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Acoustic Surveys for Cod in Trinity Bay and Bonavista Bay (NAFO Div. 3L) during spring 1997

by

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ABSTRACT

Acoustic surveys for cod were conducted in western Trinity Bay during April 1997, and in southern Bonavista Bay during June 1997. Severe ice conditions in early May prevented more extensive survey coverage. Integrated density estimates for cod were obtained using a dual-beam 38Khz transducer, and a Biosonics model 102 echosounder, in conjunction with a Femto digitizer. A series of equidistant parallel transects with a random starting point was run. A total of 116 transects were surveyed and targets classified as cod were detected on 70 transects (60.3%). Average densities of cod on most transects were generally low (<0.20 gm/m^2), but high densities (>300 gm/m^2) were observed in four adjacent transects across deep (>120 m) water in Smith Sound, Trinity Bay. This large school of pre-spawning and spawning cod extended over an area 6 nm long by 0.5 to 1.3 nm wide, was up to 70 m deep and the densest part of the school was 25-30 m up off the bottom.. Total estimated biomass for the surveyed portion of Trinity Bay was 21,783 mT, with 96.3% observed in Smith Sound. A total of 1,516 mT was estimated for southern Bonavista Bay. Biological sampling, conducted with a Yankee 36 otter trawl and hand-lines equipped with a jigger and feathered hooks revealed cod ranging in size from 35 to 80 cm (mean 58.1) in Trinity Bay and 35-72 cm (mean 53.6) in Bonavista Bay. In sampled cod, ages 5 and 7 yr (1992 and 1990 yr classes) were most strongly represented in Trinity Bay with age 5 predominating in Bonavista Bay. In Smith Sound a small proportion (6.8%) of sampled females had hydrated eggs or were spent; the remaining mature females had mostly ripe gonads (Stage Mat AP) suggesting that spawning was just beginning and that spawning occurred later in 1997 than in 1996. In Bonaviata Bay, which was sampled in June, only 10% had ripe gonads (Stage Mat AP) and there were many females with hydrated eggs or spent gonads (50%) suggesting that peak spawning had already occurred.

RÉSUMÉ

Des relevés acoustiques de la morue ont été effectués dans la partie ouest de la baie Trinity en avril 1997 et dans le sud de la baie Bonavista en juin 1997. La présence de glaces importantes au début de mai a limité la couverture des relevés. Des estimations de densité intégrée de la morue ont été obtenues à l'aide d'un transducteur à double faisceau de 38 kHz et d'un échosondeur Biosonics modèle 102 couplés à un numériseur Femto. Une série de virées parallèles équidistantes à points de départ aléatoires a été effectuée. Au total, 116 virées ont été effectuées et des cibles classées morues ont été décelées au cours de 70 virées (60,3 %). Dans la majorité des virées, la densité moyenne des morues était généralement faible (<0,20 gm/m^2), mais des densités élevées (>300 gm/m^2) ont été décelées au moment de quatre virées adjacentes traversant des eaux profondes (>120 m) dans le détroit Smith de la baie Trinity. Ce banc important de géniteurs et de pré-géniteurs qui couvrait une superficie de plus de 6 milles marins sur de 0,5 à 1,3 mille marins, pouvait atteindre 70 m d'épaisseur et la partie la plus dense du banc se trouvait à de 25 à 30 m au-dessus du fond. La biomasse totale estimée dans la partie de la baie Trinity ayant fait l'objet des relevés est de 21 783 t (métriques) dont 96,3% était concentrée dans le détroit Smith. La valeur correspondante pour le sud de la baie Bonavista est de 1 516 t. Un échantillonnage biologique au chalut Yankee 36 et à la ligne à main avec turlutte à hameçons et plumes a permis de capturer des morues dont la taille variait entre 35 et 80 cm (moyenne de 58,1) dans la baie Trinity et entre 35 et 72 cm (moyenne de 53,6) dans la baie Bonavista. Des morues prélevées, celles de 5 et 7 ans (classes de 1992 et de 1990) étaient les plus abondantes dans la baie Trinity et celles d'âge 5 dans la baie Bonavista. Dans le détroit Smith, une petite proportion (6,8%) des femelles capturées présentaient des oeufs hydratés ou avaient déjà pondu, le reste des femelles matures présentaient des gonades presque rendues à maturité (stade AP), ce qui porte à croire que le frai commençait tout juste et qu'il s'est produit plus tard en 1997 qu'en 1996. Dans la baie Bonavista, où l'échantillonnage a été réalisé en juin, seulement 10% des femelles présentaient des gonades rendues à maturité (Stade AP) et un grand nombre de femelles portaient des oeufs hydratés ou des gonades vides (50 %), ce qui porte à croire que le pic du frai était déjà passé.

Introduction:

Acoustic surveys for cod were conducted in western Trinity Bay, NF during April 1997 and southern Bonavista Bay during June 1997. The areas surveyed in Trinity Bay included from Smith Sound southward to Bull Arm and eastward to the Bellevue Peninsula and in Bonavista Bay from Newman Sound southward to Western Head. Survey design was based on acoustic work performed inshore in Trinity Bay during 1995 and 1996 on CCGS Shamook (Rose 1996, Brattey and Porter. 1997).

Since 1995 aggregations of cod have been observed during spring in Trinity Bay and Bonavista Bay while no large aggregations have been detected offshore during stratified random trawl surveys. The present survey attempts to quantify the amount of cod in the inshore regions and determine the distribution of cod in both bays. Along with acoustic data other biological characteristics of sampled cod including length frequencies, maturities, condition and parasites were collected. Oceanographic data were collected at specific sites in each study area. CCGS Shamook was used as both an acoustic and fishing platform. The survey intended to include all of Trinity Bay and southern Bonavista Bay but due to mechanical difficulties on Shamook and the movement of ice into the bay the remaining areas could not be surveyed.

Survey Area

The area surveyed in Trinity Bay (Fig. 1) encompassed three adjacent fjords (Smith Sound, Northwest Arm, and Southwest Arm) 20-30 nm long and 0.5-2.0 nm wide in the Random Island area and extending southward from Deer Harbor to Bull Arm and east to the Bellevue Peninsula. Deer Harbor area consisted of transects that were 2 nm apart and ran 5 nm from the shoreline or to 300 meters of water depth. All other areas had transect spacing of 1 nm. Stratum areas covered by the survey were numbered 38 and 40-43. The area surveyed in Bonavista Bay (Fig. 2) encompassed five adjacent arms (Newman Sound, Clode Sound, Goose Bay, Southern Bay, and Sweet Bay to Western Head) 8-20 nm long and 0.5-2.0 nm wide. Transects in the Western Head area were completed northward across Bonavista Bay to Little Denier Island. Stratum areas numbered 31-34 were covered by the survey. Stratum boundaries are defined in Wheeler (1990).

Methods:

Survey design for Trinity Bay and Bonavista Bay was based on previous acoustic surveys (Wheeler 1990) and covered the coastal zone to a depth of 300m or 5 nm offshore, whichever came first. The survey areas were divided into strata based on topography and the total stratum area measured. To assign transect positions, a perpendicular baseline was assigned to the head of each area as close to shore as the vessel could safely operate. The first mile was subdivided into a baseline plus 10 parallel lines 0.1 nm apart and the position of the first transect was chosen randomly from these lines. Transect spacing was set at 1 nm within each area and was largely based on logistic constraints (size of area, time available, and vessel speed). Transects were run at approximately 4 knots during daylight hours.

The Biosonics model 102 echosounder was calibrated for target strength using a tungsten carbide standard target. Calibration and measurement of the system was completed by DFO's hydroacoustic section. This calibration was used to assess system performance and provide TVG calibration data. Calibration parameters for data collection are based on values determined by DFO, Biosonics and Femto. These values have been used consistently among all acoustic surveys since 1990. Calibration was performed throughout the survey.

Only data collected by the Femto digitizer was analyzed because of software and computer problems with the Biosonics ESP processors. Data collected were further analyzed using the Femto data editor.

