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Canadian Juvenile Salmon Surveys in 2016-2017

by

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1. 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 2016-2017. The offshore/west coast program will conduct sampling along and off the west coast of British Columbia, whereas the inshore program will conduct sampling in the Salish Sea (encompassing the Strait of Georgia and Puget Sound). These surveys are both part of long-term research programs that were initiated in 1997-1998. In addition, Canada will conduct up to four research projects in inshore waters: 1) weekly purse seine survey in Johnstone Strait to monitor the northward migration of juvenile Fraser River Sockeye Salmon (May to July); 2) purse seine surveys in Cowichan Bay and near 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 July); 3) monthly mid-water trawl surveys in Cowichan Bay and Howe Sound to describe the distribution and movement of juvenile Chinook Salmon in inshore waters from April to September; and 4) tentative purse seine surveys in Clayoquot Sound to study distribution and timing of Chinook Salmon through this area in spring and early summer (two unconfirmed dates during May and June).

2. 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). They 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). Hence, Canada currently maintains two long-term research and monitoring programs on the marine biology of Pacific salmon, an offshore/west coast and an inshore program. These programs aim to improve understanding of 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 2016-2017, the offshore/west coast program will conduct sampling off the west coast of British Columbia along the 200 nm exclusive economic zone (EEZ) limit during the summer, and along standard transects off west coast Vancouver Island, Queen Charlotte Sound, Queen Charlotte Strait and at random sampling stations in associated inlets along west coast Vancouver Island and central coast British Columbia during the fall. The inshore program will conduct sampling in Johnstone Strait, Discovery Islands, the Strait of Georgia, Gulf Islands, Puget Sound and Clayoquot Sound. In addition, Canada will conduct up to four research projects in nearshore waters: 1) weekly purse seine surveys in Johnstone Strait to monitor the northward migration of juvenile Fraser River Sockeye Salmon (May to July); 2) purse seine surveys in Cowichan Bay and near 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 July); 3) monthly mid-water trawl surveys in Cowichan Bay and Howe Sound to describe the distribution and movement of juvenile Chinook Salmon in inshore waters from April to September; and 4) tentative purse seine surveys in Clayoquot Sound to study distribution and timing of Chinook Salmon through this area in spring and early summer (two unconfirmed dates during May and June).

This document presents general information for the juvenile Pacific salmon research surveys that have been planned for both the offshore and inshore areas of the North Pacific Ocean by Canada for fiscal year 2016-2017.

3. SURVEY OVERVIEWS

3.1. Mid-water trawl survey – CCGS *W.E. Ricker*

3.1.1. Survey Timing and Objectives

Two integrated epipelagic mid-water trawl surveys have been planned for the CCGS *W.E. Ricker* in 2016-2017. The early summer (June 21-July 17, 2016) and fall surveys (September 13-October 18, 2016) will provide continuations of data time series that have been updated annually for more than 15 years. These surveys will focus on the water bodies surrounding Vancouver Island and will include the Strait of Georgia, Gulf Islands, Juan de Fuca Strait, Johnstone Strait, Discovery Islands and Puget Sound for the summer. In addition to these areas, the fall survey will also include the west coast of Vancouver Island (Table 1 and Table 2; Figure 1, Figure 2 and Figure 3). The primary objectives of these surveys will be to (1) collect a wide range of biological data on Pacific salmon (*Oncorhynchus* spp.) and the associated epipelagic fish community, including morphometric and diet data and tissue samples for disease screening; (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; (4) describe ambient oceanographic conditions through CTD profiles; and (5) quantify the biomass of zooplankton and describe zooplankton species community composition in coastal and offshore waters of British Columbia.

The summer survey will also include an offshore leg to meet similar sampling objectives along Canada's 200nm exclusive economic zone (EEZ). An additional objective of this portion of the summer survey is to investigate the high seas distribution and migration timing of mature and immature Pacific salmon.

