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Canadian Juvenile Salmon Surveys in 2017–2018

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 2017-2018. The inshore program will conduct sampling in the Salish Sea (encompassing the Strait of Georgia and Puget Sound) whereas the offshore/west coast program will conduct sampling along and off the west coast of Vancouver Island (summer) and central coast (fall). These surveys are both part of long-term research programs that were initiated in 1997-1998, however in 2017 the offshore program will begin integrating with other pelagic research programs to develop a synoptic pelagic survey on the continental shelf off the west coast of Vancouver Island. In addition, Canada will conduct up to two additional research projects in nearshore waters: 1) purse seine surveys in Cowichan Bay and off Big Qualicum River on the east coast of Vancouver Island as part of a study examining factors contributing to mortality of juvenile Chinook salmon in southern British Columbia (May to August); and 2) monthly mid-water trawl surveys in Howe Sound to describe the nearshore habitat distribution (< 30 m), prey selection and diet overlap of juvenile salmon from April to September.

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 2017-2018, trawl surveys in June and September within the Strait of Georgia and Puget Sound and a trawl survey in October in the British Columbia central coast region will continue to follow protocols and fishing locations fished since 1998. However, in 2017-2018 the July trawl survey off the west coast of Vancouver Island will be integrated with other pelagic surveys into a single synoptic pelagic ecosystem survey. This survey will use the same mid-water trawl previously used by the offshore salmon survey program. The first year of this survey will include fishing to calibrate catch results from the independent surveys conducted over past years.

In addition to these large scale trawl programs, Canada will conduct two research projects in nearshore waters: 1) purse seine surveys in Cowichan Bay and off the Big Qualicum River on the east coast of Vancouver Island and 2) surveys on the CCGS *Neocaligus* monthly between April and September using a special mid-water trawl net designed to sample shallow (< 30 m), nearshore habitat.

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 2017-2018.

JUVENILE SALMON RESEARCH SURVEYS

GENERAL SURVEY INFORMATION

Four integrated epipelagic surface and mid-water trawl surveys have been planned for 2017-2018. These surveys would typically be conducted from the CCG vessel *W.E. Ricker*. However, due to the vessel being non-operational in 2017 the surveys will be conducted by a commercial trawl vessel under charter to the Canadian Government. The vessel for these surveys has not yet been determined but will meet the requirements to tow the gear at the speed and following the protocol of the surveys conducted since 1998. 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 14-6 days between June 15 and July 15, 2017. The early fall survey will be conducted over 18-20 days between September 15 and October 15, 2017. These surveys are continuations of surveys that have been conducted for more than 15 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) 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.

Offshore sampling

In July, a synoptic pelagic ecosystem survey is scheduled for July 6 through August 3, 2017 in continental shelf waters (< 200 m) off the west coast of Vancouver Island (Figure 2). As with the inshore Strait of Georgia surveys, fishing will be conducted by a chartered commercial trawl vessel. The survey will be the first integrated pelagic ecosystem survey, with anticipated primary focus on juvenile salmon, Pacific herring (*Clupea harengus*) and Pacific sardine (*Sagax sardinops*). Fishing will occur at selected stations, evenly distributed throughout the continental shelf region, at two depths: surface and 15 m (headrope depths). In order to provide transition from previous juvenile salmon surveys that fished solely during daytime hours, this survey 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.

In October 2017, a survey will be conducted in Queen Charlotte Sound using a chartered commercial vessel (Table 2). Weather permitting; the survey will be conducted along transects perpendicular to the coastline, at depths of 0 m, 15 m and 30 m. The primary objective of the survey is to: (1) collect biological samples of juvenile salmon for investigating condition and estimating summer growth; and (2) collect tissue for DNA analyses and identification of Canadian juvenile salmon in order to determine fall distribution.

