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## **Canadian Juvenile Salmon Surveys in 2018–2019**

by

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## **ABSTRACT**

This document provides information on the juvenile salmon research surveys planned in both offshore and inshore areas of the North Pacific Ocean by Canada for fiscal year 2018–2019. The inshore program will conduct sampling in the Salish Sea (encompassing the Strait of Georgia and Puget Sound) whereas the offshore program will conduct sampling along of the continental shelf surrounding Vancouver Island (mid-summer) and on the continental shelf in southern Queen Charlotte Sound, into Queen Charlotte Strait and through Johnstone Strait (early summer and fall). These surveys are both part of long-term research programs that were initiated in 1997–1998, however in 2017 the offshore program began integrating with other pelagic research programs to develop a synoptic pelagic survey on the continental shelf off the west coast of Vancouver Island. This integrated survey will continue in 2018. In addition, in 2018 Canada will extend sampling in inside waters in early summer to include waters of Johnstone Strait and Queen Charlotte Strait.

## **INTRODUCTION**

Pacific salmon have a complex life cycle that involves a freshwater phase for spawning and rearing, as well as an ocean phase where they spend the greater part of their lives and gain the majority of their mass and energy necessary for successfully completing their spawning migration (Groot and Margolis 1991). Pacific salmon experience heavy and highly variable losses in the ocean, with natural mortality rates generally exceeding 90-95% during their marine life (Bradford 1995). Most of this mortality is thought to occur during two critical periods: an early marine mortality that occurs within the first few weeks to months following ocean entry and a starvation-based mortality that occurs following their first winter at sea (Beamish and Mahnken 2001). Canada has maintained two long-term research and monitoring programs on the marine biology of Pacific salmon to understand the processes regulating Pacific salmon production in the marine environment, the interactions between wild and hatchery-reared salmon, the potential interactions between wild/hatchery salmon and aquaculture production, the impacts of ocean conditions and climate change on marine ecosystems and salmon resources, and to provide a sound scientific basis for optimizing hatchery production (Trudel et al. 2013).

In 2018–2019, trawl surveys in June and September within the Strait of Georgia and Puget Sound and a trawl survey in October in southern Queen Charlotte Sound region will continue to follow protocols and fishing locations fished since 1998. In addition, in June and October 2018 sampling will be conducted in Johnstone Strait and Queen Charlotte Strait. In 2018–2019 the July trawl survey on the continental shelf of Vancouver Island will continue to be integrated with other pelagic surveys into a single synoptic pelagic ecosystem survey as was done in 2018. The second year of this integrated survey will continue to include fishing to calibrate catch results from the surveys conducted over past years. All surveys will use a newly acquired mid-water trawl net, similar to the gear used previously by all surveys, but built of lighter, more modern material, and with a longer taper design. Survey time this year will also conduct targeted fishing to calibrate new gear to old gear catch rates.

This document presents general information for the juvenile salmon research surveys that have been planned in both the offshore and inshore areas by Canada for 2018–2019.

## JUVENILE SALMON RESEARCH SURVEYS

### GENERAL SURVEY INFORMATION

Five integrated epipelagic surface and mid-water trawl surveys have been planned for 2018-2019. In the past these surveys were typically conducted from the CCG vessel *W.E. Ricker*. However, due to the vessel being retired and the replacement CCG vessel *Franklin* not being operational in 2018, the surveys will be conducted by a commercial trawl vessels under charter to the Canadian Government. The *M.V. SeaCrest* will be used for the inshore surveys and for the June and October offshore surveys. The *M.V. Nordic Pearl* will be used for the July offshore survey. The *SeaCrest* was used for inshore and offshore surveys in 2017. Both charter vessels are able to tow the gear at the speed and following the protocol of the surveys conducted since 1997. Oceanographic and zooplankton sampling will occur during all trawl surveys.

