Strait of Georgia Juvenile Herring Survey, September and October 2008

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STRAIT OF GEORGIA JUVENILE HERRING SURVEY, SEPTEMBER AND OCTOBER 2008

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ABSTRACT

Thompson, M., Fort, C., and Schweigert, J. 2009. Strait of Georgia juvenile herring survey, September and October 2008. Can. Manuscr. Rep. Fish. Aquat. Sci. 2908: v + 43 p.

A survey of juvenile herring was conducted in the Strait of Georgia during late September and early October 2008. 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. Plankton tows were performed to determine food organism abundance in the study area. CTD casts were made to determine temperature, salinity and dissolved oxygen.

RESUME

Thompson, M., Fort, C., and Schweigert, J. 2009. Strait of Georgia juvenile herring survey, September and October 2008. Can. Manuscr. Rep. Fish. Aquat. Sci. 2908: v + 43 p.

Une campagne de relevés portant sur les stocks de harengs juvéniles du détroit de Georgia a été effectuée fin septembre-début octobre 2008. Des échantillons ont été prélevés dans 48 stations du détroit de Georgia situées sur les dix transects échantillonnés depuis 1990. La zone d'échantillonnage s'étendait du chenal Trincomali au sud à la baie de Smelt au nord. Des traits de plancton ont été effectués pour déterminer l'abondance de nourriture disponible dans la zone étudiée. Des sondages CTD ont également été effectués pour établir les profils de température, de salinité et d’oxygène dissous.

INTRODUCTION

Pacific herring (*Clupea pallasi*) are an important commercial and a vital forage species for many marine mammals, birds and other 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 in 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.

Purse seine surveys to determine the distribution and abundance of juvenile herring in the Strait of Georgia have been conducted annually since 1990, except for 1995 (Figure 1). The main objective of the survey was to estimate the density and relative abundance of the juvenile herring population as a potential indicator of recruitment before they have joined the spawning stock (Schweigert et. al. 2009). In addition to recruitment prediction, the surveys have contributed to a better understanding of the distribution, abundance, and ecological role of herring in the Strait of Georgia.

METHODS

The annual survey of juvenile herring in the Strait of Georgia in 2008 (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). These ten core transects have been used in juvenile herring recruitment prediction (Hay et. al. 2003). Originally, the sampling sites were chosen based on known historical herring spawning sites, and represent both nearshore and open water habitats (Haegele et. al. 2005). In 2008, sampling was conducted from September 15th to October 1st (Table 1). All 48 core stations were sampled.

Fish Sampling

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 are feeding near the surface. All sets were made "blind" 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 estimated as the number of totes released. The number of herring caught in each set was determined by dividing the total catch weight by the mean weight of sub-sampled herring. The number of other species caught was determined in the same manner (Tables 3 and 4). All fish retained for sampling were bagged and preserved in a 3.7% seawater formalin solution, 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 within two weeks of capture. From each set, 100 or more herring and all other fish species caught were identified, weighed and measured. If the set contained less than 100 herring, then all herring were weighed and measured. Consistent with standard practices, herring were measured to standard length, salmon to fork length and groundfish to total length; all to the nearest millimeter. All other fish species were measured to standard length.

Plankton Sampling

Twenty stepped oblique plankton tows were performed during the survey (Figures 3). The tows always were completed after dusk and immediately before the fishing events. A nearshore and offshore tow location was sampled for all transects. Dual 19 cm diameter bongo nets with 350 µm mesh were used for sampling, resulting in 'left' and 'right' bongo plankton samples (only left samples were processed). The bongos were lowered to 20 m (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). A General Oceanics® 2030R model flowmeter was attached to the left bongo 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)

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

In the laboratory, a volumetric splitter was used to reduce the sample size to a point 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).

When possible, plankters were identified to the lowest taxonomic level. Copepods were identified to species. Densities for all plankters were determined and expressed as plankters/ m^3.

CTD Sampling

To characterize oceanographic conditions in the surveyed area, a total of 20 CTD (conductivity – temperature – density) casts were made using a RBR XR-620 (Figure 3). A CTD cast was performed at each plankton tow location following the nearshore/offshore sampling location protocol. The CTD unit was weighted and lowered over the side of the vessel, at a rate of 1m/sec, to within two meters of the bottom. Data was downloaded to a laptop computer from the CTD unit after each day of sampling.

RESULTS

Herring

Forty-eight stations were sampled from transects 1 – 6, 8 – 11. A total of 3908 herring were weighed and measured resulting in a length frequency distribution that was distinctly unimodal (Figure 4). Three length designations for the juvenile herring age-classes were produced:

0+ = herring less than or equal to 103 mm standard length
1+ = herring between 113 mm and 132 mm standard length
2+ and older = herring greater than or equal to 140 mm standard length

Age-0+ herring occurred in 93.75 % of the stations (Table 3). Forty-five of the forty-eight stations contained age-0+ herring. The mean length and weight for age-0+ herring was 88 mm and 8.71 g respectively. A total of 102753 age-0+ were caught for a total weight of 730 kg (Table 4).

Age-1+ herring occurred in 16.7 % of the stations (Table 3). Only eight of the forty-eight stations sampled contained age-1+ herring. The mean length and weight for age-1+ herring was 116 mm and 20.85 g, respectively. A total of 56 age-1+ herring were caught for a total weight of 1.11 kg (Table 4). This represents a continuation of the weak 2007 year class when only 22 age-0+ herring were caught.

Age-2+ herring occurred in 14.58 % of the stations (Table 3). The mean length and weight for age-2+ herring was 147 mm and 43.0 g respectively. A total of 19 age-2+ herring were caught for a total weight of 0.84 kg (Table 4).

Length frequency histograms by transect location for all sampled herring are shown in Figure 5. All transects were dominated by a single age-0+ age-class. The age-0+ herring lengths show a distinct bimodal distribution likely due to time of spawning. Age-0+ herring from Trincomali Channel (Transect 6) and Yellow Point (Transect 2) make up the majority of the small herring sampled. Spawn timing data gives a mean spawn day of year (DOY) of 93. The survey sampled these herring at DOY 259, making the Trincomali and Yellow Point age-0+ herring roughly 166 days old. Compared with Henry Bay (Transect 4) age-0+ herring with a spawning average DOY of 63 and a sampling DOY of 269 making these fish roughly 206 days old. The difference of an extra 40 days of growth for the fish above Dodds Narrows can explain the bimodal length-frequency histogram for the age-0+ herring sampled. A length-weight relationship for all sampled herring from the survey showed a positive correlation coefficient (r^2) of 0.9398 (Figure 6).

Plankton

There were 25 categories of organisms identified in 20 plankton samples (Tables 5 and 6). An average of 12.5145 m^3 of water was filtered per plankton tow. *Paracalanus parvus* copepods were the only category to occur in all samples. Calanoid copepod *Paracalanus parvus,* cyclopoid copepod *Corycaeus anglicus* and *Oithona similis*, medusae (*Aequora victoria*), prosobranch gastropods, larvaceans (*Oikopleura sp.*) and shrimp larvae occurred in >90% of the samples. More than 75% of all plankton biomass captured were calanoid copepod *Paracalanus parvus*, larvaceans (*Oikopleura sp.*), cladocerans (*Podon sp.* and *Evadne sp.*) and barnacle larvae.

CTD

Two CTD casts were performed at each transect at a nearshore and offshore sampling location for a total of 20 casts. One cast was lost at Henry Bay (Transect 4). The CTD provided a range of data for temperature (^oC), salinity (ppt), dissolved oxygen (%) and depth (m) (Figure 7).

CONCLUSION

Forty-eight stations were sampled resulting in 19 different fish species recorded from purse seine sets. A total of 3908 herring were measured and weighed creating a unimodal histogram clearly representing age-0+ juvenile herring. Twenty plankton tows were performed resulting in calanoid copepod *Paracalanus parvus* and larvaceans (*Oikopleura sp.*) being the predominant organisms in numbers and biomass. Twenty CTD casts were performed providing nearshore and offshore oceanographic information for all 10 transects.

ACKNOWLEDGMENTS

The 2008 Strait of Georgia juvenile herring survey was funded by the Department of Fisheries and Oceans. This survey could not have been possible without the hard work and good cheer of skipper Doug Henderson. Plankton samples were processed by Zotec services.

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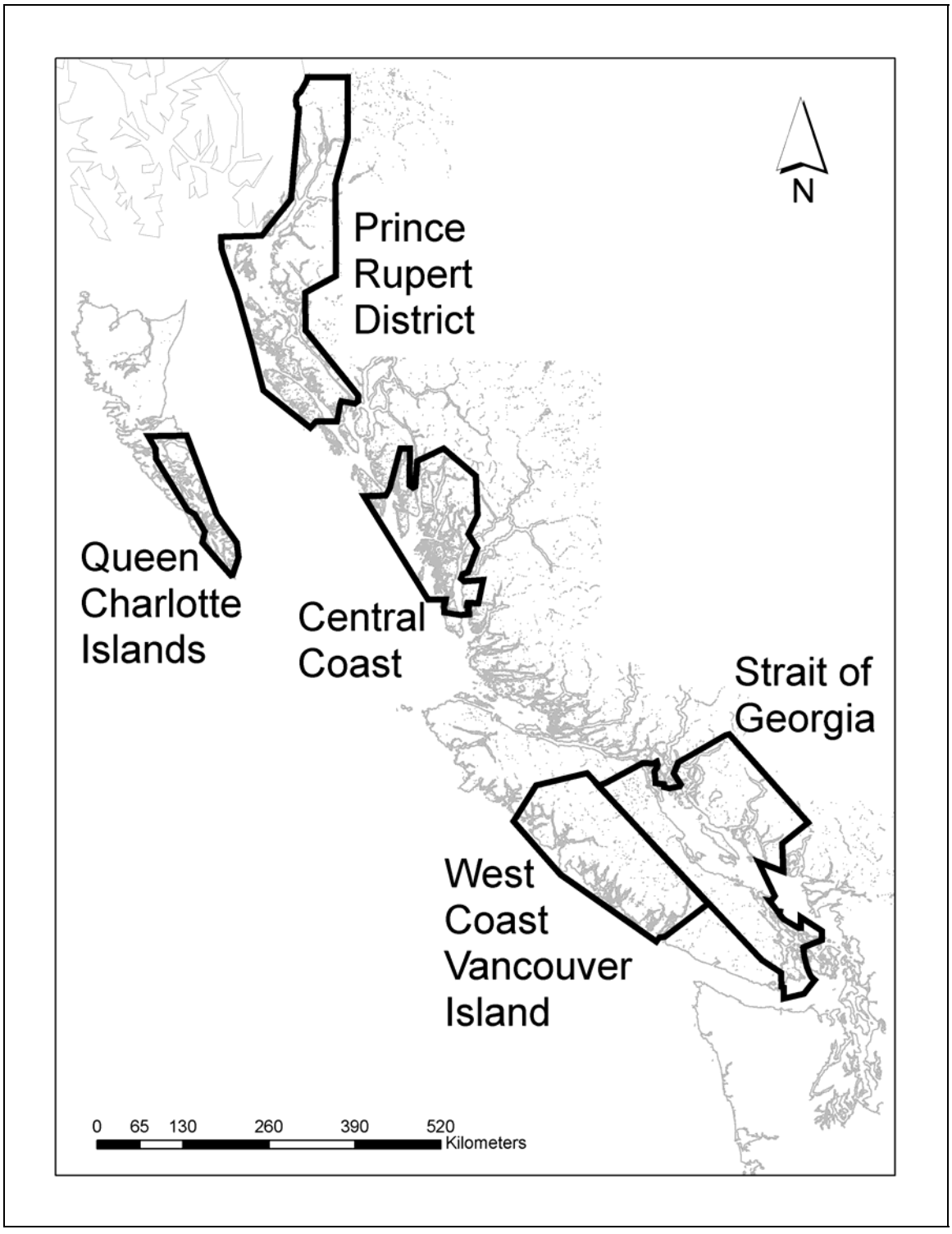


Figure 1. The five major British Columbia herring stock assessment areas.

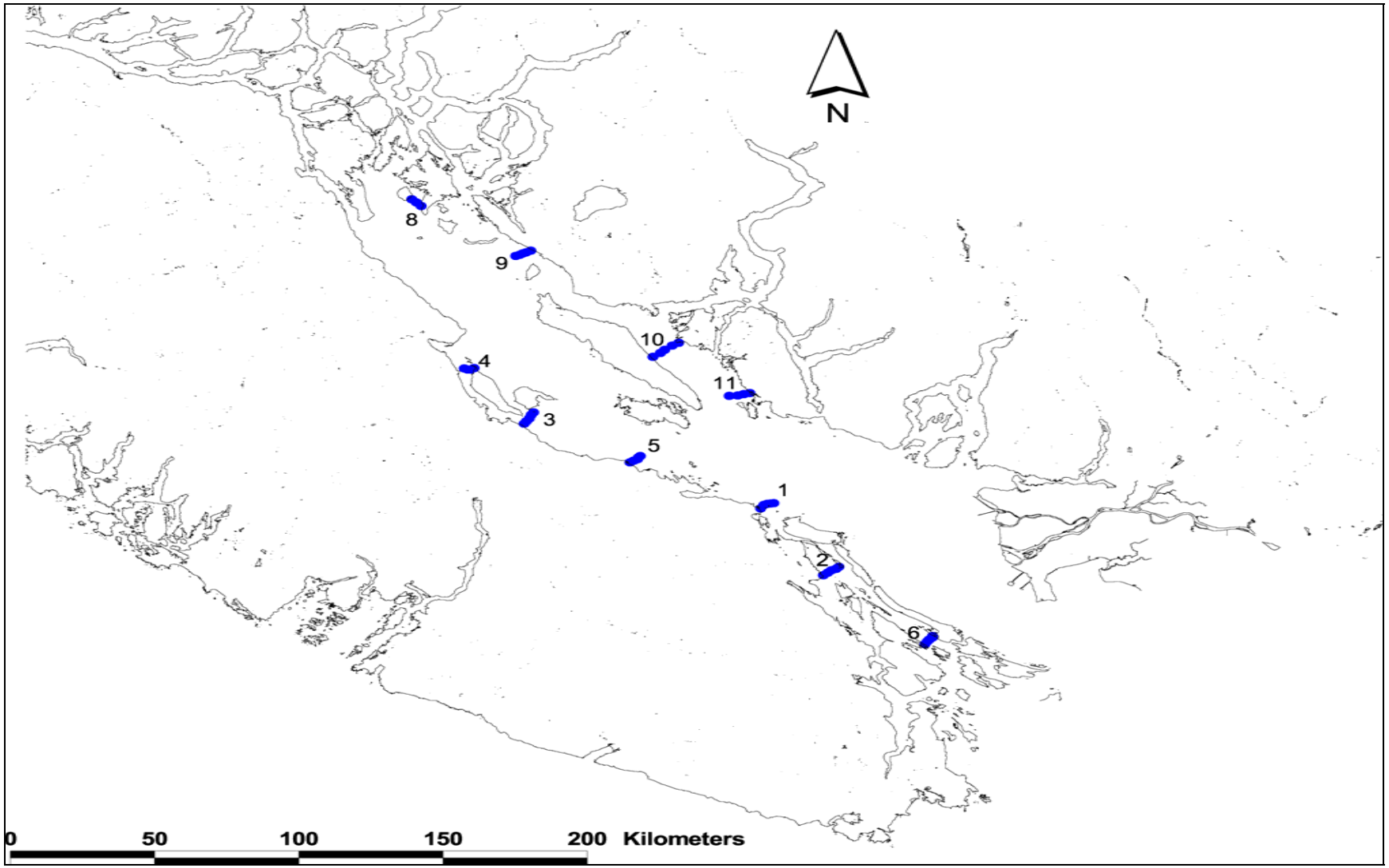


Figure 2. Purse seine set locations for the 2008 Strait of Georgia juvenile herring survey.

