Strait of Georgia Juvenile Herring Survey, September 2016

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STRAIT OF GEORGIA JUVENILE HERRING SURVEY, SEPTEMBER 2016

by

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

APPENDIX 1

ABSTRACT

Thompson, M., Boldt, J. and Grinnell, M. H. 2019. Strait of Georgia juvenile herring survey, September 2016. Can. Manuscr. Rep. Fish. Aquat. Sci. 3125: v + 49 p.

A fall juvenile herring survey of the Strait of Georgia took place September 7th to 20th, 2016. This survey serves to address several questions of early herring survival, abundance, recruitment and trophodynamics. Forty-eight 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. 2019. Strait of Georgia juvenile herring survey, September 2016. Can. Manuscr. Rep. Fish. Aquat. Sci. 3125: v + 49 p.

Un relevé automnal du hareng juvénile dans le détroit de Georgie a été réalisé entre le 7 et le 20 septembre 2016. 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 48 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 and a vital forage species for many marine mammals, birds, and fish in British Columbia's coastal waters. 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 the ten core sampling transects (1 – 6, 8 – 11); which are made up of 48 sampling stations and 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). Originally, the sampling transects were chosen based on known historical herring spawning sites and were roughly placed equal distance apart around the Strait of Georgia. Placement also represents both nearshore and open water habitats (Haegele et. al. 2005). In 2016, sampling was conducted from September 7th to 20th (Table 1). All forty-eight core stations were sampled.

Fish Sampling

In 2016, 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 feeding 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 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).

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. A General Oceanics® 2030R model flowmeter was attached to the left bongo net to determine the volume of seawater filtered. Volume filtered was calculated 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

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

We used Conductivity Temperature Depth recorder (CTD) casts to characterize oceanographic conditions in the surveyed area. We did twenty casts using a RBR XR-60 CTD at stations where zooplankton was sampled (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 close to 1 m/sec. Data from the CTD casts were subsequently downloaded to a laptop at the end of the each evening.

RESULTS

Herring

Forty-eight stations were sampled from transects 1 – 6, 8 – 11. A total of 2753 herring were weighed and measured resulting in a length frequency distribution that was distinctly bimodal for age-0+ and age-1+ herring (Figure 4). Length designations for the juvenile herring age-classes were:

0+ = herring less than or equal to 113 mm standard length
1+ = herring between 114 mm and 160 mm standard length
2+ and older = herring greater than or equal to 161 mm standard length

Catches at thirty-seven of the forty-eight stations (77.0%) contained age-0+ herring (Tables 2 and 3). The mean length and weight of age-0+ herring was 92 mm and 10.82 g respectively. A total weight of 148.80 kg and estimated 14454 individual age-0+ herring were caught (Table 4).

Catches at thirty-one of the forty-eight stations (64.6%) sampled contained age-1+ herring (Tables 2 and 3). The mean length and weight of age-1+ herring was 141 mm and 41.01 g, respectively. A total weight of 167.79 kg and estimated 3829 individual age-1+ herring were caught (Table 4).

Catches at eighteen of the forty-eight stations (37.5%) sampled contained age-2+ herring (Tables 2 and 3). The mean length and weight of age-2+ herring was 171 mm and 75.03 g, respectively. A total weight of 22.56 kg and estimated 332 individual age-2+ herring were caught (Table 4).

Length frequency histograms by transect location for all sampled herring are shown in Figure 5. The two southern transects, Trincomali (transect 6) and Yellow Point (transect 2) were dominated by age-0+ herring. The four northern Vancouver Island transects (1, 3, 4 and 5) were mainly a mix of age-0+ and age-1+ herring. The four Sunshine coast transects (8, 9, 10 and 11) were a mix of all three herring age groups. We observed an anomaly of bimodal age-1+ fish (Figure 4), with shorter age-1+ fish mainly sampled at Secret Cove (transect 11) stations (Figure 5). We will be looking at scale aging next year for better clarification of the separation of age classes. A length-weight relationship for all sampled herring from the survey showed a significant, positive correlation (R^2=0.99; Figure 6).

Zooplankton

There were 18 categories of organisms identified in 20 zooplankton samples (Tables 5, 6 and 7). An average of 16.13 m^3 of water was filtered per zooplankton tow. Calanus sp. and gastropods occurred in all 20 samples. More than 50% of all zooplankton biomass comprised larvaceans (*Oikopleura sp.* and *Fritillaria sp.*), calanus sp., and barnacles.

CTD

Two CTD casts were performed at each transect location before plankton sampling. The CTD provided a range of data for temperature (^oC), salinity (ppt), dissolved oxygen (%) and depth (m). Generally, oxygen and salinity show similar patterns as temperature with depth (Figure 7). CTD data collection has been variable throughout the survey time period; therefore, longer term data collection is required to make broader annual oceanographic observations.

CONCLUSION

Forty-eight stations were sampled resulting in 19 different fish species recorded from purse seine sets. A total of 2753 herring were measured and weighed creating a bimodal histogram clearly representing age-0+ and age-1+ juvenile herring. Twenty zooplankton tows were performed with larvaceans (*Oikopleura sp.*and *Fritillaria sp.*) being the predominant organisms in numbers and biomass.

ACKNOWLEDGMENTS

The 2016 Strait of Georgia juvenile herring survey was funded by the Pacific Salmon Foundation along with the Department of Fisheries and Oceans. This survey could not have been possible without the hard work and good cheer of skipper Doug Henderson. Zooplankton samples were processed by Zotec services.

REFERENCES

Boldt, J.L., Thompson, M., Fort, C., Rooper, C.N., Schweigert, J., Quinn II, T.J., Hay, D., and Therriault, T.W. 2015. 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.

Haegele, C.W. 1997. The occurrence, abundance and food of juvenile herring and salmon in the Strait of Georgia, British Columbia in 1990 to 1994. Can. Manuscr. Rep. Fish. Aquat. Sci. 2390: 124 p.

Haegele, C.W., Hay, D.E., Schweigert, J.F., Armstrong, R.W., Hrabok, C., Thompson, M., and Daniel, K. 2005. Juvenile herring surveys in Johnstone Strait and Georgia Straits – 1996 to 2003. Can. Data Rep. Fish. Aquat. Sci. 1171:xi + 243 p.

Hay, D.E., and McCarter, P.B. 1999. Age of sexual maturation and recruitment in Pacific herring. Can. Sci. Advis. Sec. Res. Doc. 99/175: 42 p.

Hay, D.E., Schweigert, J.F., Thompson, M., Haegele, C.W., and Midgley, P. 2003. Analyses of juvenile surveys for recruitment prediction in the Strait of Georgia. Can. Sci. Advis. Sec. Res. Doc. 2003/107: 28 p.

Hourston, A.S., and Haegele, C.W. 1980. Herring on Canada's Pacific coast. Can. Spec. Publ. Fish. Aquat. Sci. 48: 23 p.

Humphreys, R.D., and Hourston, A.S. 1978. British Columbia herring spawn deposition survey manual. Fish. Mar. Serv. Misc. Spec. Publ. 38: 40 p.

McCarter, P.B., and Hay, D.E. 2002. Eulachon embryonic egg and larval outdrift sampling manual for ocean and river surveys. Can. Tech. Rep. Fish. Aquat. Sci. 2451: 33 p.

Thompson, M., Hrabok, C., Hay, D.E., Schweigert, J., Haegele, C., and Armstrong, B. 2003. Juvenile herring surveys: methods and data base. Can. Manuscr. Rep. Fish. Aquat. Sci. 2651: 31 p.

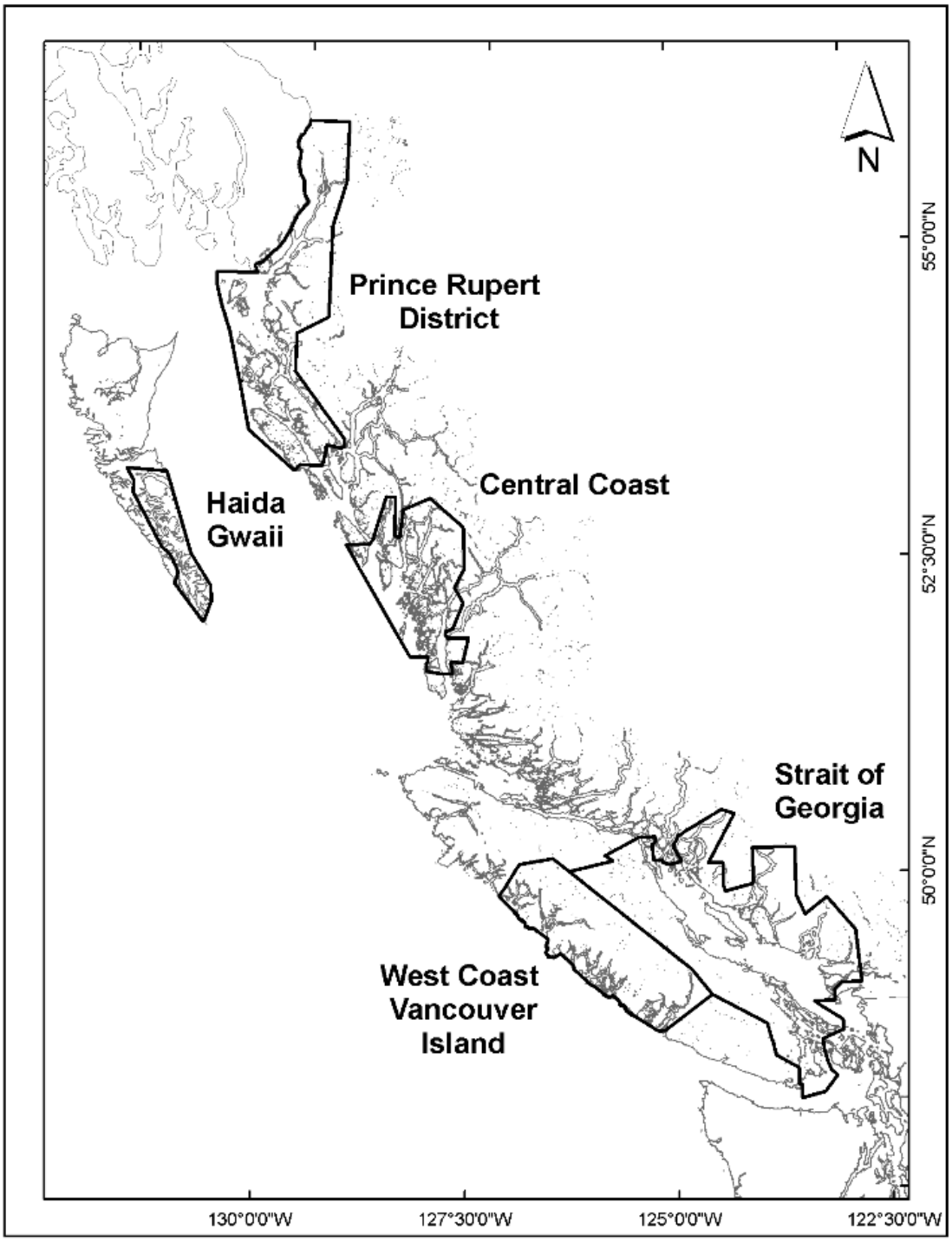


Figure 1. The five major British Columbia herring stock assessment areas.

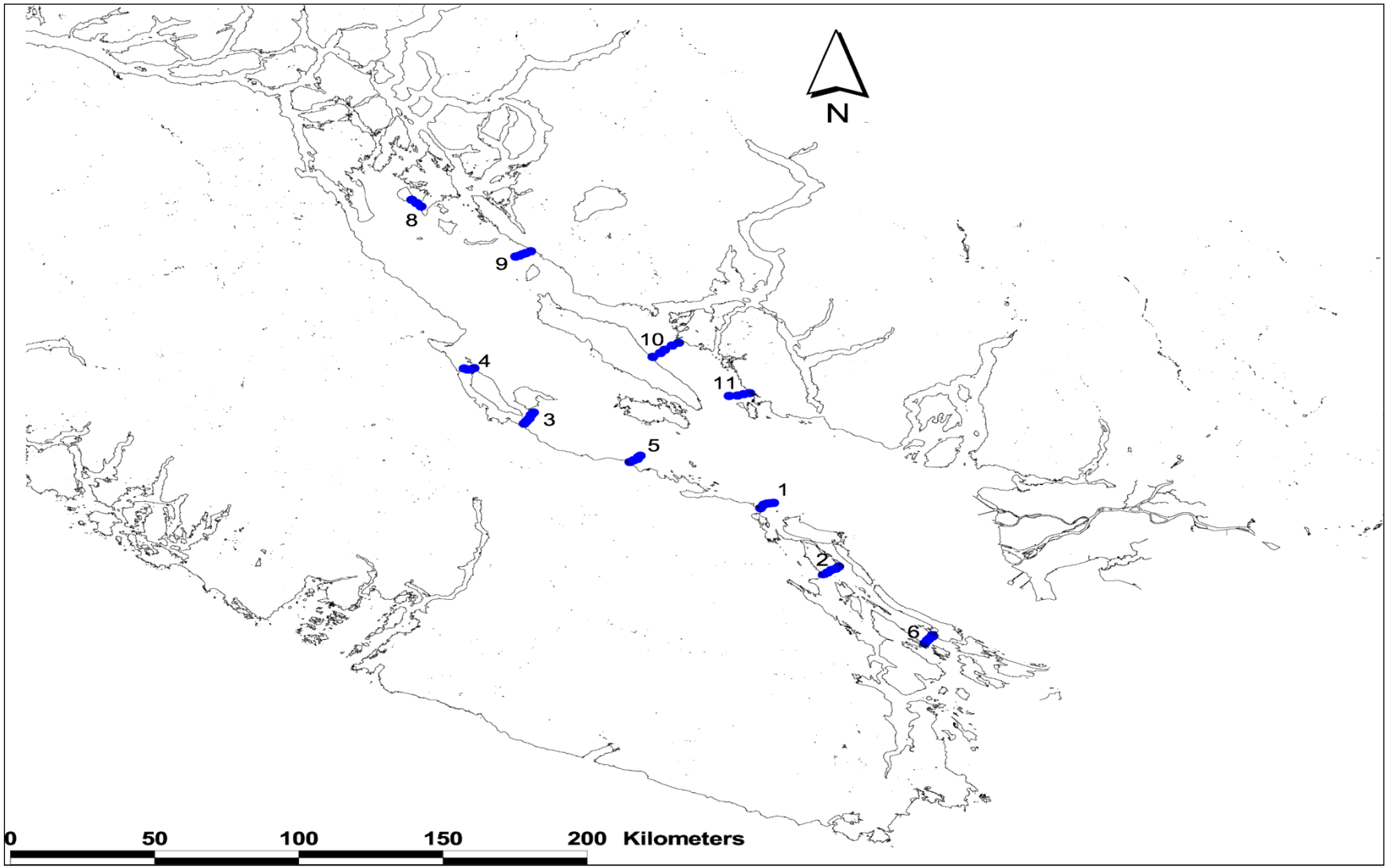


Figure 2. Purse seine set locations for the 2016 Strait of Georgia juvenile herring survey.

