Strait of Georgia Juvenile Herring Survey, September 2017

Matthew Thompson, Jennifer Boldt and Matthew Grinnell

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STRAIT OF GEORGIA JUVENILE HERRING SURVEY, SEPTEMBER 2017

by

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ABSTRACT

Thompson, M., Boldt, J. and Grinnell, M. H. 2020. Strait of Georgia juvenile herring survey, September 2017. Can. Manuscr. Rep. Fish. Aquat. Sci. 3200: v + 55 p.

A fall juvenile herring survey of the Strait of Georgia took place September 5th to 16th, 2017. This survey serves to address several questions of early herring survival, abundance, recruitment and trophodynamics. Forty-two core stations were sampled throughout the Strait of Georgia following the ten core transects that have been sampled since 1990. The survey area extends from Trincomali Channel in the south to Smelt Bay in the north. Zooplankton and physical environmental data were also collected in the study area.

RÉSUMÉ

Thompson, M., Boldt, J. and Grinnell, M. H. 2020. Strait of Georgia juvenile herring survey, September 2017. Can. Manuscr. Rep. Fish. Aquat. Sci. 3200: v + 55 p.

Un relevé automnal du hareng juvénile dans le détroit de Georgie a été réalisé entre le 5 et le 16 septembre 2017. Ce relevé visait à répondre à plusieurs questions sur la survie, l'abondance, le recrutement et la trophodynamique du hareng durant les premiers stades de son développement. Les 42 stations situées dans le détroit de Georgie ont été échantillonnées en suivant les 10 transects principaux qui font l'objet d'un échantillonnage depuis 1990. La zone du relevé s'étend du chenal Trincomali au sud jusqu'à Smelt Bay au nord. Des données sur le zooplancton et l'environnement physique ont également été recueillies dans la zone d'étude.

INTRODUCTION

Pacific Herring (*Clupea pallasi*) are an important commercial fish and a vital forage species for many marine mammals, birds, and fish in British Columbia's coastal waters. Pacific Herring (hereafter referred to as herring) spawn principally on marine vegetation in the subtidal and upper intertidal zone between February and June, with peak spawning between March and April (Humphreys and Hourston 1978). Larvae hatch after two to three weeks, and disperse with surface currents, metamorphosing into juvenile or young-of-the-year herring at a length of ~25mm (Hourston and Haegele 1980). Herring are considered juveniles or immature until they are about three years of age and have joined the sexually mature spawning population (Hay and McCarter 1999). During daylight hours, juvenile herring congregate in schools, occasionally forming mixed aggregates with other pelagic species, close to shore near the bottom (Haegele 1997). At dusk, these fish migrate into surface waters to feed on plankton. During this time they are vulnerable to purse seine gear.

To determine the distribution and abundance of juvenile herring in the Strait of Georgia (SOG) purse seine surveys have been conducted annually since 1990, except for 1995 (Figure 1). The main objective of the survey was to estimate the relative abundance of juvenile herring in the SOG. Also, a goal of this report was to update the time series index (and associated variance) of the relative biomass and abundance, as well as mean lengths and weights of age-0 herring in the SOG using methods identified in Boldt et al. (2015; see Appendix 1). Survey data provide a potential leading indicator of recruitment to the adult herring population and may provide an indicator of prey availability and quality to predators in the SOG, such as Coho and Chinook Salmon.

METHODS

The annual survey of juvenile herring in the Strait of Georgia (Figure 2) followed ten core sampling transects (1 – 6, 8 – 11; no transect 7); with 3 to 5 stations per transect, for a total of 48 sampling stations. These stations have been sampled consistently since 1990 (except 1995). Data from these ten core transects have been used to predict juvenile herring recruitment (Hay et al. 2003, Schweigert et al. 2009, Boldt et al. 2018). Originally, the sampling transects were chosen based on known historical herring spawning sites and were roughly placed equal distances apart around the Strait of Georgia. Placement also represents both nearshore and open water habitats (Haegele et al. 2005). In 2017, sampling was conducted from September 5th to 16th (Table 1). Forty-two of the forty eight core stations were sampled. Cape Cockburn (transect 10, stations 1-5) was not sampled due to bad weather and Henry Bay (transect 4, station 1) could not be sampled due to a large amount of jellyfish preventing closure of the net.

Fish Sampling

In 2017, the 12 m, aluminum-hulled Fisheries Research Vessel *Walker Rock* was used for all fishing events. A 183 m long and 27 m deep purse seine net of knotless web, resulting in an area fished of ~2665 m^2, was used for all fishing events. The body of the net had 46 m of 22.2 mm mesh at the tow end followed by 91 m of 19.0 mm mesh, and the bunt end was 46 m of 9.5 mm mesh. The net fished to a depth of 10 m, and was able to retain fish greater than 20 mm in length. All sets were made after dusk when herring were near the surface. All sets were made at the pre-determined sampling stations. Five sets were completed per night, depending on location, and length of travel between transects and the marine weather forecast. For most sets, it was possible to land the entire catch for biological sampling. On occasion, it was not practical to land a large set in its entirety, so sub-sampling was necessary. When sub-sampling was required, a 40 kg capacity tote was filled with randomly selected fish and retained for biological sampling. Several dipnet samples were taken from various parts of the net (catch) to make up the random sub-sample. The remainder of the set was released over the corkline, its size (volume) estimated as the number of totes released. All fish retained for sampling were bagged and frozen, with the exception of large predator species (e.g. adult salmon and flatfish). These fish were individually measured in the field. All retained fish were later sampled in the laboratory at the Pacific Biological Station. From each set, up to 100 herring were individually weighed and measured. Up to 25 individuals for all other species caught were identified, weighed and measured. If the set contained fewer than 100 herring, then all herring were weighed and measured. Consistent with standard practices, herring were measured to standard length, salmon to fork length, groundfish to total length and all to the nearest millimetre. All other fish species were measured to standard length. The number of herring caught in each set was determined by dividing the total catch weight by the mean individual fish weights of the subsampled herring. The number of other species caught was determined in the same manner (Tables 2 and 3). Where they existed, as a pilot study, a subsample of scales was collected from the preferred region under the pectoral fin for aging.

Zooplankton Sampling

Twenty stepped oblique zooplankton tows were performed (Figure 3). The tows were always completed after dusk and immediately before the fishing events. A nearshore and offshore tow location was sampled on all transects. Dual 19 cm diameter bongo nets with 350 μm mesh were used for sampling, resulting in 'left' and 'right' bongo zooplankton samples (only 'left' samples were processed). The bongos were lowered to 20 m depth (10 m in shallow areas) and raised by an electric winch at a rate of 1 m every 15 sec (or 1 m every 30 sec for shallow areas). The zooplankton tow was performed with the vessel doing a small circle at ~2 knots speed. Each tow took approximately 5 minutes to complete. An additional twenty vertical zooplankton tows were also performed this year for comparative sampling between the two methods. A General Oceanics® 2030R model flowmeter was attached to the left bongo net to determine the volume of seawater filtered. Volume filtered was calculated for oblique tows using the following equation (McCarter and Hay 2002):

$$\mathbf{V = (A \cdot F \cdot K) / 999{,}999}$$

where:

V = volume of water filtered through the plankton net (m^3)
A = area of net opening (0.02835 m^2)
F = number of revolutions recorded by the flow meter (m)
K = standard speed rotor constant for 7cm rotor (26,873)
999,999 = maximum rotor digit count

For vertically-towed zooplankton samples, the winch speed was too low for accurate flowmeter readings. Volume filtered was therefore calculated as $V = (\pi * \text{net radius}^2 * \text{depth of tow})$, where the depth was either 10 m (transect 1, station 1; transect 3, station 1; transect 4, station 5; and transect 5, station 1) or 20 m (all other stations).

Upon retrieval, the bongo nets were washed with a high pressure deck hose to rinse zooplankton into the codends, and the samples were preserved in 3.7% seawater formalin.

In the laboratory, a volumetric splitter was used to reduce the sample size to where organisms could be conveniently counted and identified in a counting tray using a stereo microscope under 30X magnification. Sample splitting continued until a target size of roughly 300 organisms was reached (Thompson et al. 2003).

Zooplankton was identified to the lowest possible taxonomic level. Copepods were identified to species, where possible. Densities for all zooplankton species were determined and expressed as number of animals/m^3.

CTD Sampling

A Conductivity Temperature Depth recorder (CTD) was used to characterize oceanographic conditions in the surveyed area. Twenty casts were conducted using a RBR XR-60 CTD at stations where zooplankton samples were also collected (Figure 3). One CTD cast was performed at each location before zooplankton sampling. The CTD unit was weighted and lowered over the side of the vessel to within ~2 meters of the bottom to give the largest water profile possible. Descent rate of the CTD was approximately 1 m/sec. Data from the CTD casts were subsequently downloaded to a laptop at the end of the each evening.

RESULTS

Herring

Forty-two stations were sampled from transects 1 – 6, 8, 9, 11. A total of 3,797 herring were weighed and measured resulting in a multimodal length frequency distribution (Figure 4). Length designations for juvenile herring age-classes were determined by general spacing of the length frequency histogram. Some scales were taken for aging;

however, the sample size was small (most fish had lost their scales) and did not clarify age-class length categories. Based on the length frequency plot, the following age class designations were used:

0+ = herring less than or equal to 108 mm standard length
1+ = herring between 109 mm and 154 mm standard length
2+ and older = herring greater than or equal to 155 mm standard length

All forty-two sampled stations (100%) contained age-0+ herring (Tables 2 and 3). The mean length and weight of age-0+ herring was 83 mm and 7.78 g, respectively (n = 3,557). A total weight of 191.55 kg and estimated 27,581 individual age-0+ herring were caught (Table 4).

Catches at fourteen of the forty-two stations (33.3 %) sampled contained age-1+ herring (Tables 2 and 3). The mean length and weight of age-1+ herring was 130 mm and 30.11 g, respectively (n = 236). A total weight of 13.05 kg and estimated 412 individual age-1+ herring were caught (Table 4).

Catches at four of the forty-two stations (9.5%) sampled contained age-2+ herring (Tables 2 and 3). The mean length and weight of age-2+ herring was 163 mm and 59.79 g, respectively (n = 4). A total weight of 0.46 kg and estimated 8 age-2+ herring were caught (Table 4).

Length frequency histograms by transect location for all sampled herring are shown in Figure 5. All transects were dominated by age-0+ herring. Secret Cove (transect 11) was the only location with mixed age-classes of herring (Figure 5). Due to the low numbers of sampled age-1+ and age-2+ herring, age determinations from opportunistically collected scales did not result in a clearly defined separation between age classes. A length-weight relationship for all sampled herring from the survey showed a significant, positive correlation (R^2=0.96; Figure 6).

Zooplankton

In obliquely-towed zooplankton samples, there were 24 categories of organisms identified in 20 zooplankton samples (Tables 5, 6 and 7). An average of 14.49 m^3 (± 5.06 m^3) of water was filtered per zooplankton tow. Larvaceans (*Oikopleura sp.* and *Fritillaria sp.*) occurred in all 20 samples. More than 80% of all zooplankton biomass comprised cladocerans, larvaceans (*Oikopleura sp.* and *Fritillaria sp.*), siphonophores, and barnacles.

In vertical-towed zooplankton samples, there were 24 categories of organisms identified in 20 zooplankton samples (Tables 5, 6 and 8). An average of 0.5102 m^3 of water was filtered per zooplankton tow. Larvaceans (*Oikopleura sp.* and *Fritillaria sp.*) were the most common occurring in 19 of 20 samples. More than 75% of sampled biomass comprised of larvaceans (*Oikopleura sp.* and *Fritillaria sp.*), cladocerans, siphonophores, and barnacles; this was similar to the oblique samples.

There were some station by station differences in zooplankton densities between oblique and vertical tows (not shown), but on average (across all tows) the percent of zooplankton densities were generally similar between the two methods (Figure 7). Given the issues with winch speed (i.e., too slow for vertical tows), the zooplankton estimates from the vertical tows were not deemed as reliable as the oblique tows; therefore, further comparisons were not completed.

CTD

Two CTD casts were performed at each transect location before plankton sampling. The CTD provided a range of data for temperature (^{o}C), salinity (ppt), dissolved oxygen (%) and depth (m). Generally, oxygen and salinity show similar patterns as temperature with depth (Figure 8). CTD data collection has been variable throughout the survey time period; therefore, longer term data collection is required to make broader annual oceanographic observations.

CONCLUSIONS

Forty-two stations were sampled resulting in 20 different fish species recorded from purse seine sets. A total of 3,797 herring were measured and weighed creating a multimodal histogram clearly representing age-0+ juvenile herring. Twenty zooplankton oblique tows were performed with larvaceans (*Oikopleura sp.*and *Fritillaria sp.*) being the predominant organisms in numbers and cladocerans in biomass. Vertically-towed zooplankton samples were difficult to collect given winch speeds; therefore, future sampling will address this so comparisons with oblique tows can be made.

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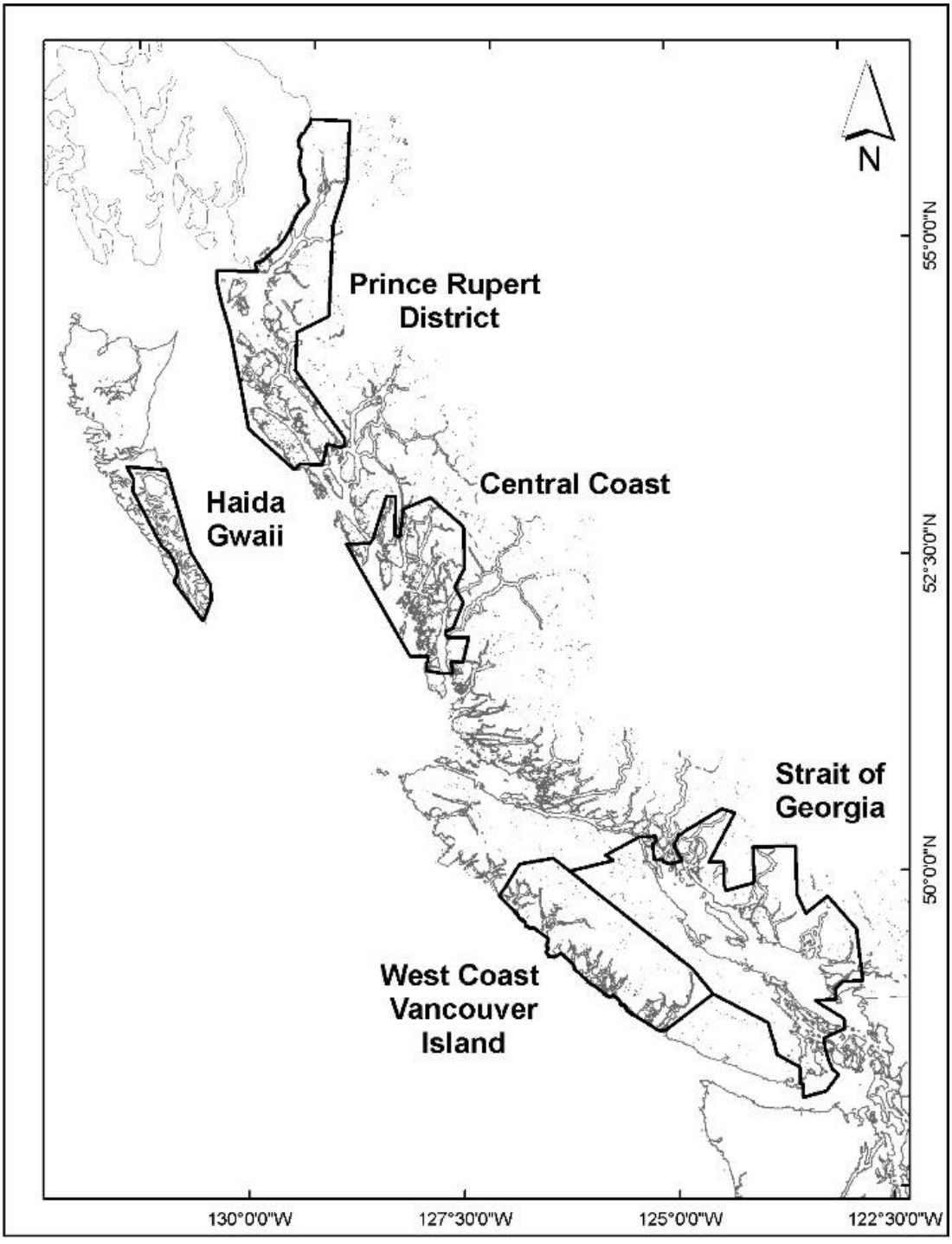


Figure 1. The five major British Columbia herring stock assessment areas.

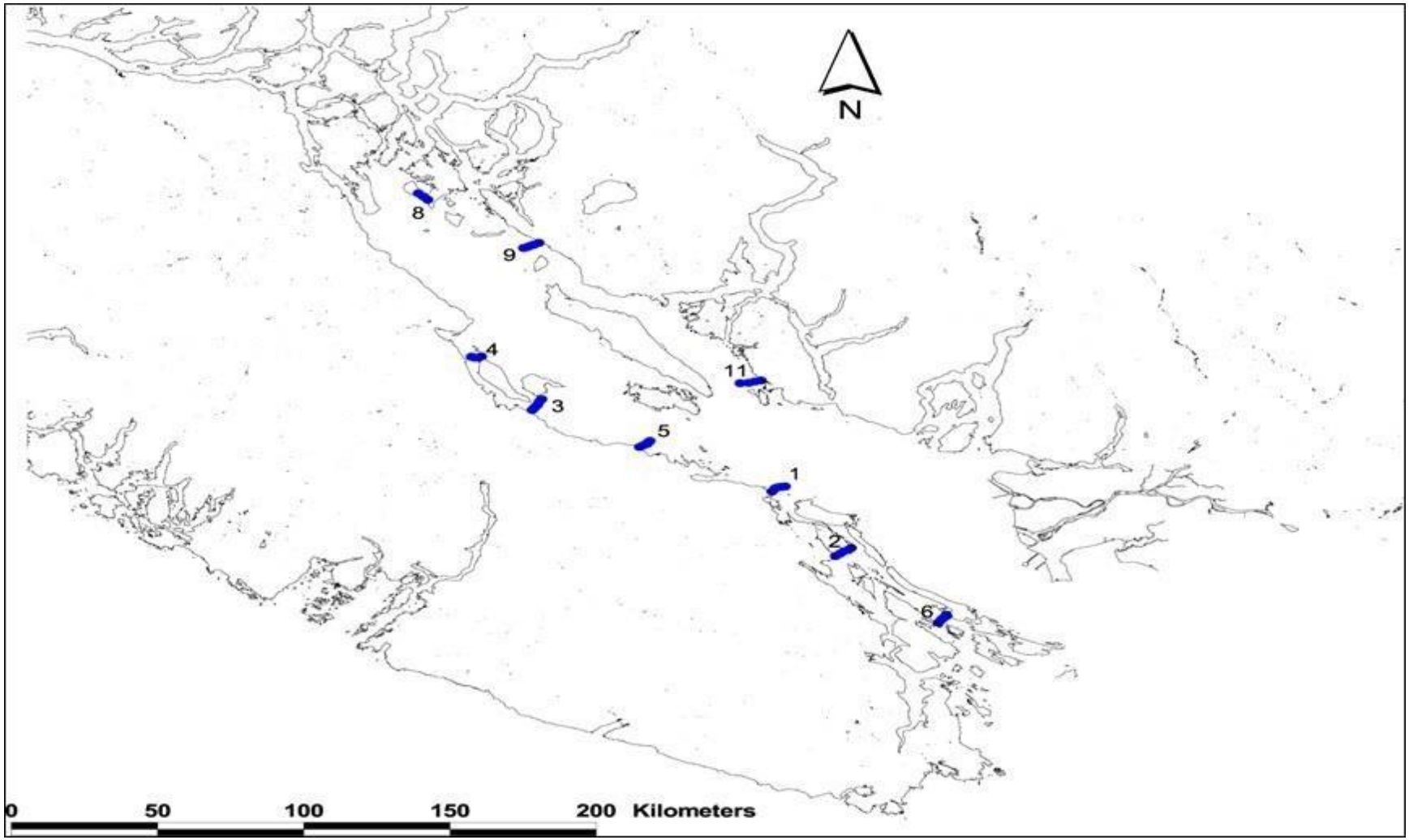


Figure 2. Purse seine set locations for the 2017 Strait of Georgia juvenile herring survey.

