Department of Fisheries and Oceans
Canadian Stock Assessment Secretariat
Research Document 97/81

Not to be cited without
permission of the authors[1]

Ministère des pêches et océans
Secrétariat canadien pour l'évaluation des stocks
Document de recherche 97/81

Ne pas citer sans
autorisation des auteurs[1]

Distribution and Abundance of Atlantic Cod from an Acoustic Survey of Bonavista Bay - Trinity Bay, Newfoundland During the Fall of 1996

by

J. P. Wheeler and D. S. Miller

Department of Fisheries and Oceans
Science Branch
P. O. Box 5667
St. John's NF
A1C 5X1

ABSTRACT

An acoustic survey was conducted during the fall of 1996 in the coastal waters of Bonavista Bay - Trinity Bay, Newfoundland. The survey area included water depths from the coastline to the 120 m contour. Echo integration along a series of equidistant parallel transects within the survey area provided distributional information, densities and a biomass estimate of Atlantic Cod. The biomass estimate was found to be very sensitive to the size of an exclusion zone adjacent to the bottom, defined during data editing to ensure that acoustic signals from the bottom were not included as fish.

RÉSUMÉ

À l'automne 1996, un levé acoustique a été effectué dans les eaux côtières de la baie de Bonavista et de la baie de la Trinité, à Terre-Neuve. La zone étudiée allait de la côte jusqu'au pourtour de 120 m. Une échointégration effectuée le long d'une série de transects parallèles équidistants dans la zone en question nous a fourni des renseignements sur la répartition, les densités des stocks ainsi qu'une estimation de la biomasse de la morue du Nord. Cette estimation de la biomasse s'est révélée très sensible à la taille d'une zone d'exclusion adjacente au fond de la mer, définie lors de la préparation des données afin que les signaux acoustiques provenant du fond ne soient pas comptés comme des poissons.

Introduction

As part of the annual research program to assess Atlantic herring stocks, an acoustic survey was conducted during the fall of 1996 in the coastal waters of Bonavista Bay - Trinity Bay to estimate herring biomass. Similar surveys have been conducted annually each fall in coastal waters along the northeast coast of Newfoundland since the early 1980's. However, due to the use of improved acoustic technology in 1996, it was possible, for the first time, to detect and integrate concentrations of fish in close proximity to the bottom. This paper describes results of these analyses and provides distributional information, densities and a biomass estimate of Atlantic cod, as detected during the survey. Caveats to the analyses are also discussed.

Methods

The herring acoustic survey design has been described in detail in stock assessment documents, most recently in Wheeler and Winters (1996). In summary, the survey area is defined as the area from the coastline to the 120 m depth contour. The survey area is divided into strata (Fig. 1) based upon geographical features and herring distribution patterns. Acoustic sampling intensity (total transect length) is allocated to these strata based upon herring distribution patterns observed in the commercial fishery and previous acoustic surveys. Within each stratum, the survey design consists of a series of equidistant parallel transects from the coastline to the 120 m depth contour. To maintain a random design, the placement of the first transect within each stratum is chosen randomly along a reference line drawn parallel to the coastline. Due to the irregular nature of the coastline, transects within strata are of unequal length. Fish densities, integrated on the transects, are weighted to adjust for transect length. A mean weighted density for the stratum is then calculated and extrapolated to the stratum area to estimate fish numbers and biomass. Strata estimates are summed to calculate a total biomass estimate for the survey area.

The survey described in this document was conducted from the *R. V. Shamook*; it commenced in Hearts Content, Trinity Bay on November 10, 1996 and terminated in Valleyfield, Bonavista Bay on December 1, 1996. Due to vessel operational delays and bad weather conditions, acoustic sampling of five strata (all considered to be areas of very low probability for herring) had to be eliminated (Fig. 1). Sampling intensity (total transect length) was allocated on a 2:6:11 ratio for low, medium, and high density strata respectively, based upon stratum area. Transects were surveyed at a vessel speed of 5.5 to 6.0 knots. Transect lengths were measured using the vessel's GPS.

In previous herring acoustic surveys, a BioSonics Model 221 echo integrator was used in conjunction with a BioSonics Model 105 echo sounder and 120 kHz transducer (operating in single beam mode). In this survey a Femto Model 9001 acoustic data acquisition system was used with the same sounder and transducer configuration. The transducer, mounted in a v-fin, was deployed at a depth of approximately 4 m astern and abeam of the port side of the vessel.

This system was calibrated immediately prior to the survey on October 16, 1996. The calibration parameters were as follows:

Source Level / Receive Sensitivity:	42.26 dB
Fixed Receiver Gain:	9.57 dB
TVG Gain:	20 log R
Attenuation Coefficient:	0.03470 dB/m
Pulse Length:	0.4 ms
Average Beam Factor:	-29.4 dB

During the survey, a detailed log record was maintained for each transect. Observations were recorded of all fish concentrations (pelagic and groundfish) detected on the echogram and oscilloscope. Where concentrations warranted, and depth and weather conditions permitted, cod were sampled during the survey using jiggers and feathered hooks. Cod were also sampled as a by-catch in research gillnets set for herring.

The acoustic data, as recorded in the detailed log, were subsequently edited using the Femto acoustic data editing system. Due to the irregular nature of the bottom topography throughout the survey, it was impossible to used a fixed bottom removal algorithm for all transects. Transects on which cod were detected were evaluated on a case by case basis; bottom removal criteria (ie. the size of the exclusion zone above the detected bottom), ranged from 0.5 to 2.0 m depending upon the bottom topography.

Only those fish concentrations considered to be cod were included; pelagic herring concentrations were excluded from the analysis.

Acoustic back-scatter (m^2/sr) was converted to fish density (g/m^2) using the following target strength - fish length relationship calculated by Rose and Porter (1996):

$$T.S. = 20 \log L - 65.5$$

Target strength per fish was converted to target strength per unit fish weight using the following cod length - weight relationship (Shelton et. al. 1996):

$$\log W = 3.0879 * \log L - 5.2106$$

Formulas used to calculate mean densities, variances, and biomass estimates remained unchanged from previous surveys and are described in Wheeler (1991).

For the purpose of plotting cod distributions, mean densities (g/m^2) were calculated per ten second interval along each transect.

Results

Cod were sampled from 15 different locations throughout the survey area (Table 1), 6 in Trinity Bay and 9 in Bonavista Bay. Sample sizes from each location ranged from 3 - 35 fish. At all sampling locations where jiggers and feathered hooks were used, cod was the only species caught; most cod were caught in close proximity to the bottom (< 2 m). In Trinity Bay, the mean length of the sampled cod was 55.8 cm (n = 73); in Bonavista Bay, it was 58.7 cm (n = 161). As there was little difference in mean lengths between the two bays, a combined mean length of 57.8 cm (n = 234) was calculated for the entire survey area and used to calculate target strength. The calculated target strength was -62.56 dB/g.

During the survey, 163 transects were surveyed from Green's Harbour, Trinity Bay to Shoe Cove Point, Bonavista Bay (Fig. 1). The total length of transects was 205.7 n.mi.

During data editing, it quickly became apparent that the size of the exclusion zone above the detected bottom was critical in determining the density and subsequent abundance of cod in close proximity to the bottom. The size of the layer which had to be excluded to ensure that bottom signal was not included as fish, was related to the bottom type and topography. In areas where there was a smooth rocky bottom, the exclusion zone could be kept very small. However, in areas where the bottom was soft (ie. muddy) and provided a weak acoustic signal or in areas where the bottom topography was very rough, the exclusion zone had be kept larger.

An analysis was conducted to determine if a standardized procedure could be followed to set the size of the exclusion zone based upon bottom type and topography. Six segments of acoustic data were selected from three of the survey transects where it was believed that no fish had been detected. These segments represented a broad range of bottom types and typography. The exclusion zone was increased in increments of 0.25 m starting at 0.25 m to a maximum of 2.00 m above the detected bottom. Residuals densities were then measured to determine at what point all of the bottom signal had been removed. Examples for three of the six data segments are presented in Figs. 2 - 4. Results were highly variable; in cases where the acoustic bottom signal was weak due to a muddy bottom, the bottom signal was not removed 2.00 m above detected bottom. Where the bottom was hard and relatively smooth, the bottom signal was removed in less than 0.5 m. It was not possible to determine a standardized bottom removal procedure. Consequently, the bottom removal algorithm was set on a case by case basis for those transects on which cod were detected.

