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# Hydroacoustic Herring Survey Results from Hecate Strait November 30 - December 10, 1992. *W. E. Ricker Cruise 92 HER*

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HYDROACOUSTIC HERRING SURVEY RESULTS FROM  
HECATE STRAIT NOVEMBER 30 - DECEMBER 10, 1992  
W. E. RICKER CRUISE 92HER

by

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ABSTRACT

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Pacific herring in Hecate Strait overwinter in two major areas: Browning Entrance on the mainland side of Hecate Strait and the inshore waters of Juan Perez Sound off the south-eastern Queen Charlotte Islands. We conducted an acoustic and fishing survey of these herring aggregations from November 30 - December 10, 1992 aboard the research vessel, W. E. RICKER. Total echo integration biomass estimates of midwater herring were 12,500 tonnes in the Browning Entrance area and 21,400 tonnes in the Juan Perez Sound area. Hydroacoustic estimates and model based stock forecasts were similar in the Queen Charlotte Islands District but were significantly different in the Browning Entrance/Prince Rupert District. A compilation of 1985-1993 model based stock forecasts and estimates are compared with acoustic survey estimates.

Key words: Pacific herring, Hecate Strait, hydroacoustic, biomass estimate, survey

RESUME

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Dans le détroit d'Hécate, le hareng du Pacifique hiverne dans deux zones principaux : l'entrée Browning, du côté continental du détroit d'Hécate, et les eaux littorales de la baie Juan Perez, au sud-est des îles de la Reine-Charlotte. Nous avons effectué entre le 30 novembre et le 10 décembre 1992, à bord du navire de recherche W.E. RICKER, un relevé acoustique et une campagne de pêche pour étudier ces concentrations de poisson. Les estimations totales, obtenues par échointégration, de la biomasse de hareng pélagique atteignaient 12 500 tonnes dans la région de l'entrée Browning et 21 400 tonnes dans la région de la baie Juan Perez. Les estimations obtenues par relevé hydroacoustique et les prévisions des stocks par modélisation étaient similaires dans la zone des îles de la Reine-Charlotte, mais nettement différentes dans le district entrée Browning/Prince Rupert. Nous comparons une compilation des prévisions et des estimations des stocks par modélisation aux estimations obtenues grâce aux relevés acoustiques.

Mots clés : hareng du Pacifique, détroit d'Hecate, hydroacoustique, estimation de la biomasse, relevé

## INTRODUCTION

The objective of this survey was to continue development of methods for hydroacoustic estimation of Pacific herring (Clupea harengus pallasi) abundance. Herring schools are sometimes difficult to integrate acoustically because of bottom echo interference and a limited echo integration range near the surface. Schools are frequently located close to the bottom during the day and near the surface at night. This behaviour makes it difficult to conduct continuous, 24 hour day echo integration surveys. We conducted several 6-8 hour sounding grids during the dawn and dusk periods to mitigate this problem. Midwater trawl fishing was restricted to midday and midnight hours. Analysis of trawl catches confirmed the species identification of acoustic targets and provided herring size and age samples. Survey grid patterns were based on results from previous winter acoustic and fishing surveys in 1984 (Kieser et al. 1987), 1985 (McCarter et al. 1987), 1987 (McCarter et al. 1988), 1988 (McCarter et al. 1989), 1990 (McCarter et al. 1991) and 1991 (McCarter et al. 1992). The survey was conducted on the Fisheries Research vessel, W. E. RICKER. A schedule is given in Appendix Table 1.

The hydroacoustic biomass estimates determined during the survey are based on standard echo integration procedures (Kieser et al. 1987). We compared our acoustic estimates with statistical stock forecasts and estimates that use spawn surveys and analyses of catch and age structure (Schweigert et al. 1993). One noteworthy aspect of the hydroacoustic estimate is that it is independent of any other methods or fishery data.

## METHODS

### HYDROACOUSTIC EQUIPMENT

The hydroacoustic equipment was installed on the W. E. RICKER and configured for echo integration. Its major components were a Biosonics model 101 (1985) echo sounder, Biosonics model 121 (1985) echo integrator and a Biosonics model 111 (1985) chart recorder. An 8 by 13 degree, Simrad (#4899) 38 kHz ceramic transducer was mounted in a torpedo-shaped body which was towed behind the vessel with a 60 m length of armoured cable. This configuration facilitated transducer calibration and minimized acoustic interference from the ship's propeller and hull. A Tektronix oscilloscope was used to monitor the echosounder output. Digital echo integrator output was stored on an IBM PC compatible microcomputer. Analog echo data were stored on a PCM/VCR digital audio recording system. The echo sounder, transducer and cable were calibrated at the hydroacoustic barge of the University of Washington, Seattle in June, 1992. A fish target strength of -32 dB/kg was used to convert the measured backscattering strength to fish density estimates. Biomass estimates were obtained by extrapolating the measured surface density over the area of interest.

### SURVEY AREA

Parallel transects 5-10 nm in length were spaced 1.0 nm apart covering four major herring overwintering areas in the Browning Entrance area (Figs. 1 and 2). The Freeman's and Whiterocks transect grids were each surveyed three times and the Bonilla and inshore Browning Entrance grids were

each surveyed once. Transects were spaced 0.5 nm apart in the confined waters of Juan Perez Sound (Figs. 3 and 4) where herring are often heavily concentrated. These transects were surveyed twice and the entrance of the sound was surveyed once. Each transect grid was completed in a 6-8 hour period primarily at dusk and dawn when most herring were in midwater in 'off bottom schools'. This was especially important in the deeper waters of Juan Perez Sound where fish are difficult to distinguish from the irregular bottom during the day and much of the biomass is shallower than the towed body at night. Transects were similar to those used during the 1990 and 1991 hydroacoustic surveys with the exception of additional intensive sounding grids conducted in Sedgwick Bay and Darwin Sound where major herring aggregations were identified. Transect spacing was set at 0.25 nm and 0.30 nm respectively in these locations.

The transducer was towed at a depth of approximately 15 metres while the ship's speed was maintained at 8-10 knots. The echo integration range or depth strata selected in the Browning Entrance area included the entire water column starting 25 m below the transducer to 5 m from the sea floor. In the deeper waters of Juan Perez Sound the integration range was set starting at 15-25 m below the transducer to a maximum range of 140 m from the transducer or to 12 m from the sea floor in shallow areas. A relatively large bottom buffer was chosen in this area to maintain bottom tracking over irregular bottom and to minimize bottom echo integration over steep edges.

#### FISHING AND SAMPLING

Fishing equipment on the W. E. RICKER included a Canadian Diamond 5 midwater trawl with 40 fathom sweeplines and 4 m<sup>2</sup> Suberkrub otter boards. Catches were brought aboard and species weights estimated. Herring samples were placed in buckets and frozen. Scales for age determinations were removed from 100 herring in each sample. Herring standard length measurements were recorded to the nearest millimetre, fish weights and gonad weights to the nearest gram and sex and maturity determined whenever possible.

#### PROCESSING OF HYDROACOUSTIC DATA

Average echo intensity values measured by the echo integrator over one minute intervals (sequences) and by selected depth strata were logged by a microcomputer. An event file was logged concurrently on a second microcomputer by entering a consecutive event number, time, position, sequence number, analog tape number and operator's comments at the start of each transect. A data logging program written in Turbo Pascal provided direct entry of the ship's Loran position and time. A set of hydroacoustic programs written in BASIC were used to generate biomass estimates and to produce transect plots. The calculated parameters included transect length (km), transect bearing, average speed (kn), area covered (km<sup>2</sup>), average distance of biomass from surface and bottom (m), volume density (kg/m<sup>3</sup>), surface density (kg/m<sup>2</sup>) and extrapolated biomass (t). Species identification of acoustic targets was based on information from the echograms and the catch compositions of midwater trawl tows. During the analysis, echo integration range strata and sequences were carefully selected to only include herring in the biomass estimate and to exclude noise and other targets and interferences. The parameter portion of the biomass control file used for this analysis is given at the beginning of Appendix Table 2.

Fish distributions were plotted on digitized Canadian hydrographic charts 3927 and 3808 using geo-referencing software (Langford, 1993). The dot

density on each figure approximates the relative interpolated density of fish. A buffer or extrapolated area around each transect grid was based on transect spacing. A corresponding set of biomass estimates were obtained using a grid and window, distance squared interpolation of the hydroacoustic surface density measurements. This provided a comparison with the biomass estimates generated from the simpler area expansion algorithm incorporated in the hydroacoustic programs. Further detail regarding the analysis and programs are given by Kieser et al. (1987).

## RESULTS AND DISCUSSION

### BIOMASS ESTIMATES

We pooled biomass estimates according to groups of transects (Table 1), those derived with the distance squared interpolator are given in parentheses. Browning Entrance transect grids, including Browning inshore, Freeman's, Whiterocks and Bonilla trawling grounds, comprised a total area of 700 km<sup>2</sup>. Maximal biomass estimates from Table 1 are 10,500 tonnes on the Freeman's grid, 762 tonnes on the Whiterocks grid, 246 tonnes on the Bonilla grid and negligible tonnage on the inshore Browning Entrance grid. Queen Charlotte Island transect grids comprised a total area of 172 km<sup>2</sup>. Biomass estimates were 21,200 tonnes in Juan Perez Sound with 17,900 tonnes concentrated at the entrance to Sedgwick Bay and 3,300 tonnes in Darwin Sound. A detailed summary of the hydroacoustic estimates by individual transect and grid pattern is given in Appendix Table 2. Biomass estimates using a distance squared interpolator were generally higher than those using a simple area expansion. The authors feel that this alternate method of representing extrapolated biomass should be further explored and validated.

### REPETITIVE HYDROACOUSTIC SURVEYS AND DISTRIBUTION PLOTS

During the dawn to dusk surveys of the Freeman's ground, herring schools appeared as numerous, small, aggregations 5-20 m from the bottom and 60-90 m from the surface. Distributions of schools were similar between surveys. A 10,500 t estimate was produced from the first coverage using a NW-SE transect pattern (transects F1-F8, Fig. 1). The second coverage did not produce a biomass estimate due to a malfunction of the 1979 integrator and excessive dolphin noise. A 5,760 t estimate was produced from the third coverage using a NE-SW transect pattern (transects F10-F19, Fig. 1). A large portion of herring school echoes were not integrated during the third coverage because they could not be clearly distinguished from bottom echoes. One other attempt at completing the Freeman's transect grid was thwarted by bad weather. The first coverage estimate (10,500 t) is considered to be the best estimate.

One daytime N-S transect survey (transects W10-W16, Fig. 2) and one night E-W transect survey (transects W1-W8, Fig. 2) of the Whiterocks ground produced a 762 t estimate and 147 t estimate respectively. An additional night survey (E-W transect pattern) produced a negligible estimate. It is likely that herring schools at night were dispersed too near the surface to be estimated and during the day portions of herring school echoes were not integrated because they could not be clearly distinguished from bottom echoes. The daytime estimate of 762 t is considered to be a minimum estimate.

A dawn survey of the Bonilla ground produced a 246 t estimate.

Herring schools were close to the bottom during this survey and portions of herring school echoes were not integrated. The estimate is considered minimum. A set of 'zig-zag' transects were conducted north of the Freeman's grid to determine if large concentrations of herring were located adjacent to our standard transects grids. One thousand and forty tonnes were estimated in the Edye Passage area and the inshore Browning Entrance area produced a negligible estimate.