Data on ships track, set position and CTD casts were recorded using Bioplot navigational software. A written log was maintained to record events along each transect. Fishing set detail information was recorded as per trawl surveys. Biological samples were collected with handlines, gillnets, and a Yankee 36 shrimp trawl

Acoustic data collection and signal processing

During the survey a detailed log and paper echogram were recorded for each transect. The echosounder ping rate was set to 1 ping per second. Acoustic data were collected along the predetermined transects and digitized to individual Femto files. Between transect data were collected and stored for distribution analysis. Each data file was then edited to remove bottom, shadowing, noise and all other biological species except cod. The remaining backscatter was then integrated (acoustic density echo integration) to provide densities in grams per square meter. These densities were then extrapolated to the entire stratum area to provide a biomass estimate.

The average length of cod sampled within a stratum was converted to an average target strength (TS) per fish using the following relationship derived specifically for cod by Rose and Porter (1996).

$$TS(fish)=20\log L - 66.0$$

where L=cod fork length in cm.

A length-weight relationship was then used to determine the average weight of fish observed in each strata.

$$\ln(wt)=-12.234 + 3.145\ln(len)$$

Acoustic data integration requires the TS to be in grams per meter squared. To convert TS in terms of length to TS per gram we use the formula. (Anderson, et al 1998):

$$TS\ (db/gm)=TS(fish)\ -10Log\ (1/mean\ weight\ per\ fish)-30\ dB$$

Cod density(gm/m^3) was estimated using the following formula:

$$Density\ (gm/m^3) = V_R^2 K$$

Where V_R is average rms. Voltage at depth R and K is as follows:

$$K = 10^{-(Rs + Tx + Bf + TS + 10\log(c\tau\pi))/10}$$

Rs is the transducer receiving sensitivity in decibels
Tx is the transducer source level in decibels
Bf is the average expected beam pattern for the transducer in decibels
TS is the target strength per gram in decibels
Go is the fixed gain of the echosounder in decibels
C is the speed of sound in seawater in meters/second
T is the pulse length of the echosounder
π is psi

Cod density (gm/m^2) of surface area was then calculated by summing the estimates of cubic meter densities over the depth of the acoustic sampling. Data were integrated to provide estimates of cod density at one minute intervals, for entire transects.

Acoustic survey results

Integrated density estimates were calculated for the 116 transects within the survey areas. The formulas used to compute mean densities, variances, and biomass estimates within each stratum and overall biomass are described in Wheeler (1990). Briefly, mean densities per transect were standardized to account for differences in transect length and these were used to compute an overall average density for the stratum area. Stratum variances given in Table 1 indicate the extent to which transect densities vary around the overall stratum mean.

Estimated cod biomass in the two surveyed areas was 21783 and 1516 metric tons for Trinity Bay and Bonavista Bay, respectively (Table 2). Targets classified as cod were detected on 70 (60% of 116) transects. Highest densities (>300 gm/m^2) were observed on four transects across deep water in the area of Smith Sound, Trinity Bay (Fig. 3). Smith Sound area accounts for 96% of the observed acoustic biomass. Transect densities ranged from < 0.6 to > 1000 gm/m^2 (Figs 3-7).

Cod densities for Northwest Arm (Fig. 4) were low with the highest densities (<2.1 gm/m^2) located on two transects at the western end and one transect at the eastern end of the arm. Southwest Arm (Fig. 5) densities were highest on two transects (< 45.0 gm/m^2) in the middle of the arm. Deer Harbor (Fig. 6) and Bull Arm (Fig. 7) densities were extremely low with transect densities measuring <0.6 gm/m^2).

Several transects around Dildo were completed before mechanical problems and ice conditions forced Shamook to leave the area. No significant densities of cod were observed in this area. There was insufficient coverage to complete an estimate for this stratum. Transects in the Bellevue area located high densities of juvenile capelin in the deep channel across Bellevue.

No significant aggregations of cod were located in Bonavista Bay (Table 1). Densities along each transect were low throughout all strata and ranged from >0.05 gm/m^2 to <100gm/m^2 (Figs. 8-11). Highest densities of cod (>90gm/m^2) were located in Goose Bay (Fig. 9). Cod were widely distributed in stratum 33 (Clode Sound) and stratum 34, which includes Southern Bay, Sweet Bay and Western Head (Figs 10,11).

Plots of sum density by minimum depth (Fig. 12a,b-13a,b) for Trinity Bay indicate that the main aggregation of cod was located in Smith Sound and was restricted to the deep basins (>120m to <240m). Significantly less dense patches (<1.00 gm/m^2) were located throughout the sound. Cod in Newman Sound were located in both shallow (10m-50m) and deep (~250m) water. Plots of sum density by minimum depth (Figs 14a,b-17a,b) for Bonavista Bay indicate that cod were observed throughout all depth ranges. The majority of cod were located in depths ranging from ~30m to 160m.

Echograms (Figs. 18,19) indicate a very different pattern of distribution and density between Trinity Bay (Smith Sound) and Bonavista Bay (Goose Bay). Both transects indicate that cod were located in the deepest portions and not on the slopes or in shallow water. The distribution pattern for Smith Sound indicates a dense and large aggregation of cod while Goose Bay indicates a low density patch with only single cod observed. With the exception of Smith Sound the distribution pattern for aggregated cod located elsewhere was similar to Goose Bay, transect 8. The aggregation of cod located in Smith Sound was ~70m deep and the densest part of the aggregation was 25-30m up off the bottom (Fig 18). It extended over an area of 6 nm long by 0.5-1.3 nm wide.

Biological sampling

A wide range of sizes of cod was observed in Trinity Bay (Fig.19); average length was 58.1 cm with no clear evidence of more than one mode in the length frequency. Cod sampled in Bonavista Bay were on average about 5 cm smaller again with no evidence of more than one mode. Several age classes were present (2-17 years in Trinity Bay, 3-8 years in Bonavista Bay). Ages 5 and 7 years (1992 and 1990 year classes) were most strongly represented in Trinity Bay with age 5 predominating in Bonavista Bay (Fig. 19). The bimodality in the age composition in Trinity Bay was evident in both Smith Sound (Fig. 18) and NW Arm, even though the cod in these areas were caught with different gears (hand-lines in NW Arm, otter trawl in Smith Sound). An adjusted (by LF) age-length key for Trinity Bay cod was also constructed (Table 3). Average lengths and weights at age of these cod were comparable to those of cod sampled in Smith Sound at the end of 1995 (Brattey 1997).

A considerable portion of the cod sampled in NW Arm and Smith Sound were immature fish (Table 4). Mean size of those sampled for maturity ranged from 55.4 to 57.3 cm. Among the adult females most (41 and 62%) had not yet spawned but were destined to spawn later in 1997 (Stage Mat AP). There were few actively spawning fish (Mat BP and Mat CP, 3-4%) in the samples from either area. This result contrasts with the finding in 1996 when 62.1% of the fish sampled from an aggregation in the deep water in outer Smith Sound during April 15-26th were spawning (Brattey 1997) and suggests that spawning may have occurred later in 1997.

Mean lengths of cod sampled for maturity (Table 4) in Bonavista Bay ranged from 39 -72 cm; these samples showed a large portion of immature (40%) and spent (38%) females. Ten percent of females had not yet spawned (Mat AP) but were destined to spawn later in 1997. Active spawning fish (Mat BP and Mat CP) totaled 12%. The maturity data therefore suggest that the majority of cod sampled had completed the spawning cycle when the acoustic survey was undertaken.