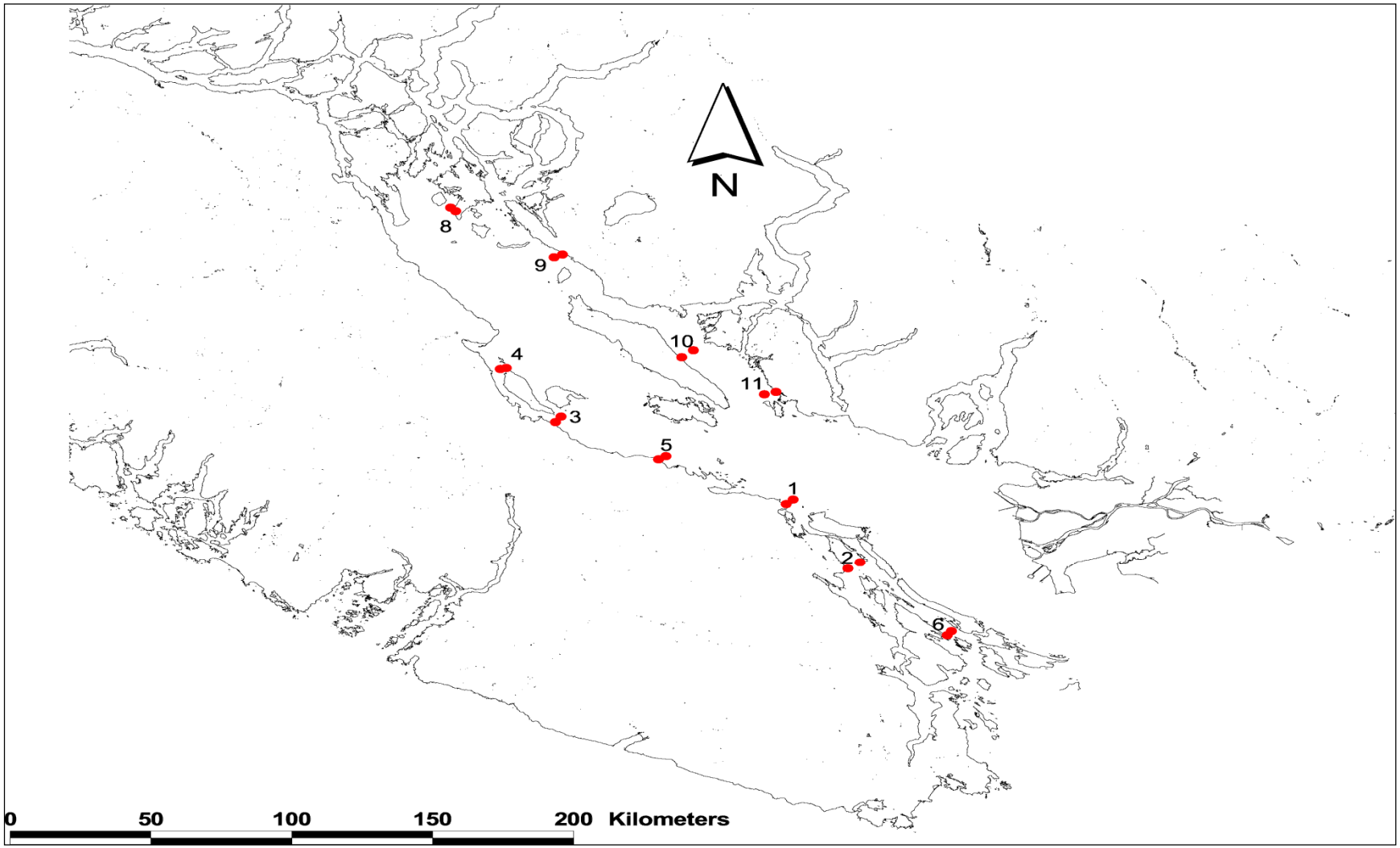


Figure 3. Zooplankton and CTD stations for 2016 Strait of Georgia juvenile herring survey.

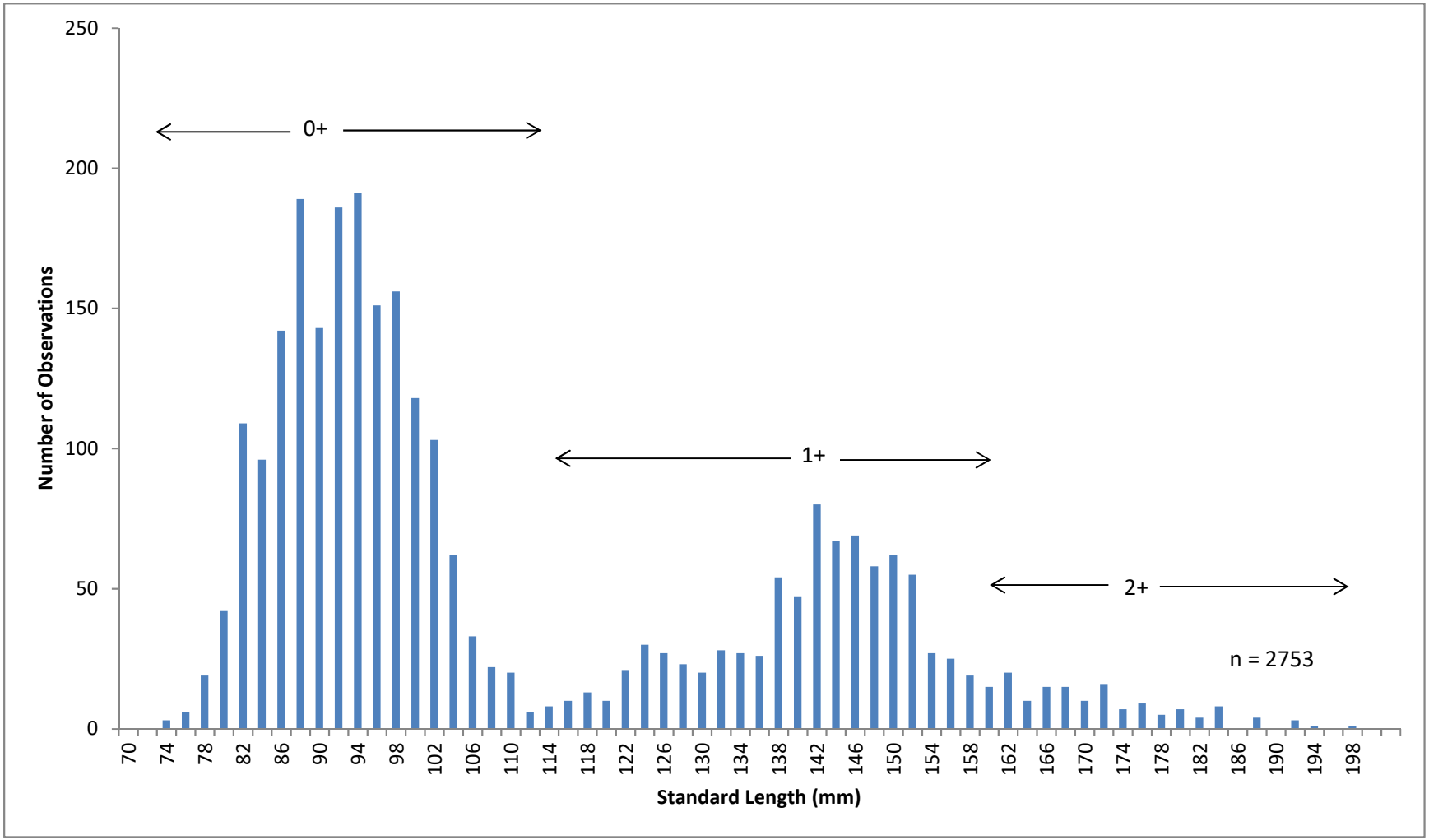


Figure 4. Length-frequency distribution for all herring sampled during the 2016 Strait of Georgia juvenile herring survey.

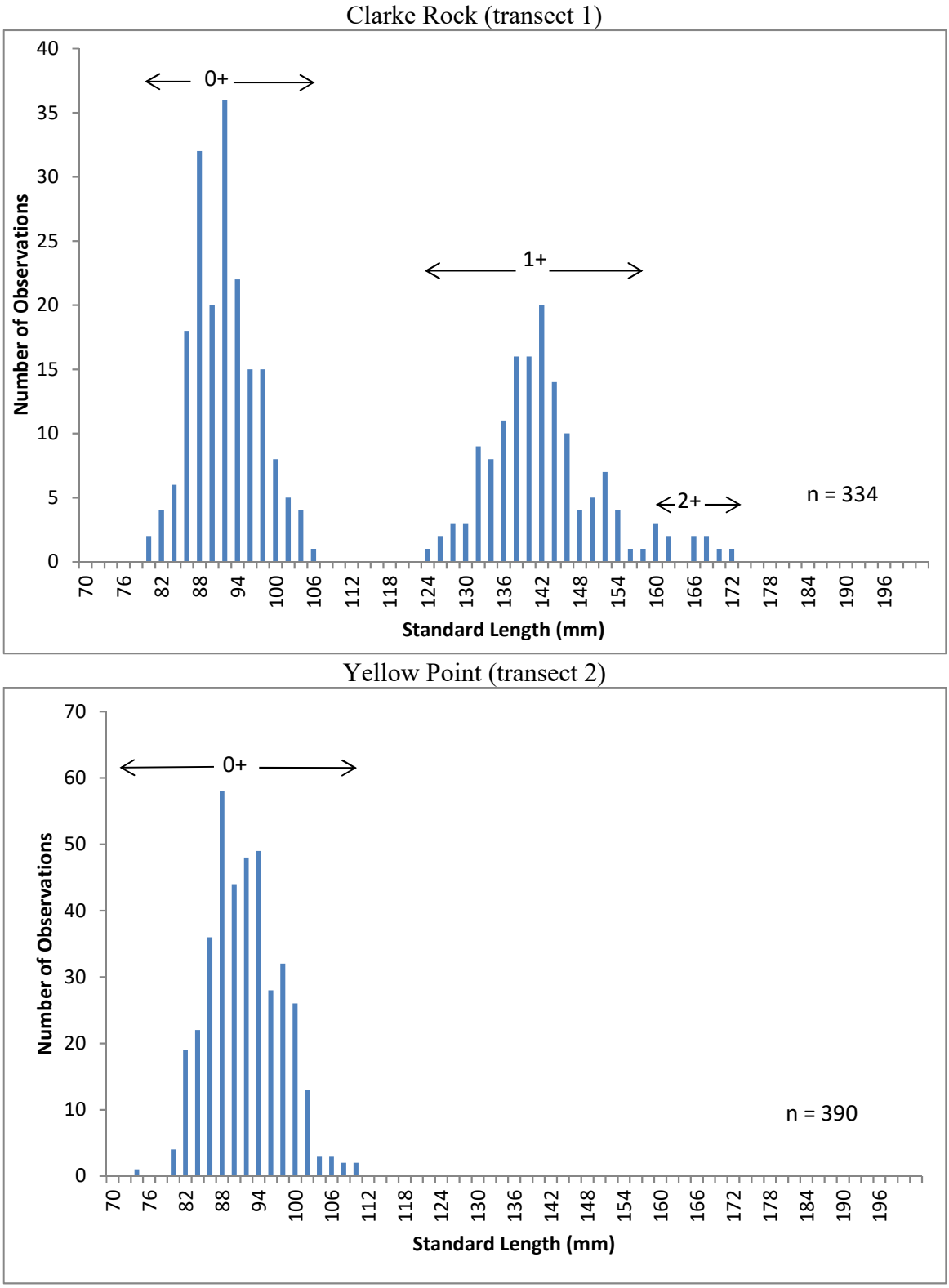
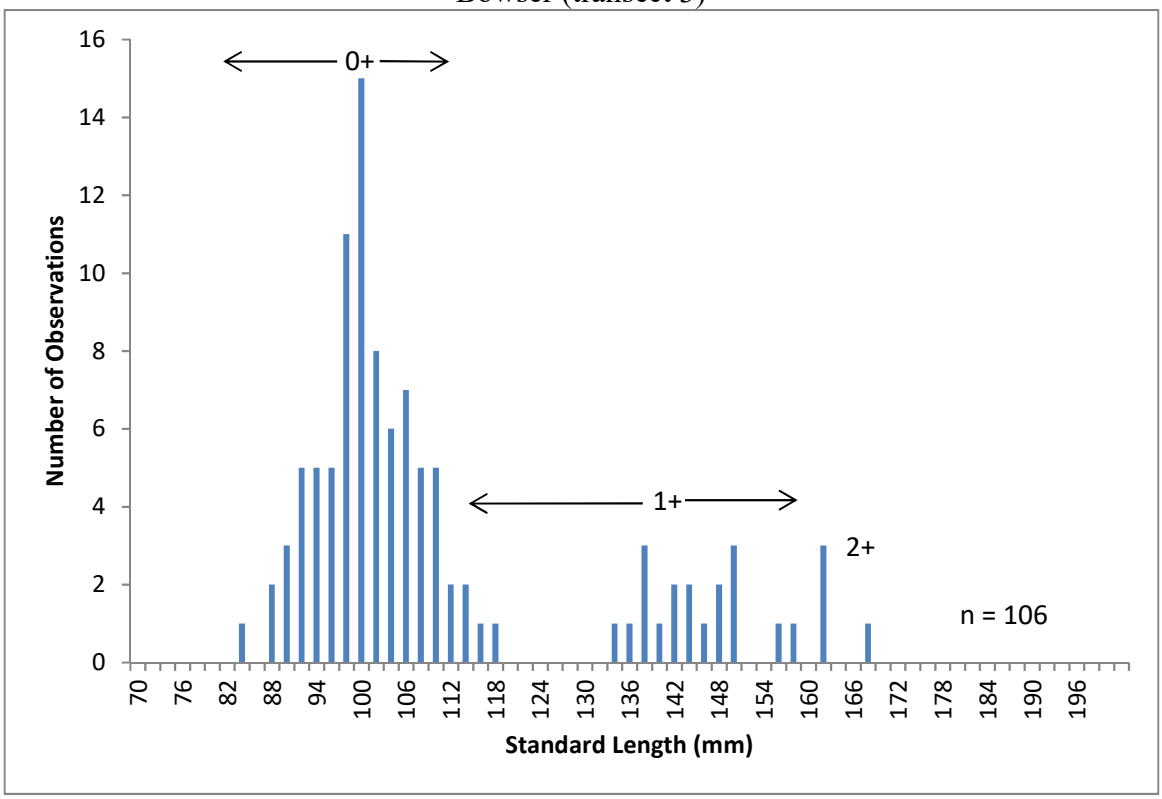


Figure 5. Length-frequency histograms of juvenile herring by transect location for the 2016 Strait of Georgia juvenile herring survey.

Bowser (transect 3)



Henry Bay (transect 4)