Cod were distributed widely throughout the survey area and were detected on 68 (41.7%) of the transects (Figs. 5 - 8). On these 68 transects, cod were detected in 835 (5.9%) of 14109 ten second intervals. Cod densities within these intervals ranged from 0.000 - 2.944 kg/m^2, with a mean density of 0.002 kg/m^2. Cod were most prevalent in the northern portion of Bonavista Bay, the two largest concentrations occurring on transects near Salvage and Gulch Island. In Trinity Bay, the largest concentrations of cod occurred in Smith Sound, near Barton and in Northwest Arm near Fosters Point.

Cod were distributed in water depths as shallow as 5 m throughout the survey area (Fig. 9). However, most occurred in water depths of 30 - 75 m, with peak densities in depths of approximately 45 m. Approximately 97% of the detected cod densities were detected in water depths less than or equal to 75 m.

A biomass estimate of 5570 t was derived from the survey area (Table 2, Fig. 10), 4040 t (73%) in Bonavista Bay and 1530 t (27%) in Trinity Bay. Cod were detected in 13 of the 16 surveyed strata, none of which accounted for greater than 19% of the estimated biomass. Consequently, the coefficient of variation based upon survey design (Table 2) was relatively low (0.253).

Discussion

Although herring acoustic surveys have been conducted on an annual basis for many years, this was the first time that it has been possible to detect and integrate concentrations of fish in close proximity to the bottom. The Femto data acquisition system, used for the first time in 1996, digitizes and stores the acoustic signal at a higher resolution than the BioSonics integrator, formally used in these surveys. This allows for better resolution of the bottom signal and any acoustic targets in close proximity to the bottom.

However, bottom resolution is still highly dependent upon bottom topography. A flat, hard bottom will provide a more distinct and well-defined bottom signal than a rough or muddy bottom. Given the rough bottom topography in most of the survey area and in most coastal Newfoundland waters, an exclusion zone or window above the bottom must be defined to ensure that acoustic signals from the bottom are not included as fish. In estimating abundance of fish that are in close proximity to the bottom, it is critical that this exclusion zone be minimized in order to integrate as many of the fish as possible. Analysis of data from this survey suggests that due to the highly variable bottom topography, it is impossible to select a standardized procedure for establishing the size of this exclusion zone. On average, it was possible to restrict this exclusion zone to 0.75 - 1.00 m for data collected during this survey. As a test to determine the effect of the size of the exclusion zone, biomass was estimated using a 2.00 m exclusion zone. The estimate of 1990 t was less than 40% of that presented in Table 2.

Technically, it may be possible to further reduce the size of the exclusion zone in future surveys by using a narrower beam transducer with better bottom resolution capabilities. However, this must first be tested; there is also a trade-off in using a narrower beam transducer as it reduces the ensonifed volume.

Although the biological sampling of cod was limited in the survey, both in sample numbers and sampling gears, results between the two bays were very consistent. The mean length derived from the samples (57.8 cm) was also very consistent with data provided by Davis (pers. comm.) and Brattey (pers. comm.) for Bonavista and Trinity bays in 1996.

There is always a degree of uncertainty in converting acoustic back-scatter to fish numbers and biomass using target strength - fish length relationships.. However, given the extensive work of Rose and Porter (1996), this source of error should be limited for these data. The effect of the exclusion zone is much more of a concern.

It should also be noted that this survey was designed to estimate herring abundance. The selection of the 120 m depth contour as the outer boundary of the survey area and the use of a 120 kHz transducer, which is suitable for water depths <150 m, are appropriate for herring but may not be so for cod.

The use of the Femto data acquisition system has shown that it is technically feasible to detect and integrate concentrations of cod in close proximity to the bottom during such surveys. The potential to quantify these estimates will depend upon many factors, one of the more important being the minimization of the exclusion zone. Further research is required before attempting to estimate cod acoustically in broad-scaled surveys.

Acknowledgements

We would like to thank the crew of the *R. V. Shamook* for their assistance in conducting this survey. Their willingness to collect biological samples whenever possible added greatly to the success of the trip.

We would also like to thank commercial fishers throughout the survey area who provided valuable fish distributional information which was utilized in determining survey design.

Finally, but not least, we would like to thank Pelagic Section personnel who contributed to the success of the survey.

References

Rose, G. R. and D. R. Porter. 1996. Target strength studies on Atlantic cod (*Gadus morhua*) in Newfoundland waters. ICES J. Mar. Sci. 53: 259-265.

Shelton, P. A., D. E. Stansbury, E. F. Murphy, G. R. Lilly, and J. Brattey. 1996. An assessment of the cod stock in NAFO Div. 2J+3KL. DFO Atl. Fish. Res. Doc. 96/80, 65 p.

Wheeler, J. P. 1991. Newfoundland east coast herring - 1990 acoustic survey results. CAFSAC Res. Doc. 91/1, 43 p.

Wheeler, J. P. and G. H. Winters. 1996. Newfoundland east and southeast coast herring - an assessment of stocks to the spring of 1995. DFO Atl. Fish. Res. Doc. 96/63, 65 p.

Table 1. Cod sampling details, Shamook Trip #261, Bonavista Bay - Trinity Bay, 1996

Date	Stratum	Location	Gear	Mean Lgt. (cm)	Range (cm)	n
Nov. 11	44	New Harbour Point, T. B.	jiggers	64.0	-	11
Nov. 14	41	Queens Cove, T. B.	jiggers	49.1	38 - 73	7
Nov. 16	40	Fosters Point, T. B.	gillnets	58.4	34 - 88	9
Nov. 16	40	Fosters Point, T. B.	jiggers	56.1	47 - 70	14
Nov. 16	40	Strong Island, T. B.	jiggers	58.0	50 - 80	7
Nov. 17	40	Strong Island, T. B.	gillnets	56.2	54 - 62	5
Nov. 17	38	Indian Island, T. B.	jiggers	58.0	46 - 68	5
Nov. 17	38	Barton, T. B.	jiggers	60.0	50 - 81	6
Nov. 18	38	Indian Island, T. B.	gillnets	41.8	30 - 53	9
Nov. 20	32	Cannings Cove, B. B.	jiggers	61.6	53 - 73	5
Nov. 21	33	Dumpling Cove, B. B.	gillnets	66.8	32 - 82	35
Nov. 23	31	South Broad Cove, B. B.	gillnets	62.7	52 - 73	6
Nov. 24	30	Hail Island, B. B.	jiggers	50.3	43 - 59	14
Nov. 26	29	Willis Reach, B. B.	jiggers	54.6	38 - 70	15
Nov. 26	29	Coal Island, B. B.	jiggers	54.3	41 - 61	21
Nov. 27	29	Muddy Cove, B. B.	gillnets	47.3	36 - 55	3
Nov. 28	28	Shoal Bay, B. B.	jiggers	56.2	43 - 70	21
Nov. 29	28	Shoal Bay, B. B.	gillnets	60.7	52 - 68	32
Nov. 29	27	Black Duck Cove, B. B.	jiggers	54.8	38 - 70	9

Table 2. Cod biomass estimate, by stratum, for Bonavista Bay - Trinity Bay from the 1996 fall acoustic survey.