Nearshore sampling

Five mid-water trawl surveys have also been planned for the *CCGS Neocaligus*, each 5 days in duration occurring mid-month from April – September (Table 3; Figure 1). The fishing will be in Howe Sound, a mainland inlet just north of the Fraser River. The vessel will be equipped with a trawl net with a mouth opening of 12 m wide X 6 m deep. The size of the survey vessel and net permits sampling in shallower waters that are closer to shore than the *CCGS W.E. Ricker* or other large commercial trawl vessel could fish. The primary objective of these surveys will be to investigate the distribution and migration of juvenile salmon in these nearshore areas. The small size of the net mouth opening allows for fine-scale observation on depth distribution, and trawling will occur at the surface, 10 m, 20 m and 30 m. In addition, research will focus on prey selection and diet overlap between species, including overlap between hatchery and wild Chinook salmon. Temperature at depth will be recorded on each trawl haul and zooplankton sampling will be conducted at each trawl station.

Purse seine surveys are planned for two regions in 2017: Cowichan Bay and Big Qualicum River region (Figure 1). The primary objective of the purse seine surveys will be to examine changes in condition and growth of both hatchery-reared and wild Chinook salmon during the early marine period. The surveys will be conducted monthly between May and August (Table 4). This work is part of a Canada/US collaborative program examining factors regulating early marine survival of juvenile Chinook and coho salmon.

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 4.5 – 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.

On the west coast of Vancouver Island and in Queen Charlotte Sound, the chartered commercial trawl vessel will utilize the same mid-water trawl gear. The net will be fished at approximately 5 knots, for 15 minutes at the 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 the fall in Queen Charlotte Sound will be during daytime hours only, and will include sets from the surface to 30 m.

The *CCGS Neocaligus* will fish a medium sized mid-water trawl at about 4-5 knots in the surface nearshore waters of the southern Strait of Georgia and Gulf Islands. This is a new net designed to be fished from the smaller vessel in nearshore waters. The net opening will be approximately 12 m wide by 6 m deep. Similar to the large trawl net, it has small mesh bunt (0.5 cm) to retain juvenile salmon and will be equipped with a trawl eye to facilitate fishing at various depths. Fishing will be conducted during daylight hours. Set duration will be 10-30 minutes depending on fishing area to prevent excessive catches of fish. Vessel details for the *CCGS Neocaligus* can be found at: http://www.ccg-gcc.gc.ca/Fleet/Vessel?vessel_id=86.

Purse seine operations will be conducted from chartered commercial salmon seine vessels using a 300 m purse seine with small mesh bunt (0.5 cm) designed for retaining juvenile fish. Fishing will be monthly from early May through August 2017. Fishing will occur in daylight hours.

SAMPLING PROTOCOLS

During trawl surveys, catch in the cod end of net is emptied into 40 litre totes. Catch 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.

Purse seine surveys permit release of non targeted catch by retaining the bunt of net in water alongside the vessel. Non target species (may include pink salmon, chum salmon, and Pacific herring) are enumerated as released directly from the bunt when possible. The remaining fish in the bunt are transferred by dip nets to live tanks on deck that have flow through water supply. Fish in live tanks are sorted to species for subsequent sampling.

Overall 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 in 95% ethanol for stock identification using microsatellite DNA (Beacham et al. 2001, 2005, 2006). In addition, calcified-structures (i.e. scales and otoliths) are sampled for age 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 5.

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. 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). The diet analyst for this work has been the same trained, qualified person for all of the surveys and is the same individual that performs diet analysis in the laboratory from frozen or preserved stomachs. 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 such as stable isotopes, fatty acid

analysis, Cesium analysis, fish health analysis, or for additional DNA samples and/or laboratory examination of stomach contents.

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°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 μm) 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 19 – July 5, 2017). *PRELIMINARY ONLY*

Date	General area of operations
June 19, 2017	PBS Nanaimo, loading
June 20-July 2, 2017	Strait of Georgia, Gulf Island, eastern Discovery Islands
July 3-5, 2017	Puget Sound
July 5, 2017	Offloading in Nanaimo, BC

Table 2. Tentative fall survey itinerary for the chartered commercial trawl vessel (September 15 – October 16, 2017). *PRELIMINARY ONLY*

