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Canadian Juvenile Salmon Surveys in 2020–2021

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 2020–2021. The plan presented is the scheduled fishing for this period of time. However, due to the limitations and personal distancing required as a result of the Covid19 pandemic, it is anticipated that several of these surveys may be modified or cancelled.

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. 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 and 2020 will be the third year of this integration.

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 2020–2021, trawl surveys in June and September within the Strait of Georgia and Puget Sound will continue to follow protocols and fishing locations fished since 1998. Additional sampling to examine impacts of increased Chinook salmon releases from the Fraser River and Puget Sound will be conducted in the southern portion of the Strait of Georgia within US waters during both surveys. In 2020 the July trawl survey on the continental shelf of Vancouver Island will continue to be integrated as a synoptic pelagic ecosystem survey similar to 2017-2019 (King et al., 2019; Boldt et al. 2019). In 2020, all

these surveys will use a recently 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 (Anderson et al., 2019). Survey work in October 2020 will focus in Queen Charlotte Sound, with initial gear testing for the larger trawl net used in the Gulf of Alaska International Year of the Salmon survey onboard the *Pacific Legacy* in March 2020. This net is similar in construction to the nearshore net but with the ability to fish a larger vertical opening. The survey will also focus on forage fish and extended oceanographic sampling such as rosette deployment. Transects will be completed from coastal Queen Charlotte Sound to offshore to provide a linkage to the anticipated IYS survey of March 2021. The March 2021 survey will be conducted for four weeks in the Gulf of Alaska and will be undertaken to examine the overwintering condition and distribution of Pacific salmon. This survey will be Canada's contribution to the International Year of the Salmon winter survey.

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 2020-2021.

JUVENILE SALMON RESEARCH SURVEYS

GENERAL SURVEY INFORMATION

Five integrated epipelagic surface and mid-water trawl surveys have been planned for 2020–2021. 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 for the past two years were conducted by commercial trawl vessels under charter to the Canadian Government. In 2020 the surveys will be conducted for the first time by the new CCG vessel *Franklin*. This new vessel has the capacity to tow the gear at similar speeds and configuration as the past vessels. However, the size of the vessel may limit some nearshore areas that have been fished in the past. 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, 2020. The early fall survey will be conducted over 24 days between September 10 and October 4, 2020. These surveys are continuations of surveys that have been conducted for 21 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 (Figure 1). The primary objectives of these surveys will be to (1) collect biological information, distribution, condition and abundance estimates on juvenile 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) examine possible interactions between juvenile salmon and other pelagic species encountered in surveys including diet overlap and competition and predation (4) describe the ambient oceanographic conditions, and (5) quantify the biomass of zooplankton and describe zooplankton species community composition in coastal waters of British Columbia. In 2020, additional focus will be given to examine the condition and distribution of Chinook salmon resulting from increased hatchery releases from Chilliwack hatchery on the Fraser River and on juvenile salmon from entering the ocean from stock that spawn above the slide that occurred on the Fraser River in 2019.

Offshore sampling

In July, an integrated pelagic ecosystem survey (King et al., 2019) is scheduled for July 5–August 5, 2020 in continental shelf waters (< 200 m) of Vancouver Island, including southern Queen Charlotte Sound (Figure 2). Fishing will be conducted by the CCG vessel the *Franklin*. The focus is on juvenile Pacific salmon and Pacific herring (*Clupea harengus*). 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, this integrated pelagic survey expands from previous juvenile salmon surveys that fished solely during daytime hours. As with 2017-2019, this survey in 2020 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 other important pelagic fishes for predator-prey and bioenergetics studies. The survey will be collecting acoustic data along standard transect lines during daytime hours.

From October 6–16, 2020 trawl net testing and oceanographic gear deployment will take place in Queen Charlotte Sound. This survey work is in preparation for the March 2021 IYS survey in the Gulf of Alaska. *Franklin* vessel crew will become familiar with the larger trawl net to be used in 2021; expanded oceanographic sampling will be tested for the first time on board the new vessel. Time permitting, transects will be surveyed from coastal Queen Charlotte Sound to offshore areas to provide biological samples bridging summer surveys and the winter 2021 survey in the Gulf of Alaska

International Year of the Salmon Gulf of Alaska sampling

The Canadian survey, in support of the multi-nation North Pacific survey for the International Year of the Salmon, will take place February 20–March 23, 2021. Fishing will occur at stations approximately 60 nautical miles apart and given travel duration along with vessel crew restrictions, two stations will likely be completed per day. Actual station locations will depend on the number of nations participating in the 2021 survey but will fall within the designated regions outlined in the preliminary cruise plan (NPAFC, 2020). It is anticipated that in addition to trawl sets, Canada will be conducting CTD casts, along with rosette and Niskin sampling, and bongo tows for zooplankton sampling. Time permitting, trawling for forage fish using a Tucker trawl will be conducted. Where possible, sampling will follow the protocol outlined in the preliminary cruise plan (NPAFC, 2020).

FISHING GEAR AND FISHING OPERATION

In all nearshore surveys the CCG fishing vessel *Franklin* will fish a large mid-water trawl (LFS 7740). This net has a small mesh bunt (0.5 cm) to retain juvenile salmon and other small pelagic fish. In the Strait of Georgia surveys the net will be fished at 4.5 – 5 knots for 30 minutes with the headrope at the surface, 15 m, 30 m, 45 m or 60 m depth. All fishing will be conducted during daylight hours. The survey methodology will follow the protocols and procedures described in Beamish et al. (2000), Sweeting et al. (2003) and Trudel et al. (2013). A similar mouth opening of these previous surveys of approximately 30 m wide by 15 m deep is expected with this net. The opening of the net will be measured acoustically by an acoustic trawl eye mounted on the headrope.