3.1.2. Fishing Gear and Operations

The CCGS *W.E. Ricker* will fish a large mid-water trawl with small mesh bunt (0.5 cm) to retain juvenile Pacific salmon. The net is generally fished at 4.5 – 5 knots for 10-30 minutes either at the surface, 15m, 30m, 45m or 60m with occasional sets conducted at deeper depths. During the inshore portion of the survey, fishing is conducted during daylight hours (0600 to 1800). During the offshore leg, fishing will be conducted overnight (1900 to 0700) in order to sample Pacific salmon when they are expected to be concentrated at the surface. 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 head rope.

Vessel details for the *CCGS W.E. Ricker* can be found at: http://www.ccg-gcc.gc.ca/Fleet/Vessel?vessel_id=116.

3.1.3. Sampling Protocol

During trawl surveys, the entire catch is emptied from the cod end into 40 litre totes. Catch is sorted by 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 all non-target species (for example, Spiny dogfish, Walleye Pollock, flatfish species, etc.) are measured, enumerated and released live as quickly as possible. In the event of large catches, a random subsample of each species is measured and total catch is estimated.

3.2. Mid-water trawl survey – *CCGS Neocaligus*

3.2.1. Survey Timing and Objectives

Five mid-water trawl surveys have also been planned for the *CCGS Neocaligus* (Table 3). This small vessel will be equipped with a small mid-water trawl (18 m wide by 5 m deep). The size of the survey vessel and trawl net permits sampling in shallower nearshore waters than the *CCGS W.E. Ricker*. The primary objective of these trawl surveys is to investigate the distribution and migration of juvenile Chinook, Sockeye and Coho Salmon in nearshore areas (Figure 2).

3.2.2. Fishing Gear and Operations

The *CCGS Neocaligus* will fish its small mid-water trawl at roughly 4-5 knots on the surface nearshore waters of Howe Sound and Cowichan Bay. Similar to the large trawl net, it has small mesh bunt (0.5cm) to retain juvenile salmon and is equipped with a trawl eye sensor to facilitate fishing at various depth strata (surface to 30m head rope depth, in 5m increments). Fishing will be conducted during daylight hours (0700 to 1900). Set duration will be 10-30 minutes (depending on the fishing area) to limit excessive fish catches. Vessel details for the *CCGS Neocaligus* can be found at: http://www.ccg-gcc.gc.ca/Fleet/Vessel?vessel_id=86.

3.2.3. Sampling Protocols

During this trawl survey, the catch is emptied from the cod end into 40 litre totes. Catch is sorted by species and enumerated to characterize the nekton community in epipelagic waters of British Columbia. Catch of non-target species (for example, Spiny dogfish, Walleye Pollock, flatfish species, etc.) are measured, enumerated and released live as quickly as possible. In the event of large catches, a random subsample of each species is measured and total catch is estimated.

3.3. Purse seine surveys – Lower Johnstone Strait/Discovery Islands, Cowichan Bay and Big Qualicum River, Clayoquot Sound

3.3.1. Survey Timing and Objectives

Purse seine surveys are planned for four regions in 2016-2017: lower Johnstone Strait/Discovery Islands, Cowichan Bay, marine waters adjacent to the Big Qualicum River estuary and Clayoquot Sound (Figure 2 and Figure 4).

The primary objective of the survey in Johnstone Strait/Discovery Islands will be to determine the timing of migration of juvenile Sockeye Salmon from the Fraser River out of the Strait of Georgia, however all salmon species will be studied. This survey will run weekly from mid-May to July (Table 4; Figure 4). DNA samples will be collected to allow migration timing to be examined at a stock-specific level. This survey, in conjunction with the trawl surveys in the Strait of Georgia, will also examine changes in condition and growth rates of juvenile Sockeye Salmon encountered during their early marine residence.

