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## Canadian Juvenile Salmon Surveys in 2015-2016

by

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## **ABSTRACT**

This document provides information on the juvenile salmon research surveys that have been planned in both the offshore and inshore areas by Canada for 2015-2016. The offshore program will conduct sampling off the west coast of British Columbia, whereas the inshore program will conduct sampling in the Strait of Georgia and Puget Sound. These surveys are both long-term surveys that were initiated in 1997-1998. In addition to these two long-term programs, Canada will conduct three research projects in nearshore waters: 1) weekly purse seine survey in Johnstone Strait to monitor the northward migration of juvenile Fraser River Sockeye Salmon (May-July), 2) purse seine surveys in Cowichan Bay and off Big Qualicum River on the east coast of Vancouver Island as part of a study examining the factor causing mortality of juvenile Chinook Salmon in Southern British Columbia, and 3) monthly mid-water trawl surveys performed from the CCGS *NeoCaligus* using a trawl net designed to sample shallow water to describe the dispersion of juvenile Chinook Salmon in nearshore waters.

## **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 Mankhen 2001). Hence, Canada currently maintains 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 2015-2016, the offshore program will conduct sampling off the west coast of British Columbia, and the inshore program will conduct sampling in the Strait of Georgia and Puget Sound. In addition to these two long-term programs, Canada will conduct three research projects in nearshore waters: 1) weekly purse seine survey in Johnstone Strait to monitor the northward migration of juvenile Fraser River Sockeye Salmon (May-July), 2) purse seine surveys in Cowichan Bay and off the Big Qualicum River on the east coast of Vancouver Island as part of a study examining the factor causing early marine mortality of juvenile Chinook Salmon in Southern British Columbia, and 3) mid-water trawl surveys performed from the CCGS *NeoCaligus* using using a trawl net designed to sample shallow water to describe the dispersion of juvenile Chinook Salmon in nearshore waters. 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 2015-2016.

## **JUVENILE SALMON RESEARCH SURVEYS**

### *TRAWL AND PURSE SEINE SURVEYS*

#### *GENERAL SURVEY INFORMATION*

Two integrated epipelagic mid-water trawl surveys have been planned for the CCGS *W.E. Ricker* in 2015-2016. The early summer (June 23-July 19, 2015) and fall survey (September 15-October 26, 2015) will be conducted by the *W.E. Ricker* and are continuations of surveys that have been conducted for more than 15 years. These surveys will focus on the water bodies surrounding Vancouver Island as well as the central coast of British Columbia and will include the Strait of Georgia, Gulf Islands, Juan de Fuca Strait, Johnstone Strait, Queen Charlotte Strait, Queen Charlotte Sound, the west coast of Vancouver Island, and Puget Sound (Table 1-2; Figure 1-2). 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 (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.

Five mid-water trawl surveys have also been planned for the CCGS *Neocaligus* (Table 3). This vessel will be equipped with a trawl with mouth opening 18 m X 5 m. The size of the survey vessel and net permits sampling in shallower waters than the CCGS *W.E. Ricker*. The primary objectives of these surveys will be to investigate the distribution and migration of juvenile Fraser River and Cowichan Bay salmon in the nearshore areas (Figure 3).

Purse seine surveys are planned for three regions in 2015: lower Johnstone Strait, Cowichan Bay and Big Qualicum River area (Figure 2). The primary objective of the survey in Johnstone Strait 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. The survey will run weekly from mid-May to July (Table 4; Figure 4). DNA samples will be collected to allow the migration timing to be examined at a stock level. This survey, in conjunction with the trawl surveys in the Strait of Georgia, will also be examining changes in condition and level of growth of the juvenile Sockeye Salmon during their early marine residence.

The primary objective of the purse seine survey in Cowichan Bay will be to examine changes in condition and growth of both hatchery-reared and wild Cowichan River Chinook Salmon during the early marine period. The surveys will be conducted monthly between May and July (Table 5). This work is part of a program examining factors regulating early marine survival. In 2015 similar sampling will also be conducted with purse seine off the Big Qualicum River on the east coast of Vancouver Island (Figure 2) approximately 7-10 days after the release of hatchery reared Chinook Salmon (Table 5). This survey is an expansion of the Cowichan Bay study and will be focussed on

collecting juvenile Coho Salmon and Chinook Salmon from the Big Qualicum River during their first weeks in the ocean.

Additional scientists are encouraged to participate on any of these surveys, pending security clearance, which generally requires several months advance effort, and the number of berths available.

#### *FISHING GEAR AND FISHING OPERATION*

The CCGS *W.E. Ricker* and chartered 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, 15m, 30m, 45m or 60m 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. Vessel details for the CCGS *W.E. Ricker* can be found at: [http://www.ccg-gcc.gc.ca/Fleet/Vessel?vessel\\_id=116](http://www.ccg-gcc.gc.ca/Fleet/Vessel?vessel_id=116).