One dusk survey in Juan Perez Sound produced an estimate of 7,000 t with ninety-five percent of this biomass detected in several, near bottom schools along transect J3 adjacent to Ramsay Island (Fig. 3). Darwin Sound was not surveyed during this first coverage and several herring schools were not fully integrated. A second coverage of Juan Perez Sound the following dawn produced a 21,200 t estimate with 17,900 t located in a dense, midwater school (50-70 m depth) at the entrance to Sedgwick Bay and 3,300 t in another school (30-40 m depth) in Darwin Sound. Schools were sounded along adjacent transects in similar formations. Intensive survey grids of these two areas were completed during the following afternoon and evening producing a 10,096 t estimate in Sedgwick Bay and 3,240 t in Darwin Sound (Fig. 4). Both of these estimates, however, are considered minimum because many herring schools were too close to the bottom and their echoes were not fully integrated. The transects were conducted in a staggered sequence to minimize school disturbance and the possibility of double sampling. A day survey of the entrance to Juan Perez Sound (P transects) produced a 156 t estimate.

#### TRAWL FISHING AND SAMPLING

We fished major acoustic targets with midwater trawls during the day on the Freeman's ground and during the night in Sedgwick Bay and Darwin Sound (Table 2). The trawl net opening was about 8 m during most tows. Two, half hour tows on the Freeman's ground each yielded approximately 60 kg of herring. A five minute tow in Sedgwick Bay yielded 2 tonnes of herring and another in Darwin Sound the following evening yielded 1.5 tonnes of herring. No other fish species were caught. Herring size and sex frequency data is recorded in Table 3. Herring size and age frequency histograms are shown in Figures 5 and 6.

#### TEMPERATURE, SALINITY AND PLANKTON DATA

Three 'Cooperative Plankton Research' (COPRA) CTD/plankton stations were completed using the Guildline system and a 0.25 m<sup>2</sup> bongo equipped with 250 µm black Nitex nets. Table 4 summarizes the CTD data collected during the survey.

#### COMPARISON OF HYDROACOUSTIC ESTIMATES WITH OTHER BIOMASS ESTIMATES

Schweigert et al. (1993) predicted stock biomass for the Queen Charlotte Islands District from age-structured and escapement models as 22,600 t and 12,800 t respectively. They made these forecasts in the fall of 1992. Both forecasts assume that new recruitment to these stocks will be similar to the "historical average". The average of both models produced a 17,700 t forecast. This compares with a hydroacoustic survey estimate of 21,400 t in the SE Queen Charlotte Islands area.

In the Prince Rupert District, the predicted stock biomass from age-structured and escapement models were 126,800 t and 55,100 t respectively.

Only the escapement model estimate was used to forecast because of some uncertainty in the age-structured model stock estimate (Schweigert, et al. 1993). The hydroacoustic survey estimate was 12,500 t in the Browning Entrance area. Although the different annual estimates (Table 5) do not track precisely (Fig. 7), they all indicate similar biomass.

#### CONCLUSIONS

Overwintering Hecate Strait herring were in the same areas as previous winter surveys: 1984 (Kieser et al. 1987) and 1985-1991 (McCarter et al. 1987, 1988, 1989, 1991, 1992). In the Prince Rupert District, annual acoustic biomass estimates have fluctuated between 12,500 and 32,000 tonnes based on 1984-1992 winter hydroacoustic surveys (Table 5). In the Queen Charlotte Island area these estimates fluctuated between 10,000 and 33,000 tonnes during the same time. Other assessment methods based on spawn surveys and analyses of catch and age structure (Schweigert, et al. 1993) show similar fluctuations during these years (Fig. 7). More effort must be expended to ensure complete and consistent coverage of overwintering herring schools. Depth coverage limitations of the present echo integration system require a survey design that coincides with the diurnal migration patterns of herring at all locations. It is not always possible to plan a survey so that herring schools are consistently in an amenable configuration for echo integration. For this reason we rely on repeated and timely surveys of several, small transect grids as opposed to single, large area surveys (continuous day and night sounding).

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Table 1. Summary of herring biomass estimates (t) by locality obtained during W. E. RICKER cruise, November 30 - December 10, 1992. A corresponding biomass estimate that was determined using a distance squared interpolation is shown below in parentheses.

Locality	Event Number	Transect Name	Survey Area (km <sup>2</sup> )	Estimated Biomass (t)	Time (PST)	Date (D/M/Y)
Freeman's ground	1-26	F1-F8	221.8	10,500 <sup>a</sup> (12,011)	08:59-17:02	02.12.92
Whiterock ground	27-45	W1-W8	138.2	neg. <sup>b</sup>	17:17-22:40	02.12.92
Browning inshore	46-66	E6-E1	166.8	neg. <sup>b</sup>	22:49-24:00 00:00-05:20	02.12.92 03.12.92
Freeman's ground	66-84	F1-F8	226.7	no est. <sup>a</sup>	05:20-13:33	03.12.92
Freeman's ground (incomplete)	86-94	F8-F6	86.3	-	16:24-20:12	03.12.92
Freeman's ground	96-118	F19-F10	225.3	5,760 <sup>a</sup> (6,515)	09:14-18:13	04.12.92
Whiterock ground	120-136	W1-W8	133.1	147 <sup>b</sup>	19:42-24:00 00:00-01:00	04.12.92 05.12.92
Bonilla ground	137-153	B10-B15	177.6	246	01:22-07:57	05.12.92
Edye Passage	156-182	R0-R24	177.5	1,040	12:20-18:18	05.12.92
Juan Perez Sound (excl. Darwin Snd.)	189-207	J1-J14	81.3	7,000 <sup>a</sup> (11,245)	14:53-20:46	06.12.92
Juan Perez Sound (incl. Darwin Snd.)	208-238	J1-J14	106.7	21,200 (23,016)	00:56-08:15	07.12.92
Juan Perez Entr.	239-254	P9-P2	65.2	156 (159)	08:23-13:02	07.12.92
Sedgwick Bay	255-270	S1-S8	29.0	10,096 <sup>a</sup> (9,222)	15:13-19:15	07.12.92
Darwin Sound	272-282	D1-D5	15.1	3,240 <sup>a</sup> (5,247)	19:58-21:28	07.12.92
Whiterock ground	285-303	W10-W16	159.3	762 <sup>a</sup>	09:25-15:45	08.12.92

<sup>a</sup>minimum estimate due to incompletely integrated herring school echoes.  
<sup>b</sup>minimum estimate due to limited depth coverage (near surface).

Table 2. Midwater trawling locations and species compositions of catches made by the W. E. RICKER, November 30 - December 10, 1992.

Tow number	1	2	3	4
Date (Day/Mo.)	03/12	05/12	06/12	07/12
Time (P.S.T.)	14:55	10:35	22:54	22:57
Duration (min)	35	40	5	5
Location	Freeman's	Freeman's	Sedgwick Bay	Darwin Sound
Start				
Latitude (o ')	53 47.4	53 49.5	52 36.5	52 32.6
Longitude (o ')	130 55.1	130 55.0	131 31.6	131 39.4
Finish				
Latitude (o ')	53 46.1	53 47.5	52 36.2	52 32.3
Longitude (o ')	130 53.0	130 54.3	131 31.3	131 39.3
Bottom depth (m)				
Start	81	90	141	80
Finish	87	-	147	83
Net depth (m)				
Start	60	70	80	55
Finish	65	75	85	55
Speed (kts)	3-4	3-4	3-4	3-4
Warp length (m)	150	175	185	135
Pacific herring	60	60	2000	1500
Total catch (kg)	60	60	2000	1500

Table 3. Size (mm) and sex frequency of Pacific herring samples from midwater trawl catches achieved during W. E. RICKER cruise, November 30 - December 10, 1992.

Sample	#1		#2		#3		#4	
Location	Freeman's		Freeman's		Sedgwick Bay		Darwin Sound	
Date	Dec. 3, 1992		Dec. 5, 1992		Dec. 6, 1992		Dec. 7, 1992	
Time	14:55		10:35		22:54		22:57	
Length (mm)	Male	Female	Male	Female	Male	Female	Male	Female
147-149	-	1	1	-	-	-	-	-
150-152	-	-	0	3	-	-	-	-
153-155	-	-	3	2	-	-	-	-
156-158	-	-	2	1	-	-	-	-
159-161	-	-	2	0	-	-	-	-
162-164	-	1	2	1	-	1	-	-
165-167	-	1	1	0	-	0	-	-
168-170	2	1	2	2	1	0	-	-
171-173	1	1	3	2	0	0	-	-
174-176	8	4	7	5	0	0	-	-
177-179	6	7	7	2	2	1	-	1
180-182	4	2	2	6	0	0	-	0
183-185	5	4	2	5	4	1	2	0
186-188	7	6	6	2	2	1	0	1
189-191	3	1	5	1	3	2	2	1
192-194	2	6	2	3	1	3	4	3
195-197	2	3	0	1	4	6	3	5
198-200	2	2	1	3	3	7	8	9
201-203	0	3	0	2	4	6	4	11
204-206	1	1	1	1	4	5	3	6
207-209	0	2	1	0	5	4	2	0
210-212	5	2	1	1	3	2	2	3
213-215	0	1	-	4	3	4	3	3
216-218	0	1	-	0	3	7	1	3
219-221	0	-	-	2	2	0	5	2
222-224	0	-	-	-	2	1	0	7
225-227	1	-	-	-	0	1	0	1
228-230	0	-	-	-	0	0	0	1
231-233	1	-	-	-	0	0	1	1
234-236	-	-	-	-	1	1	-	1
Total	50	50	51	49	47	53	40	60

Table 4. Summary of CTD data collected during W. E. RICKER cruise, November 30 - December 10, 1992.

Station Name	Latitude (deg min)	Longitude (deg min)	Date (Y/M/D)	Time	Max Depth (m)	Surface Salin (o/oo)	Surface Temp (° C)	CTD Cast Number
CPF1	49 22.0	124 05.0	921130	1338	204	28.40	8.85	1
CPF2	49 28.0	124 30.0	921130	1606	290	28.90	9.01	2
CPE1	51 00.0	127 50.0	921201	0845	130	31.79	9.91	3

Table 5. Comparison of 1985-1993 stock size and forecasted stock size using age-structured and escapement models with the stock estimate using winter hydroacoustic surveys. A dash indicates no winter hydroacoustic surveys conducted. All estimates are in tonnes.

Year	Queen Charlotte Islands				Prince Rupert District			
	Forecast		Stock size		Forecast		Stock size	
	age	escap.	winter survey	catch+ spawners	age	escap.	winter survey	catch+ spawners
1985	31000	31700	-	23830	33000	26400	31500	38740
1986	21300	8000	9500	10222	38000	32888	32000	38865
1987	20700	5500	-	17338	31300	21000	-	44411
1988	15000	11000	15500	16802	44500	31800	15300	40060
1989	19100	11700	16200	27283	47100	28100	25900	21405
1990	48400	22100	-	32076	57400	14800	-	24087
1991	25600	20900	32600	19954	60700	19400	15200	24141
1992	19600	16600	9800	13230	87700	30500	31500	42254
1993	22600	12800	21400	?	126800	55100	12500	?

