2001 season (Grant et al. 2014 [SEF report]). Second, the more accurate estimates of near shore migration provided by the DIDSON were required by any stratified method which matched species proportions with estimates of total salmon for near-shore and off-shore portions of the migration. Third, the high resolution DIDSON images permit the measurement of individual fish lengths which led to the possibility of using a fish lengths and a mixture model as a tool for estimating species proportions (Fleischman and Burwen 2003; Xie et al. 2013; Grant et al. 2014). The developments led to the application of various methods, including length-based mixture models for estimates species proportions on subsequent years. The particular methods applied in each of the years 2011, 2013, and 2015 are documented in Grant et al. (2014, Appendix A).

### **Mission Escapement Estimates Using Hydroacoustic, Whonnock, and Fishwheel Data**

For each year, we obtained the PSC hydroacoustic counts of salmon that were partitioned into 5 m intervals across the river channel and used these to derive the number of salmon migrating in three spatial strata: 1) within 50 m of the south bank (left), within 50 m of the north bank (right) and 3) in the remainder of the river channel (center). In 2009, the Whonnock gillnet test fishery and fishwheels were operated from 27 June to 20 September, therefore, species composition estimates were available for the entire migration period for Sockeye and Pink salmon. In 2009, daily species composition estimates from the Whonnock gillnet test fishery were applied to the center channel counts while the daily species composition estimates from the fishwheels were applied to the other two (shoreline) strata to produce estimates for Sockeye, Pink, and Chinook salmon that passed the Mission hydroacoustic site (Robichaud et al. 2010).

Estimates of the number of Sockeye and Pink salmon migration past the Mission hydroacoustic site in 2011, 2013, and 2015 were derived by combining the available species composition data with the following assumptions: 1) for July, the Whonnock species composition estimates are suitable to estimate the Sockeye and Pink portion for both near shore and center channel hydroacoustic counts since essential no Pink salmon were caught in the fishwheels or Whonnock test fishery prior to the beginning of August; 2) for August, the Whonnock and fishwheel species composition estimates were used as described above for 2009; and 3) for September, the Whonnock species composition estimates are suitable for the center channel counts and the near shore counts were assumed to be all Pink salmon based on the September fishwheel data collected in 2009 and 2011.

## **RESULTS**

### **Comparison of Species Composition Estimates**

The Whonnock and fishwheel catch data for 2009, 2011, 2013, and 2015 show a similar pattern in the estimates of the percent Sockeye in their respective catches (Figures 3-6). Sockeye consistently represent 80-90 of the salmon caught in the Whonnock gillnet test fishery in the first half of August and decline to values near 50% by the end of August. The Sockeye portion of fishwheel catches was similar to that observed in the Whonnock test fishery in early August but are consistently much lower in the second half of August. In 2013, the Pink salmon run was notably later than in the other years and this was the only year when the Whonnock and fishwheel estimates were similar until 21 August. For 2009 and 2011, the estimates of Sockeye proportions implied by PSC's best judgement in these years are intermediate to the Whonnock and fishwheel estimates, consistent with, though not directly resulting from, a stratified

approach. The stark contrast in the pattern of Sockeye proportions from these two time series and the Whonnock time series illustrated why a stratified method is required to avoid biases associated with the application of species proportions from only off-shore or near-shore areas.

In 2013 and 2015, the Sockeye proportions obtained from length-based method resulting from the processing of individual fish targets in the DIDSON images were more similar to those obtained from the fishwheel than the Whonnock data. However, substantial differences have been observed between the DIDSON length-based species composition estimates for near-shore strata and those derived from fishwheel samples (Figures 5 and 6). Both methods have their strengths and weaknesses. For the fishwheel, species are identified accurately, but Sockeye and Pink salmon may not be equally vulnerable to the gear. For the DIDSON, both species should be equally vulnerable to being observed in the image, but the measurement of lengths from DIDSON images is imprecise and the length distributions of Sockeye and Pink salmon are highly overlapped. To date, the PSC estimates of Sockeye proportions derived from DIDSON length-based approach have tended to be higher than those derived from the fishwheel samples in late August but often lower in the first 2-3 weeks of August. The need to understand the potential causes of the discrepancies between DIDSON and fishwheel based species proportions has led to the development of a proposal for a detail examination of any differences observed between the length-based and fishwheel estimates in 2017.

### **Mission Escapement Estimates and Their Comparison with PSC Estimates**

Tables 1-4 provide estimates of the number of Sockeye and Pink salmon passing the Mission Hydroacoustic site from 12 July to 20 September each year. These values were compared with the final estimates for these periods prepared by the PSC (Figures 7-10). The estimates of Pink salmon obtained for the two methods were very similar because both methods estimated high proportions of Pink salmon during the periods late in the season when the bulk of the total salmon migrated passed Mission. The estimates of Sockeye salmon generated from the stratified application of the fishwheel and Whonnock data were generally smaller than the PSC estimates. Since there is no independent estimate of the true number of Sockeye passing in these years, further studies would be needed to determine the reasons for the observed differences in these estimates.

## **DISCUSSION**

### **Species Composition at Mission**

One of the major sources of uncertainty in the Mission hydroacoustic estimates for Sockeye is the across-channel species composition at the Mission hydroacoustic site. In odd-numbered years, substantial numbers of Pink salmon migrate upstream past the Mission hydroacoustic site in August and September along with summer and late-summer Sockeye stocks. In recent years the abundance of Chinook migrating past Mission in August has increased substantially, and this combined with low abundance years for Summer-run Sockeye (e.g., 2008) creates further species-composition issues for the Mission hydroacoustic site. Historically, data from the Whonnock gillnet test fishery has been used to determine the species composition at the Mission site for periods when Pink salmon abundance is not a factor (i.e., even-numbered years and July in odd-numbered years). Pacific Salmon Commission biologists have recognized that the abundance ratio of Fraser Sockeye to Pink salmon in August-September marine test fisheries (in odd-numbered years) is substantially different from those derived from the Whonnock gillnet test

fishery. This recognition was emphasized by the large bias in Sockeye estimates generated during the 2005 season (PSC 2009). Fishwheel data from the Mission Railway Bridge sites sampled in 2007 confirmed previous observations that Pink salmon tend to be more abundant close to shore than in the center of the channel and the ratio of Pink to Sockeye is substantially different between near-shore and off-shore sampling locations (Robichaud et al. 2008). The estimates of species proportions derived from the DIDSON length-based method in 2013 and 2015 provided additional evidence of the predominance of Pink salmon in near-shore waters (Fleischman and Burwen 2003; Xie et al. 2013; Grant et al. 2014).

In 2009, 2011, 2013, and 2015, the deployment of DIDSON technology in near-shore areas improved the accuracy of estimates of near-shore salmon migration and PSC partitioned the Mission hydroacoustic counts into near-shore and off-shore strata, so the species composition estimates from the fishwheels could be applied to the near-shore counts, and species composition from Whonnock gillnet test fishery catches could be applied to the off-shore counts. The resulting daily estimates of the number of Sockeye passing Mission were consistent with the PSC's 'best judgement' estimates of the daily Sockeye abundance at Mission except for periods late in the year, when the stratified estimates were larger than the PSC estimates.

In each year examined, the transition from mostly Sockeye to mostly Pink salmon in near-shore waters occurred in August. In two years (2009 and 2015), the percent Sockeye in fishwheel catches began to diverge from those in the Whonnock test fishery in early August. In 2011, fishwheel operations didn't start until mid-August when Sockeye percentages were already lower in the fishwheel catches. In 2013, the percent Sockeye in the fishwheel and Whonnock catches were similar until 20 August, when they diverged rapidly from those in the Whonnock test fishery and Sockeye were less than 2% of the fishwheel catch at the end of August, as observed in other odd years. In the two years (2009 and 2011) when the fishwheels were operated until 20 September, Pink salmon comprised over 99% of the salmon caught in September. Therefore, the key period for application of a stratified method estimating species proportions, is clearly August.

The total costs for operating the fishwheels at the Crescent Island site for most of August in recent years has been \$55,000. The daily costs for fishwheel operations with a local three person crew, crew boat and routine maintenance has been \$900/d. The remainder of the costs are associated with annual fishwheel repairs, deployment, demobilization, and data analysis and reporting. These costs are kept reasonable because PSF and DFO have provided the large and small fishwheels, respectively, at no cost to the project. Regular maintenance and a reliable off channel storage site have ensured that both fishwheels and the shoreline abutment are in working order and readily available for deployment at the Crescent Island site.

By comparison the costs of processing the DIDSON length measurements during the August period is approximately \$18,000. This cost corresponds to the hiring of a one person crew dedicated to measuring a sample of approximately 30 fish per day from each bank. That costs is minimal because the PSC needs to operate DIDSONs on each shore to estimate Pink salmon abundance.

The DIDSON length-based method is less expensive than the fishwheel method for providing the daily near-shore species composition estimates in August, but the fishwheel operation offers a number of additional benefits including:

1. The method is more direct and required less technical interpretation;

2. The gear provides a platform for biological sampling (e.g., lengths, DNA) and tagging;
3. Information is gathered from other species (e.g., sturgeon, coho); and
4. It engages First Nations and provides harvest opportunities.

A more detailed examination of the differences between the near-shore species composition estimates derived from the fishwheel and DIDSON length-based methods is required to identify the most scientifically defensible method for estimating near-shore species composition and whether spatially-stratified species composition and sonar counts can provide a more reliable estimate of the Sockeye and Pink salmon abundance at Mission than the method based on Whonnock Sockeye CPUE.