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 18 m wide by 5 m small. Similar to the large trawl net, it has small mesh bunt (0.5cm) 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](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 (0.5cm) designed for retaining juvenile fish. Fishing will be weekly or monthly depending on region and will occur from early May through late-July 2015. Fishing will occur in daylight hours and in Johnstone Strait will be primarily during slack tides.

#### *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 as quickly as possible.

Purse seine surveys permits release of non targeted catch by retaining the bunt of net in water alongside the vessel. Non target species (may include Pink Salmon and Chum Salmon, Pacific herring) are enumerated as released directly from 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.

The overall biological sampling protocols 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. Clips of pelvic and pectoral fins, while not as prevalent as in years past, are also recorded. A total or random sample of juvenile salmon species collected are measured and weighed. 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 age determination. The number varies 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 6.

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 % 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 has been the same trained, qualified person for all of the surveys and is the same individual that performs diet analysis in the laboratory. A subsample of the catch is preserved frozen individually at  $-20^{\circ}\text{C}$  or  $-80^{\circ}\text{C}$  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. It will also include, when available, 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 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 fiber 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 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, BC) 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 *CCGS WE Ricker* (June 23 – July 19, 2015).

<b>Date</b>	<b>General area of operations</b>
June 23	PBS Nanaimo, loading
June 24-July 7	Strait of Georgia, Gulf Island, eastern Discovery Islands
July 8-9	Puget Sound
July 10-18	Juan de Fuca Strait, west coast Vancouver Island, Hecate Strait, Queen Charlotte Strait, Johnstone Strait.
July 19	PBS Nanaimo, unloading

**Table 2.** Tentative fall survey itinerary for the *CCGS WE Ricker* (September 15 – October 26, 2015). *PRELIMINARY ONLY*

<b>Date</b>	<b>General area of operations</b>
September 16	PBS Nanaimo, loading
September 17-28	Strait of Georgia, eastern Discovery Islands, Gulf Islands
September 29 -October 1	Puget Sound
October 2-10	Juan de Fuca Strait, West Coast Vancouver Island
October 11-12	Return to Nanaimo for crew change
October 13-23	Johnstone Strait, Queen Charlotte Strait/Sound
October 24-25	Return to PBS Nanaimo, unloading

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

<b>Date</b>	<b>General area of operations</b>
April 20-24	Gulf Islands, Roberts Banks, Howe Sound
May 25-29	Gulf Islands, Roberts Banks, Howe Sound
June 22-26	Gulf Islands, Roberts Banks, Howe Sound
July 16-20	Gulf Islands, Roberts Banks, Howe Sound
August 22-26	Gulf Islands, Roberts Banks, Howe Sound

**Table 4.** Tentative schedule for the purse seine survey in Johnstone Strait (charter vessel to be determined)

<b>Date</b>	<b>General area of operations</b>
May 11-12	Discovery Islands, Johnstone Strait
May 25-26	Discovery Islands, Johnstone Strait
June 1-2	Discovery Islands, Johnstone Strait
June 8-9	Discovery Islands, Johnstone Strait
June 17-18	Discovery Islands, Johnstone Strait
June 25-26	Discovery Islands, Johnstone Strait
July 3-4	Discovery Islands, Johnstone Strait
July 10-11	Discovery Islands, Johnstone Strait
July 17-18	Discovery Islands, Johnstone Strait