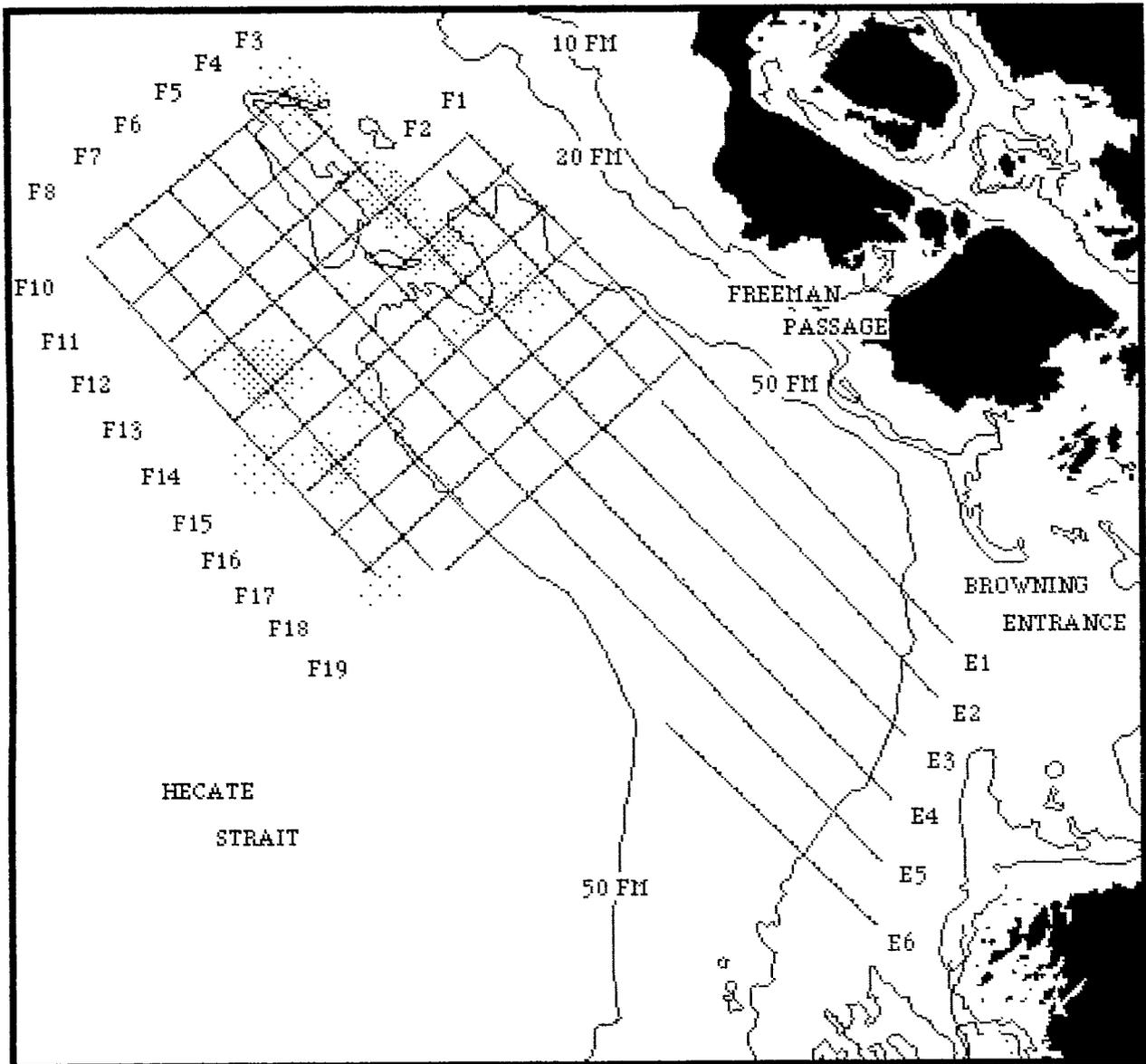


Fig. 1. Transect locations and composite herring distributions in northern Browning Entrance during W. E. RICKER cruise 92HER, November 30 - December 10, 1992. F1-F8 Freeman's NW-SE grid, F10-F19 Freeman's NE-SW grid, E1-E6 Browning Entrance inshore grid.

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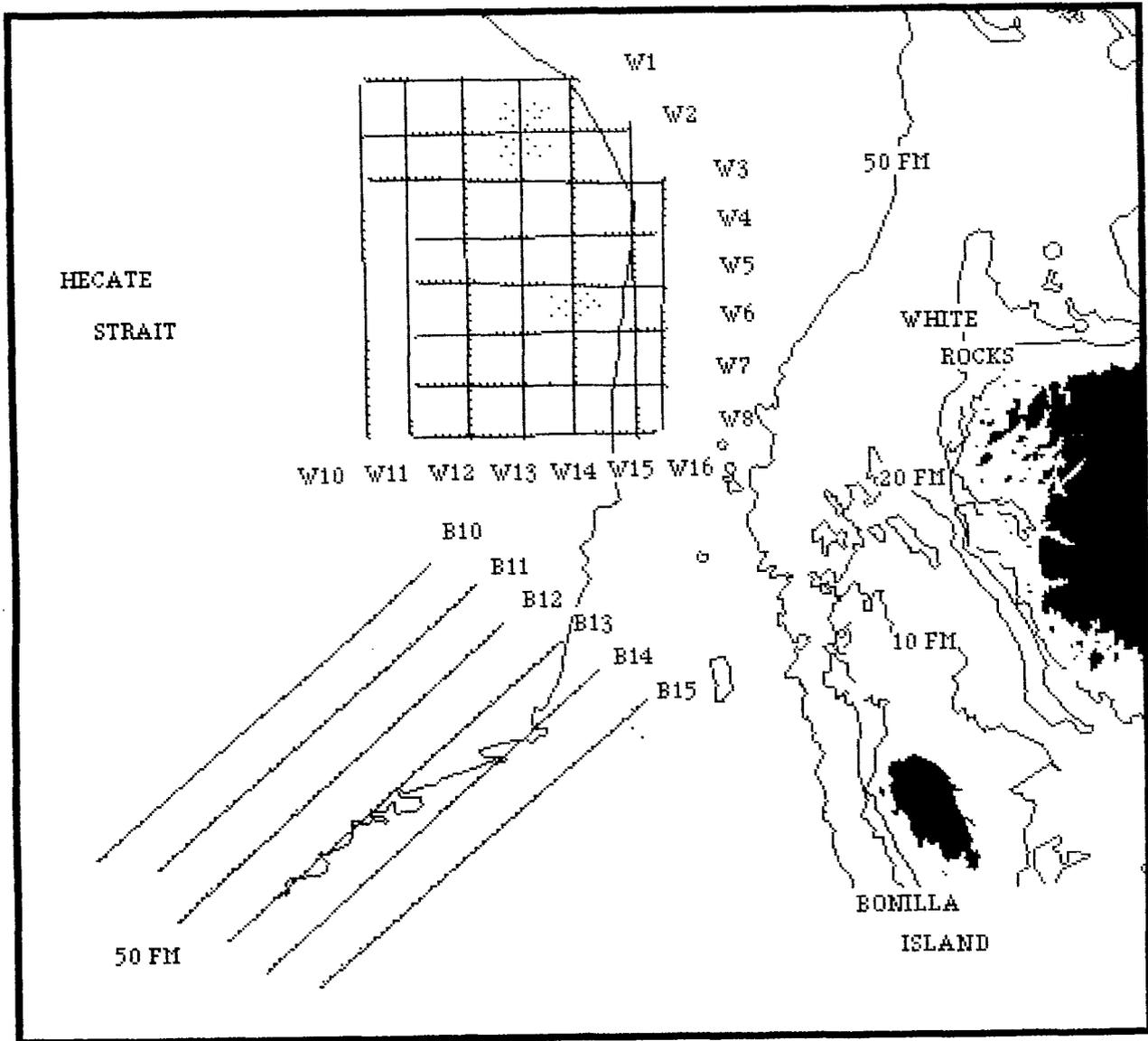
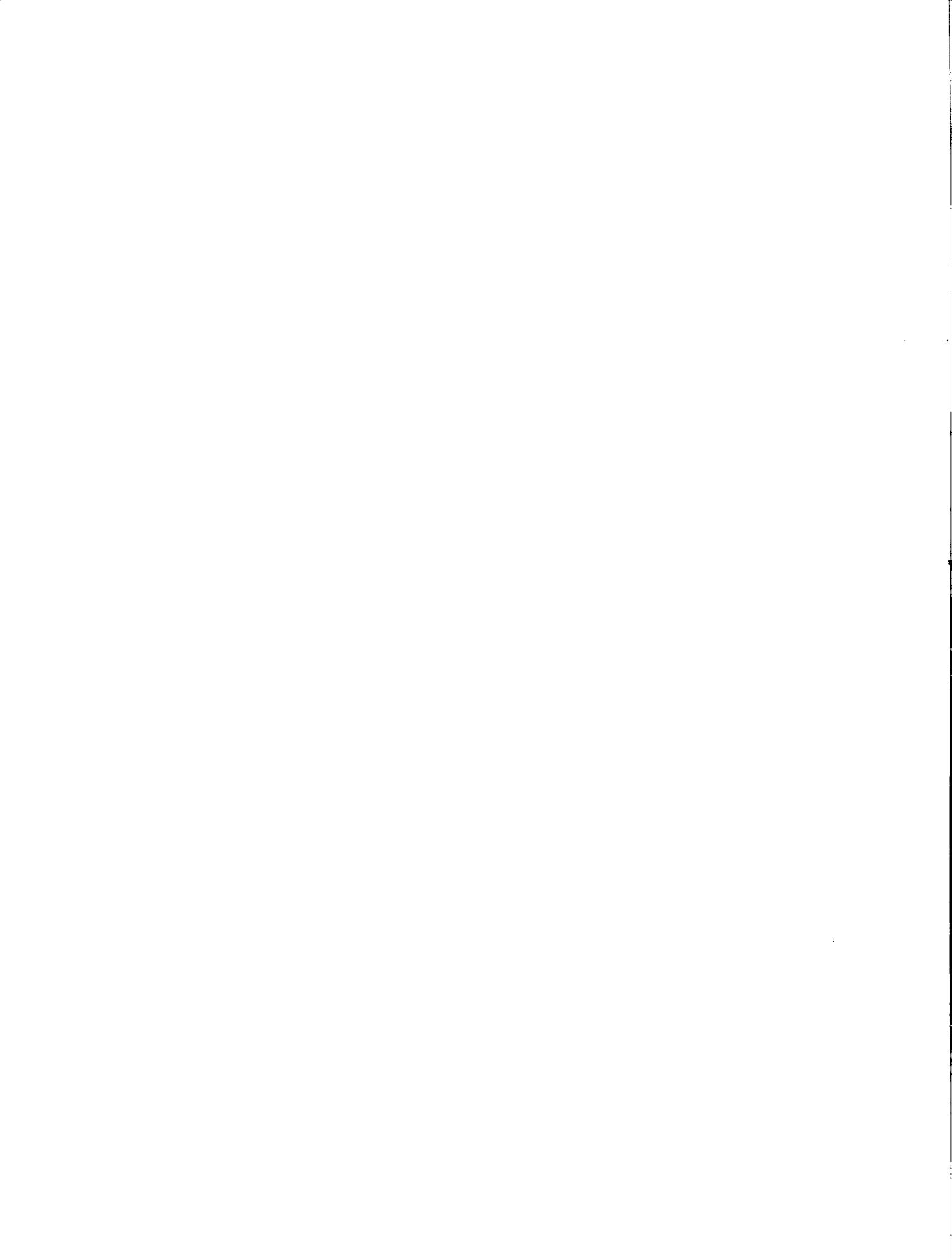


Fig. 2. Transect locations and composite herring distributions in southern Browning Entrance during W. E. RICKER cruise 92HER, November 30 - December 10, 1992. W1-W8 Whiterocks E-W grid, W10-W16 Whiterocks N-S grid, B10-B15 Bonilla Island grid.