### Inshore Sampling

Two surveys are scheduled to fish in the Strait of Georgia and Puget Sound (Salish Sea). The early summer survey will be conducted over 18 days between June 15 and July 5, 2018. The early fall survey will be conducted over 18 days between September 10 and October 4, 2018. These surveys are continuations of surveys that have been conducted for 20 years. The surveys will focus on the Strait of Georgia and associated waters including Gulf Islands, Discovery Islands, Johnstone Strait, and Juan de Fuca Strait. In addition, fishing in Puget Sound in US waters will be conducted with collaboration with US scientists (Table 1-2; Figure 1). The primary objectives of these surveys will be to (1) collect biological information on Pacific salmon (*Oncorhynchus* spp.) and associated epipelagic fish community, (2) collect DNA samples for stock identification purposes and to examine stock specific information on migration timing and distribution of juvenile salmon, (3) enumerate stomach contents of juvenile Pacific salmon, (4) collect tissues and whole bodies to determine the energy density and fatty acid profile of juvenile Pacific salmon over their first marine year (5) examine possible interactions between juvenile salmon and other pelagic species encountered in surveys including diet overlap and competition and predation (6) describe the ambient oceanographic conditions, and (7) quantify the biomass of zooplankton and describe zooplankton species community composition in coastal waters of British Columbia.

### Offshore sampling

A synoptic pelagic ecosystem survey is schedule for July 5 -29, 2018 in continental shelf waters (< 200 m) of Vancouver Island, including southern Queen Charlotte Sound (Figure 2). Fishing will be conducted by a chartered commercial trawl vessel, the *M.V. Nordic Pearl*. The survey is a developing integrated pelagic ecosystem survey, with anticipated primary focus on juvenile salmon, Pacific herring (*Clupea harengus*) and Pacific sardine (*Sagax sardinops*). The survey has a random, stratified design for fishing locations, with strata determined by bathymetry (50-100 m; 100-200 m) and known ecosystem delineations, for example where zooplankton composition typically changes. Stations (approximately n=70) are randomly selected from a gridded suite of blocks (4 x 4 km) such that fishing effort within each strata is weighted to the relative strata area to the total sample area. Fishing will occur at two headrope depths: surface and 15 m. Since most pelagic forage fish migrate to surface waters during the night time, this integrated pelagic survey is transitioning from previous juvenile salmon surveys that fished solely during daytime hours. As with 2017, this survey in 2018 will conduct fishing at each station, and

depth combination once during daytime hours and again during night-time hours. The primary objectives of the survey are to: (1) provide biomass estimates of pelagic fish assemblages; (2) examine species distribution and association with oceanographic conditions and prey communities; (3) collect oceanographic data and provide zooplankton sampling; (4) collect biological samples, including tissue collection for DNA analyses and identification of juvenile salmon stocks; and (5) enumerate stomach contents of juvenile salmon, Pacific herring and Pacific sardine for predator-prey and bioenergetics studies. The survey will be collecting acoustic data along standard transect lines during daytime hours.

June 9-15, 2018 and October 1-7, 2018 surveys will be conducted in southern Queen Charlotte Sound and Johnstone Strait using the chartered commercial vessel *M.V. SeaCrest*. Weather permitting; the survey will be conducted along transects perpendicular to the coastline, at headrope depths of 0 m, 15 m and 30 m (Figure 3). This survey is part of a long-time series investigating the growth and marine survival of juvenile Pacific salmon as they migrate out of the Strait of Georgia, through Johnstone Strait. In recent years, this survey has expanded to include all components of the pelagic ecosystem and to focus on additional estimates of salmon condition in relation to prey availability, predator consumption, utilizing diet, stable isotopes, and energy density analyses. In 2017, and again in 2018, this survey will provide an empirical test of the proposed “Trophic Gauntlet Hypothesis” (McKinnell et al. 2014) for the marine survival of migrating juvenile sockeye salmon from the Fraser River. Overall, the survey objectives remain: 1) Provide estimates of juvenile Pacific salmon, and determine their diet, relative growth and energy density at different locations of their migration to open ocean through Johnstone Strait; 2) Collect information on associated physical oceanography; 3) Assess the distribution and biomass of zooplankton.