The remaining purse seine surveys will be conducted at differing intervals (4 Cowichan surveys, 2 Big Qualicum surveys and 2 Clayoquot surveys) from early May through late July (Table 5 and Table 6). The primary objective of these surveys is to examine changes in condition and growth of both hatchery-reared and wild Chinook and Coho Salmon during the early marine period to improve understanding of factors that regulate early marine survival. Samples obtained on these surveys will be compared with reference samples taken from associated hatcheries and watersheds to provide a measure of change during early marine residence.

3.3.2. Fishing Gear and Operations

Purse seine operations will be conducted from chartered commercial salmon seine vessels using a 300 m purse seine with small mesh bunt (50 mm) designed for retaining juvenile fish. Fishing will occur in daylight hours and in Johnstone Strait will be primarily during slack tides.

3.3.3. Sampling Protocols

Purse seine surveys permit the release of non-target catch by keeping the bunt of the net in the water alongside the vessel. Non-target species (for example, Pink Salmon, Chum Salmon and Pacific herring) are enumerated and released directly from the bunt when possible. Fish remaining in the bunt are transferred by dip net to live tanks on deck that have flow-through salt water supply. Fish in live tanks are then sorted to species for subsequent sampling.

4. BIOLOGICAL SAMPLING PROTOCOL

The overall biological sampling protocols for Pacific salmon are consistent among all surveys. Coho Salmon, Chinook Salmon and Sockeye Salmon are scanned and examined for the presence of CWT, pit tag and fin clips. Although not observed as commonly as they once were, the presence of pelvic and pectoral fin clips are also recorded. A minimum of 15 to 30 randomly selected samples per salmon species per trawl set are measured and weighed, depending on the total catch size. Tissue from the operculum (using a hole-punch) 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 subsequent age

determination. The number of samples varies by survey, depending on specific objectives and the total number of fish caught. A general outline of sample numbers by survey and sample type is provided in Table 7.

Stomach contents (from cardiac to pyloric constrictions) of juvenile Pacific 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. The taxonomic resolution of prey identification is at least to family, but often to genus, depending on particular prey items (e.g., Sweeting and Beamish 2009, Duffy et al. 2010). When time permits, stomachs of certain non-salmonid species are also examined (e.g., Pacific Hake, Spiny dogfish, Walleye Pollock, Pacific herring). Diet analyses since 1998 have been conducted by the same person for all surveys, both in the field and in the laboratory.

A subsample of the catch is preserved frozen individually at -20°C or -80°C for various chemical and calorimetric analyses such as stable isotopes, for additional DNA samples if required and for laboratory examination of stomach contents.

Biological data collected for each salmon include species common name, fork length (mm) and/or total length (mm) and observed fin clip(s). It will also include, whenever possible, whole body weight (g wet), sex, stomach content weight (g wet), % water that is 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 showed non-overlapping size modes for Chum Salmon, Coho Salmon, Pink Salmon, and Sockeye Salmon (Trudel et al. 2007a). For Chinook Salmon, we used a combination of fish length along with coded-wire tag recoveries of known-age fish, DNA analyses and scale pattern to separate juveniles from adults, and life history types (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 or 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).

5. OCEANOGRAPHIC SAMPLING PROTOCOL

At oceanographic stations, the scientific crew conducts CTDs (conductivity-temperature-depth) casts. At select stations on the *CCGS W.E. Ricker*, oceanographic sampling will also collect seawater samples at 10 m from the surface with a Niskin bottle for nutrient (nitrate, phosphate, silicate) and chlorophyll-a analysis. Seawater for nitrate, phosphate, and silicate samples will be collected in acid-washed, polypropylene test tubes (two per station). Standard volumes of seawater from the Niskin sampler (330mL) will be filtered through glass fibre filter (GF/F) disks for chlorophyll-a analysis. These will be folded and placed in glass scintillation vials. All samples will be stored frozen at -20°C . Sea surface

waters will also be collected at some stations and preserved in Lugols iodine solution for analysis to determine presence and estimated concentrations 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+ CTD (or SBE 25 data logging CTD). Salinity calibration samples from select CTD casts may be collected over the course of the surveys when depths are great enough that salinity values become stable (usually greater than 500m depths). The oceanographic data collected on these surveys will be analysed and archived in databases maintained at the Institute of Ocean Sciences (Sidney, British Columbia).