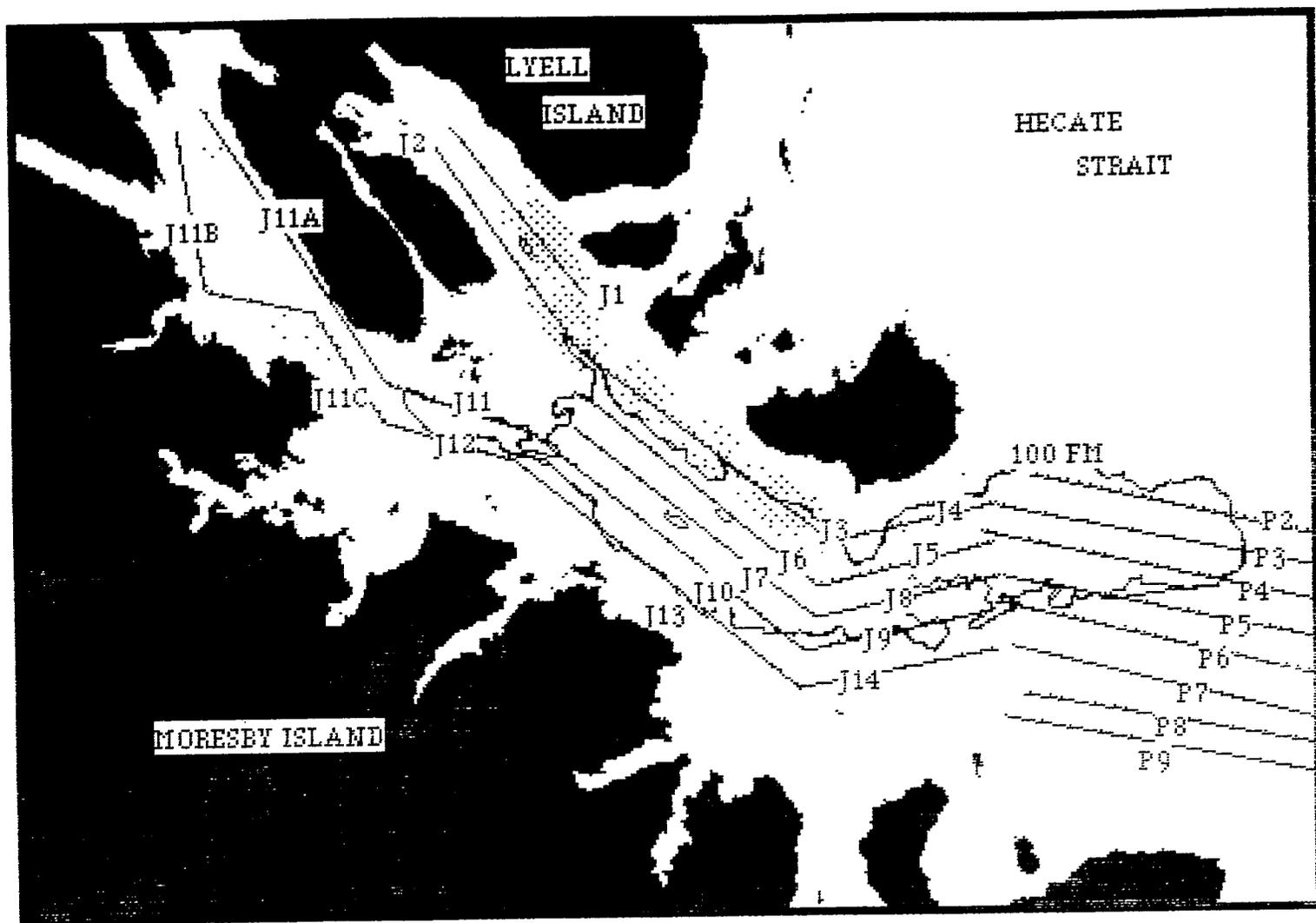
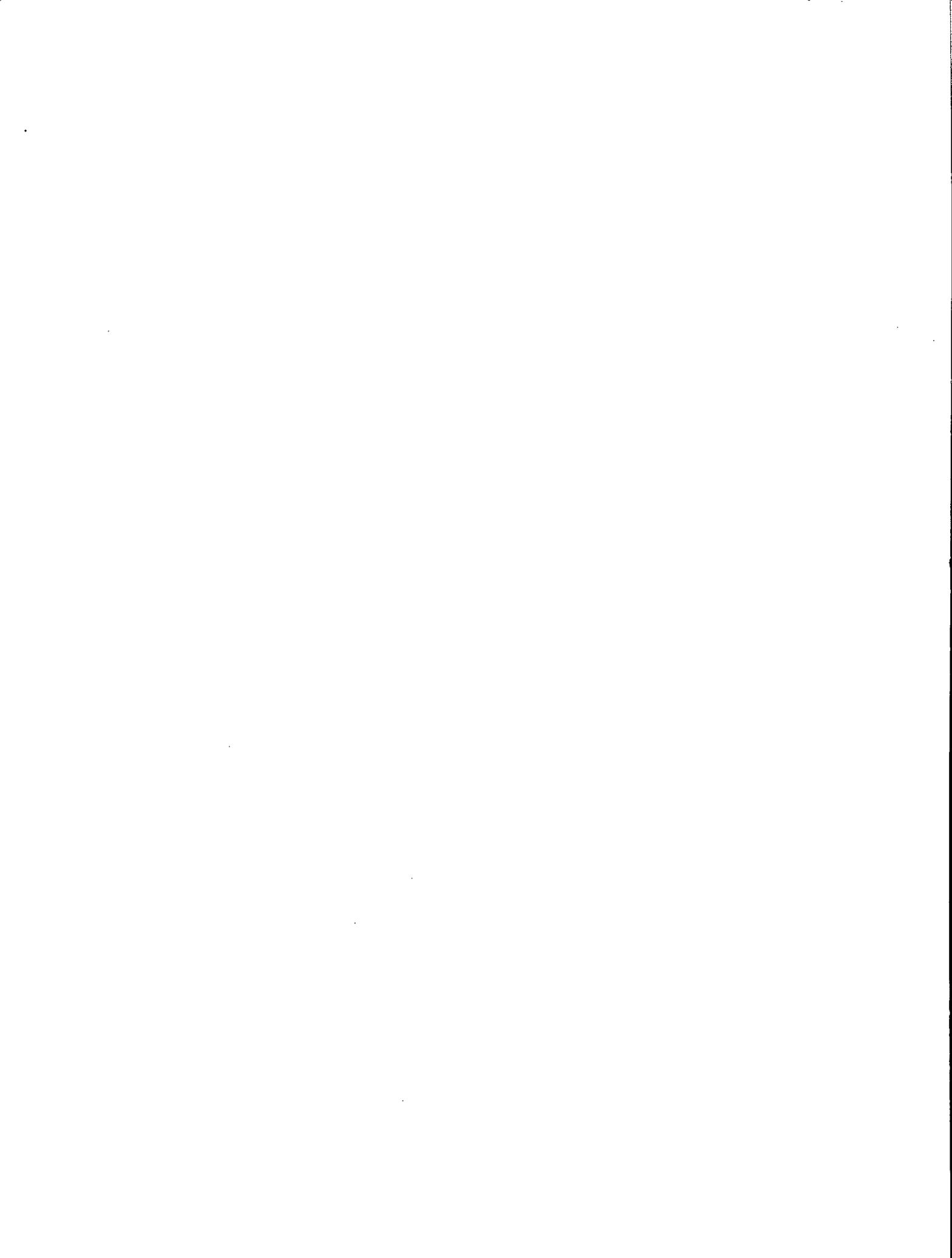


Fig. 3. Transect locations and composite herring distributions in Juan Perez Sound during W. E. RICKER cruise 92HER, November 30 - December 10, 1992. J1-J14 Juan Perez Sound grid, P2-P9 Juan Perez entrance grid.