STRATUM	STRATUM AREA (sq. m)	TRANSECT NUMBER	TRANSECT LENGTH (n.mi.)	TRANSECT AREA (sq. m)	TRANSECT WEIGHTING FACTOR	CALCULATE DENSITY (g/sq. m)	WEIGHTED DENSITY (g/sq. m)	STRATUM BIOMASS (t)
27	2.770E+08	149	1.94	3592.9	1.263	0.0000	0.0000	
		150	0.94	1740.9	0.612	0.0000	0.0000	
		151	1.71	3166.9	1.113	0.0719	0.0800	
		152	3.11	5759.7	2.025	1.8603	3.7666	
		153	3.29	6093.1	2.142	0.3969	0.8501	
		154	3.38	6259.8	2.201	1.1278	2.4817	
		155	3.43	6352.4	2.233	0.1287	0.2874	
		156	1.87	3463.2	1.217	0.0000	0.0000	
		157	0.68	1259.4	0.443	0.0000	0.0000	
		158	0.40	740.8	0.260	0.0000	0.0000	
		159	0.36	666.7	0.234	0.2917	0.0684	
		160	0.47	870.4	0.306	0.0000	0.0000	
		161	0.33	611.2	0.215	5.3123	1.1413	
		162	0.29	537.1	0.189	0.0000	0.0000	
		163	0.84	1555.7	0.547	0.0000	0.0000	
		15		2844.7			0.5784	160
28	2.000E+08	138	0.90	1666.8	0.417	0.0000	0.0000	
		139	0.89	1648.3	0.413	0.0000	0.0000	
		140	1.30	2407.6	0.603	10.7034	6.4538	
		141	0.96	1777.9	0.445	4.0706	1.8125	
		142	1.72	3185.4	0.798	0.0000	0.0000	
		143	2.72	5037.4	1.262	4.9653	6.2642	
		144	4.76	8815.5	2.208	6.6529	14.6882	
		145	3.63	6722.8	1.684	6.0912	10.2556	
		146	1.96	3629.9	0.909	2.0664	1.8785	
		147	2.72	5037.4	1.262	0.4528	0.5713	
		10		3992.9			4.1924	838
29	2.080E+08	125	0.90	1666.8	0.397	0.1577	0.0626	
		126	2.48	4593.0	1.093	0.4529	0.4952	
		127	4.68	8667.4	2.063	7.8656	16.2293	
		128	4.86	9000.7	2.143	0.2523	0.5406	
		129	2.61	4833.7	1.151	12.7642	14.6878	
		130	2.34	4333.7	1.032	11.6738	12.0434	
		131	1.74	3222.5	0.767	0.8755	0.6716	
		132	0.58	1074.2	0.256	0.0000	0.0000	
		133	1.03	1907.6	0.454	4.7221	2.1443	
		134	0.66	1222.3	0.291	0.6986	0.2033	
		135	3.07	5685.6	1.354	1.6816	2.2761	
		11		4200.7			4.4867	933
30	2.800E+08	111	2.02	3741.0	0.828	1.1525	0.9546	
		112	3.04	5630.1	1.247	0.0000	0.0000	
		113	6.07	11241.6	2.489	7.2890	18.1422	
		114	2.12	3926.2	0.869	0.4992	0.4340	
		115	1.40	2592.8	0.574	0.0000	0.0000	
		116	1.28	2370.6	0.525	1.6960	0.8902	
		117	1.38	2555.8	0.566	6.6005	3.7350	
		118	2.20	4074.4	0.902	0.8694	0.7843	
		119	3.18	5889.4	1.304	0.4351	0.5673	
		120	2.86	5296.7	1.173	0.3914	0.4590	

Table 2 (cont'.). Cod biomass estimate, by stratum, for Bonavista Bay - Trinity Bay from the 1996 fall acoustic survey.

STRATUM	STRATUM AREA (sq. m)	TRANSECT NUMBER	TRANSECT LENGTH (n.mi.)	TRANSECT AREA (sq. m)	TRANSECT WEIGHTING FACTOR	CALCULATE DENSITY (g/sq. m)	WEIGHTED DENSITY (g/sq. m)	STRATUM BIOMASS (t)
31 (cont.)		121	2.29	4241.1	0.939	18.6257	17.4896	
		122	1.70	3148.4	0.697	0.0000	0.0000	
		123	1.43	2648.4	0.586	0.4034	0.2365	
		15		4516.6			2.7308	765
31	1.200E+08	101	0.56	1037.1	0.454	0.0000	0.0000	
		102	0.62	1148.2	0.503	0.0000	0.0000	
		103	0.88	1629.8	0.714	0.0000	0.0000	
		104	0.98	1815.0	0.795	0.0000	0.0000	
		105	1.58	2926.2	1.281	0.0000	0.0000	
		106	0.77	1426.0	0.624	0.0000	0.0000	
		107	1.82	3370.6	1.476	0.0000	0.0000	
		108	2.89	5352.3	2.344	0.0000	0.0000	
		109	0.89	1648.3	0.722	0.0000	0.0000	
		110	1.34	2481.7	1.087	0.0000	0.0000	
		10		2283.5			0.0000	0
32	7.200E+07	95	0.81	1500.1	0.768	29.0026	22.2674	
		96	1.30	2407.6	1.232	0.8815	1.0862	
		2		1953.9			11.6768	841
33	6.600E+07	97	0.83	1537.2	0.871	20.2222	17.6214	
		98	0.93	1722.4	0.976	1.1495	1.1223	
		99	0.75	1389.0	0.787	1.5051	1.1851	
		100	1.30	2407.6	1.365	0.0000	0.0000	
		4		1764.0			4.9822	329
34	1.340E+08	91	1.64	3037.3	0.953	0.0000	0.0000	
		92	0.96	1777.9	0.558	0.0000	0.0000	
		93	3.07	5685.6	1.785	0.0000	0.0000	
		94	1.21	2240.9	0.703	0.0000	0.0000	
		4		3185.4			0.0000	0
38	9.200E+07	79	0.34	629.7	0.653	0.0000	0.0000	
		80	0.35	648.2	0.672	0.0000	0.0000	
		81	0.56	1037.1	1.075	8.0279	8.6316	
		82	0.16	296.3	0.307	0.0000	0.0000	
		83	0.30	555.6	0.576	0.0000	0.0000	
		84	0.22	407.4	0.422	0.0000	0.0000	
		85	0.47	870.4	0.902	1.7026	1.5364	
		86	0.50	926.0	0.960	1.2123	1.1638	
		87	0.26	481.5	0.499	0.0000	0.0000	
		88	1.32	2444.6	2.534	1.3922	3.5284	
		89	1.20	2222.4	2.304	8.9755	20.6796	
		90	0.57	1055.6	1.094	93.6535	102.4944	
		12		964.6			11.5028	1058

Table 2 (cont'.). Cod biomass estimate, by stratum, for Bonavista Bay - Trinity Bay from the 1996 fall acoustic survey.

STRATUM	STRATUM AREA (sq. m)	TRANSECT NUMBER	TRANSECT LENGTH (n.mi.)	TRANSECT AREA (sq. m)	TRANSECT WEIGHTING FACTOR	CALCULATE DENSITY (g/sq. m)	WEIGHTED DENSITY (g/sq. m)	STRATUM BIOMASS (t)
39	9.200E+07	59	0.69	1277.9	0.809	6.2657	5.0714	
		60	0.99	1833.5	1.161	0.0000	0.0000	
		61	1.56	2889.1	1.830	0.0000	0.0000	
		62	0.17	314.8	0.199	0.0000	0.0000	
		4		1578.8			1.2678	117
40	7.700E+07	63	0.11	203.7	0.163	0.0000	0.0000	
		64	0.10	185.2	0.148	0.0000	0.0000	
		65	0.20	370.4	0.295	0.0000	0.0000	
		66	0.57	1055.6	0.842	0.3648	0.3072	
		67	0.54	1000.1	0.798	1.6309	1.3011	
		68	0.46	851.9	0.680	1.6751	1.1384	
		69	0.26	481.5	0.384	0.0000	0.0000	
		70	0.27	500.0	0.399	0.0000	0.0000	
		71	0.99	1833.5	1.463	0.0000	0.0000	
		72	0.97	1796.4	1.433	6.0732	8.7032	
		73	1.43	2648.4	2.113	7.5552	15.9615	
		74	1.90	3518.8	2.807	0.0000	0.0000	
		75	0.79	1463.1	1.167	0.0000	0.0000	
		76	1.05	1944.6	1.551	0.9699	1.5046	
		77	0.89	1648.3	1.315	0.0000	0.0000	
		78	0.30	555.6	0.443	0.0000	0.0000	
		16		1253.6			1.8072	139
41	5.400E+07	30	0.52	963.0	1.329	0.0000	0.0000	
		31	0.98	1815.0	2.505	13.0309	32.6397	
		32	0.71	1314.9	1.815	0.5196	0.9429	
		33	0.32	592.6	0.818	0.0000	0.0000	
		34	0.26	481.5	0.665	0.0000	0.0000	
		35	0.26	481.5	0.665	0.0000	0.0000	
		36	0.27	500.0	0.690	0.0000	0.0000	
		37	0.22	407.4	0.562	0.0000	0.0000	
		38	0.36	666.7	0.920	0.0000	0.0000	
		39	0.21	388.9	0.537	0.0000	0.0000	
		40	0.25	463.0	0.639	0.0000	0.0000	
		41	0.39	722.3	0.997	0.0000	0.0000	
		42	0.20	370.4	0.511	0.0000	0.0000	
		43	0.86	1592.7	2.198	5.8148	12.7814	
		44	0.25	463.0	0.639	0.0000	0.0000	
		45	0.20	370.4	0.511	0.0000	0.0000	
		46	0.17	314.8	0.435	0.0000	0.0000	
		47	0.13	240.8	0.332	0.0000	0.0000	
		48	0.75	1389.0	1.917	2.6356	5.0523	
		49	0.26	481.5	0.665	0.0000	0.0000	
		50	0.19	351.9	0.486	0.0000	0.0000	
		51	0.31	574.1	0.792	0.0000	0.0000	
		52	0.39	722.3	0.997	0.0000	0.0000	
		53	0.31	574.1	0.792	0.0000	0.0000	
		54	0.33	611.2	0.843	10.6663	8.9965	
		55	0.13	240.8	0.332	2.1157	0.7030	
		56	0.80	1481.6	2.045	0.0000	0.0000	
		57	0.15	277.8	0.383	0.0000	0.0000	
		58	0.22	407.4	0.562	0.0000	0.0000	
		29		724.6			2.1074	114

Table 2 (cont'.). Cod biomass estimate, by stratum, for Bonavista Bay - Trinity Bay from the 1996 fall acoustic survey.