## **CONCLUSIONS**

- Spatially stratified hydroacoustic counts can be combined with species composition data from the fishwheel data, DIDSON length-based methods, and Whonnock test fisheries to produce estimates of the number of Sockeye and Pink salmon that pass the Mission hydroacoustic site in odd-number years.
- The fishwheel data and DIDSON length-based method strongly support other observations of major differences in the species composition between near-shore and off-shore waters in the lower Fraser River. When Pink salmon are present in the Fraser River, they are a larger portion of the salmon in near-shore areas than in off-shore areas.
- Substantial differences have been observed between the DIDSON length-based species composition estimates and those derived from fishwheel samples for near-shore waters.
- A more detailed examination of the differences between the near-shore species composition estimates derived from the fishwheel and DIDSON length-based methods is required to identify the most scientifically defensible method for estimating near-shore species composition in August, in years with high Pink salmon abundance.
- The need to understand the potential causes of the discrepancies between DIDSON and fishwheel based species proportions has led to the development of a proposal for a detail examination of any differences observed between the length-based and fishwheel estimates in 2017.

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**TABLES**

**Table 1. Daily estimates of Sockeye and Pink salmon passing Mission based on PSC hydroacoustic counts and species composition from the Whonnock test fishery and Crescent Island fishwheels, 2009.**

Date	Mission Total Salmon			% Sockeye Salmon		% Pink Salmon		Sockeye Estimate			Pink Estimate		
	Left	Center	Right	Shore	Center	Shore	Center	Shore	Center	Total	Shore	Center	Total
12-Jul	2,501	5,196	6,363	74%	56%	0%	0%	6,595	2,897	9,492	0	0	0
13-Jul	2,685	6,770	3,997	76%	53%	0%	0%	5,093	3,597	8,690	0	0	0
14-Jul	2,425	2,344	2,918	78%	51%	0%	0%	4,172	1,184	5,356	0	0	0
15-Jul	1,501	1,845	1,286	73%	48%	0%	0%	2,043	884	2,927	0	0	0
16-Jul	2,079	2,398	2,194	61%	45%	0%	0%	2,593	1,085	3,678	0	0	0
17-Jul	2,086	3,257	3,376	55%	43%	0%	0%	3,025	1,388	4,413	0	0	0
18-Jul	1,200	1,392	871	49%	40%	0%	0%	1,014	557	1,571	0	0	0
19-Jul	1,246	10,094	4,987	50%	37%	0%	0%	3,116	3,701	6,818	0	0	0
20-Jul	648	4,718	1,570	57%	44%	0%	0%	1,267	2,059	3,326	0	0	0
21-Jul	2,093	8,964	4,836	66%	53%	0%	0%	4,561	4,738	9,299	0	0	0
22-Jul	3,293	6,116	2,904	65%	59%	0%	0%	4,001	3,627	7,628	0	0	0
23-Jul	2,789	4,382	2,496	67%	62%	0%	0%	3,523	2,722	6,245	0	0	0
24-Jul	4,546	7,289	6,478	65%	67%	0%	0%	7,146	4,859	12,006	0	0	0
25-Jul	4,373	13,709	10,318	68%	59%	0%	0%	10,047	8,140	18,186	0	0	0
26-Jul	6,655	9,442	6,151	72%	58%	0%	0%	9,235	5,508	14,742	0	0	0
27-Jul	11,245	9,797	3,877	73%	57%	0%	0%	10,977	5,537	16,514	0	0	0
28-Jul	13,901	8,175	9,634	72%	96%	0%	0%	16,903	7,819	24,723	0	0	0
29-Jul	17,854	14,455	7,543	76%	95%	0%	0%	19,187	13,674	32,861	0	0	0
30-Jul	15,434	14,599	5,952	76%	92%	0%	0%	16,328	13,382	29,710	0	0	0
31-Jul	15,384	7,392	6,331	74%	91%	0%	0%	16,028	6,711	22,739	0	0	0
01-Aug	21,691	5,319	7,478	64%	88%	0%	0%	18,758	4,674	23,432	0	0	0
02-Aug	43,565	8,978	8,346	65%	84%	0%	0%	33,518	7,510	41,029	0	0	0
03-Aug	47,424	10,640	15,804	80%	79%	0%	0%	50,724	8,396	59,120	0	0	0
04-Aug	41,514	9,187	13,505	88%	75%	0%	0%	48,524	6,902	55,427	0	0	0
05-Aug	48,033	12,899	9,983	91%	78%	0%	0%	52,852	10,122	62,974	0	0	0
06-Aug	27,315	7,005	6,525	91%	80%	0%	0%	30,689	5,591	36,279	55	0	55
07-Aug	29,352	13,869	5,872	90%	83%	0%	0%	31,540	11,512	43,052	112	0	112
08-Aug	74,538	13,545	5,025	86%	82%	1%	0%	68,433	11,133	79,566	1,053	0	1,053
09-Aug	88,773	19,342	14,671	80%	82%	5%	1%	82,710	15,895	98,605	4,733	192	4,924
10-Aug	89,381	14,745	18,185	74%	81%	9%	1%	79,259	11,996	91,255	9,521	125	9,646
11-Aug	91,527	22,824	13,469	66%	79%	14%	1%	68,968	17,946	86,914	15,183	174	15,357
12-Aug	52,768	19,848	28,310	61%	76%	19%	0%	49,104	15,105	64,209	15,074	0	15,074
13-Aug	51,675	29,714	24,020	47%	66%	27%	6%	35,621	19,574	55,195	20,692	1,651	22,342
14-Aug	43,260	20,423	23,467	36%	68%	39%	10%	23,912	13,790	37,702	25,734	2,095	27,829
15-Aug	91,289	17,424	17,558	27%	74%	46%	9%	29,685	12,934	42,619	50,465	1,603	52,068
16-Aug	92,229	21,505	13,032	26%	81%	51%	5%	26,966	17,490	44,456	53,695	1,071	54,766
17-Aug	54,008	32,808	11,585	25%	80%	54%	4%	16,431	26,169	42,601	35,248	1,347	36,595
18-Aug	85,851	26,351	16,401	26%	76%	55%	4%	26,590	20,143	46,732	55,774	1,035	56,808
19-Aug	80,573	32,739	31,251	26%	73%	56%	5%	29,295	23,802	53,097	62,370	1,633	64,002
20-Aug	60,401	52,136	37,555	23%	71%	53%	5%	22,111	37,009	59,120	52,192	2,790	54,982
21-Aug	61,453	47,898	24,117	19%	71%	57%	6%	15,930	34,109	50,039	48,810	2,903	51,713
22-Aug	164,002	37,514	21,663	14%	68%	59%	7%	26,748	25,685	52,434	109,354	2,704	112,057
23-Aug	123,550	33,028	15,391	6%	61%	75%	9%	8,161	20,011	28,172	104,205	3,109	107,314
24-Aug	79,742	22,185	11,044	4%	52%	81%	15%	3,222	11,498	14,719	73,756	3,239	76,995
25-Aug	78,706	24,452	14,512	3%	49%	83%	13%	2,793	12,054	14,847	77,041	3,100	80,141
26-Aug	65,315	24,451	16,703	5%	47%	83%	17%	3,751	11,572	15,324	67,694	4,106	71,801
27-Aug	40,907	27,769	20,812	5%	38%	84%	16%	2,860	10,617	13,478	52,085	4,492	56,577
28-Aug	40,846	21,004	10,393	3%	42%	94%	24%	1,296	8,911	10,207	48,128	5,092	53,220
29-Aug	61,649	12,734	5,806	1%	42%	96%	28%	691	5,358	6,049	64,888	3,549	68,437
30-Aug	42,456	16,673	9,716	1%	41%	97%	35%	551	6,875	7,427	50,587	5,844	56,431
31-Aug	55,629	16,244	6,458	1%	36%	97%	39%	536	5,879	6,415	60,240	6,265	66,505
01-Sep	123,669	20,647	10,808	1%	24%	98%	54%	720	5,055	5,774	132,319	11,137	143,457
02-Sep	263,301	8,696	13,722	0%	14%	99%	75%	569	1,174	1,743	275,072	6,500	281,573
03-Sep	299,218	13,575	24,384	0%	5%	100%	89%	105	679	784	322,868	12,100	334,968
04-Sep	363,512	15,414	43,492	0%	4%	100%	93%	104	619	723	406,382	14,382	420,764
05-Sep	411,075	15,609	64,521	0%	4%	100%	94%	841	688	1,529	473,704	14,666	488,369
06-Sep	540,767	29,136	92,575	1%	7%	99%	90%	5,138	2,153	7,291	626,777	26,232	653,009
07-Sep	671,555	40,809	65,531	5%	14%	94%	81%	34,170	5,885	40,054	693,967	33,110	727,077
08-Sep	931,877	27,787	90,099	1%	25%	98%	68%	12,467	7,005	19,471	1,006,392	18,781	1,025,174
09-Sep	893,533	80,743	108,028	1%	28%	99%	64%	7,008	22,429	29,436	992,396	51,322	1,043,719
10-Sep	651,414	83,328	150,296	0%	36%	100%	48%	218	29,704	29,922	801,273	39,955	841,228
11-Sep	644,077	73,870	118,889	0%	14%	100%	59%	516	10,094	10,610	762,193	43,588	805,780
12-Sep	457,420	69,709	63,061	0%	4%	100%	72%	361	2,625	2,986	519,759	49,876	569,634
13-Sep	398,226	45,054	53,367	0%	2%	100%	74%	482	1,115	1,597	450,790	33,233	484,023
14-Sep	379,046	23,686	54,377	0%	2%	100%	70%	429	542	971	432,565	16,644	449,209
15-Sep	572,745	24,799	50,717	0%	3%	100%	71%	1,053	645	1,698	622,409	17,657	640,067
16-Sep	858,210	25,210	39,216	0%	1%	100%	79%	0	352	352	893,702	19,975	913,677
17-Sep	757,351	187,289	82,529	0%	1%	99%	86%	0	1,236	1,236	834,185	160,401	994,587
18-Sep	628,060	112,049	98,380	0%	0%	98%	88%	0	524	524	714,723	98,589	813,313
19-Sep	521,138	87,053	86,601	0%	1%	94%	84%	0	803	803	568,530	72,759	641,288
20-Sep	272,507	78,614	52,303	0%	1%	94%	82%	0	600	600	303,854	64,661	368,516
Total	12,782,058	1,880,665	1,935,634					1,103,263	638,259	1,741,522	12,992,550	863,686	13,856,236