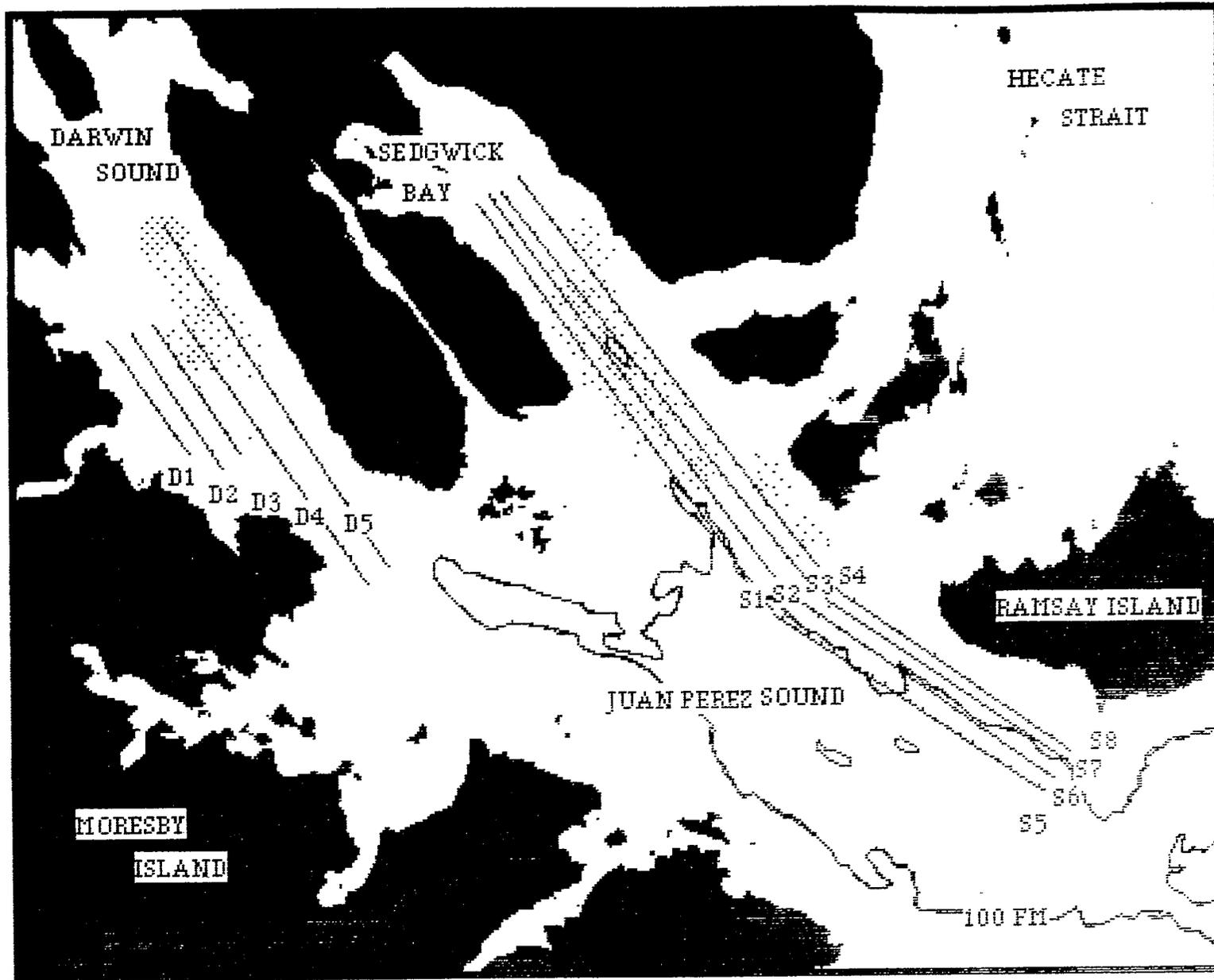
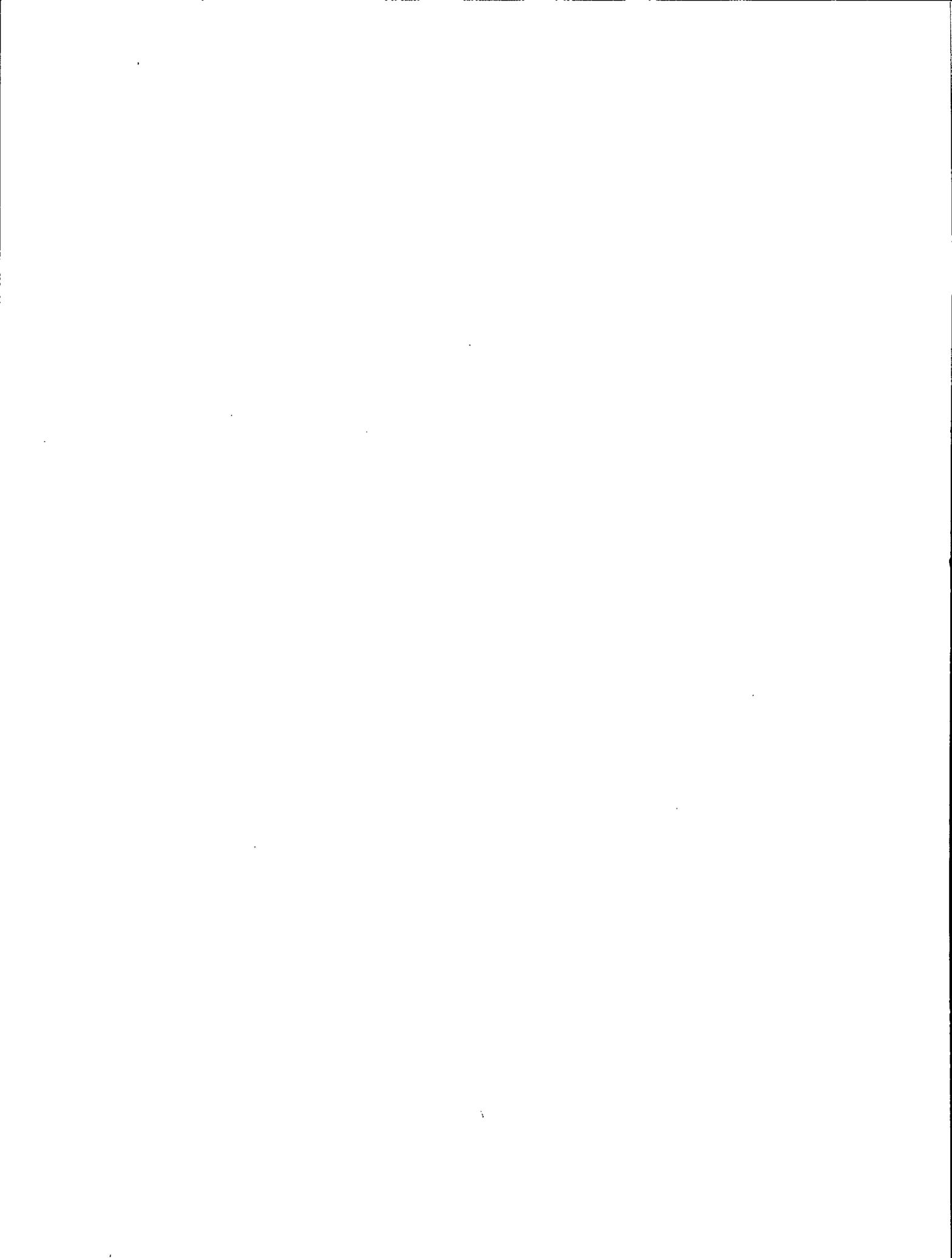
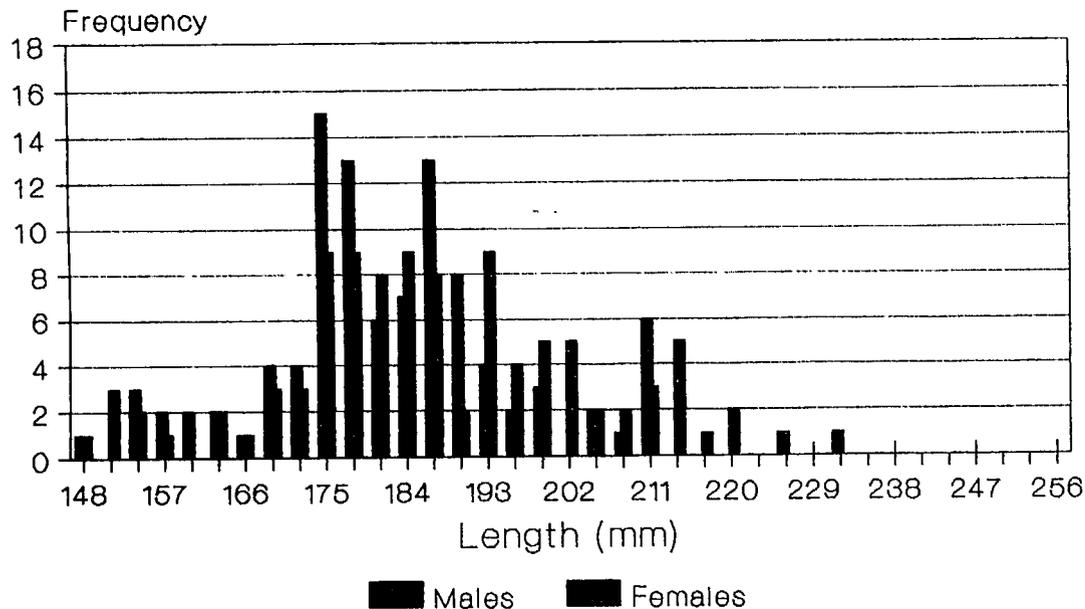


Fig. 4. Transect locations and herring distributions in Juan Perez Sound during W. E. RICKER cruise 92HER, November 30 - December 10, 1992. S1-S8 Sedgwick Bay intensive grid, D1-D5 Darwin Sound intensive grid.



## Browning Entrance (n = 200) Trawl tows #1 & #2



## Juan Perez Sound (n = 200) Trawl tows #3 & #4

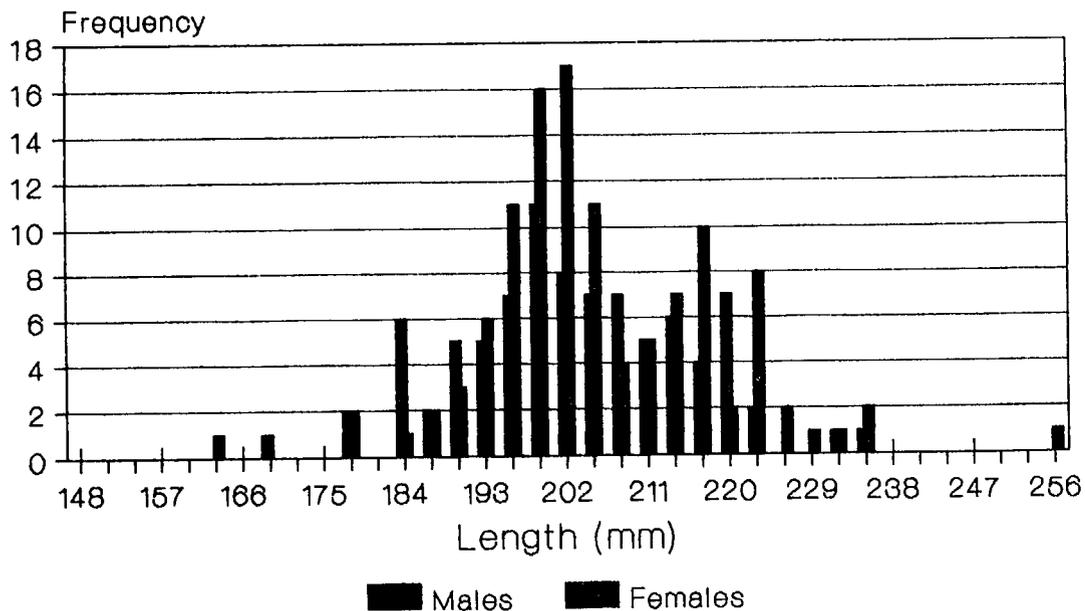
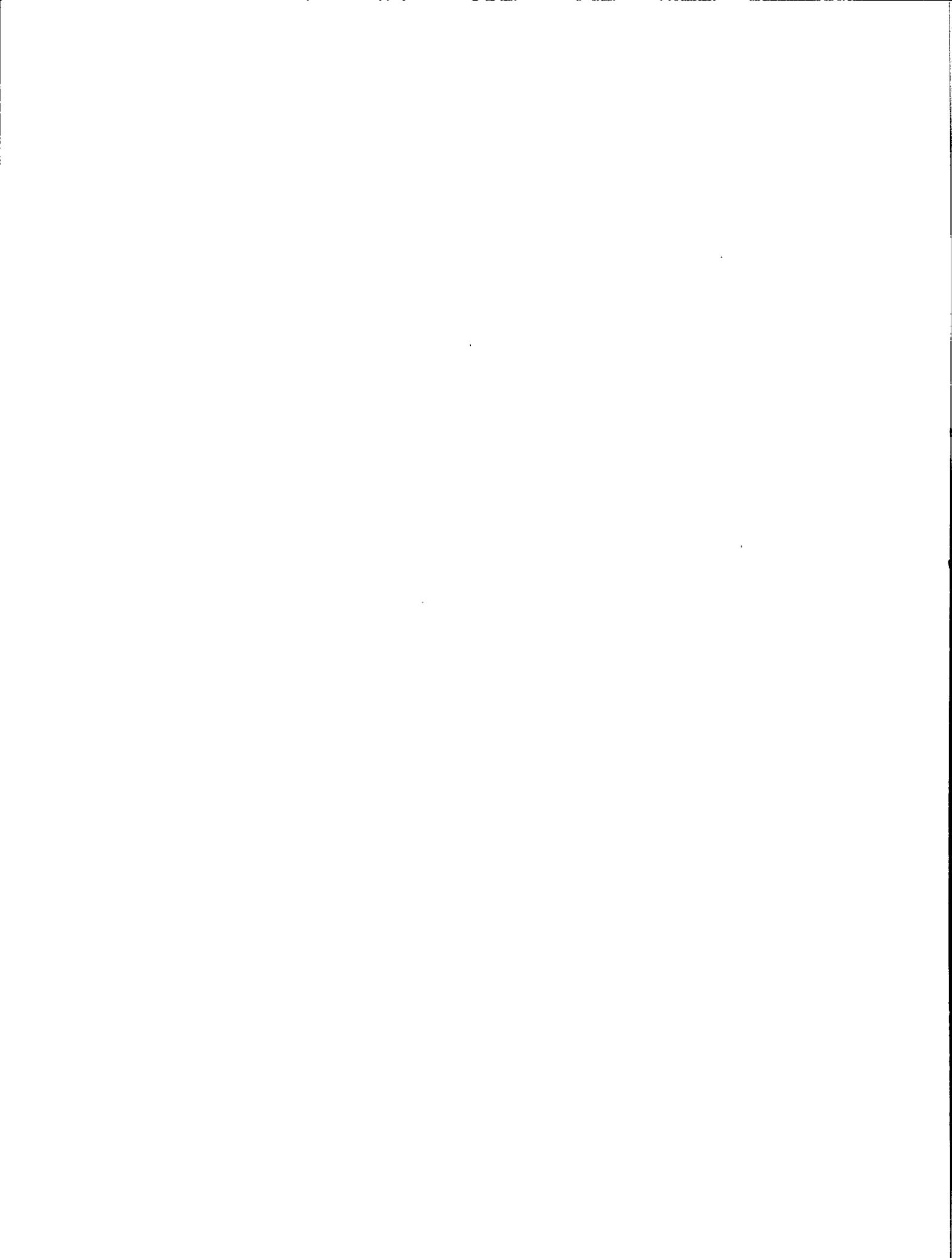
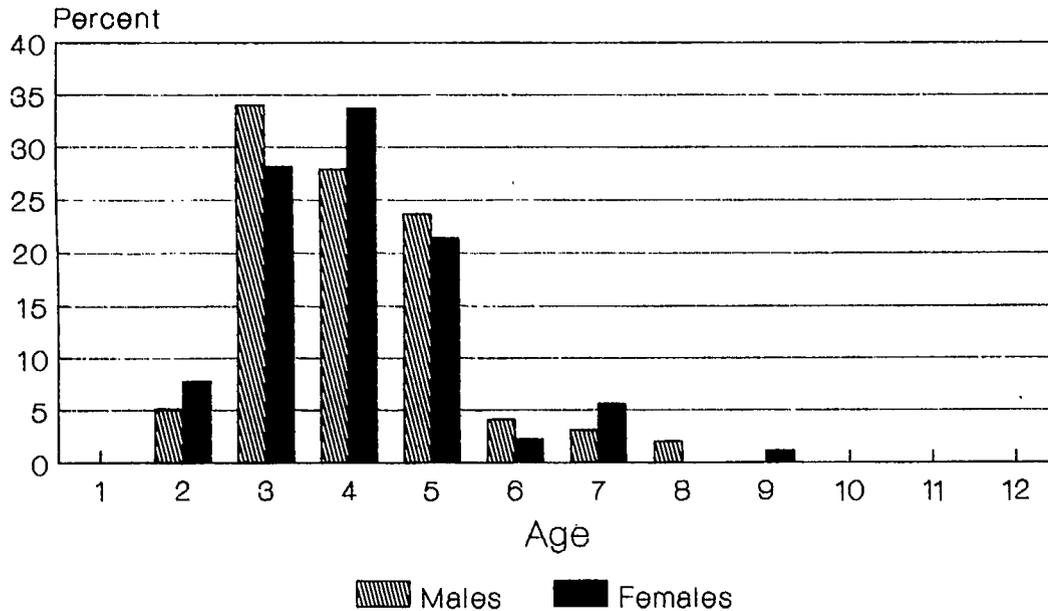


