

Canadian Juvenile Salmon Surveys in 2014-2015

by

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ABSTRACT

In this document, we present the juvenile salmon research surveys that have been planned in both the offshore and inshore areas by Canada for 2014-2015. 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. 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 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) a mid-water trawl survey performed with a small net (4m x 4m) 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 bulk 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 predation-based 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 2014-2015, 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. 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 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) a mid-water trawl survey performed with a small net (4m x 4m) to describe the dispersion of juvenile Chinook Salmon in nearshore waters. In this document, we present the juvenile salmon research surveys that have been planned in both the offshore and inshore areas by Canada for 2014-2015.

JUVENILE SALMON RESEARCH SURVEYS

TRAWL AND PURSE SEINE SURVEYS GENERAL SURVEY INFORMATION

Four integrated epipelagic mid-water trawl surveys have been planned for the CCGS *W.E. Ricker* (3) and chartered commercial trawler (1) in 2014-15. The early summer (June 24-July 21, 2014) and fall survey (September 16-November 8, 2014) will be conducted by the *W.E. Ricker* and are continuations of surveys that have been conducted for the past 10-15 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). An additional survey will be conducted in the Strait of Georgia during early June (approximately May 31-June 9) using a chartered commercial trawler. The survey will follow the same track line as the surveys conducted by the *W.E. Ricker* in this region (Table 3, Figure 2). During the winter (March 5-16, 2015) a survey will be conducted by the *W.E. Ricker* and will focus on the waters between Vancouver Island and the mainland of BC (Table 4, 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) describe the ambient oceanographic conditions, and (4) 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 5). This vessel will be equipped with a 4 m x 4 m trawl to access shallow waters. 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 3-4).

Purse seine surveys are planned for two regions in 2014: lower Johnstone Strait and Cowichan Bay (Figure 3-4). In Johnstone Strait the primary objective of the survey will be to determine the timing of migration of juvenile Sockeye Salmon from the Fraser River through this region. DNA samples will be collected to allow this 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 this critical early marine. In Cowichan Bay the primary objective of the survey will be to examine changes in condition and growth of both hatchery-reared and wild Cowichan River Chinook Salmon during the early marine period as part of a program to examine factors regulating early marine survival.

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 mid-water trawl with small mesh bunt 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.

The CCGS *Neocaligus* will fish a small mid-water trawl at about 4 knots in the surface nearshore waters of the southern Strait of Georgia and Gulf Islands. The net opening is 4m x 4m with small mesh bunt to retain juvenile salmon. Fishing will be conducted during daylight hours. Set duration will be 30 minutes unless limited by fishing area. 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 (0.5cm) designed for retaining juvenile fish. Fishing will be weekly or bi-weekly depending on region and will occur from early May through mid-July 2014. Fishing will occur in daylight hours and in Johnstone Strait will be during slack tides. To reduce mortality, the purse seine is not completely dried on recovery. The bunt is left submerged to allow the fish to remain swimming in a pool alongside the fishing vessel.

On all trawl surveys, the cod end of net is emptied into 40 litre totes. The catch is sorted by species. On the purse seine surveys non salmon catch is enumerated and released, as much as possible, directly from the bunt of net. When possible a similar procedure is used for Pink Salmon and Chum Salmon. The remainder of the juvenile salmon are transferred by dip net to a live tank on board vessel. These salmon are sorted and Coho Salmon, Chinook Salmon and Sockeye Salmon are placed into individual live tanks for subsequent sampling.

For all surveys all catch is enumerated and measured onboard the ship to characterize the nekton community in epipelagic waters of British Columbia and Puget Sound (Brodeur et al. 2006; Orsi et al. 2007). The numbers of fish sampled for the different surveys and areas varies depending on the primary objectives of the survey. A general outline of sample numbers is provided in Table 8. The overall sampling protocols remain consistent among the surveys.

For 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. For all juvenile salmon species collected, a random sub-sample (Table 8) 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.

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, stomach 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 at the Pacific Biological Station (PBS). 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. 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 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 these biological data, blood plasma will be 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., in press). A subsample of 5-10 salmon will also be taken immediately upon retrieval of the catch, with emphasis on the liveliest fish and tissue samples (muscle, brain, liver etc), and 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; in press).