**Table 2. Daily estimates of Sockeye and Pink salmon passing Mission based on PSC hydroacoustic counts and species composition from the Whonnock test fishery and Crescent Island fishwheels, 2011.**

Date	Mission Total Salmon			% Sockeye Salmon		% Pink Salmon		Sockeye Estimate			Pink Estimate		
	Left	Center	Right	Shore	Center	Shore	Center	Shore	Center	Total	Shore	Center	Total
12-Jul	1,740	6,095	3,299	44%	44%	0%	0%	2,239	2,709	4,948	0	0	0
13-Jul	1,825	4,131	3,087	0%	0%	0%	0%	0	0	0	0	0	0
14-Jul	2,006	2,899	823	60%	60%	0%	0%	1,697	1,740	3,437	0	0	0
15-Jul	1,702	3,623	1,975	25%	25%	0%	0%	919	906	1,825	0	0	0
16-Jul	1,889	3,175	1,309	47%	47%	0%	0%	1,492	1,482	2,974	0	0	0
17-Jul	1,423	2,783	1,051	20%	20%	0%	0%	495	557	1,051	0	0	0
18-Jul	282	1,071	295	70%	70%	0%	0%	404	749	1,153	0	0	0
19-Jul	128	805	360	11%	11%	0%	0%	54	89	144	0	0	0
20-Jul	304	1,075	1,132	25%	25%	0%	0%	359	269	628	0	0	0
21-Jul	287	1,615	633	36%	36%	0%	0%	335	587	922	0	0	0
22-Jul	889	3,497	853	32%	32%	0%	0%	560	1,124	1,684	0	0	0
23-Jul	1,874	6,477	581	50%	50%	0%	0%	1,228	3,238	4,466	0	0	0
24-Jul	1,455	8,780	2,841	34%	34%	0%	0%	1,467	2,998	4,465	0	0	0
25-Jul	2,584	5,599	614	54%	54%	0%	0%	1,732	3,033	4,765	0	0	0
26-Jul	3,130	6,535	844	69%	69%	0%	0%	2,732	4,493	7,225	0	0	0
27-Jul	4,443	8,118	3,200	67%	67%	0%	0%	5,095	5,412	10,507	0	0	0
28-Jul	4,461	12,411	3,159	66%	66%	0%	0%	5,037	8,204	13,241	0	0	0
29-Jul	5,004	10,454	3,431	76%	76%	0%	0%	6,445	7,987	14,432	0	0	0
30-Jul	5,343	8,381	3,067	80%	80%	0%	0%	6,728	6,705	13,433	0	0	0
31-Jul	4,774	9,277	2,085	85%	85%	0%	0%	5,850	7,913	13,763	0	0	0
01-Aug	4,192	7,410	2,177	82%	82%	0%	0%	5,252	6,110	11,362	0	0	0
02-Aug	3,000	8,647	3,496	84%	84%	0%	0%	5,444	7,247	12,690	0	0	0
03-Aug	7,788	8,299	4,971	90%	90%	0%	0%	11,422	7,429	18,850	0	0	0
04-Aug	6,499	13,561	4,171	88%	88%	0%	0%	9,363	11,900	21,263	0	0	0
05-Aug	14,857	13,903	6,856	86%	86%	0%	0%	18,712	11,981	30,693	0	0	0
06-Aug	33,458	26,811	18,408	88%	88%	0%	0%	45,692	23,620	69,312	0	0	0
07-Aug	27,772	22,892	15,196	78%	78%	0%	0%	33,515	17,856	51,371	0	0	0
08-Aug	20,920	33,674	15,805	75%	89%	5%	1%	27,530	30,086	57,616	1,823	276	2,099
09-Aug	18,510	24,660	9,742	72%	94%	10%	1%	20,320	23,265	43,585	2,804	155	2,959
10-Aug	15,031	19,786	14,250	69%	93%	15%	0%	20,171	18,445	38,616	4,360	0	4,360
11-Aug	18,439	19,174	13,545	66%	86%	20%	3%	21,062	16,534	37,596	6,349	556	6,905
12-Aug	19,019	30,716	7,437	63%	86%	25%	2%	16,619	26,405	43,024	6,565	719	7,284
13-Aug	15,876	10,048	7,843	60%	84%	30%	2%	14,179	8,457	22,636	7,063	167	7,230
14-Aug	12,773	16,192	6,521	57%	88%	35%	1%	10,947	14,223	25,170	6,703	219	6,922
15-Aug	11,248	17,836	10,027	54%	80%	40%	4%	11,425	14,236	25,662	8,447	655	9,101
16-Aug	19,633	33,426	3,995	51%	71%	45%	5%	11,972	23,749	35,721	10,554	1,786	12,340
17-Aug	27,101	30,258	6,441	48%	62%	44%	7%	16,076	18,845	34,921	14,687	2,123	16,810
18-Aug	32,357	45,066	9,074	60%	76%	32%	4%	25,025	34,171	59,196	13,092	1,981	15,073
19-Aug	15,909	29,645	5,620	54%	76%	39%	7%	11,653	22,560	34,213	8,480	2,051	10,531
20-Aug	22,624	33,254	11,157	48%	73%	47%	9%	16,163	24,214	40,377	15,936	2,906	18,841
21-Aug	18,944	21,583	11,568	42%	81%	55%	8%	12,684	17,392	30,076	16,769	1,676	18,445
22-Aug	13,136	27,794	6,323	35%	69%	63%	17%	6,868	19,069	25,937	12,209	4,612	16,821
23-Aug	15,247	20,326	5,998	38%	61%	59%	18%	8,142	12,490	20,632	12,459	3,673	16,132
24-Aug	21,515	23,597	7,491	19%	63%	76%	7%	5,554	14,839	20,394	22,063	1,703	23,766
25-Aug	29,359	27,316	5,753	15%	78%	83%	9%	5,229	21,442	26,671	29,229	2,350	31,579
26-Aug	26,094	22,743	4,443	14%	61%	83%	19%	4,383	13,882	18,265	25,495	4,431	29,926
27-Aug	22,650	29,732	8,679	14%	67%	84%	18%	4,327	20,024	24,350	26,234	5,461	31,695
28-Aug	24,817	27,376	5,115	13%	37%	84%	48%	3,972	10,139	14,111	25,137	13,181	38,319
29-Aug	37,950	25,759	9,244	13%	65%	84%	16%	6,007	16,799	22,806	39,751	4,200	43,951
30-Aug	36,687	27,660	7,647	12%	56%	84%	17%	5,403	15,559	20,962	37,451	4,610	42,061
31-Aug	40,749	25,244	8,344	2%	41%	96%	46%	1,089	10,467	11,556	46,916	11,698	58,614
01-Sep	151,769	25,473	12,774	1%	53%	97%	17%	1,635	13,458	15,092	160,367	4,326	164,692
02-Sep	117,258	17,772	13,028	0%	29%	100%	60%	86	5,160	5,246	129,941	10,606	140,548
03-Sep	201,863	28,125	26,518	0%	39%	99%	37%	0	10,887	10,887	226,824	10,434	237,258
04-Sep	96,772	32,760	28,973	0%	35%	100%	39%	0	11,480	11,480	125,745	12,880	138,625
05-Sep	743,410	63,228	80,661	0%	25%	100%	61%	0	15,807	15,807	824,070	38,830	862,901
06-Sep	1,098,914	88,755	117,126	0%	41%	100%	44%	0	36,566	36,566	1,216,040	38,893	1,254,933
07-Sep	1,262,318	95,518	288,569	0%	28%	100%	66%	1,280	26,638	27,917	1,547,048	62,961	1,610,009
08-Sep	1,401,602	102,375	250,320	0%	30%	100%	64%	0	30,219	30,219	1,649,957	65,372	1,715,329
09-Sep	1,361,888	96,141	217,852	0%	16%	100%	81%	723	15,147	15,870	1,577,209	77,628	1,654,837
10-Sep	1,061,889	123,449	158,408	0%	32%	100%	58%	2,392	39,299	41,691	1,215,854	72,190	1,288,044
11-Sep	527,097	70,763	84,577	0%	42%	100%	49%	0	30,028	30,028	610,365	34,683	645,049
12-Sep	452,656	98,807	86,862	0%	13%	99%	75%	0	12,950	12,950	535,774	74,345	610,119
13-Sep	268,189	94,071	86,366	0%	5%	100%	85%	324	4,817	5,141	352,934	80,187	433,121
14-Sep	93,134	59,110	58,129	0%	18%	100%	67%	143	10,900	11,043	150,690	39,826	190,516
15-Sep	225,153	47,260	47,229	0%	17%	100%	78%	0	8,254	8,254	271,368	36,740	308,107
16-Sep	222,048	38,173	41,486	0%	13%	100%	82%	0	4,939	4,939	263,034	31,382	294,416
17-Sep	347,076	57,551	42,174	0%	23%	100%	72%	255	13,281	13,535	388,910	41,171	430,081
18-Sep	479,903	54,237	59,153	0%	34%	100%	60%	0	18,199	18,199	538,290	32,434	570,724
19-Sep	336,878	58,302	227,366	0%	28%	100%	55%	0	16,132	16,132	561,952	32,264	594,216
20-Sep	539,185	54,132	61,624	0%	44%	98%	45%	0	23,650	23,650	589,813	24,438	614,251
Total	11,668,697	2,137,195	2,281,174					467,906	941,439	1,409,346	13,336,760	892,778	14,229,537