#### *FISHING GEAR AND FISHING OPERATION*

In the Strait of Georgia and associated waters the chartered commercial trawl vessel will fish a large mid-water trawl with small mesh bunt (0.5 cm) to retain juvenile salmon. The net is generally fished at approximately 5 knots for 30 minutes either at the surface, 15 m, 30 m, 45 m or 60 m with occasional sets conducted at deeper depths. Fishing is conducted during daylight hours. The net design and survey methodology is fully described in Beamish et al. (2000), Sweeting et al. (2003) and Trudel et al. (2013). In good sea conditions, this configuration typically achieves a mouth opening that is approximately 30 m wide by 15 m deep as measured acoustically by a Scanmar trawl eye mounted on the headrope. In addition, some sets will be conducted with a new trawl net (LFS 7740) to begin to develop comparative catch statistics. The new net has been designed to reduce drag and possible blow out in the cod end. The fishing speed and protocols will be the same as the original survey net.

On the west coast of Vancouver Island and in Queen Charlotte Sound, the chartered commercial trawl vessel will utilize the new mid-water trawl gear (LFS 7740), drawing on the calibration fishing from the inshore surveys. The net will be fished at approximately 5 knots, for 20 minutes at headrope depths of surface and 15 m. Fishing in the summer off the west coast of Vancouver Island will be during both daytime and night time hours, replicating within a 12 hour period the station and depth combinations. Fishing in early summer and the fall in southern Queen Charlotte Sound will be during daytime hours only, and will include sets with headrope depths of 30 m.

### *SAMPLING PROTOCOLS*

During trawl surveys, catch in the cod end is sorted to species and enumerated to characterize the nekton community in epipelagic waters of British Columbia and Puget Sound (Brodeur et al. 2006; Orsi et al. 2007). Catch of non target species including spiny dogfish, walleye pollock, flatfish species etc. are measured (subsample), enumerated and released live. For large (< 1 tonne) catches, sub-samples are retained, sorted, with species enumerated; these sub-samples are extrapolated to provide catch composition and catch rates for the whole catch sample.

The biological sampling protocols are consistent among all surveys. Coho salmon, Chinook salmon and sockeye salmon are scanned and examined for the presence of coded wire tag, PIT tag and fin clip. Clips of pelvic and pectoral fins, while not as prevalent as in past years, are also recorded. For all salmon species, a total or random sample of juveniles collected are measured and weighed. Tissue from the operculum or a caudal fin clip is preserved on Watrin paper or in 95% ethanol for stock identification using microsatellite DNA (Beacham et al. 2001, 2005, 2006). In addition, calcified-structures (i.e. scales and/or otoliths) are sampled for age determination and early marine growth analysis. The number sampled will vary by survey depending on the specific objectives of the survey and the total number of fish caught. A general outline of sample numbers by survey and sampling process are provided in Table 3.

For the inshore survey, stomach contents (from oesophagus to the pyloric sphincter) of juvenile salmon are removed for dietary analyses either directly on board the ship or in the laboratory (Brodeur et al. 2007; Sweeting and Beamish 2009). Estimates of percent fullness, total volume and degree of overall digestion are recorded. Finally, the entire stomach contents are broken down into percent contribution by individual prey groups. Dependent on particular items, the level of prey identification is at least to family, but often to the genus level (e.g., Sweeting and Beamish 2009, Duffy et al. 2010). When time permits, stomachs of certain non-salmonids species are also examined (e.g., Pacific hake, spiny dogfish, walleye pollock, Pacific herring). In addition to the work at sea, a subsample of the catch is preserved or frozen individually at  $-20^{\circ}\text{C}$  or  $-80^{\circ}\text{C}$  for various chemical and calorimetric analyses such as stable isotopes, fatty acid analysis, Cesium analysis, fish health analysis, or for additional DNA samples and/or laboratory examination of stomach contents. In addition, a subsample of 5-10 salmon may be taken immediately upon retrieval of the catch and tissue samples (muscle, brain, liver etc) removed. These tissues are either immediately frozen in liquid Nitrogen, dry ice or  $-80^{\circ}\text{C}$  ultra-cold freezer or preserved in RNA-later for gene expression studies in Pacific salmon that are performed in conjunction with K. Miller-Saunders at the Pacific Biological Station (Miller et al. 2013, 2014).