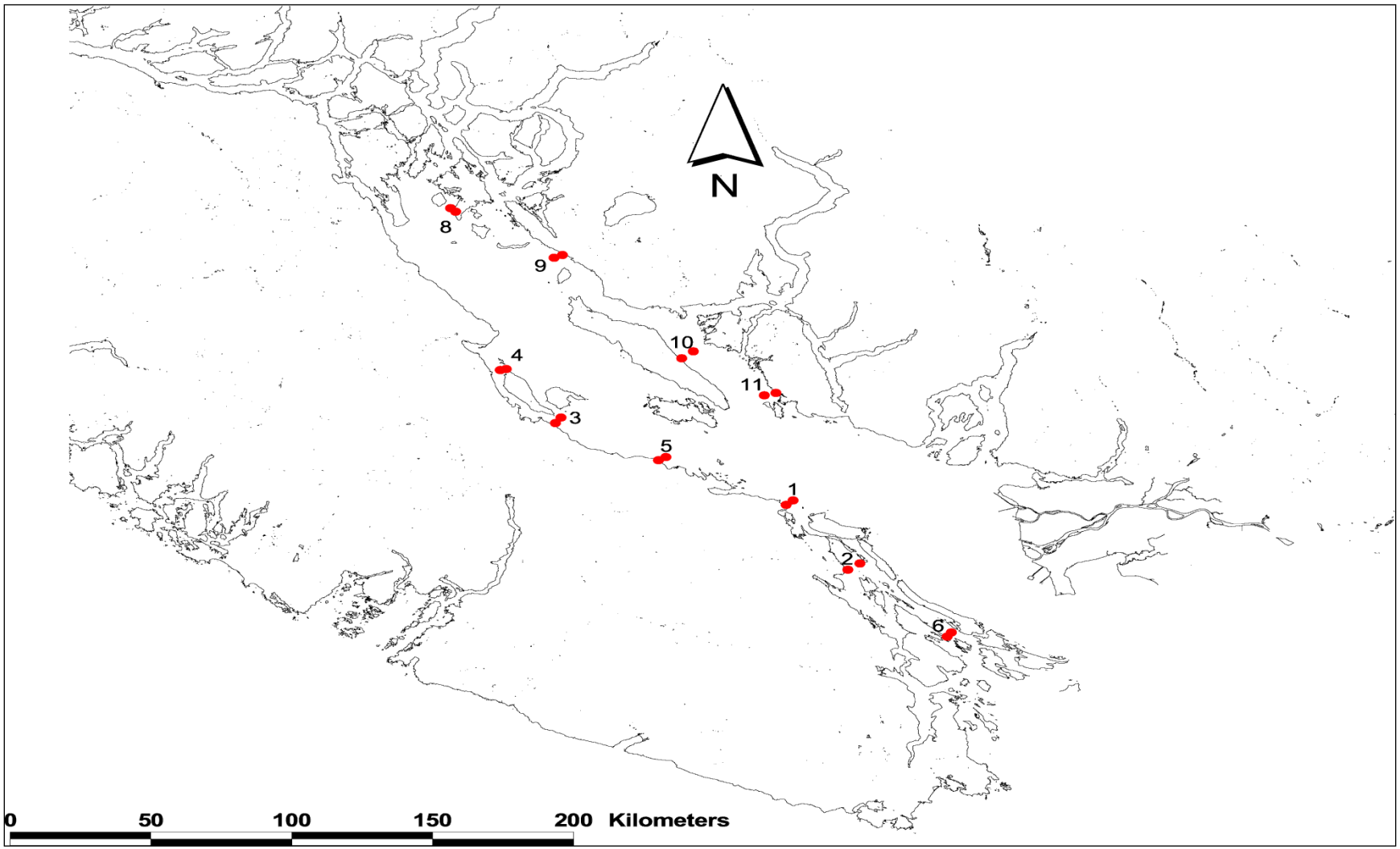


Figure 3. Zooplankton and CTD stations for 2017 Strait of Georgia juvenile herring survey.

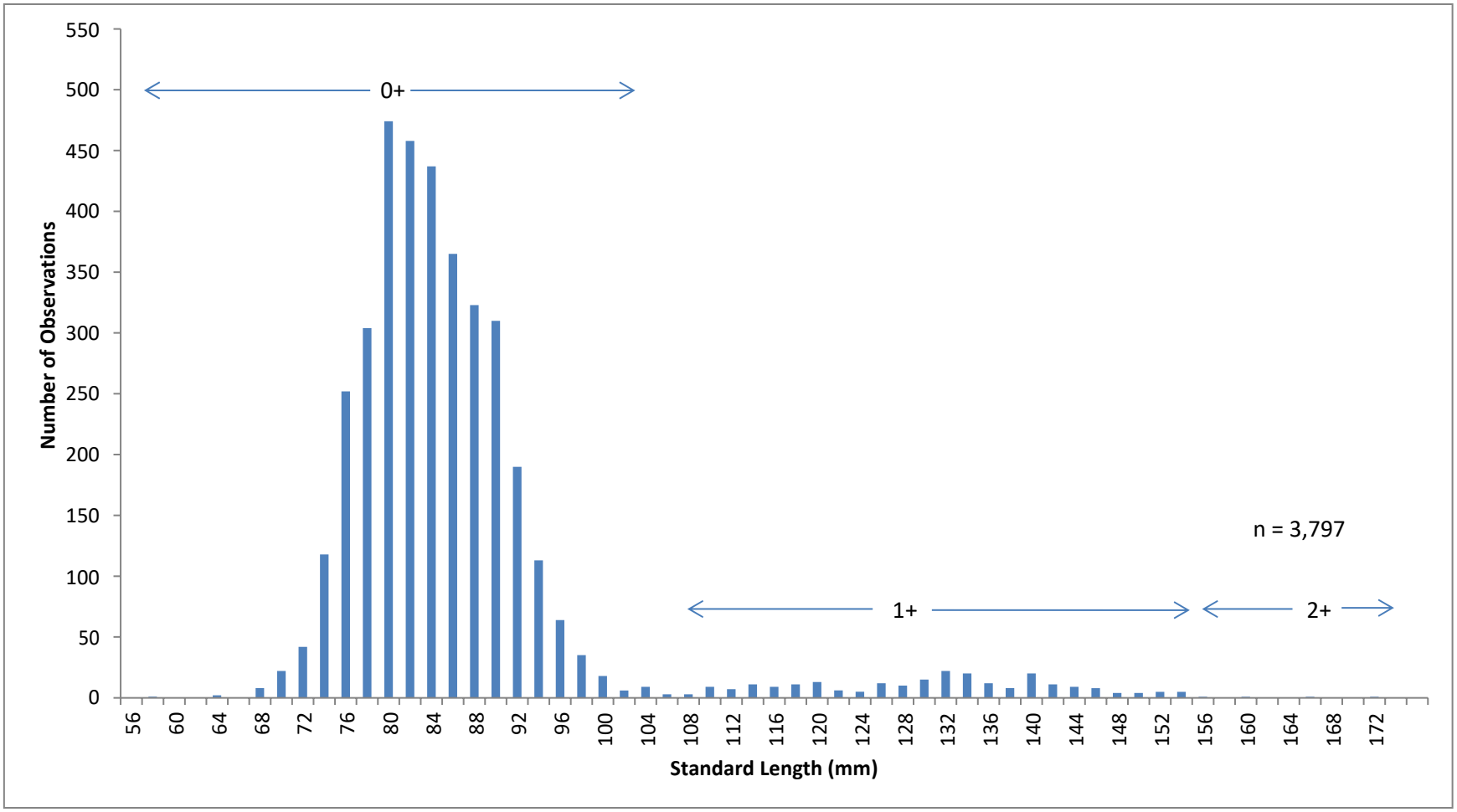
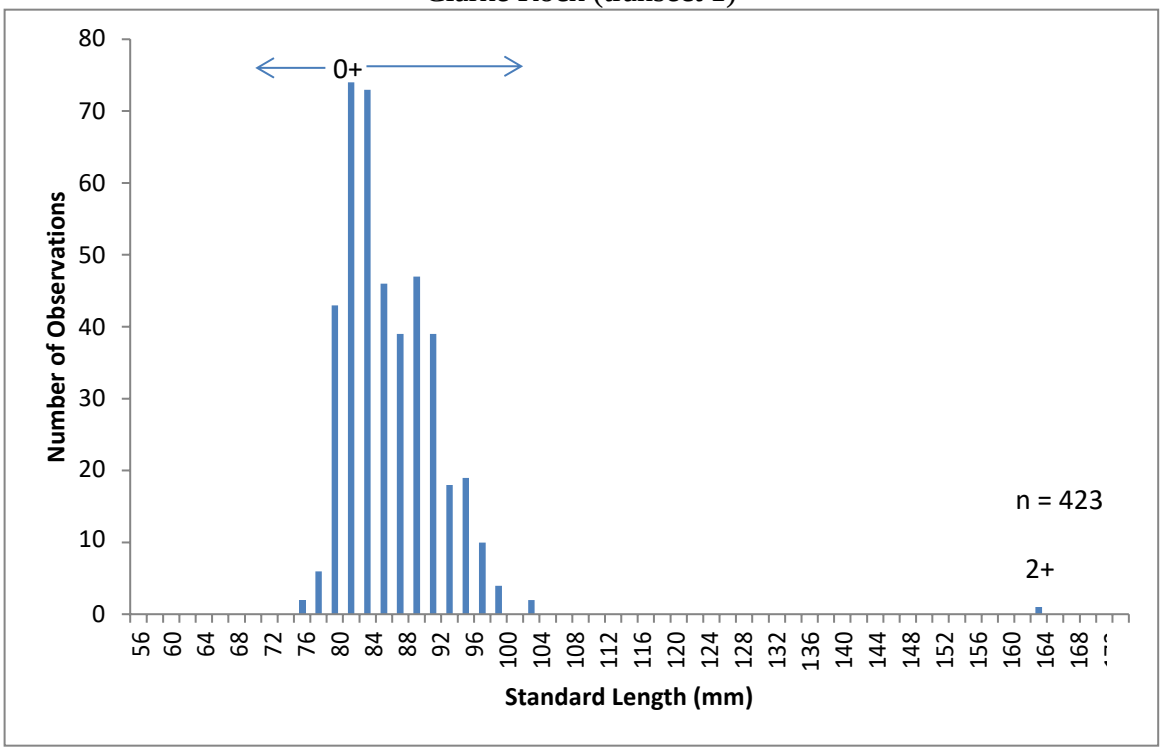


Figure 4. Length-frequency distribution for all herring sampled during the 2017 Strait of Georgia juvenile herring survey.

Clarke Rock (transect 1)



Yellow Point (transect 2)

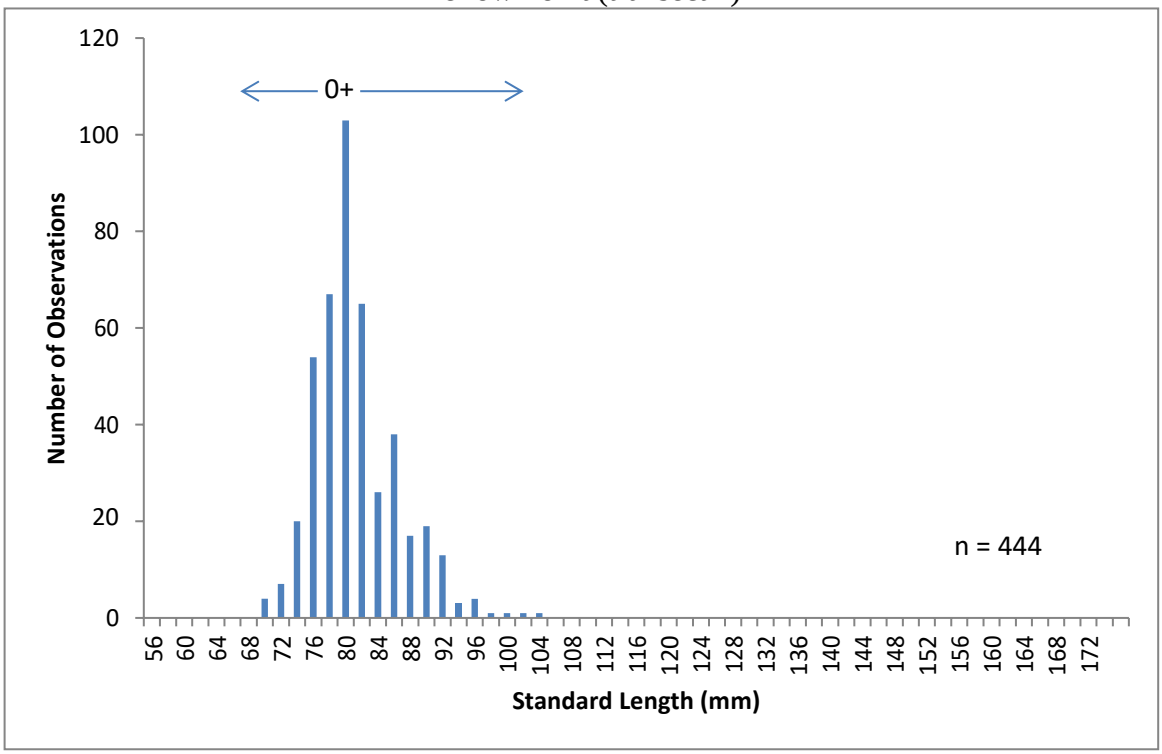
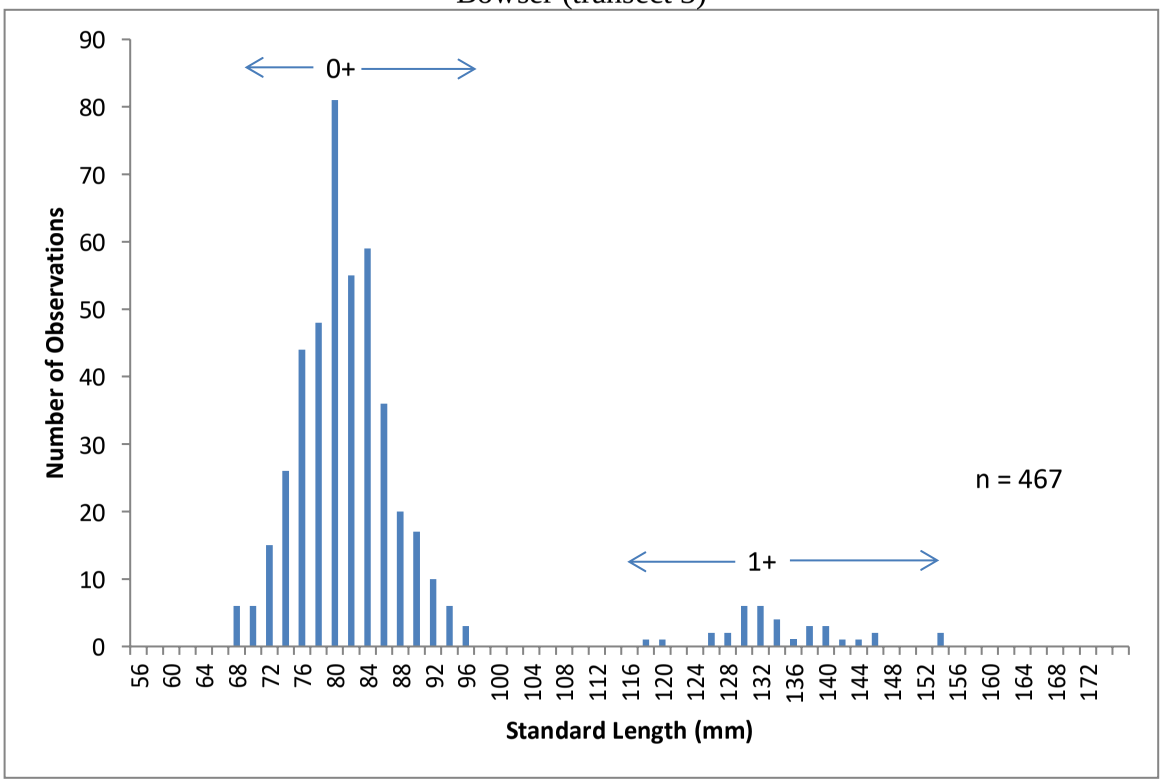


Figure 5. Length-frequency histograms of juvenile herring by transect location for the 2017 Strait of Georgia juvenile herring survey.