**Table 3. Daily estimates of Sockeye and Pink salmon passing Mission based on PSC hydroacoustic counts and species composition from the Whonnock test fishery and Crescent Island fishwheels, 2013.**

Date	Mission Total Salmon			% Sockeye Salmon		% Pink Salmon		Sockeye Estimate			Pink Estimate		
	Left	Center	Right	Shore	Center	Shore	Center	Shore	Center	Total	Shore	Center	Total
12-Jul	10,822	3,910	341	62%	62%	0%	0%	6,869	2,406	9,275	0	0	0
13-Jul	11,220	4,061	530	75%	75%	0%	0%	8,813	3,046	11,858	0	0	0
14-Jul	7,795	2,772	2,621	67%	67%	0%	0%	6,944	1,848	8,792	0	0	0
15-Jul	7,649	3,876	0	57%	57%	0%	0%	4,371	2,215	6,586	0	0	0
16-Jul	7,985	6,134	0	68%	68%	0%	0%	5,463	4,197	9,661	0	0	0
17-Jul	9,487	2,347	4,145	80%	80%	0%	0%	10,906	1,878	12,783	0	0	0
18-Jul	9,175	1,858	1,161	71%	71%	0%	0%	7,315	1,315	8,629	0	0	0
19-Jul	4,692	2,237	1,473	71%	71%	0%	0%	4,363	1,583	5,946	0	0	0
20-Jul	5,866	3,060	1,487	62%	62%	0%	0%	4,524	1,883	6,408	0	0	0
21-Jul	8,400	2,311	2,200	75%	75%	0%	0%	7,950	1,733	9,683	0	0	0
22-Jul	11,885	3,257	5,996	73%	73%	0%	0%	13,004	2,369	15,373	0	0	0
23-Jul	12,504	1,308	1,215	68%	68%	0%	0%	9,329	889	10,218	0	0	0
24-Jul	15,101	5,028	1,134	86%	86%	0%	0%	14,021	4,342	18,364	0	0	0
25-Jul	14,191	3,358	2,538	95%	95%	0%	0%	15,872	3,185	19,057	0	0	0
26-Jul	14,179	4,860	2,429	100%	100%	0%	0%	16,609	4,860	21,469	0	0	0
27-Jul	9,996	5,251	3,656	83%	83%	0%	0%	11,278	4,338	15,616	0	0	0
28-Jul	19,452	3,641	7,328	83%	83%	0%	0%	22,317	3,034	25,351	0	0	0
29-Jul	27,898	6,259	4,959	70%	70%	0%	0%	23,000	4,381	27,381	0	0	0
30-Jul	43,730	2,482	8,111	95%	95%	0%	0%	49,485	2,369	51,854	0	0	0
31-Jul	55,963	3,670	7,292	92%	92%	0%	0%	58,127	3,372	61,499	0	0	0
01-Aug	57,187	9,422	5,717	82%	82%	0%	0%	51,671	7,740	59,411	0	0	0
02-Aug	40,793	15,518	5,276	93%	93%	0%	0%	43,064	14,506	57,571	0	0	0
03-Aug	23,815	19,963	7,399	90%	76%	0%	0%	28,093	15,124	43,216	0	0	0
04-Aug	11,014	13,498	6,578	94%	88%	0%	0%	16,492	11,810	28,302	0	0	0
05-Aug	13,973	8,268	7,853	79%	91%	0%	1%	17,296	7,538	24,834	0	122	122
06-Aug	35,357	10,078	5,278	93%	87%	0%	0%	37,985	8,789	46,774	0	0	0
07-Aug	41,945	16,522	12,929	94%	92%	1%	0%	51,445	15,206	66,650	686	0	686
08-Aug	44,467	13,126	11,081	73%	89%	16%	0%	40,399	11,685	52,084	9,090	0	9,090
09-Aug	50,561	12,242	12,300	85%	83%	3%	1%	53,510	10,188	63,697	2,078	86	2,164
10-Aug	45,684	10,608	10,226	83%	83%	0%	0%	46,325	8,763	55,089	0	0	0
11-Aug	45,058	8,381	8,340	78%	81%	0%	0%	41,837	6,759	48,596	0	0	0
12-Aug	61,246	11,347	7,777	87%	87%	1%	3%	60,184	9,883	70,067	421	366	787
13-Aug	65,662	5,678	6,656	91%	81%	2%	0%	65,538	4,577	70,114	1,507	0	1,507
14-Aug	92,210	9,715	8,699	90%	90%	1%	0%	90,705	8,727	99,432	1,134	0	1,134
15-Aug	81,571	9,967	12,256	93%	91%	0%	0%	87,416	9,115	96,532	0	0	0
16-Aug	71,684	10,738	9,581	98%	88%	0%	1%	79,672	9,474	89,146	0	105	105
17-Aug	69,492	6,595	7,361	90%	86%	2%	6%	68,979	5,682	74,661	1,260	406	1,666
18-Aug	67,287	8,400	10,613	85%	90%	5%	1%	66,423	7,576	74,000	3,825	82	3,908
19-Aug	73,852	10,250	14,043	86%	81%	8%	7%	76,007	8,333	84,340	7,204	727	7,932
20-Aug	100,040	8,582	13,324	72%	72%	22%	10%	81,848	6,167	88,015	25,401	890	26,291
21-Aug	81,733	15,053	15,530	60%	77%	30%	12%	58,358	11,628	69,986	28,980	1,784	30,764
22-Aug	104,807	16,428	15,765	45%	73%	39%	13%	53,818	11,963	65,780	47,608	2,106	49,714
23-Aug	75,476	17,664	15,106	51%	71%	38%	18%	45,871	12,626	58,498	34,258	3,206	37,464
24-Aug	75,469	11,160	11,683	42%	64%	47%	8%	36,894	7,154	44,048	40,671	858	41,529
25-Aug	123,172	18,734	18,343	23%	60%	68%	22%	32,128	11,200	43,328	96,383	4,073	100,456
26-Aug	123,989	16,582	16,626	21%	58%	74%	21%	29,715	9,624	39,339	103,471	3,479	106,950
27-Aug	96,043	37,075	24,543	4%	56%	89%	25%	4,425	20,737	25,162	107,311	9,112	116,422
28-Aug	180,116	24,838	16,371	27%	50%	64%	34%	53,285	12,342	65,626	125,441	8,485	133,926
29-Aug	138,572	15,720	14,911	8%	64%	88%	18%	12,215	10,030	22,245	134,364	2,893	137,257
30-Aug	143,794	20,494	14,388	8%	46%	90%	41%	12,199	9,416	21,615	142,730	8,493	151,223
31-Aug	209,959	46,584	35,520	2%	27%	97%	67%	4,446	12,628	17,074	239,128	31,150	270,277
01-Sep	207,100	34,838	54,691	2%	43%	98%	49%	4,298	14,989	19,286	256,060	17,014	273,074
02-Sep	263,191	74,671	61,764	1%	28%	99%	64%	2,716	20,704	23,420	320,882	47,518	368,400
03-Sep	381,464	45,490	71,209	0%	32%	100%	59%	1,602	14,753	16,356	450,870	26,843	477,713
04-Sep	254,306	37,529	46,342	0%	9%	100%	84%	411	3,384	3,795	299,825	31,377	331,202
05-Sep	262,350	27,283	52,829	1%	18%	98%	61%	2,679	4,913	7,592	309,333	16,725	326,059
06-Sep	252,648	17,758	48,112	1%	24%	98%	66%	2,422	4,250	6,671	295,432	11,687	307,118
07-Sep	274,319	28,018	54,463	0%	8%	100%	81%	0	2,226	2,226	328,782	22,644	351,426
08-Sep	477,896	42,876	174,138	0%	4%	100%	82%	0	1,839	1,839	652,034	35,059	687,093
09-Sep	557,864	54,953	140,900	0%	8%	100%	86%	0	4,270	4,270	698,763	47,311	746,074
10-Sep	376,081	26,081	136,867	0%	7%	100%	84%	0	1,717	1,717	512,949	22,002	534,951
11-Sep	274,084	36,965	98,570	0%	7%	100%	79%	0	2,603	2,603	372,655	29,155	401,810
12-Sep	229,284	16,574	54,837	0%	3%	100%	86%	0	490	490	284,120	14,319	298,439
13-Sep	188,876	10,963	72,109	0%	3%	100%	95%	0	299	299	260,986	10,415	271,401
14-Sep	186,479	8,762	34,969	0%	2%	100%	73%	0	195	195	221,447	6,361	227,808
15-Sep	115,676	9,722	26,928	0%	2%	100%	90%	0	198	198	142,604	8,734	151,338
16-Sep	208,116	8,273	28,020	0%	1%	100%	89%	0	69	69	236,136	7,380	243,517
17-Sep	160,501	10,766	30,589	0%	2%	100%	89%	0	179	179	191,091	9,540	200,631
18-Sep	285,143	10,874	87,769	0%	2%	100%	89%	0	163	163	372,912	9,633	382,545
19-Sep	789,230	16,603	47,090	0%	0%	100%	89%	0	49	49	836,320	14,696	851,016
20-Sep	455,433	12,509	83,273	0%	0%	100%	75%	0	50	50	538,706	9,331	548,037
21-Sep	369,959	16,776	61,455	0%	2%	100%	64%	0	337	337	431,414	10,706	442,120
22-Sep	375,497	12,108	60,285	0%	0%	100%	53%	0	58	58	435,781	6,458	442,239
23-Sep	331,680	10,783	47,972	0%	0%	100%	50%	0	51	51	379,652	5,417	385,069
24-Sep	192,680	10,248	14,167	0%	1%	100%	28%	0	54	54	206,848	2,897	209,745
25-Sep	223,717	11,047	9,351	0%	0%	100%	31%	0	0	0	233,068	3,413	236,480
26-Sep	82,367	8,724	3,487	0%	1%	100%	16%	0	53	53	85,855	1,375	87,229
Total	10,529,956	1,132,104	2,042,876					1,762,928	450,127	2,213,055	10,507,476	506,433	11,013,909