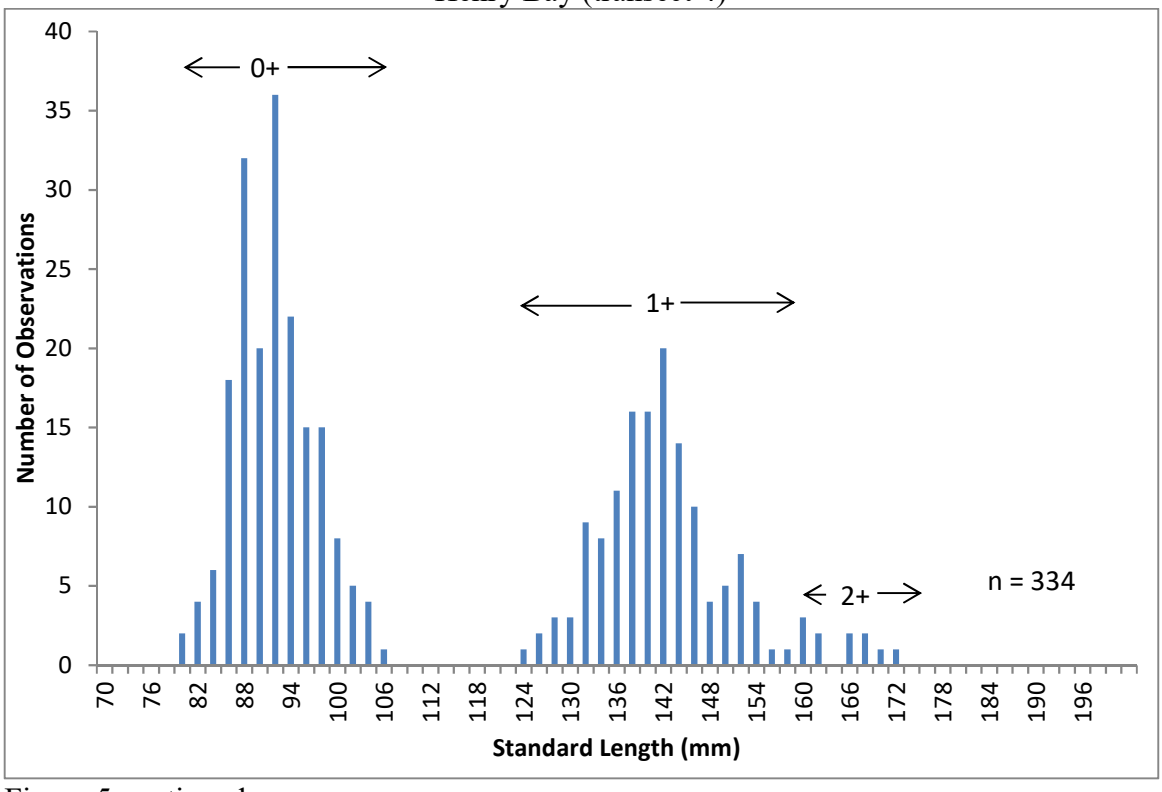
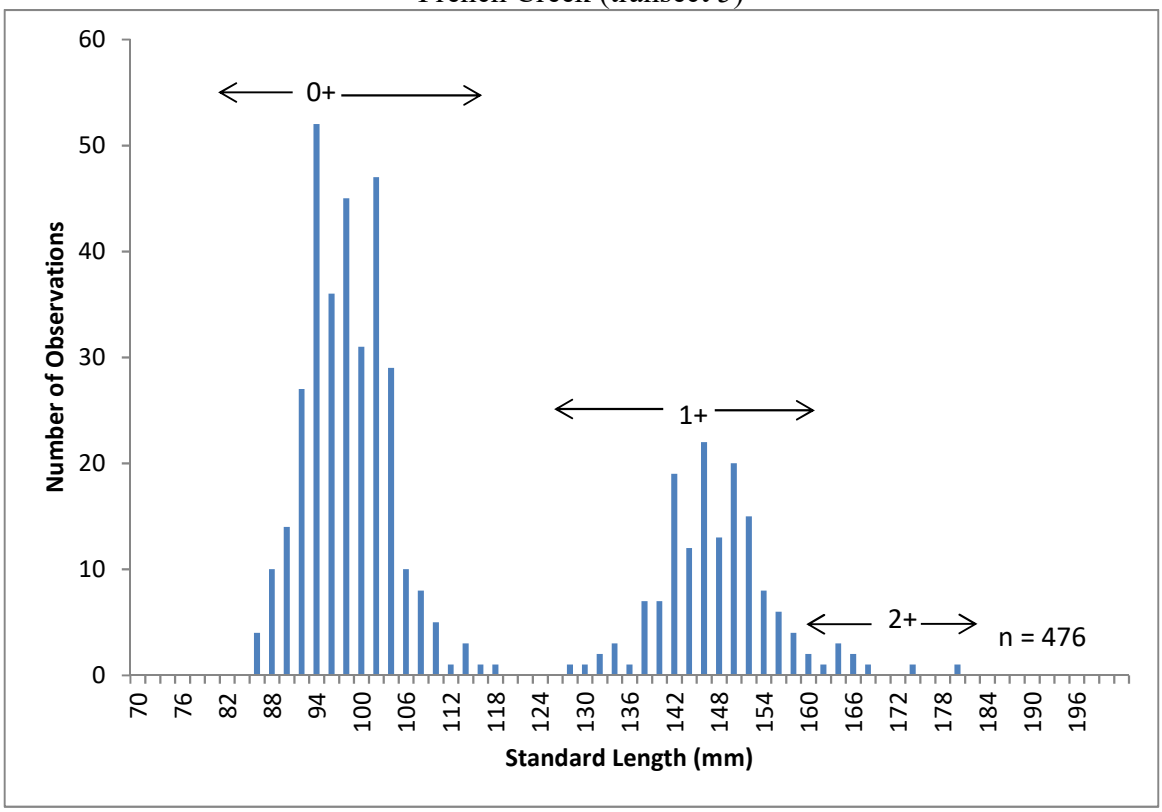


Figure 5 continued.

French Creek (transect 5)



Trincomali Channel (transect 6)

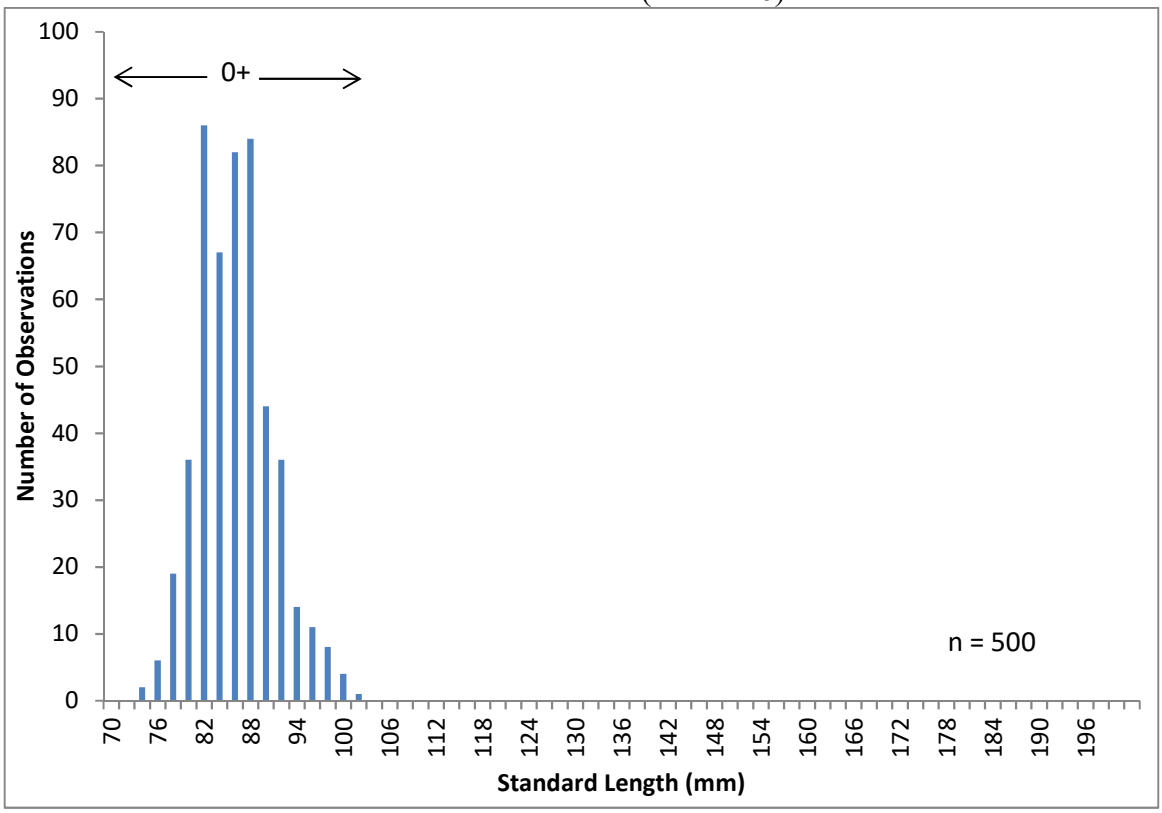
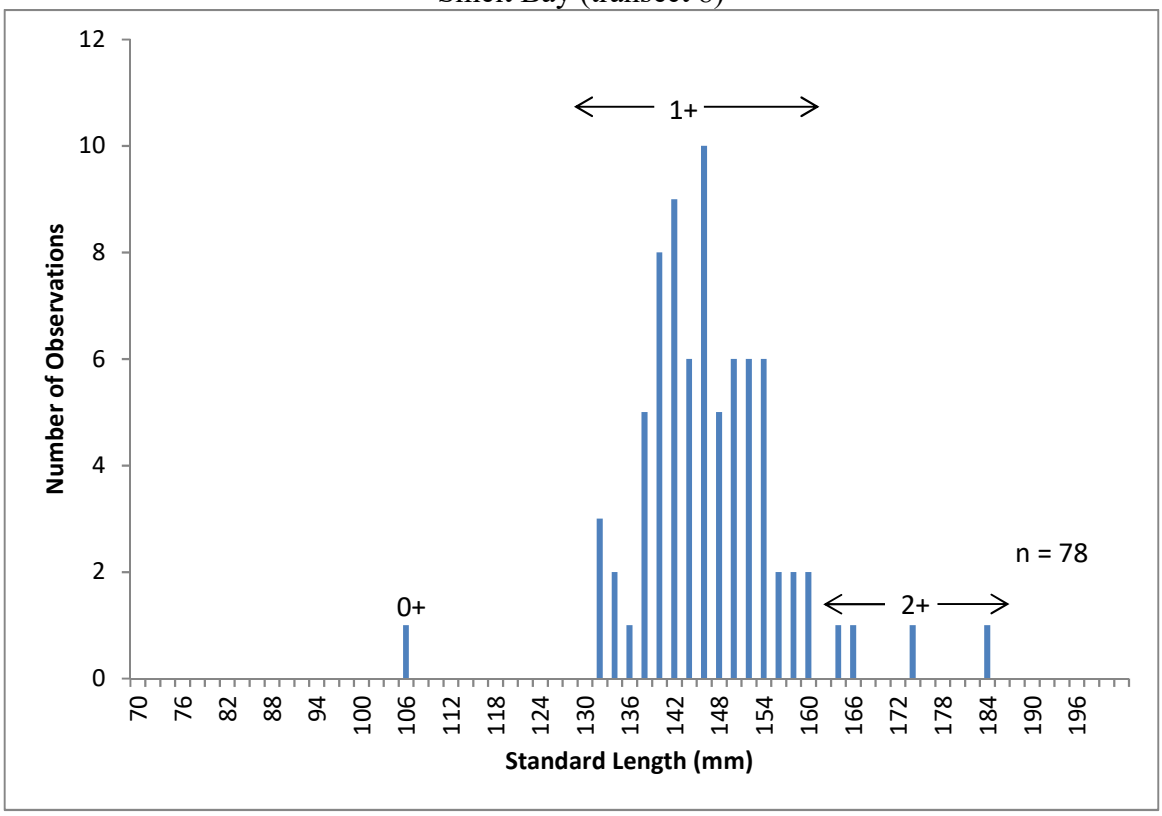


Figure 5 continued.

Smelt Bay (transect 8)



Atrevida Reef (transect 9)

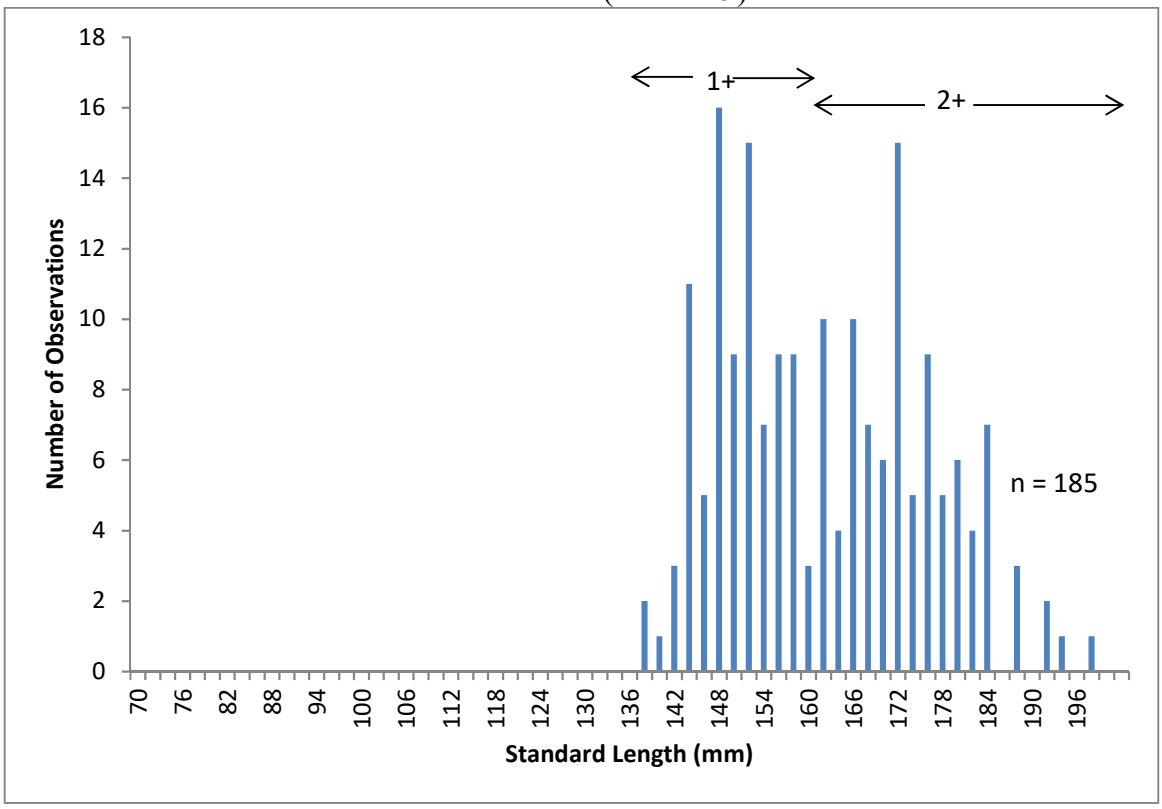
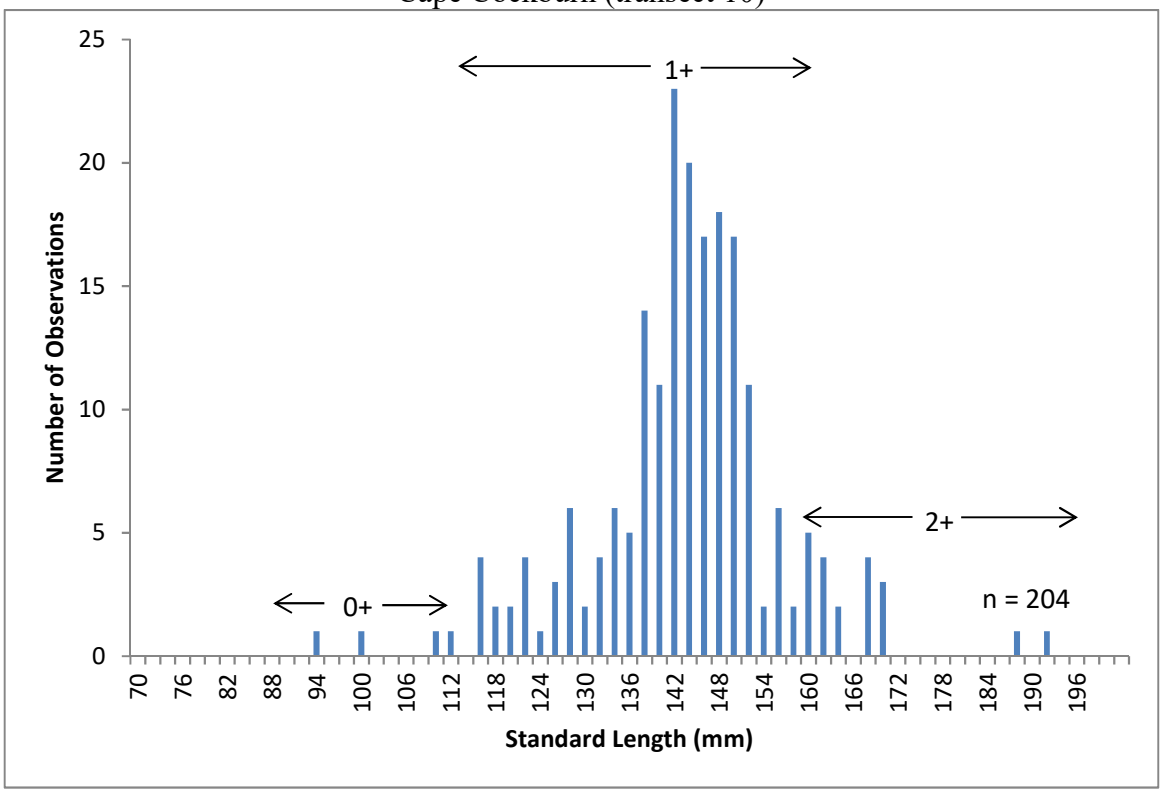


Figure 5 continued.