Bowser (transect 3)



Henry Bay (transect 4)

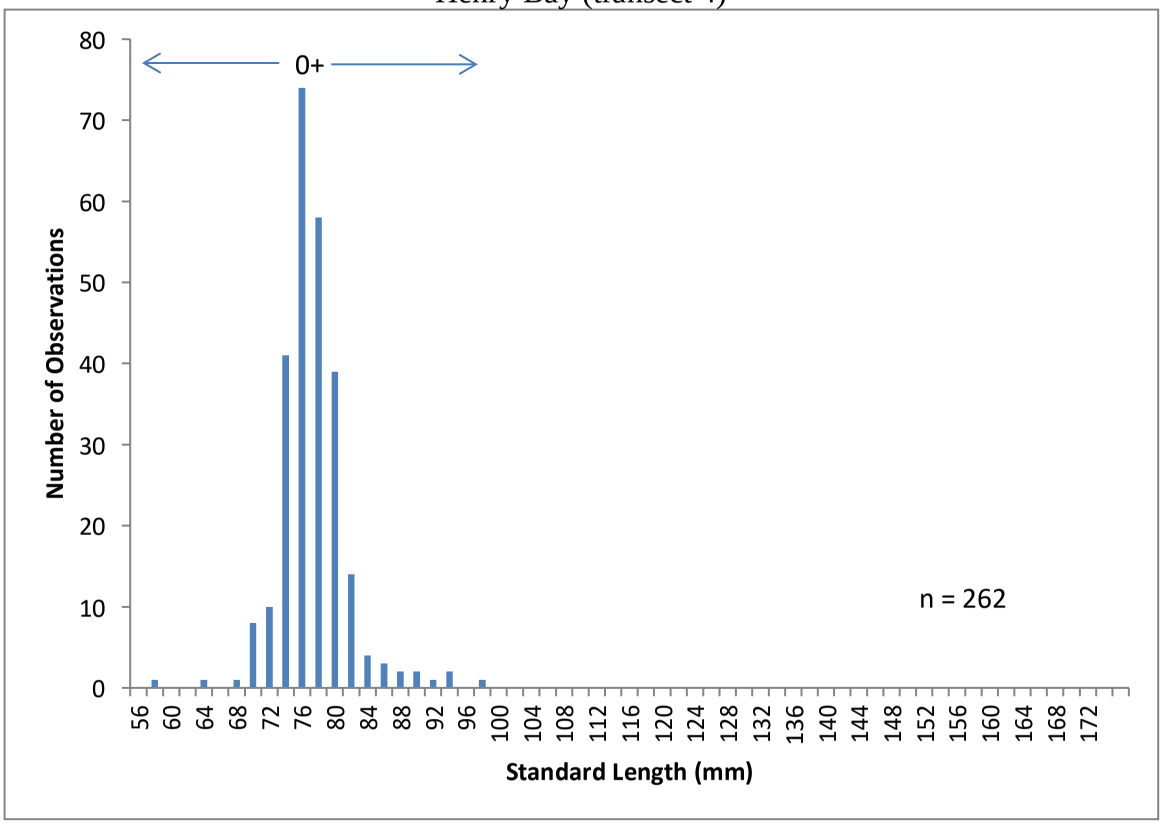
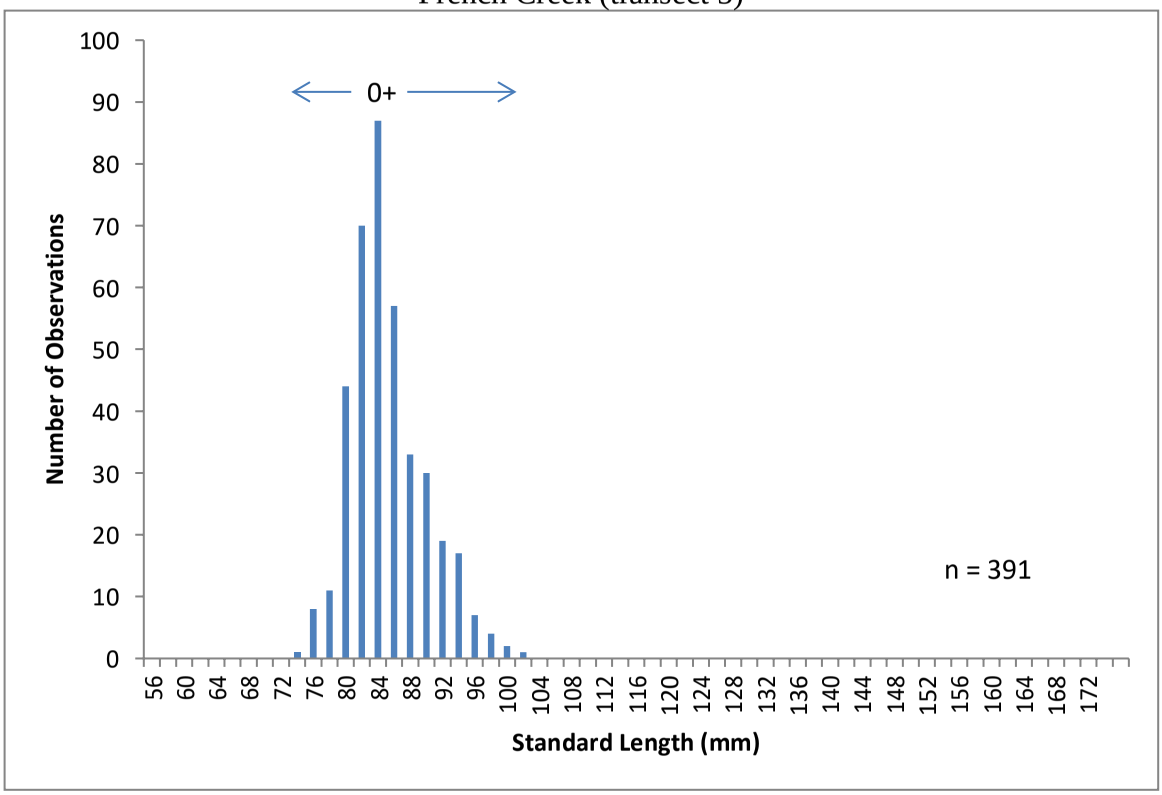


Figure 5 continued.

French Creek (transect 5)



Trincomali Channel (transect 6)

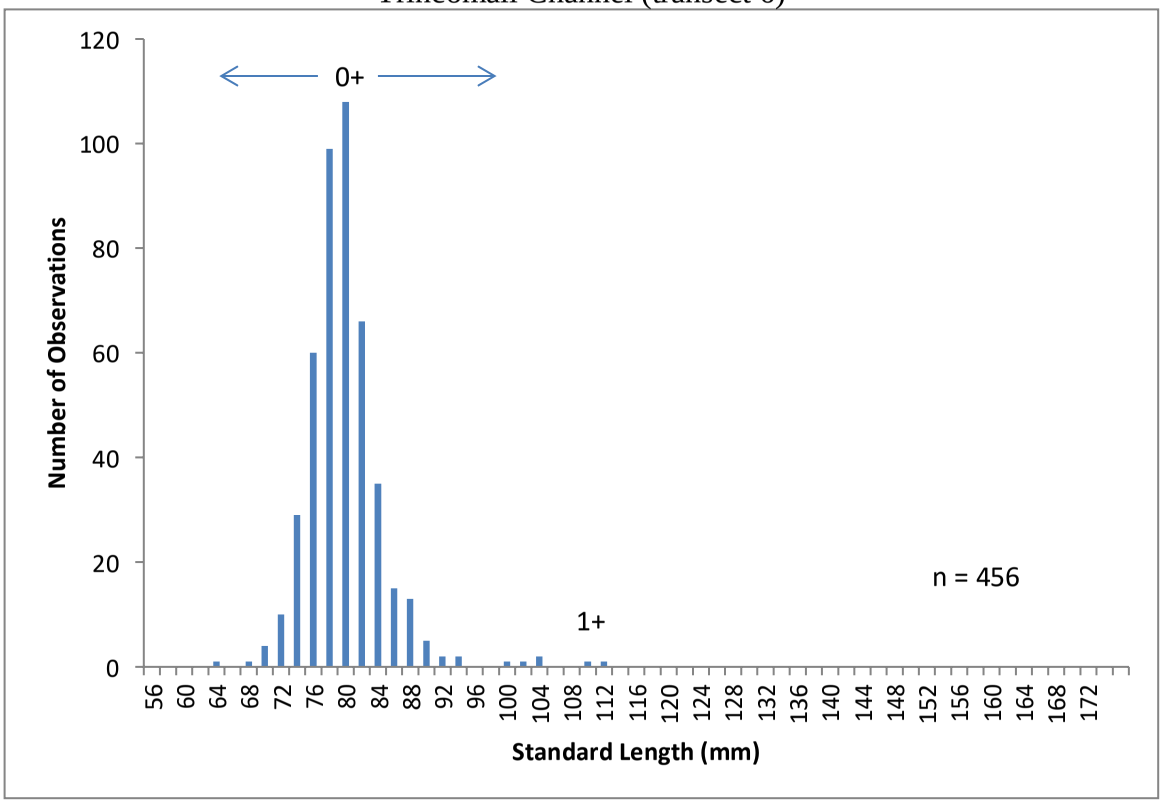
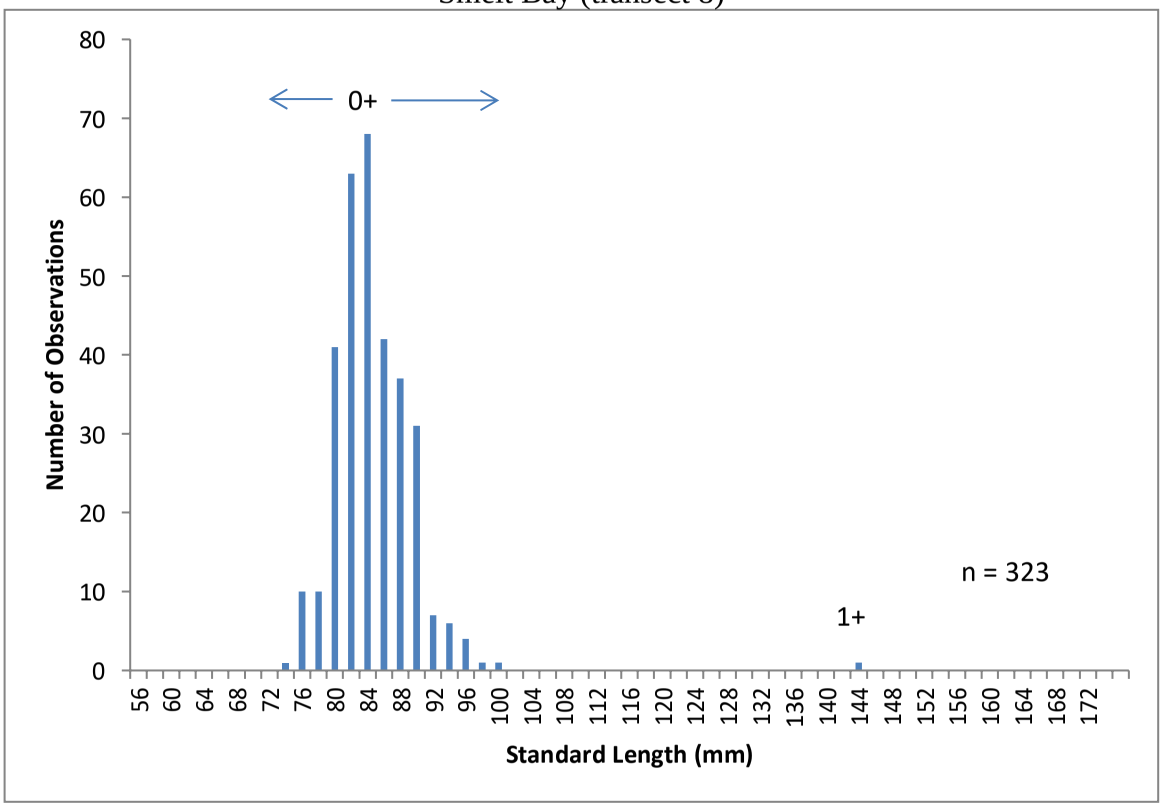


Figure 5 continued.

Smelt Bay (transect 8)



Atrevida Reef (transect 9)

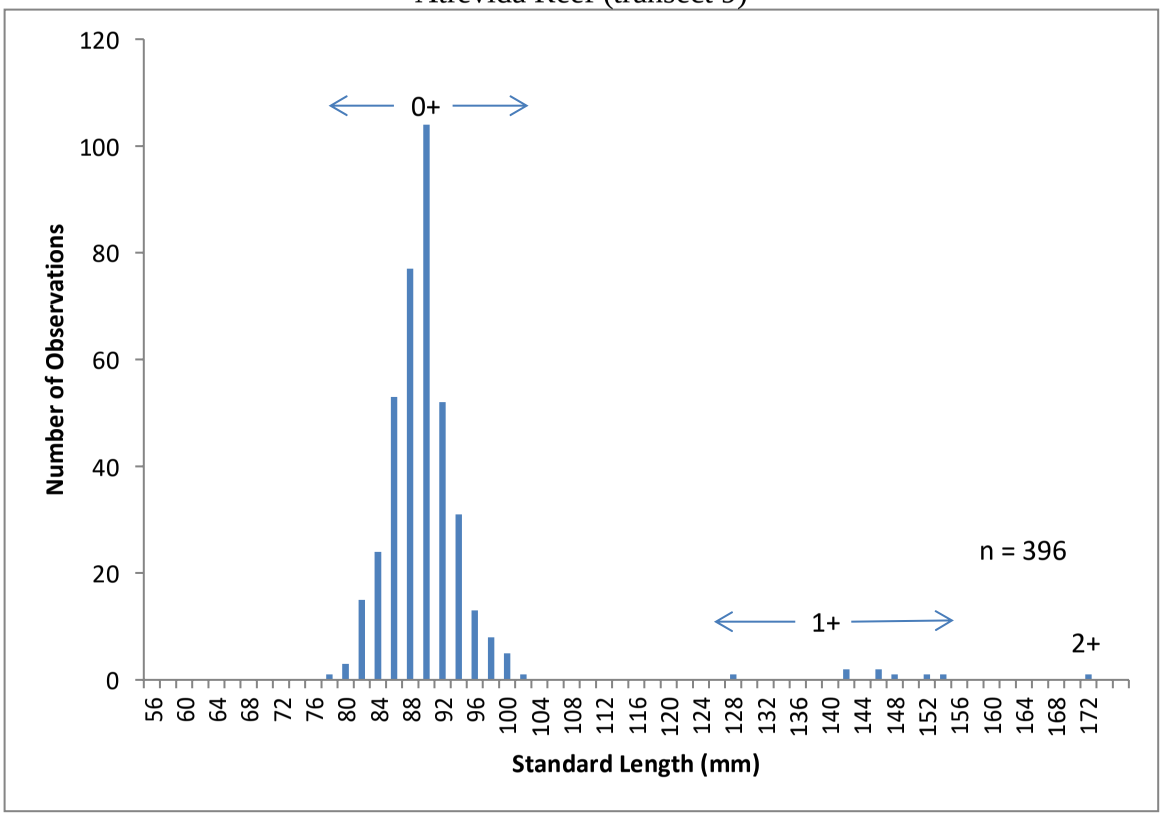


Figure 5 continued.

Secret Cove (transect 11)

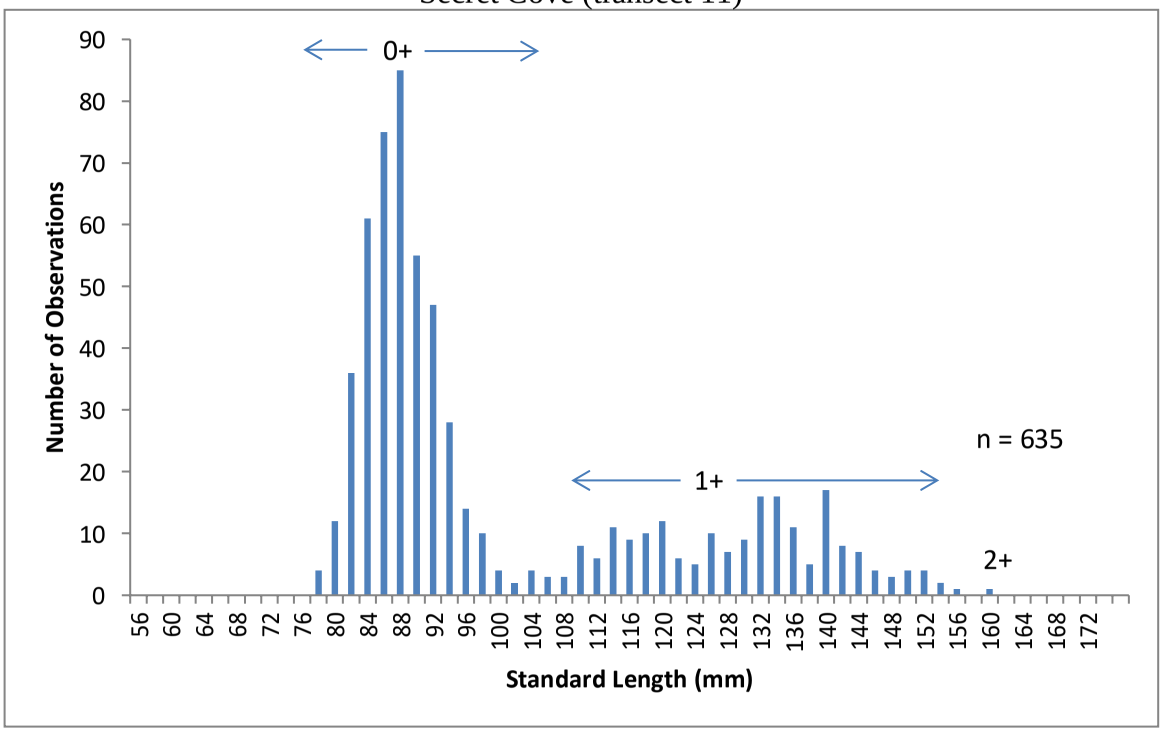


Figure 5 continued.

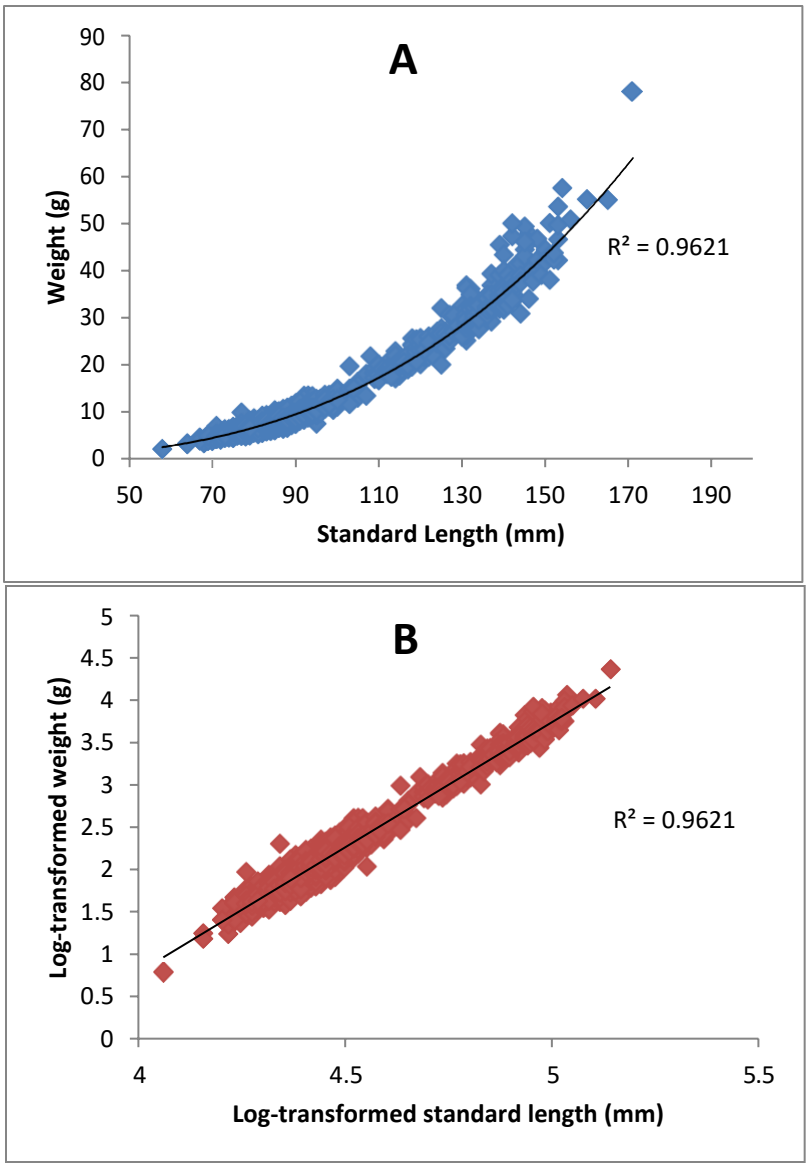


Figure 6. Non-transformed (A) and double log-transformed (B) length-weight relationships for all herring sampled during the 2017 Strait of Georgia juvenile herring survey.