6. ZOOPLANKTON SAMPLING PROTOCOL

On the *CCGS W.E. Ricker*, vertical bongo tows will be conducted with two 57 cm diameter Nitex nets (250 µm mesh) to approximately 250 m or within 10 m of the bottom. One of the nets is equipped with a TSK flowmeter. Zooplankton collected from the non-flowmeter side will be preserved in 10% Formalin (3.7% formaldehyde) and sent to the zooplankton laboratory at the Institute of Ocean Sciences, Fisheries and Oceans Canada (Sidney, BC) for species identification and enumeration. Zooplankton taken from the net with the flowmeter will be sorted into four size fractions by sieving through stacked 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 species identification data will be stored in a database maintained at the Institute of Ocean Sciences (Sidney, British Columbia), while the dried samples and associated weight data will be stored at the Pacific Biological Station (Nanaimo, British Columbia).

On the purse seine vessels, zooplankton samples will be collected via a single SCOR net (single 50cm diameter hoop with 250 µm mesh Nitex net and cod end. The sample will be preserved in 10% Formalin (3.7% formaldehyde).

7. CONCLUSION

This report provides an overview of the inshore and offshore Pacific salmon research surveys and sampling protocols planned by Canada for fiscal year 2016/2017 in the North Pacific Ocean. Additional scientists are encouraged to participate on any of these surveys, pending space on board the research vessel and obtaining the necessary level of security clearance (which can be a lengthy process).

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9. TABLES

Table 1. Tentative itinerary for the CCGS W.E. Ricker summer survey (June 21 – July 17, 2016).

Dates	General area of operations
June 21	PBS Nanaimo, loading
June 22-July 4	Strait of Georgia, Gulf Islands, Discovery Islands
July 5-8	Puget Sound and Juan de Fuca Strait
July 9-16	Offshore night fishing (up to 200 nm off west coast Vancouver Island and Haida Gwaii)
July 17	PBS Nanaimo, unloading

Table 2. Tentative itinerary for the CCGS WE Ricker fall survey (September 13 – October 17, 2016). PRELIMINARY ONLY.

Date	General area of operations
September 13	PBS Nanaimo, loading
September 14-October 1	Strait of Georgia, Gulf Islands, Discovery Islands
October 2-4	Puget Sound
October 5-9	Juan de Fuca Strait, West Coast Vancouver Island
October 10-11	Ship crew change (Victoria or Port Alberni)
October 12-17	West Coast Vancouver Island, Queen Charlotte Sound, Queen Charlotte Strait, Johnstone Strait
October 17	Return to PBS Nanaimo, unloading

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

Date	General area of operations
April 16-22	Gulf Islands, Howe Sound
May 13-18	Gulf Islands, Howe Sound
June 20-24	Gulf Islands, Howe Sound
July 21-25	Gulf Islands, Howe Sound
August 25-29	Gulf Islands, Howe Sound
September 19-24	Gulf Islands, Howe Sound

Table 4. Tentative schedule for the purse seine survey in Johnstone Strait/Discovery Islands (charter vessel TBD).

Date	General area of operations
May 10-11	Discovery Islands, Johnstone Strait
May 17-18	Discovery Islands, Johnstone Strait
May 24-25	Discovery Islands, Johnstone Strait
May 31-June 1	Discovery Islands, Johnstone Strait
June 7-8	Discovery Islands, Johnstone Strait
June 14-15	Discovery Islands, Johnstone Strait
June 21-22	Discovery Islands, Johnstone Strait
June 28-29	Discovery Islands, Johnstone Strait
July 6-7	Discovery Islands, Johnstone Strait
July 12-13	Discovery Islands, Johnstone Strait

Table 5. Tentative schedule for the purse seine surveys in Cowichan Bay and off Big Qualicum River (charter vessel TBD).