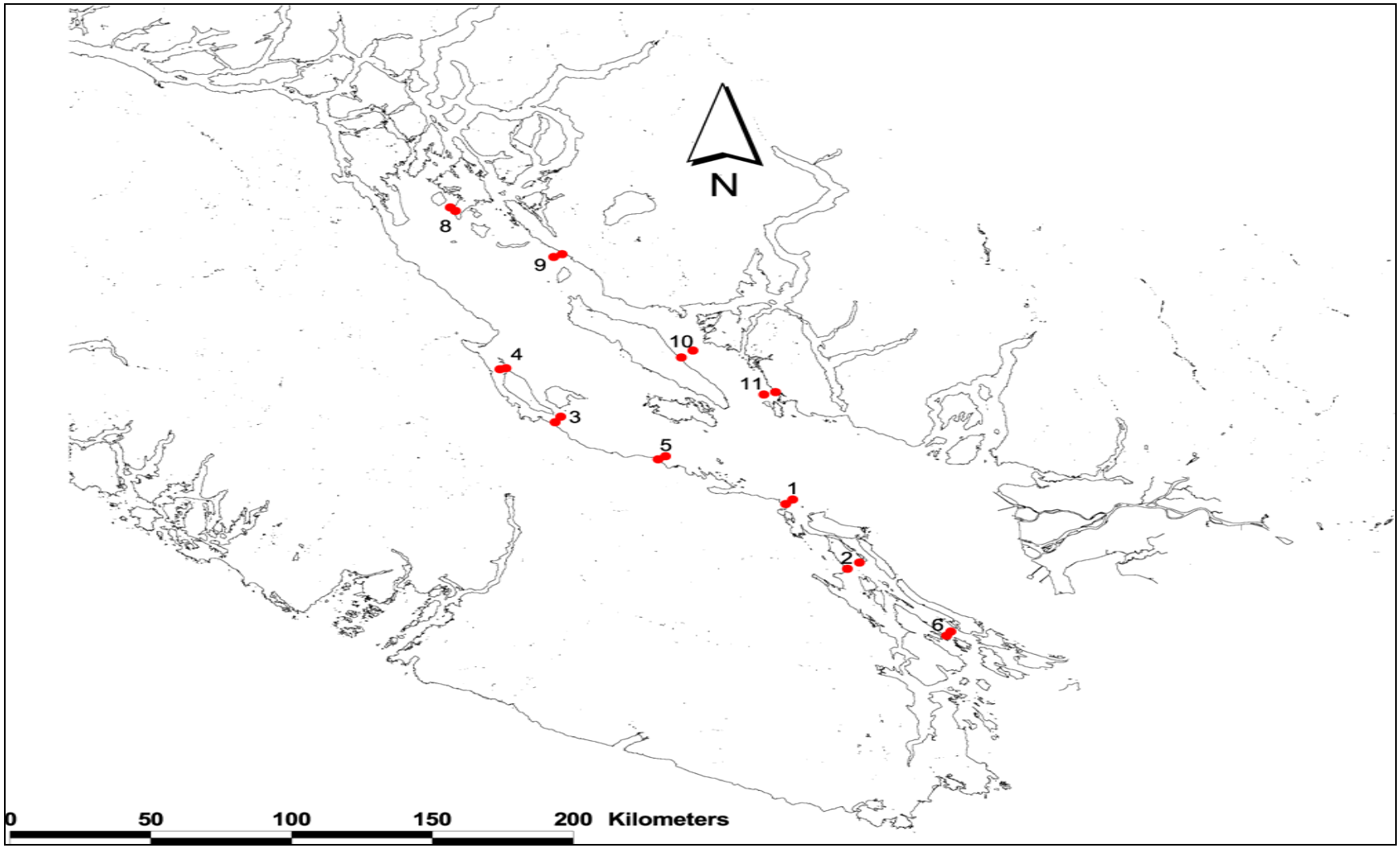


Figure 3. Plankton stations and CTD cast locations for the 2008 Strait of Georgia juvenile herring survey.

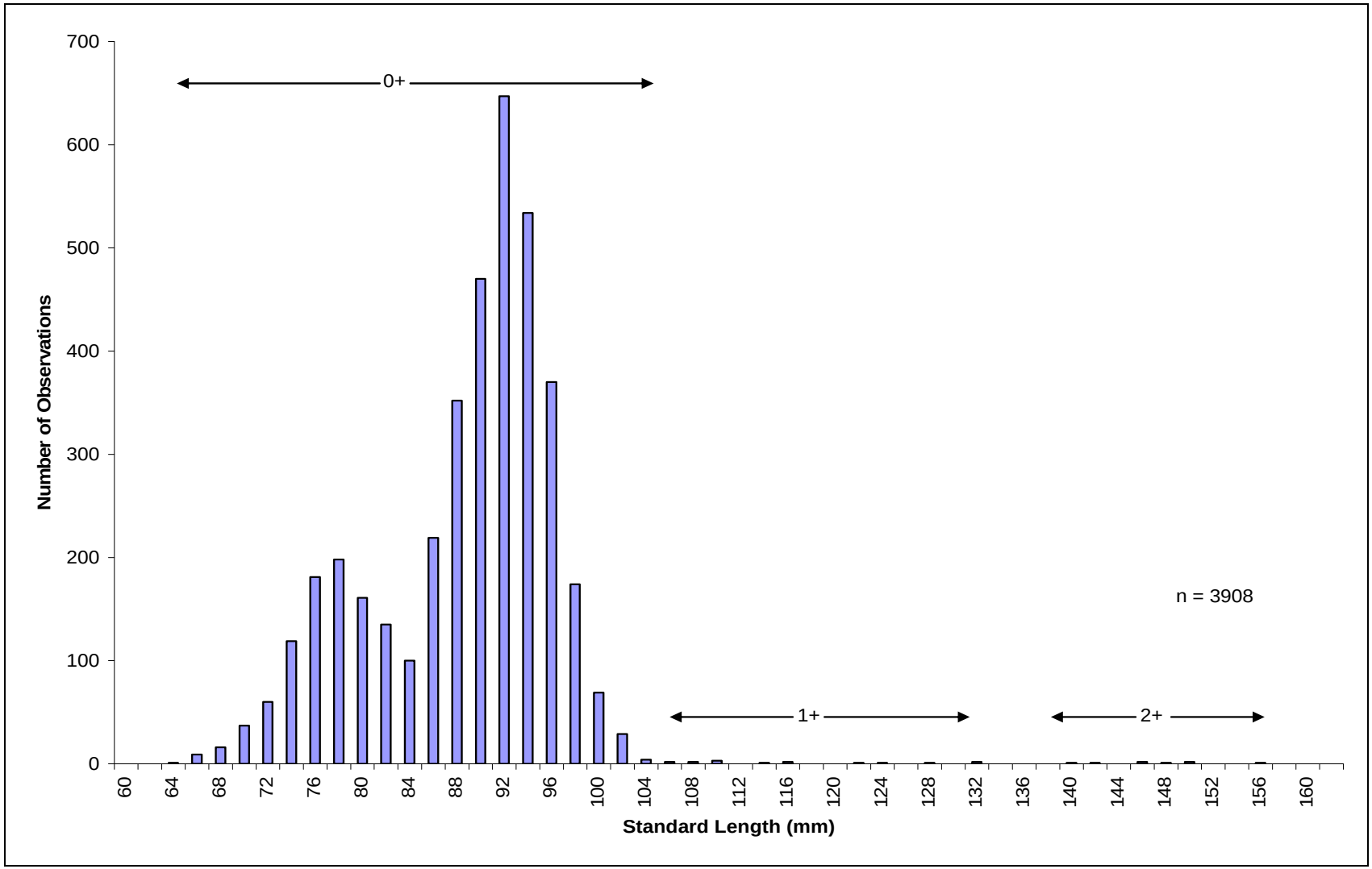
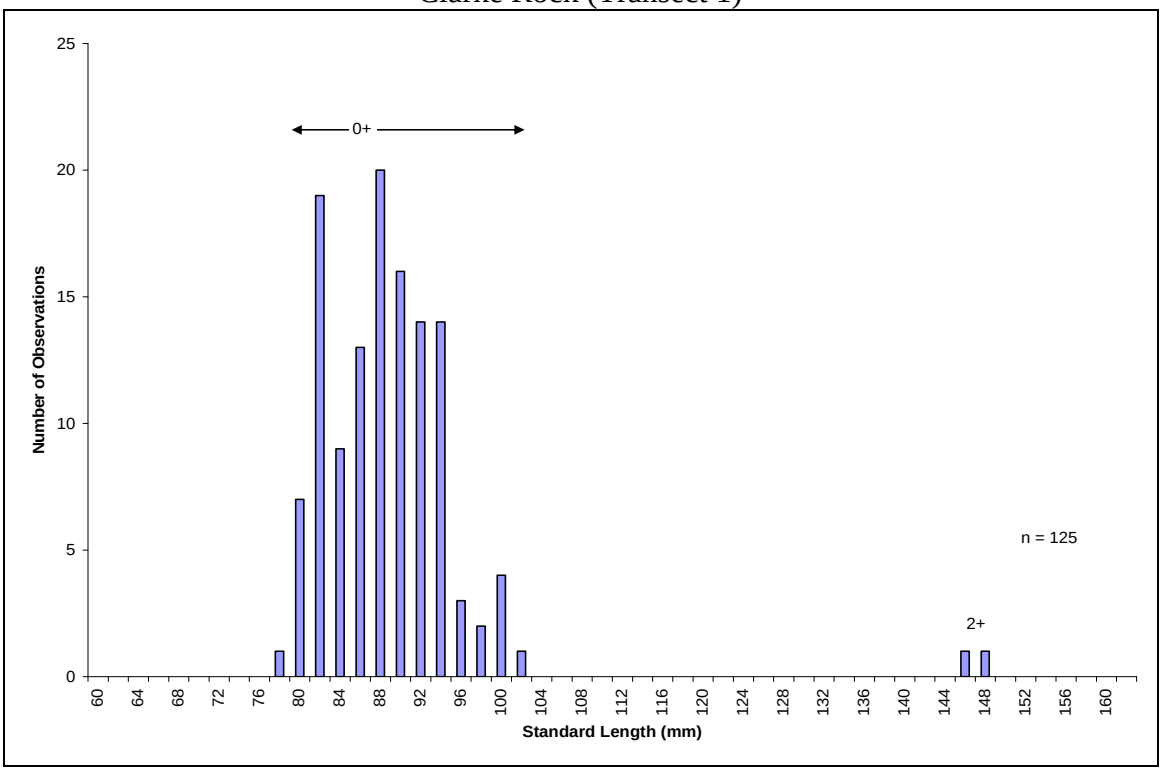


Figure 4. Length-frequency distribution for all herring sampled during the 2008 Strait of Georgia juvenile herring survey.

Clarke Rock (Transect 1)



Yellow Point (Transect 2)

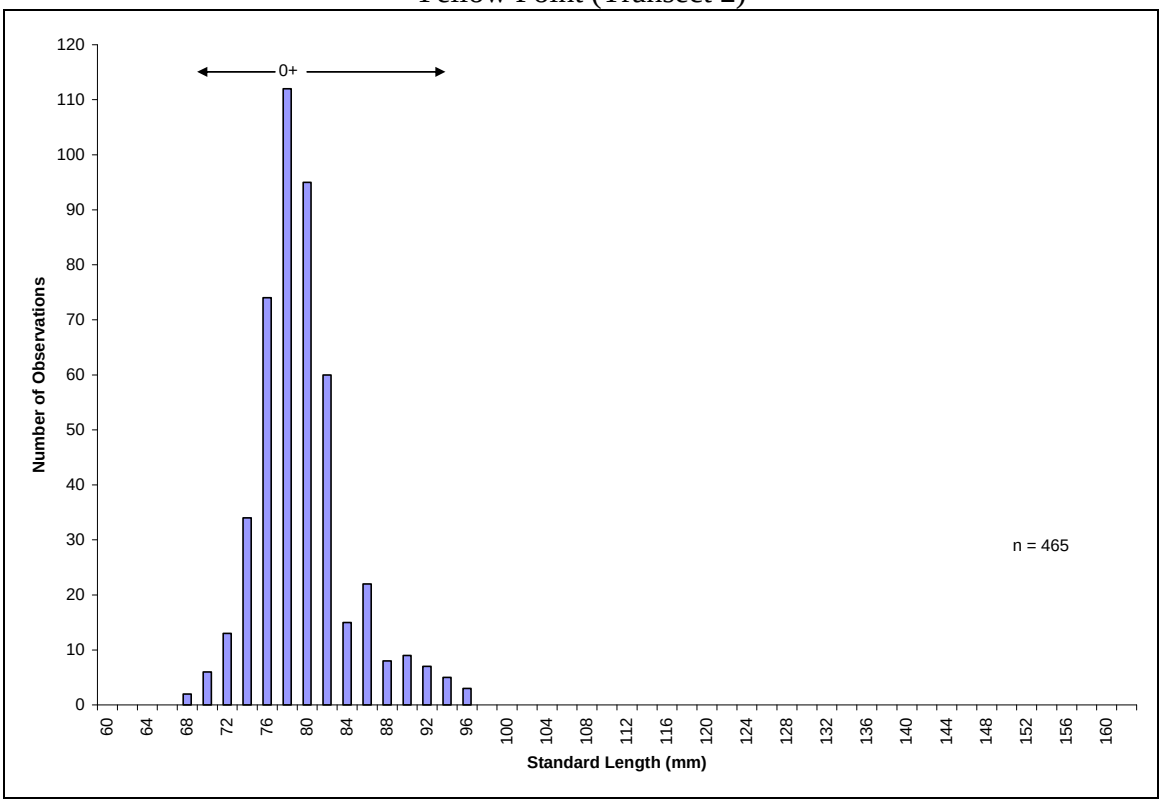
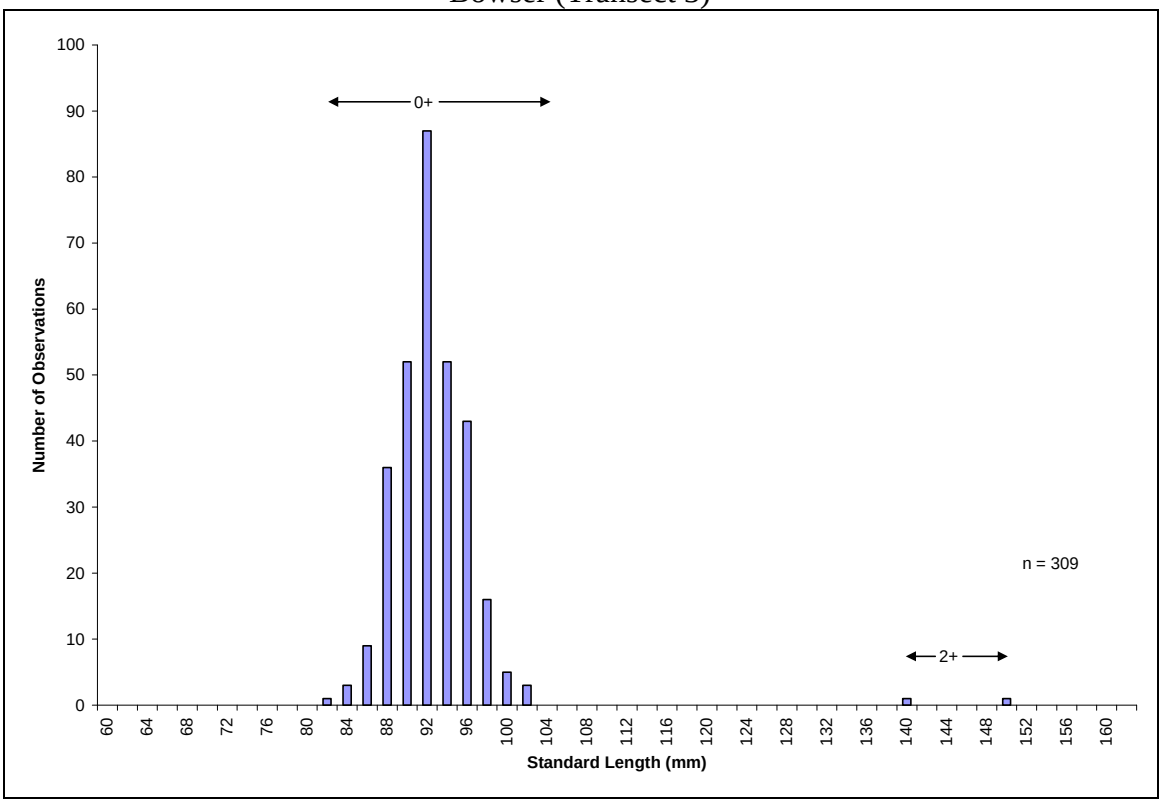


Figure 5. Length-frequency histograms of juvenile herring by transect location for the 2008 Strait of Georgia survey.