Table 2.	Smith Sound	NW Arm	Bonavista Bay
	21-24/Apr/97	25/Apr/97	24-30/Jun/97
No of cod	74	114	50
Mean length ± SD	57.3 ± 10.18	55.4 ± 11.32	54.4 ± 8.56
Range	31-82	32-120	39 - 72
% Immature	27	53.5	40
% Mat AP	62.2	41.2	10
% Mat BP	0	1.8	4
% Mat CP	2.7	1.8	8
% Spent	4.1	0.9	38
% other	4.1	0.9	-

CTD data were collected at predetermined stations throughout the survey area and at fishing sets (Fig.22). Water temperatures of greater than 0.0 ^{0}C occurred from the surface to a depth of ~30 meters in Smith Sound and to a depth of ~60 meters in Newman Sound. Newman Sound surface temperatures had warmed to 4.0^{0}C by June. The large aggregation of cod in Smith Sound (Fig 18) was located at depths of 125-200 meters where water temperatures ranged from –0.4 to -0.8^{0}C (Fig. 23). Cod in Newman Sound were observed at very low densities in water depths of 30-300m where temperatures ranged from -1.0 to 1.5^{0}C. The cold intermediate layer (-1.0 C) was located between 60 and 180 meters. Both areas have >0.0 ^{0}C water in depths >210 m.

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Table 1. Cod biomass estimate for Trinity and Bonavista Bays from 1997 Div. 3L.

Stratum	Stratum Area	Transect	Transect Length(nm)	Transect Area(m2)	Weighting Factor	Density (gm/m2)	Wt Density (gm/m2)	(Den-mean wtd den)^2	wt factr^2	Col K * Col L	Absolute Stratum Var.	Standard Error	Biomass Estimate T
SS(38)	1.06E+08	SS2	0.88	1629.76	0.88	0.00	0.00	39129.56	0.77	30150.99			
		SS3	1.14	2111.28	1.14	0.24	0.27	39036.28	1.29	50478.85			
		SS4	1.34	2481.68	1.34	806.92	1078.58	371014.23	1.79	662874.64			
		SS5	1.07	1981.64	1.07	1060.60	1132.01	744404.65	1.14	848023.46			
		SS6	0.85	1574.20	0.85	519.04	440.09	103189.08	0.72	74182.74			
		SS7	0.76	1407.52	0.76	394.21	298.85	38572.79	0.57	22168.66			
		SS8	0.50	926.00	0.50	163.06	81.32	1207.99	0.25	300.49			
		SS9	0.66	1222.32	0.66	124.64	82.06	5353.65	0.43	2320.43			
		SS10	0.72	1333.44	0.72	1.59	1.14	38503.40	0.52	19860.73			
		SS11	0.87	1611.24	0.87	0.00	0.00	39129.56	0.75	29469.63			
		SS12	0.79	1463.08	0.79	0.01	0.01	39126.59	0.62	24297.27			
		SS13	1.10	2037.20	1.10	13.15	14.43	34101.28	1.20	41057.01			
		SS14	1.05	1944.60	1.05	7.42	7.77	36250.84	1.10	39767.46			
		SS15	1.16	2148.32	1.16	0.67	0.78	38864.82	1.34	52036.00			
		SS16	1.70	3148.40	1.70	3.15	5.33	37894.94	2.88	108970.84			
		ss17	1.45	2685.40	1.45	15.46	22.36	33252.77	2.09	69565.69			
	Count	16	Average	1856.63		194.38	197.81			8648.02	9.72E+19	9857.44	20968 T
NW(40)	9.40E+07	NW1	0.68	1259.36	0.81	0.85	0.69	0.18	0.66	0.12			
		NW2	0.70	1296.40	0.83	2.05	1.71	2.65	0.70	1.84			
		NW3	1.39	2574.28	1.66	0.05	0.09	0.14	2.75	0.37			
		NW4	1.00	1852.00	1.19	0.07	0.09	0.12	1.42	0.17			
		NW5	0.62	1148.24	0.74	0.06	0.05	0.13	0.55	0.07			
		NW6	0.83	1537.16	0.99	0.02	0.02	0.16	0.98	0.16			
		NW7	0.59	1092.68	0.70	0.00	0.00	0.18	0.49	0.09			
		NW8	1.00	1852.00	1.19	0.00	0.00	0.18	1.42	0.25			
		NW9	0.74	1370.48	0.88	1.31	1.16	0.80	0.78	0.62			
	count	9	Average	1553.62		0.49	0.42			0.05	4.54E+14	21.31	46 T

Table 1. Cont'

Stratum	Stratum Area	Transect	Transect Length(nm)	Transect Area(m2)	Weighting Factor	Density (gm/m2)	Wt Density (gm/m2)	(Den-mean wtd den)^2	wt factr^2	Col K * Col L	Absolute Stratum Var.	Standard Error	Biomass Estimate T
SW(41)	6.40E+07	SW1	0.53	982.09	0.66	0.00	0.00	136.93	0.44	60.10			
		SW2	0.63	1167.39	0.79	13.16	13.16	2.11	0.62	1.31			
		SW3	0.84	1556.52	1.05	0.13	0.13	133.87	1.10	147.59			
		SW4	0.88	1630.64	1.10	45.00	45.00	1109.04	1.21	1341.94			
		SW5	1.12	2075.36	1.40	0.22	0.22	131.88	1.96	258.49			
	Count	5	Average	1482.40			11.70			90.47	3.71E+17	608.74	749 T
DH(42)	1.81E+08	DH1	2.47	4576.91	0.59	0.000	0.000	0.000	0.35	0.000			
		DH3	3.02	5596.06	0.73	0.000	0.000	0.000	0.53	0.000			
		DH5	3.4	6300.20	0.82	0.000	0.000	0.000	0.67	0.000			
		DH7	5.92	10969.76	1.42	0.000	0.000	0.000	2.02	0.000			
		DH9	6	11118.00	1.44	0.003	0.004	0.000	2.08	0.000			
	Count	5	Average	7712.19			0.001			0.000	1.61E+10	0.13	0.49 T
BA(43)	1.42E+08	BA1	0.57	1056.21	0.23	0.00	0.00	0.02	0.05	0.00			
		BA2	1.04	1927.12	0.41	0.00	0.00	0.02	0.17	0.00			
		BA3	1.43	2649.79	0.57	0.00	0.00	0.02	0.32	0.01			
		BA4	2.18	4039.54	0.86	0.00	0.00	0.02	0.74	0.01			
		BA5	4.53	8394.09	1.79	0.48	0.86	0.12	3.21	0.38			
		BA6	5.28	9783.84	2.09	0.05	0.10	0.01	4.36	0.03			
		BA7	2.68	4966.04	1.06	0.00	0.00	0.02	1.12	0.02			
	Count	7	Average	4688.09			0.14			0.02	4.05E+14	20.13	20 T

Table 1. cont'

Stratum	Stratum Area	Transect	Transect Length(nm)	Transect Area(m2)	Weighting Factor	Density (gm/m2)	Wt Density (gm/m2)	(Den-mean wtd den)^2	Weighting Factor^2	Col K * Col L	Absolute Stratum Var.	Standard Error	Biomass Estimate T
NS(31)	1.34E+08	NS1	0.50	926.00	0.21	0.05	0.01	0.00	0.04	0.00			
		NS2	0.65	1203.80	0.28	0.08	0.02	0.01	0.08	0.00			
		NS3	1.00	1852.00	0.42	0.00	0.00	0.00	0.18	0.00			
		NS4	0.97	1796.44	0.41	1.36	0.56	1.85	0.17	0.31			
		NS5	0.76	1407.52	0.32	3.67	1.18	13.45	0.10	1.39			
		NS6	1.04	1926.08	0.44	2.18	0.96	4.76	0.19	0.93			
		NS7	0.93	1722.36	0.39	0.00	0.00	0.00	0.16	0.00			
		NS8	1.80	3333.60	0.76	0.00	0.00	0.00	0.58	0.00			
		NS9	1.07	1981.64	0.45	24.12	10.94	581.90	0.21	119.62			
		NS10	1.24	2296.48	0.53	0.87	0.46	0.76	0.28	0.21			
		NS11	1.43	2648.36	0.61	0.20	0.12	0.04	0.37	0.02			
		NS12	0.85	1574.20	0.36	0.29	0.11	0.09	0.13	0.01			
		NS13	3.70	6852.40	1.57	0.08	0.13	0.01	2.46	0.02			
		NS14	3.75	6945.00	1.59	0.00	0.00	0.00	2.52	0.00			
		NS15	4.25	7871.00	1.80	0.00	0.00	0.00	3.24	0.00			
		NS16	0.46	851.92	0.19	0.00	0.00	0.00	0.04	0.00			
		NS17	0.54	1000.08	0.23	0.02	0.00	0.00	0.05	0.00			
		NS18	0.40	740.80	0.17	0.00	0.00	0.00	0.03	0.00			
		NS19	0.62	1148.24	0.26	0.01	0.00	0.00	0.07	0.00			
		NS20	1.51	2796.52	0.64	0.00	0.00	0.00	0.41	0.00			
		NS21	1.92	3555.84	0.81	0.00	0.00	0.00	0.66	0.00			
		NS22	2.36	4370.72	1.00	0.00	0.00	0.00	1.00	0.00			
	Count	22	Average	2672.77		1.50	0.66			0.27	4.7612E+15	69.00146	88 T