Cape Cockburn (transect 10)



Secret Cove (transect 11)

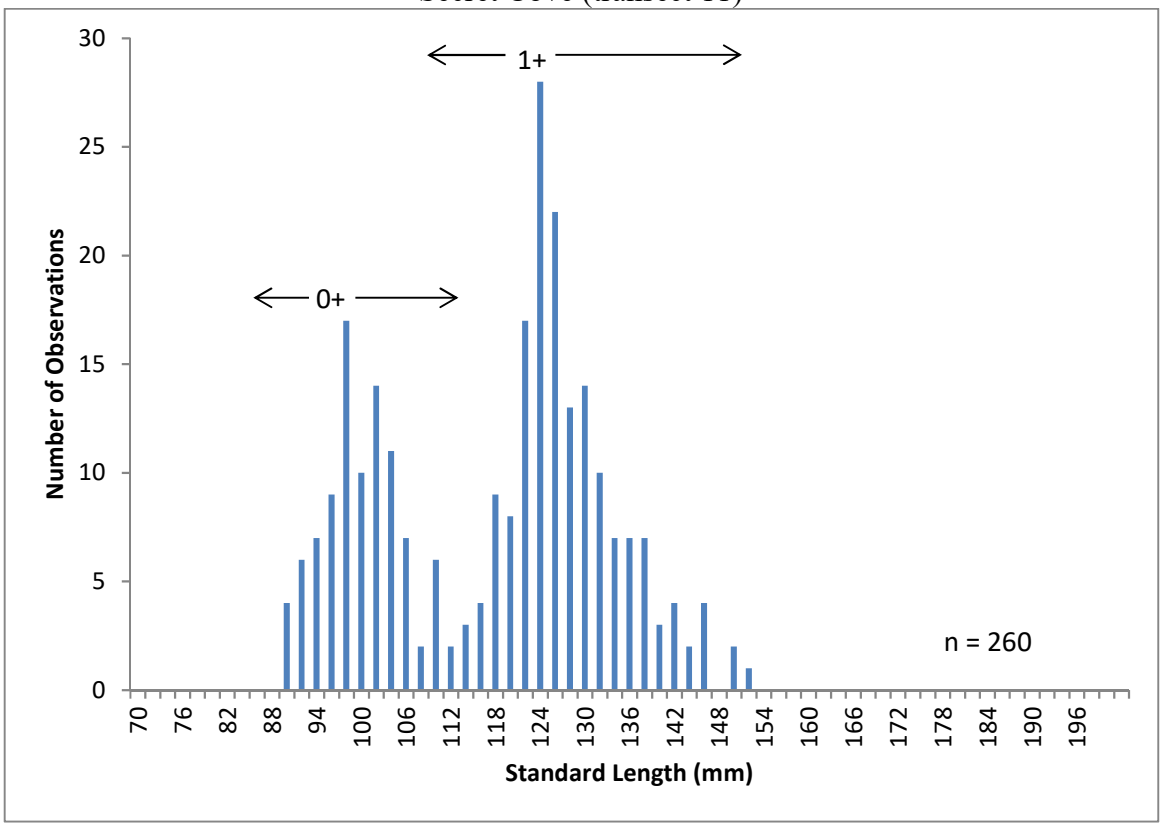


Figure 5 continued.

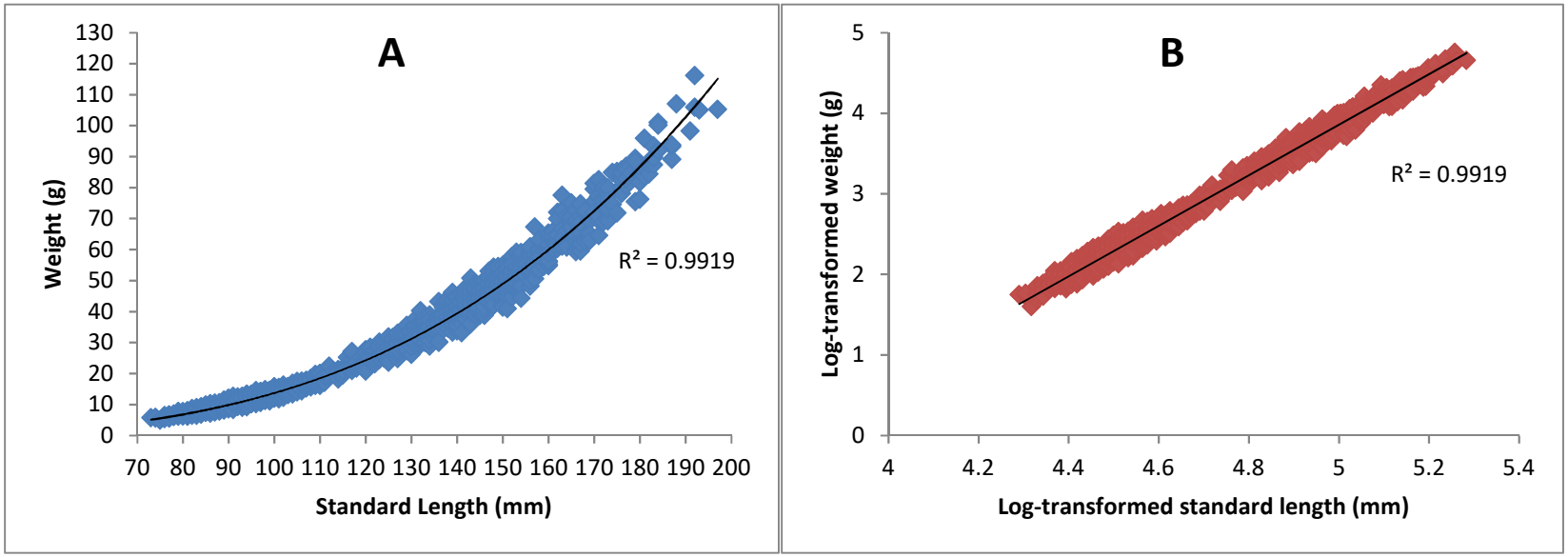


Figure 6. Nontransformed (A) and log-transformed (B) length-weight relationship for all herring sampled during the 2016 Strait of Georgia juvenile herring survey.

Clarke Rock (transect 1)

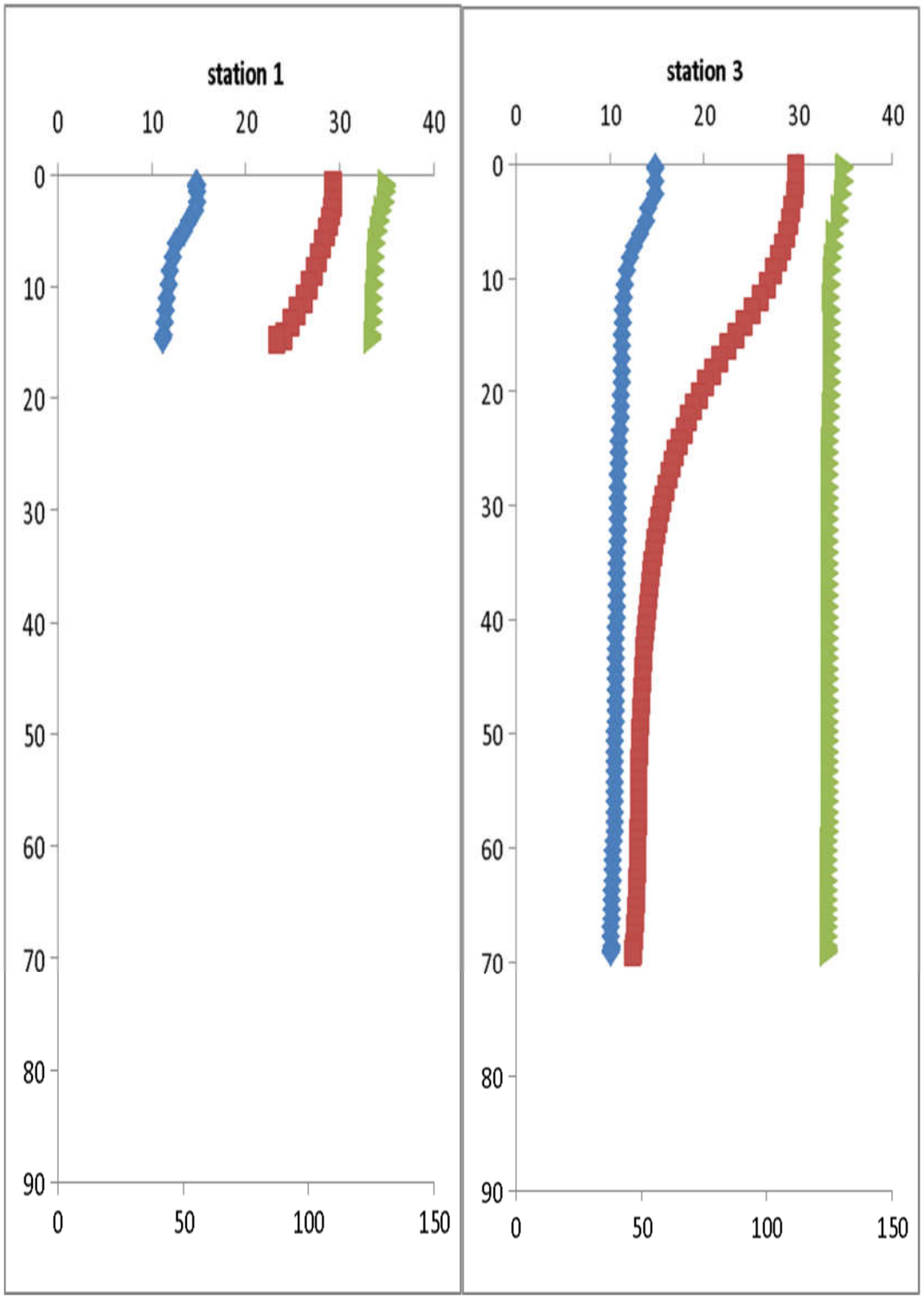


Figure 7. Temperature (blue), salinity (green) and dissolved oxygen (red) profiles from CTD casts during the 2016 Strait of Georgia juvenile herring survey.

Yellow Point (transect 2)

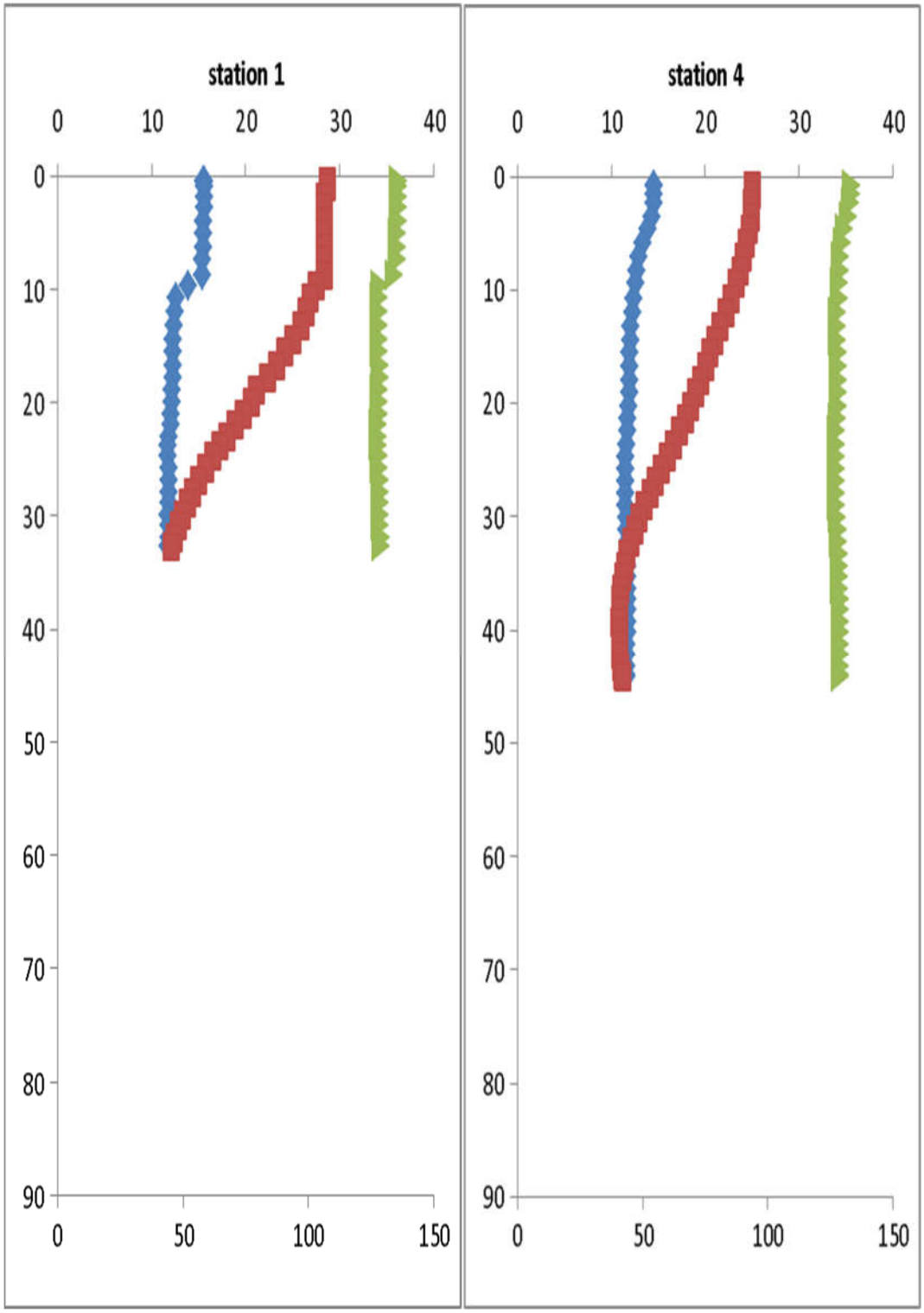


Figure 7 continued.

Bowser (transect 3)

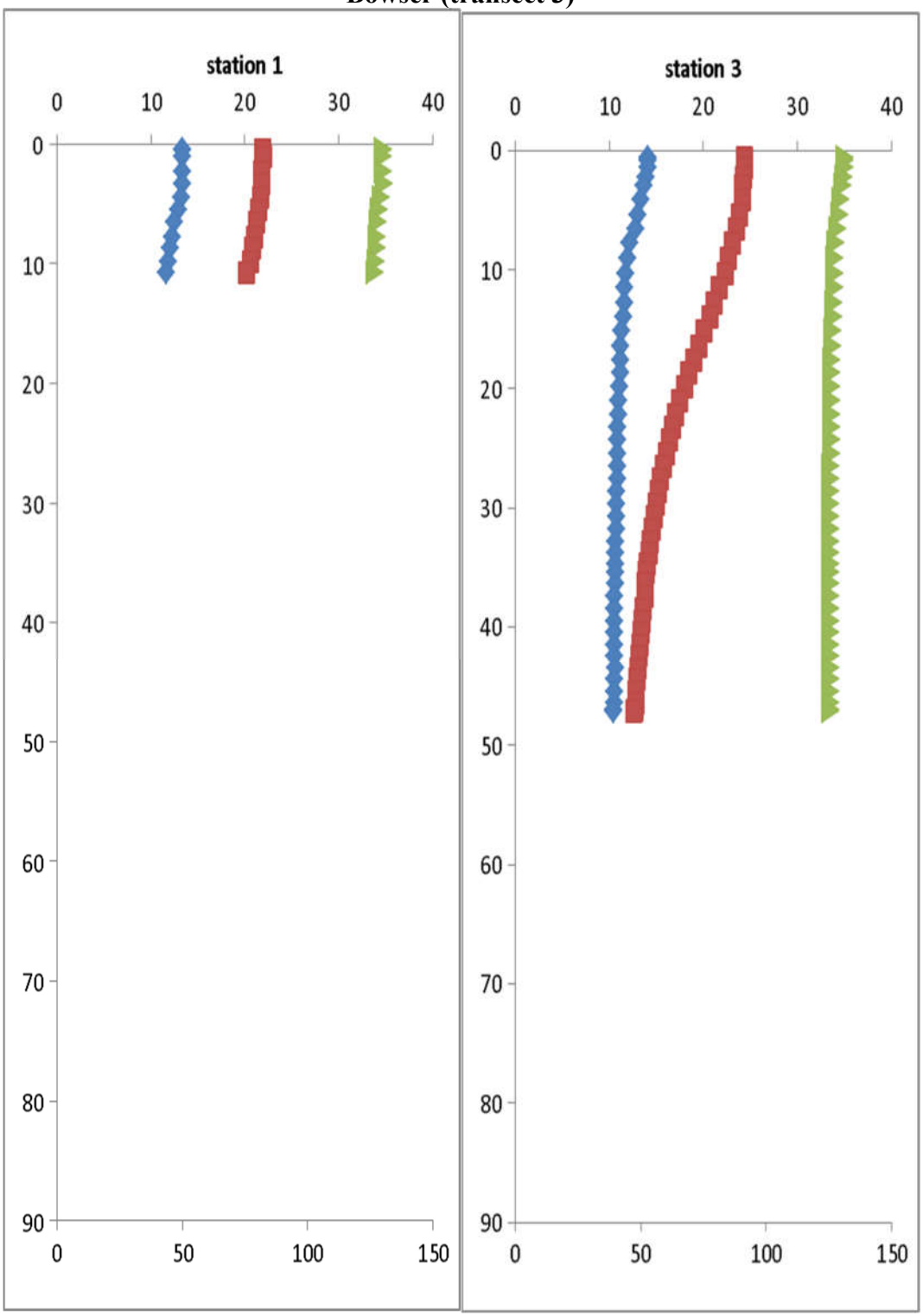


Figure 7 continued.