STRATUM	STRATUM AREA (sq. m)	TRANSECT NUMBER	TRANSECT LENGTH (n.mi.)	TRANSECT AREA (sq. m)	TRANSECT WEIGHTING FACTOR	CALCULATE DENSITY (g/sq. m)	WEIGHTED DENSITY (g/sq. m)	STRATUM BIOMASS (t)
42	1.810E+08	17	0.84	1555.7	0.899	0.0000	0.0000	
		18	0.70	1296.4	0.749	0.0000	0.0000	
		19	0.46	851.9	0.492	0.0000	0.0000	
		20	1.34	2481.7	1.434	0.0000	0.0000	
		21	0.73	1352.0	0.781	0.0000	0.0000	
		22	0.85	1574.2	0.909	0.0910	0.0828	
		23	1.05	1944.6	1.123	1.9653	2.2079	
		24	1.29	2389.1	1.380	0.1041	0.1437	
		25	1.12	2074.2	1.198	0.0000	0.0000	
		26	0.55	1018.6	0.588	0.2315	0.1362	
		27	0.84	1555.7	0.899	0.0000	0.0000	
		28	1.86	3444.7	1.990	0.6651	1.3236	
		29	0.52	963.0	0.556	1.2238	0.6809	
		13		1730.9			0.3519	64
43	1.110E+08	11	2.93	5426.4	1.717	0.0000	0.0000	
		12	5.56	10297.1	3.258	0.2154	0.7017	
		13	0.30	555.6	0.176	0.0000	0.0000	
		14	0.92	1703.8	0.539	0.0000	0.0000	
		15	0.26	481.5	0.152	0.0000	0.0000	
		16	0.27	500.0	0.158	6.8197	1.0789	
		6		3160.7			0.2968	33
44	1.640E+08	3	2.33	4315.2	0.796	0.0000	0.0000	
		4	4.22	7815.4	1.441	0.0000	0.0000	
		5	4.01	7426.5	1.369	0.0000	0.0000	
		6	4.57	8463.6	1.560	0.1585	0.2473	
		7	2.91	5389.3	0.994	0.0000	0.0000	
		8	2.22	4111.4	0.758	0.0000	0.0000	
		9	1.54	2852.1	0.526	0.0000	0.0000	
		10	1.63	3018.8	0.557	0.1088	0.0606	
		8		5424.0			0.0385	6
45	9.500E+07	1	1.14	2111.3	0.689	0.0000	0.0000	
		2	2.17	4018.8	1.311	0.0000	0.0000	
		2		3065.1			0.0000	0
		Total Transect Length =	205.67				Total Estimated Biomass =	5397
							S.E. =	1396
							C.V. =	0.259

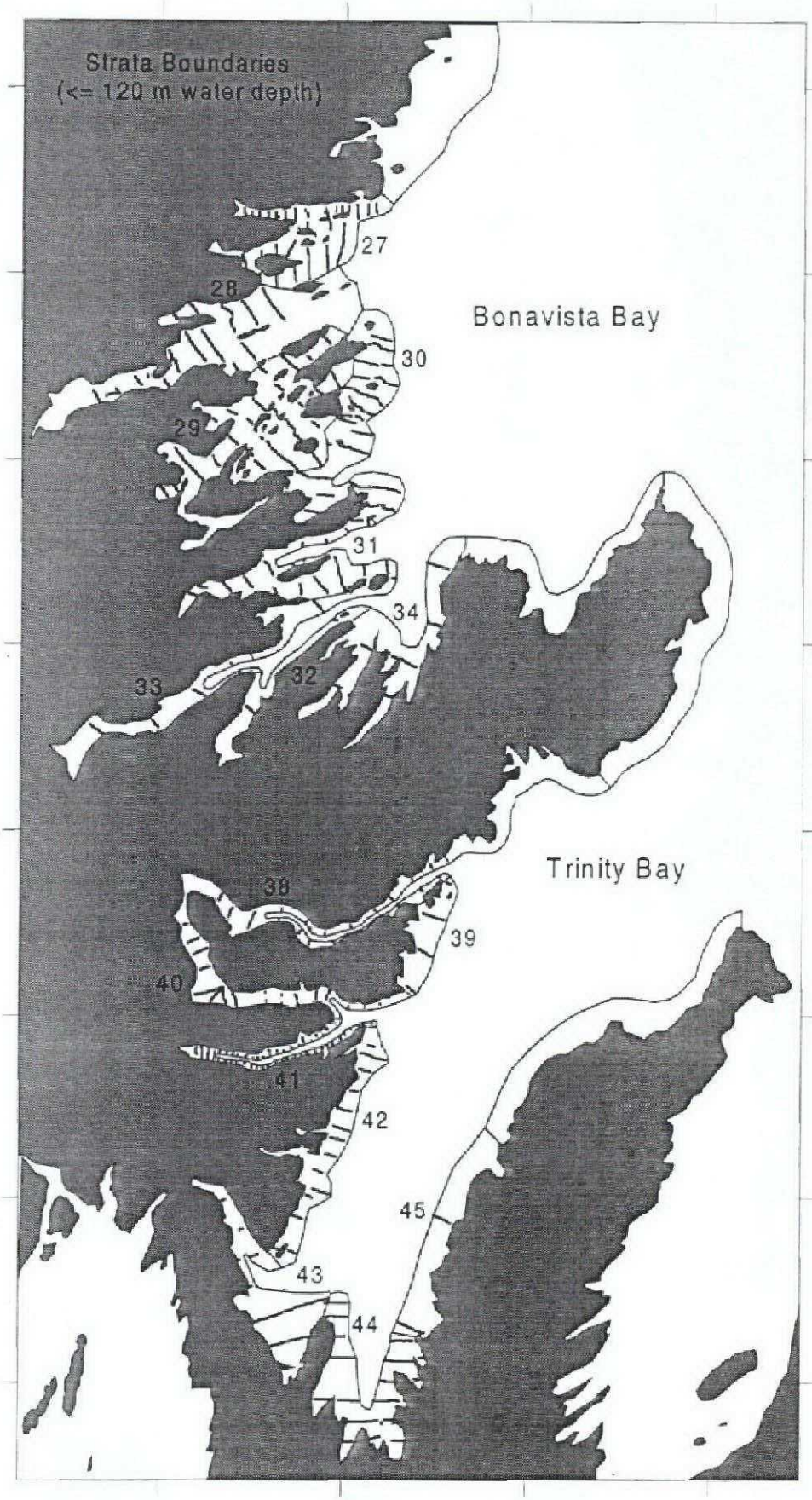


Fig.1. Area map of Bonavista Bay - Trinity Bay indicating survey strata and transects for the 1996 fall acoustic survey.