Bowser (Transect 3)



Henry Bay (Transect 4)

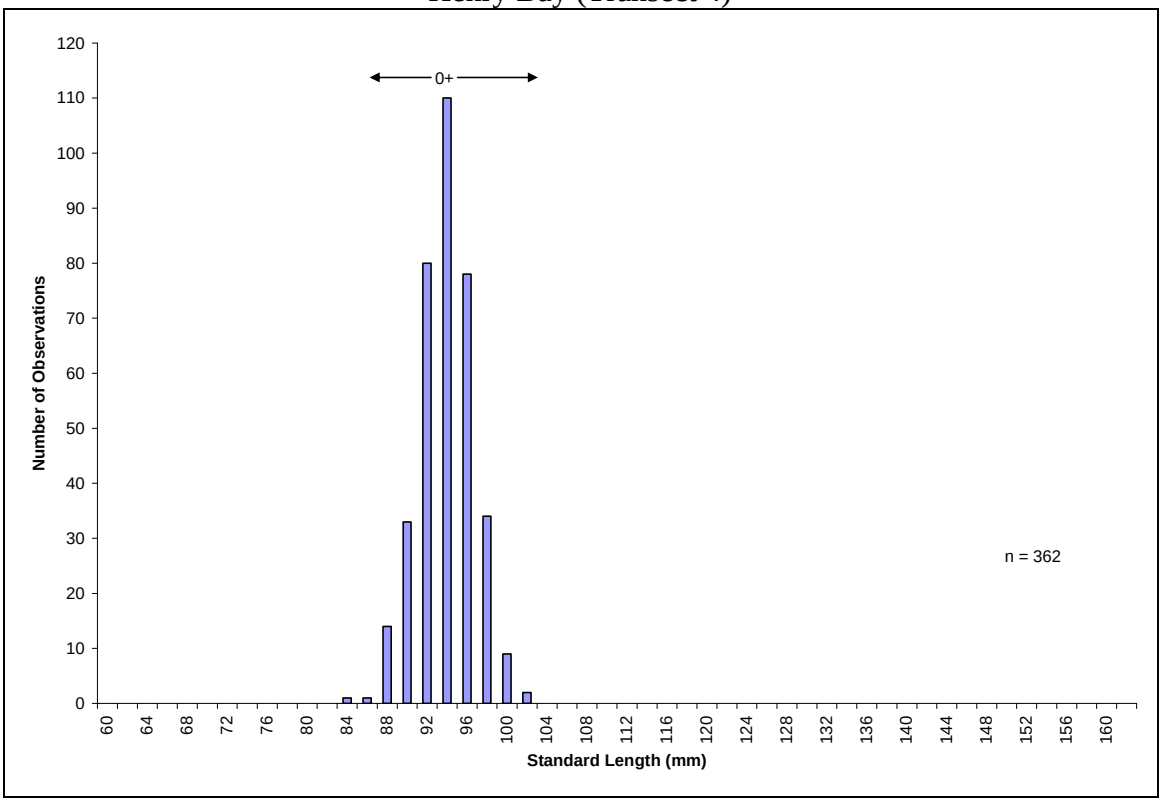
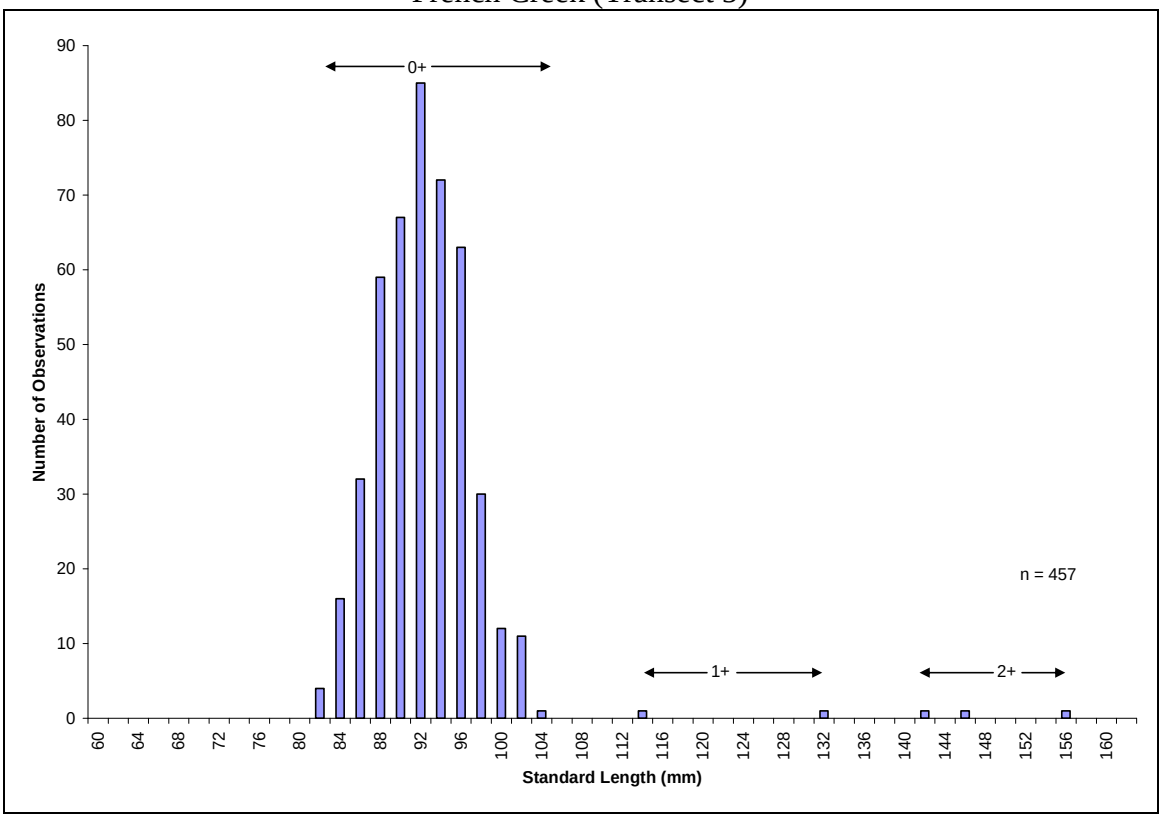


Figure 5…continued

French Creek (Transect 5)



Trincomali Channel (Transect 6)

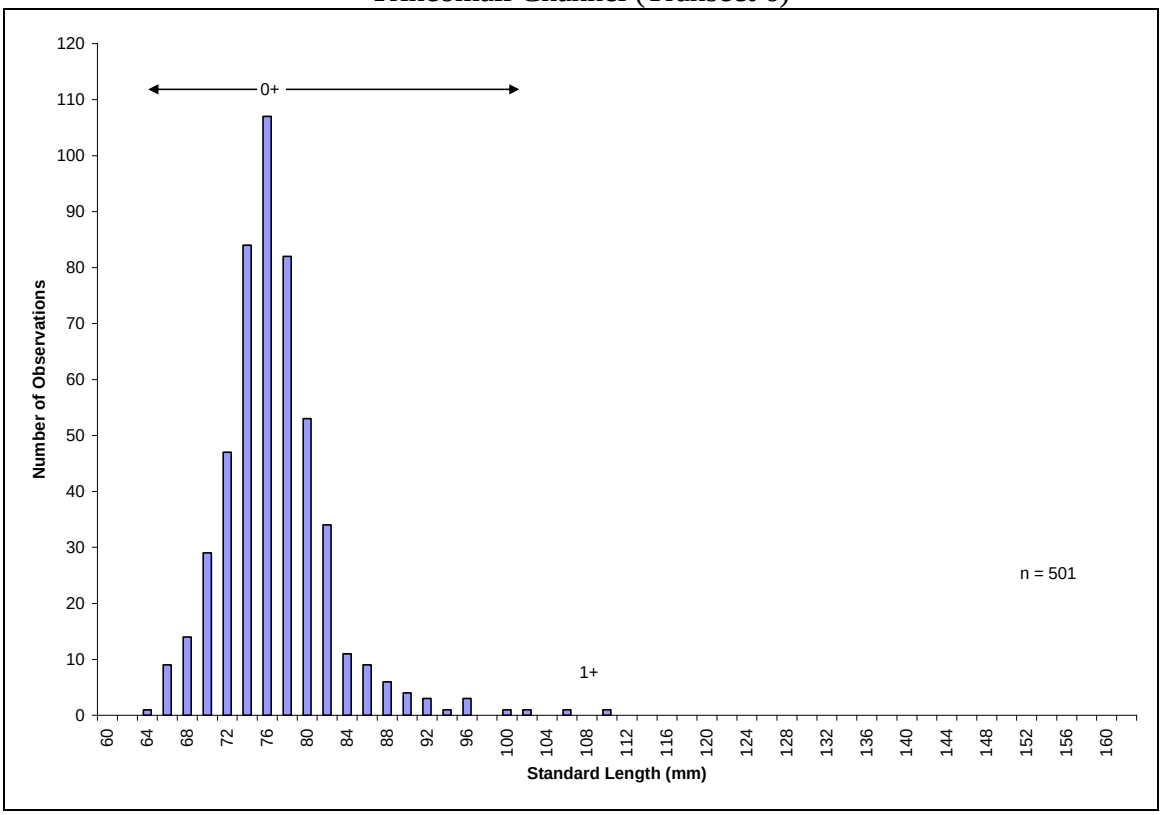
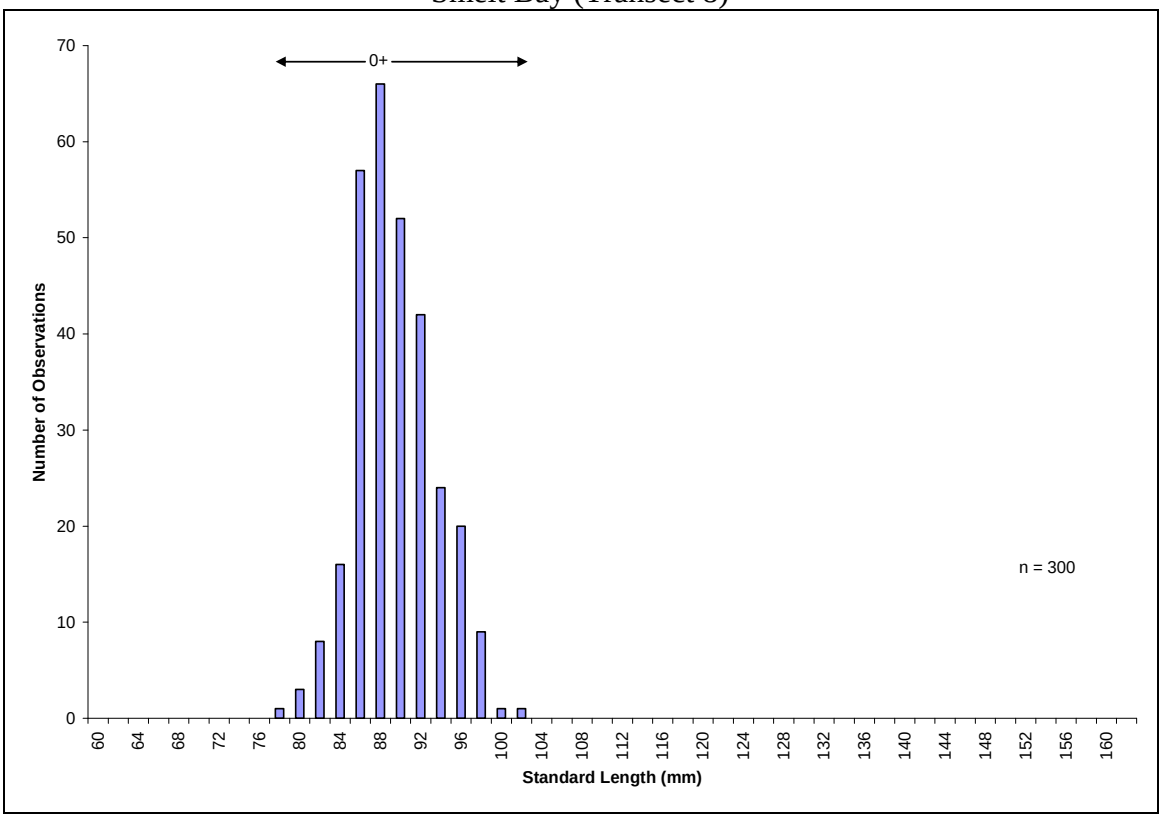


Figure 5…continued

Smelt Bay (Transect 8)



Atrevida Reef (Transect 9)