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. 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 24 – July 21, 2014).

Date	General area of operations
June 24	PBS Nanaimo, loading
June 25-July 7	Strait of Georgia, Gulf Island, eastern Discovery Islands
July 8-10	Western Discovery Islands, Johnstone Strait, Queen Charlotte Strait
July 11-13	Hecate Strait and associated inlets
July 14-16	Queen Charlotte Sound, Jonstone Strait and travel
July 17-19	Juan de Fuca and Puget Sound
July 20	PBS Nanaimo, unloading

Table 2. Tentative fall survey itinerary for the *CCGS WE Ricker* (September 16 – November 8, 2014).

Date	General area of operations
September 16	PBS Nanaimo, loading
September 17-30	Strait of Georgia, eastern Discovery Islands, Gulf Islands
October 1-6	Johnstone Strait, Queen Charlotte Strait, Howe Sound
October 7-12	Strait Puget Sound and Juan de Fuca Strait
October 13-14	Nanaimo – Crew Change & Maintenance
October 15-23	West Coast Vancouver Island
October 24-November 7	Queen Charlotte Sound, Central and North Coast
November 8	PBS Nanaimo, unloading

Table 3. Tentative winter survey itinerary the *CCGS WE Ricker* (March 5-16, 2015).

Date	General area of operations
March 5	PBS Nanaimo, loading
March 6-7	Gulf Islands
March 8-16	Strait of Georgia
March 16	PBS Nanaimo, off loading

Table 4. Tentative spring survey itinerary for the chartered vessel (May 31- June 9, 2014).

Date	General area of operations
May 31	PBS Nanaimo, loading
June 1-9	Strait of Georgia, Discovery Islands (East)
June 9	PBS Nanaimo, off loading

Table 5. Tentative schedule and itinerary for the *CCGS Neocaligus*

Date	General area of operations
April 14-18	Gulf Islands, Roberts Banks, Howe Sound
May 19-23	Gulf Islands, Roberts Banks, Howe Sound
June 23-26	Gulf Islands, Roberts Banks, Howe Sound
July 21-24	Gulf Islands, Roberts Banks, Howe Sound
September 11-16	Gulf Islands, Roberts Banks, Howe Sound

Table 6. Tentative schedule for the purse seine survey in Johnstone Strait

Date
May 23-24
May 29-30
June 5-6
June 13-14
June 20-21
June 26-27
July 3-4

Table 7. Tentative schedule for the beach and purse seine surveys in Cowichan Bay

Week
May 8-9
May 20-21
June 2-3
June 23-24
July 15-16

Table 8. General sampling information (species and sample size) by gear type

	Species	250 Trawl	4x4 trawl	Purse seine
Enumerated	All	All	All	All
Random sample length	Non salmon	50-200	50-200	30-50
Biological sampling	Juvenile salmon	20-100 (At sea)	20-100 (At sea)	30-50 (Frozen -80)