Table 1. Cont'

Stratum	Stratum Area	Transect	Transect Length(nm)	Transect Area(m2)	Weighting Factor	Density (gm/m2)	Wt Density (gm/m2)	(Den-mean wtd den)^2	Weighting Factor^2	Col K * Col L	Absolute Stratum Var.	Standard Error	Biomass Estimate T
GB(32)	9.60E+07	GB1	0.51	944.52	0.27	0.00	0.00	18.37	0.07	1.30			
		GB2	0.52	963.04	0.27	0.00	0.00	18.37	0.07	1.35			
		GB3	0.54	1000.08	0.28	0.00	0.00	18.37	0.08	1.45			
		GB4	0.70	1296.40	0.36	0.00	0.00	18.37	0.13	2.44			
		GB5	0.99	1833.48	0.52	1.17	0.60	9.71	0.27	2.58			
		GB6	0.72	1333.44	0.38	3.71	1.39	0.33	0.14	0.05			
		GB7	2.59	4796.68	1.35	1.43	1.93	8.16	1.82	14.84			
		GB8	1.05	1944.60	0.55	117.94	64.50	13380.85	0.30	4001.84			
		GB10	1.27	2352.04	0.66	0.19	0.12	16.81	0.44	7.36			
		GB12	2.16	4000.32	1.13	0.00	0.00	18.37	1.27	23.25			
		GB14	1.53	2833.56	0.80	0.01	0.01	18.27	0.64	11.60			
		GB15	2.28	4222.56	1.19	0.00	0.00	18.37	1.41	25.90			
		GB16	3.00	5556.00	1.56	0.00	0.00	18.37	2.44	44.84			
		GB17	1.25	2315.00	0.65	0.00	0.00	0.00	0.42	0.00			
		GB18	0.48	888.96	0.25	0.07	0.02	0.01	0.06	0.00			
		GB19	0.57	1055.64	0.30	0.00	0.00	0.00	0.09	0.00			
	Count	16	Average	2333.52	0.66	7.78	4.29			17.2450	1.59E+17	398.66	411 T
CS(33)	7.30E+07	CS1	0.93	1722.36	0.22	31.29	6.85	842.61	0.05	40.35			
		CS2	0.90	1666.80	0.21	2.72	0.58	0.21	0.04	0.01			
		CS3	1.14	2111.28	0.27	43.58	11.69	1706.91	0.07	122.81			
		CS4	1.24	2296.48	0.29	0.50	0.15	3.12	0.09	0.27			
		CS5	0.86	1592.72	0.20	7.59	1.54	28.40	0.04	1.16			
		CS6	1.18	2185.36	0.28	1.47	0.41	0.64	0.08	0.05			
		CS8	0.78	1444.56	0.18	7.85	1.44	31.22	0.03	1.05			
		CS10	1.01	1870.52	0.24	0.00	0.00	5.13	0.06	0.29			
		CS12	1.33	2463.16	0.31	0.01	0.00	5.08	0.10	0.50			
		CS14	1.03	1907.56	0.24	0.00	0.00	5.13	0.06	0.30			
	Count	10	Average	1926.08	0.24	9.50	2.26			1.8532	9.88E+15	99.37618	165 T

Table 1. Cont'

Stratum	Stratum Area	Transect	Transect Length(nm)	Transect Area(m2)	Weighting Factor	Density (gm/m2)	Wt Density (gm/m2)	(Den-mean wtd den)^2	Weighting Factor^2	Col K * Col L	Absolute Stratum Var.	Standard Error	Biomass Estimate T
SB(34)	1.57E+08	SB1	0.16	296.32	0.31	0.09	0.03	0.01	0.10	0.00			
		SB2	0.18	333.36	0.35	1.68	0.59	2.83	0.12	0.35			
		SB3	0.30	555.60	0.59	38.41	22.59	1475.33	0.35	510.49			
		SB4	0.52	963.04	1.02	0.00	0.00	0.00	1.04	0.00			
		SB5	0.40	740.80	0.78	0.00	0.00	0.00	0.62	0.00			
		SB6	0.73	1351.96	1.43	0.44	0.63	0.20	2.05	0.40			
		SB7	0.21	388.92	0.41	0.00	0.00	0.00	0.17	0.00			
		SB8	1.20	2222.40	2.35	0.00	0.00	0.00	5.54	0.00			
		SB9	2.65	4907.80	5.20	0.62	3.20	0.38	27.00	10.22			
		SB10	2.92	5407.84	5.73	3.96	22.70	15.72	32.78	515.21			
		SB11	0.24	444.48	0.47	0.00	0.00	0.00	0.22	0.00			
		SB12	0.33	611.16	0.65	0.00	0.00	0.00	0.42	0.00			
		SB13	0.43	796.36	0.84	0.00	0.00	0.00	0.71	0.00			
		SB14	0.57	1055.64	1.12	0.00	0.00	0.00	1.25	0.00			
		SB15	0.61	1129.72	1.20	0.62	0.74	0.39	1.43	0.55			
		SB16	0.33	611.16	0.65	2.41	1.56	5.80	0.42	2.43			
		SB17	0.88	1629.76	1.73	2.62	4.52	6.85	2.98	20.41			
		SB18	0.93	1722.36	1.82	1.30	2.38	1.70	3.33	5.64			
		SB19	1.25	2315.00	2.45	0.10	0.24	0.01	6.01	0.06			
		SB20	2.02	3741.04	3.96	0.93	3.70	0.87	15.69	13.71			
		SB21	1.46	2703.92	2.86	0.00	0.00	0.00	8.20	0.00			
		OH1	4.00	7408.00	7.84	0.00	0.00	0.00	61.51	0.00			
		OH3	3.75	6945.00	7.35	0.00	0.00	0.00	54.07	0.00			
		OH5	4.47	8278.44	8.76	0.20	1.78	0.04	76.82	3.15			
		OH7	6.22	11519.44	12.20	0.02	0.25	0.00	148.74	0.06			
		OH8	5.47	10130.44	10.73	0.10	1.03	0.01	115.04	1.06			
	Count	26	Average	3008.08			2.54			1.806263159	4.45226E+16	211.0038	398 T

Table 2. Summary Table of Spring Acoustic Biomass Estimates for Trinity and Bonavista Bays(1997)

Ship	Trip	Area	Location	Stratum	Date Surveyed Day/Month/Year	Biomass Estimate (mTons)
Shamook	265	Trinity Bay	Smith Sound	38	21-24/04/97	20968.0
			Northwest Arm	40	25/04/97	46.0
			Southwest Arm	41	26/04/97	749.0
			Deer Harbour	42	27/04/97	0.5
			Bull Arm	43	28/04/97	20.0
					Subtotal	21783.5
Shamook	266	Bonavista Bay	Newman Sound	31	24-25/06/97	88.0
			Goose Bay	32	25-26/06/97	627.0
			Clode Sound	33	27/06/97	676.0
			Sweet Bay	34	28/06/97	125.0
			Western Head	34	29/06/97	
			Southern Bay	34	30/06/97	
					Subtotal	1516.0
					Total	23299.5

Table 3. Adjusted age-length key for cod sampled in Trinity Bay during Shamook Trip 265 (April 1997).