**Table 4. Daily estimates of Sockeye and Pink salmon passing Mission based on PSC hydroacoustic counts and species composition from the Whonnock test fishery and Crescent Island fishwheels, 2015.**

Date	Mission Total Salmon			% Sockeye Salmon		% Pink Salmon		Sockeye Estimate			Pink Estimate		
	Left	Center	Right	Shore	Center	Shore	Center	Shore	Center	Total	Shore	Center	Total
12-Jul	3,285	1,310	193	100%	100%	0%	0%	3,479	1,310	4,789	0	0	0
13-Jul	730	626	906	78%	78%	0%	0%	1,272	487	1,759	0	0	0
14-Jul	608	1,159	757	56%	56%	0%	0%	758	644	1,402	0	0	0
15-Jul	1,163	893	531	21%	21%	0%	0%	363	191	554	0	0	0
16-Jul	4,028	851	293	48%	48%	0%	0%	2,066	407	2,473	0	0	0
17-Jul	3,469	2,277	474	63%	63%	0%	0%	2,465	1,423	3,888	0	0	0
18-Jul	5,481	4,212	512	48%	48%	0%	0%	2,890	2,031	4,921	0	0	0
19-Jul	5,478	3,384	1,720	40%	40%	0%	0%	2,879	1,354	4,233	0	0	0
20-Jul	6,360	4,902	1,625	50%	50%	0%	0%	3,993	2,451	6,444	0	0	0
21-Jul	5,681	4,918	949	40%	40%	0%	0%	2,652	1,967	4,619	0	0	0
22-Jul	7,320	2,991	906	71%	71%	0%	0%	5,876	2,137	8,012	0	0	0
23-Jul	8,044	2,642	1,192	40%	40%	0%	0%	3,694	1,057	4,751	0	0	0
24-Jul	14,125	6,431	1,128	75%	75%	0%	0%	11,440	4,823	16,264	0	0	0
25-Jul	13,883	4,336	687	81%	81%	0%	0%	11,795	3,510	15,305	0	0	0
26-Jul	9,899	4,761	2,051	54%	54%	0%	0%	6,435	2,563	8,998	0	0	0
27-Jul	12,206	3,973	3,152	89%	89%	0%	0%	13,652	3,532	17,184	0	0	0
28-Jul	7,239	5,167	1,928	70%	70%	0%	0%	6,417	3,617	10,033	0	0	0
29-Jul	9,891	3,568	3,494	86%	86%	2%	2%	11,503	3,066	14,569	209	56	265
30-Jul	10,538	7,953	1,637	79%	79%	0%	0%	9,565	6,249	15,815	0	0	0
31-Jul	13,332	2,832	3,145	70%	70%	0%	0%	11,595	1,993	13,587	0	0	0
01-Aug	14,836	6,994	1,694	81%	81%	0%	0%	13,455	5,692	19,148	0	0	0
02-Aug	14,975	8,683	1,887	91%	91%	0%	0%	15,348	7,904	23,252	0	0	0
03-Aug	27,033	12,180	2,842	76%	76%	0%	1%	22,558	9,197	31,755	0	124	124
04-Aug	38,884	11,709	2,463	80%	88%	0%	0%	33,078	10,245	43,323	0	0	0
05-Aug	35,008	15,727	3,411	86%	91%	2%	0%	33,180	14,339	47,519	582	0	582
06-Aug	36,985	18,660	2,355	97%	87%	1%	0%	38,231	16,273	54,504	554	0	554
07-Aug	38,554	17,916	4,843	93%	92%	2%	0%	40,471	16,489	56,960	975	0	975
08-Aug	24,068	22,273	7,734	54%	89%	27%	0%	17,124	19,829	36,952	8,562	0	8,562
09-Aug	12,209	12,687	4,662	43%	83%	18%	4%	7,285	10,558	17,842	3,067	529	3,596
10-Aug	24,665	17,384	7,453	61%	83%	15%	6%	19,465	14,361	33,826	4,866	1,122	5,988
11-Aug	25,312	14,216	6,042	74%	81%	2%	9%	23,325	11,464	34,789	765	1,292	2,057
12-Aug	24,201	13,388	5,753	52%	87%	10%	3%	15,601	11,661	27,262	3,120	343	3,463
13-Aug	30,061	8,982	5,981	48%	81%	41%	2%	17,449	7,239	24,688	14,874	156	15,031
14-Aug	38,152	10,413	2,226	65%	90%	13%	0%	26,333	9,354	35,688	5,267	0	5,267
15-Aug	45,695	13,140	4,818	84%	91%	3%	3%	42,304	12,017	54,321	1,263	453	1,716
16-Aug	61,754	17,006	7,471	84%	88%	13%	8%	58,295	15,006	73,300	9,109	1,327	10,435
17-Aug	51,100	28,507	6,284	73%	86%	12%	7%	41,851	24,560	66,412	6,903	2,112	9,015
18-Aug	56,401	21,158	9,479	46%	90%	41%	13%	30,116	19,084	49,200	26,822	2,738	29,560
19-Aug	51,186	23,999	11,031	33%	81%	50%	3%	20,739	19,509	40,248	31,109	787	31,896
20-Aug	75,924	12,182	9,939	35%	72%	55%	7%	30,424	8,753	39,177	47,326	846	48,172
21-Aug	86,156	13,696	10,443	13%	77%	62%	13%	12,202	10,580	22,782	59,993	1,786	61,780
22-Aug	77,721	27,254	15,562	20%	73%	61%	15%	18,363	19,847	38,209	56,558	4,088	60,646
23-Aug	80,829	20,912	15,696	19%	71%	59%	16%	18,647	14,948	33,595	57,038	3,433	60,471
24-Aug	85,525	17,226	18,675	10%	64%	71%	19%	10,736	11,042	21,778	73,887	3,267	77,154
25-Aug	88,568	29,555	12,489	10%	60%	79%	11%	10,066	17,669	27,734	80,121	3,367	83,488
26-Aug	70,419	15,545	16,206	13%	58%	79%	27%	11,131	9,023	20,153	68,235	4,145	72,381
27-Aug	115,164	23,499	14,327	8%	56%	84%	30%	10,995	13,143	24,138	108,724	7,142	115,866
28-Aug	99,786	14,118	13,198	3%	50%	91%	36%	3,494	7,015	10,510	102,501	5,053	107,554
29-Aug	105,838	32,552	16,351	4%	64%	91%	42%	4,781	20,769	25,550	111,564	13,810	125,374
30-Aug	92,556	18,989	16,669	2%	46%	96%	40%	1,691	8,725	10,415	105,167	7,662	112,829
31-Aug	125,452	14,106	7,415	0%	27%	99%	39%	200	3,824	4,024	131,667	5,470	137,136
01-Sep	119,577	16,870	4,621	0%	43%	100%	32%	0	7,258	7,258	124,198	5,405	129,603
02-Sep	145,808	23,689	26,600	0%	28%	100%	59%	0	6,568	6,568	172,408	13,915	186,323
03-Sep	331,253	21,783	32,033	0%	32%	100%	61%	0	7,065	7,065	363,286	13,206	376,492
04-Sep	381,760	21,199	69,432	0%	9%	100%	63%	0	1,911	1,911	451,192	13,438	464,630
05-Sep	516,657	16,290	81,692	0%	18%	100%	64%	0	2,934	2,934	598,350	10,484	608,833
06-Sep	459,288	19,449	78,709	0%	24%	100%	57%	0	4,654	4,654	537,997	11,145	549,142
07-Sep	292,232	19,143	98,168	0%	8%	100%	54%	0	1,521	1,521	390,401	10,292	400,693
08-Sep	310,934	13,993	19,268	0%	4%	100%	34%	0	600	600	330,202	4,810	335,012
09-Sep	145,292	27,383	10,386	0%	8%	100%	44%	0	2,128	2,128	155,678	12,132	167,810
10-Sep	104,385	15,812	22,542	0%	7%	100%	36%	0	1,041	1,041	126,927	5,659	132,586
11-Sep	154,878	14,472	23,858	0%	7%	100%	46%	0	1,019	1,019	178,736	6,640	185,376
12-Sep	149,757	15,638	42,499	0%	3%	100%	49%	0	463	463	192,256	7,589	199,844
13-Sep	115,321	11,778	29,606	0%	3%	100%	63%	0	321	321	144,927	7,465	152,393
14-Sep	123,115	17,718	17,120	0%	2%	100%	45%	0	394	394	140,235	8,015	148,250
15-Sep	78,765	8,665	14,122	0%	2%	100%	34%	0	176	176	92,886	2,964	95,851
16-Sep	55,906	15,969	16,625	0%	1%	100%	25%	0	133	133	72,531	3,992	76,523
17-Sep	45,481	9,060	12,101	0%	2%	100%	35%	0	151	151	57,582	3,132	60,714
18-Sep	43,769	10,618	6,079	0%	2%	100%	52%	0	159	159	49,848	5,522	55,370
19-Sep	28,831	10,328	4,661	0%	0%	100%	29%	0	30	30	33,492	3,004	36,496
20-Sep	20,596	8,192	4,012	0%	0%	100%	31%	0	33	33	24,608	2,536	27,144
Total	5,521,384	921,889	906,812					763,727	483,489	1,247,216	5,358,568	222,453	5,581,021