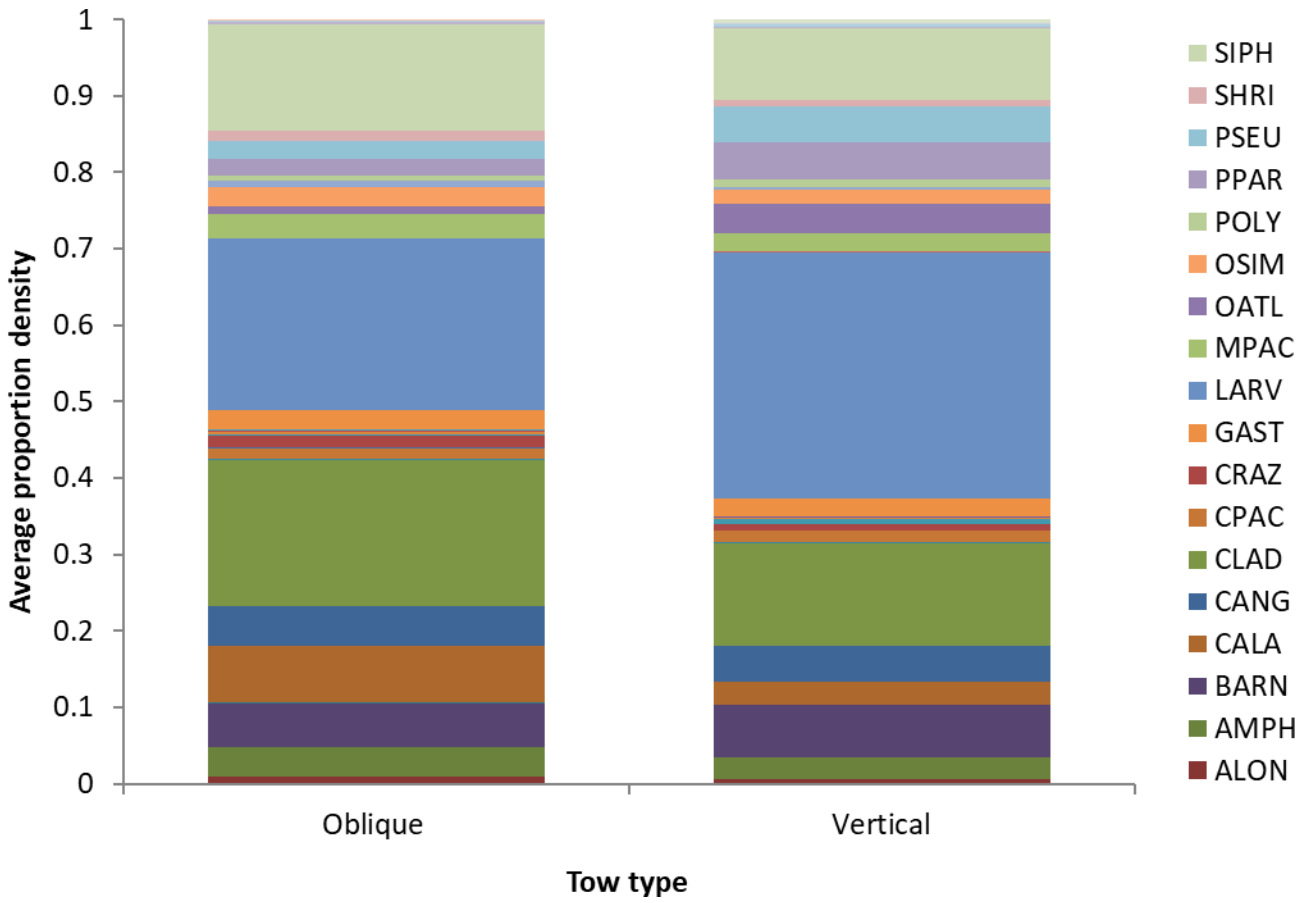


Figure 7. Average proportion zooplankton densities in oblique and vertical bongo tows from the 2017 Strait of Georgia juvenile herring survey. Only major zooplankton taxonomic groups are shown in the legend; see Tables 5 and 6 for acronym definitions.

Clarke Rock (transect 1)

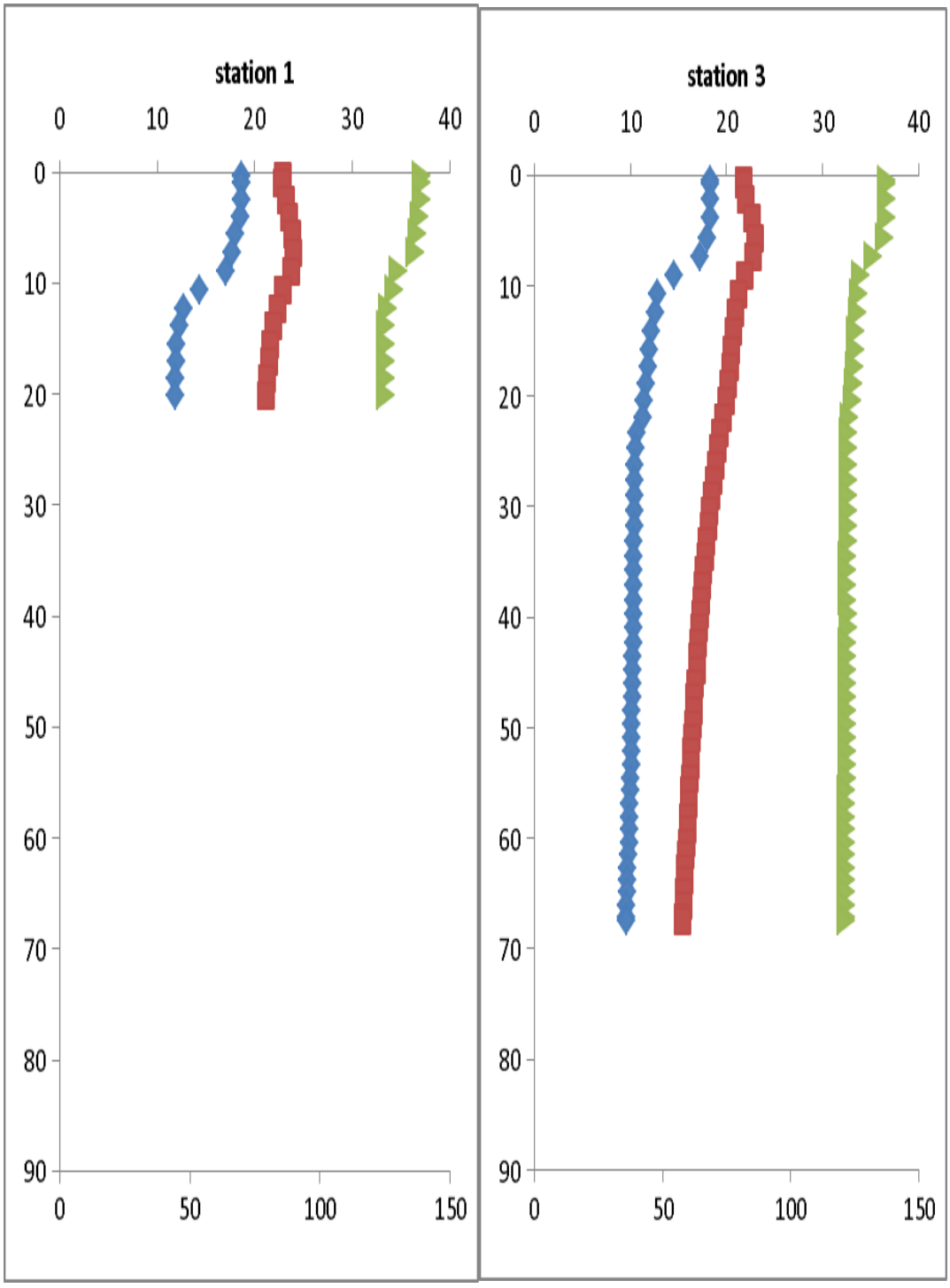


Figure 8. Temperature (°C, blue), salinity (mS/cm, green) and dissolved oxygen (%, red) y-axis profiles from CTD casts during the 2017 Strait of Georgia juvenile herring survey. Depth (m) y-axis.

Yellow Point (transect 2)

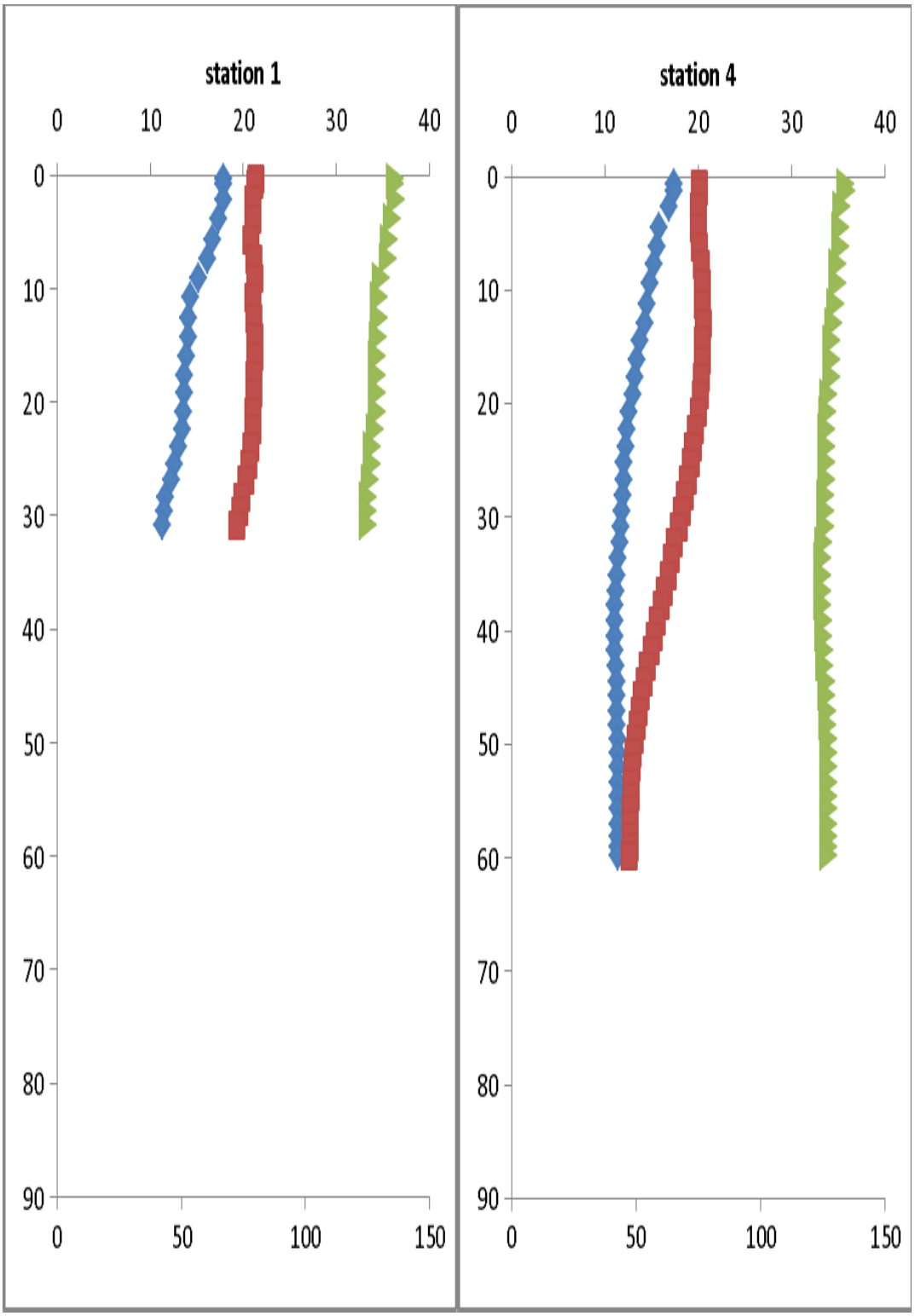


Figure 8 continued.

Bowser (transect 3)

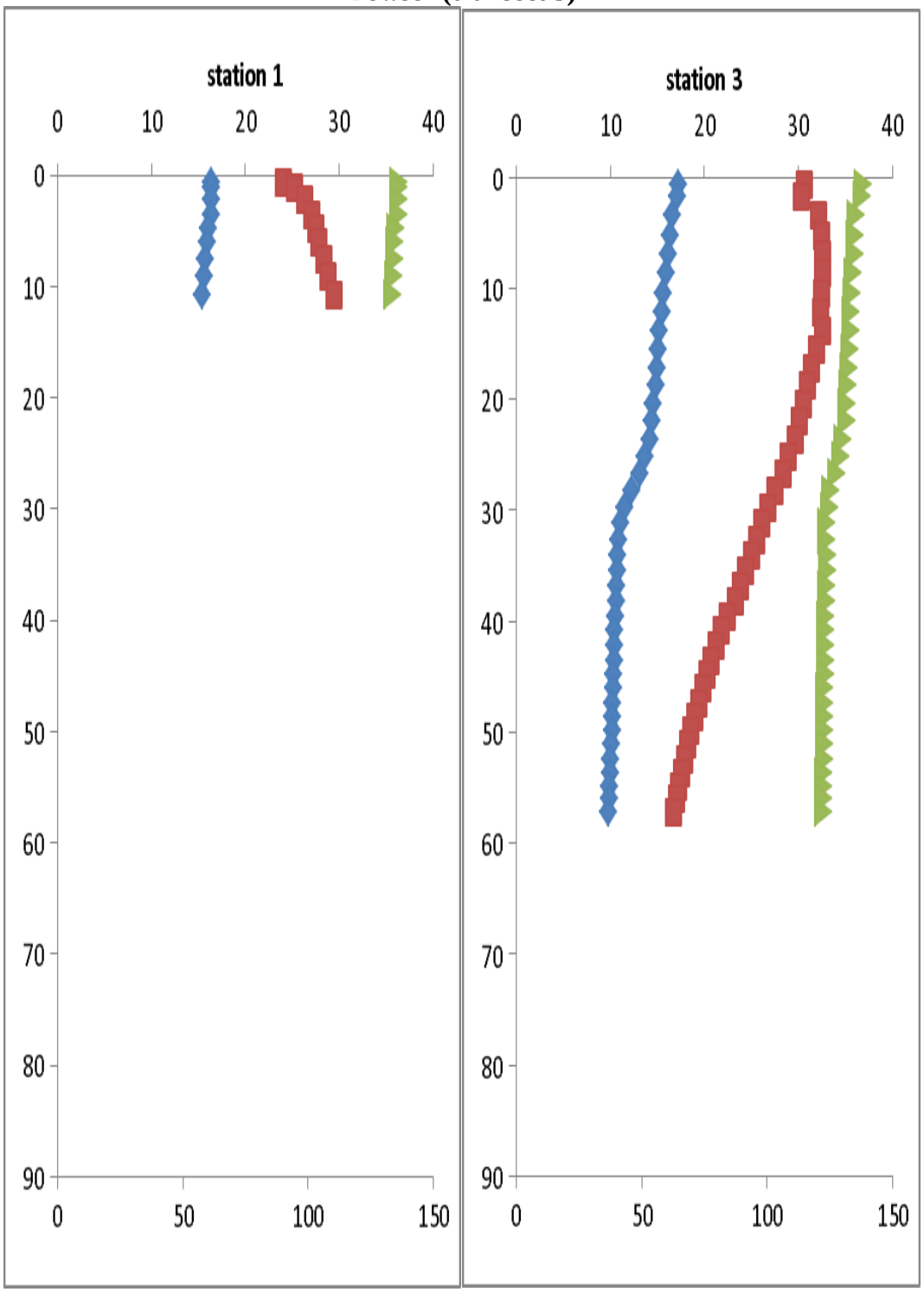


Figure 8 continued.

Henry Bay (transect 4)

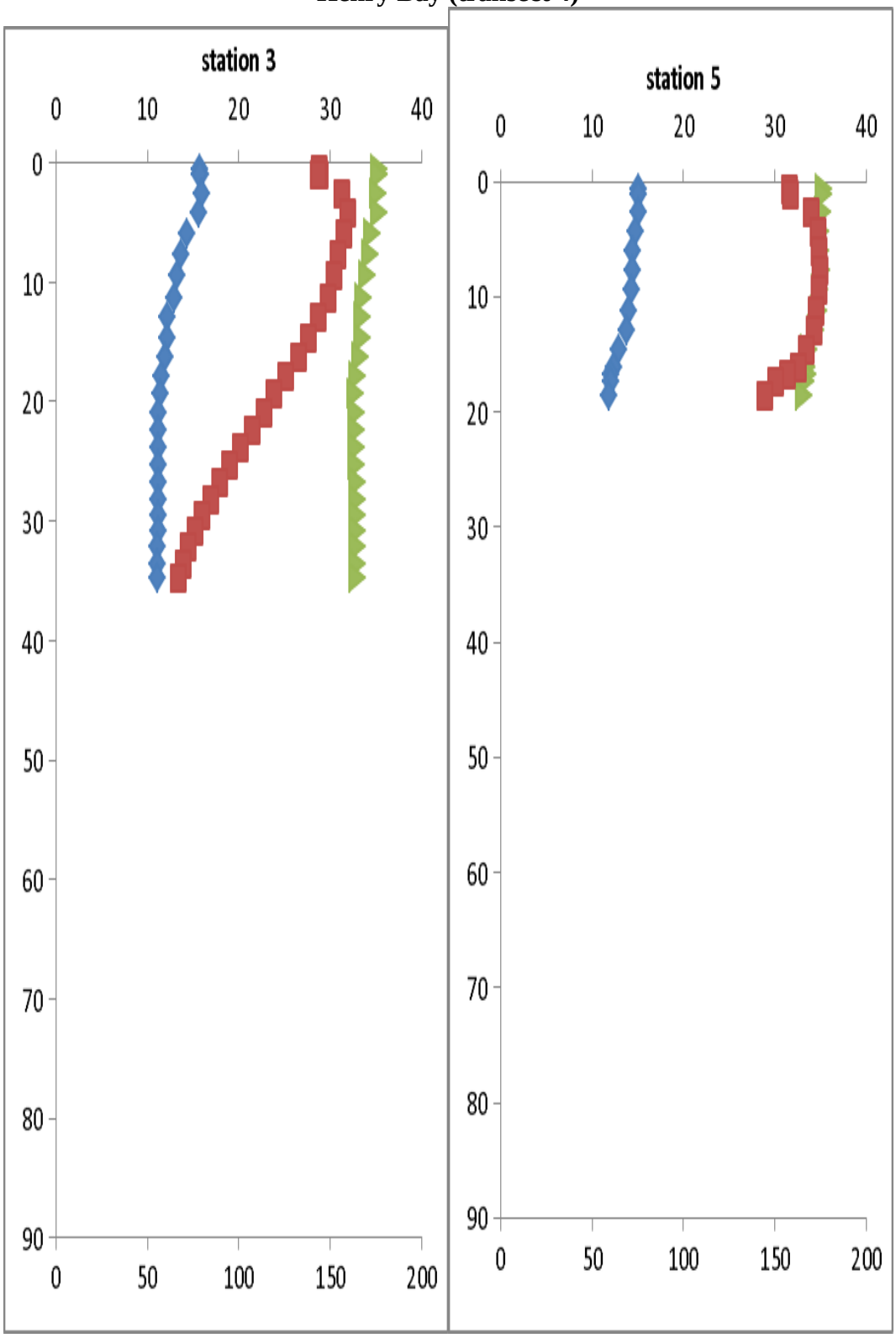


Figure 8 continued.