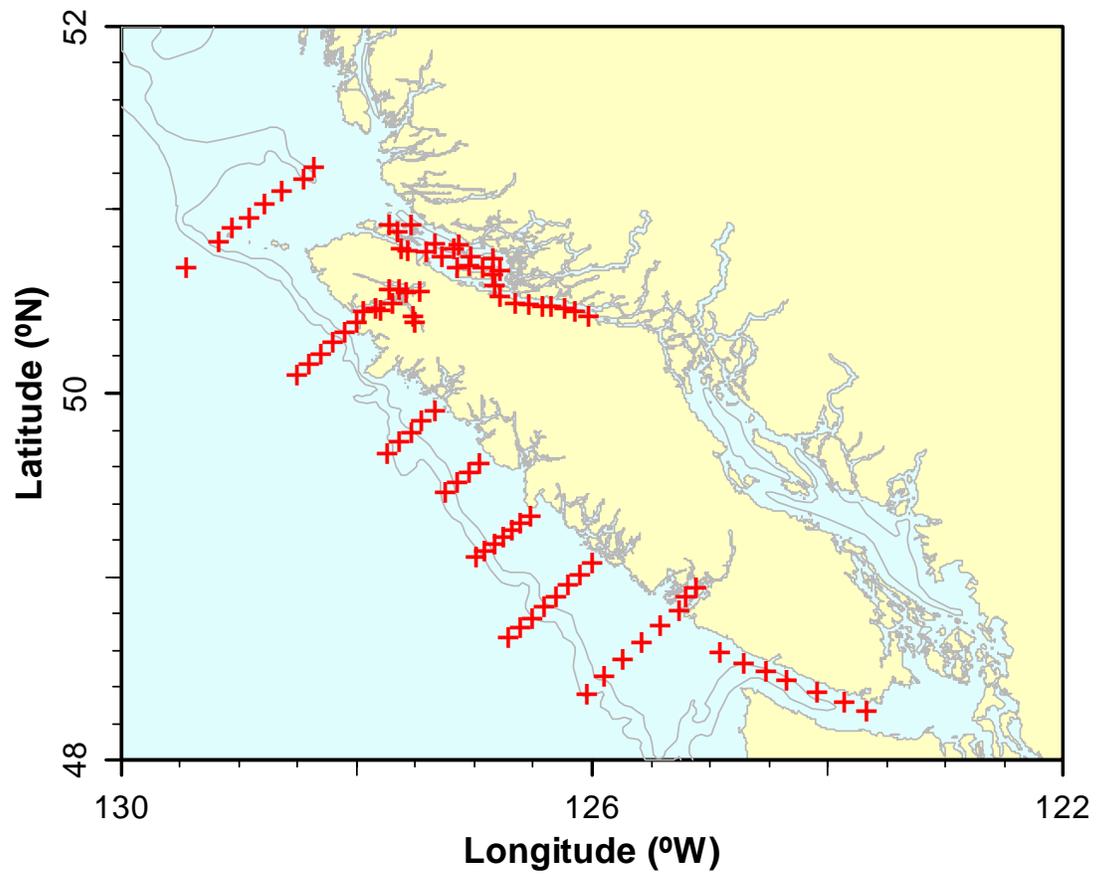


Figure 1. Tentative survey stations for the CCGS *WE Ricker* on the west coast of Vancouver Island, Queen Charlotte Sound and Queen Charlotte Strait.