Fig. 5. Length frequency histograms of Pacific herring samples collected during W. E. RICKER cruise 92HER, November 30 - December 10, 1993.



## Browning Entrance (n = 186) Trawl tows #1 & #2



## Juan Perez Sound (n = 171) Trawl tows #3 & #4

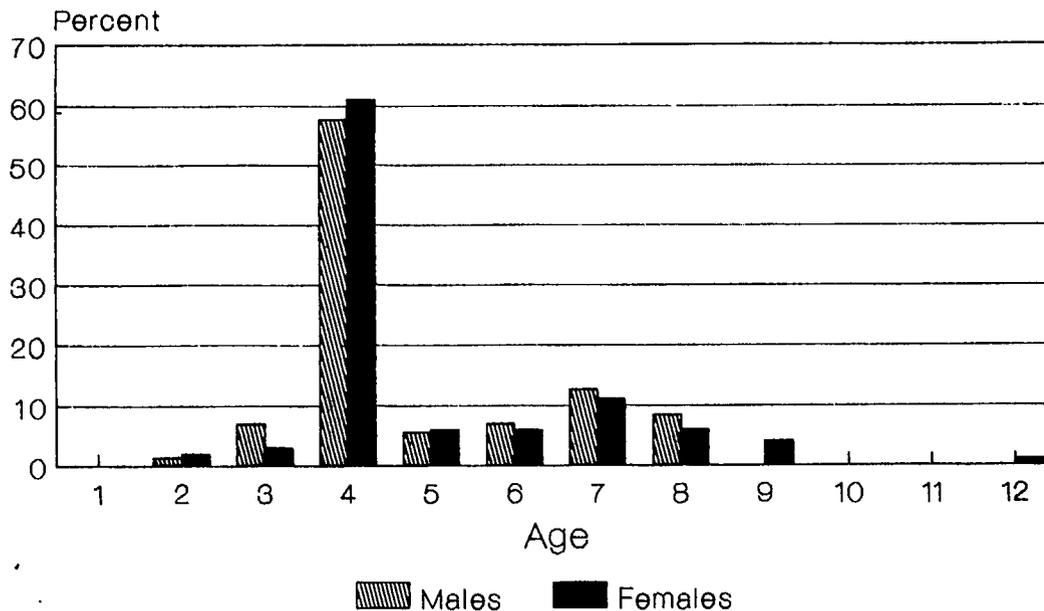
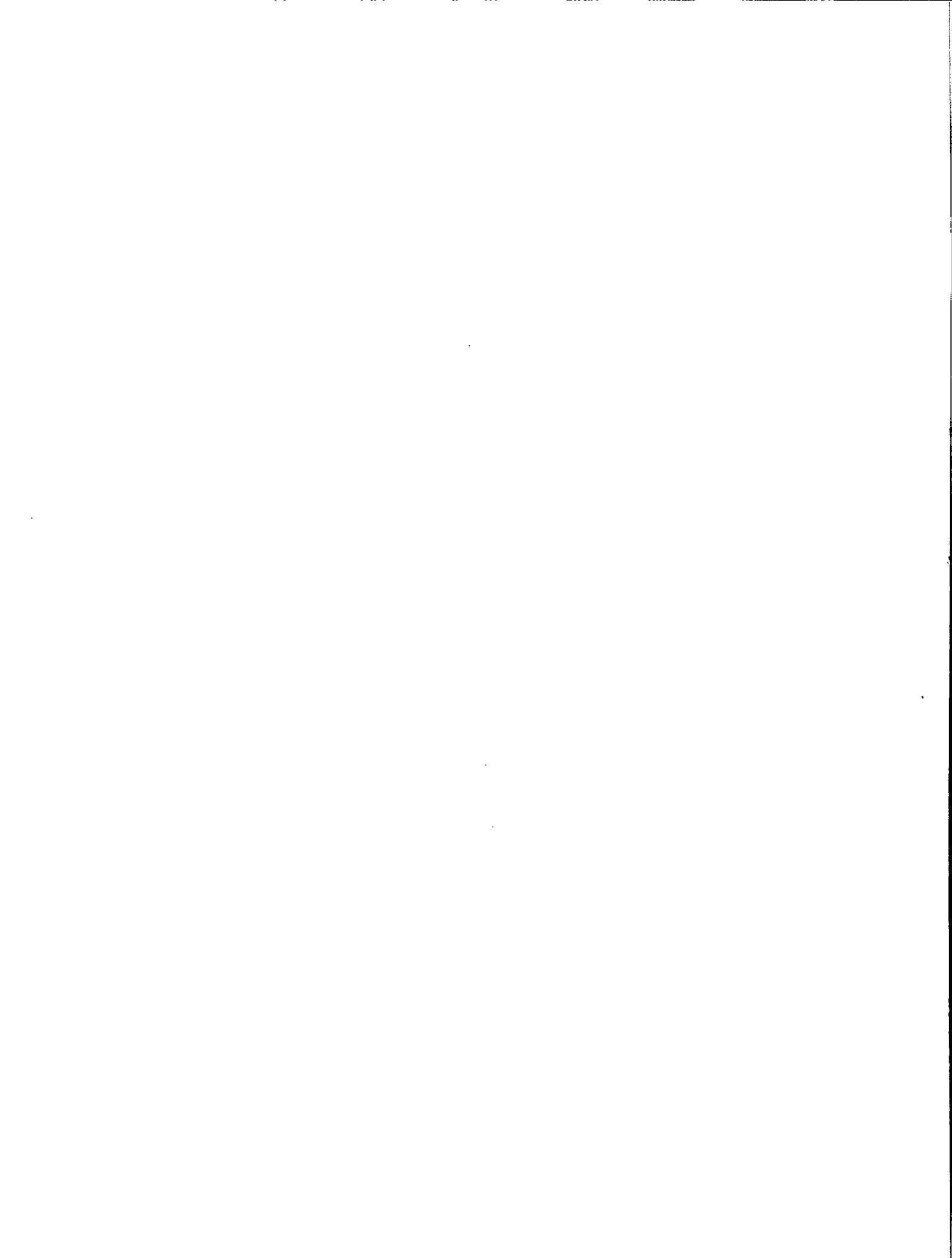
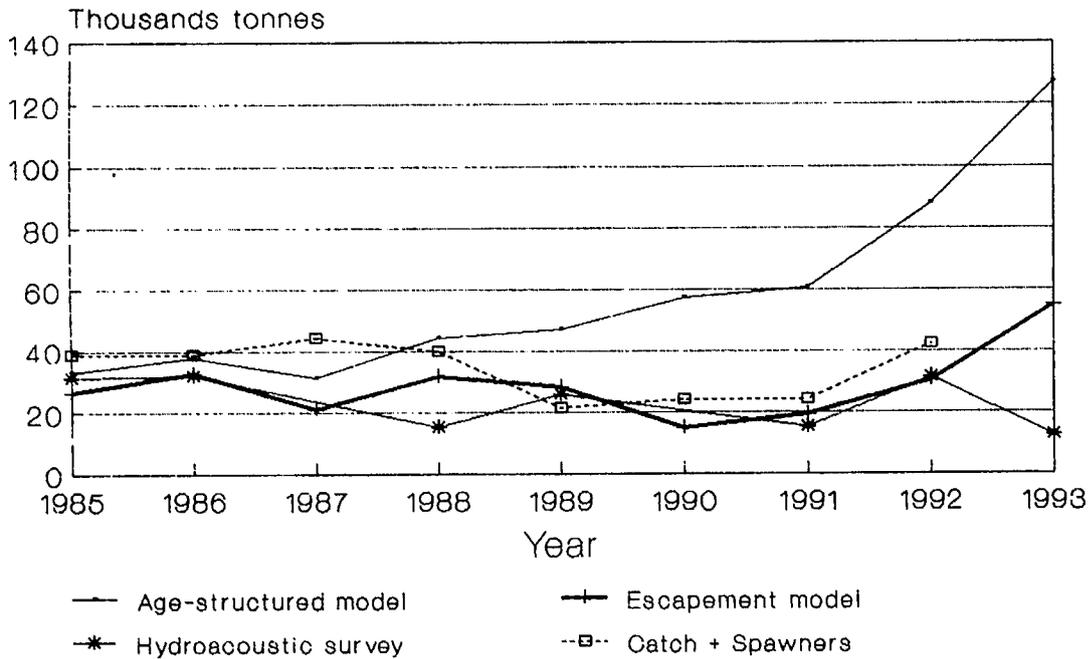


Fig. 6. Age composition of Pacific herring samples collected during W. E. RICKER cruise 92HER, November 30 - December 10, 1993.