	Ages															
Length	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
19.0			1													
31.0				4												
34.0				6	6											
37.0				6	8											
40.0				2	28		2									
43.0					41	28										
46.0					50	72										
49.0					9	195	9									
52.0						185	26	13								
55.0						108	62	40								
58.0						33	66	85								
61.0							59	130	21							
64.0							18	129	18							
67.0							6	77	42	6						
70.0								34	28	6						
73.0								14		14	7					
76.0								5	16	16						
79.0								4	4	7	4					
Totals	0	0	1	17	142	622	249	531	128	49	11	0	0	0	0	0
Av/Len	0.00	0.00	19.00	35.09	43.14	50.79	57.47	62.61	67.70	73.79	75.04	0.00	0.00	0.00	0.00	0.00
Av/Wgt	0.00	0.00	0.05	0.36	0.69	1.14	1.67	2.17	2.77	3.61	3.80	0.00	0.00	0.00	0.00	0.00

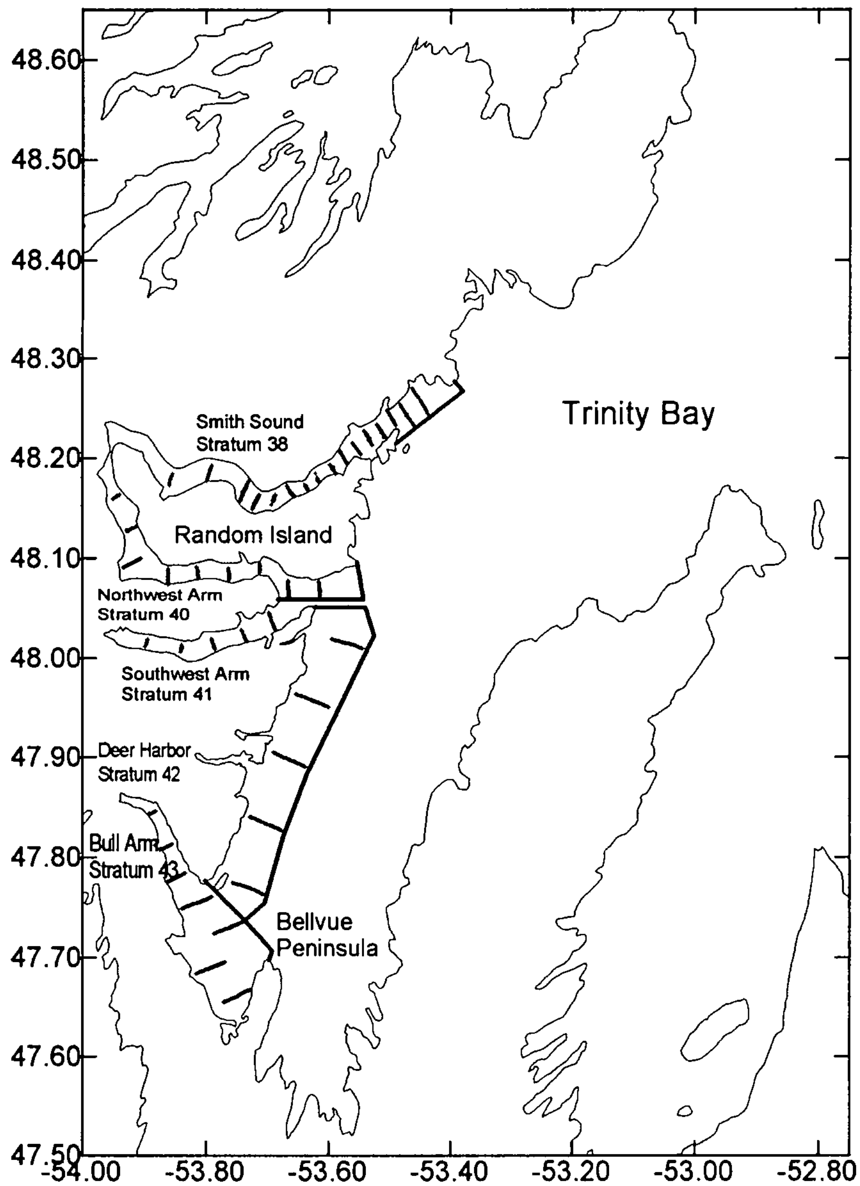


Fig. 1 Area map of Trinity Bay indicating survey strata and transects

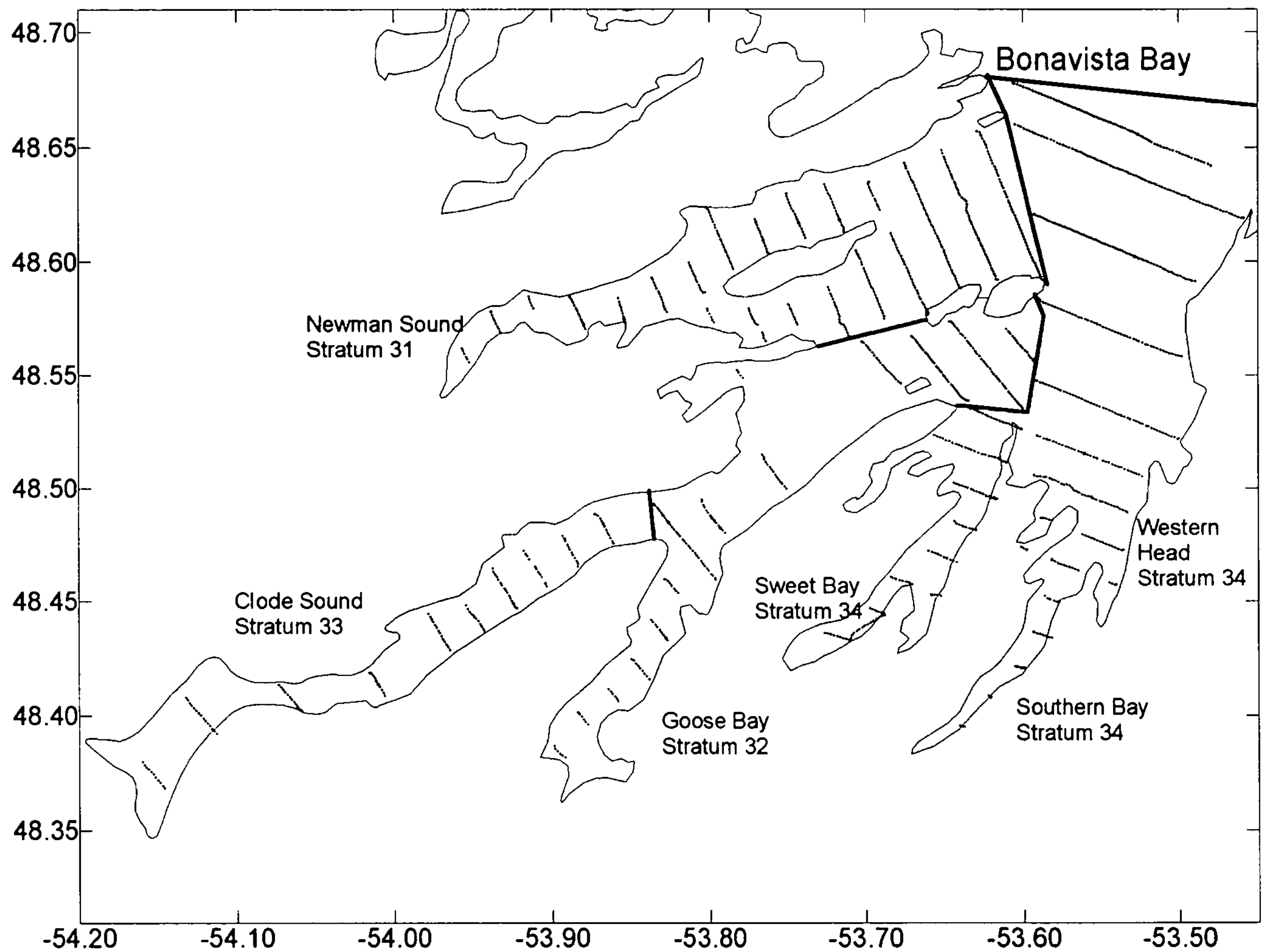


Fig. 2 Area map of Bonavista Bay indicating survey strata and transects

Fig. 3

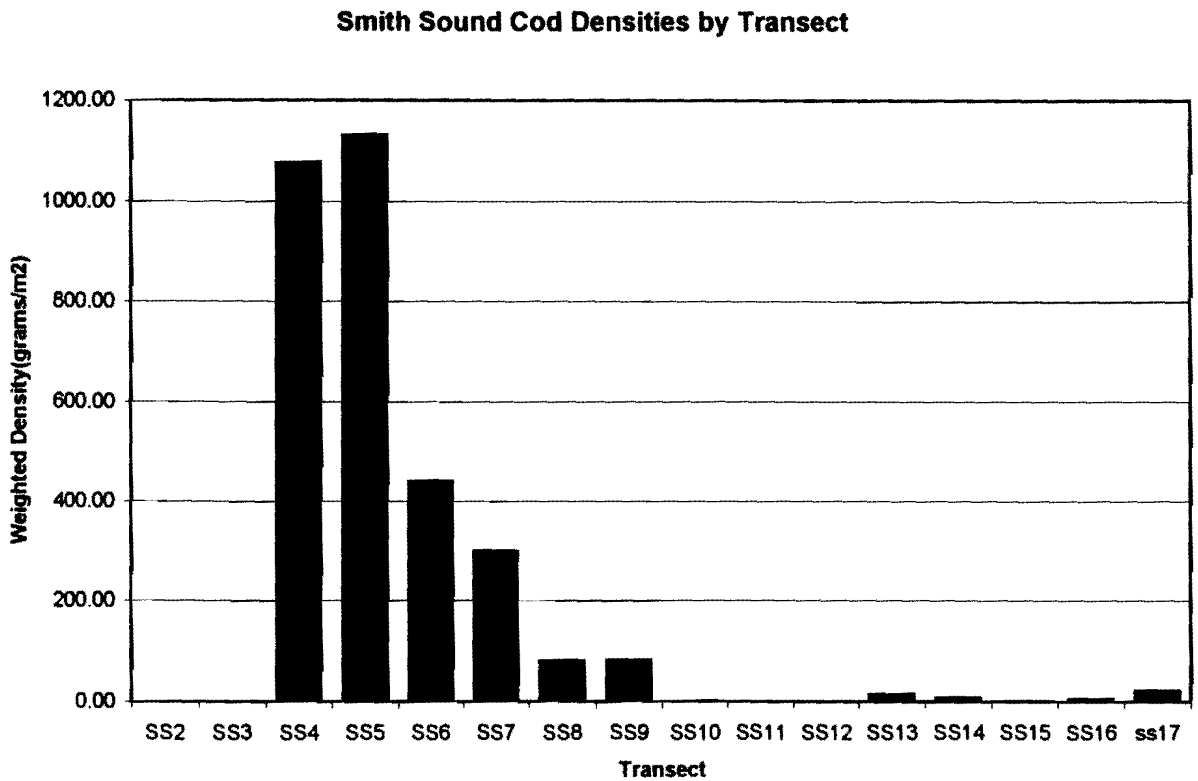

Smith Sound Cod Densities by Transect
1200.00
1000.00
800.00
600.00
400.00
200.00
0.00
Weighted Density(grams/m2)
SS2
SS3
SS4
SS5
SS6
SS7
SS8
SS9
SS10
SS11
SS12
SS13
SS14
SS15
SS16
ss17
Transect

Fig. 4

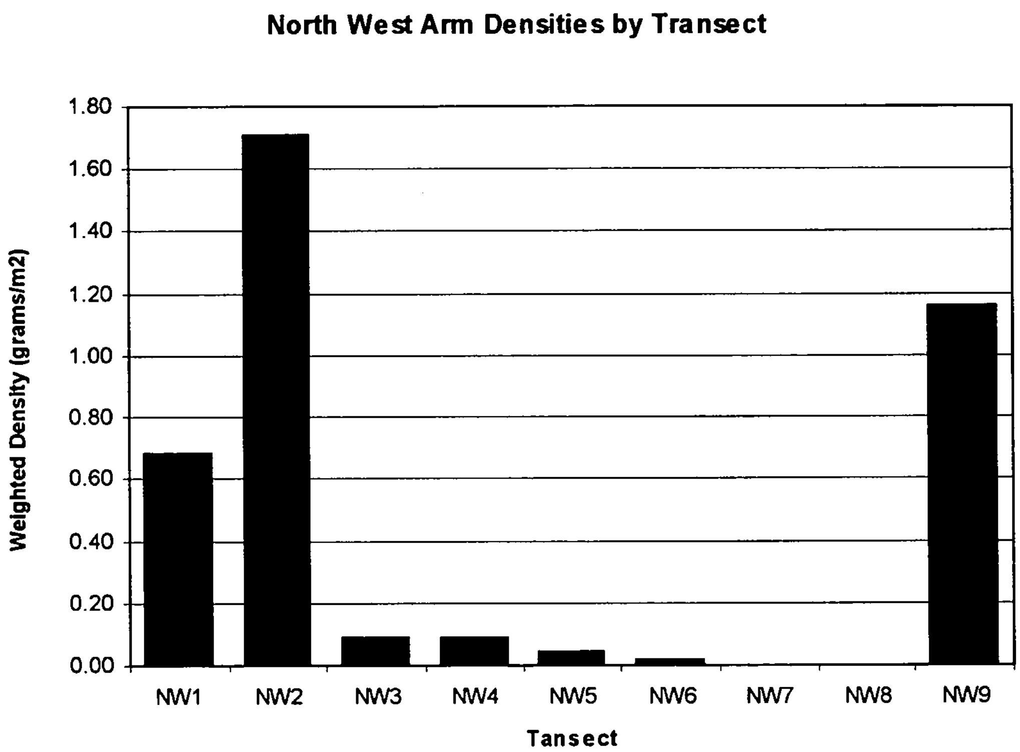

North West Arm Densities by Transect
Weighted Density (grams/m2)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
NW1
NW2
NW3
NW4
NW5
NW6
NW7
NW8
NW9
Tansect

Fig. 5.