**FIGURES**

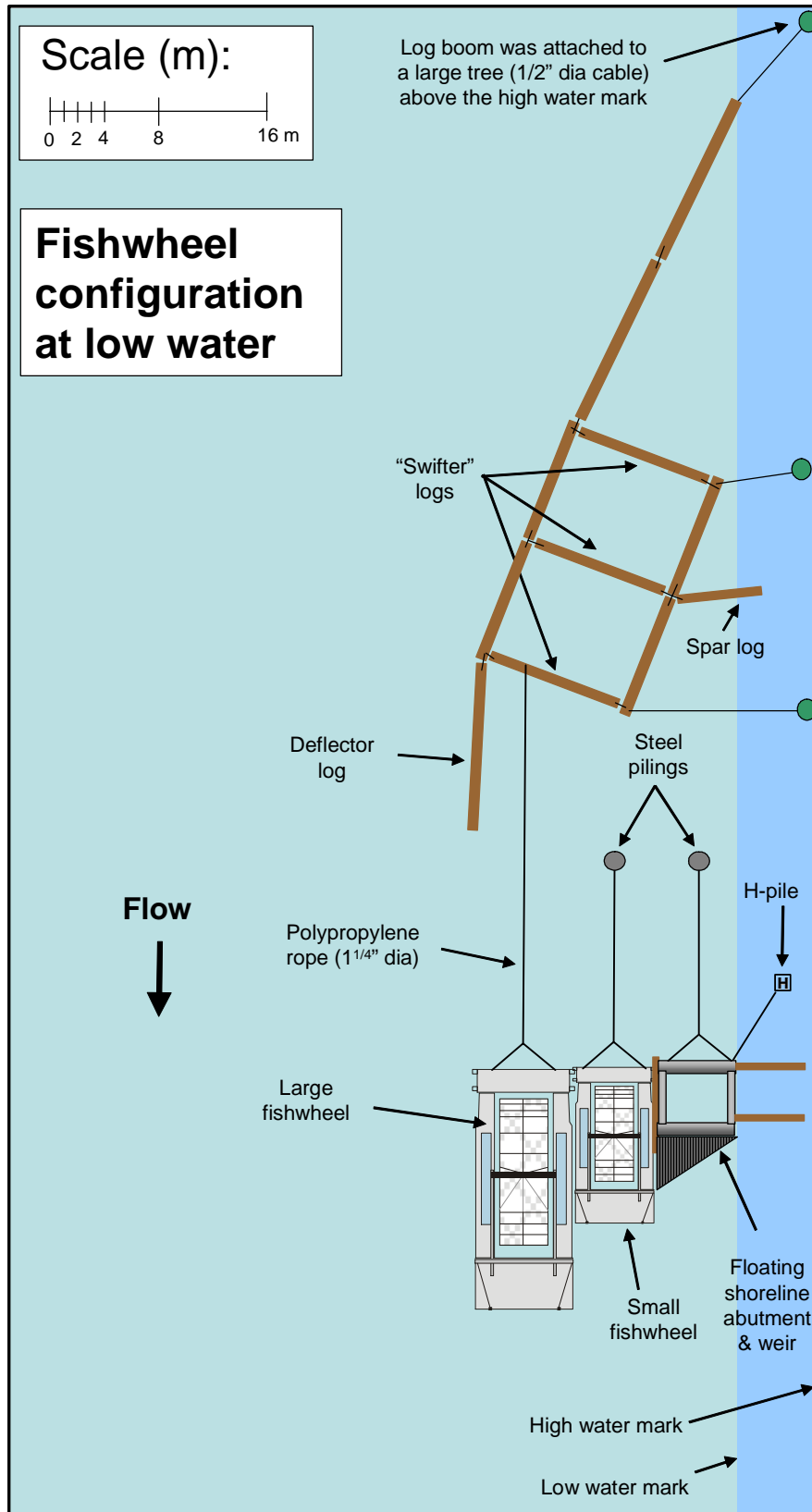
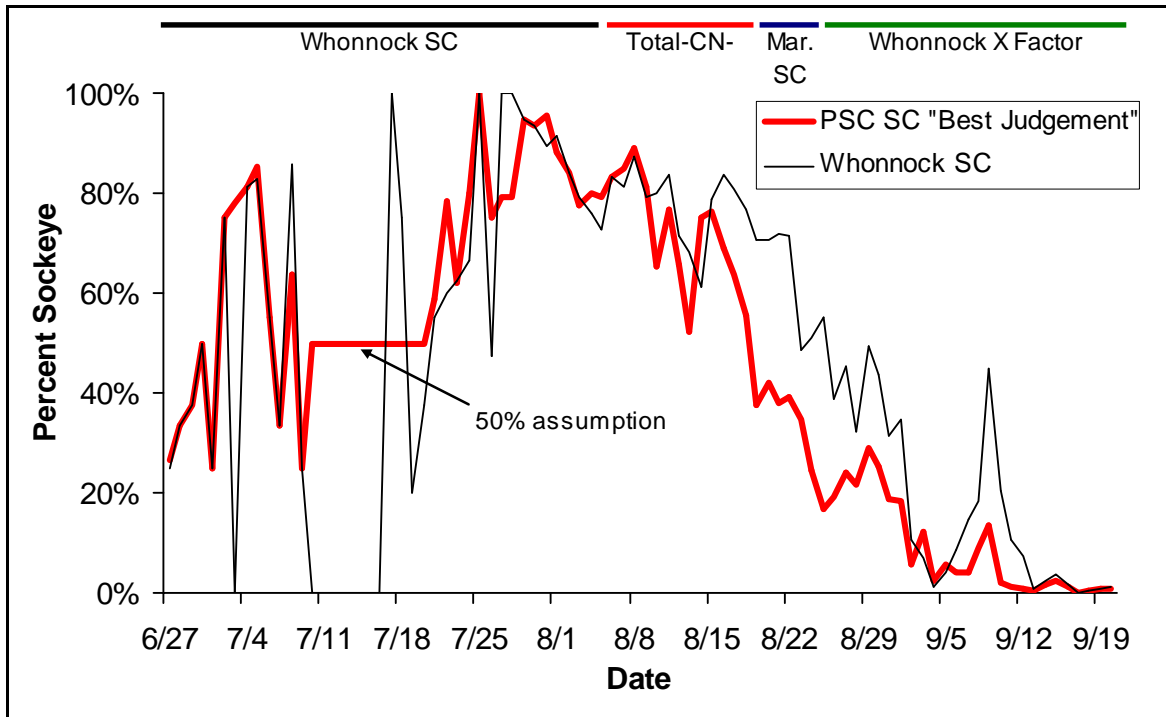


Figure 1. Schematic of the Crescent site showing the location of the log boom assembly, steel pilings, fishwheels, and floating shoreline abutment, 2009.



**Figure 2.** The Mission species composition from ‘best judgement’ Mission species-specific fish abundance estimates (PSC, unpublished data). Four data sources were used (indicated by ‘time-line symbols’ at top of figure): species composition data from the Whonnock gillnet test-fishery (variously smoothed or interpolated); Mission counts less Chinook and Pink salmon estimates; species composition data from the marine test fisheries; and Whonnock test fishery Sockeye catch multiplied by a factor (from Robichaud et al. 2010, Figure 12).

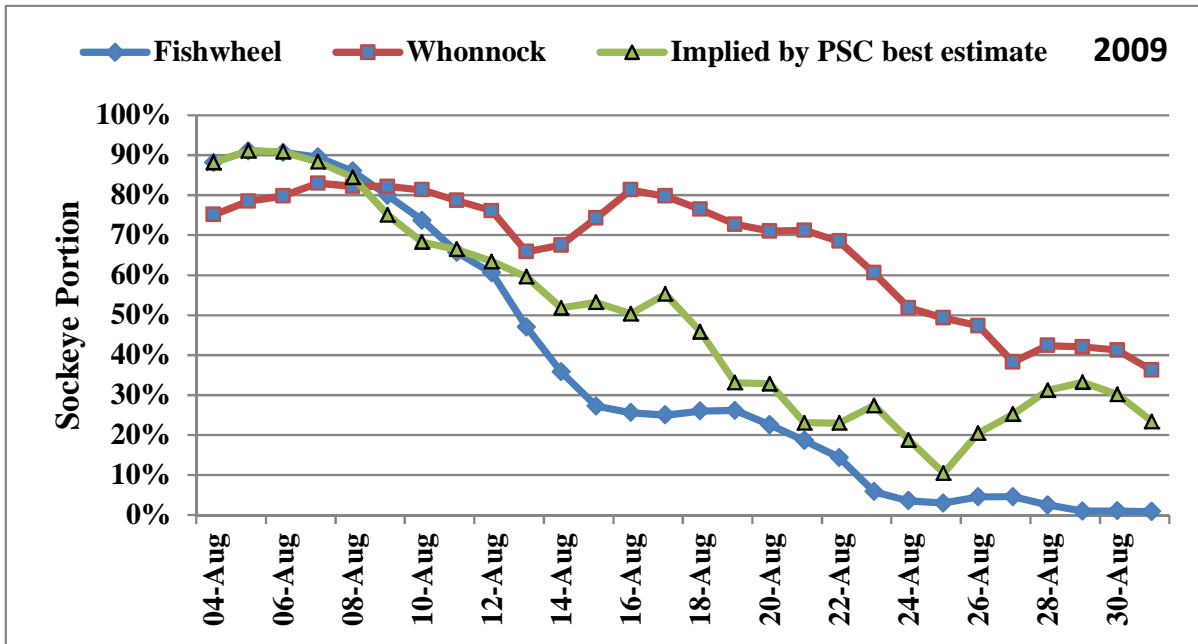


Figure 3. Sockeye portion derived from daily catches in the Crescent Island fishwheels, Whonnock gillnet test fishery, and the implied PSC best estimate for 2009.