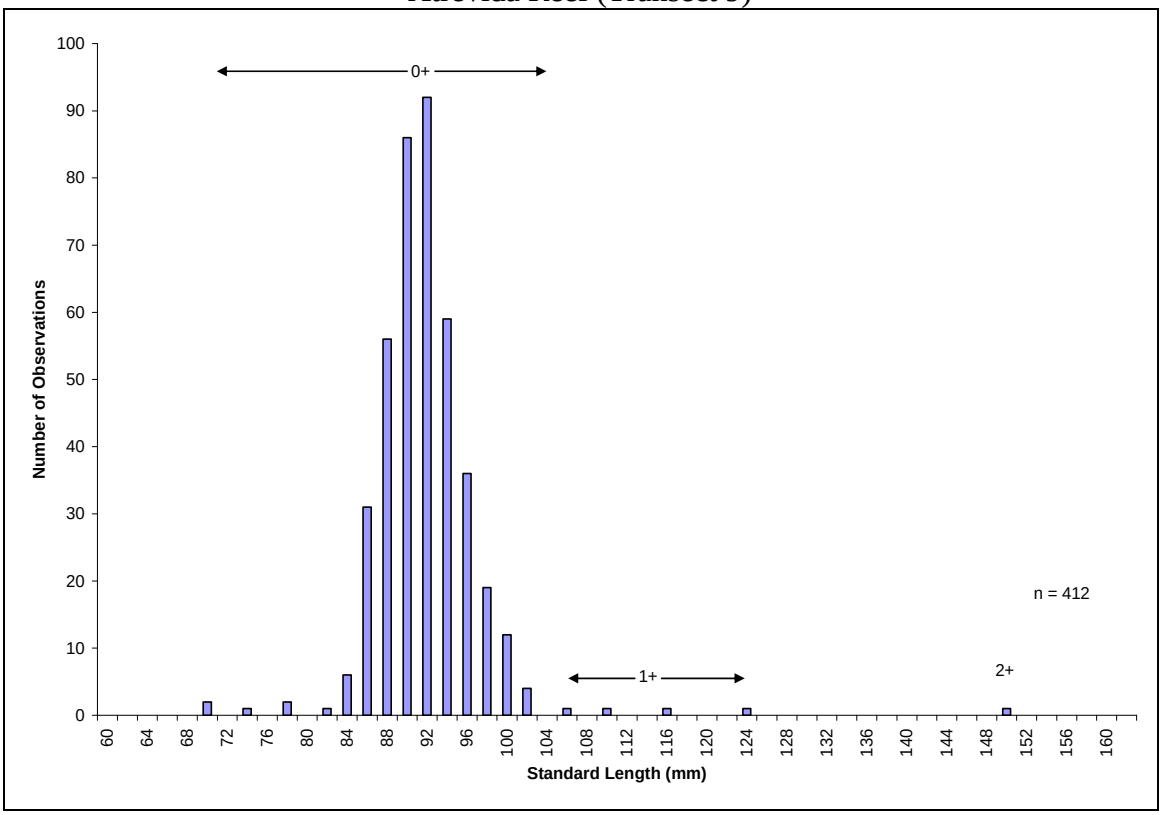
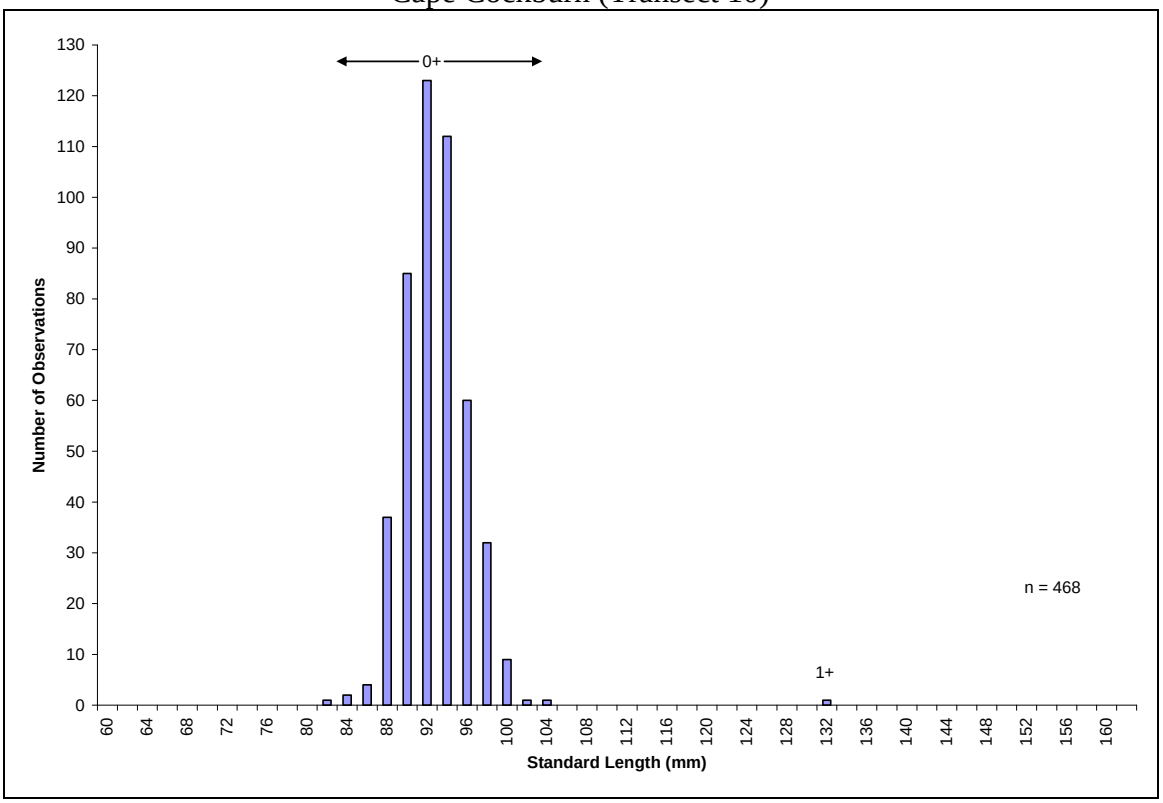
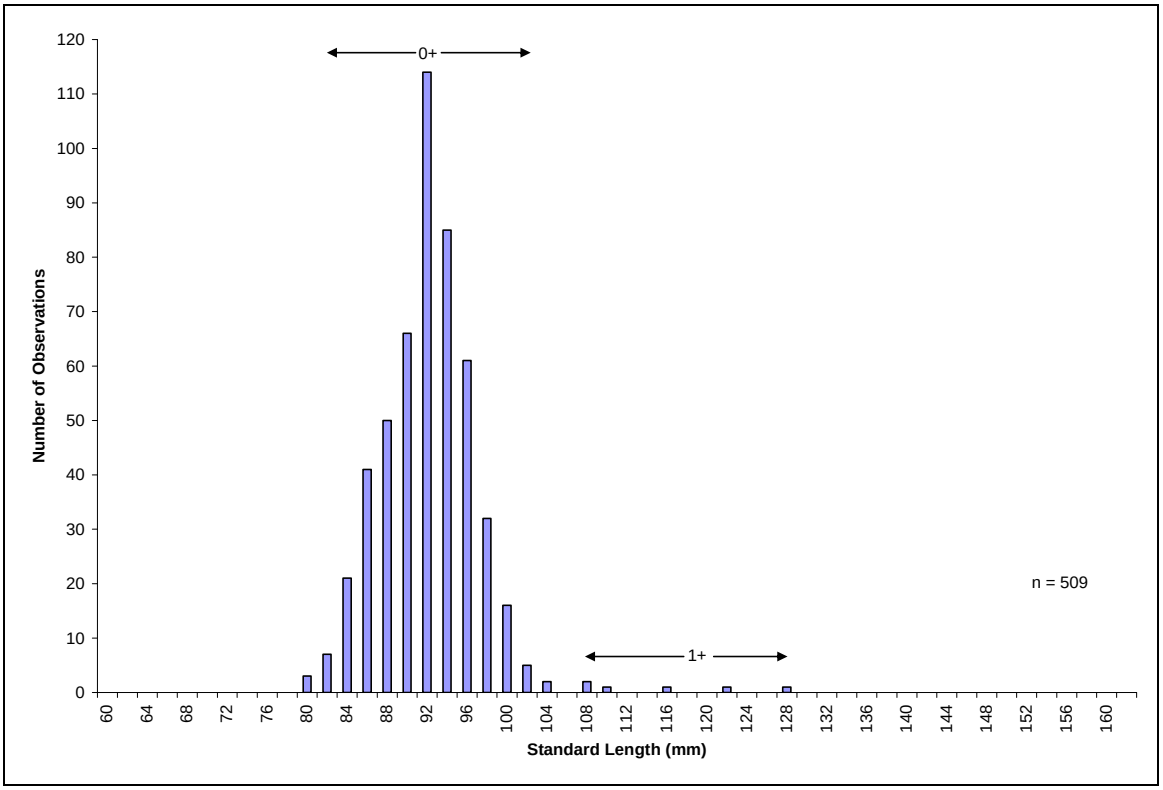


Figure 5…continued

Cape Cockburn (Transect 10)



Secret Cove (Transect 11)



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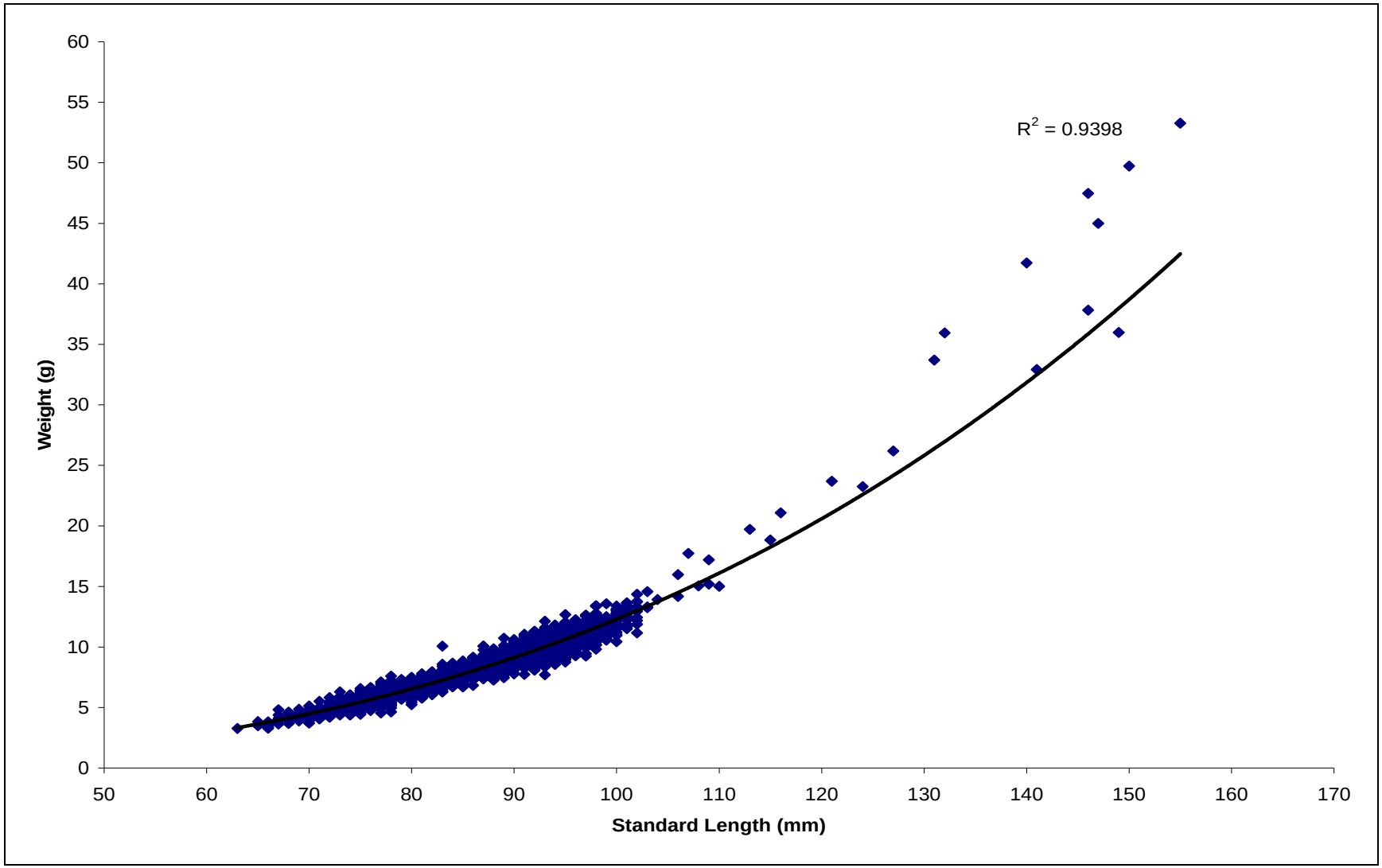


Figure 6. Length-weight relationship for all herring sampled during the 2008 Strait of Georgia juvenile herring survey.

Clarke Rock (Transect 1)

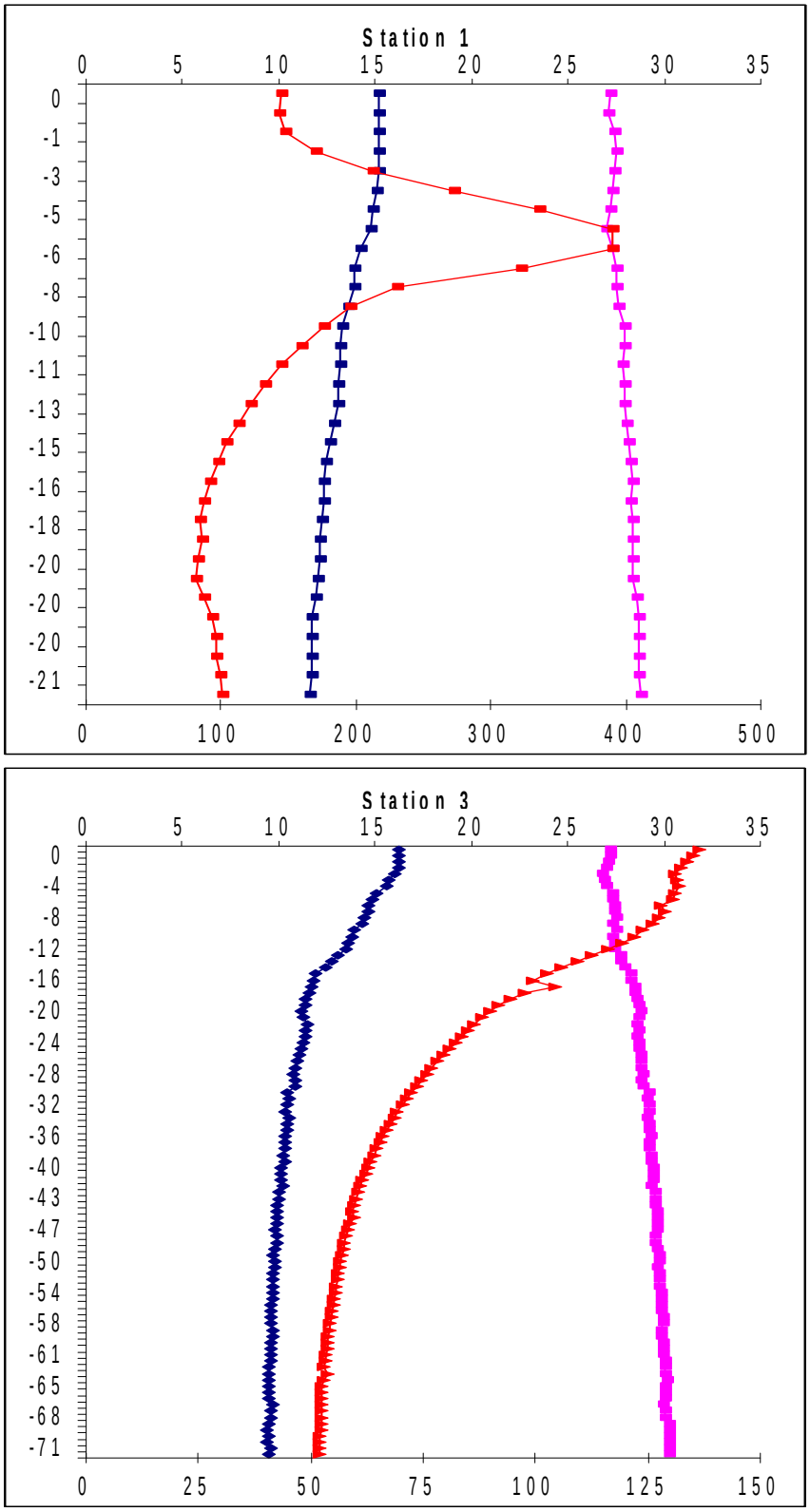


Figure 7. Temperature, salinity and dissolved oxygen profiles from CTD casts during the 2008 Strait of Georgia juvenile herring survey.