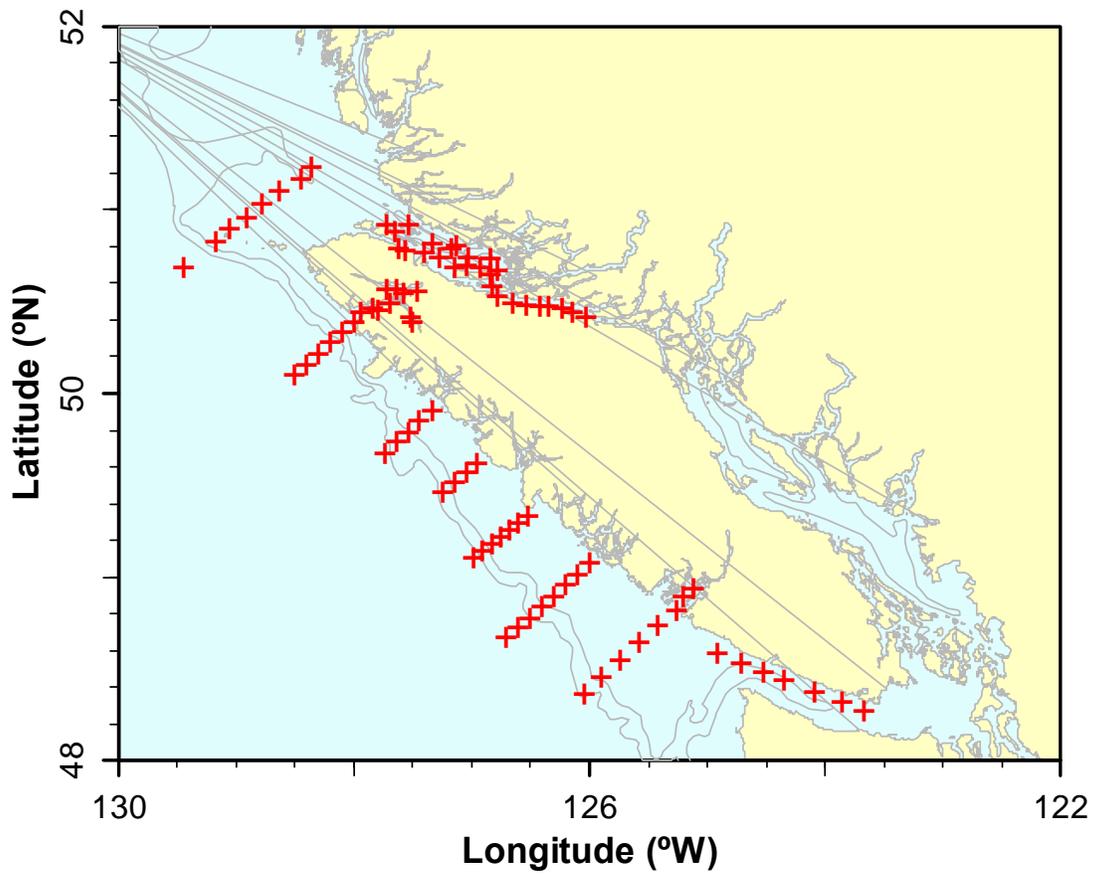
**Table 5.** Tentative schedule for the beach and purse seine surveys in Cowichan Bay and off Big Qualicum River

<b>Cowichan</b>	<b>Big Qualicum</b>
May 7-8	
June 1-2	June 4-5
June 29-30	
July 28-29	July 31-August 1

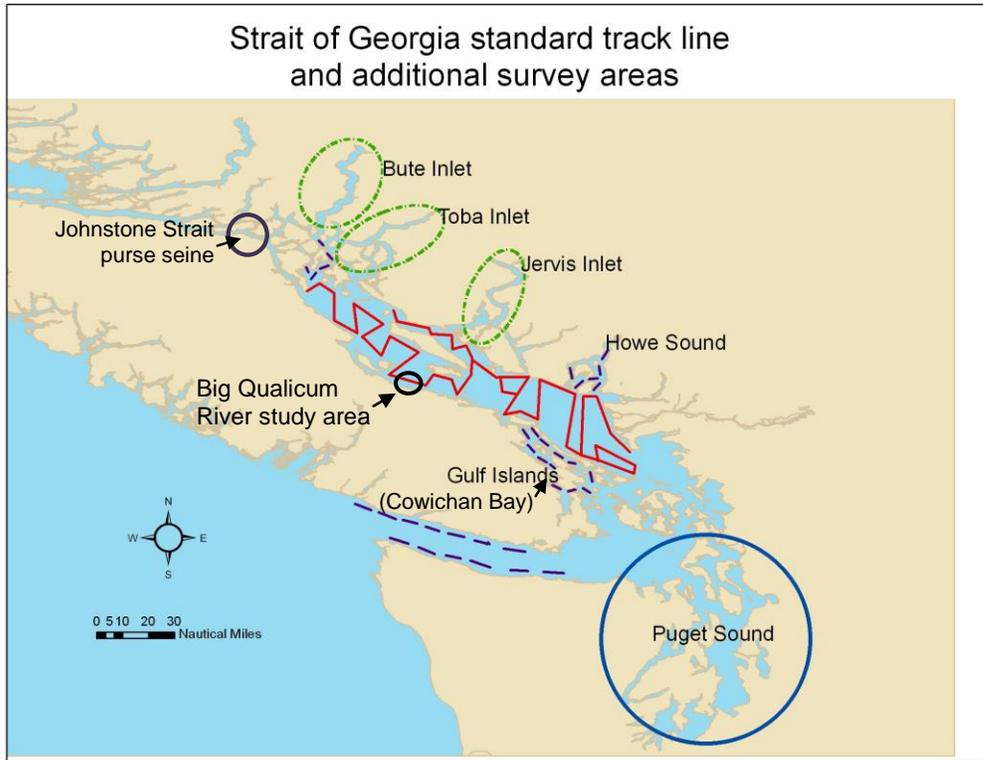
**Table 6.** General sampling information (species and sample size) by gear type