French Creek (transect 5)

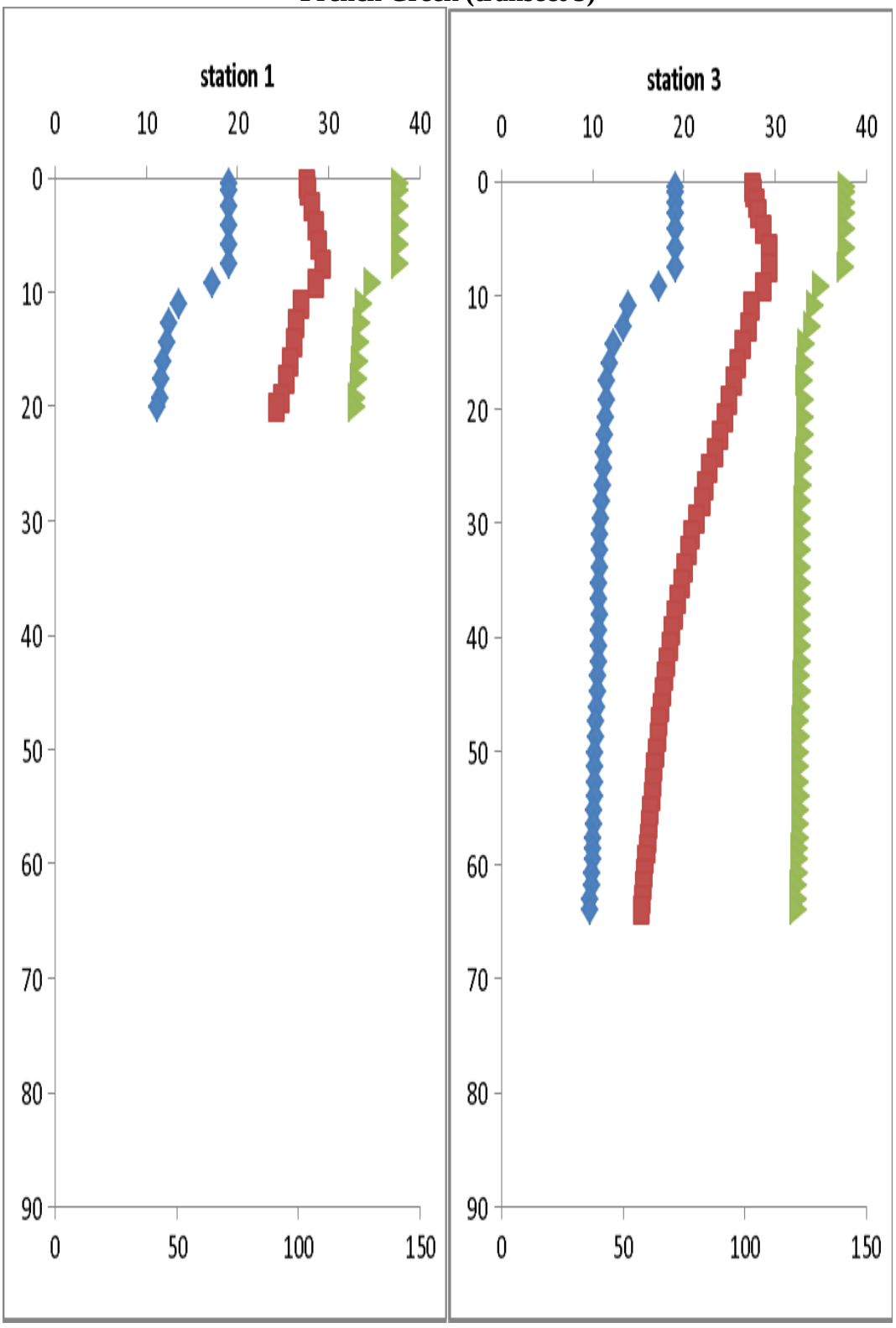


Figure 8 continued.

Trincomali Channel (station 6)

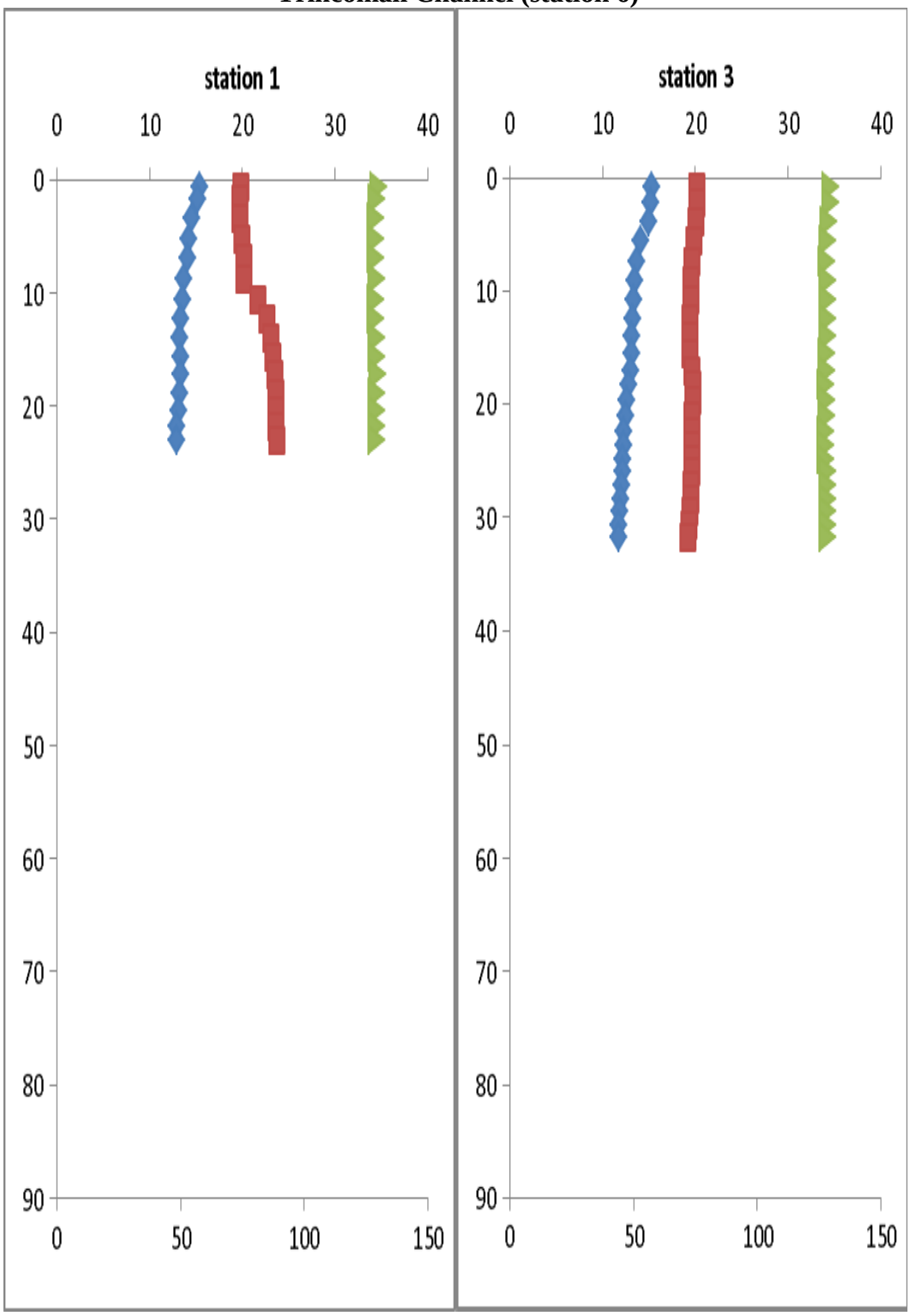


Figure 8 continued.

Smelt Bay (transect 8)

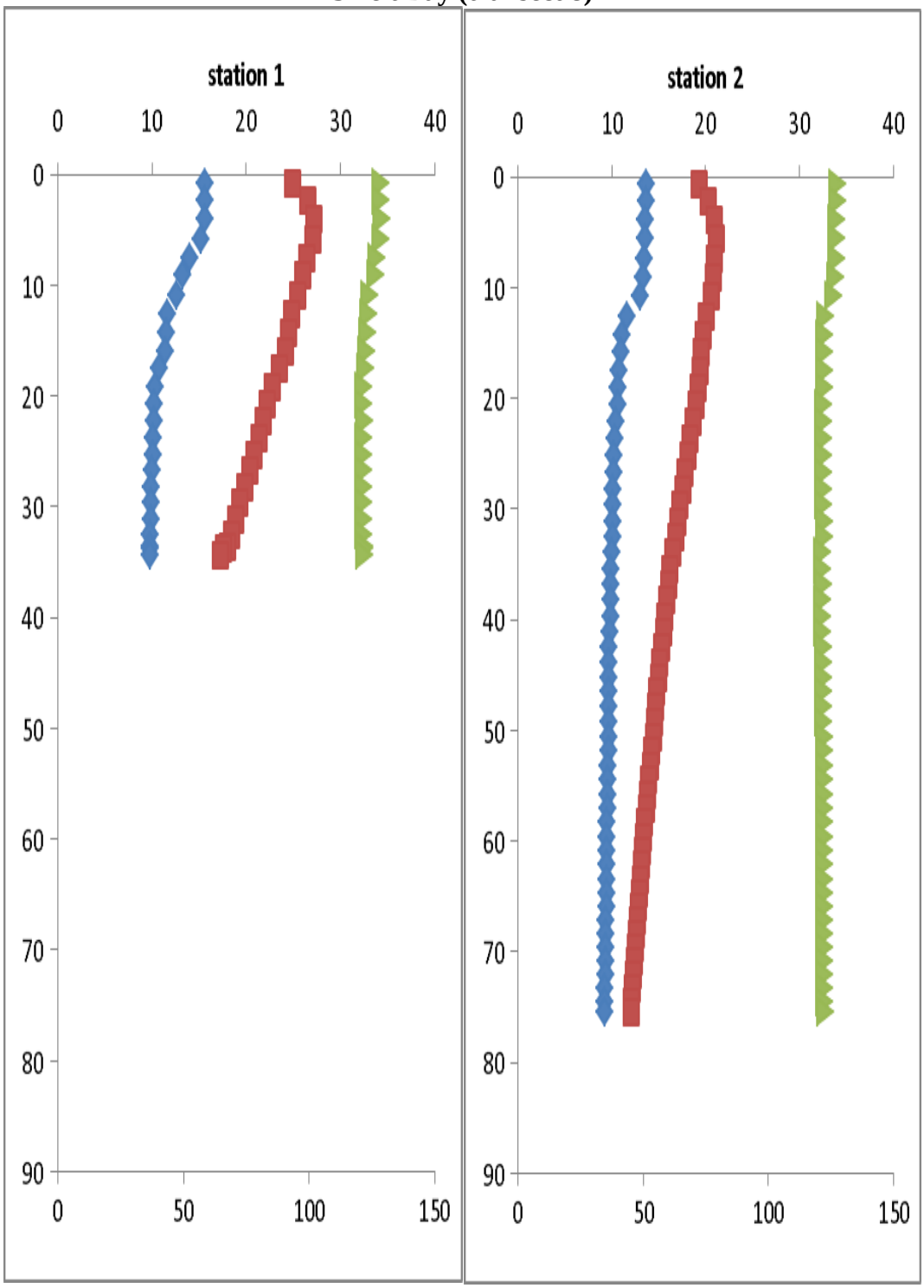


Figure 8 continued.

Atrevida Reef (transect 9)

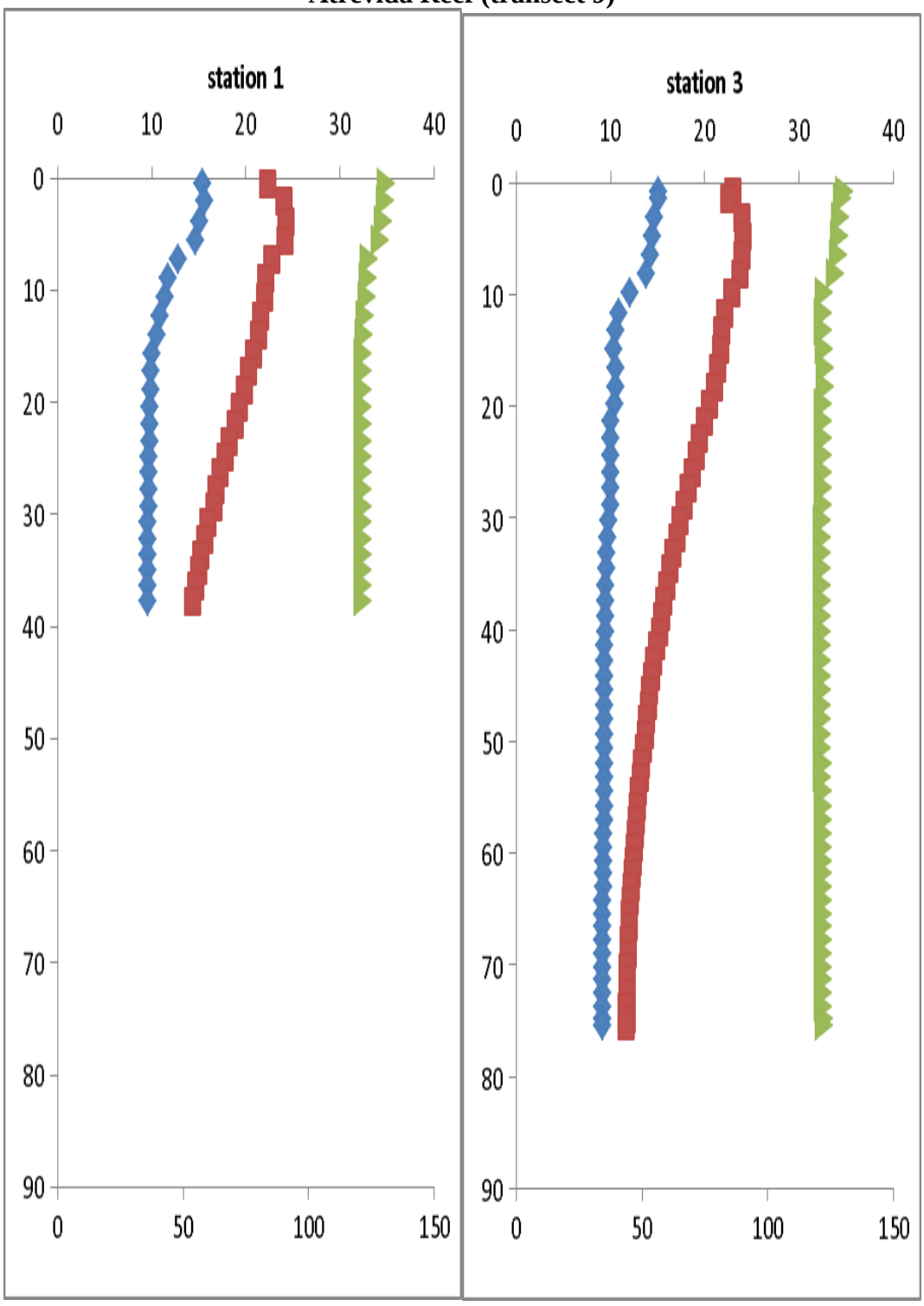


Figure 8 continued.

Cape Cockburn (transect 10)

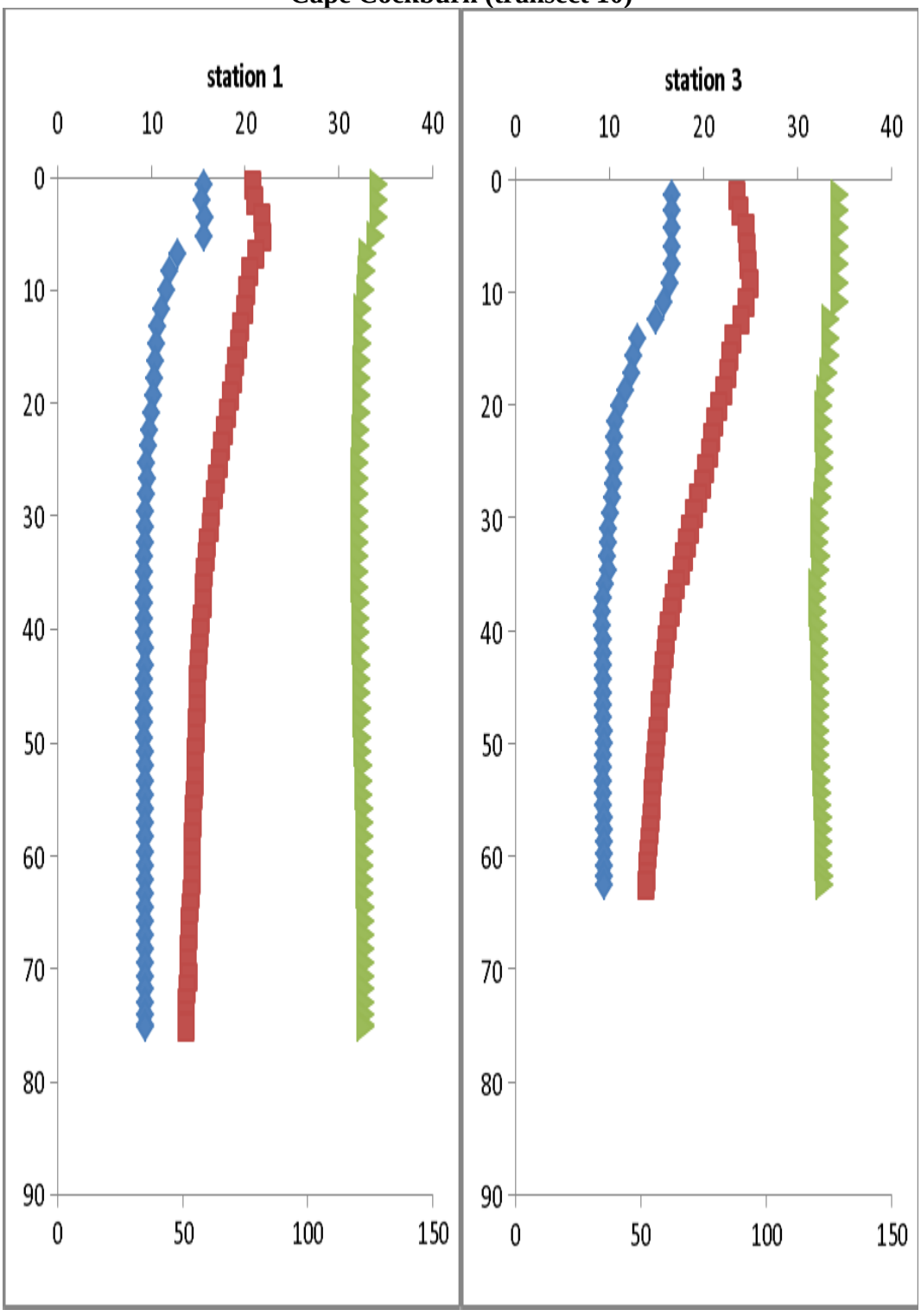


Figure 8 continued.