Yellow Point (Transect 2)

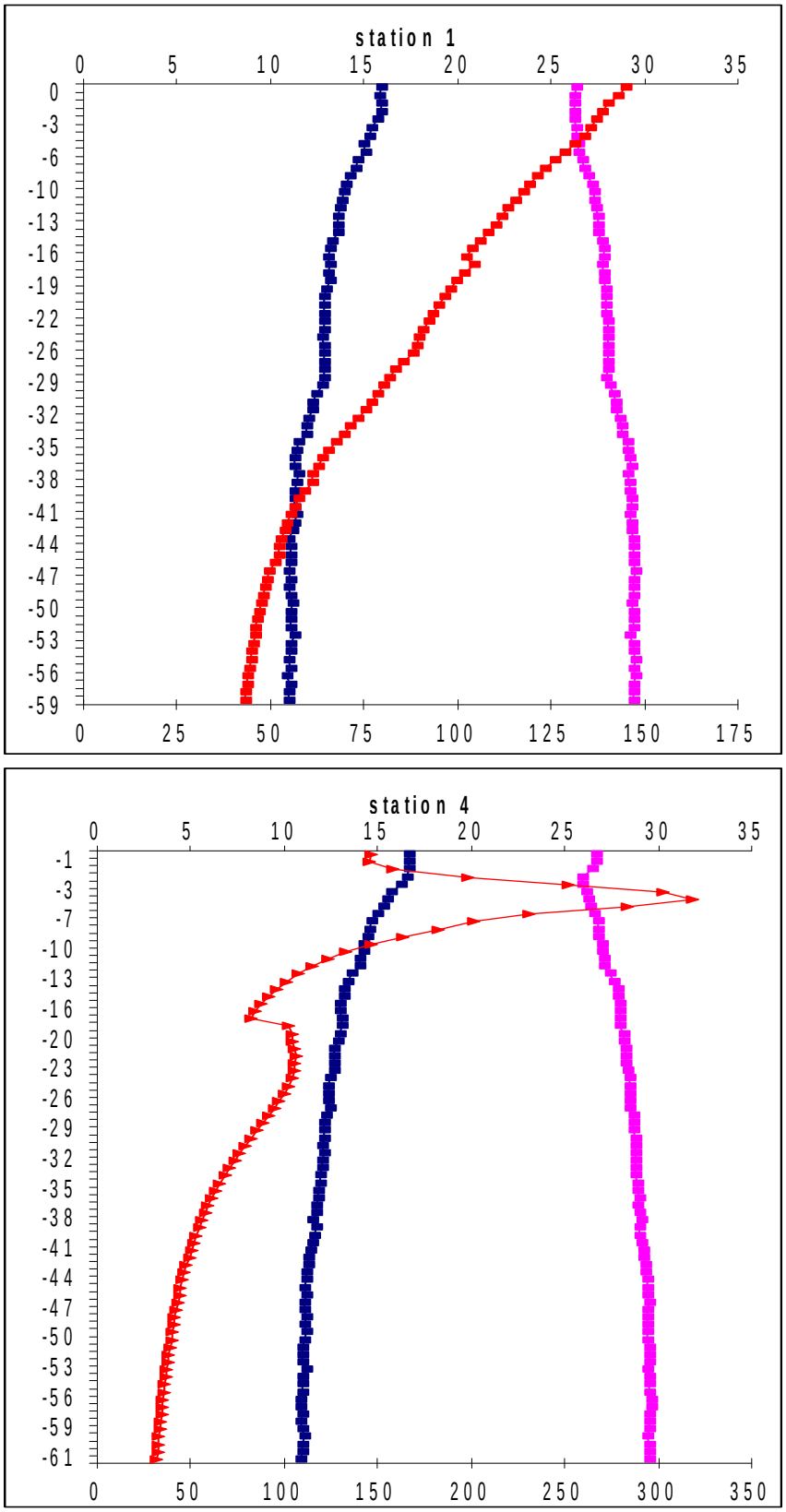


Figure 7…continued

Bowser (Transect 3)

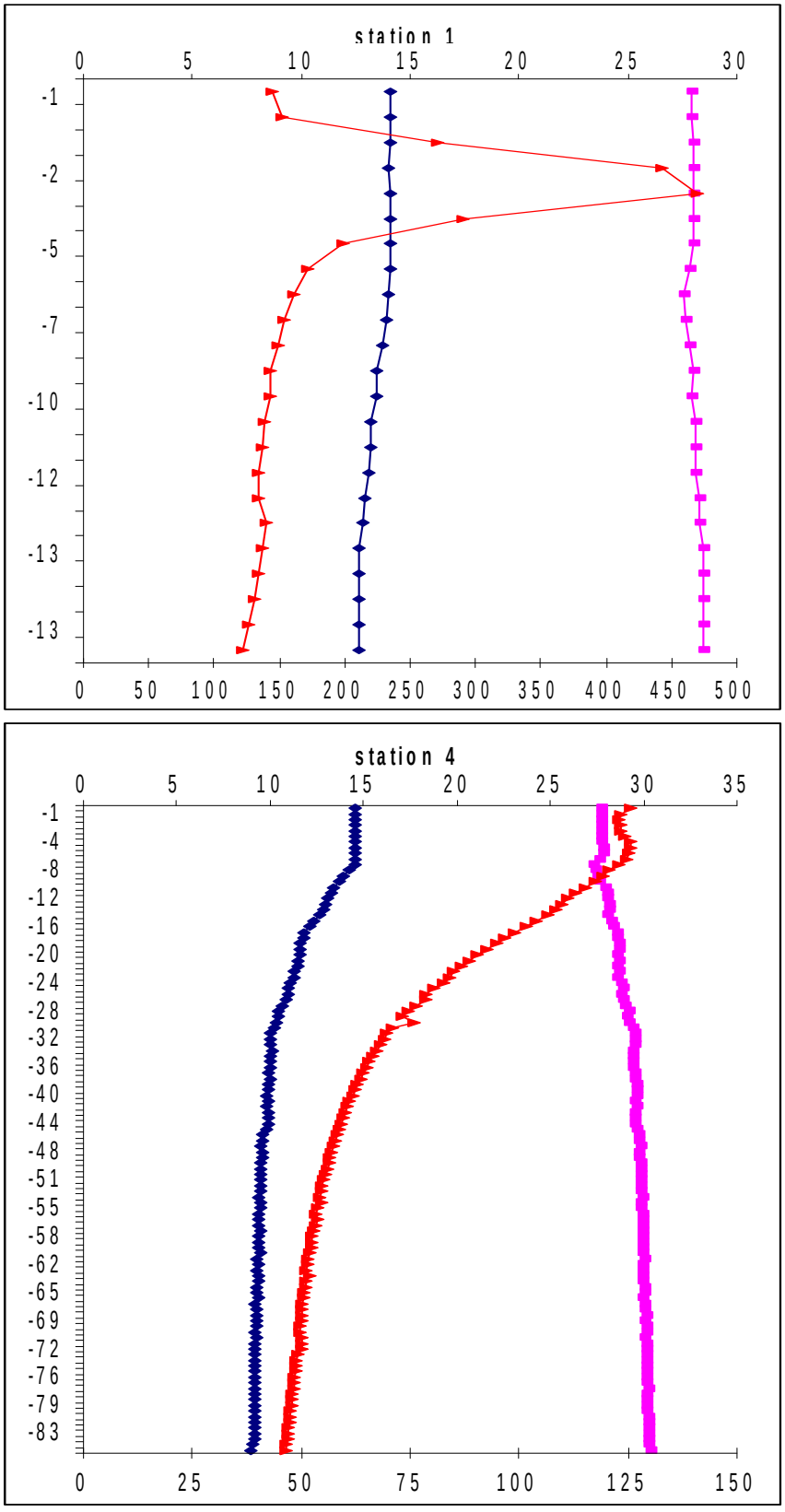
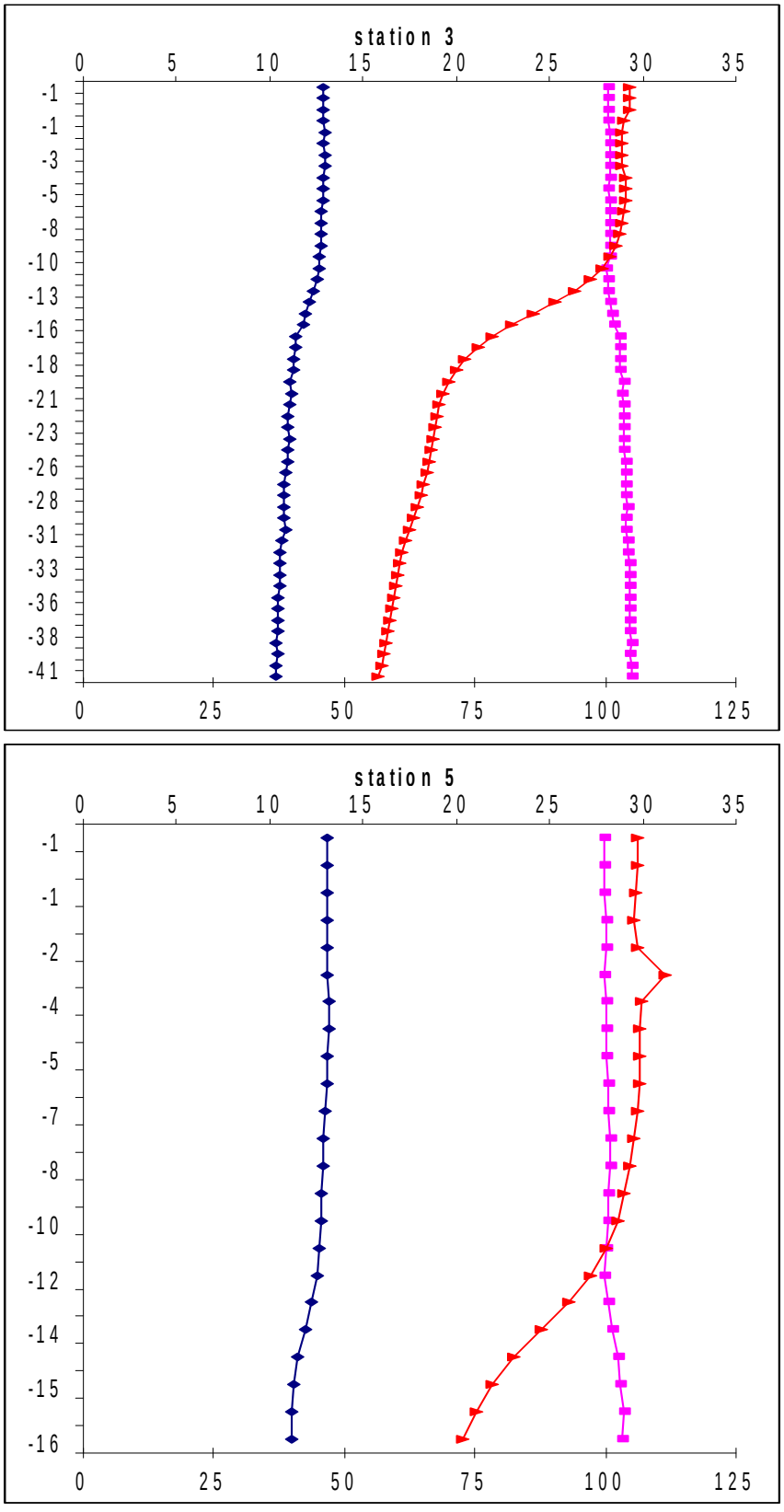


Figure 7…continued

Henry Bay (Transect 4)



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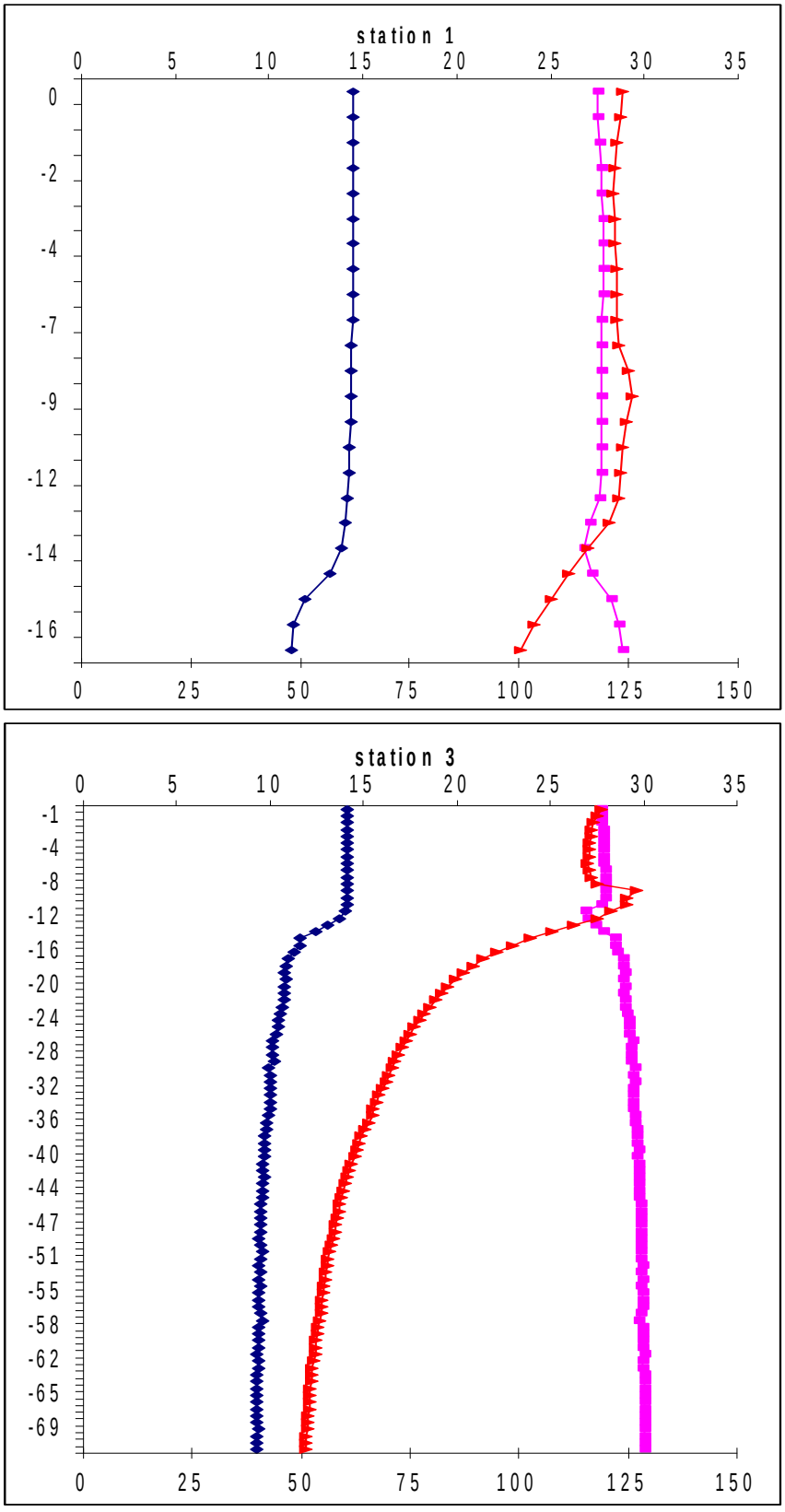
French Creek (Transect 5)