	Species	250 Trawl (Ricker)	180 Trawl (Neocaligus)	Purse seine
Enumerated	All	All	All	All
Random sample length	Non salmon	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)

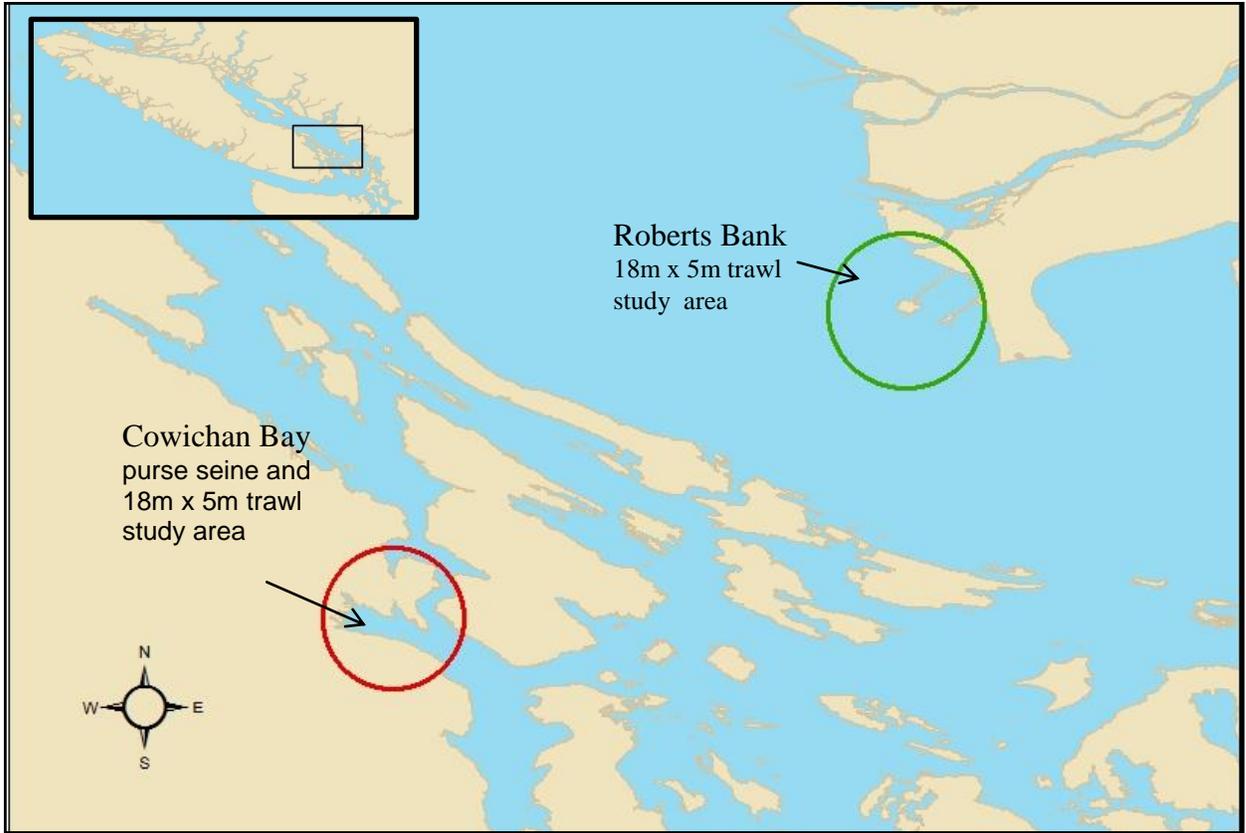
\*Biological sampling may include length, weight, tissue for DNA analysis, otolith and scale collection, diet, muscle tissue, blood samples, individual organ collection.



**Figure 1.** Tentative survey stations for the CCGS *WE Ricker* on the west coast of Vancouver Island, Queen Charlotte Sound and Queen Charlotte Strait.



**Figure 2.** 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. Juan de Fuca strait tracklines 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. The purse seines surveys will be conducted in the southern Johnstone Strait (purple circle) and Cowichan Bay in the Gulf Islands.



**Figure 3.** Region of study in Cowichan Bay (red circle) and Roberts Bank region (green circle) in the southern Strait of Georgia and Gulf Islands.



**Figure 4.** Region of purse seine surveys in southern Johnstone Strait (red circle). All juvenile salmon migrating north from the Strait of Georgia pass through this channel. Several of the multiple channels throughout the Discovery Islands are also fished during the surveys.