Henry Bay (transect 4)

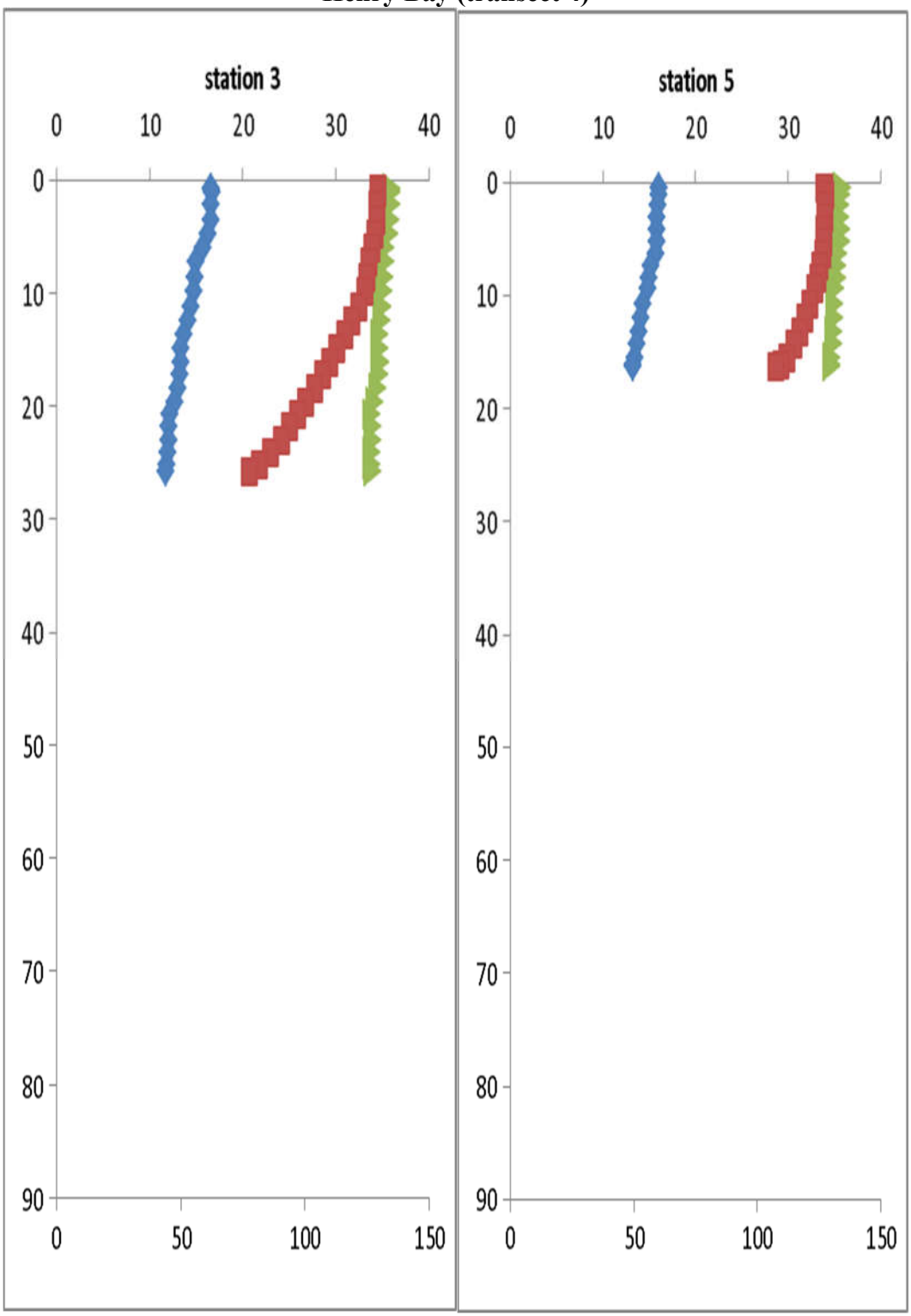


Figure 7 continued.

French Creek (transect 5)

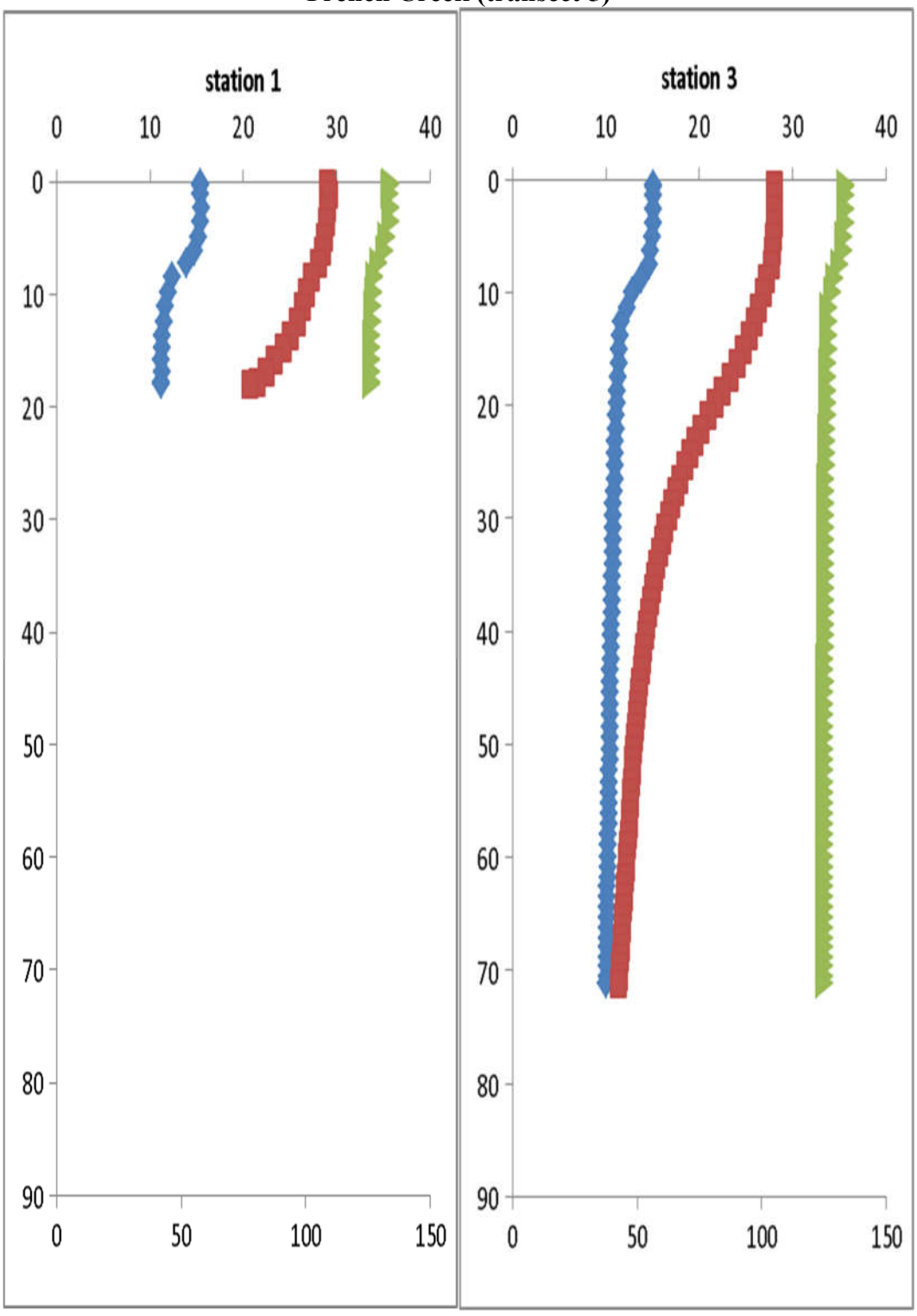


Figure 7 continued.

Trincomali Channel (station 6)

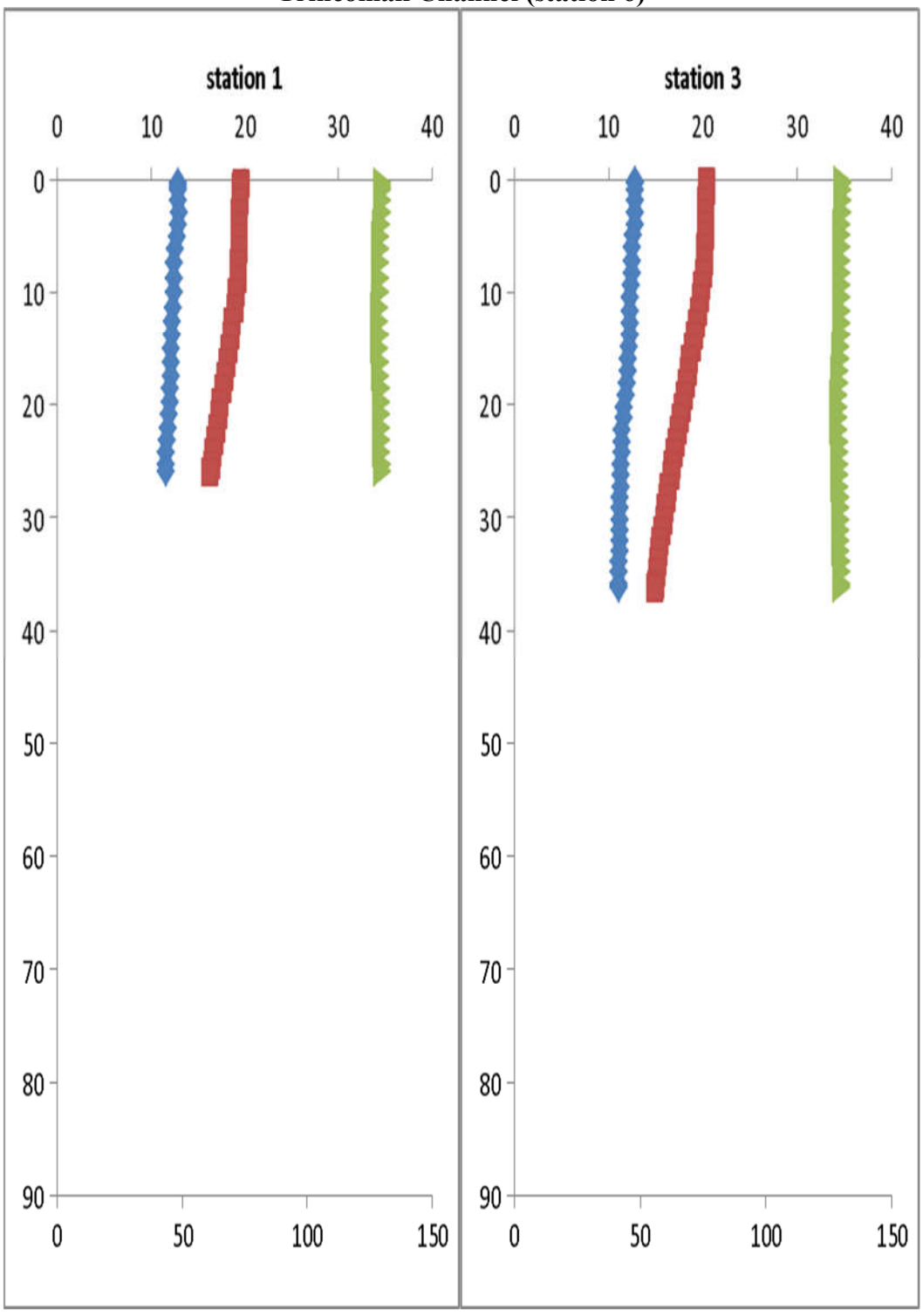


Figure 7 continued.

Smelt Bay (transect 8)

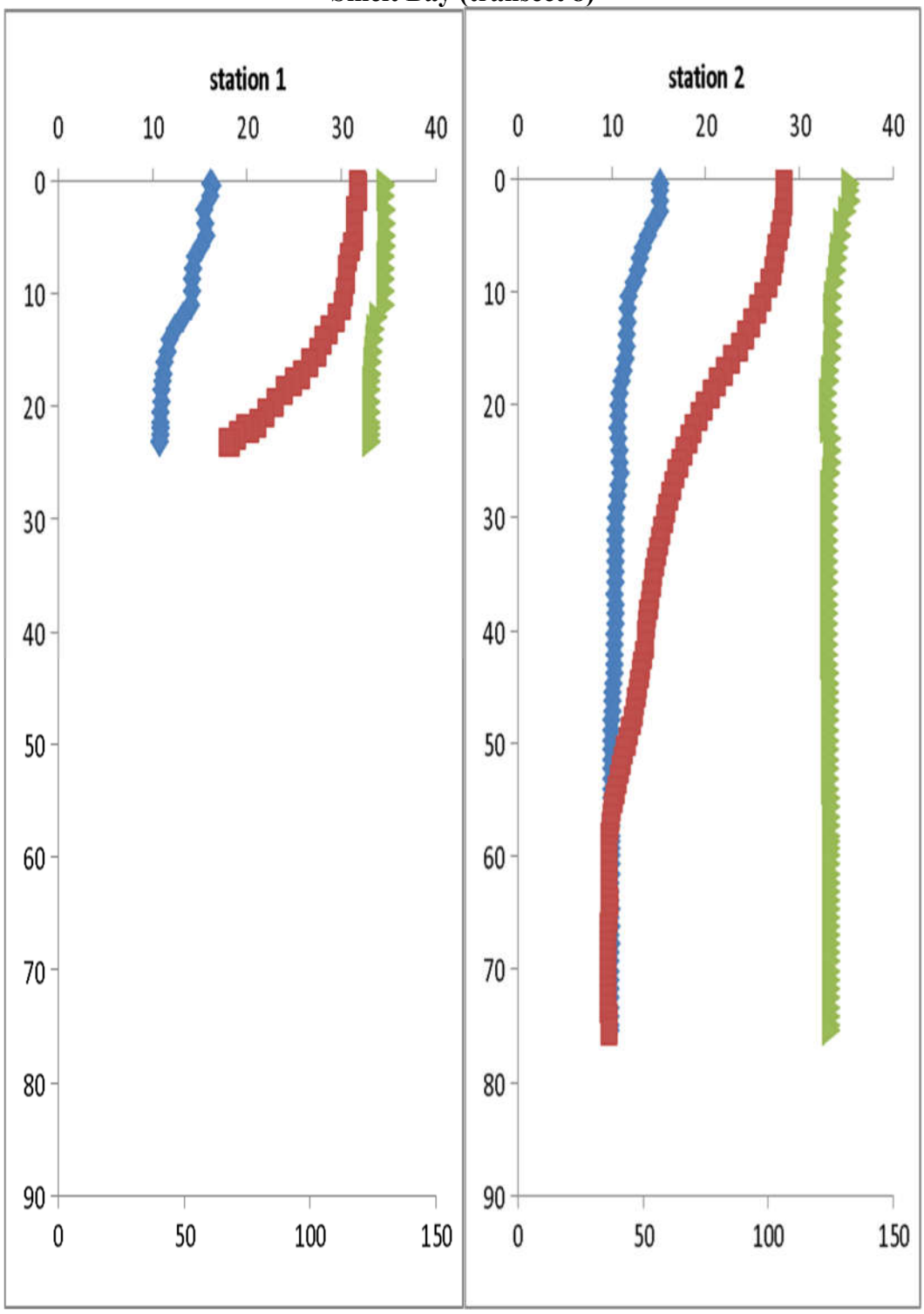
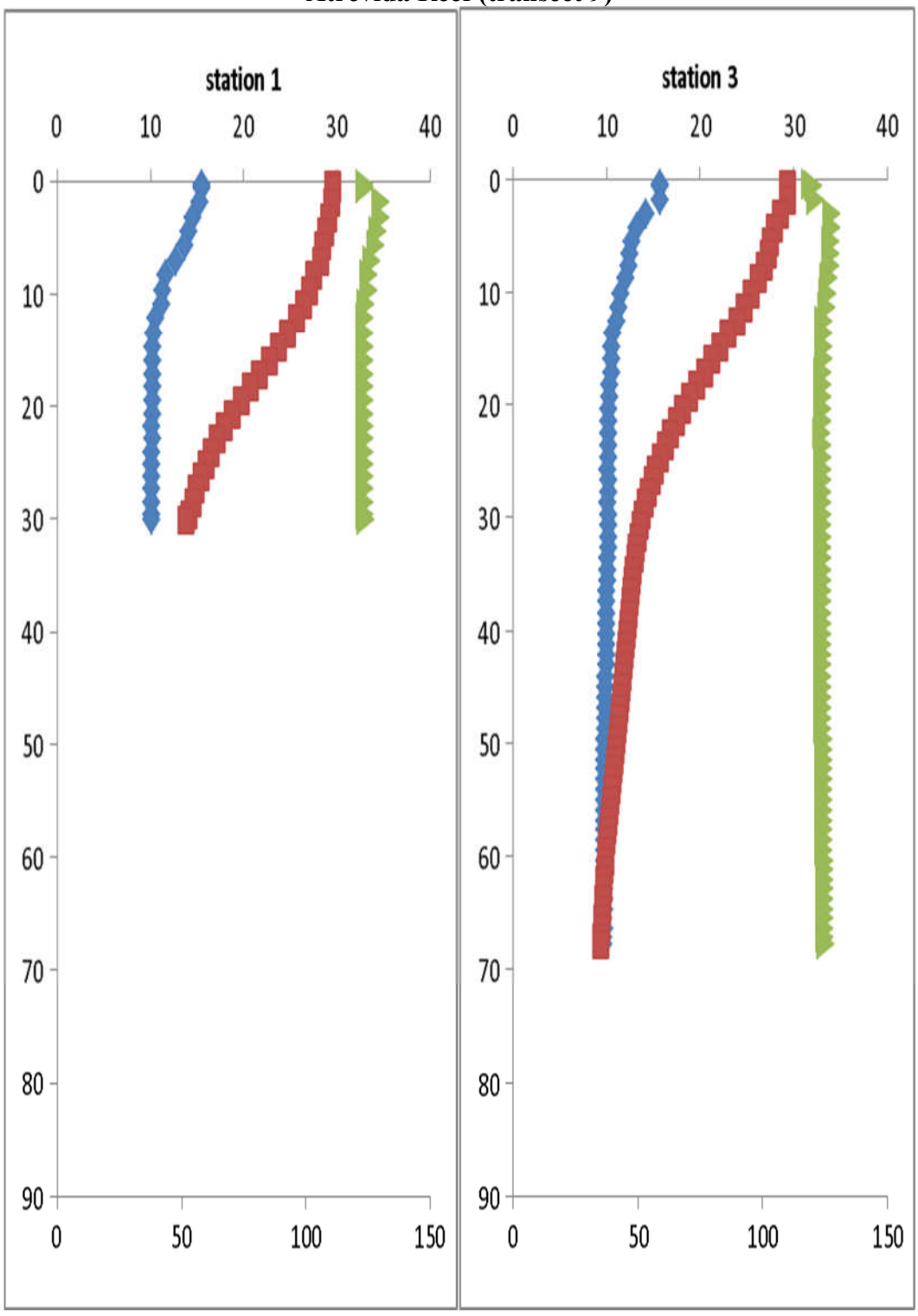