## Prince Rupert District



## Queen Charlotte Islands

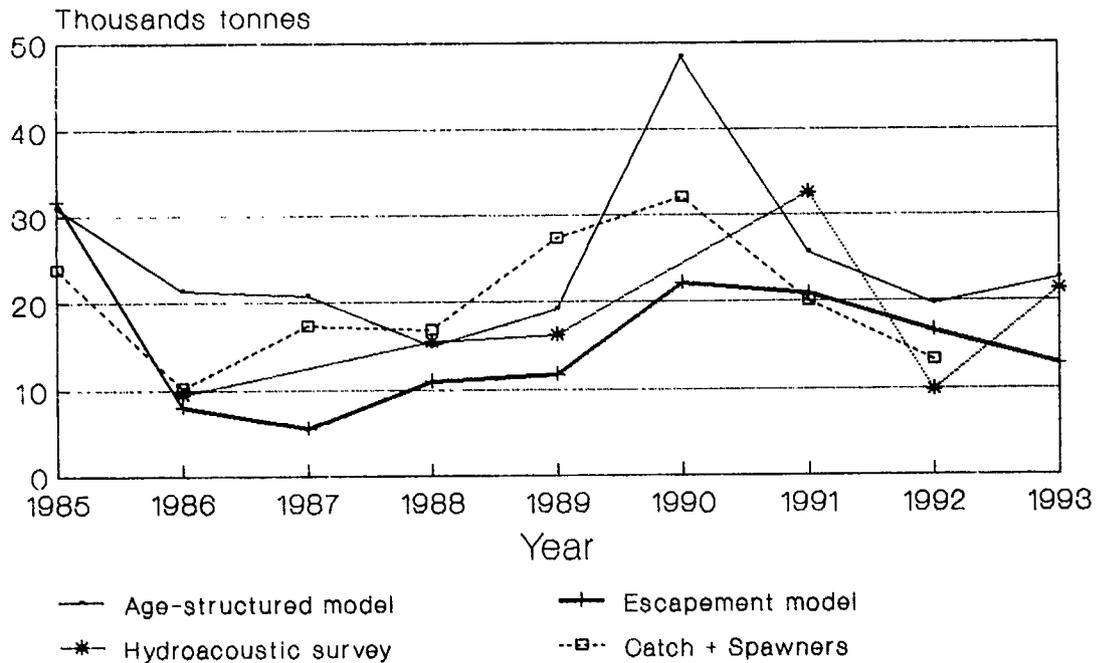
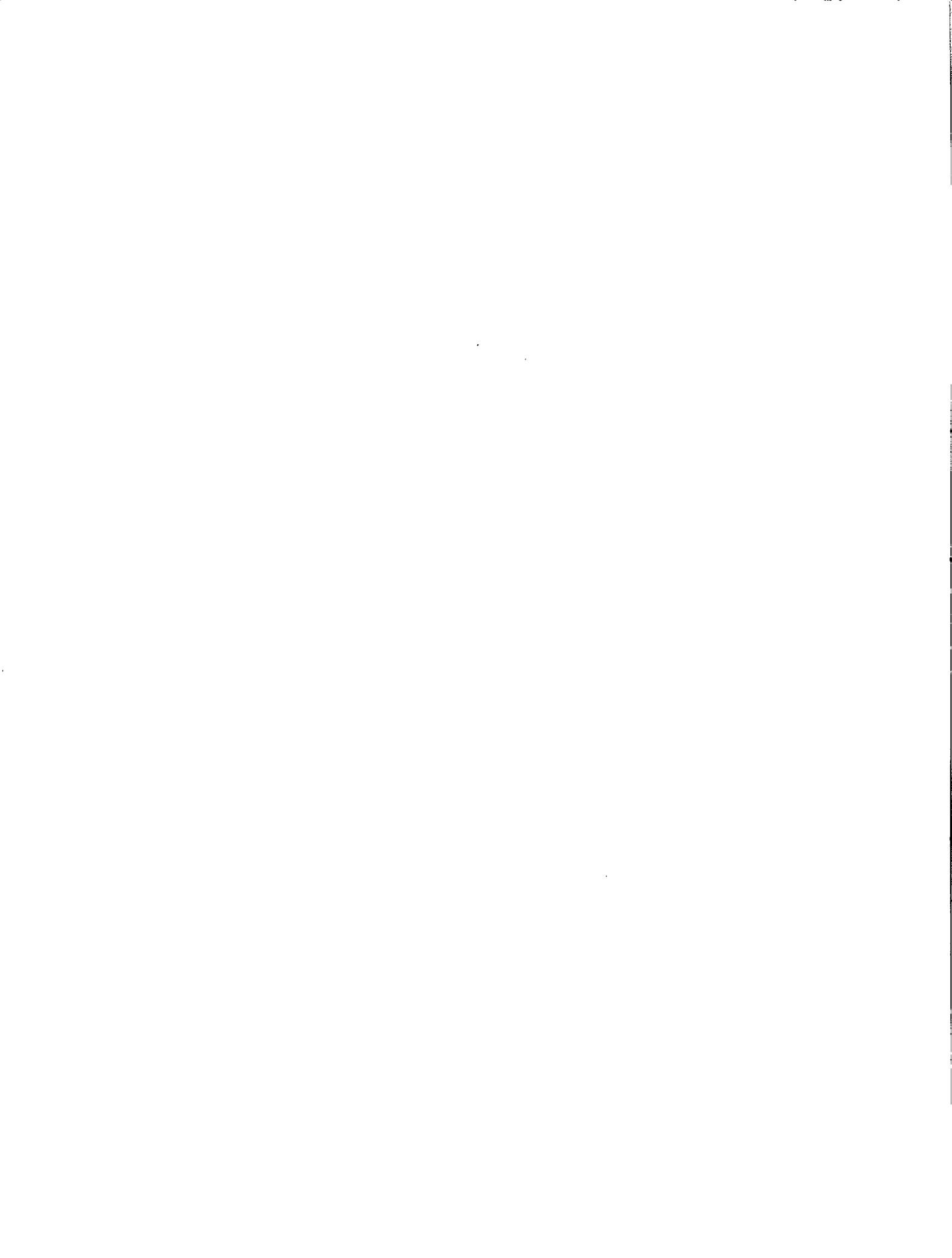


Fig. 7. A comparison of hydroacoustic biomass estimates with forecasted stock biomass from age-structured and escapement models in the Prince Rupert and Queen Charlotte Island Districts for 1985-1993.



Appendix Table 1. Cruise schedule of the W. E. RICKER, November 30 - December 10, 1992.

Date	Time	Activity
30 Nov	08:00	Load D-5 midwater trawl net, sweeplines and supplies
	08:30	Scientific party, D. Hay, B. McCarter, P. Withler and G. Dovey board W. E. RICKER at PBS, Nanaimo
	11:35	W. E. RICKER depart Departure Bay, Nanaimo
	13:26	CTD/BONGO at COPRA STATION CPF1 (Ballenas Is.)
	16:10	CTD/BONGO at COPRA STATION CPF2 (Sisters Is.)
01 Dec	08:49	CTD/BONGO at COPRA STATION CPE1 (Pine Is.)
02	08:26	Deploy towed body transducer exiting Principe Channel
	08:59	Commence transects F1-F8 (Freeman's ground)
	17:17	Commence transects W1-W8 (Whiterocks ground)
	22:49	Commence transects E6-E1 (Browning Entrance - inshore)
03	05:20	Commence transects F1-F8 (Freeman's ground)
	14:55	Commence trawl fishing tow #1 on the Freeman's ground
	16:24	Commence transects F8-F6 (Freeman's ground)
	20:12	Abort F-grid survey (bad weather)
04	09:14	Commence transects F19-F10 (Freeman's ground)
	19:42	Commence transects W1-W8 (Whiterocks ground)
05	01:22	Commence transects B10-B15 (Bonilla ground)
	10:35	Commence trawl fishing tow #2 on the Freeman's ground
	12:20	Commence transects R0-R24 (Edye Passage)
	18:18	Proceed to Bonilla Island COPRA station
06	00:40	Bonilla COPRA station cancelled due to weather
	00:45	Proceed to Juan Perez Sound
	14:53	Commence transects J1-J14 (Juan Perez Sound)
	22:54	Commence trawling fishing tow #3 in Sedgwick Bay
07	00:56	Commence transects J1-J14 (Juan Perez Sound)
	08:23	Commence transects P9-P2 (Juan Perez - entrance)
	15:13	Commence transects S1-S8 (Sedgwick Bay)
	19:58	Commence transects D1-D5 (Darwin Sound)
08	22:57	Commence trawl fishing tow #4 in Darwin Sound
	00:00	Proceed to Browning Entrance
	09:25	Commence transects W10-W16 (Whiterocks ground)
	15:45	Proceed to PBS via inside Passage
09	08:00	Re-run Freeman first coverage analog data through integrator
10	13:00	W. E. RICKER return Departure Bay, Nanaimo
11	08:00	Offload fishing gear, equipment and samples

Appendix Table 2. Parameter and biomass summary of W. E. RICKER cruise, November 30 - December 10, 1992. The event number, transect name, transect length, extrapolated area, volume density, surface density and total biomass are given for each transect. The total number of transects, total extrapolated area and total biomass is summed for each transect grid pattern. Parameters used for biomass estimation are described as follows:

Current parameters	Description
IDA 92HERO1.N89	Input echo integration file (file name)
TLL 220.90	Transmit level (dB) re 1 uPascal ! Univ. of Wash. calibrations, June 92.
RSS -133.37	Receiver sensitivity (dB) re 1 Volt/uPascal
BFF -17.55	Beam factor (dB)
REF 1.0	Reference range for receiver TVG (m)
ALP .0099	Absorption coefficient for receiver TVG (dB/m)
SOU 1490.0	Speed of sound in water (m/sec)
TAU 0.6	Pulse length (m/sec)
GAI -1.4 -12.0	Bandpass + shell gain (dB) Receiver gain (dB)
TVC 0,0	Near range and TVG correction factor (dB)
TVG 20,0.0099 20,0.0099	Time varied gain = $20 \log R + 2*ALP*R$
TSS -32.0	Target strength (dB/Kg)
MME 0,100	Min. & max. accepted integration value ( $V^2$ )
DEP 25,200	Min. & max. depth strata or window (m) ! Also used DEP 25,140 in Juan Perez Sound
UNI NM	Units for DPP and WID: km or nm
DPP 0.001	Distance per ping (UNI/ping)
WID 1.0	Width of transects (nm) ! Also used widths of 0.5, 0.3 and 0.25
FRA 1	Fraction of total biomass for species
AVE 1	Number of Sequences to be averaged
! FIR	First Sequence chosen
! LAS	Last Sequence chosen
EVE 3 13:54 53 41.0 130 40.4	Event number, Time, Position (Lat./Long.)
DAT 04-DEC-92	Date DD-MMM-YY
TRA E5 48 95 2880 7.5 317 0.7 9	T-name Seq1 Seq2 Pit Dis Bea TimeD Speed
LOU	Zero 1. cumulative biomass output
ZER	Zero 1. and 2. cumulative biomass output
EXI	Close files, exit

A mean transmit level (TLL 220.90 dB) and receiver sensitivity (RSS -133.37 dB) were determined during June/92 SYSTEM CALIBRATIONS at the hydroacoustic barge of the University of Washington, Seattle. The system was comprised of a Biosonics model 101 (1985) echo sounder, Biosonics model 121 (1985) echo integrator and Simrad 38 kHz transducer #4899 (1981) with 300 m cable.

Appendix Table 2 (cont'd).