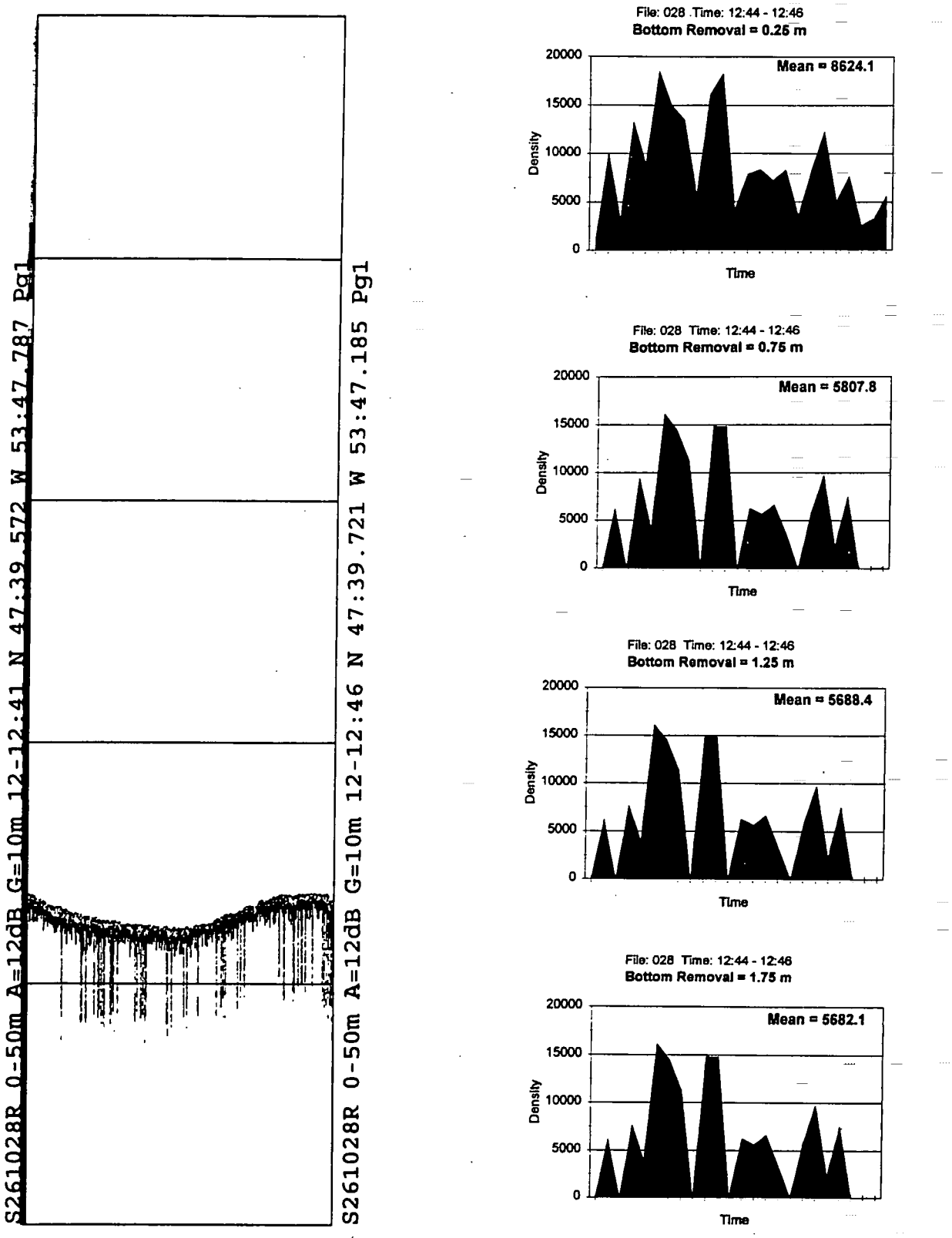


Fig. 2. Example of an echogram (10 m grid lines) with relatively flat bottom but weak bottom signal. Charts indicate substantial residual bottom signal up to 1.75 m above detected bottom.

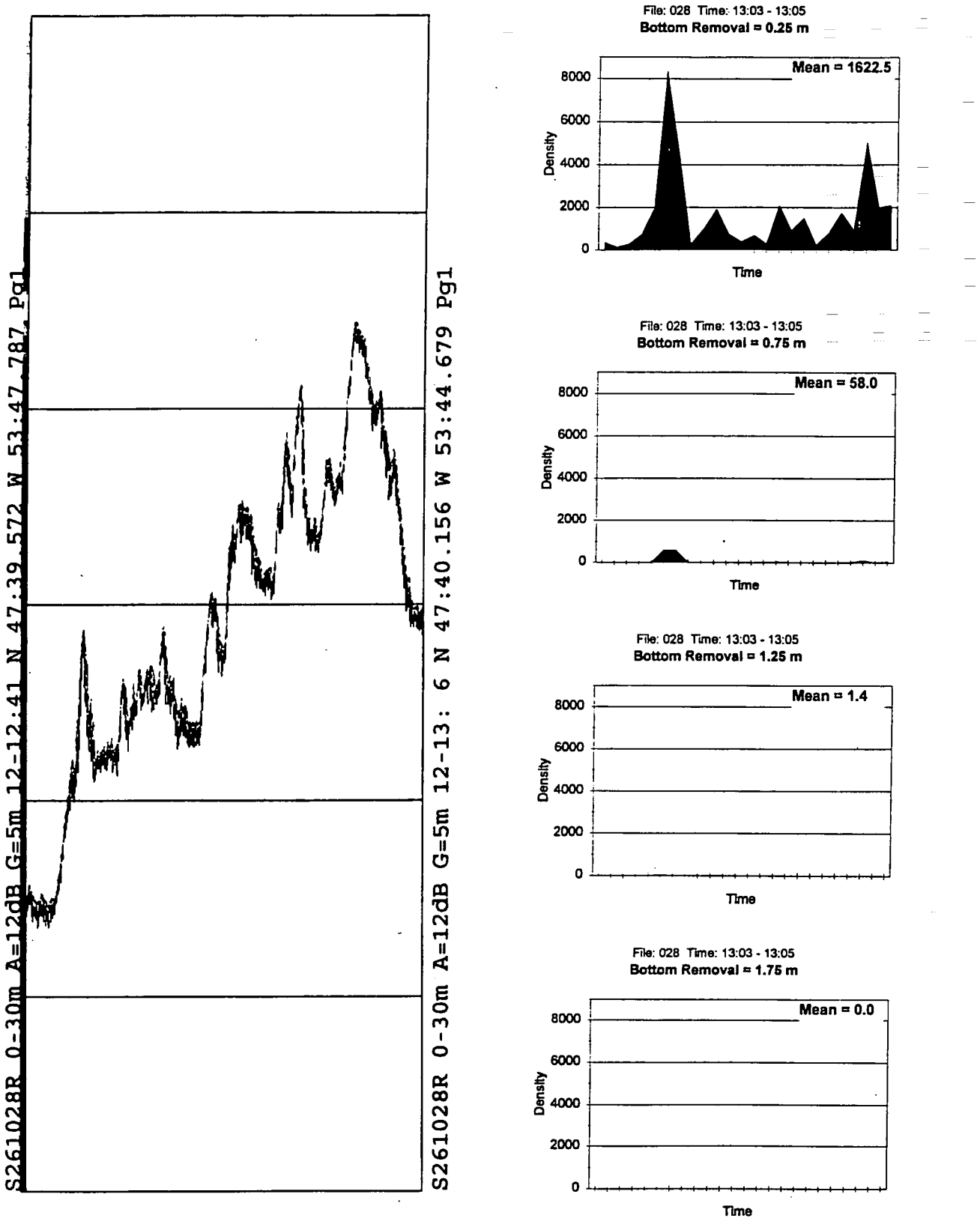
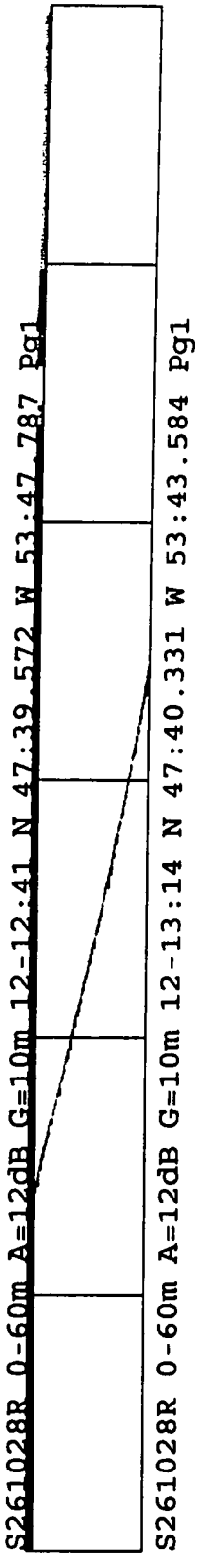
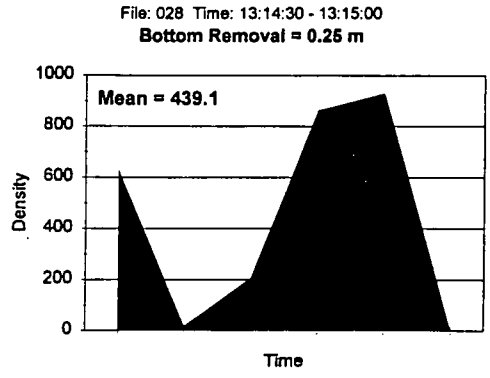


Fig. 3. Example of an echogram (5 m grid lines) with very rough topography but strong bottom signal. Charts indicate no residual bottom signal 1.75 m above detected bottom.