Figure 7 continued.

Atrevida Reef (transect 9)



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Cape Cockburn (transect 10)

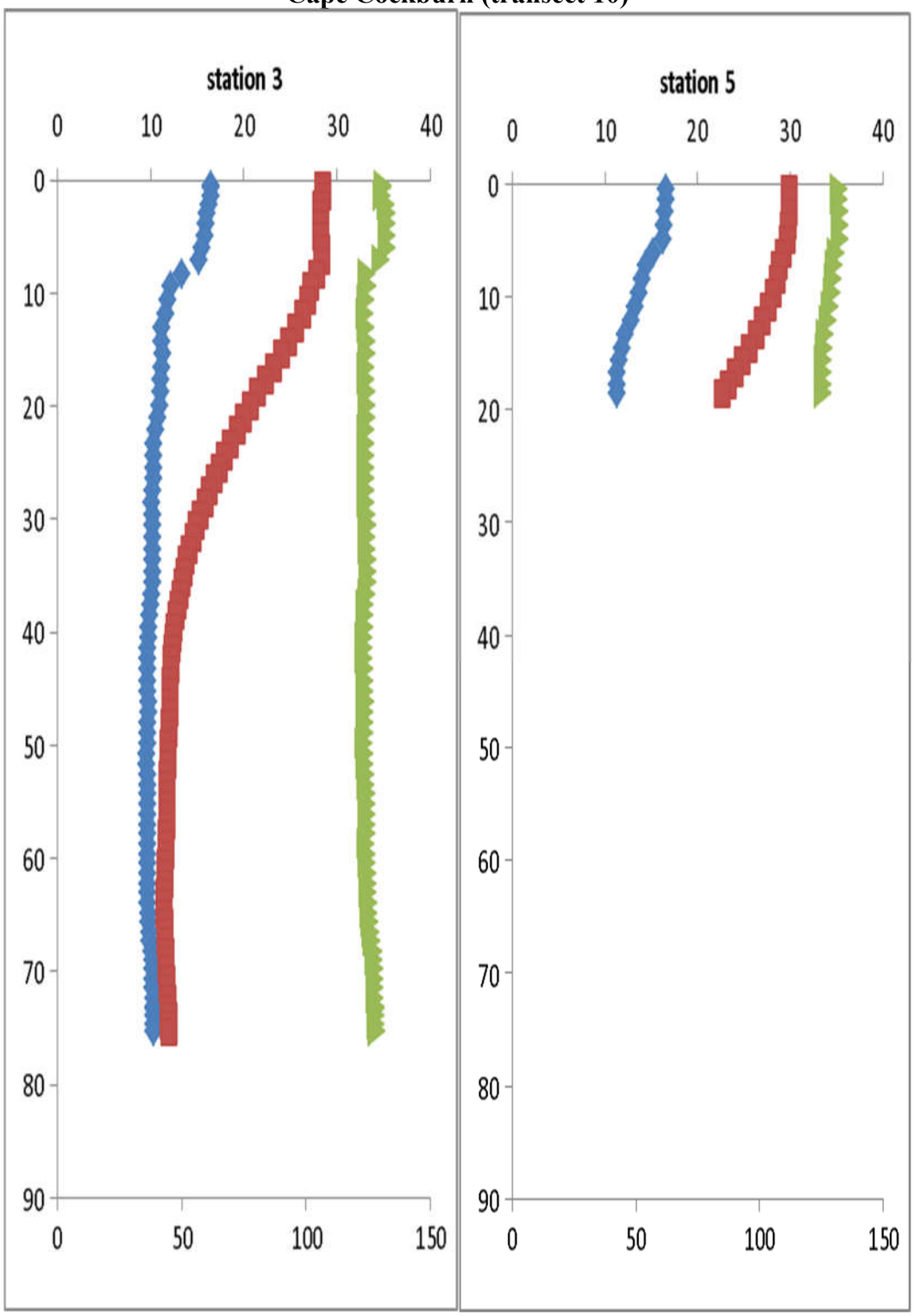

Figure 7 continued.

Secret Cove (transect 11)

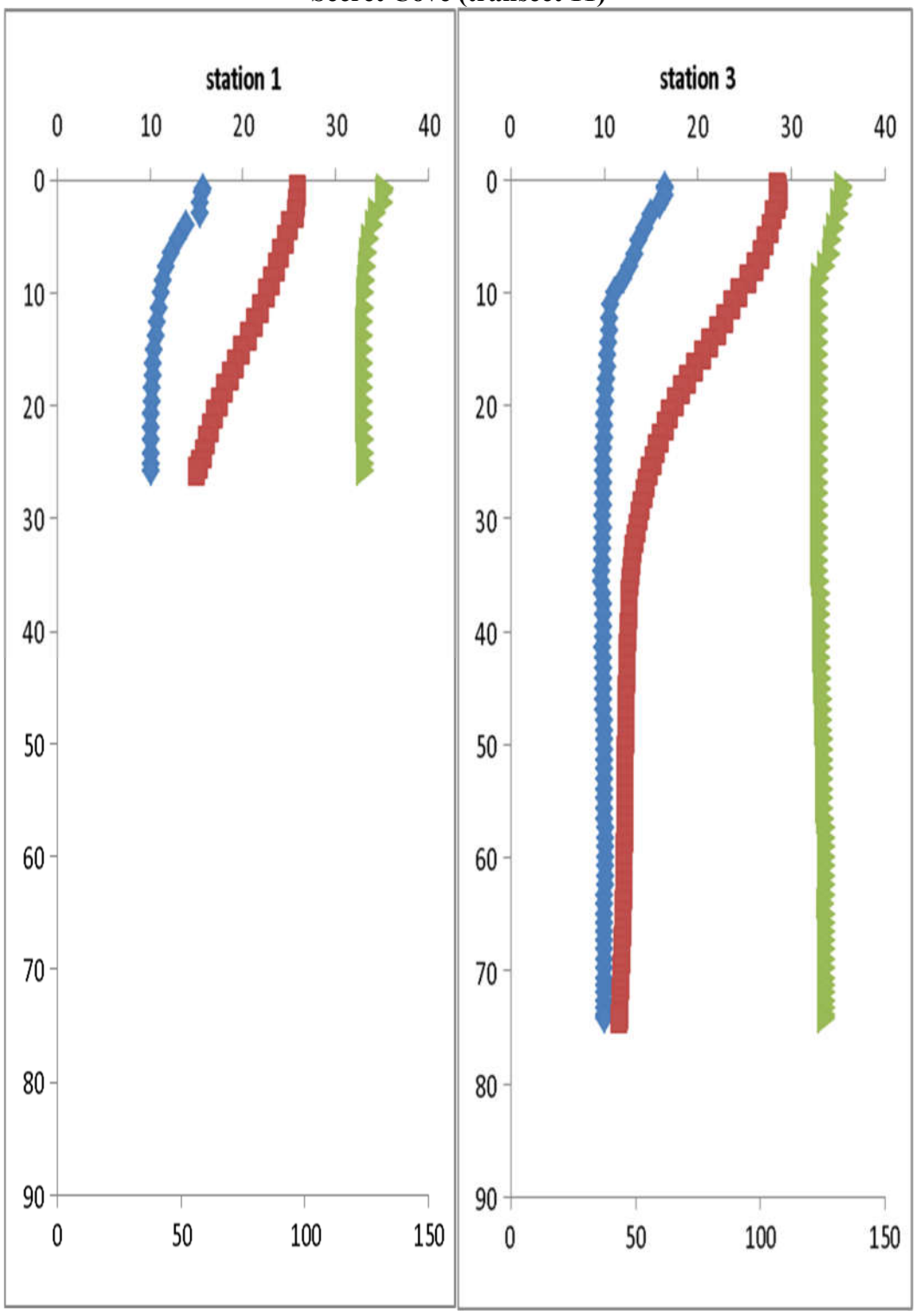

Figure 7 continued.

Table 1. Summary of the purse seine set locations from the 2016 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)
2016	9	7	2	1	2045	Trincomali Channel	48.855	-123.430
2016	9	7	2	2	2115	Trincomali Channel	48.862	-123.423
2016	9	7	2	3	2145	Trincomali Channel	48.867	-123.417
2016	9	7	2	4	2210	Trincomali Channel	48.873	-123.407
2016	9	7	2	5	2235	Trincomali Channel	48.877	-123.407
2016	9	8	6	1	2050	Yellow Point	49.042	-123.747
2016	9	8	6	2	2115	Yellow Point	49.050	-123.733
2016	9	8	6	3	2140	Yellow Point	49.056	-123.722
2016	9	8	6	4	2205	Yellow Point	49.060	-123.708
2016	9	8	6	5	2235	Yellow Point	49.066	-123.698
2016	9	9	1	1	2040	Clarke Rock	49.224	-123.943
2016	9	9	1	2	2105	Clarke Rock	49.233	-123.932
2016	9	9	1	3	2130	Clarke Rock	49.237	-123.922
2016	9	9	1	4	2150	Clarke Rock	49.237	-123.912
2016	9	9	1	5	2215	Clarke Rock	49.238	-123.902
2016	9	12	11	1	2040	Secret Cove	49.535	-123.977
2016	9	12	11	2	2105	Secret Cove	49.532	-123.995
2016	9	12	11	3	2130	Secret Cove	49.528	-124.014
2016	9	12	11	4	2200	Secret Cove	49.527	-124.040
2016	9	12	11	5	2230	Secret Cove	49.523	-124.060
2016	9	13	10	5	2040	Cape Cockburn	49.632	-124.278
2016	9	13	10	4	2105	Cape Cockburn	49.642	-124.255
2016	9	13	10	3	2135	Cape Cockburn	49.651	-124.242
2016	9	13	10	2	2205	Cape Cockburn	49.662	-124.218
2016	9	13	10	1	2230	Cape Cockburn	49.670	-124.198
2016	9	14	8	3	2020	Smelt Bay	50.054	-125.030
2016	9	14	8	2	2045	Smelt Bay	50.046	-125.016
2016	9	14	8	1	2120	Smelt Bay	50.036	-125.000
2016	9	14	9	1	0130	Atrevida Reef	49.916	-124.659
2016	9	14	9	2	0150	Atrevida Reef	49.912	-124.673
2016	9	14	9	3	0215	Atrevida Reef	49.909	-124.684
2016	9	14	9	4	0235	Atrevida Reef	49.906	-124.694
2016	9	14	9	5	0255	Atrevida Reef	49.902	-124.707

Table 1 continued.

Year	Month	Day	Transect	Station	Seine Set Time	Location Name	DD Lat (N)	DD Long (W)
2016	9	15	4	5	2030	Henry Bay	49.602	-124.836
2016	9	15	4	4	2050	Henry Bay	49.598	-124.846
2016	9	15	4	3	2110	Henry Bay	49.598	-124.856
2016	9	15	4	2	2130	Henry Bay	49.601	-124.866
2016	9	15	4	1	2155	Henry Bay	49.593	-124.875
2016	9	19	3	1	2020	Bowser	49.452	-124.680
2016	9	19	3	2	2040	Bowser	49.459	-124.672
2016	9	19	3	3	2105	Bowser	49.467	-124.663
2016	9	19	3	4	2130	Bowser	49.476	-124.657
2016	9	19	3	5	2150	Bowser	49.482	-124.651
2016	9	20	5	5	2035	French Creek	49.366	-124.317
2016	9	20	5	4	2105	French Creek	49.362	-124.323
2016	9	20	5	3	2135	French Creek	49.358	-124.327
2016	9	20	5	2	2155	French Creek	49.353	-124.338
2016	9	20	5	1	2215	French Creek	49.348	-124.350

Table 2. Summary of the number and weight by species, transect, and station for 2016 Strait of Georgia juvenile herring survey.

Transect	Station	Location Name	Species	Number	Weight (Kg)*
1	1	Clarke Rock	**Pacific herring age-0+**	102	1.06
			Pacific herring age-1+	70	2.66
			Pacific herring age-2+	6	0.37
			Chinook salmon	22	1.65
			Chum salmon	14	1.32
			Northern anchovy	2	0.06
			Tube-snout	2	trace
1	2	Clarke Rock	**Pacific herring age-0+**	42	0.43
			Pacific herring age-1+	24	1.14
			Pacific herring age-2+	2	0.14
			Chinook salmon	38	3.84
			Chum salmon	20	2.08
			Northern anchovy	2	0.06
			Pipefish	2	trace
1	3	Clarke Rock	**Pacific herring age-0+**	114	1.16
			Pacific herring age-1+	12	0.52
			Pacific herring age-2+	4	0.28
			Chinook salmon	24	2.03
			Chum salmon	20	2.15
			Hake, juvenile	12	0.41
1	4	Clarke Rock	**Pacific herring age-0+**	100	1.12
			Pacific herring age-1+	74	3.09
			Pacific herring age-2+	2	0.14
			Hake, juvenile	32	1.00
			Chum salmon	8	0.91
			Chinook salmon	6	0.53
1	5	Clarke Rock	**Pacific herring age-0+**	78	0.82
			Pacific herring age-1+	116	4.99
			Pacific herring age-2+	2	0.13
			Hake, juvenile	34	0.57
			Chinook salmon	4	0.36

* weights <0.01 kg referred to as trace

Table 2 continued.