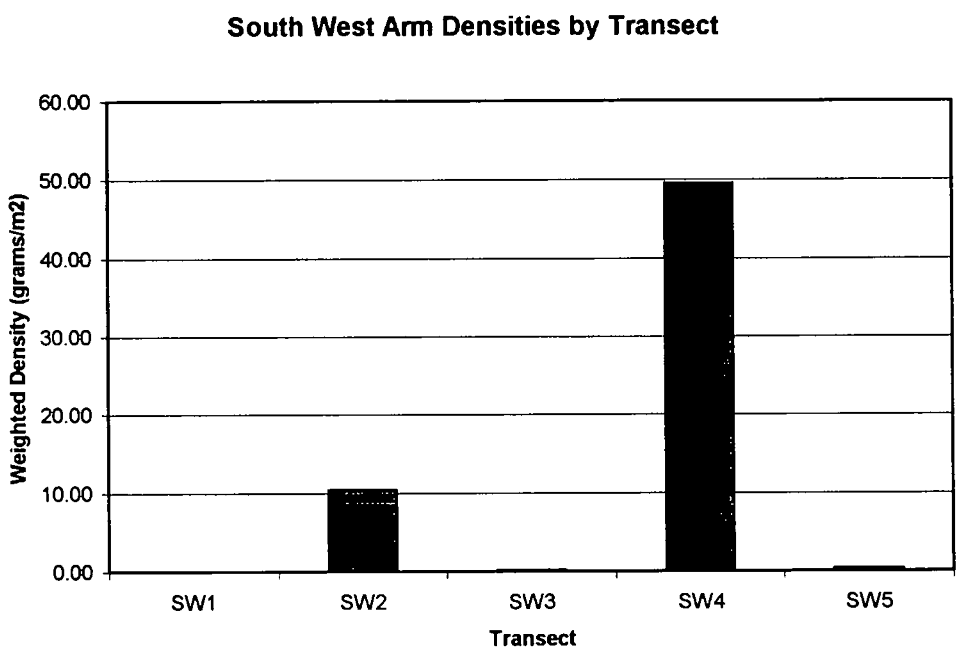
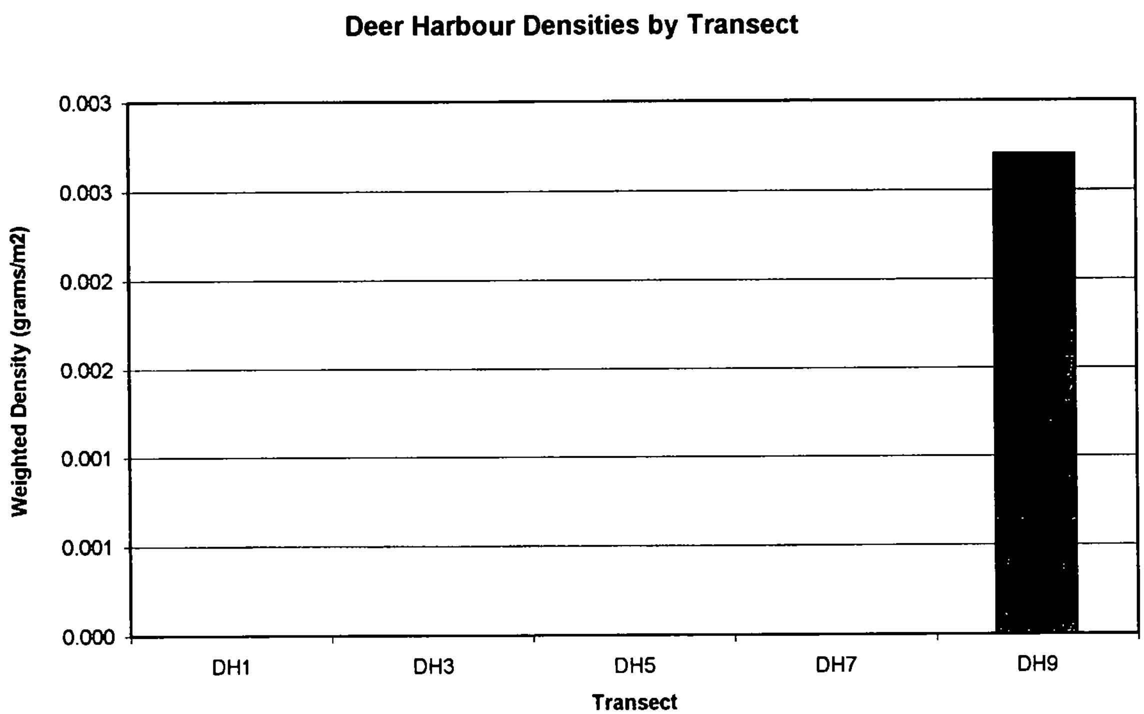

South West Arm Densities by Transect
60.00
50.00
40.00
30.00
20.00
10.00
0.00
Weighted Density (grams/m2)
SW1
SW2
SW3
SW4
SW5
Transect

Fig 6.



Deer Harbour Densities by Transect
0.003
0.003
0.002
0.002
0.001
0.001
0.000
Weighted Density (grams/m2)
DH1
DH3
DH5
DH7
DH9
Transect

Fig. 7

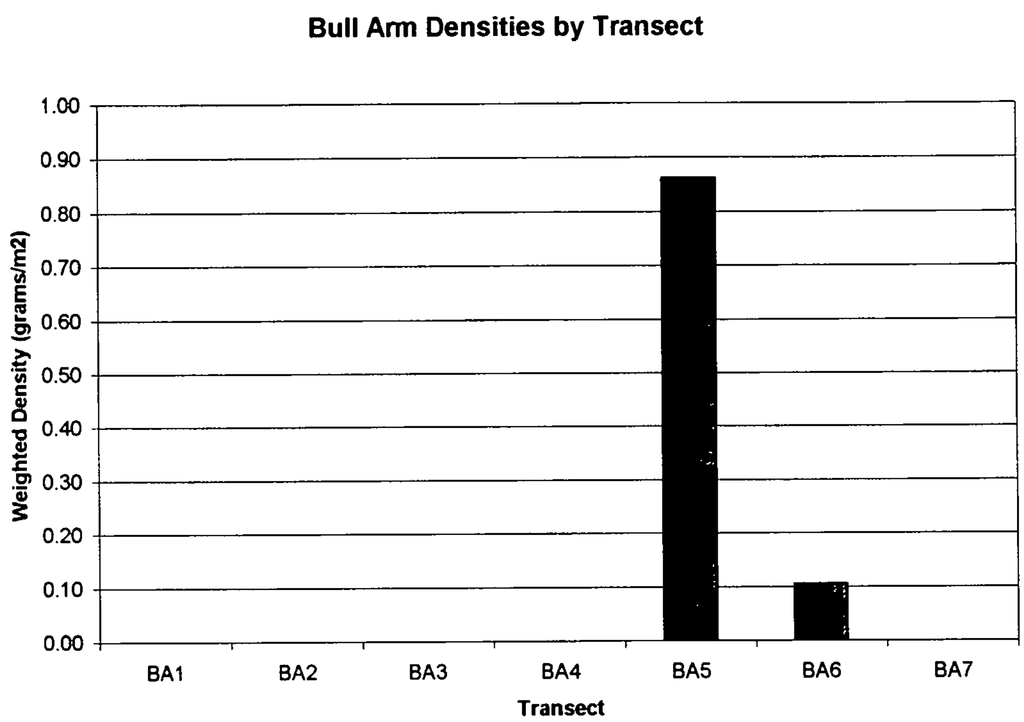

Bull Arm Densities by Transect
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
Weighted Density (grams/m2)
BA1
BA2
BA3
BA4
BA5
BA6
BA7
Transect