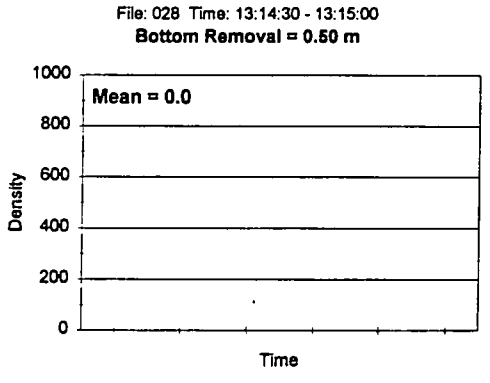


Fig. 4. Example of an echogram (10 m grid lines) with very steep topography but strong bottom signal. Charts indicate no residual bottom signal 0.50 m above detected bottom.

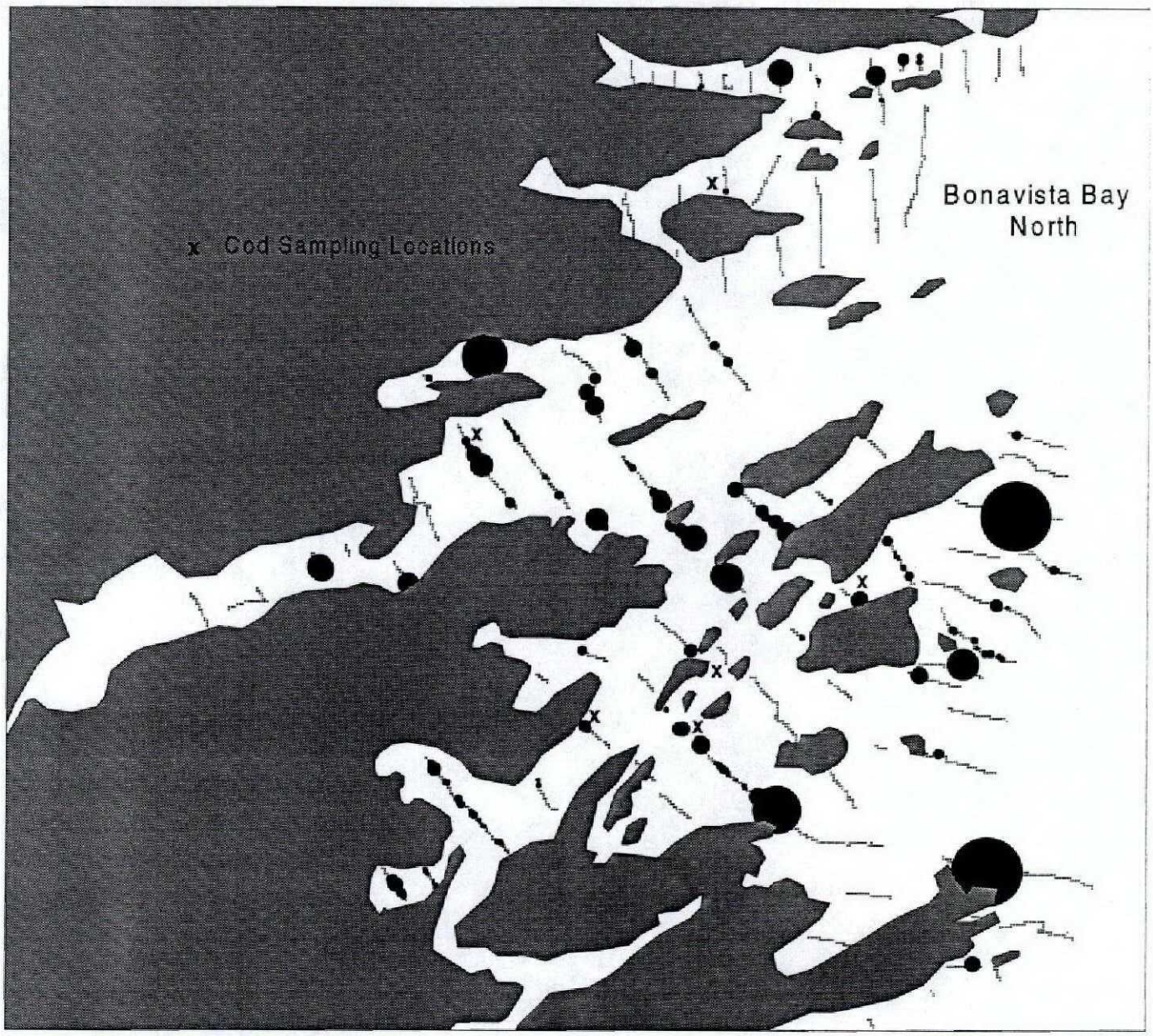


Fig. 5. Distributions and densities of cod on transects in the northern portion of Bonavista Bay during the 1996 fall acoustic survey.

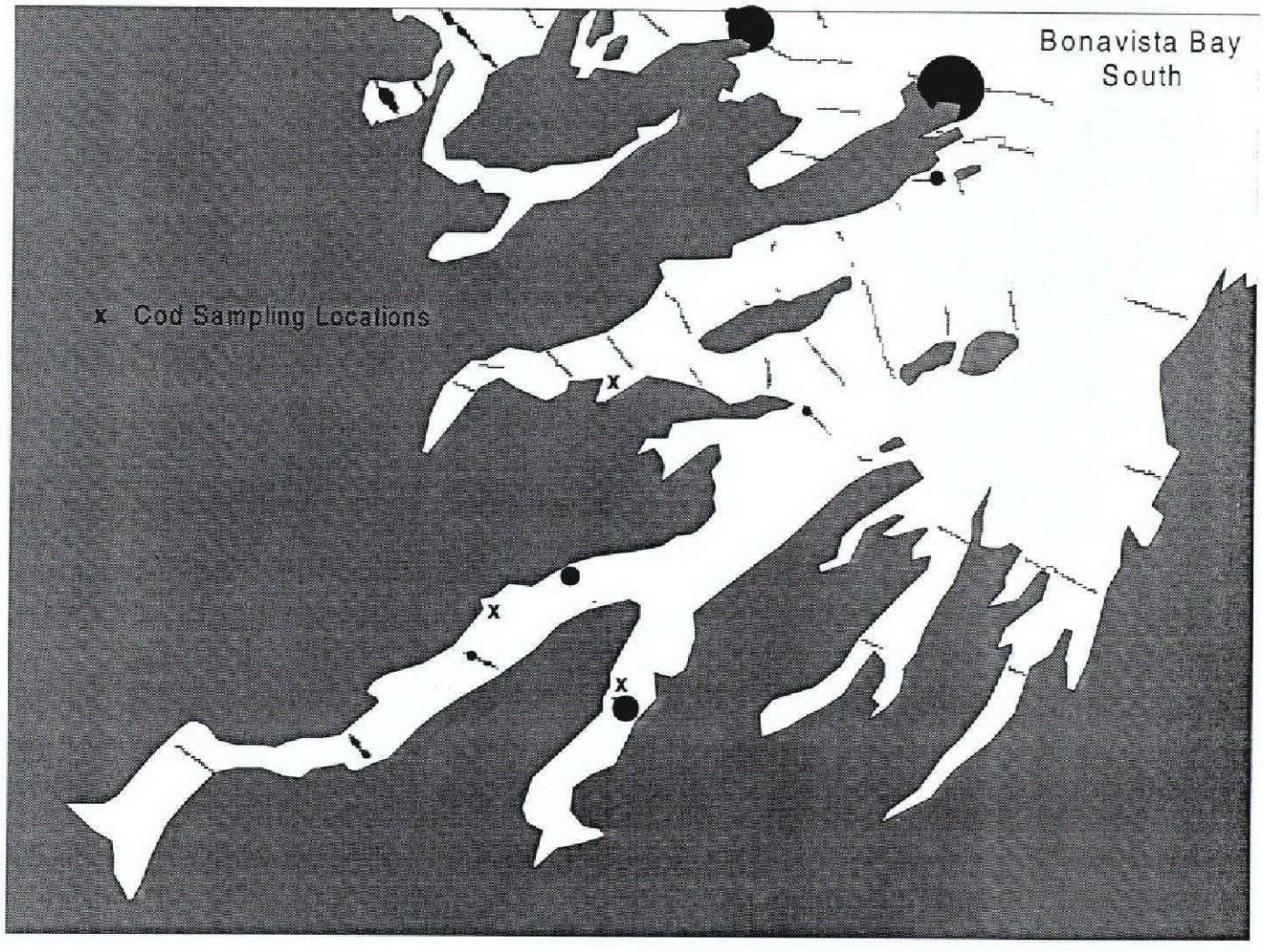


Fig. 6. Distribution and densities of cod on transects in the southern portion of Bonavista Bay during the 1996 fall acoustic survey.