Secret Cove (transect 11)

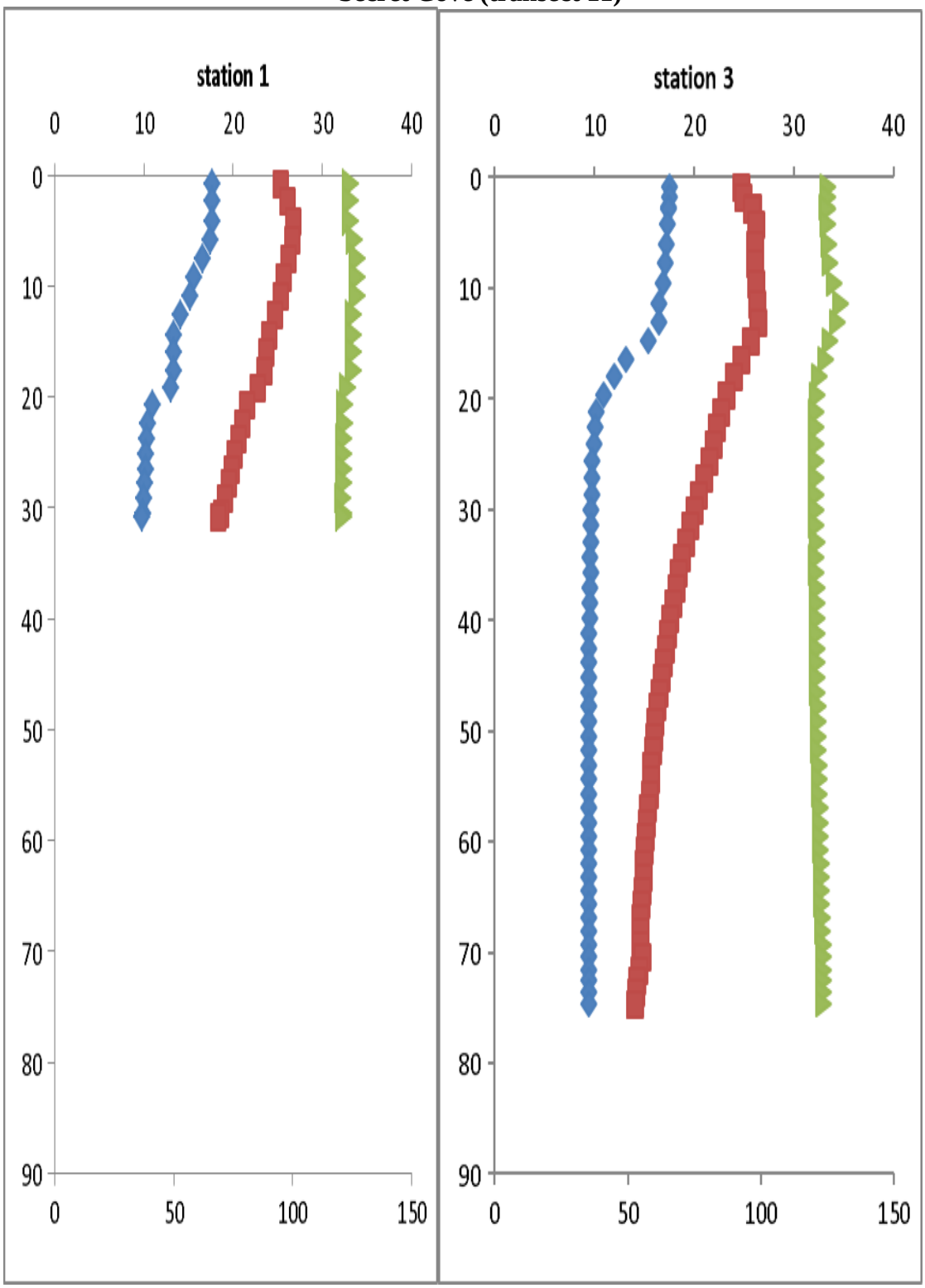


Table 1. Summary of the purse seine set locations from the 2017 Strait of Georgia juvenile herring survey. DD = decimal degrees.

Year	Month	Day	Transect	Station	Seine Set Time	Location Name	DD Lat (N)	DD Long (W)
2017	9	5	6	1	20:40	Trincomali Channel	48.855	-123.430
2017	9	5	6	2	21:10	Trincomali Channel	48.862	-123.423
2017	9	5	6	3	21:35	Trincomali Channel	48.867	-123.417
2017	9	5	6	4	22:00	Trincomali Channel	48.873	-123.407
2017	9	5	6	5	22:30	Trincomali Channel	48.877	-123.407
2017	9	6	2	5	20:35	Yellow Point	49.066	-123.698
2017	9	6	2	4	21:00	Yellow Point	49.060	-123.708
2017	9	6	2	3	21:20	Yellow Point	49.056	-123.722
2017	9	6	2	2	21:45	Yellow Point	49.050	-123.733
2017	9	6	2	1	22:10	Yellow Point	49.042	-123.747
2017	9	8	5	5	21:05	French Creek	49.366	-124.317
2017	9	8	5	4	21:30	French Creek	49.362	-124.323
2017	9	8	5	3	22:05	French Creek	49.358	-124.327
2017	9	8	5	2	22:25	French Creek	49.353	-124.338
2017	9	8	5	1	23:00	French Creek	49.348	-124.350
2017	9	11	11	1	20:40	Secret Cove	49.535	-123.977
2017	9	11	11	2	21:05	Secret Cove	49.532	-123.995
2017	9	11	11	3	21:35	Secret Cove	49.528	-124.014
2017	9	11	11	4	21:55	Secret Cove	49.527	-124.040
2017	9	11	11	5	22:25	Secret Cove	49.523	-124.060
2017	9	13	8	3	21:35	Smelt Bay	50.054	-125.030
2017	9	13	8	2	22:00	Smelt Bay	50.046	-125.016
2017	9	13	8	1	22:25	Smelt Bay	50.036	-125.000
2017	9	13	9	5	01:20	Atrevida Reef	49.902	-124.707
2017	9	13	9	4	01:45	Atrevida Reef	49.906	-124.694
2017	9	13	9	3	02:10	Atrevida Reef	49.909	-124.684
2017	9	13	9	2	02:35	Atrevida Reef	49.912	-124.673
2017	9	13	9	1	02:55	Atrevida Reef	49.916	-124.659
2017	9	14	4	5	20:30	Henry Bay	49.602	-124.836
2017	9	14	4	4	21:00	Henry Bay	49.598	-124.846
2017	9	14	4	3	21:25	Henry Bay	49.598	-124.856
2017	9	14	4	2	21:50	Henry Bay	49.601	-124.866
2017	9	14	4	1	22:20	Henry Bay	49.593	-124.875

Table 1 continued.

Year	Month	Day	Transect	Station	Seine Set Time	Location Name	DD Lat (N)	DD Long (W)
2017	9	15	3	1	20:30	Bowser	49.452	-124.680
2017	9	15	3	2	20:50	Bowser	49.459	-124.672
2017	9	15	3	3	21:10	Bowser	49.467	-124.663
2017	9	15	3	4	21:30	Bowser	49.476	-124.657
2017	9	15	3	5	21:50	Bowser	49.482	-124.651
2017	9	16	1	5	21:00	Clarke Rock	49.238	-123.902
2017	9	16	1	4	21:20	Clarke Rock	49.237	-123.912
2017	9	16	1	3	21:45	Clarke Rock	49.237	-123.922
2017	9	16	1	2	22:05	Clarke Rock	49.233	-123.932
2017	9	16	1	1	22:30	Clarke Rock	49.224	-123.943

Table 2. Summary of catch numbers and weights by species, transect, and station for the 2017 Strait of Georgia juvenile herring survey.

Transect	Station	Location Name	Species	Number	Weight (Kg)*
1	1	Clarke Rock	**Pacific herring age-0+**	5089	22.11
			Shiner perch	231	2.84
			Plainfin midshipman	49	0.45
			Walleye pollock, juvenile	35	0.20
			Shrimp	14	0.06
1	2	Clarke Rock	**Pacific herring age-0+**	2072	15.98
			Pacific herring age-1+	4	0.13
			Walleye pollock, juvenile	252	1.48
			Squid	4	trace
1	3	Clarke Rock	**Pacific herring age-0+**	1864	15.06
			Squid	228	0.34
			Walleye pollock, juvenile	4	0.03
1	4	Clarke Rock	**Pacific herring age-0+**	1715	15.59
			Northern anchovy	335	7.34
			Chinook salmon	10	0.74
			Pacific herring age-2+	5	0.28
1	5	Clarke Rock	**Pacific herring age-0+**	22	0.21
			Chinook salmon	5	0.38
2	1	Yellow Point	**Pacific herring age-0+**	44	0.27
			Chum salmon	6	0.26
			Northern anchovy	3	trace
			Plainfin midshipman	2	trace
			Squid	2	0.02
			Chinook salmon	2	0.09
			Crab	1	trace
			Tubesnout	1	trace
			Shiner perch	1	trace
2	2	Yellow Point	**Pacific herring age-0+**	384	2.74
			Squid	5	trace
			Chum salmon	3	0.22
			Northern anchovy	1	0.02

* weights <0.01 kg referred to as trace

Table 2 continued.

Transect	Station	Location Name	Species	Number	Weight (Kg)*
2	3	Yellow Point	**Pacific herring age-0+**	521	3.55
			Squid	3	0.01
			Plainfin midshipman	2	0.01
			Northern anchovy	1	0.02
			Chinook salmon	1	0.05
			Sculpin	1	0.06
2	4	Yellow Point	**Pacific herring age-0+**	316	2.14
			Northern anchovy	82	1.57
			Squid	46	0.16
			Chum salmon	2	0.12
2	5	Yellow Point	**Pacific herring age-0+**	677	4.27
			Squid	12	0.02
			Northern anchovy	1	trace
			Sculpin	1	0.04
			Chum salmon	1	0.05
3	1	Bowser	**Pacific herring age-0+**	32	0.22
			Plainfin midshipman	8	0.01
			Chum salmon	5	0.18
			Sculpin	5	0.27
			Chinook salmon	4	0.23
			Flatfish	4	0.47
			Shiner perch	3	0.05
			Pipefish	2	trace
			Squid	1	0.03
3	2	Bowser	**Pacific herring age-0+**	1600	11.92
			Pacific herring age-1+	12	0.49
			Northern anchovy	8	0.05
			Chinook salmon	8	1.54

Table 2 continued.

Transect	Station	Location Name	Species	Number	Weight (Kg)*
3	3	Bowser	**Pacific herring age-0+**	466	3.52
			Pacific herring age-1+	26	0.92
			Northern anchovy	22	0.09
			Walleye pollock, juvenile	20	0.14
			Three-spine stickleback	4	trace
			Squid	4	trace
			Chum salmon	2	0.06
			Plainfin midshipman	2	0.11
			Chinook salmon	2	0.30
3	4	Bowser	**Pacific herring age-0+**	2720	19.08
			Pacific herring age-1+	55	1.94
			Squid	20	0.01
			Northern anchovy	15	0.05
			Three-spine stickleback	5	trace
3	5	Bowser	**Pacific herring age-0+**	2961	19.42
			Pacific herring age-1+	56	1.73
			Northern anchovy	133	0.36
4	2	Henry Bay	**Pacific herring age-0+**	238	1.42
			Northern anchovy	276	0.45
			Walleye pollock, juvenile	120	0.40
			Plainfin midshipman	44	0.10
			Squid	4	trace
			Snake prickleback	4	0.01
			Pacific sand lance	2	0.01
			Shiner perch	2	0.01
4	3	Henry Bay	**Pacific herring age-0+**	155	1.03
			Northern anchovy	2200	16.44
			Walleye pollock, juvenile	95	0.33
			Squid	20	0.03
			Pacific sand lance	5	0.01
			Gunnel	5	0.03

Table 2 continued.

Transect	Station	Location Name	Species	Number	Weight (Kg)*
4	4	Henry Bay	**Pacific herring age-0+**	578	3.47
			Squid	16	0.02
			Gunnel	8	0.05
			Plainfin midshipman	6	0.15
			Spiny dogfish	2	0.30
4	5	Henry Bay	**Pacific herring age-0+**	12	0.10
			Walleye pollock, juvenile	28	0.12
			Shiner perch	26	0.16
			Plainfin midshipman	12	0.01
			Gunnel	11	0.07
			Squid	10	0.02
			Sculpin	4	0.26
			Northern anchovy	2	0.05
5	1	French Creek	**Pacific herring age-0+**	615	4.26
			Plainfin midshipman	52	0.31
			Shiner perch	33	0.22
			Squid	8	0.11
			Tubesnout	6	trace
			Three-spine stickleback	3	trace
			Chinook salmon	2	0.07
			Greenling	1	trace
			Flatfish	1	0.26
5	2	French Creek	**Pacific herring age-0+**	234	2.06
			Plainfin midshipman	69	1.75
			Squid	19	0.02
			Three-spine stickleback	4	trace
			Chinook salmon	4	0.40
			Northern anchovy	3	0.01
			Tubesnout	1	trace
			Walleye pollock, juvenile	1	0.01
			Hake, juvenile	1	0.04

Table 2 continued.

Transect	Station	Location Name	Species	Number	Weight (Kg)*
5	3	French Creek	**Pacific herring age-0+**	82	0.69
			Squid	65	0.05
			Chinook salmon	7	1.39
			Plainfin midshipman	6	0.38
			Three-spine stickleback	4	trace
			Greenling	1	0.00
			Northern anchovy	1	0.02
5	4	French Creek	**Pacific herring age-0+**	106	0.92
			Chinook salmon	21	5.00
			Tubesnout	1	trace
5	5	French Creek	**Pacific herring age-0+**	3	0.03
			Chum salmon	1	0.11
6	1	Trincomali Channel	**Pacific herring age-0+**	450	2.91
			Pacific herring age-1+	2	0.04
			Chum salmon	1	0.03
6	2	Trincomali Channel	**Pacific herring age-0+**	140	0.87
			Chum salmon	2	0.07
6	3	Trincomali Channel	**Pacific herring age-0+**	574	3.79
			Squid	7	0.01
			Chum salmon	1	0.05
6	4	Trincomali Channel	**Pacific herring age-0+**	52	0.32
			Three-spine stickleback	1	trace
			Chum salmon	1	0.09
6	5	Trincomali Channel	**Pacific herring age-0+**	247	1.73
			Chum salmon	5	0.23
			Squid	3	0.05
			Northern anchovy	2	0.03
			Three-spine stickleback	1	0.00
			Pacific sand lance	1	trace

Table 2 continued.

Transect	Station	Location Name	Species	Number	Weight (Kg)*
8	1	Smelt Bay	**Pacific herring age-0+**	342	2.77
			Northern anchovy	11	0.06
			Three-spine stickleback	3	trace
			Squid	3	0.02
			Plainfin midshipman	1	0.01
			Pacific herring age-1+	1	0.04
			Chum salmon	1	0.05
8	2	Smelt Bay	**Pacific herring age-0+**	610	4.99
			Northern anchovy	4390	16.19
			Three-spine stickleback	5	trace
			Walleye pollock, juvenile	5	0.02
8	3	Smelt Bay	**Pacific herring age-0+**	572	4.53
			Northern anchovy	142	0.54
			Pacific sand lance	4	0.01
			Chinook salmon	4	0.32
9	1	Atrevida Reef	**Pacific herring age-0+**	1285	12.31
			Pacific herring age-1+	15	0.62
			Northern anchovy	35	0.03
			Squid	20	0.01
			Three-spine stickleback	10	trace
			Tubesnout	5	trace
			Chum salmon	5	0.31
9	2	Atrevida Reef	**Pacific herring age-0+**	173	1.57
			Chum salmon	2	0.13
			Pacific herring age-1+	1	0.05
			Chinook salmon	1	0.14
9	3	Atrevida Reef	**Pacific herring age-0+**	65	0.63
			Pacific herring age-1+	3	0.15
			Chum salmon	8	0.71
			Chinook salmon	3	0.31
			Three-spine stickleback	2	trace
			Pacific herring age-2+	1	0.08

Table 2 continued.

Transect	Station	Location Name	Species	Number	Weight (Kg)*
9	4	Atrevida Reef	**Pacific herring age-0+**	48	0.47
			Chum salmon	6	0.32
			Pacific sand lance	2	0.01
			Shrimp	1	trace
			Chinook salmon	1	0.20
9	5	Atrevida Reef	**Pacific herring age-0+**	74	0.70
			Chinook salmon	2	0.09
			Gunnel	1	trace
			Pacific herring age-1+	1	0.05
			Chum salmon	1	0.12
11	1	Secret Cove	**Pacific herring age-0+**	117	0.95
			Chinook salmon	14	0.32
11	2	Secret Cove	**Pacific herring age-0+**	113	1.05
			Pacific herring age-1+	86	2.05
			Hake, juvenile	82	0.22
			Pipefish	3	0.00
			Chum salmon	3	0.04
			Chinook salmon	2	0.05
11	3	Secret Cove	**Pacific herring age-0+**	66	0.56
			Pacific herring age-1+	149	4.94
			Pacific herring age-2+	1	0.05
			Hake, juvenile	37	0.11
			Walleye pollock, juvenile	10	0.10
			Pipefish	2	trace
			Sockeye salmon	1	0.01
			Chum salmon	1	0.02
11	4	Secret Cove	**Pacific herring age-0+**	108	0.98
			Pacific herring age-1+	1	0.04
			Pacific herring age-2+	1	0.06
			Sockeye salmon	2	0.03
			Chinook salmon	2	0.11
			Chum salmon	1	0.07

Table 2 continued.