For the offshore surveys, all stomach contents analysis are done at sea by survey staff. The stomach contents are determined from the anterior most part of the oesophagus to the pyloric sphincter. Prey items are separated into taxonomic groups, to the lowest taxonomic level (typically species or genus) possible. For each prey item group, the total volume ( $\text{cm}^3$ ) is measured using a volumetric sampler. The relative digestion state (fresh, 25%, 50%, 75% and fully digested) are estimated for each prey item group.

Biological data collected for each salmon will include species common name, fork length (mm) and/or total length (mm), and observed fin clip. It will also include, when available, whole body weight (g wet), sex, stomach content weight (g wet), percent water (based on the ratio of dry to wet whole body weight), coded wire tag number, and PIT tag number. Age separation is generally determined based on examination of fork length distributions that show non-

overlapping size modes for chum salmon, coho salmon, pink salmon, and sockeye salmon (Trudel et al. 2007a). For Chinook salmon, a combination of fish length along with coded wire tag recoveries of known-age fish, DNA analyses and scale pattern and life history types will be used to separate juveniles from adults, (Fisher et al. 2007; Trudel et al. 2007b, 2009), as there is considerable overlap among size modes that represent the multiple age groups.

In addition to the biological data listed above additional sampling may be conducted on some surveys. This includes blood plasma which is extracted from a subsample of the catch to measure the hormone Insulin Growth Factor-I (IGF-I) to map the growth performance of juvenile salmon in the Strait of Georgia and surrounding waters (Beckman 2011; Ferris et al. 2014). In addition, a subsample of 5-10 salmon may be taken immediately upon retrieval of the catch and tissue samples (muscle, brain, liver etc) removed. These tissues are either immediately frozen in liquid Nitrogen, dry ice or  $-80^{\circ}\text{C}$  ultra-cold freezer or preserved in RNA-later for gene expression studies in Pacific salmon that are performed in conjunction with K. Miller-Saunders at the Pacific Biological Station (Miller et al. 2013, 2014).

### *OCEANOGRAPHIC SAMPLING*

At oceanographic stations, the scientific crew will conduct CTD (conductivity-temperature-depth) casts. On some surveys oceanographic sampling will also (1) collect seawater samples at 10 m from the surface with a Niskin bottle for nitrate, phosphate, silicate, and salinity, and (2) filter surface seawater on GF/F glass fibre filter disks for chlorophyll a. Nitrate, phosphate, and silicate samples will be collected in acid-washed glass test tubes, whereas the glass fibre disks will be folded and placed in polypropylene scintillation vials. All these samples will be stored frozen. Sea surface waters will also be collected in some surveys and preserved in Lugol's Iodine Solution to determine the concentration of harmful algae (Esenkulova et al. 2015). CTD casts will be conducted to 250 m or within 5 m of the bottom with a Seabird SBE 911+ probe. Several calibration samples from selected CTD casts will be collected over the course of the survey with Niskin bottles at depths where the salinities are stable. The oceanographic data collected in these surveys will be stored on a database maintained at the Institute of Ocean Sciences (Sidney, British Columbia).