Transect	Station	Location Name	Species	Number	Weight (Kg)*
2	1	Yellow Point	**Pacific herring age-0+**	450	4.78
			Squid	184	0.76
			Northern anchovy	102	0.12
			Plainfin midshipman	4	0.01
			Chinook salmon	2	0.12
			Pipefish	2	trace
2	2	Yellow Point	**Pacific herring age-0+**	89	0.97
			Northern anchovy	529	0.78
			Squid	24	0.10
			Surf perch	8	0.85
			Plainfin midshipman	5	0.03
			Chinook salmon	4	0.29
			Chum salmon	1	0.09
			Three-spine stickleback	1	0.01
2	3	Yellow Point	**Pacific herring age-0+**	304	3.53
			Northern anchovy	172	0.30
			Squid	48	0.14
			Plainfin midshipman	4	trace
2	4	Yellow Point	**Pacific herring age-0+**	71	0.74
			Northern anchovy	494	0.93
			Squid	47	0.18
			Chinook salmon	2	0.19
2	5	Yellow Point	**Pacific herring age-0+**	18	0.18
			Squid	111	0.55
			Northern anchovy	28	0.08
			Chinook salmon	2	0.17
			Pacific sand lance	1	0.01

Table 2 continued.

Transect	Station	Location Name	Species	Number	Weight (Kg)*
3	1	Bowser	**Pacific herring age-0+**	35	0.47
			Pacific herring age-1+	2	0.04
			Squid	29	0.27
			Plainfin midshipman	21	0.01
			Chinook salmon	3	0.20
			Flatfish	3	0.08
			Sculpin	3	0.32
			Pipefish	2	trace
			Pacific sand lance	1	0.01
			Surf perch	1	0.02
3	2	Bowser	**Pacific herring age-0+**	37	0.51
			Pacific herring age-1+	5	0.18
			Pacific herring age-2+	1	0.07
			Chum salmon	23	2.34
			Chinook salmon	17	1.51
			Plainfin midshipman	14	0.01
			Flatfish	2	0.04
			Squid	2	0.01
			Pipefish	1	trace
3	3	Bowser	**Pacific herring age-0+**	1	0.02
			Pacific herring age-1+	1	0.04
			Chum salmon	31	3.52
			Chinook salmon	16	1.45
			Squid	16	0.15
			Plainfin midshipman	12	0.01
3	4	Bowser	**Pacific herring age-0+**	2	0.03
			Pacific herring age-1+	11	0.51
			Pacific herring age-2+	3	0.19
			Squid	17	0.16
			Chinook salmon	13	1.36
			Chum salmon	5	0.50
			Coho salmon	2	0.24
			Northern anchovy	2	0.01
3	5	Bowser	**Pacific herring age-0+**	10	0.13
			Pacific herring age-1+	6	0.22
			Chinook salmon	50	5.04
			Chum salmon	8	0.96

Table 2 continued.

Transect	Station	Location Name	Species	Number	Weight (Kg)*
4	1	Henry Bay	**Pacific herring age-0+**	3	0.03
			Squid	278	2.42
			Plainfin midshipman	2	trace
			Chinook salmon	1	0.04
			Chum salmon	1	0.07
			Pipefish	1	trace
4	2	Henry Bay	**Pacific herring age-0+**	1760	22.02
			Plainfin midshipman	17	0.01
4	3	Henry Bay	**Pacific herring age-0+**	2511	31.43
4	4	Henry Bay	**Pacific herring age-0+**	16	0.18
			Squid	35	0.09
			Northern anchovy	11	0.02
			Gunnel	2	0.02
			Snake prickleback	2	0.02
			Chinook salmon	1	0.06
			Chum salmon	1	0.10
			Plainfin midshipman	1	trace
4	5	Henry Bay	**Pacific herring age-0+**	1	0.02
			Northern anchovy	10	0.09
			Squid	7	0.03
			Plainfin midshipman	1	trace
5	1	French Creek	**Pacific herring age-0+**	175	2.31
			Pacific herring age-1+	2775	124.31
			Pacific herring age-2+	175	10.92
5	2	French Creek	**Pacific herring age-0+**	148	1.82
			Pacific herring age-1+	12	0.39
			Squid	24	0.38
			Chinook salmon	16	1.86
			Chum salmon	4	0.66

Table 2 continued.

Transect	Station	Location Name	Species	Number	Weight (Kg)*
5	3	French Creek	**Pacific herring age-0+**	115	1.39
			Pacific herring age-1+	5	0.21
			Squid	4	0.06
			Chinook salmon	3	0.42
			Coho salmon	1	0.29
			Northern anchovy	1	0.02
5	4	French Creek	**Pacific herring age-0+**	654	7.91
			Pacific herring age-1+	10	0.37
			Pacific herring age-2+	2	0.14
			Squid	14	0.24
			Chinook salmon	4	0.77
			Chum salmon	2	0.22
			Hake, juvenile	2	0.19
5	5	French Creek	**Pacific herring age-0+**	46	0.54
			Pacific herring age-1+	38	1.67
			Pacific herring age-2+	6	0.37
			Squid	100	1.79
			Chum salmon	6	0.55
			Hake, juvenile	6	0.22
			Chinook salmon	2	0.43
			Coho salmon	2	0.57
6	1	Trincomali Channel	**Pacific herring age-0+**	2604	22.93
6	2	Trincomali Channel	**Pacific herring age-0+**	1735	14.68
			Pacific sand lance	5	trace
6	3	Trincomali Channel	**Pacific herring age-0+**	1216	10.14
6	4	Trincomali Channel	**Pacific herring age-0+**	400	3.28
			Squid	10	0.07
			Chum salmon	2	0.16
6	5	Trincomali Channel	**Pacific herring age-0+**	1515	12.73

Table 2 continued.

Transect	Station	Location Name	Species	Number	Weight (Kg)*
8	1	Smelt Bay	**Pacific herring age-1+**	63	2.77
			Pacific herring age-2+	3	0.21
			Squid	15	0.01
			Chinook salmon	5	0.71
			Three-spine stickleback	5	trace
			Hake, juvenile	1	trace
8	2	Smelt Bay	**Pacific herring age-0+**	1	0.02
			Pacific herring age-1+	10	0.46
			Pacific herring age-2+	1	0.07
			Squid	50	0.51
			Chum salmon	19	2.61
			Chinook salmon	4	0.41
			Northern anchovy	1	0.01
8	3	Smelt Bay	Squid	40	0.98
			Pipefish	1	trace
9	1	Atrevida Reef	**Pacific herring age-1+**	5	0.24
			Pacific herring age-2+	2	0.14
			Squid	17	0.06
			Chinook salmon	3	0.29
			Northern anchovy	3	trace
9	2	Atrevida Reef	**Pacific herring age-1+**	18	0.91
			Pacific herring age-2+	41	3.20
			Squid	2	0.06
			Chum salmon	1	0.14
			Hake, juvenile	1	trace
9	3	Atrevida Reef	**Pacific herring age-1+**	21	1.07
			Pacific herring age-2+	18	1.45
			Pipefish	2	trace
			Three-spine stickleback	1	trace
9	4	Atrevida Reef	**Pacific herring age-1+**	45	2.34
			Pacific herring age-2+	34	2.63
			Chinook salmon	1	0.08
			Chum salmon	1	0.18

Table 2 continued.

Transect	Station	Location Name	Species	Number	Weight (Kg)*
9	5	Atrevida Reef	**Pacific herring age-1+**	1	0.06
			Chinook salmon	3	0.49
			Chum salmon	1	0.24
10	1	Cape Cockburn	**Pacific herring age-0+**	4	0.06
			Pacific herring age-1+	43	1.34
			Three-spine stickleback	10	0.01
			Northern anchovy	7	0.03
			Chinook salmon	5	0.36
			Chum salmon	5	0.59
			Squid	1	0.03
10	2	Cape Cockburn	**Pacific herring age-1+**	176	7.64
			Pacific herring age-2+	10	0.70
			Hake, juvenile	10	0.02
			Chinook salmon	2	0.12
			Plainfin midshipman	2	trace
10	3	Cape Cockburn	**Pacific herring age-1+**	112	5.38
			Pacific herring age-2+	20	1.42
			Hake, juvenile	70	1.84
			Squid	2	0.05
10	4	Cape Cockburn	**Pacific herring age-1+**	6	0.28
			Hake, juvenile	74	2.65
			Plainfin midshipman	20	0.01
			Walleye pollock, adult	1	0.34
10	5	Cape Cockburn	**Pacific herring age-1+**	2	0.08
			Squid	159	1.99
			Chinook salmon	21	2.77
			Plainfin midshipman	3	trace
11	1	Secret Cove	**Pacific herring age-0+**	2	0.04
			Pacific herring age-1+	4	0.12
			Chinook salmon	66	5.46
			Northern anchovy	52	0.25
			Three-spine stickleback	42	0.07
			Chum salmon	20	2.30
			Squid	10	0.14
			Hake, juvenile	2	0.09

Table 2 continued.

Transect	Station	Location Name	Species	Number	Weight (Kg)*
11	2	Secret Cove	**Pacific herring age-0+**	47	0.66
			Pacific herring age-1+	149	4.42
			Northern anchovy	35	0.18
			Hake, juvenile	7	0.12
			Chinook salmon	3	0.23
			Chum salmon	1	0.17
11	3	Secret Cove	**Pacific herring age-0+**	43	0.59
			Pacific herring age-1+	12	0.34
			Northern anchovy	4	0.01
			Chinook salmon	3	0.23
			Chum salmon	2	0.22
11	4	Secret Cove	**Pacific herring age-0+**	4	0.06
			Pacific herring age-1+	1	0.03
			Chinook salmon	5	11.79
			Chum salmon	1	0.13
11	5	Secret Cove	**Pacific herring age-0+**	1	0.01
			Hake, juvenile	21	0.22
			Pacific lamprey	1	0.01

Table 3. Percent occurrence by species in purse seine sets for the Strait of Georgia juvenile herring survey in 2016.

Common Name	Scientific Name	Number of sets	Percent Occurrence
Pacific herring age-0+	*Clupea pallasi* in year of birth	37	77.1
Pacific herring age-1+	*Clupea pallasi* in first year	31	64.6
Pacific herring age-2+	*Clupea pallasi* in second or more years	18	37.5
Bay pipefish	*Syngnathus griseolineatus*	7	14.6
Chinook salmon	*Oncorhyncus tshawytscha*	32	66.7
Chum salmon	*Oncorhyncus keta*	24	50.0
Coho salmon	*Oncorhyncus kisutch*	3	6.3
Flatfish	*Parophyrus vetulus, Lepidopsetta bilineata, Platichthys stellatus, Citharichthys stigmaens*	2	4.2
Gunnel	*Apodichthys flavidus, Pholis laeta*	1	2.1
Hake, juvenile	*Merluccius productus*	13	27.1
Northern anchovy	*Engraulis mordax mordax*	17	35.4
Pacific lamprey	*Lampetra tridentatus*	1	2.1
Pacific sand lance	*Ammodytes hexapterus*	3	6.3
Plainfin midshipman	*Porichthys notatus*	13	27.1
Sculpin	*Hemilepidotus hemilepidotus*	1	2.1
Snake prickleback	*Lumpenus sagitta*	1	2.1
Squid	*Loligo opalescens, Gonatus fabricii*	26	54.2
Surf perch	*Hyperprosopon ellipticum*	1	2.1
Three-spine stickleback	*Gasterosteus aculeatus*	5	10.4
Tube-snout	*Aulorhynchus flavidus*	1	2.1
Walleye Pollock, adult	*Gadus chalcogrammus*	1	2.1

* 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 2016 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	188	79-105	91	5.06	6.91-15.93	10.40	1.83	436	4.59
Yellow Point	2	390	74-109	91	5.88	5.65-18.63	10.82	2.12	932	10.20
Bowser	3	80	84-111	100	6.06	7.98-19.10	13.64	2.46	85	1.16
Henry Bay	4	220	85-110	96	4.48	9.31-19.27	12.30	1.66	4291	53.68
French Creek	5	319	85-112	97	5.26	7.68-19.01	12.10	2.02	1138	13.97
Trincomali	6	500	73-102	86	4.83	4.95-14.25	8.40	1.45	7470	63.77
Smelt Bay	8	1	-	105	-	-	15.75	-	1	0.02
Atrevida Reef	9	-	-	-	-	-	-	-	-	-
Cape Cockburn	10	4	94-111	104	8.18	11.21-20.03	15.73	4.67	4	0.06
Secret Cove	11	96	89-113	100	5.59	10.50-22.32	14.04	2.31	97	1.37
All Locations		1798	73-113	92	7.24	4.95-22.32	10.82	2.60	14454	148.80

Table 4 continued.

Age-1+ Herring

			Length (mm)			Weight (g)				
Location Name	**Transect**	**Number Sampled**	**Range**	**Mean**	**SD**	**Range**	**Mean**	**SD**	**N**	**Wt (Kg)**
Clarke Rock	1	138	123-160	141	7.33	28.96-59.63	41.92	6.33	296	12.40
Yellow Point	2	-	-	-	-	-	-	-	-	-
Bowser	3	22	114-158	139	13.00	20.57-59.82	39.77	11.07	25	0.98
Henry Bay	4	-	-	-	-	-	-	-	-	-
French Creek	5	148	114-160	145	8.38	18.26-59.09	43.95	6.97	2840	126.94
Trincomali	6	-	-	-	-	-	-	-	-	-
Smelt Bay	8	73	131-160	145	6.85	30.93-60.53	44.21	6.46	73	3.23
Atrevida Reef	9	90	138-160	150	5.29	36.21-67.30	51.29	5.73	90	4.62
Cape Cockburn	10	185	116-160	142	9.61	20.95-65.34	42.02	8.93	339	14.71
Secret Cove	11	164	114-151	128	7.75	20.44-49.78	29.54	5.57	166	4.91
All Locations		820	114-160	141	10.74	18.26-67.30	41.01	9.52	3829	167.79

Age-2+ Herring

			Length (mm)			Weight (g)				
Location Name	**Transect**	**Number Sampled**	**Range**	**Mean**	**SD**	**Range**	**Mean**	**SD**	**N**	**Wt (Kg)**
Clarke Rock	1	8	161-171	166	3.54	59.23-75.42	66.02	5.26	16	1.06
Yellow Point	2	-	-	-	-	-	-	-	-	-
Bowser	3	4	161-167	163	2.71	60.73-67.03	63.57	2.62	4	0.25
Henry Bay	4	-	-	-	-	-	-	-	-	-
French Creek	5	9	161-179	167	5.54	59.75-75.43	64.13	5.13	183	11.42
Trincomali	6	-	-	-	-	-	-	-	-	-
Smelt Bay	8	4	163-184	172	9.33	59.33-91.84	71.33	14.96	4	0.29
Atrevida Reef	9	95	161-197	173	8.22	59.22-107.05	78.15	11.13	95	7.42
Cape Cockburn	10	15	161-192	169	9.06	59.50-116.15	70.62	14.90	30	2.12
Secret Cove	11	-	-	-	-	-	-	-	-	-
All Locations		135	161-197	171	8.27	59.22-116.15	75.03	12.02	332	22.56

Table 5. Organisms by phylum, and with abbreviations, observed in zooplankton samples collected during the 2016 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
CEPH	Cephalopod
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
SHRI	Shrimp zoea
Chaetognatha	
CHAE	Chaetognaths; mainly *Sagitta sp.*
Chordata	
LARV	Larvaceans; mainly *Oikopleura sp.* and some *Fritillaria sp.*
Ectoproct	
ECTO	Ectoprocts
Miscellaneous	
EGGS	Unidentified eggs; either euphausiid or teleost

Table 6. Abbreviations for calanoid and cyclopoid copepods identified in the 2016 zooplankton samples from the Strait of Georgia juvenile herring survey.