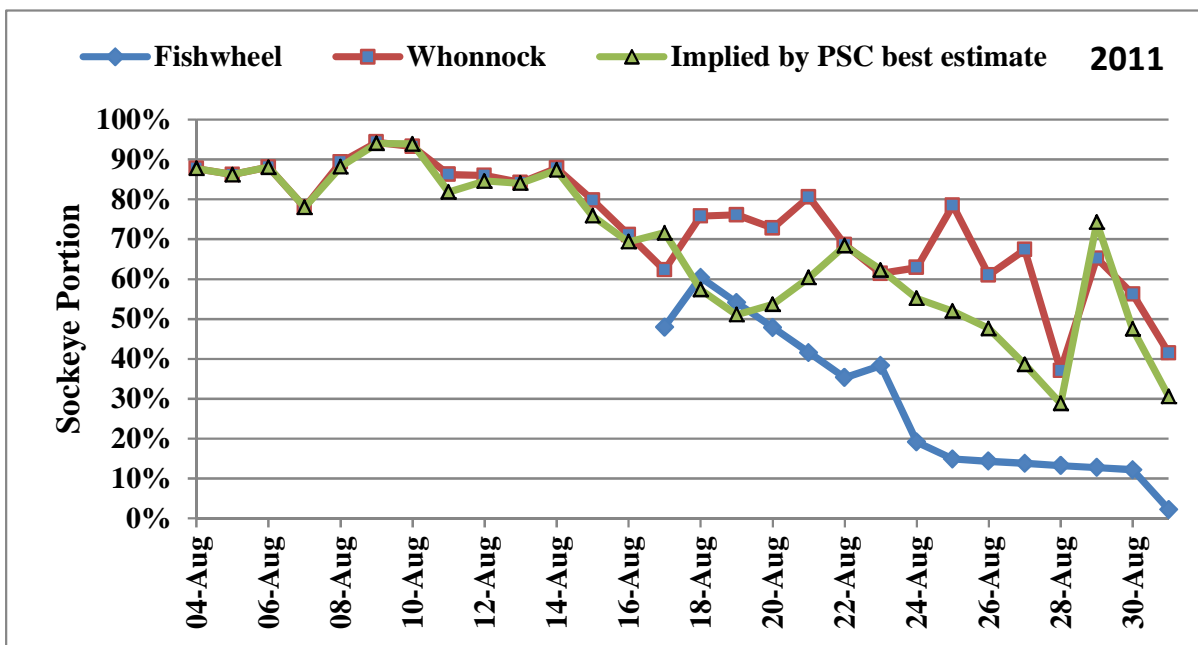


Figure 4. Sockeye portion derived from daily catches in the Crescent Island fishwheels, Whonnock gillnet test fishery, and the implied PSC best estimate for 2011.

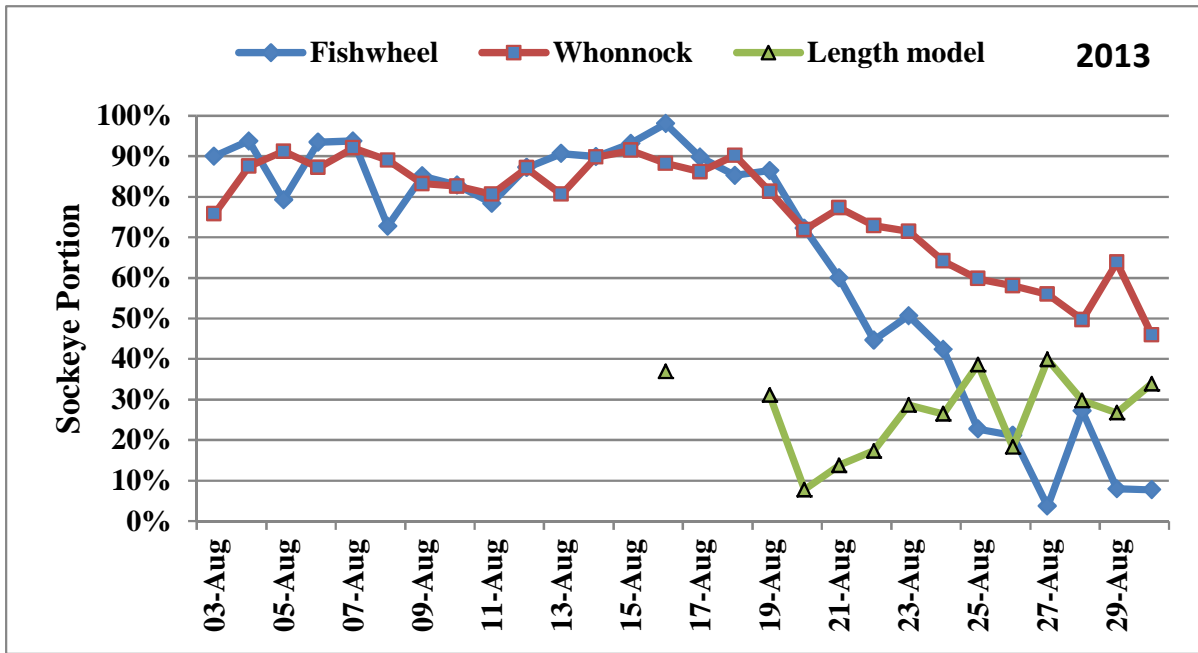


Figure 5. Sockeye portion derived from daily catches in the Crescent Island fishwheels, Whonnock gillnet test fishery, and the DIDSON length model method for 2013.

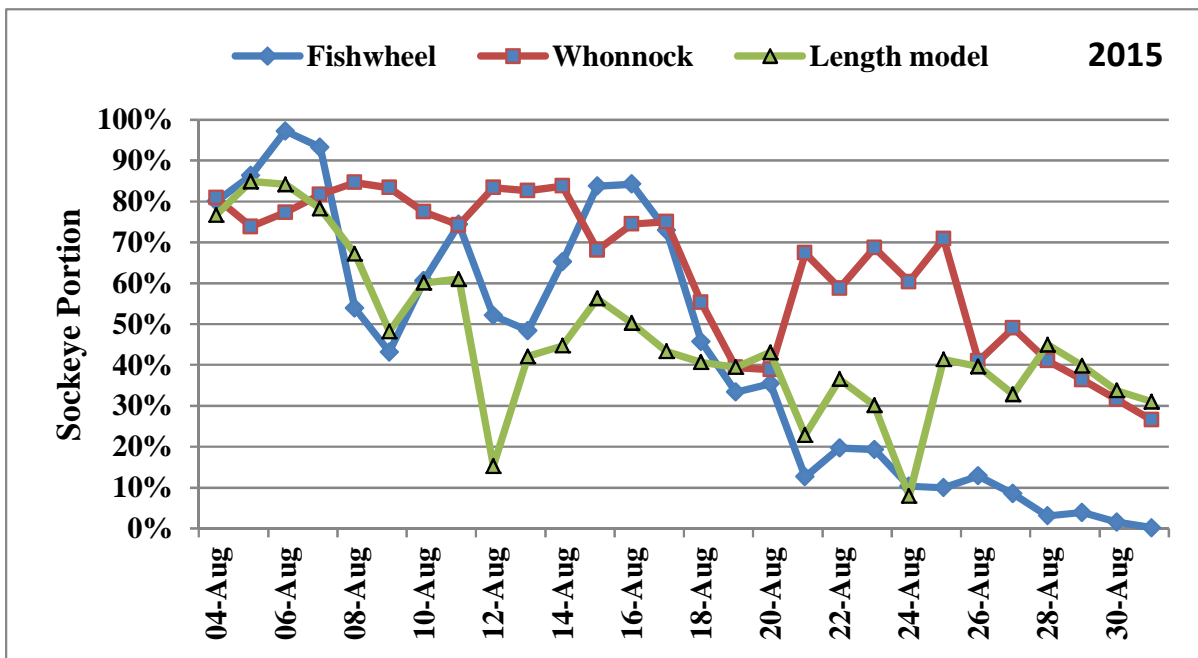


Figure 6. Sockeye portion derived from daily catches in the Crescent Island fishwheels, Whonnock gillnet test fishery, and the DIDSON length model method for 2015.