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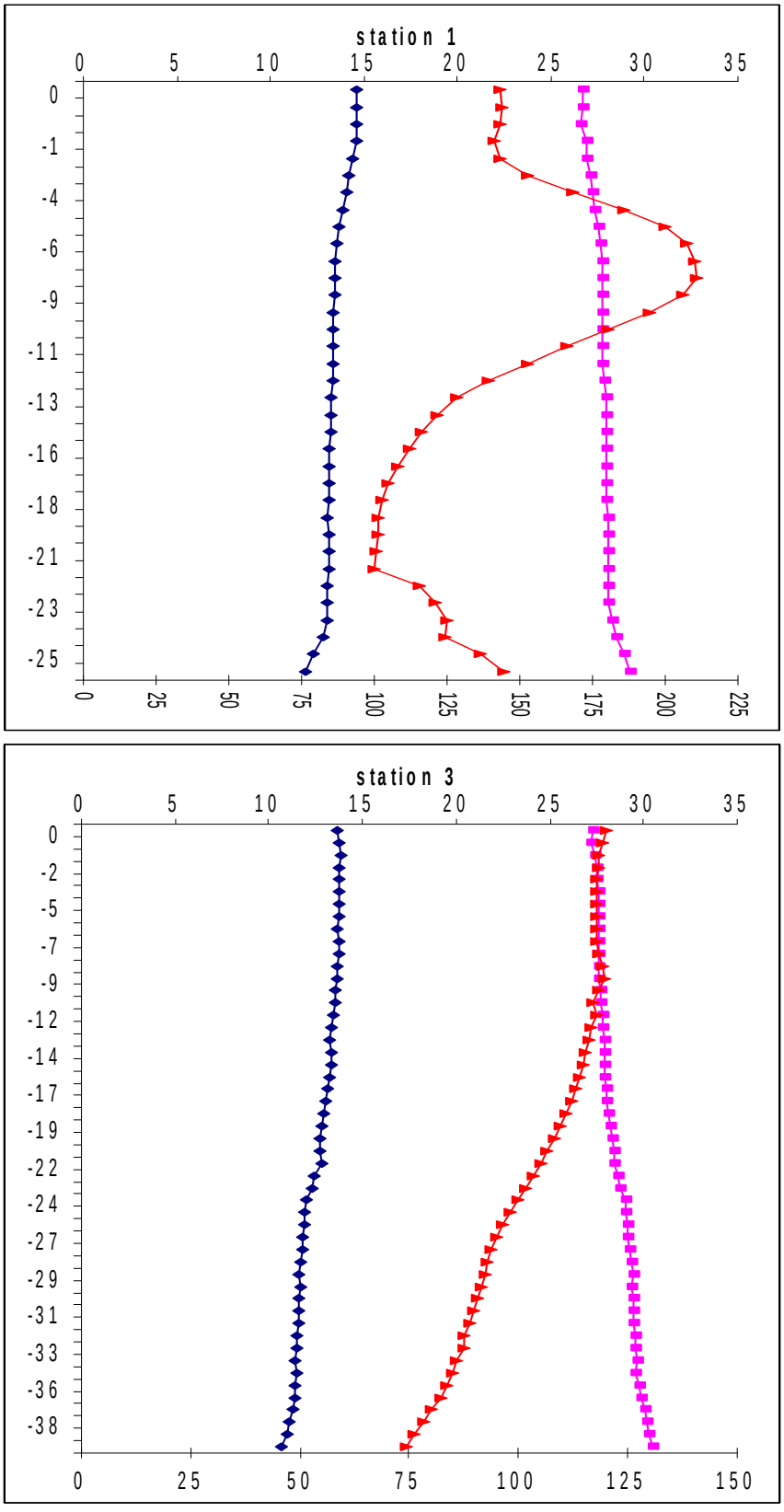
Trincomali Channel (Transect 6)



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Smelt Bay (Transect 8)

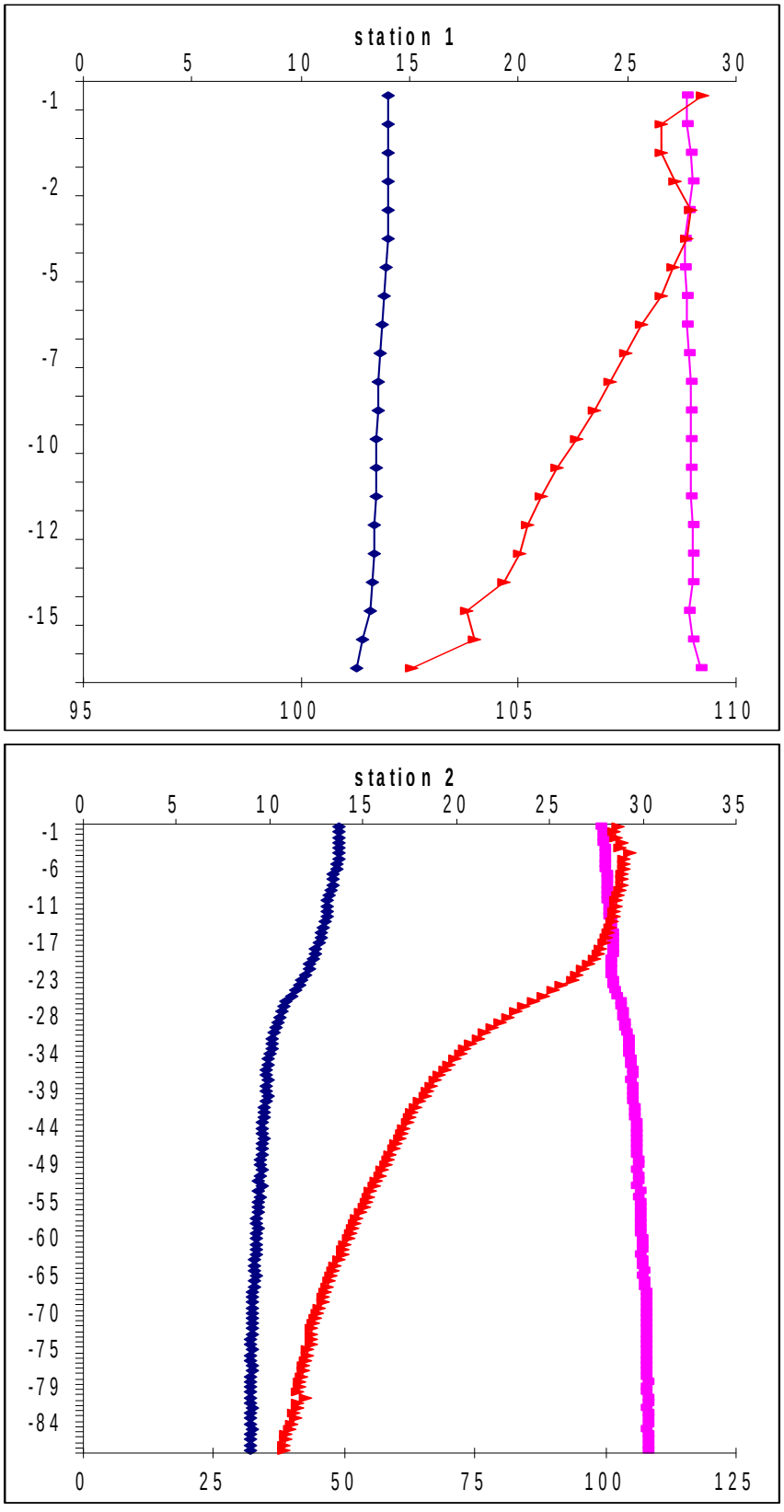

Figure 7…continued

Atrevida Reef (Transect 9)

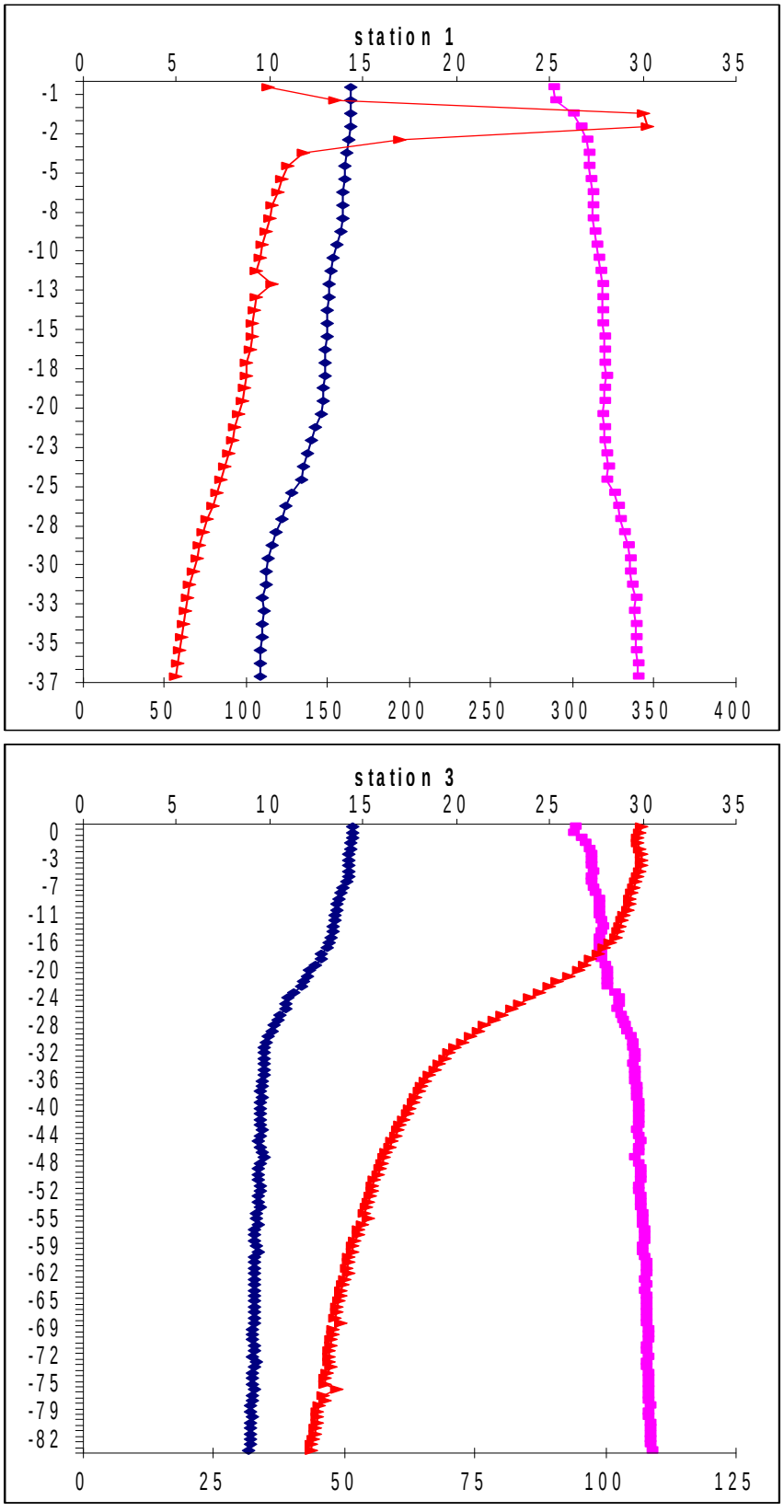

Figure 7…continued

Cape Cockburn (Transect 10)

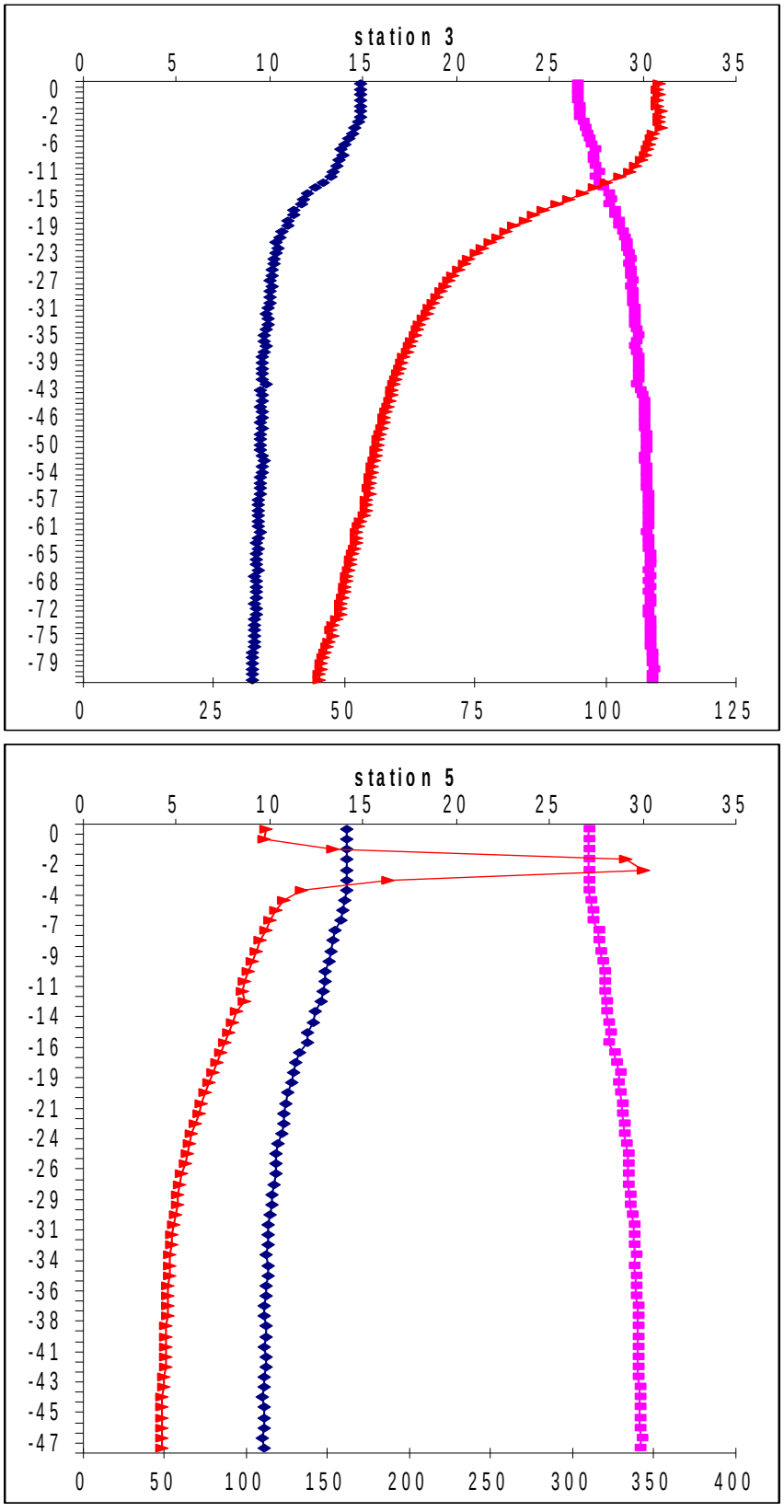

Figure 7…continued

Secret Cove (Transect 11)

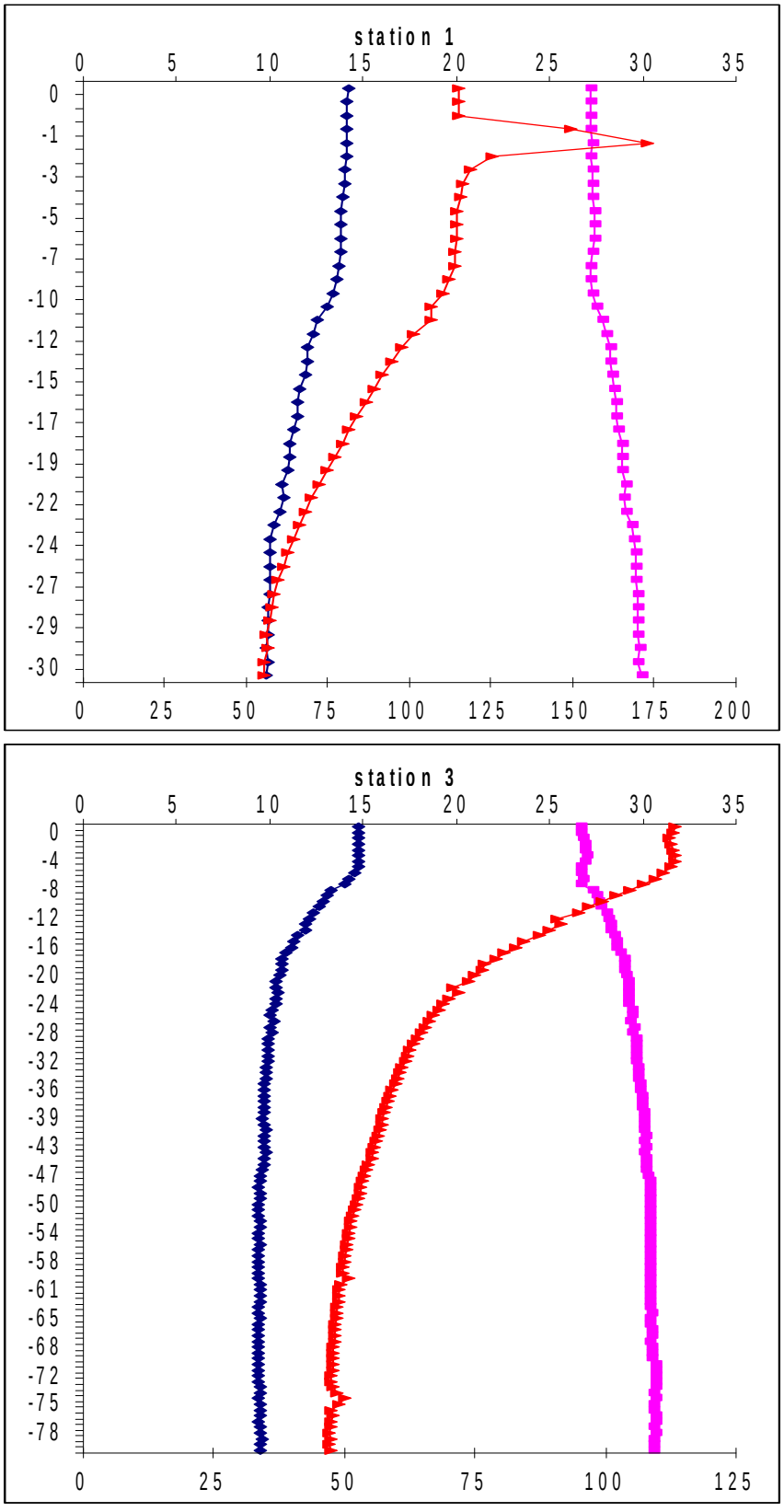

Figure 7…continued

Table 1. Summary of the purse seine set locations from the 2008 Strait of Georgia juvenile herring survey.