Dates	General area of operations
May 4-5	Cowichan Bay
May 30-31	Cowichan Bay
June 2-3	Big Qualicum River
June 27-28	Cowichan Bay
June 30-July 1	Big Qualicum River
July 28-29	Cowichan Bay

Table 6. Tentative schedule for the purse seine surveys in Clayoquot Sound (charter vessel TBD).

Dates	General area of operations
May 16-21	Millar Channel, Herbert Inlet, Sydney Inlet, Shelter Inlet
June 13-18	Millar Channel, Herbert Inlet, Sydney Inlet, Shelter Inlet

Table 7. General sampling information (species and sample size) by gear type.

	Species	250 Trawl (Ricker)	180 Trawl (Neocaligus)	Purse seine
Enumerated	All	All	All	All
Length & Weight (Random sample)	Non salmonids	50-200	50-200	30-50
	Juvenile salmon	50-100	50-100	50-100
Biological sampling*	Juvenile salmon	20-100 (At sea)	20-100 (At sea)	30-50 (Frozen -80°C)
Zooplankton	--	Bongo	Bongo/SCOR net	SCOR net
CTD	--	SBE 9/11+ or mini-rosette	SBE25/19	SBE25/19

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

10.FIGURES

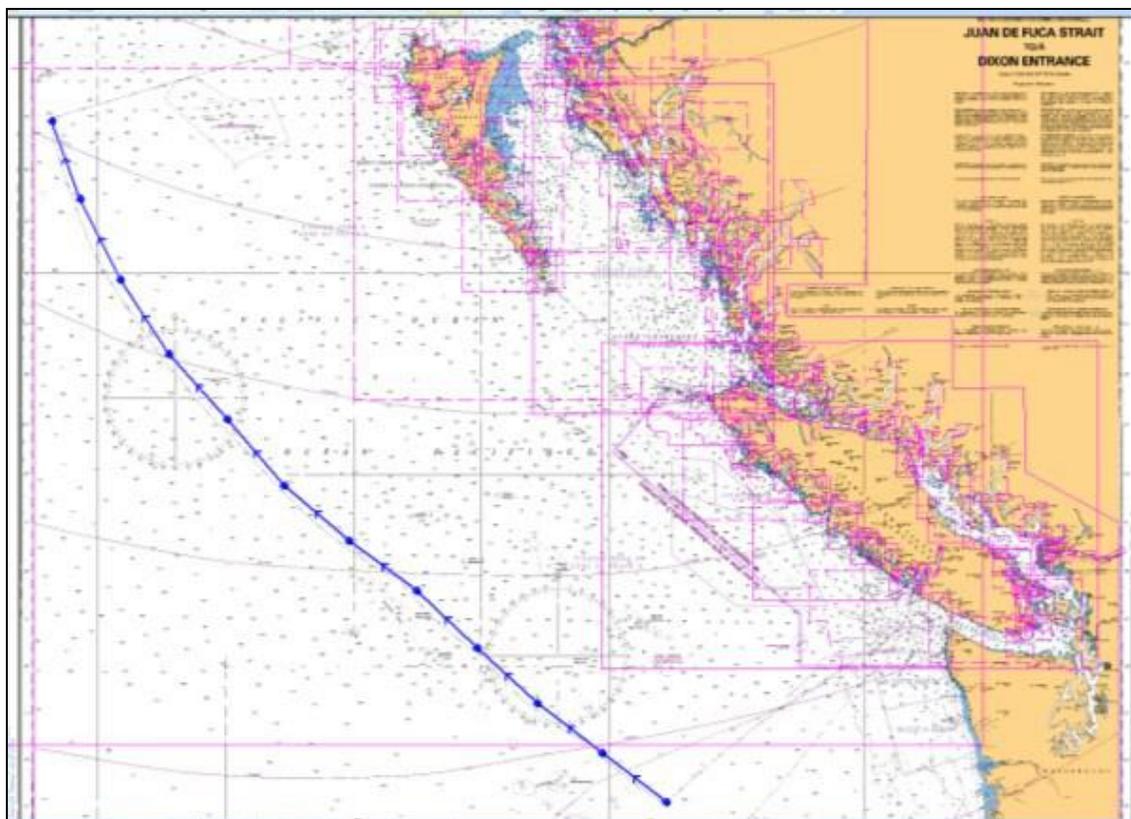


Figure 1. Tentative sampling stations for the summer offshore CCGS W.E. Ricker survey along Canada's 200nm exclusive economic zone limit (July 6-17, 2016).