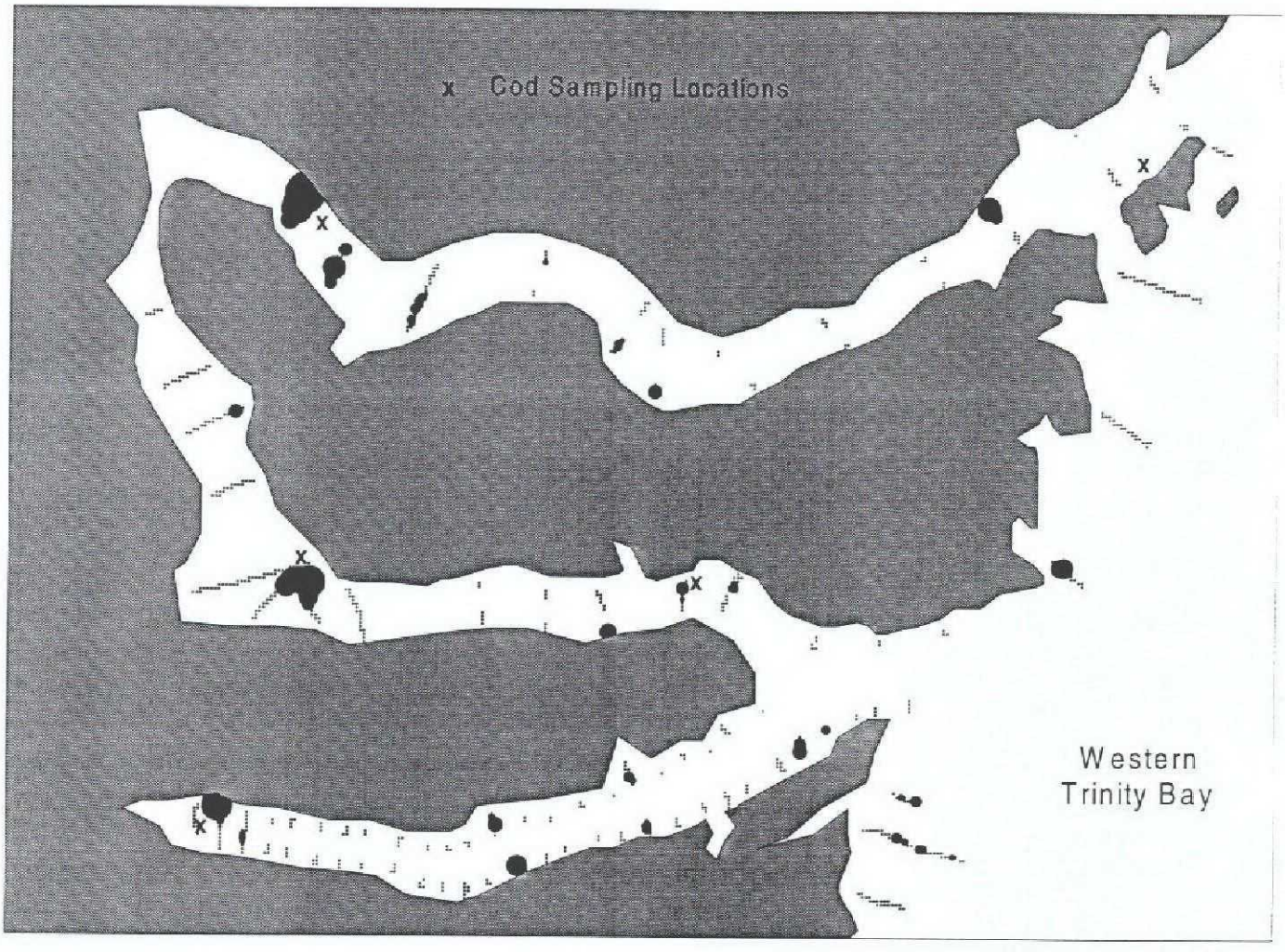


Fig. 7. Distribution and densities of cod on transects in the western portion of Trinity Bay during the 1996 fall acoustic survey.

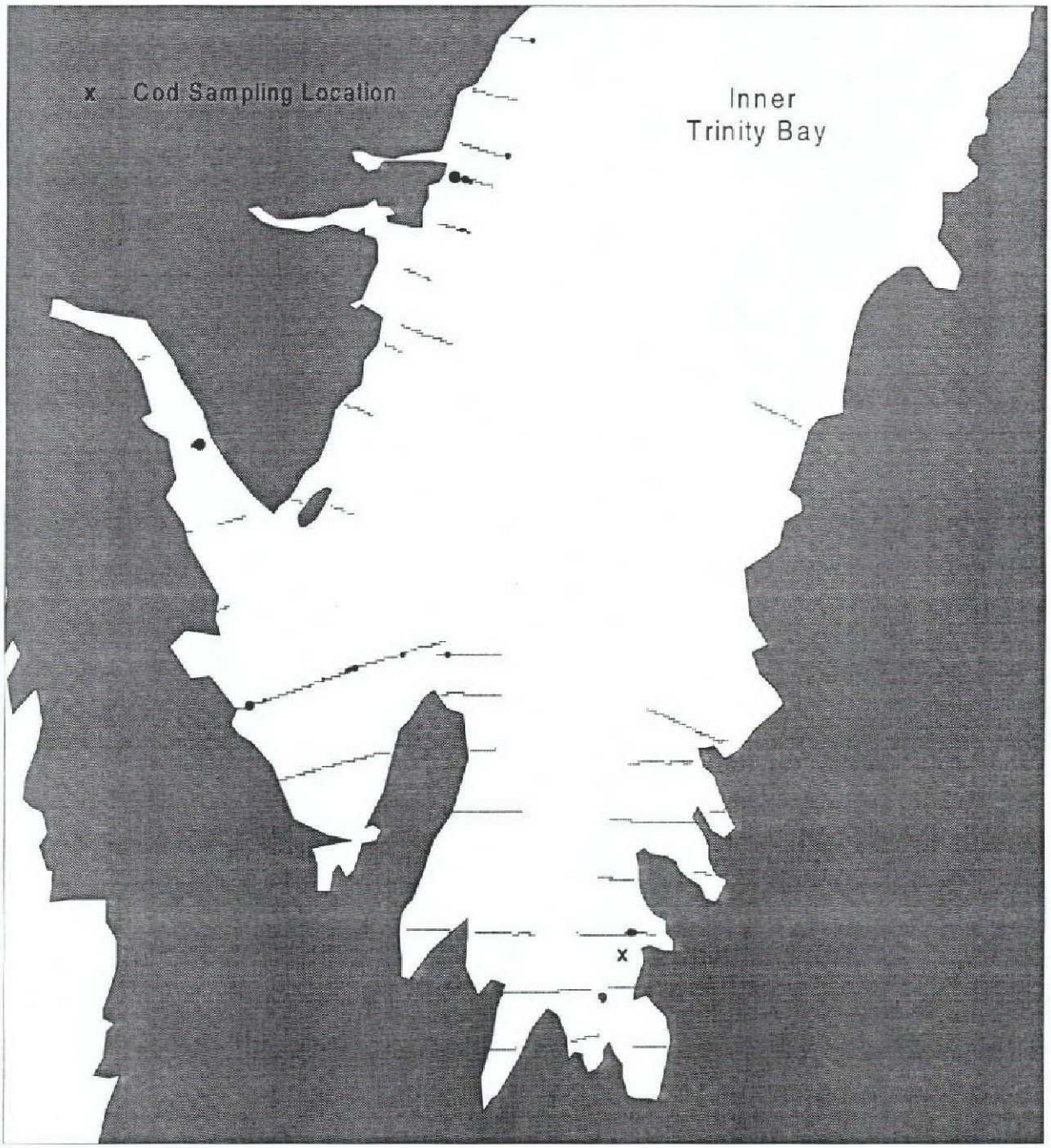


Fig. 8. Distribution and densities of cod on transects in the inner portion of Trinity Bay during the 1996 fall acoustic survey.