On the west coast of Vancouver Island and in Queen Charlotte Sound 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.

In the Gulf of Alaska winter survey, a larger net will be fished. This net has similar configuration and cod end to the LFS 7740 but has a vertical opening up to 30m. This net will be fished at a target speed of 5 knots.

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 juvenile salmon from all species collected are measured and weighed. Tissue from the operculum or a caudal fin clip is preserved on Whatman 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 and growth determination. 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 1.

For the inshore survey, stomach contents (from cardiac to pyloric constrictions) 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. The entire stomach contents are broken down into percent contribution by individual prey groups. Dependent on the diet items and level of digestion, the level of prey identification will vary but will be to at least family and often to the genus level (e.g., Sweeting and Beamish 2009, Duffy et al. 2010). When time permits, stomachs of 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°C or -80°C for various chemical and calorimetric analyses including stable isotopes, fatty acid analysis, energy density, fish health screening, or for additional DNA samples and/or laboratory examination of stomach contents.

For the offshore surveys, all catch species are enumerated and biologically sampled, including stomach content analyses. 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 (King et al. 2019). For the offshore surveys, all stomach contents analysis are identified at sea by survey staff (King et al. 2018). 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 (cm^3) is measured using a volumetric sampler. The relative digestion state (fresh, 50%, and fully digested) are estimated for each prey item group.

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°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). Additionally, during Strait of Georgia surveys, water samples for eDNA analysis will be collected during sets. This information will be compared with catch to develop methodologies for using this procedure to assess species or to identify species that are not being caught in the surveys.

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 µm) to either 150 m or 250 m, depending on survey, or within 10 m of the bottom. One of the nets is equipped with a flowmeter to estimate volume of water sampled. 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. 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.

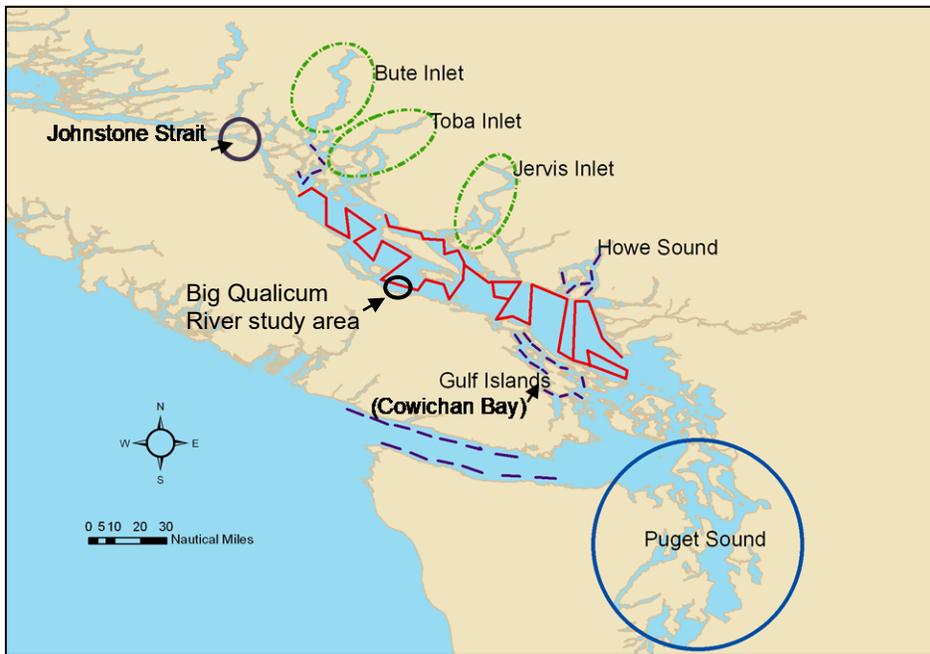


Figure 1. Generalized map of Strait of Georgia, British Columbia. Track lines for the July and September surveys are shown in red. The Gulf Islands region is in the south-west portion of the strait, bounded by Vancouver Island on the western side. Boundary Bay extends south from Point Roberts along the 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.

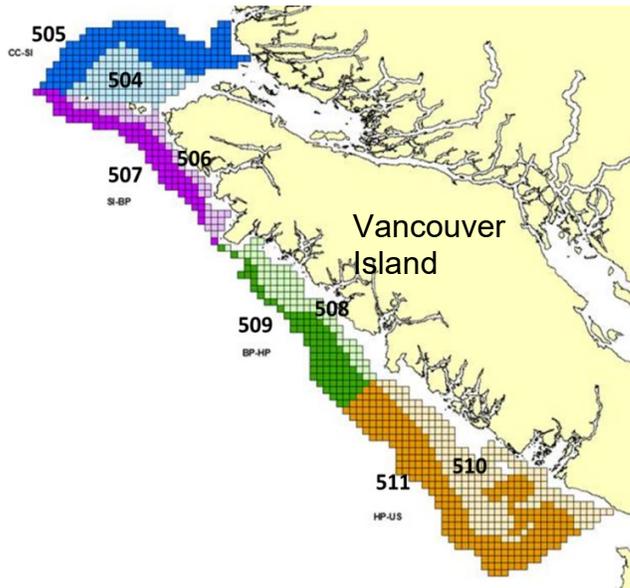


Figure 2. Survey strata (505–511) and 4 x 4 km grids of the Integrated Pelagic Ecosystem Survey on the continental shelf of Vancouver Island. Strata are based on bathymetry (50-100 m; 100–200 m) and known ecosystem delineations. Random fishing locations will be selected (approximately n=70) and fished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