EVE #	TRA \$	Len km	Area km <sup>2</sup>	Vol D kg/m <sup>3</sup>	Surf D kg/m <sup>2</sup>	Biomass t	# #	Area km <sup>2</sup>	Biomass t	Std %
1.0	F1	11.2	20.7	2.53E-04	7.80E-03	1.62E+02	FREEMAN'S (NW-SE grid)			
5.0	F2	10.8	19.9	5.73E-04	3.09E-02	6.17E+02				
8.0	F3	17.0	31.4	3.01E-03	1.71E-01	5.37E+03				
11.0	F4	16.8	31.2	4.19E-04	2.43E-02	7.58E+02				
14.0	F5	16.6	30.7	2.01E-04	1.25E-02	3.85E+02				
16.0	F6	15.5	28.7	6.47E-04	2.62E-02	7.51E+02				
20.0	F7	16.6	30.7	2.18E-03	7.16E-02	2.19E+03				
24.0	F8	15.4	28.5	4.44E-04	1.03E-02	2.95E+02	8	221.8	10528	17
96.0	F19	11.3	20.9	2.86E-05	2.05E-03	4.28E+01	FREEMAN'S (NE-SW grid)			
99.0	F18	13.9	25.7	1.06E-04	6.44E-03	1.66E+02				
101.0	F17	13.6	25.1	4.20E-04	2.44E-02	6.13E+02				
104.0	F16	13.5	24.9	1.58E-03	7.99E-02	1.99E+03				
106.0	F15	13.7	25.3	9.44E-04	4.28E-02	1.08E+03				
108.0	F14	13.6	25.3	9.53E-04	4.04E-02	1.02E+03				
110.0	F13	13.4	24.8	8.29E-04	3.22E-02	7.98E+02				
113.0	F12	9.7	18.0	4.68E-05	1.82E-03	3.27E+01				
115.0	F11	9.8	18.1	7.13E-06	2.55E-04	4.60E+00				
117.0	F10	9.2	17.1	9.69E-06	3.49E-04	5.97E+00	10	225.2	5753	11
120.0	W1	7.7	14.2	3.03E-05	1.24E-03	1.76E+01	WHITEROCKS (E-W grid)			
122.0	W2	9.5	17.6	1.11E-05	4.88E-04	8.57E+00				
124.0	W3	10.6	19.6	4.45E-05	1.68E-03	3.29E+01				
127.0	W4	8.5	15.8	3.26E-05	1.22E-03	1.93E+01				
129.0	W5	8.9	16.5	3.44E-05	1.33E-03	2.19E+01				
131.0	W6	9.0	16.7	2.85E-05	1.31E-03	2.18E+01				
133.0	W7	9.0	16.6	1.16E-05	5.74E-04	9.55E+00				
135.0	W8	8.7	16.1	1.76E-05	9.89E-04	1.59E+01	8	133.1	148	5
137.0	B10	16.2	30.0	1.45E-06	3.34E-05	1.00E+00	BONILLA (NE-SW grid)			
140.0	B11	15.4	28.5	1.44E-05	4.96E-04	1.41E+01				
143.0	B12	15.9	29.5	9.48E-06	4.23E-04	1.25E+01				
146.0	B13	16.3	30.1	1.86E-05	1.02E-03	3.08E+01				
149.0	B14	16.3	30.2	1.87E-05	1.21E-03	3.65E+01				
152.0	B15	15.8	29.2	6.46E-05	5.17E-03	1.51E+02	6	177.5	246	23

Appendix Table 2 (cont'd).

EVE #	TRA \$	Len km	Area km <sup>2</sup>	Vol D kg/m <sup>3</sup>	Surf D kg/m <sup>2</sup>	Biomass t	# #	Area km <sup>2</sup>	Biomass t	Std %
155.0	R0	10.4	19.2	1.39E-04	2.03E-03	3.90E+01	EDYE PASS (zig-zag trans)			
159.0	R1	7.2	13.4	9.67E-05	4.63E-03	6.19E+01				
161.0	R3	4.0	7.4	3.43E-05	1.90E-03	1.41E+01				
162.0	R4	2.8	5.1	1.51E-04	1.07E-02	5.49E+01				
163.0	R5	7.1	13.1	3.56E-05	1.94E-03	2.54E+01				
164.0	R6	1.7	3.1	9.01E-05	4.29E-03	1.33E+01				
165.0	R7	3.2	5.9	5.78E-05	3.55E-03	2.08E+01				
166.0	R8	4.6	8.6	5.26E-05	5.32E-03	4.56E+01				
167.0	R9	7.7	14.4	9.44E-05	8.50E-03	1.22E+02				
168.0	R10	4.2	7.9	4.88E-04	3.00E-02	2.36E+02				
171.0	R14	4.1	7.5	7.59E-05	6.03E-03	4.55E+01				
172.0	R15	9.2	17.1	7.08E-05	7.28E-03	1.24E+02				
173.0	R16	1.6	3.0	1.66E-04	1.32E-02	3.94E+01				
174.0	R17	2.9	5.3	4.56E-05	2.07E-03	1.10E+01				
175.0	R18	1.4	2.6	7.90E-05	4.15E-03	1.08E+01				
176.0	R19	10.8	20.0	6.81E-05	5.33E-03	1.07E+02				
177.0	R20	1.9	3.5	3.32E-05	2.52E-03	8.81E+00				
178.0	R21	2.4	4.5	3.66E-05	3.78E-03	1.69E+01				
179.0	R22	1.3	2.4	3.28E-05	2.93E-03	6.93E+00				
180.0	R23	3.1	5.7	3.79E-05	2.85E-03	1.62E+01				
181.0	R24	4.3	7.9	3.31E-05	1.97E-03	1.56E+01	21	177.6	1035	5
189.0	J1	7.8	7.3	8.18E-05	7.45E-03	5.41E+01	JUAN PEREZ SOUND (first)			
191.1	J2	7.0	6.5	1.15E-04	8.98E-03	5.84E+01				
192.0	J3	9.0	8.3	8.04E-03	8.04E-01	6.68E+03				
193.0	J4	4.7	4.4	1.01E-05	7.37E-04	3.23E+00				
195.0	J5	5.2	4.8	1.25E-05	1.31E-03	6.29E+00				
196.0	J6	8.6	7.9	4.31E-05	4.53E-03	3.60E+01				
198.0	J7	8.9	8.3	3.99E-05	4.19E-03	3.47E+01				
200.0	J8	5.3	4.9	1.23E-05	1.29E-03	6.36E+00				
202.0	J9	5.4	5.0	1.76E-05	1.80E-03	8.99E+00				
203.0	J10	9.8	9.1	3.91E-05	4.13E-03	3.75E+01				
205.0	J13	10.3	9.5	7.34E-05	7.26E-03	6.91E+01				
206.0	J14	5.7	5.3	2.75E-05	2.17E-03	1.15E+01	12	81.3	7006	27

Appendix Table 2 (cont'd).

EVE #	TRA \$	Len km	Area km <sup>2</sup>	Vol D kg/m <sup>3</sup>	Surf D kg/m <sup>2</sup>	Biomass t	# #	Area km <sup>2</sup>	Biomass t	Std %
208.0	J1	6.1	5.7	2.35E-02	2.15E+00	1.22E+04	JUAN PEREZ SOUND (second)			
212.0	J2	7.1	6.6	1.08E-02	8.66E-01	5.70E+03				
213.0	J3	8.9	8.3	7.54E-05	7.85E-03	6.49E+01				
214.0	J4	4.7	4.4	2.21E-05	1.92E-03	8.35E+00				
216.0	J5	5.1	4.7	2.77E-05	2.91E-03	1.38E+01				
217.0	J6	8.6	8.0	3.78E-05	3.97E-03	3.16E+01				
219.0	J7	8.6	8.0	3.14E-05	3.30E-03	2.63E+01				
221.0	J8	5.3	5.0	1.66E-05	1.76E-03	8.71E+00				
223.0	J9	5.5	5.1	4.50E-05	4.97E-03	2.53E+01				
224.0	J10	9.8	9.1	4.52E-05	5.14E-03	4.67E+01				
226.0	J11	4.5	4.1	1.94E-04	1.78E-02	7.35E+01				
227.0	J11A	9.5	8.8	1.55E-03	7.64E-02	6.74E+02				
230.0	J11B	4.6	4.3	7.83E-05	4.26E-03	1.81E+01				
232.0	J11C	3.2	3.0	5.07E-03	4.54E-01	1.36E+03				
233.0	J11D	3.8	3.5	2.48E-03	2.13E-01	7.40E+02				
234.0	J12	3.8	3.6	1.51E-04	1.44E-02	5.14E+01				
236.0	J13	10.3	9.5	1.36E-04	1.34E-02	1.28E+02				
237.0	J14	5.7	5.3	9.07E-06	7.45E-04	3.91E+00	18	107.0	21175	14
239.0	P9	9.1	8.4	2.04E-05	8.61E-04	7.24E+00	JUAN PEREZ ENTRANCE			
241.0	P8	8.3	7.7	1.36E-05	7.87E-04	6.03E+00				
243.0	P7	8.7	8.1	1.49E-05	1.16E-03	9.36E+00				
245.0	P6	8.8	8.2	1.32E-05	9.58E-04	7.84E+00				
247.0	P5	8.7	8.0	1.05E-04	1.04E-02	8.35E+01				
249.0	P4	9.5	8.8	1.44E-05	1.61E-03	1.42E+01				
251.0	P3	9.1	8.5	1.34E-05	1.53E-03	1.29E+01				
253.0	P2	8.2	7.5	1.73E-05	1.98E-03	1.49E+01	8	65.2	156	17
255.0	S1	9.8	4.5	9.00E-04	8.65E-02	3.92E+02	SEDGWICK BAY (intensive)			
258.0	S3	9.8	4.5	1.06E-03	9.44E-02	4.29E+02				
260.0	S2	9.8	4.5	1.82E-02	1.64E+00	7.45E+03				
262.0	S4	10.1	4.7	5.19E-03	3.30E-01	1.54E+03				
263.0	S8	5.4	2.5	7.66E-04	4.27E-02	1.07E+02				
265.0	S6	6.0	2.8	2.73E-04	2.85E-02	7.97E+01				
267.0	S7	5.5	2.6	2.64E-04	2.40E-02	6.12E+01				
269.0	S5	6.1	2.8	1.31E-04	1.34E-02	3.79E+01	8	28.9	10097	25
272.0	D1	2.7	1.8	1.87E-04	1.99E-02	3.52E+01	DARWIN SOUND (intensive)			
274.0	D2	3.2	2.1	1.51E-04	1.07E-02	2.23E+01				
276.0	D3	3.0	2.0	6.56E-04	2.42E-02	4.74E+01				
278.0	D4	6.3	4.1	2.14E-03	1.79E-01	7.32E+02				
280.0	D5	8.0	5.2	5.94E-03	4.63E-01	2.40E+03	5	15.2	3237	32
285.0	W10	12.8	23.7	3.50E-06	3.91E-05	9.28E-01	WHITEROCKS (N-S grid)			
289.0	W11	13.0	24.0	1.57E-05	1.93E-04	4.64E+00				
293.0	W12	13.2	24.5	3.31E-06	6.10E-05	1.49E+00				
296.0	W13	13.1	24.4	7.28E-04	1.69E-02	4.10E+02				
298.0	W14	13.0	24.1	2.17E-04	1.18E-02	2.84E+02				
300.0	W15	11.6	21.5	1.65E-05	1.62E-03	3.49E+01				
302.0	W16	9.3	17.2	1.49E-05	1.50E-03	2.57E+01	7	159.4	762	22