Date	General area of operations
September 16, 2017	PBS Nanaimo, loading
September 17-28, 2017	Strait of Georgia, eastern Discovery Islands, Gulf Islands
September 29 -October 1, 2017	Puget Sound
Oct 2-4, 2017	Western Discovery Islands/Johnstone Strait
Oct 5-14, 2017	Queen Charlotte Sound track lines
Oct 15-16, 2017	Transit to Nanaimo and offload

Table 3. Tentative schedule and itinerary for the *CCGS Neocaligus*

Date	General area of operations
April 17-21, 2017	Howe Sound
May 16-20, 2017	Howe Sound
June 21-25, 2017	Howe Sound
July 17-21, 2017	Howe Sound
August 22-26, 2017	Howe Sound
September 26-October 1, 2017	Howe Sound

Table 4. Tentative schedule for the purse seine surveys in Cowichan Bay and off Big Qualicum River on the eastern coast of Vancouver Island

Cowichan Bay	Big Qualicum
May 9-10, 2017	
June 5-6, 2017	June 8-9, 2017
July 10-11, 2017	July 13-14, 2017
August 21-22, 2017	

Table 5. General sampling information (species and sample size) by gear type

	Species	250 Trawl (trawl charter)	180 Trawl (Neocaligus)	Purse seine
Enumerated	All	All	All	All
Random sample length	Non salmon (by species)	50-200	50-200	30-50
	Juvenile salmon (by species)	50-100	50-100	50-100
Biological sampling*	Juvenile salmon (by species)	20-100 (At sea)	20-100 (At sea)	30-50 (Frozen -80°C)

*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.

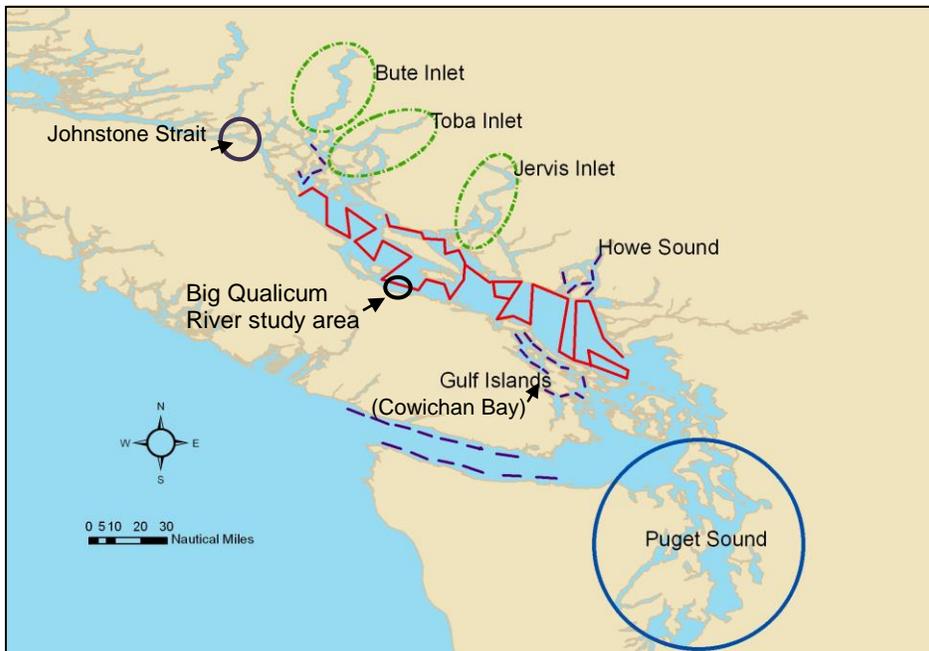


Figure 1. Generalized map of Strait of Georgia, British Columbia. Track lines for the July and September surveys are shown in red. The Gulf Islands region is in the south-west portion of the strait, bounded by Vancouver Island on the western side. Boundary Bay extends south from Point Roberts along the 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. Tentative survey area for the trawl survey on the west coast of Vancouver Island. This survey will be an integrated pelagic ecosystem survey. Specific set locations are currently under review but will occur in waters < 200 m along the west coast of Vancouver Island.