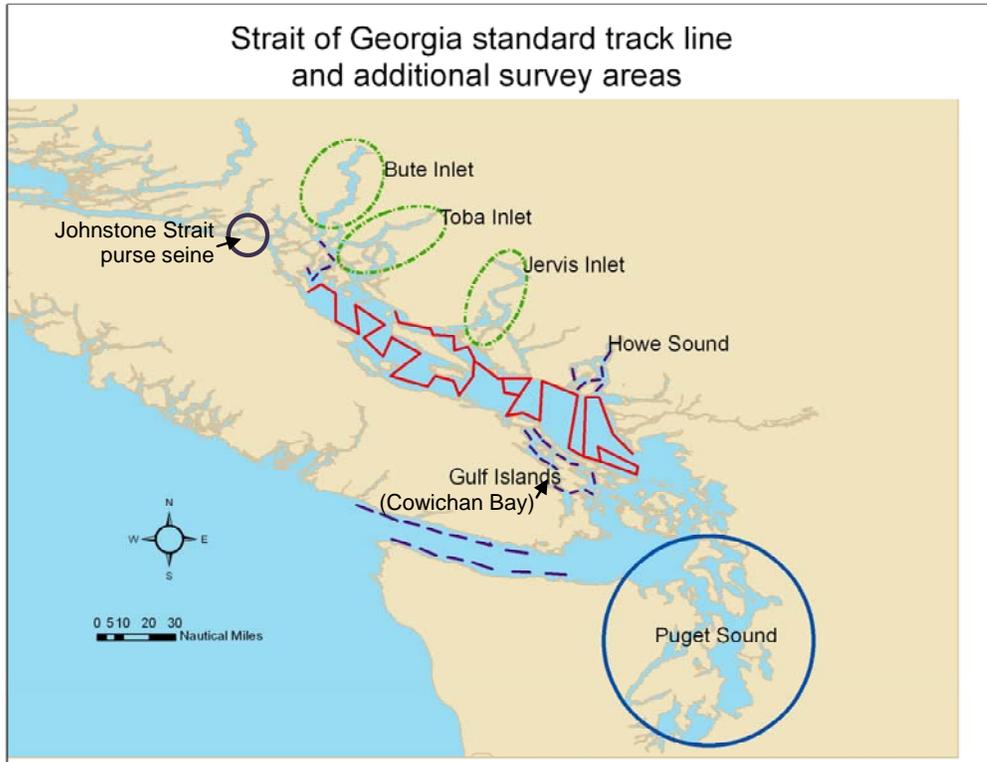


Figure 2. Generalized map of Strait of Georgia, British Columbia. Track lines for the July and September surveys are shown in red. The Gulf Islands region is in the south-west portion of the strait, bounded by Vancouver Island on the western side. Boundary Bay extends south from Point Roberts along the 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.

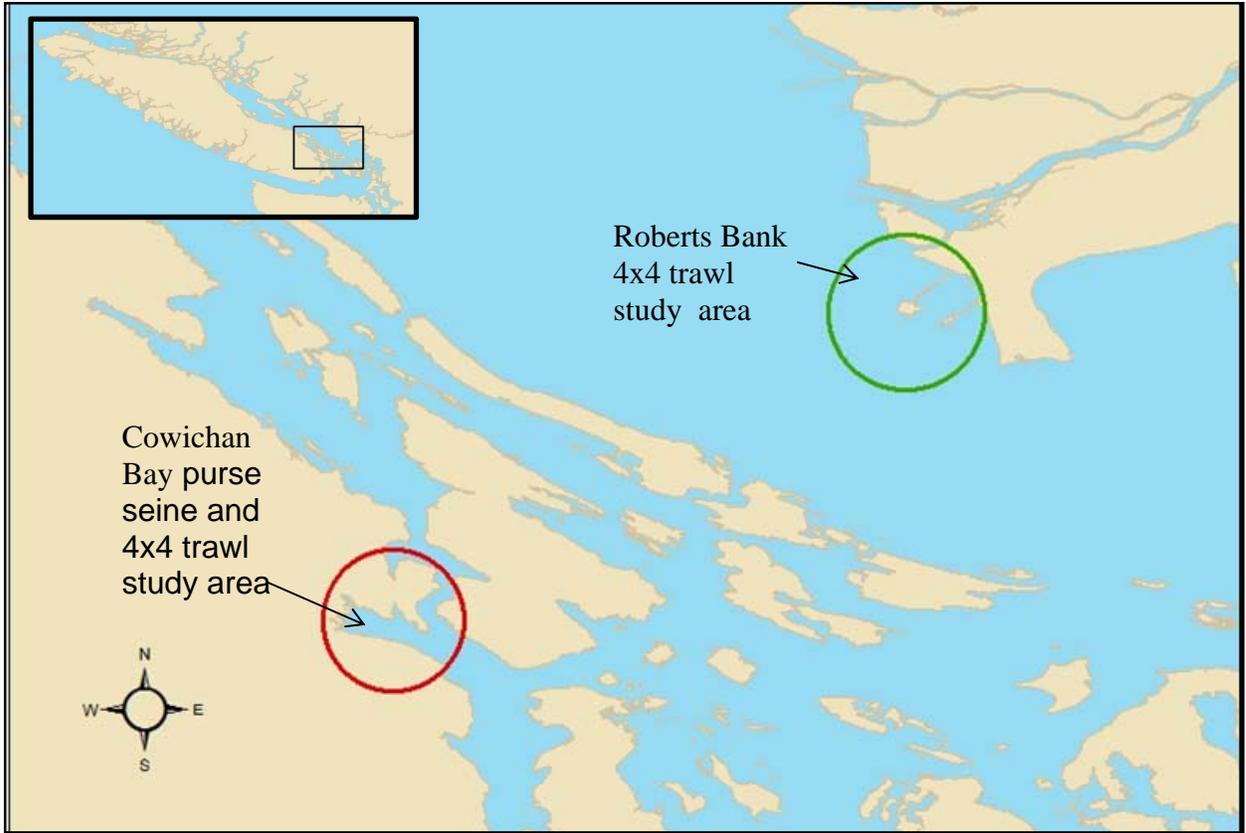


Figure 3. Region of study in Cowichan Bay (red circle) and Roberts Bank region (green circle) in the southern Strait of Georgia and Gulf Islands.



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.