Transect	Station	Location Name	Species	Number	Weight (Kg)*
11	5	Secret Cove	**Pacific herring age-0+**	39	0.36
			Hake, juvenile	9	0.02
			Chinook salmon	2	0.04
			Chum salmon	2	0.16

Table 3. Percent occurrence by species in purse seine sets for the Strait of Georgia juvenile herring survey in 2017.

Common Name	Scientific Name	Number of sets	Percent Occurrence
Pacific herring age-0+	*Clupea pallasi* in year of birth	42	100.0
Pacific herring age-1+	*Clupea pallasi* in first year	14	33.3
Pacific herring age-2+	*Clupea pallasi* in second or more years	4	9.5
Bay pipefish	*Syngnathus griseolineatus*	3	7.1
Chinook salmon	*Oncorhyncus tshawytscha*	20	47.6
Chum salmon	*Oncorhyncus keta*	22	52.4
Crab	*unidentified species*	1	2.4
Flatfish	*Parophyrus vetulus, Lepidopsetta bilineata, Platichthys stellatus,*or *Citharichthys stigmaens*	2	4.8
Greenling	*Hexogrammos sp.*	2	4.8
Gunnel	*Apodichthys flavidus,* or *Pholis laeta*	4	9.5
Hake, juvenile	*Merluccius productus*	4	9.5
Northern anchovy	*Engraulis mordax mordax*	20	47.6
Pacific sand lance	*Ammodytes hexapterus*	5	11.9
Plainfin midshipman	*Porichthys notatus*	12	28.6
Sculpin	*Hemilepidotus hemilepidotus*	4	9.5
Shrimp	*unidentified species*	2	4.8
Snake prickleback	*Lumpenus sagitta*	1	2.4
Sockeye salmon	*Oncorhyncus nerka*	2	4.8
Spiny dogfish	*Squalus acanthias*	1	2.4
Squid	*Loligo opalescens,* or *Gonatus fabricii*	21	50.0
Surf perch	*Hyperprosopon ellipticum*	6	14.3
Three-spine stickleback	*Gasterosteus aculeatus*	11	26.2
Tube-snout	*Aulorhynchus flavidus*	5	11.9
Walleye pollock, juvenile	*Gadus chalcogrammus*	10	23.8

* Jellyfish occurrence is not included due to the large quantities usually encountered and the inability to correctly quantify.

Table 4. Summary of the number of herring sampled, range of standard lengths (mm), mean lengths, range of weights (g), mean weights, and standard deviations for three age classes sampled during the 2017 Strait of Georgia juvenile herring survey. Total catch in numbers (N) and weight (Wt) of all herring are shown for each transect.

Age-0+ Herring

			Length (mm)			Weight (g)				
Location Name	**Transect**	**Number Sampled**	**Range**	**Mean**	**SD**	**Range**	**Mean**	**SD**	**N**	**Wt (Kg)**
Clarke Rock	1	422	75-103	86	5.21	5.88-14.56	8.39	1.74	10762	68.95
Yellow Point	2	444	69-104	81	5.29	3.96-14.37	7.04	1.38	1942	12.97
Bowser	3	432	67-96	81	5.39	3.45-11.46	7.00	1.38	7779	54.16
Henry Bay	4	262	58-98	77	4.25	2.19-12.84	6.16	1.08	983	6.02
French Creek	5	391	74-101	85	4.78	5.35-15.03	8.28	1.67	1040	7.95
Trincomali	6	454	64-104	79	4.47	3.25-14.51	6.45	1.10	1463	9.62
Smelt Bay	8	322	73-99	84	4.25	5.08-12.34	8.11	1.24	1524	12.29
Atrevida Reef	9	387	78-101	89	3.78	6.83-13.75	9.51	1.21	1645	15.68
Secret Cove	11	443	78-108	88	5.09	5.73-21.87	8.82	1.70	443	3.91
All Locations		3557	58-108	83	6.09	2.19-21.87	7.78	1.77	27581	191.55

Age-1+ Herring

			Length (mm)			Weight (g)				
Location Name	**Transect**	**Number Sampled**	**Range**	**Mean**	**SD**	**Range**	**Mean**	**SD**	**N**	**Wt (Kg)**
Clarke Rock	1	-	-	-	-	-	-	-	-	-
Yellow Point	2	-	-	-	-	-	-	-	-	-
Bowser	3	35	118-153	134	7.85	21.27-47.82	34.74	6.31	149	5.08
Henry Bay	4	-	-	-	-	-	-	-	-	-
French Creek	5	-	-	-	-	-	-	-	-	-
Trincomali	6	2	109-112	111	2.12	17.04-18.06	17.55	0.72	2	0.04
Smelt Bay	8	1	144	144	-	41.53	41.53	-	1	0.04
Atrevida Reef	9	8	128-154	145	7.86	30.84-57.57	47.27	7.54	20	0.87
Secret Cove	11	190	109-153	129	11.55	16.81-53.63	28.61	7.34	236	7.03
All Locations		236	109-154	130	11.48	16.81-57.57	30.11	8.23	412	13.19

Table 4 continued.

Age-2+ Herring

			Length (mm)			Weight (g)				
Location Name	**Transect**	**Number Sampled**	**Range**	**Mean**	**SD**	**Range**	**Mean**	**SD**	**N**	**Wt (Kg)**
Clarke Rock	1	1	165	165	-	55.04	55.04	-	5	0.28
Yellow Point	2	-	-	-	-	-	-	-	-	-
Bowser	3	-	-	-	-	-	-	-	-	-
Henry Bay	4	-	-	-	-	-	-	-	-	-
French Creek	5	-	-	-	-	-	-	-	-	-
Trincomali	6	-	-	-	-	-	-	-	-	-
Smelt Bay	8	-	-	-	-	-	-	-	-	-
Atrevida Reef	9	1	171	171	-	78.09	78.09	-	1	0.08
Secret Cove	11	2	156-160	158	2.83	50.86-55.18	53.02	3.05	2	0.11
All Locations		4	156-171	163	6.48	50.86-78.09	59.79	12.36	8	0.46

Table 5. Organisms by phylum, and with abbreviations, observed in zooplankton samples collected during the 2017 Strait of Georgia juvenile herring survey.

Coelenterata	
COEL	Medusae - *Aequorea victoria*
SIPH	Siphonophores
Ctenophora	
CTEN	Ctenophores
Annelida	
POLY	Polychaetes
Mollusca	
GAST	Prosobranch gastropods
PELE	Pelecypods
Arthropoda	
AMPH	Amphipods
BARN	Barnacle, unknown stage
CLAD	Cladocerans; *Podon sp.* and *Evadne sp.*
CNAU	Unidentified copepod nauplii
COPE	Copepods (see Table 6 for list of species)
CRAM	Crab megalopea, including porcillinadea
CRAZ	Crab zoea, including porcillinadea
EUPA	Adult euphausiids; mainly *Euphausia pacifica*
EUPL	Larval euphausiids; mainly *Euphausia pacifica*
OSTR	Ostracods
SEAL	*Caligus sp.*
SHRI	Shrimp zoea
TRAS	*Thysanoessa raschii*
TSPI	*Thysanoessa spinifera*
Chaetognatha	
CHAE	Chaetognaths; mainly *Sagitta sp.*
Chordata	
LARV	Larvaceans; mainly *Oikopleura sp.* and some *Fritillaria sp.*
TELA	Teleosts (fish larvae)
Echinoderm	
ECHI	Echinoderms
Ectoproct	
ECTO	Ectoprocts
Rotifera	
ROTI	Rotifers
Miscellaneous	
EGGS	Unidentified eggs; either euphausiid or teleost

Table 6. Abbreviations for calanoid and cyclopoid copepods identified in the 2017 zooplankton samples from the Strait of Georgia juvenile herring survey.

Calanoid copepods	
ADIV	*Aetidius divergens*
ALON	*Acartia longiremis*
CABD	*Centropages abdominates*
CALA	*Calanus sp.*
CPAC	*Calanus pacificus*
EBUN	*Eucalanus bungii*
EELO	*Eucalanus elongatus*
ELON	*Epilabidocera longipedata*
METR	*Metridia sp.*
MPAC	*Metridia pacifica*
OBOR	*Oncaea borealis*
PPAR	*Paracalanus parvus*
PSEU	*Pseudocalanus sp.*
SMIN	*Scolecithricella minor*
TDIS	*Tortanus discaudatus*
UCAL	Unidentified calanoid copepod
Cyclopoid copepods	
CANG	*Corycaeus anglicus*
OATL	*Oithona atlantica*
OSIM	*Oithona similis*
Harpacticoid copepods	
UHAR	Unidentified harpacticoid copepod

Table 7. Volume of water filtered and number of zooplankton per m^3 of water in oblique tow samples collected during the 2017 Strait of Georgia juvenile herring survey. Species codes as shown in Tables 5 and 6.

Location	Tran	Stn	Volume (m^3)	ADIV	ALON	AMPH	BARN	CABD	CALA	CANG	CHAE	CLAD
Clarke Rock	1	1	14.651	-	0.8	-	0.5	-	-	0.5	-	25.4
		3	8.881	-	1.8	11.7	0.5	-	103.4	-	-	5.0
Yellow Point	2	1	18.205	-	-	-	10.8	-	-	-	-	42.2
		4	14.506	-	-	0.6	8.8	-	13.2	17.6	-	30.9
Bowser	3	1	4.789	-	6.7	-	267.3	-	-	-	-	1403.2
		3	9.955	-	6.4	-	6.7	3.2	0.6	3.2	-	810.0
Henry Bay	4	3	2.941	-	-	0.3	185.0	10.9	-	-	-	435.3
		5	0.848	-	-	-	254.7	-	18.9	9.4	-	858.6
French Creek	5	1	13.329	-	-	-	7.2	0.6	-	0.6	-	181.9
		3	15.463	-	9.3	16.6	10.9	-	18.2	0.5	-	7.2
Trincomali Channel	6	1	17.330	-	3.7	18.7	27.9	-	13.9	20.3	0.1	20.3
		3	17.609	-	0.5	7.9	19.1	-	1.4	2.3	0.1	9.1
Smelt Bay	8	1	17.363	-	3.7	2.8	1.8	-	3.9	-	-	19.4
		2	15.438	-	-	3.1	6.2	-	-	-	-	20.7
Atrevida Reef	9	1	17.078	-	0.2	2.7	12.2	-	3.3	4.7	0.1	-
		3	18.480	0.9	2.6	9.3	-	-	14.2	1.7	0.1	-
Cape Cockburn	10	1	16.701	-	0.2	0.2	4.2	-	0.7	12.9	-	-
		3	15.079	-	-	95.2	-	2.1	107.2	21.2	1.6	4.2
Secret Cove	11	1	21.086	-	0.8	8.3	11.8	0.8	12.0	7.6	-	3.8
		3	18.091	0.1	-	3.6	-	-	18.8	43.3	-	3.5

Table 7 continued.

Location	Tran	Stn	CNAU	COEL	CPAC	CRAM	CRAZ	CTEN	ECHI	ECTO	EELO	EGGS	ELON
Clarke Rock	1	1	-	-	-	-	1.2	-	-	-	-	0.3	-
		3	-	-	12.2	0.2	2.5	-	-	-	-	-	-
Yellow Point	2	1	-	2.2	-	-	10.5	0.4	-	7.0	-	-	-
		4	-	1.1	-	0.6	11.6	1.7	-	-	-	-	-
Bowser	3	1	-	-	-	0.2	0.4	-	-	-	-	-	-
		3	-	-	-	0.7	1.4	-	-	-	-	-	0.2
Henry Bay	4	3	-	2.7	-	-	-	-	21.8	-	-	0.3	-
		5	-	-	-	-	-	-	-	-	-	9.4	-
French Creek	5	1	-	-	-	-	0.1	-	-	-	-	0.2	-
		3	-	0.3	5.3	1.2	0.9	-	-	0.5	-	-	-
Trincomali Channel	6	1	-	1.1	-	0.1	12.0	0.2	-	-	-	0.1	1.8
		3	0.9	0.3	-	0.2	5.2	-	-	0.9	-	-	-
Smelt Bay	8	1	-	-	-	-	8.1	-	-	-	-	-	-
		2	-	-	8.8	3.1	5.2	-	-	-	-	-	-
Atrevida Reef	9	1	-	-	0.3	-	0.2	-	-	0.5	-	-	-
		3	-	0.1	0.3	0.1	1.7	-	-	-	-	-	-
Cape Cockburn	10	1	-	-	-	-	1.9	-	-	-	-	-	-
		3	-	-	68.4	-	0.3	-	-	-	-	-	-
Secret Cove	11	1	-	-	0.0	-	5.5	-	-	5.3	-	2.3	-
		3	-	0.1	0.1	0.1	1.0	-	-	-	0.1	-	0.1

Table 7 continued.

Location	Tran	Stn	EUPA	EUPL	GAST	LARV	MPAC	OATL	OSIM	OSTR	POLY	PPAR	PSEU
Clarke Rock	1	1	-	-	-	9.6	-	-	0.3	-	-	-	-
		3	1.2	-	5.2	1.8	29.1	1.8	1.8	4.7	1.8	-	-
Yellow Point	2	1	-	-	21.1	101.9	-	-	-	-	-	7.0	-
		4	-	-	-	132.4	-	-	-	-	0.1	8.8	-
Bowser	3	1	-	-	40.1	868.7	-	-	-	-	-	6.7	-
		3	-	-	32.1	259.1	-	-	32.1	-	-	35.4	54.6
Henry Bay	4	3	-	-	76.2	579.8	-	-	21.8	-	43.5	141.5	32.6
		5	-	-	-	518.9	-	-	132.1	-	-	207.6	-
French Creek	5	1	-	-	5.4	4.8	0.1	-	0.6	-	-	0.6	-
		3	0.4	-	1.6	44.0	0.9	1.6	7.2	-	-	2.1	-
Trincomali Channel	6	1	-	1.8	11.1	186.5	-	-	14.8	-	1.9	12.0	1.8
		3	-	1.9	6.4	150.8	-	-	1.4	-	0.9	2.3	3.6
Smelt Bay	8	1	-	-	2.8	44.0	-	-	1.8	0.5	0.9	0.9	5.5
		2	-	-	6.2	119.2	2.6	-	-	-	4.1	-	4.1
Atrevida Reef	9	1	0.1	-	2.6	2.4	9.4	3.3	1.6	3.0	0.4	0.2	3.3
		3	-	1.7	1.7	3.6	15.9	10.4	-	-	-	-	26.8
Cape Cockburn	10	1	-	-	1.4	0.5	2.6	-	3.8	-	-	-	0.5
		3	0.9	0.3	4.2	10.6	17.3	2.1	6.4	34.0	27.1	-	4.2
Secret Cove	11	1	-	-	9.1	46.3	-	-	4.6	-	-	5.3	-
		3	-	0.1	3.5	57.6	-	-	8.8	-	0.9	15.0	-

Table 7 continued.

Location	Tran	Stn	ROTI	SHRI	SIPH	SMIN	TDIS	TELA	TSPI	UCAL
Clarke Rock	1	1	-	3.3	0.3	-	-	-	-	-
		3	-	0.9	5.4	-	-	-	-	-
Yellow Point	2	1	-	8.3	405.6	-	-	-	-	-
		4	-	8.8	461.1	-	-	0.6	-	-
Bowser	3	1	-	1.3	-	-	6.7	-	-	-
		3	-	2.3	1.2	-	-	-	-	-
Henry Bay	4	3	10.9	2.7	24.8	-	54.4	-	-	1.0
		5	-	9.4	113.2	-	-	-	-	-
French Creek	5	1	-	-	-	-	-	-	-	-
		3	-	1.3	-	-	1.0	-	0.3	-
Trincomali Channel	6	1	-	5.2	1.9	-	1.8	0.1	-	-
		3	-	2.2	0.3	-	-	0.1	-	0.1
Smelt Bay	8	1	-	2.8	153.2	-	0.9	-	-	-
		2	-	5.2	431.5	-	-	-	-	-
Atrevida Reef	9	1	-	0.4	0.1	-	-	-	-	0.1
		3	-	0.1	1.0	6.1	-	-	-	-
Cape Cockburn	10	1	-	0.7	0.2	-	-	-	-	-
		3	-	0.8	3.2	-	-	2.7	-	-
Secret Cove	11	1	-	6.0	2.7	-	-	-	0.04	-
		3	-	0.4	1.0	-	-	-	-	-

Table 8. Volume of water filtered and number of zooplankton per m^3 of water in vertical tow samples collected during the 2017 Strait of Georgia juvenile herring survey. Species codes as shown in Tables 5 and 6. A calculated volume for 20m and 10m tows was used, see text for explanation.

Location	Tran	Stn	Volume (m^3)	ADIV	ALON	AMPH	BARN	CABD	CALA	CANG	CHAE	CLAD
Clarke Rock	1	1	0.283	-	35.29	14.12	63.52	7.06	-	63.52	-	204.67
		3	0.567	-	-	35.29	-	-	29.99	-	-	-
Yellow Point	2	1	0.567	-	-	84.69	508.14	-	-	112.92	-	56.46
		4	0.567	-	-	-	70.58	-	155.27	37.05	-	70.58
Bowser	3	1	0.283	-	-	-	1411.51	-	-	-	-	3246.47
		3	0.567	-	14.12	14.12	70.58	-	14.12	84.69	-	1298.59
Henry Bay	4	3	0.567	-	-	-	331.70	-	-	-	-	345.82
		5	0.283	-	-	-	275.24	-	-	14.12	-	776.33
French Creek	5	1	0.283	-	-	-	98.81	-	-	7.06	-	2074.92
		3	0.567	3.53	21.17	52.93	45.87	-	38.82	10.59	-	10.59
Trincomali Channel	6	1	0.567	-	-	42.35	268.19	-	3.53	28.23	-	77.63
		3	0.567	-	-	31.76	208.20	-	-	21.17	-	21.17
Smelt Bay	8	1	0.567	-	21.17	7.06	28.23	-	-	7.06	-	77.63
		2	0.567	-	-	14.12	141.15	-	-	14.12	-	56.46
Atrevida Reef	9	1	0.567	-	1.76	5.29	-	-	-	15.88	-	-
		3	0.567	1.76	-	54.70	1.76	1.76	10.59	14.12	-	-
Cape Cockburn	10	1	0.567	-	-	1.76	8.82	-	19.41	70.58	-	-
		3	0.567	-	-	458.74	-	-	1111.56	141.15	21.17	-
Secret Cove	11	1	0.567	-	-	7.06	63.52	-	1.76	52.93	7.06	49.40
		3	0.567	-	3.53	-	14.12	-	72.34	162.32	8.82	-

Table 8 continued.