Calanoid copepods	
ADIV	*Aetidius divergens*
ALON	*Acartia longiremis*
CABD	*Centropages abdominates*
CALA	*Calanus sp.*
CMAR	*Calanus marshallae*
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

Table 7. Volume of water filtered and number of zooplankton per m^3 of water in samples collected during the 2016 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	CEPH	CHAE
Clarke Rock	1	1	15.196	-	-	1.1	16.9	-	6.3	4.2	-	2.2
		3	16.390	-	-	32.5	0.5	-	0.7	9.8	-	0.1
Yellow Point	2	1	16.949	-	-	9.9	1.9	-	49.1	-	-	1.9
		4	15.357	-	-	10.2	-	-	165.1	6.3	-	-
Bowser	3	1	13.584	-	3.5	-	77.7	-	31.7	28.3	-	0.1
		3	17.826	-	0.9	9.9	3.6	-	3.4	0.9	-	0.1
Henry Bay	4	3	10.211	-	50.1	0.1	727.1	-	77.2	-	-	-
		5	8.716	-	-	-	484.7	3.7	99.1	3.7	0.1	-
French Creek	5	1	15.834	-	1.2	-	1.1	-	0.7	-	-	-
		3	19.234	-	-	20.6	0.4	0.1	34.5	-	-	0.8
Trincomali	6	1	9.967	-	-	6.6	147.7	-	28.9	25.7	-	-
		3	6.314	-	-	20.7	770.3	-	66.8	60.8	-	-
Smelt Bay	8	1	19.933	-	-	6.6	0.9	-	62.8	9.6	-	0.8
		2	17.777	-	72.0	21.2	-	-	825.2	14.4	-	-
Atrevida Reef	9	1	21.758	-	8.8	-	0.7	0.1	100.2	-	-	-
		3	20.002	-	12.8	8.2	0.4	-	388.2	-	-	-
Cape Cockburn	10	3	18.572	-	-	26.8	0.1	-	915.1	-	-	1.0
		5	20.207	-	-	4.1	3.8	-	394.4	-	-	0.4
Secret Cove	11	1	19.193	3.3	-	2.1	19.9	-	260.2	3.3	-	0.3
		3	19.585	-	-	5.5	0.3	-	348.3	13.1	-	0.3

Table 7 continued.

Location	Tran	Stn	CLAD	CMAR	CNAU	COEL	CPAC	CRAM	CRAZ	CTEN	EBUN	ECTO	EELO
Clarke Rock	1	1	4.2	-	-	3.2	-	-	-	-	-	1.1	-
		3	-	0.1	-	-	0.3	-	0.2	-	0.1	-	0.1
Yellow Point	2	1	-	-	-	1.9	0.1	-	-	41.5	-	-	-
		4	-	-	-	9.0	44.5	-	4.4	7.6	-	-	-
Bowser	3	1	28.3	-	-	-	-	-	0.1	0.1	-	-	-
		3	2.7	-	-	-	-	-	-	0.1	-	-	-
Henry Bay	4	3	1115.7	-	-	12.8	-	0.4	0.1	-	-	-	-
		5	572.8	-	-	0.7	-	0.1	0.2	-	-	-	-
French Creek	5	1	0.6	-	-	-	-	-	0.3	-	-	-	-
		3	-	-	0.2	-	-	-	0.2	-	-	-	-
Trincomali	6	1	-	-	-	14.0	-	0.1	0.8	0.9	-	-	-
		3	-	-	40.5	42.8	-	0.3	20.7	22.0	-	-	-
Smelt Bay	8	1	-	-	-	25.6	0.1	-	2.4	2.3	-	0.8	-
		2	-	0.1	-	14.9	7.3	-	1.8	38.7	-	-	-
Atrevida Reef	9	1	-	0.1	-	0.4	0.0	0.1	2.6	-	0.1	-	-
		3	-	4.4	-	0.4	7.4	-	1.2	-	-	-	-
Cape Cockburn	10	3	-	0.4	-	-	1.8	-	1.7	2.9	-	-	-
		5	-	-	-	0.2	0.0	-	-	-	-	0.2	0.1
Secret Cove	11	1	0.4	-	-	0.2	-	-	1.3	-	-	-	-
		3	-	-	-	-	0.2	-	-	-	-	0.1	-

Table 7 continued.

Location	Tran	Stn	EGGS	ELON	EUPA	EUPL	GAST	LARV	METR	MPAC	OATL	OBOR	OSIM
Clarke Rock	1	1	862.3	-	-	1.1	43.2	95.8	-	-	44.2	-	176.9
		3	472.5	-	0.1	1.0	0.5	3.2	-	97.6	60.5	-	-
Yellow Point	2	1	1.9	-	-	-	9.4	45.3	-	-	-	-	-
		4	31.3	-	0.1	-	31.3	68.8	-	-	-	-	12.5
Bowser	3	1	-	-	-	-	68.3	106.0	-	0.7	2.4	1.2	13.0
		3	-	-	-	0.9	11.7	58.3	-	61.4	14.4	-	22.4
Henry Bay	4	3	0.1	-	-	-	125.4	1002.8	-	-	-	-	188.0
		5	-	-	-	0.1	161.6	499.3	-	-	-	-	69.8
French Creek	5	1	-	-	-	-	1.1	0.8	0.1	-	0.3	-	0.6
		3	-	-	-	7.3	2.7	1.7	103.6	-	-	-	16.6
Trincomali	6	1	-	-	-	-	25.7	1142.9	-	-	-	-	144.5
		3	-	-	0.2	-	60.8	2534.0	-	-	10.1	-	344.6
Smelt Bay	8	1	-	0.1	0.1	5.6	45.0	2.4	3.7	-	-	-	1.6
		2	-	-	-	22.5	43.2	-	45.7	-	-	-	-
Atrevida Reef	9	1	-	-	0.7	25.7	2.6	-	17.6	-	5.9	-	11.8
		3	-	0.4	13.2	44.0	4.8	6.2	68.1	-	-	-	-
Cape Cockburn	10	3	-	-	0.2	83.6	1.7	-	-	23.0	13.8	-	-
		5	-	-	0.0	5.7	0.8	0.2	-	20.7	34.8	-	-
Secret Cove	11	1	-	-	0.1	7.7	1.0	0.4	-	-	13.3	-	-
		3	-	-	0.1	9.3	0.5	-	-	18.3	6.5	-	-

Table 7 continued.

Location	Tran	Stn	OSTR	PELE	POLY	PPAR	PSEU	SHRI	SIPH	SMIN	TDIS	UCAL	UHAR
Clarke Rock	1	1	-	2.2	11.6	23.2	2.1	5.3	2.3	-	-	-	-
		3	1.7	-	0.8	-	29.3	1.8	1.5	2.0	-	-	-
Yellow Point	2	1	-	-	-	-	-	7.6	354.9	-	-	-	-
		4	-	-	0.1	-	-	7.6	251.3	-	-	-	-
Bowser	3	1	-	-	-	21.9	64.8	-	0.1	-	-	-	-
		3	-	0.9	-	-	23.3	-	0.1	-	-	-	-
Henry Bay	4	3	-	-	100.4	847.4	203.7	25.8	12.7	-	-	-	-
		5	-	-	-	162.2	14.0	0.9	0.2	-	-	0.1	-
French Creek	5	1	-	0.1	-	0.6	0.8	-	0.1	-	-	-	0.3
		3	0.2	-	-	1.7	26.6	0.2	-	-	1.7	-	-
Trincomali	6	1	-	6.4	6.4	35.3	12.8	6.5	58.6	-	-	-	-
		3	-	60.8	-	62.9	42.6	0.5	20.4	10.1	-	-	-
Smelt Bay	8	1	-	-	1.6	20.2	62.6	13.6	6.1	-	-	-	-
		2	-	-	1.8	146.5	151.2	8.6	26.1	-	-	-	-
Atrevida Reef	9	1	0.4	-	-	5.9	58.8	21.6	-	-	-	-	-
		3	-	-	-	6.4	236.8	3.8	0.4	-	-	-	-
Cape Cockburn	10	3	-	-	-	-	82.7	0.9	0.1	-	-	-	-
		5	-	-	-	-	25.3	6.3	-	-	-	-	-
Secret Cove	11	1	-	-	-	-	26.7	5.2	0.1	-	-	-	-
		3	3.2	-	-	-	241.8	0.7	-	-	-	-	-

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 2016 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 CPUE (weight and abundance) of age-0 herring varied interannually with no significant overall trend during 1992-2016 (Figures A1 and Table A1). A peak in average catches has not been observed within the last 4 years of the time series. In 2016, mean estimates were lower than those in 2015 (Figure A1 and Table A1). For example, the mean catch weight in 2016 was approximately 3.0 kg, but in 2015 was 4.9 kg. Estimates of CVs ranged from 23% to 81% with an average of 47% (Figure A1 and Table A1). In 2016, 1,798 age-0 herring were measured; they were heavier and longer than fish measured in most years, but smaller than those in measured in 2015 (Figure A2). 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.

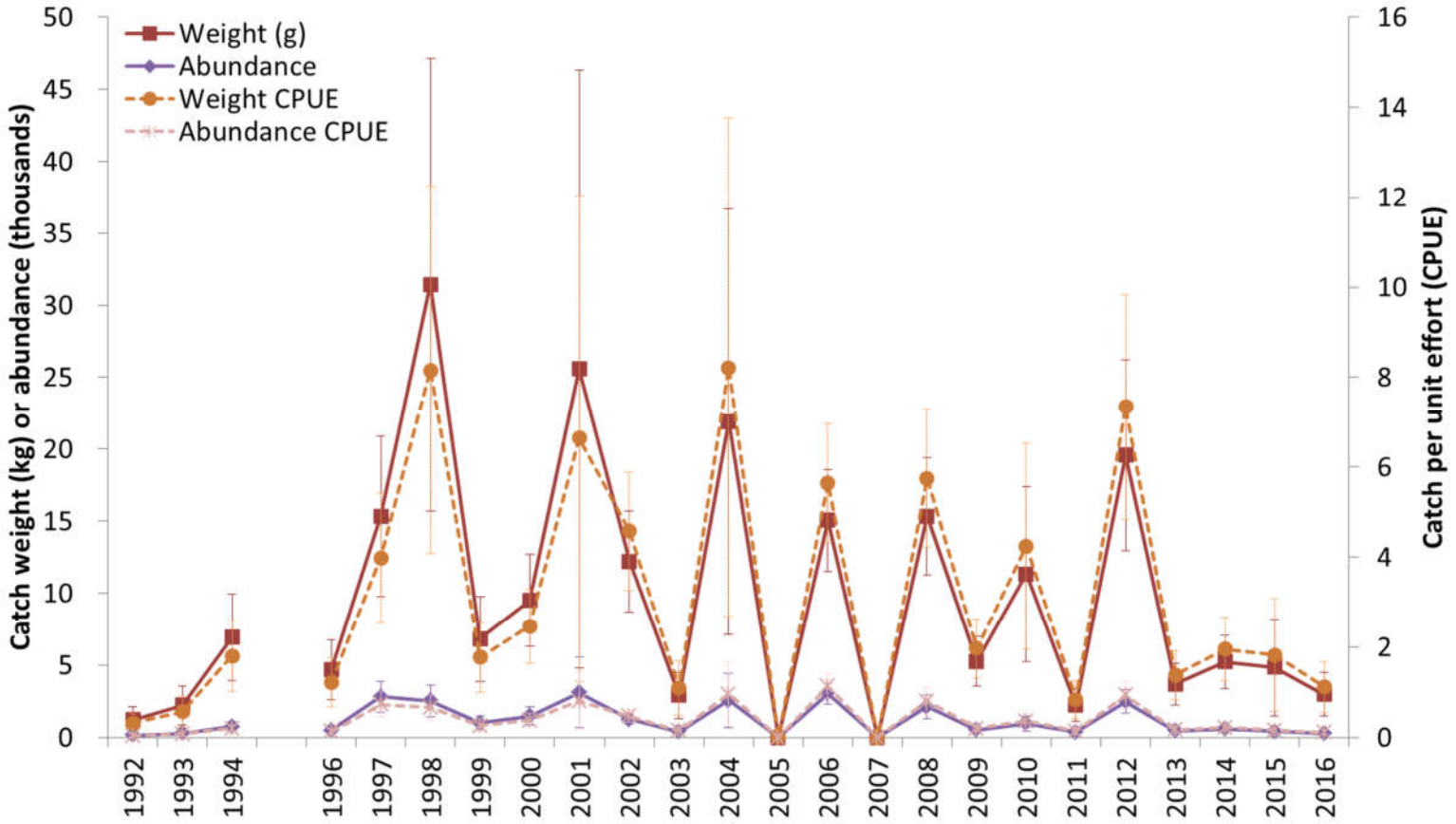

Figure A1. Estimates of catch weight (g), catch weight-per-unit-effort (weight CPUE; g/m^2), abundance, and abundance CPUE (number/m^2) of age-0 herring caught in the Strait of Georgia juvenile herring survey at core transects and stations during 1992-2016 (no survey in 1995). Estimates were calculated 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.

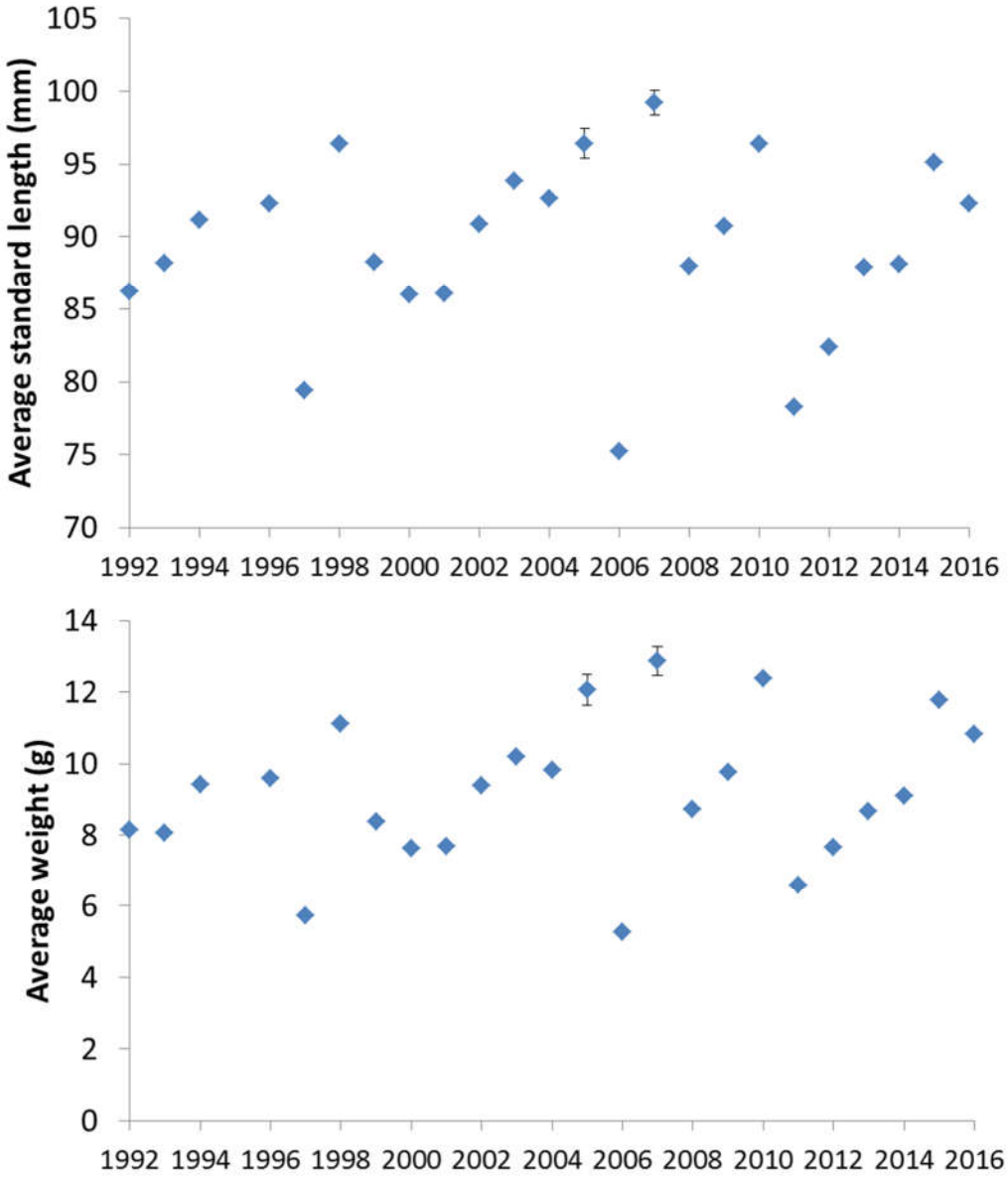

Figure A2. Age-0 herring mean standard lengths (mm; top panel) and weights (g; bottom panel) measured in the laboratory during 1992-2016 (no survey in 1995). Standard error bars are shown.

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 1992-2016 (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