### *ZOOPLANKTON SAMPLING*

Vertical bongo tows will be conducted with two 57 cm diameter Nitex nets (mesh 253  $\mu$ m) to approximately 150 m or within 10 m of the bottom. One of the nets is equipped with a flowmeter. Zooplankton collected from the flowmeter side will be preserved in 10% formalin and sent to the zooplankton laboratory at the Institute of Ocean Sciences, Fisheries and Oceans Canada (Sidney, British Columbia) for species classification and enumeration. Zooplankton taken from the net without flowmeter will be sorted into four size fractions by successively sieving through 8.0, 1.7, 1.0, and 0.25 mm screens. Each size fraction will then be weighed wet, dried at 60°C for 48 hours, re-weighed, and stored in plastic bags for future stable isotope, bomb calorimetry, and proximate analyses. The zooplankton data collected in these surveys will be stored on a database maintained at the Institute of Ocean Sciences (Sidney, British Columbia).

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**Table 1.** Tentative summer survey itinerary for the chartered commercial trawl vessel (June 18–July 5, 2018). *PRELIMINARY ONLY*

Date	General area of operations
June 18, 2018	PBS Nanaimo, loading
June 20–July 2, 2018	Strait of Georgia, Gulf Island, eastern Discovery Islands
July 3–5, 2018	Puget Sound
July 5, 2018	Offloading in Nanaimo, BC

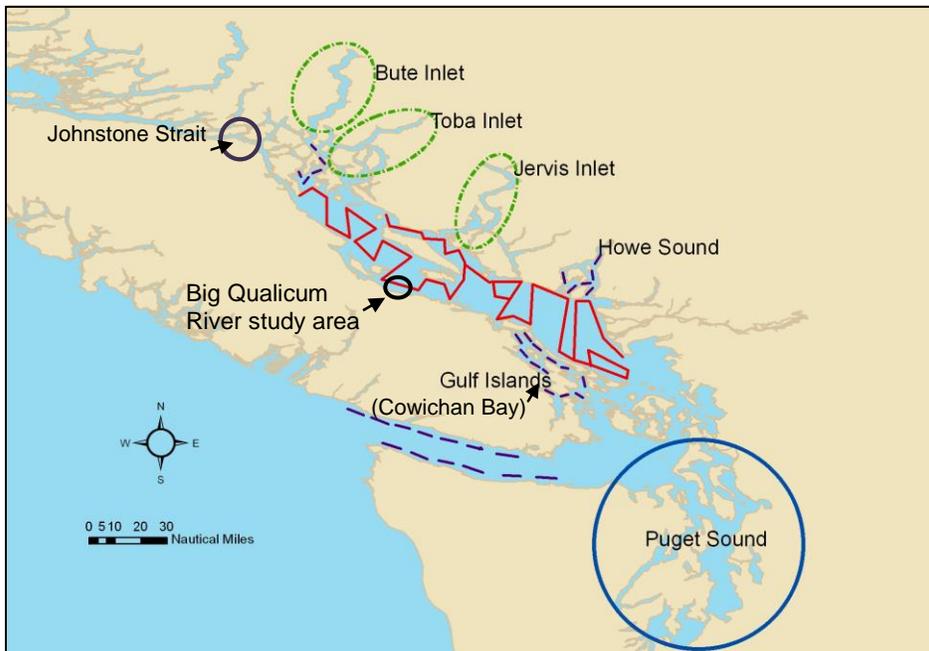
**Table 2.** Tentative fall survey itinerary for the chartered commercial trawl vessel (September 10–27, 2018). *PRELIMINARY ONLY*

Date	General area of operations
September 10, 2018	PBS Nanaimo, loading
September 11–24, 2018	Strait of Georgia, eastern Discovery Islands, Gulf Islands
September 25–26, 2018	Puget Sound
September 27, 2018	Transit to Nanaimo and offload