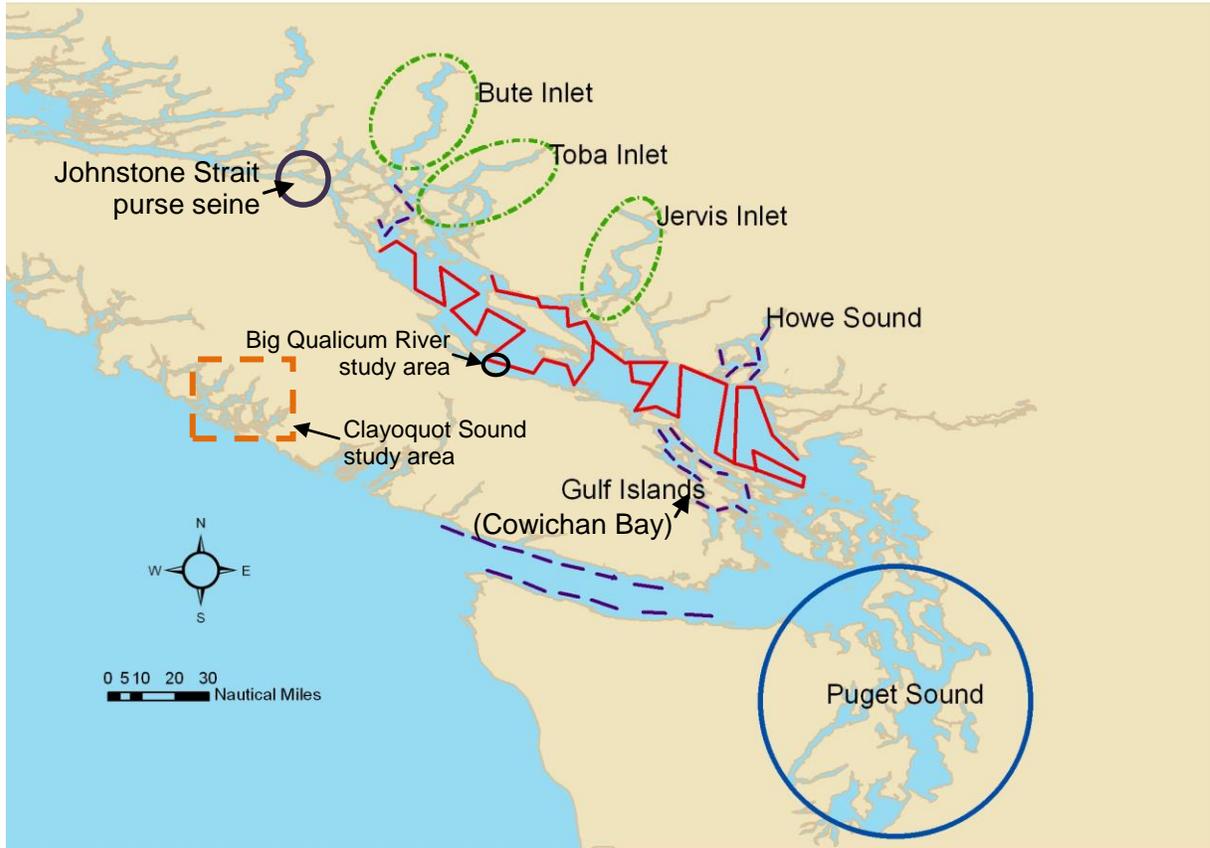


Figure 2. Tentative sampling areas for all proposed summer inshore Canadian research programs (May-July 2016). Track lines for the July CCGS W.E. Ricker trawl survey in the Strait of Georgia, Puget Sound and Juan de Fuca Strait are shown with a solid red line, blue circle and purple dashed lines, respectively. The Gulf Islands region—including Cowichan Bay—in the southwest portion of the Strait of Georgia, bounded by Vancouver Island on the western side (black dashed line) will be sampled by purse seine and trawl. Purse seine surveys in the eastern Discovery Islands and lower Johnstone Strait regions include the purple dashed lines at the northern end of the Strait of Georgia and lower portions of Bute and Toba Inlet (green dashed ovals and purple circle). Purse seine surveys will also Big Qualicum River (black circle) and Clayoquot Sound, west coast Vancouver Island (orange dashed square).