Year	Month	Day	Transect	Station	Seine Set Time	Location Name	DD Lat (N)	DD Long (W)
2008	9	15	6	1	2035	Trincomali Channel	48.855	123.430
2008	9	15	6	2	2100	Trincomali Channel	48.862	123.423
2008	9	15	6	3	2120	Trincomali Channel	48.867	123.417
2008	9	15	6	4	2140	Trincomali Channel	48.873	123.407
2008	9	15	6	5	2200	Trincomali Channel	48.877	123.407
2008	9	16	2	5	2030	Yellow Point	49.066	123.698
2008	9	16	2	4	2055	Yellow Point	49.060	123.708
2008	9	16	2	3	2115	Yellow Point	49.056	123.722
2008	9	16	2	2	2135	Yellow Point	49.050	123.733
2008	9	16	2	1	2200	Yellow Point	49.042	123.747
2008	9	17	1	1	2030	Clarke Rock	49.224	123.943
2008	9	17	1	2	2050	Clarke Rock	49.233	123.932
2008	9	17	1	3	2115	Clarke Rock	49.237	123.922
2008	9	17	1	4	2135	Clarke Rock	49.237	123.912
2008	9	17	1	5	2155	Clarke Rock	49.238	123.902
2008	9	22	5	5	2030	French Creek	49.366	124.317
2008	9	22	5	4	2050	French Creek	49.362	124.323
2008	9	22	5	3	2120	French Creek	49.358	124.327
2008	9	22	5	2	2140	French Creek	49.353	124.338
2008	9	22	5	1	2200	French Creek	49.348	124.350
2008	9	23	3	1	2030	Bowser	49.452	124.680
2008	9	23	3	2	2050	Bowser	49.459	124.672
2008	9	23	3	3	2115	Bowser	49.467	124.663
2008	9	23	3	4	2140	Bowser	49.476	124.657
2008	9	23	3	5	2200	Bowser	49.482	124.651
2008	9	25	4	5	2015	Henry Bay	49.602	124.836
2008	9	25	4	4	2045	Henry Bay	49.598	124.846
2008	9	25	4	3	2105	Henry Bay	49.598	124.856
2008	9	25	4	2	2125	Henry Bay	49.601	124.866
2008	9	25	4	1	2155	Henry Bay	49.593	124.875
2008	9	28	8	3	2135	Smelt Bay	50.054	125.030
2008	9	28	8	2	2200	Smelt Bay	50.046	125.016
2008	9	28	8	1	2225	Smelt Bay	50.036	125.000
2008	9	29	9	1	2035	Atrevida Reef	49.916	124.659
2008	9	29	9	2	2055	Atrevida Reef	49.912	124.673
2008	9	29	9	3	2120	Atrevida Reef	49.909	124.684
2008	9	29	9	4	2140	Atrevida Reef	49.906	124.694
2008	9	29	9	5	2200	Atrevida Reef	49.902	124.707
2008	9	30	10	5	2115	Cape Cockburn	49.632	124.278
2008	9	30	10	4	2140	Cape Cockburn	49.642	124.255
2008	9	30	10	3	2205	Cape Cockburn	49.651	124.242
2008	9	30	10	2	2235	Cape Cockburn	49.662	124.218
2008	9	30	10	1	2305	Cape Cockburn	49.670	124.198

Table 1 continued…

Year	Month	Day	Transect	Station	Seine Set Time	Location Name	DD Lat (N)	DD Long (W)
2008	10	1	11	1	2025	Secret Cove	49.535	123.977
2008	10	1	11	2	2045	Secret Cove	49.532	123.995
2008	10	1	11	3	2110	Secret Cove	49.528	124.014
2008	10	1	11	4	2140	Secret Cove	49.527	124.040
2008	10	1	11	5	2205	Secret Cove	49.523	124.060

Table 2. Summary of the number and weight by species, transect, and station for 2008 Strait of Georgia juvenile herring survey.

Transect	Station	Location Name	Species	Number	Weight (Kg)*
1	1	Clarke Rock	**Pacific herring Age-0+**	10416	86.91
1	2	Clarke Rock	**Pacific herring Age-0+**	7	0.07
			Pacific herring Age-2+	1	0.04
			Sandlance	4	0.01
			Chum salmon	2	0.07
1	3	Clarke Rock	**Pacific herring Age-0+**	11	0.10
			Chum salmon	5	0.23
			Pink salmon	4	0.23
			Chinook salmon	2	0.09
			Coho salmon	1	0.03
			Juvenile hake	1	trace
			Sandlance	1	trace
1	4	Clarke Rock	**Pacific herring Age-0+**	5	0.05
			Pacific herring Age-2+	1	0.04
			Chum salmon	5	0.21
			Chinook salmon	4	0.18
1	5	Clarke Rock	Pink salmon	13	0.63
			Chum salmon	4	0.17
			Chinook salmon	3	0.11
			Coho salmon	1	0.03
			Sockeye salmon	1	0.01
2	1	Yellow Point	**Pacific herring Age-0+**	65	0.40
			Midshipman	7	trace
			Chinook salmon	2	0.05
			Greenling	1	0.04
			Sandlance	1	trace
			Three-spine Stickleback	1	trace
2	2	Yellow Point	**Pacific herring Age-0+**	3069	22.78
2	3	Yellow Point	**Pacific herring Age-0+**	4102	30.27
2	4	Yellow Point	**Pacific herring Age-0+**	6644	44.81
2	5	Yellow Point	**Pacific herring Age-0+**	5929	38.65

Table 2 continued…

Transect	Station	Location Name	Species	Number	Weight (Kg)*
3	1	Bowser	Flatfish	9	0.11
			Sandlance	6	0.02
			Juvenile Pollock	5	0.09
			Midshipman	3	0.06
			Chinook salmon	2	0.10
			Gunnel	2	0.01
			Shiner Perch	2	0.05
			Chum salmon	1	0.04
3	2	Bowser	**Pacific herring Age-0+**	145	1.42
			Midshipman	4	0.09
			Flatfish	3	0.04
			Chinook salmon	2	0.19
			Octopus	2	trace
			Gunnel	1	0.01
			Juvenile Pollock	1	0.01
3	3	Bowser	**Pacific herring Age-0+**	2075	21.17
			Pacific herring Age-2+	5	0.21
			Chinook salmon	10	0.63
			Midshipman	10	0.28
3	4	Bowser	**Pacific herring Age-0+**	1152	11.27
			Pacific herring Age-2+	3	0.15
			Juvenile Pollock	105	1.56
			Midshipman	18	1.26
			Chinook salmon	3	0.20
			Juvenile hake	3	0.02
			Pink salmon	3	0.19
3	5	Bowser	**Pacific herring Age-0+**	7	0.07
4	1	Henry Bay	**Pacific herring Age-0+**	243	2.51
			Gunnel	1	0.01
			Midshipman	1	trace
			Snake Prickleback	1	trace
4	2	Henry Bay	**Pacific herring Age-0+**	62	0.63
			Midshipman	4	trace
			Sandlance	1	trace
4	3	Henry Bay	**Pacific herring Age-0+**	278	2.88
			Midshipman	6	trace
			Sandlance	1	trace

Table 2 continued…

Transect	Station	Location Name	Species	Number	Weight (Kg)*
4	4	Henry Bay	**Pacific herring Age-0+**	1620	16.83
			Chinook salmon	5	0.26
4	5	Henry Bay	Midshipman	25	0.02
			Juvenile Pollock	17	0.29
			Sandlance	3	0.01
			Chinook salmon	1	0.13
			Gunnel	1	0.01
			Sculpin	1	0.04
5	1	French Creek	**Pacific herring Age-0+**	744	6.55
			Pacific herring Age-1+	6	0.17
			Pacific herring Age-2+	6	0.30
			Northern Anchovy	3	0.06
			Chinook salmon	3	0.58
5	2	French Creek	**Pacific herring Age-0+**	52	0.45
			Midshipman	12	0.66
5	3	French Creek	**Pacific herring Age-0+**	100	0.92
			Chinook salmon	1	0.05
			Midshipman	1	0.14
5	4	French Creek	**Pacific herring Age-0+**	604	6.08
			Pacific herring Age-2+	2	0.07
			Chinook salmon	2	0.62
5	5	French Creek	**Pacific herring Age-0+**	1017	10.41
6	1	Trincomali Channel	**Pacific herring Age-0+**	568	3.10
			Pacific herring Age-1+	1	0.01
			Pink salmon	2	0.05
			Chinook salmon	1	0.06
			Sculpin	1	0.07
6	2	Trincomali Channel	**Pacific herring Age-0+**	1650	9.06
			Pacific herring Age-1+	2	0.03
6	3	Trincomali Channel	**Pacific herring Age-0+**	776	4.24
6	4	Trincomali Channel	**Pacific herring Age-0+**	430	2.36
6	5	Trincomali Channel	**Pacific herring Age-0+**	39925	203.78

Table 2 continued…

Transect	Station	Location Name	Species	Number	Weight (Kg)*
8	1	Smelt Bay	**Pacific herring Age-0+**	2653	25.86
			Sandlance	35	0.09
			Chinook salmon	7	0.31
			Chum salmon	7	0.75
8	2	Smelt Bay	**Pacific herring Age-0+**	2535	23.28
			Chum salmon	10	1.03
			Sandlance	5	0.02
8	3	Smelt Bay	**Pacific herring Age-0+**	652	5.87
			Sandlance	60	0.17
			Midshipman	20	0.01
			Chum salmon	8	0.41
			Gunnel	4	0.03
			Northern Anchovy	2	0.03
			Juvenile Pollock	2	0.02
			Shiner Perch	2	0.03
9	1	Atrevida Reef	**Pacific herring Age-0+**	8	0.06
			Pacific herring Age-2+	1	0.04
			Chinook salmon	2	0.05
			Chum salmon	2	0.09
			Sandlance	2	0.01
			Pink salmon	1	0.03
9	2	Atrevida Reef	**Pacific herring Age-0+**	654	5.98
			Juvenile hake	4	0.03
9	3	Atrevida Reef	**Pacific herring Age-0+**	2085	20.63
			Pacific herring Age-1+	15	0.27
			Juvenile hake	35	0.23
			Midshipman	5	trace
9	4	Atrevida Reef	**Pacific herring Age-0+**	2766	26.43
9	5	Atrevida Reef	**Pacific herring Age-0+**	2265	22.03
			Pacific herring Age-1+	5	0.12
			Chinook salmon	5	0.13

Table 2 continued…

Transect	Station	Location Name	Species	Number	Weight (Kg)*
10	1	Cape Cockburn	**Pacific herring Age-0+**	365	3.58
			Chum salmon	8	0.36
			Chinook salmon	6	0.18
			Sockeye salmon	6	0.09
			Pink salmon	4	0.19
			Three-spine Stickleback	4	0.01
			Northern Anchovy	1	0.02
			Juvenile hake	1	trace
10	2	Cape Cockburn	**Pacific herring Age-0+**	192	1.89
			Juvenile hake	8	0.04
			Chum salmon	1	0.09
			Coho salmon	1	0.03
			Sandlance	1	0.00
10	3	Cape Cockburn	**Pacific herring Age-0+**	63	0.62
			Pacific herring Age-1+	1	0.03
			Juvenile hake	2	0.01
10	4	Cape Cockburn	**Pacific herring Age-0+**	160	1.49
			Coho salmon	1	0.13
			Juvenile hake	1	0.01
			Midshipman	1	0.01
10	5	Cape Cockburn	**Pacific herring Age-0+**	104	1.00
			Chum salmon	4	0.18
			Chinook salmon	3	0.13
			Pink salmon	1	0.04
11	1	Secret Cove	**Pacific herring Age-0+**	1775	16.19
			Northern Anchovy	5	0.08
			Chinook salmon	5	0.11
			Three-spine Stickleback	5	0.01
11	2	Secret Cove	**Pacific herring Age-0+**	2020	18.94
			Pacific herring Age-1+	25	0.45
			Juvenile Pollock	355	2.71
			Juvenile hake	45	0.24
			Sandlance	5	0.01
11	3	Secret Cove	**Pacific herring Age-0+**	124	1.23
			Pacific herring Age-1+	1	0.03
			Chum salmon	6	0.30

Table 2 continued…

Transect	Station	Location Name	Species	Number	Weight (Kg)*
11	4	Secret Cove	**Pacific herring Age-0+**	165	1.66
			Juvenile hake	17	0.12
			Chinook salmon	12	0.81
			Coho salmon	3	0.14
11	5	Secret Cove	**Pacific herring Age-0+**	2471	25.55
			Chum salmon	14	0.90
			Juvenile hake	7	0.04

Table 3. Percent occurrence by species in purse seine sets for the Strait of Georgia juvenile herring survey in 2008.

Species Caught		Percent Occurrence
Common Name*	**Scientific Name**	**2008**
Pacifc Herring Age-0+	*Clupea pallasi* young-of-the-year	93.75
Pacifc Herring Age-1+	*Clupea pallasi* in first year	16.67
Pacifc Herring Age-2+	*Clupea pallasi* in second year or more	14.58
Chinook salmon	*Oncorhyncus tshawytscha*	43.75
Chum salmon	*Oncorhyncus keta*	29.17
Midshipman	*Porichthys notatus*	29.17
Sandlance	*Ammodytes hexapterus*	27.08
Juvenile Pacific Hake	*Merluccius productus*	22.92
Pink salmon	*Oncorhyncus gorbuscha*	14.58
Juvenile Pollock	*Theragra chalcogramma*	12.50
Coho salmon	*Oncorhyncus kisutch*	10.42
Gunnel	*Apodichthys flavidus* or *Pholis laeta*	10.42
Northern Anchovy	*Engraulis mordax mordax*	8.33
Three-spine Stickleback	*Gasterosteus aculeatus*	6.25
Flatfish	*Parophyrus vetulus, Lepidopsetta bilineata, Platichthys stellatus,* or *Citharichthys stigmaens*	4.17
Sculpin	*Leptocottus armatus*	4.17
Shiner Perch	*Cymatogaster aggregata*	4.17
Sockeye salmon	*Oncorhyncus nerka*	4.17
Greenling	*Hexagrammos sp.*	2.08
Octocpus	*Enteroctopus doflein*	2.08
Snake Prickleback	*Lumpenus sagitta*	2.08

* Squid and 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 fish sampled, range of length, mean length, range of weight, mean weight, and standard deviations for three herring age classes. Total catch in numbers (N) and weight (Wt) of all herring by transect for 2008.