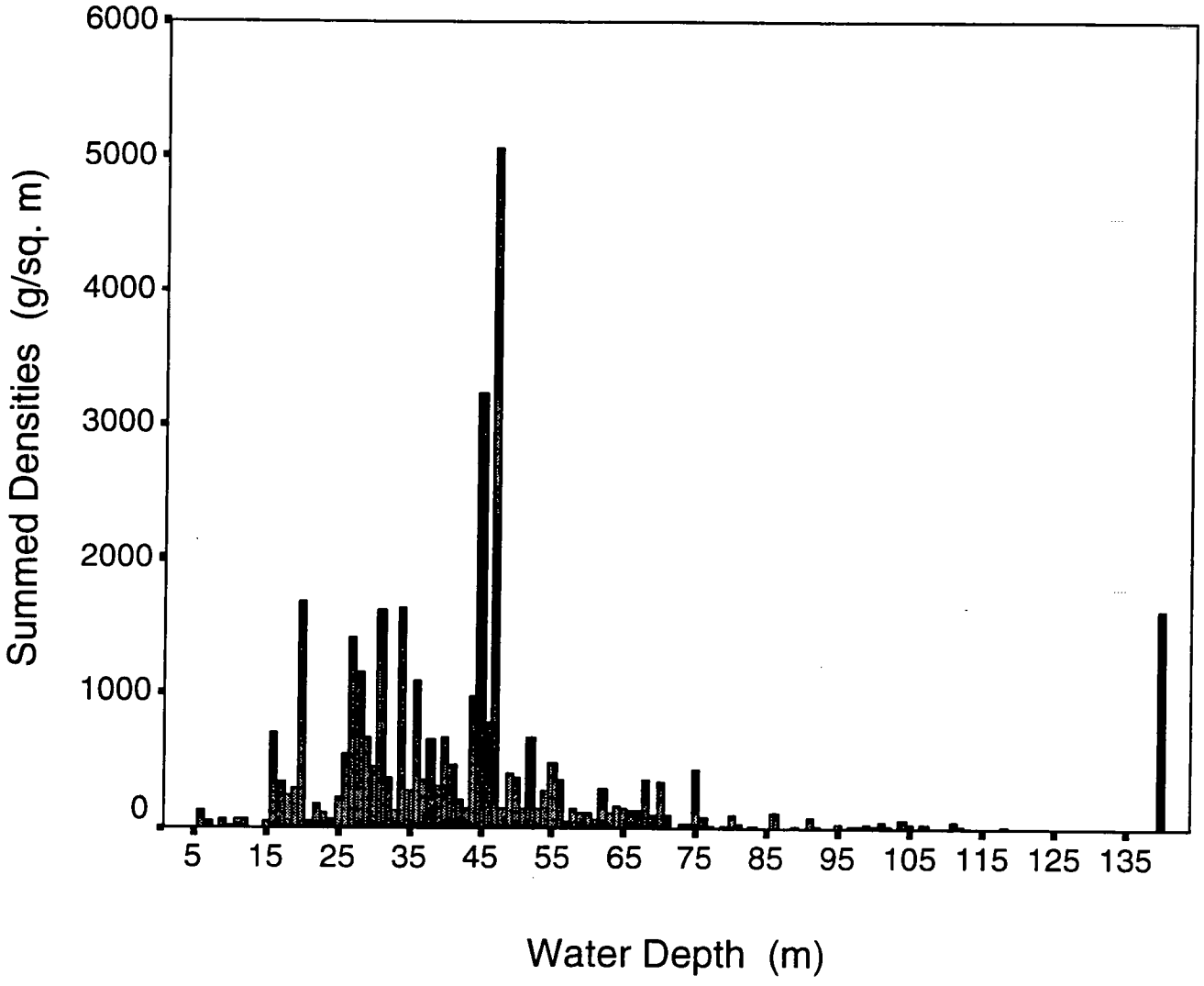


Fig. 9. Distribution of cod densities, by water depth, as detected on transects in Bonavista Bay - Trinity Bay during the 1996 fall acoustic survey.

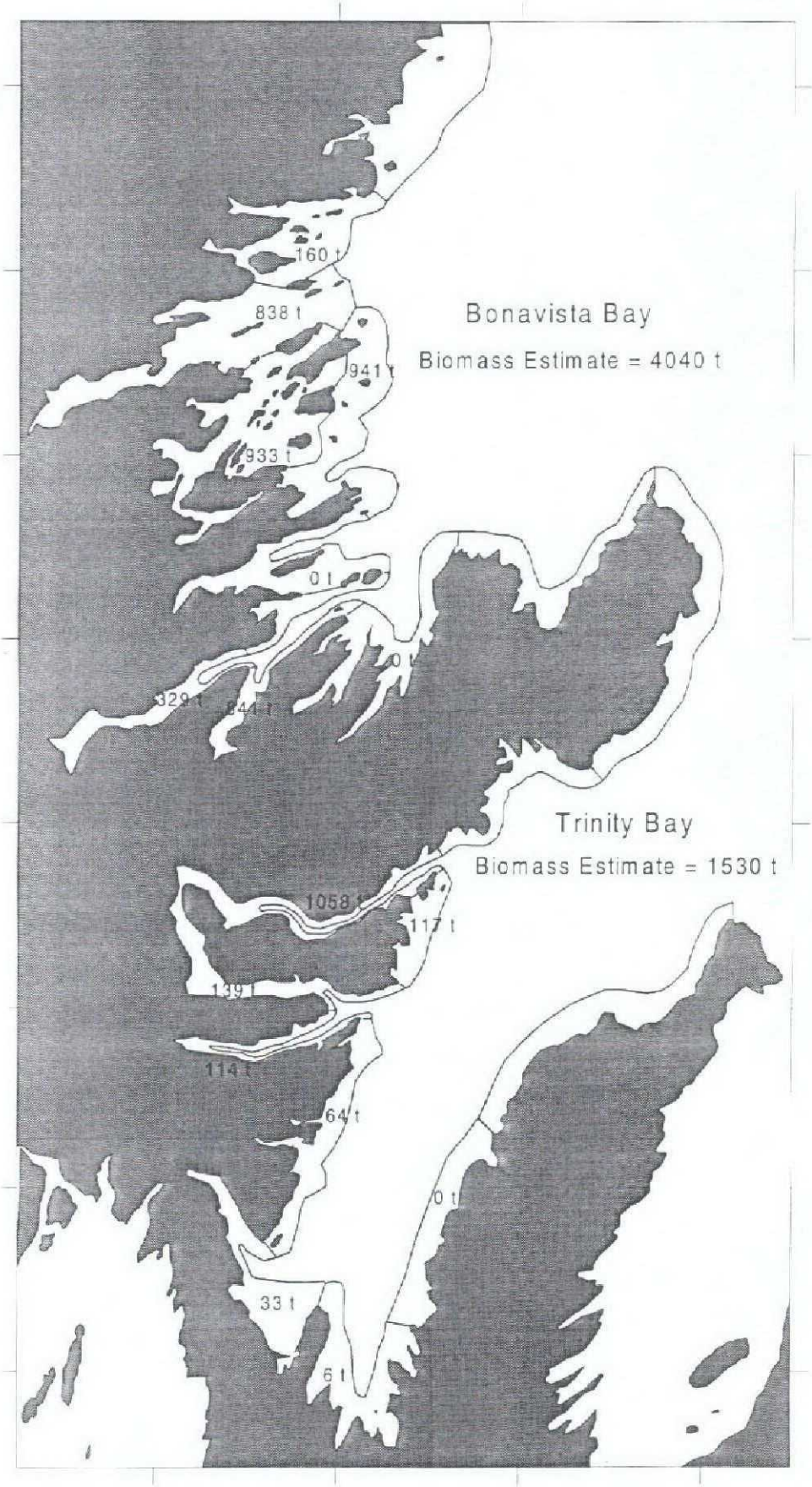


Fig. 10. Cod biomass estimates by survey strata from 1996 fall acoustic survey.