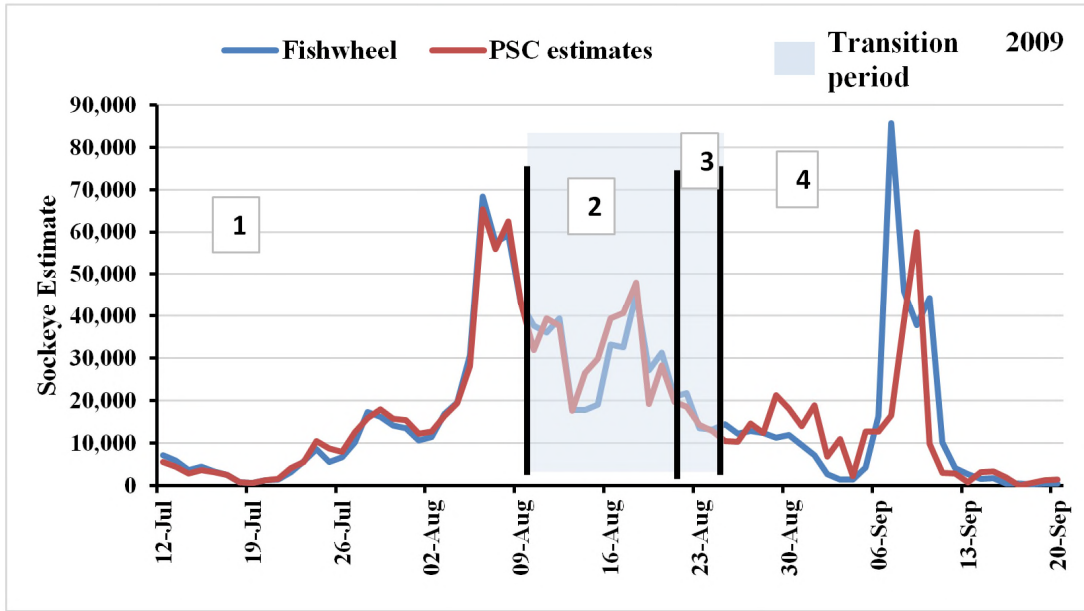


Figure 7. Daily estimates of the number of Sockeye passing the Mission hydroacoustic site derived from spatially stratified sonar estimates, near-shore species composition fishwheels catch data and off-shore species composition from the Whonnock gillnet test fishery (blue line). The PSC estimates (red line) were derived from different data sources for each of the four period shown: 1) species composition data from the Whonnock gillnet test-fishery (smoothed or interpolated for small or missing sample days); 2) Mission counts less Chinook and Pink salmon estimates (10-21 August); 3) species composition data from the marine test fisheries (22-26 August); and 4) Whonnock test fishery Sockeye catch multiplied by a factor (after 26 August 2009).

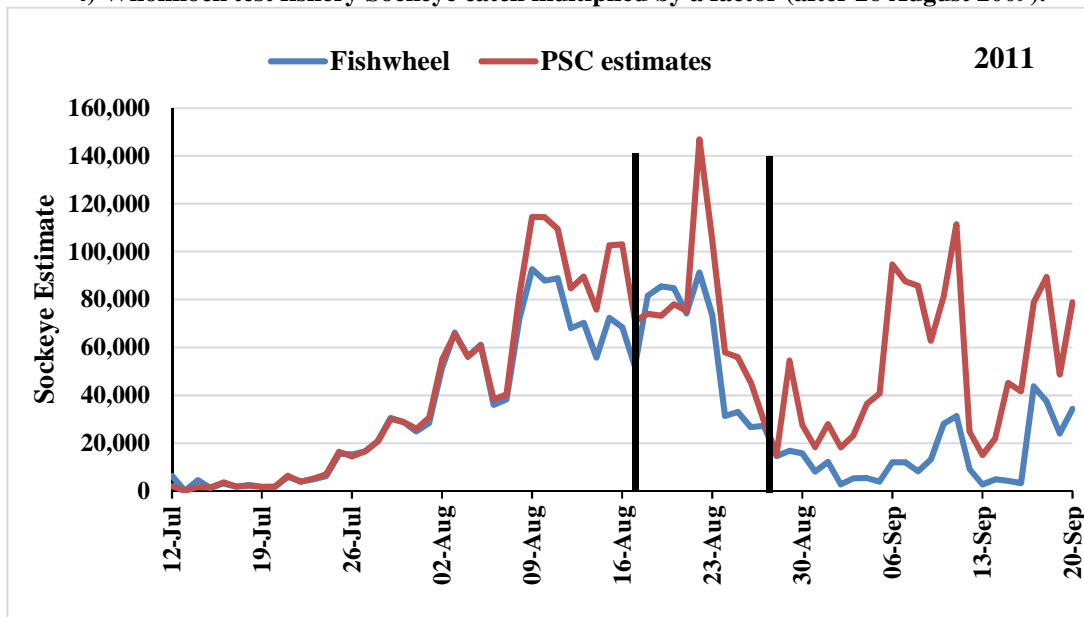


Figure 8. Daily estimates of the number of Sockeye passing the Mission hydroacoustic site derived from spatially stratified sonar estimates, near-shore species composition fishwheels catch data and off-shore species composition from the Whonnock gillnet test fishery (blue line). The PSC estimates (red line) were derived marine relative abundance for 17-28 August and Whonnock CPUE after 28 August 2011.

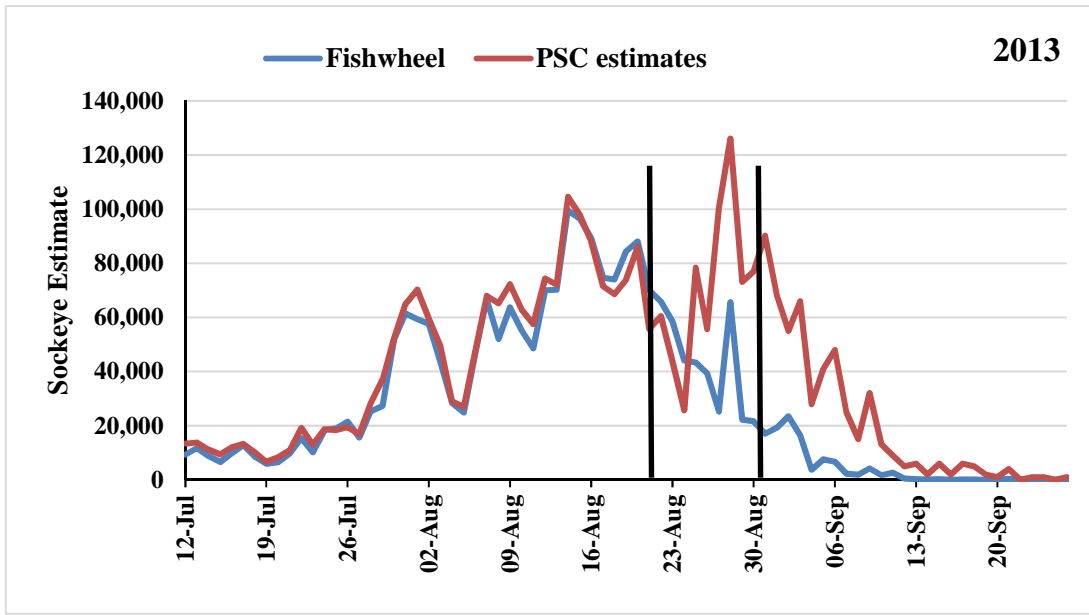


Figure 9. Daily estimates of the number of Sockeye passing the Mission hydroacoustic site derived from spatially stratified sonar estimates, near-shore species composition fishwheels catch data and off-shore species composition from the Whonnock gillnet test fishery (blue line). The PSC estimates (red line) were derived length-based mixture model for 21-31 August and Whonnock CPUE after 31 August 2013.

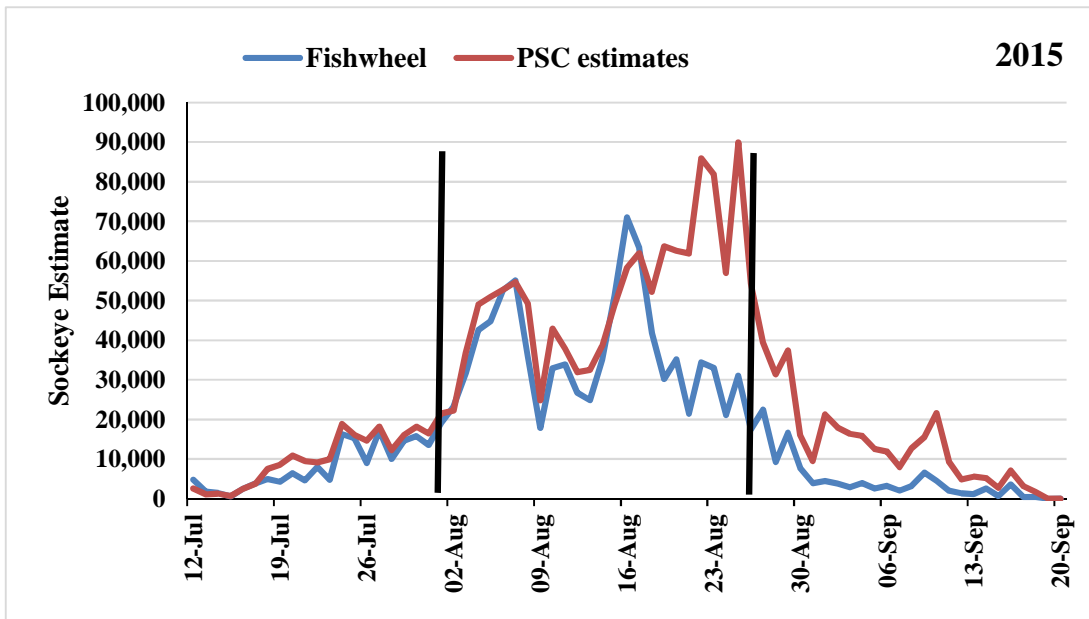


Figure 10. Daily estimates of the number of Sockeye passing the Mission hydroacoustic site derived from spatially stratified sonar estimates, near-shore species composition fishwheels catch data and off-shore species composition from the Whonnock gillnet test fishery (blue line). The PSC estimates (red line) were derived length-based mixture model for 1-26 August and Whonnock CPUE after 26 August 2015.