Age-0+			Length (mm)			Weight (g)				
Location Name	**Transect**	**Sampled**	**Range**	**Mean**	**SD**	**Range**	**Mean**	**SD**	**N**	**Wt (Kg)**
Clarke Rock	1	123	78-101	88	5.13	6.16-13.42	8.61	1.39	10439	87.1
Yellow Point	2	465	67-96	79	4.59	4.23-11.29	6.70	1.12	19809	136.9
Bowser	3	307	82-102	92	3.38	6.58-13.39	9.84	1.01	3379	33.9
Henry Bay	4	362	83-102	93	2.76	7.45-12.44	10.31	0.75	2203	22.8
French Creek	5	452	81-104	92	4.20	6.17-14.36	9.37	1.42	2517	24.4
Trincomali	6	499	63-101	76	5.11	3.27-13.26	5.47	1.18	43349	222.5
Smelt Bay	8	300	78-101	89	3.89	6.05-13.38	9.18	1.11	5840	55.0
Atrevida Reef	9	407	69-102	91	4.15	4.27-13.64	9.65	1.27	7778	75.1
Cape Cockburn	10	467	81-103	92	2.99	5.87-13.32	9.64	0.99	884	8.6
Secret Cove	11	503	80-103	91	4.22	6.47-14.57	9.44	1.19	6555	63.6
All Locations		3885	63-104	88	7.39	3.27-14.57	8.71	1.96	102753	730.0

Age-1+			Length (mm)			Weight (g)				
Location Name	**Transect**	**Sampled**	**Range**	**Mean**	**SD**	**Range**	**Mean**	**SD**	**N**	**Wt (Kg)**
Clarke Rock	1	-	-	-	-	-	-	-	-	-
Yellow Point	2	-	-	-	-	-	-	-	-	-
Bowser	3	-	-	-	-	-	-	-	-	-
Henry Bay	4	-	-	-	-	-	-	-	-	-
French Creek	5	2	113-132	123	13.44	19.72-35.95	27.84	11.48	6	0.20
Trincomali	6	2	106-109	108	2.12	14.17-15.20	14.69	0.72	3	0.04
Smelt Bay	8	-	-	-	-	-	-	-	-	-
Atrevida Reef	9	4	106-124	114	8.02	15.97-23.26	19.38	3.38	20	0.40
Cape Cockburn	10	1	131	131	-	33.7	33.70	-	1	0.03
Secret Cove	11	6	107-127	115	7.97	15.01-26.19	19.41	4.60	26	0.50
All Locations		15	106-132	116	9.17	14.17-35.95	20.85	6.72	56	1.10

Table 4 continued…

Age-2+			Length (mm)			Weight (g)				
Location Name	**Transect**	**Sampled**	**Range**	**Mean**	**SD**	**Range**	**Mean**	**SD**	**N**	**Wt (Kg)**
Clarke Rock	1	2	146-147	147	0.70	37.82-44.99	41.41	5.07	2	0.08
Yellow Point	2	-	-	-	-	-	-	-	-	-
Bowser	3	2	140-150	145	7.07	41.72-49.73	45.73	5.66	8	0.36
Henry Bay	4	-	-	-	-	-	-	-	-	-
French Creek	5	3	141-155	147	7.09	32.91-53.27	44.55	10.49	8	0.37
Trincomali	6	-	-	-	-	-	-	-	-	-
Smelt Bay	8	-	-	-	-	-	-	-	-	-
Atrevida Reef	9	1	149	149	-	35.99	35.99	-	1	0.04
Cape Cockburn	10	-	-	-	-	-	-	-	-	-
Secret Cove	11	-	-	-	-	-	-	-	-	-
All Locations		8	140-155	147	4.83	32.91-53.27	42.99	7.11	19	0.84

Table 5. Grouping of organisms, by phylum with abbreviations from the 2008 plankton tows from the Strait of Georgia juvenile herring survey.

Coelenterata	
COEL	Medusae - *Aequorea victoria*
SIPH	Siphonophores
Ctenophora	
CTEN	Ctenophores
Annelida	
POLY	Polychaetes - segmented worms
Mollusca	
GAST	Prosobranch gastropods
PELE	Pelecypods
LHEL	*Limacina helicina*
Arthropoda	
AMPH	Amphipods
BARN	Barnacle, unknown stage
CLAD	Cladocerans; *Podon sp.* and *Evadne sp.*
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*
MYSI	Mysids
OSTR	Ostracods
SHRI	Shrimp zoea
TSPI	*Thysanoessa spinifera*
Ectoprocta	
ECTO	Ectoprocts; mainly *Membranipora sp.* larvae
Echinodermata	
ECHI	Echinoderm larvae
Chaetognatha	
CHAE	Chaetognaths; mainly *Sagitta sp.*
Chordata	
LARV	Larvaceans; mainly *Oikopleura sp.*
FISHL	Teleost larvae
Miscellaneous	
EGGS	Unidentified eggs; either euphausiid or teleost

Table 6. Abbreviations for calanoid and cyclopoid copepods identified in 2008 plankton samples from the Strait of Georgia juvenile herring survey.

Calanoid copepods	
ALON	*Acartia longiremis*
CABD	*Centropages abdominales*
CALA	*Calanus sp.*
CCOL	*Canadacia columbiae*
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.*
TDIS	*Tortanus discaudatus*
UCAL	Unidentified or mixed juvenile calanoids
Cyclopoid copepods	
CANG	*Corycaeus anglicus*
OATL	*Oithona atlantica*
OITH	*Oithona sp.*
OSIM	*Oithona similis*
SEAL	*Caligus sp.*

Table 7. Number of zooplankton per m^3 of water by set in samples from the 2008 Strait of Georgia juvenile herring survey. Species codes as shown in table 6.

Location	Tran	Stn	Volume (m^3)	ALON	AMPH	BARN	CABD	CALA	CANG	CCOL	CHAE	CLAD	COEL
Clarke Rock	1	1	13.0330	3.7	-	81.2	1.2	-	1.2	-	-	97.0	0.2
Clarke Rock	1	3	16.8422	13.3	3.4	17.1	1.9	9.4	11.4	-	0.1	4.7	0.1
Yellow Point	2	1	13.8885	-	-	99.4	2.3	-	4.6	-	-	513.8	0.9
Yellow Point	2	4	14.1278	-	4.5	79.3	-	5.5	13.6	-	-	108.7	14.7
Bowser	3	1	3.7940	-	0.3	527.1	4.2	-	4.2	-	-	227.7	1.6
Bowser	3	4	9.5917	10.0	7.1	53.4	-	3.5	46.7	-	-	26.7	0.4
Henry Bay	4	3	13.7613	-	0.1	425.5	8.6	20.1	41.9	-	-	41.9	2.4
Henry Bay	4	5	10.8320	5.9	-	1004.4	-	11.8	23.6	-	-	378.1	0.4
French Creek	5	1	7.1820	17.8	-	57.9	-	-	2.2	-	-	238.4	0.3
French Creek	5	3	7.8379	-	-	8.2	2.0	33.7	20.4	-	-	-	0.3
Trincomali Channel	6	1	4.6381	103.5	-	310.5	6.9	6.9	69.0	-	-	96.6	29.8
Trincomali Channel	6	3	4.1513	107.9	-	123.3	-	-	38.5	-	-	123.3	15.4
Smelt Bay	8	1	14.7951	15.5	-	29.9	3.2	-	0.5	-	-	50.8	0.5
Smelt Bay	8	2	15.9554	3.0	0.1	29.1	2.0	11.2	-	-	-	45.1	2.0
Atrevida Reef	9	1	17.0708	-	0.1	0.5	-	8.0	7.5	-	-	-	2.3
Atrevida Reef	9	3	16.6540	1.9	1.4	1.0	-	16.1	2.9	-	0.6	2.9	1.9
Cape Cockburn	10	3	17.6825	1.8	19.5	-	-	38.9	10.9	0.9	1.4	-	-
Cape Cockburn	10	5	17.3420	4.6	0.2	-	5.8	29.4	8.3	-	-	-	0.2
Secret Cove	11	1	12.4745	1.3	1.8	7.7	-	11.5	52.6	-	-	-	1.8
Secret Cove	11	3	18.6349	0.9	3.8	-	-	25.8	18.0	-	0.4	-	0.6

Table 7 continued…

Location	Tran	Stn	COPE	CPAC	CRAM	CRAZ	CTEN	EBUN	ECHI	ECTO	EELO	EGGS	ELON
Clarke Rock	1	1	-	-	-	0.2	-	-	-	-	-	6.1	-
Clarke Rock	1	3	-	1.9	-	0.1	-	0.2	-	-	-	12.3	-
Yellow Point	2	1	-	-	0.1	5.5	0.4	-	6.9	2.3	-	2.4	-
Yellow Point	2	4	-	1.4	0.6	3.5	0.6	-	31.7	-	-	4.5	0.3
Bowser	3	1	-	-	16.9	0.8	-	-	-	-	-	4.5	-
Bowser	3	4	-	8.9	0.5	-	-	-	-	-	-	-	0.1
Henry Bay	4	3	2.3	-	0.2	5.5	-	-	-	2.3	-	0.1	-
Henry Bay	4	5	17.7	-	0.5	1.7	0.1	-	-	-	-	-	-
French Creek	5	1	-	-	-	-	-	-	-	-	-	0.1	-
French Creek	5	3	-	4.5	0.1	0.1	-	-	-	-	-	-	0.1
Trincomali Channel	6	1	-	-	0.2	12.9	1.5	-	-	20.7	-	6.9	-
Trincomali Channel	6	3	15.4	-	-	7.9	0.5	-	-	15.4	-	-	-
Smelt Bay	8	1	1.6	-	-	-	0.1	-	-	-	-	-	-
Smelt Bay	8	2	-	0.6	0.1	0.3	1.5	-	-	-	-	-	-
Atrevida Reef	9	1	-	-	-	0.1	0.6	-	-	-	-	-	-
Atrevida Reef	9	3	-	-	0.1	1.0	0.5	-	-	-	-	-	-
Cape Cockburn	10	3	-	-	0.5	-	-	-	-	-	2.7	-	0.5
Cape Cockburn	10	5	-	-	-	-	-	-	-	-	-	-	-
Secret Cove	11	1	-	-	0.2	0.2	0.6	-	-	10.3	-	-	-
Secret Cove	11	3	-	1.7	-	0.2	-	-	-	-	-	-	0.1

Table 7 continued…

Location	Tran	Stn	EUPA	EUPL	FISHL	GAST	LARV	LHEL	METR	MPAC	MYSI	OATL	OBOR
Clarke Rock	1	1	-	-	-	-	104.4	-	-	-	-	-	-
Clarke Rock	1	3	-	-	-	3.8	25.6	-	-	-	-	-	-
Yellow Point	2	1	-	12.0	-	-	62.2	-	-	-	-	-	11.5
Yellow Point	2	4	-	9.1	-	18.1	90.6	-	-	-	-	-	-
Bowser	3	1	-	-	-	50.6	274.1	-	-	-	-	-	-
Bowser	3	4	0.4	3.3	-	16.7	56.7	-	-	5.7	-	-	-
Henry Bay	4	3	-	0.1	-	16.3	95.3	-	-	-	0.1	-	-
Henry Bay	4	5	-	-	-	11.8	189.1	-	-	-	0.3	-	-
French Creek	5	1	-	-	-	33.4	155.9	-	-	-	-	-	-
French Creek	5	3	-	-	-	8.2	87.8	-	-	0.1	-	-	-
Trincomali Channel	6	1	-	-	0.2	48.3	1221.2	-	-	0.2	-	-	-
Trincomali Channel	6	3	-	-	-	30.8	1510.8	-	-	-	-	-	-
Smelt Bay	8	1	-	-	0.1	4.9	21.1	-	-	0.1	-	-	-
Smelt Bay	8	2	-	-	-	16.0	12.0	-	-	0.4	-	-	2.0
Atrevida Reef	9	1	-	-	-	10.8	14.5	-	-	-	0.1	0.5	-
Atrevida Reef	9	3	-	-	-	4.8	6.7	-	-	0.1	-	-	-
Cape Cockburn	10	3	105.0	-	-	12.7	-	0.9	23.4	130.3	-	-	-
Cape Cockburn	10	5	23.1	-	-	5.5	-	-	9.8	-	-	-	-
Secret Cove	11	1	1.4	2.6	-	12.8	19.2	-	-	0.4	0.5	-	-
Secret Cove	11	3	0.3	1.0	0.1	2.6	0.9	-	10.3	16.9	-	-	-

Table 7 continued…

Location	Tran	Stn	OITH	OSIM	OSTR	PELE	POLY	PPAR	PSEU	SEAL	SHRI	SIPH
Clarke Rock	1	1	-	19.6	-	-	-	12.3	-	-	0.3	-
Clarke Rock	1	3	-	25.6	0.9	-	3.0	98.8	17.1	-	0.2	7.8
Yellow Point	2	1	4.6	-	-	-	13.8	6.9	-	-	2.9	157.4
Yellow Point	2	4	-	4.5	-	-	13.6	48.9	-	-	22.5	133.2
Bowser	3	1	-	25.3	-	-	-	156.8	-	-	2.1	30.3
Bowser	3	4	-	20.0	-	-	-	133.1	41.1	0.1	0.6	0.7
Henry Bay	4	3	-	53.5	-	-	4.7	38.4	-	-	8.0	5.9
Henry Bay	4	5	-	17.7	-	-	-	41.4	5.9	-	0.6	-
French Creek	5	1	-	6.7	-	-	-	207.2	-	-	0.4	-
French Creek	5	3	-	14.3	-	-	-	71.2	50.3	-	-	0.5
Trincomali Channel	6	1	-	20.7	-	-	6.9	186.3	6.9	0.2	34.1	10.1
Trincomali Channel	6	3	-	23.1	-	7.7	7.7	92.5	-	-	9.2	0.7
Smelt Bay	8	1	-	8.1	0.1	-	-	53.4	2.0	-	3.4	0.6
Smelt Bay	8	2	-	5.0	-	-	3.0	103.9	47.8	-	1.3	0.1
Atrevida Reef	9	1	-	12.7	0.1	-	-	44.4	10.9	-	0.2	6.0
Atrevida Reef	9	3	-	15.4	-	-	-	77.8	20.2	-	1.3	2.4
Cape Cockburn	10	3	-	-	21.7	-	12.7	9.0	37.3	-	-	-
Cape Cockburn	10	5	-	1.8	-	-	-	35.3	27.7	-	1.4	-
Secret Cove	11	1	-	12.8	-	-	0.1	34.6	28.2	-	2.4	0.6
Secret Cove	11	3	-	2.6	0.9	-	0.4	21.5	80.7	-	0.1	1.7

Location	Tran	Stn	TDIS	TSPI	UCAL
Clarke Rock	1	1	-	-	1.2
Clarke Rock	1	3	-	-	-
Yellow Point	2	1	-	-	20.7
Yellow Point	2	4	-	-	0.3
Bowser	3	1	-	-	0.5
Bowser	3	4	-	-	66.1
Henry Bay	4	3	12.6	-	-
Henry Bay	4	5	29.5	-	-
French Creek	5	1	-	-	0.1
French Creek	5	3	-	0.5	0.8
Trincomali Channel	6	1	-	-	-
Trincomali Channel	6	3	-	-	77.1
Smelt Bay	8	1	-	-	-
Smelt Bay	8	2	-	-	-
Atrevida Reef	9	1	-	0.1	-
Atrevida Reef	9	3	-	-	0.2
Cape Cockburn	10	3	-	-	-
Cape Cockburn	10	5	-	0.2	-
Secret Cove	11	1	-	0.2	-
Secret Cove	11	3	-	0.1	-