Location	Tran	Stn	CNAU	COEL	CPAC	CRAM	CRAZ	CTEN	EBUN	ECHI	ECTO	EELO	EGGS
Clarke Rock	1	1	-	-	-	-	14.12	-	-	-	-	-	7.06
		3	-	1.76	47.64	1.76	1.76	-	-	-	-	0.18	-
Yellow Point	2	1	-	-	-	-	-	-	-	141.15	-	-	-
		4	-	-	-	-	28.23	14.12	-	14.12	-	-	-
Bowser	3	1	-	-	-	-	-	-	-	-	-	-	-
		3	-	-	-	-	17.64	-	-	-	-	-	-
Henry Bay	4	3	-	15.88	-	-	24.70	-	-	7.06	-	-	-
		5	-	-	-	-	10.59	-	-	-	-	-	-
French Creek	5	1	-	-	-	3.53	-	-	-	-	-	-	-
		3	-	-	12.35	1.76	-	-	-	3.53	-	-	-
Trincomali Channel	6	1	7.06	7.06	-	-	98.81	7.06	-	42.35	7.06	-	-
		3	-	-	-	-	21.17	3.53	-	10.59	7.06	-	-
Smelt Bay	8	1	-	-	-	-	15.88	-	-	-	-	-	-
		2	-	-	-	5.29	51.17	-	-	-	-	-	-
Atrevida Reef	9	1	-	-	-	-	1.76	-	-	-	-	-	-
		3	-	-	-	-	-	-	-	1.76	-	-	-
Cape Cockburn	10	1	-	1.76	-	-	-	-	-	5.29	-	-	-
		3	-	14.12	508.14	-	7.06	-	0.18	-	-	-	-
Secret Cove	11	1	10.59	-	-	-	-	-	-	-	28.23	-	-
		3	-	-	-	-	-	-	-	7.06	-	-	-

Table 8 continued.

Location	Tran	Stn	EUPA	EUPL	GAST	LARV	METR	MPAC	OATL	OBOR	OSIM	OSTR	PELE
Clarke Rock	1	1	-	-	155.27	628.12	-	-	14.12	-	7.06	-	-
		3	5.29	-	-	-	-	52.93	-	-	-	1.76	-
Yellow Point	2	1	-	-	-	2597.17	-	-	-	-	28.23	-	28.23
		4	-	-	56.46	903.36	-	-	-	-	37.05	-	-
Bowser	3	1	-	-	169.38	4855.59	-	-	-	-	84.69	-	-
		3	-	-	14.12	1185.67	-	-	-	-	127.04	-	-
Henry Bay	4	3	-	-	119.98	63.52	-	-	-	-	21.17	-	-
		5	-	-	63.52	303.47	-	-	-	-	70.58	-	-
French Creek	5	1	-	-	28.23	169.38	-	-	-	-	-	-	-
		3	-	-	-	222.31	-	-	45.87	-	-	-	-
Trincomali Channel	6	1	-	7.06	35.29	1397.39	-	-	-	-	49.40	-	-
		3	-	-	10.59	949.24	-	-	-	-	-	-	-
Smelt Bay	8	1	-	-	42.35	628.12	-	-	-	-	77.63	-	-
		2	-	-	56.46	959.82	-	28.23	-	14.12	42.35	-	-
Atrevida Reef	9	1	-	-	1.76	14.12	-	1.76	45.87	-	7.06	5.29	-
		3	-	-	5.29	33.52	8.82	-	21.17	-	5.29	-	-
Cape Cockburn	10	1	-	-	5.29	21.17	-	1.76	33.52	-	-	-	-
		3	24.70	-	84.69	2089.03	-	1640.88	-	-	-	141.15	-
Secret Cove	11	1	-	-	21.17	479.91	-	-	42.35	-	70.58	-	-
		3	-	-	28.23	543.43	-	-	35.29	-	24.70	-	-

Table 8 continued.

Location	Tran	Stn	POLY	PPAR	PSEU	SEAL	SHRI	SIPH	SMIN	TDIS	TRAS	UCAL	UHAR
Clarke Rock	1	1	-	21.17	14.12	-	63.52	7.06	-	14.12	-	42.35	-
		3	-	-	-	1.76	3.53	54.70	-	-	1.76	-	-
Yellow Point	2	1	56.46	28.23	-	-	28.23	1383.28	-	-	-	-	-
		4	70.58	70.75	-	-	28.23	1397.39	-	-	-	-	-
Bowser	3	1	28.23	-	-	-	-	-	-	-	-	28.23	-
		3	-	98.81	225.84	-	17.64	-	-	-	-	14.12	-
Henry Bay	4	3	28.23	74.10	-	-	22.94	65.28	-	38.82	-	7.06	-
		5	63.52	204.67	7.06	-	-	42.35	-	42.35	-	-	-
French Creek	5	1	-	56.46	7.06	-	17.64	-	-	-	-	-	-
		3	-	17.64	-	-	3.53	-	-	3.53	-	-	-
Trincomali Channel	6	1	14.12	218.78	52.93	-	28.23	37.05	-	-	-	-	-
		3	3.53	7.06	3.53	-	7.06	-	-	-	-	10.59	-
Smelt Bay	8	1	26.47	49.40	-	-	14.12	562.84	-	-	-	28.23	-
		2	-	14.12	14.12	-	42.35	1039.22	-	-	-	70.58	-
Atrevida Reef	9	1	-	1.76	21.17	-	1.76	1.76	-	-	-	0.18	-
		3	-	5.29	326.41	-	-	-	19.41	-	-	-	-
Cape Cockburn	10	1	1.76	5.29	-	-	1.76	-	-	-	-	-	-
		3	444.62	-	-	-	-	77.63	-	-	-	-	-
Secret Cove	11	1	7.06	202.90	-	-	-	14.12	-	-	-	3.53	3.53
		3	-	335.23	8.82	-	-	7.06	-	-	-	-	

APPENDIX 1

An index of relative biomass and abundance of juvenile Pacific Herring in the Strait of Georgia

The Strait of Georgia (SOG) juvenile herring and nearshore pelagic ecosystem survey collects time-series information that can be used to estimate the relative abundance of age-0 herring and perhaps provide a forecast of recruitment to the adult spawning population. This information may also represent trends in prey availability to Coho and Chinook Salmon and other predators in the SOG. The index (and associated variance) of the relative biomass or abundance of age-0 herring in the SOG was updated with the 2017 survey data using methods identified in Boldt et al. (2015). In addition, annual variation in herring lengths and weights were examined.

Estimates of mean catch weights (g), abundance, and Catch Per Unit Effort (CPUE; weight and abundance) of age-0 herring varied interannually with no significant overall trend during 1992-2017 (Figures A1 and Table A1). In 2017, age-0 herring estimates increased compared to 2016; however, the interannual variability in mean estimates has been relatively low compared to observations prior to 2012, when there was a pattern of alternating high (with high associated variance estimates) and low indices every two or three years (Figure A1 and Table A1). Estimates of CVs ranged from 23% to 81% with an average of 47% (Figure A1 and Table A1). In 2017, age-0 herring measured were lighter and shorter than fish measured in most years (Figure A2), however their condition (residuals from a double-log-transformed length weight regression) was still above average (not shown). During the time series, there was no significant linear trend in mean lengths or weights of age-0 herring (Figure A2).

Literature cited:

Boldt, J.L., Thompson, M., Fort, C., Rooper, C.N., Schweigert, J., Quinn II, T.J., Hay, D., and Therriault, T.W. An index of relative biomass, abundance, and condition of juvenile Pacific Herring (*Clupea pallasi*) in the Strait of Georgia, British Columbia. Can. Manuscr. Rep. Fish. Aquat. Sci. 3081: x + 80 p.

Thompson, S.K. 1992. Sampling. John Wiley and Sons, Inc. New York. 343 p.

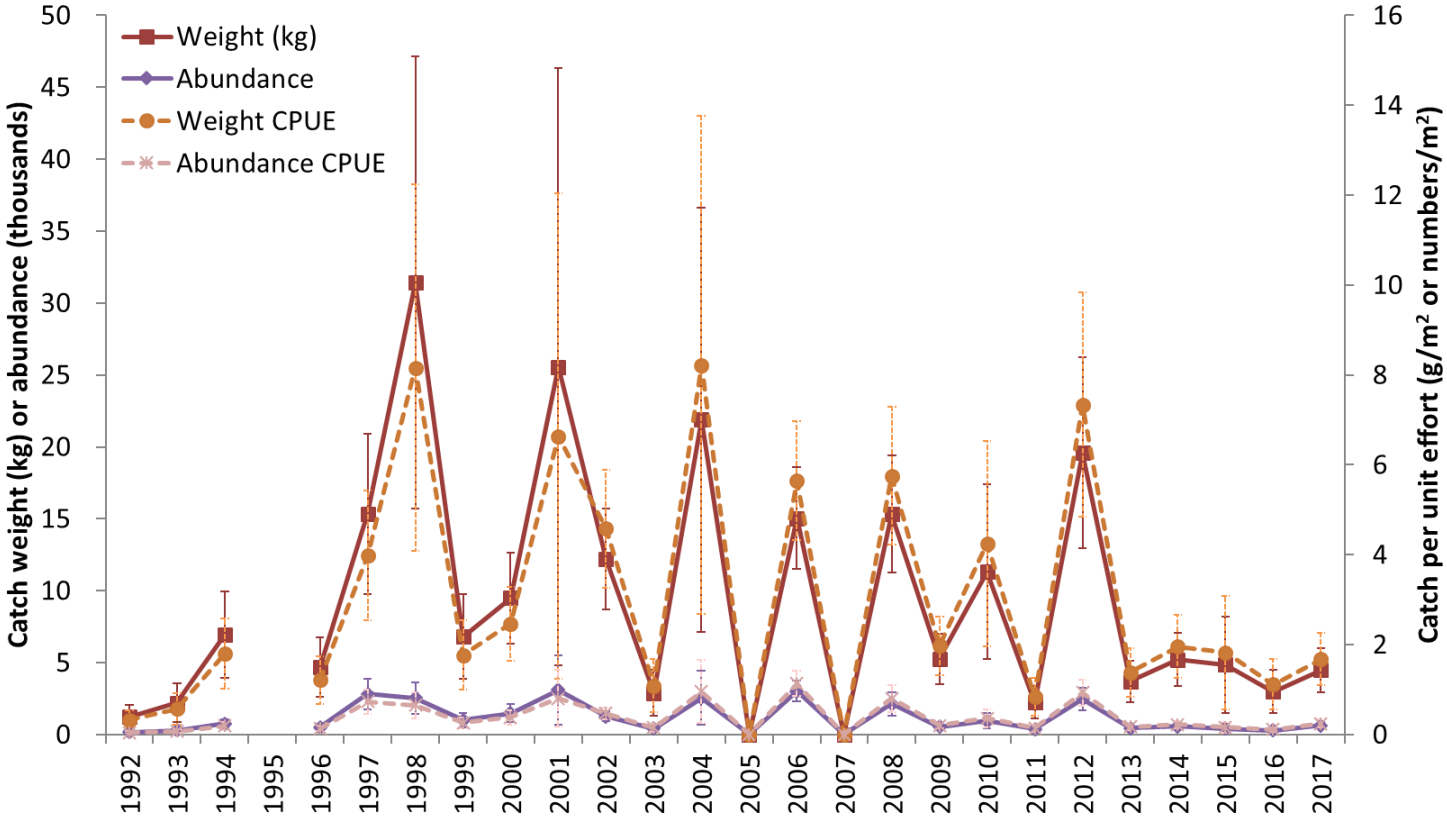


Figure A1. Estimates of catch weight (kg), catch weight-per-unit-effort (weight CPUE; g/m^2), abundance, and abundance CPUE (number/m^2) of age-0 herring caught in the Strait of Georgia juvenile herring survey at core transects and stations during 1992-2017 (no survey in 1995). Estimates were calculated using a two-stage method (see Boldt et al. 2015). Estimates of CPUE were calculated by dividing catch weight (or abundance) by the area fished by the net (assuming the net length changed in 2002 from 220 m to 183 m; see Boldt et al. 2015 for details). Standard error bars (using the Thompson 1992 variance estimator) are shown.

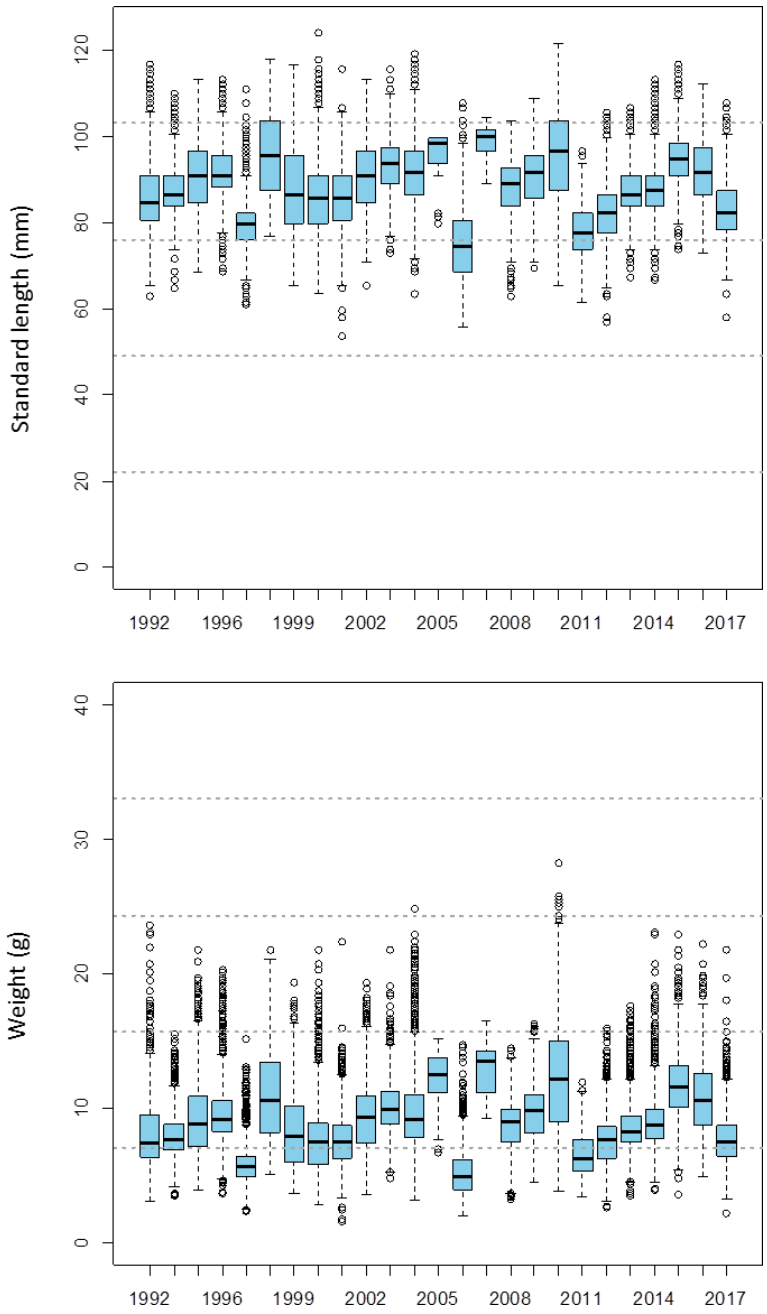


Figure A2. Boxplots of age-0 herring standard lengths (mm; top panel) and weights (g; bottom panel) measured in the laboratory during 1992-2017 (no survey in 1995). Standard error bars are shown.

Table A1. Mean catch weight (g), catch weight per unit effort (CPUE; g/m^2), abundance, abundance CPUE (number/m^2), standard error (SE), and coefficient of variation (CV) of age-0 herring caught in the Strait of Georgia juvenile herring survey at core transects and stations during 1992-2017 (no survey in 1995). Two-stage sampling formulae (Thompson 1992) were used to calculate the mean and variance.

Year	Weight (g)	SE	CV	Weight CPUE (g/m^2)	SE	CV	Abundance	SE	CV	Abundance CPUE (number/m^2)	SE	CV
1992	1226.333	852.076	0.695	0.318	0.221	0.695	163.358	122.426	0.749	0.042	0.032	0.749
1993	2206.211	1337.446	0.606	0.573	0.347	0.606	285.847	178.452	0.624	0.074	0.046	0.624
1994	6930.616	3010.497	0.434	1.799	0.782	0.434	748.304	334.987	0.448	0.194	0.087	0.448
1995												
1996	4669.740	2065.650	0.442	1.212	0.536	0.442	499.247	228.320	0.457	0.130	0.059	0.457
1997	15341.900	5569.885	0.363	3.983	1.446	0.363	2813.467	1072.734	0.381	0.730	0.278	0.381
1998	31418.933	15708.446	0.500	8.157	4.078	0.500	2529.717	1111.968	0.440	0.657	0.289	0.440
1999	6809.267	2963.350	0.435	1.768	0.769	0.435	1001.333	485.487	0.485	0.260	0.126	0.485
2000	9490.827	3175.900	0.335	2.464	0.824	0.335	1472.513	626.178	0.425	0.382	0.163	0.425
2001	25568.172	20777.096	0.813	6.638	5.394	0.813	3100.970	2429.038	0.783	0.805	0.631	0.783
2002	12197.863	3497.051	0.287	4.577	1.312	0.287	1249.845	345.835	0.277	0.469	0.130	0.277
2003	2900.546	1597.512	0.551	1.088	0.599	0.551	399.895	247.569	0.619	0.150	0.093	0.619
2004	21901.546	14754.345	0.674	8.218	5.536	0.674	2556.415	1889.527	0.739	0.959	0.709	0.739
2005	10.596	5.108	0.482	0.004	0.002	0.482	0.840	0.396	0.472	0.000	0.000	0.472
2006	15045.055	3526.160	0.234	5.645	1.323	0.234	3020.660	738.642	0.245	1.133	0.277	0.245
2007	6.804	4.281	0.629	0.003	0.002	0.629	0.528	0.315	0.596	0.000	0.000	0.596
2008	15334.313	4082.787	0.266	5.754	1.532	0.266	2132.927	806.846	0.378	0.800	0.303	0.378
2009	5261.335	1737.286	0.330	1.974	0.652	0.330	533.687	175.386	0.329	0.200	0.066	0.329
2010	11322.919	6089.296	0.538	4.249	2.285	0.538	957.535	534.899	0.559	0.359	0.201	0.559
2011	2233.234	1128.388	0.505	0.838	0.423	0.505	381.820	206.055	0.540	0.143	0.077	0.540
2012	19564.914	6640.157	0.339	7.341	2.492	0.339	2480.540	791.017	0.319	0.931	0.297	0.319

2013	3688.389	1443.124	0.391	1.384	0.542	0.391	460.198	191.919	0.417	0.173	0.072	0.417
2014	5215.187	1856.540	0.356	1.957	0.697	0.356	581.953	224.927	0.387	0.218	0.084	0.387
2015	4855.123	3343.553	0.689	1.822	1.255	0.689	428.560	301.774	0.704	0.161	0.113	0.704
2016	2976.148	1499.108	0.504	1.117	0.563	0.504	289.093	157.325	0.544	0.108	0.059	0.544
2017	4472.289	1536.429	0.344	1.678	0.577	0.344	640.950	237.764	0.371	0.241	0.089	0.371