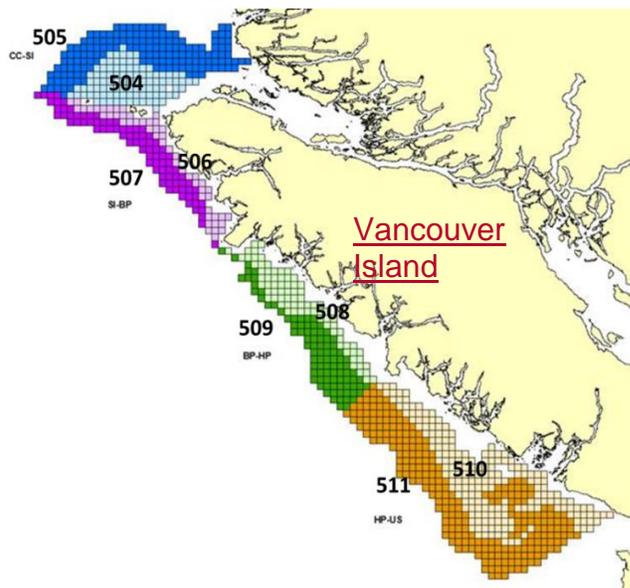
**Table 3.** General sampling information (species and sample size) by gear type

	Species	Sample size
Enumerated	All	All
Random sample length	Non salmon (by species)	50-200
	Juvenile salmon (by species)	50-100
Biological sampling*	Juvenile salmon (by species)	20-100 (At sea)

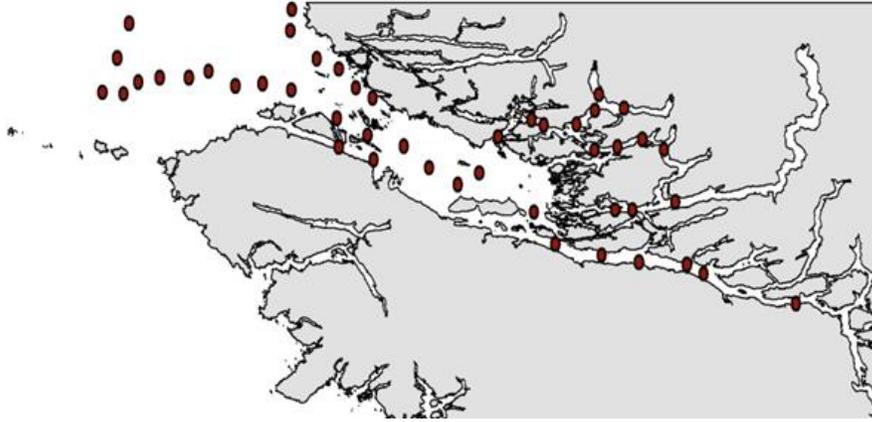
\*Biological sampling may include length, weight, tissue for DNA analysis, otolith and scale collection, diet, muscle tissue, blood samples, individual organ or tissue collection for fish health screening.



**Figure 1.** Generalized map of Strait of Georgia, British Columbia. Track lines for the July and September surveys are shown in red. The Gulf Islands region is in the south-west portion of the strait, bounded by Vancouver Island on the western side. Boundary Bay extends south from Point Roberts along the eastern shoreline. Puget Sound set locations are not shown in this map but region is circled. Set locations in Juan de Fuca strait are essentially along either shoreline, as the middle areas are traffic lanes. Eastern Discovery Islands included the purple dashed lines at northern end of Strait of Georgia and lower portions of Bute and Toba Inlet. Western Discovery Islands and Johnstone Strait is the region north of the Strait of Georgia including the Islands in this region. Queen Charlotte Sound (fall survey) is northwest of this region. The nearshore purse seine surveys will be conducted in Cowichan Bay in the Gulf Islands and off Big Qualicum River along central Vancouver Island. The nearshore trawl survey will be conducted in Howe Sound.



**Figure 2.** Survey strata (505–511) and 4 x 4 km grids of the integrated pelagic trawl survey on the continental shelf of Vancouver Island. Strata are based on bathymetry (50–100 m; 100-200 m) and known ecosystem delineations. Random fishing locations will be selected (n=70) and fished once during daylight hours and once during nighttime hours.



**Figure 3:** Tentative fishing locations for June and October offshore salmon surveys in southern Queen Charlotte Sound, Queen Charlotte Strait and Johnstone Strait based on 2017 fishing locations.