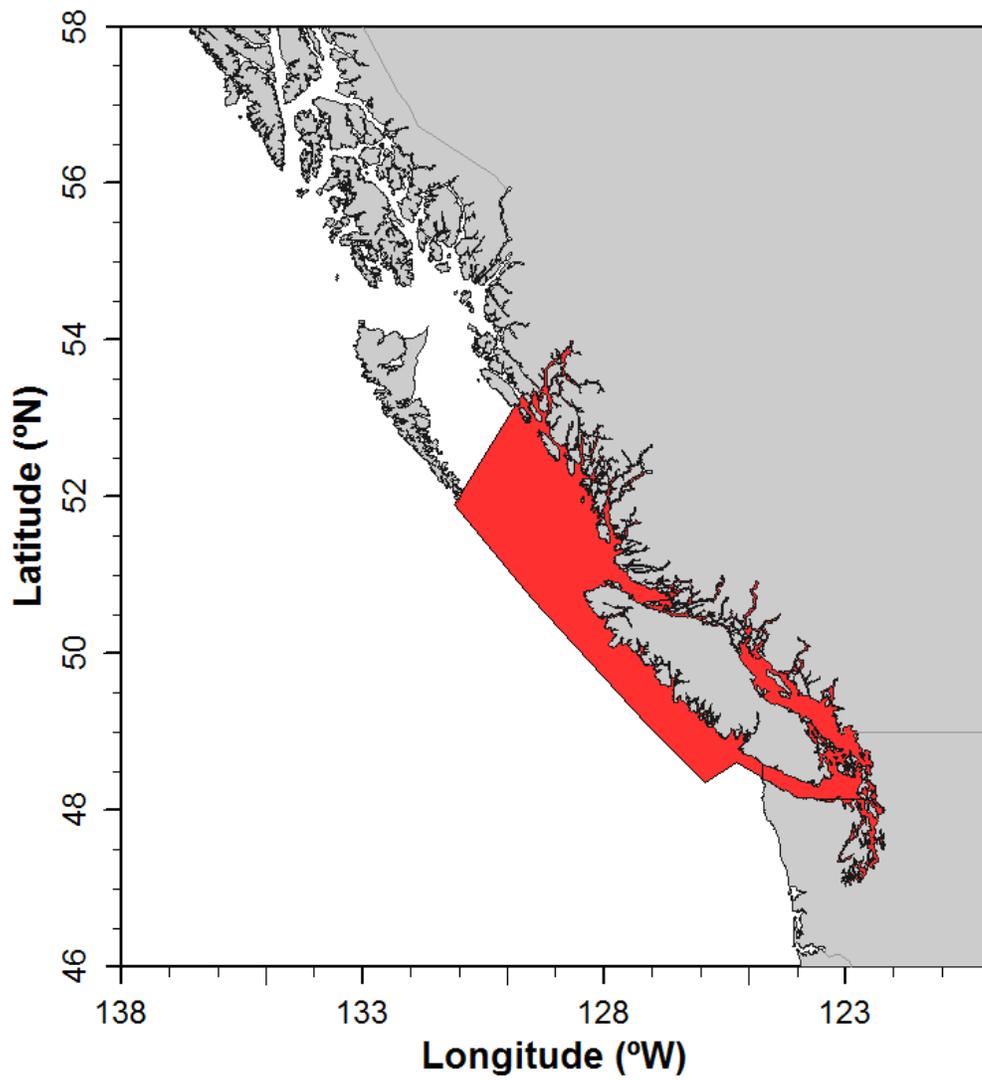


Figure 3. Tentative sampling areas for the inshore and offshore/west coast CCGS W.E. Ricker fall survey (September 13 – October 18, 2016).

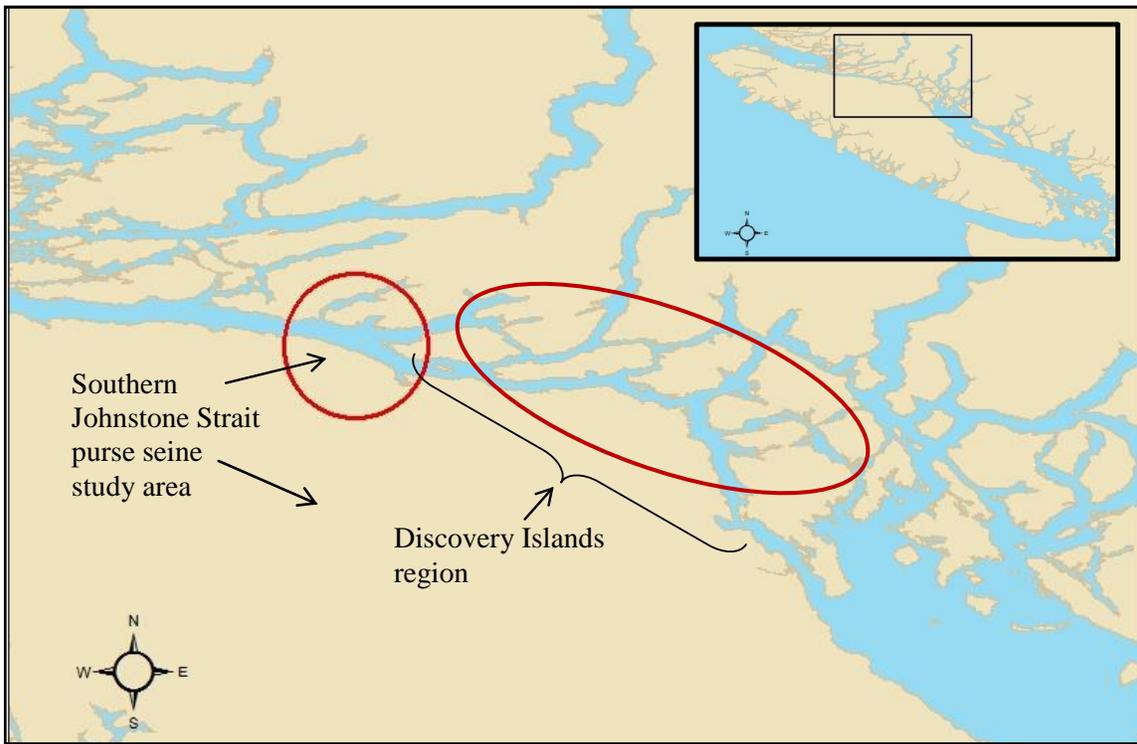


Figure 4. Region to be covered by purse seine surveys in lower Johnstone Strait/Discovery Islands (red circles). All juvenile Pacific salmon migrating north from the Strait of Georgia pass through this channel. Several of the channels throughout the Discovery Islands are also fished during these surveys.