Fig. 8

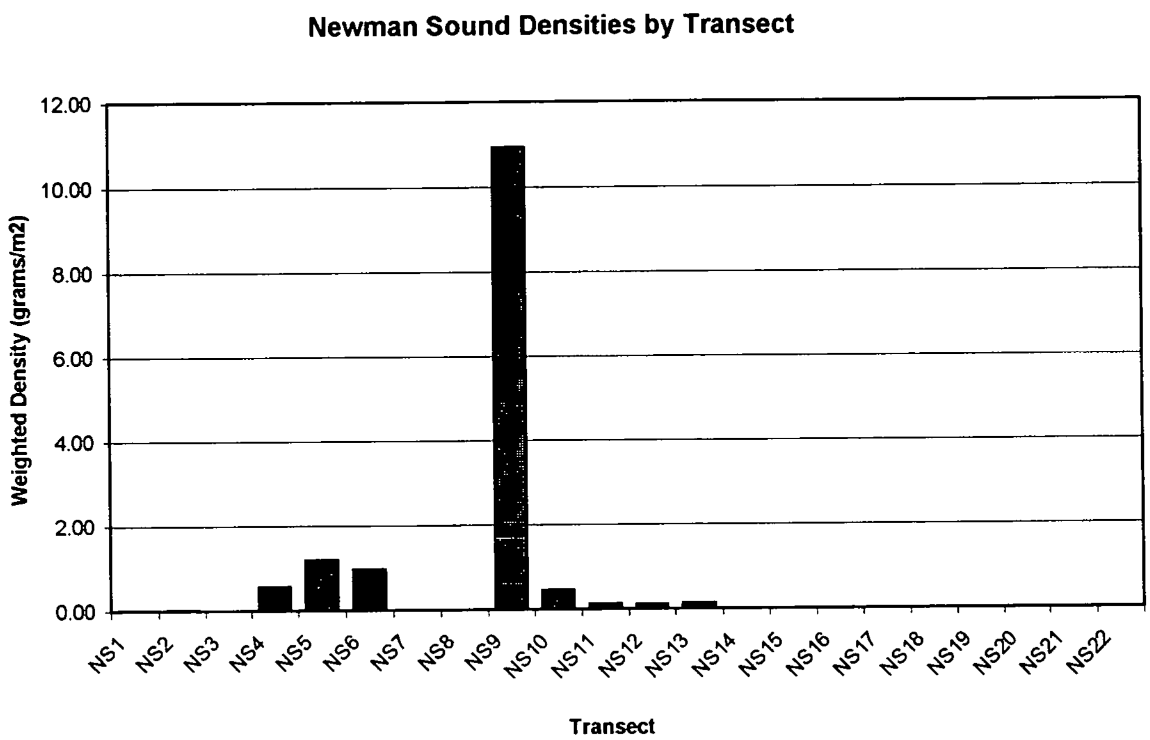
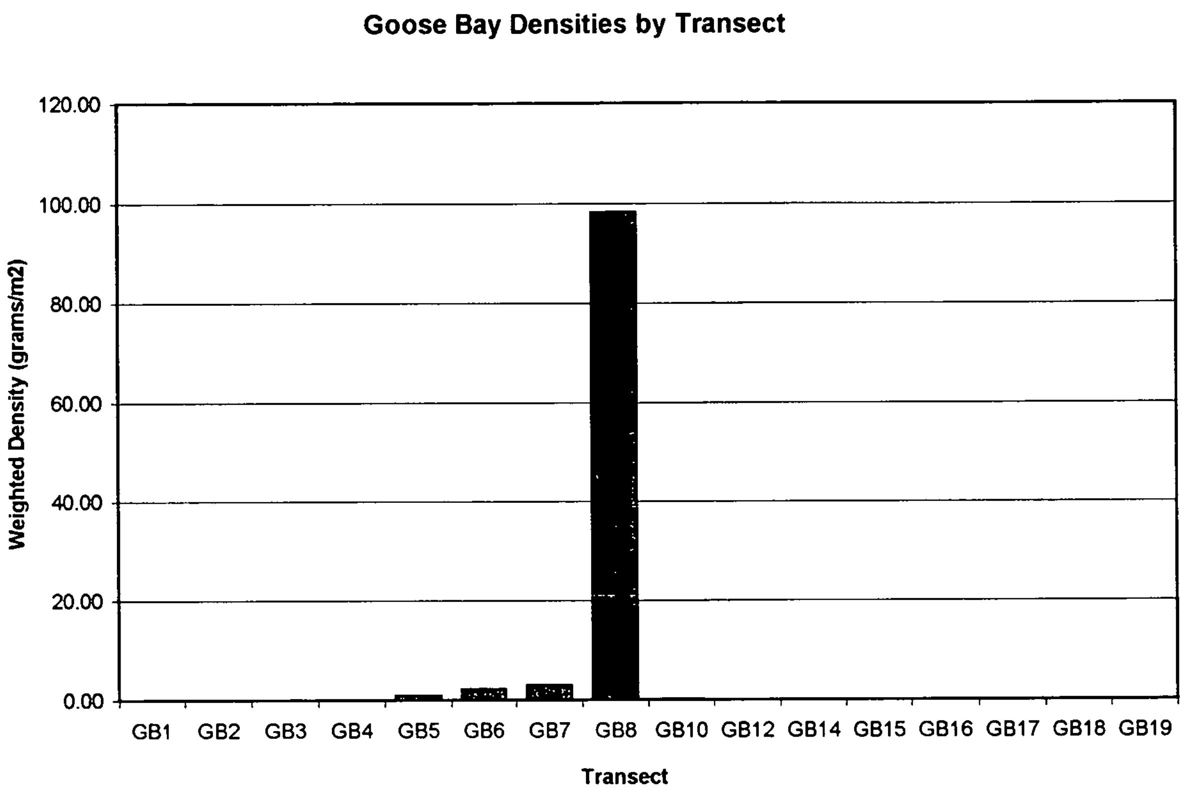

Newman Sound Densities by Transect
Weighted Density (grams/m2)
12.00
10.00
8.00
6.00
4.00
2.00
0.00
NS1
NS2
NS3
NS4
NS5
NS6
NS7
NS8
NS9
NS10
NS11
NS12
NS13
NS14
NS15
NS16
NS17
NS18
NS19
NS20
NS21
NS22
Transect

Fig. 9



Goose Bay Densities by Transect
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Weighted Density (grams/m2)
GB1
GB2
GB3
GB4
GB5
GB6
GB7
GB8
GB10
GB12
GB14
GB15
GB16
GB17
GB18
GB19
Transect

Fig. 10

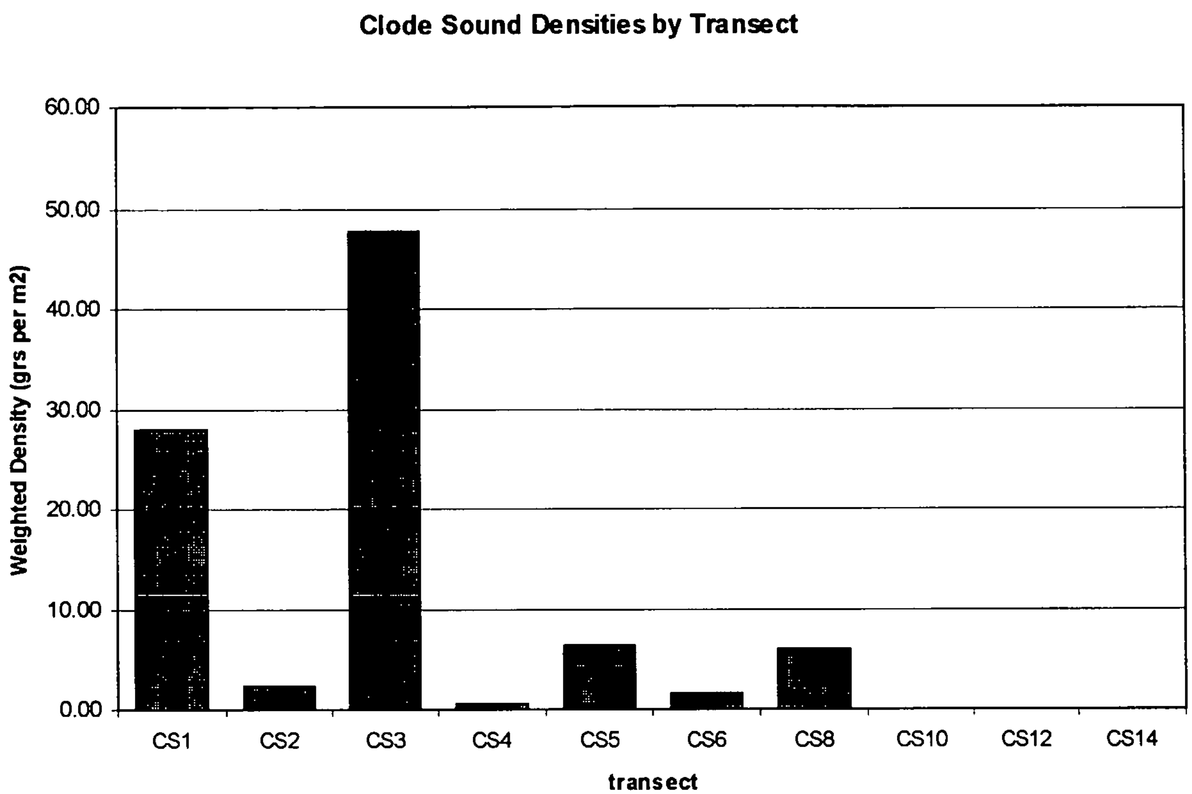
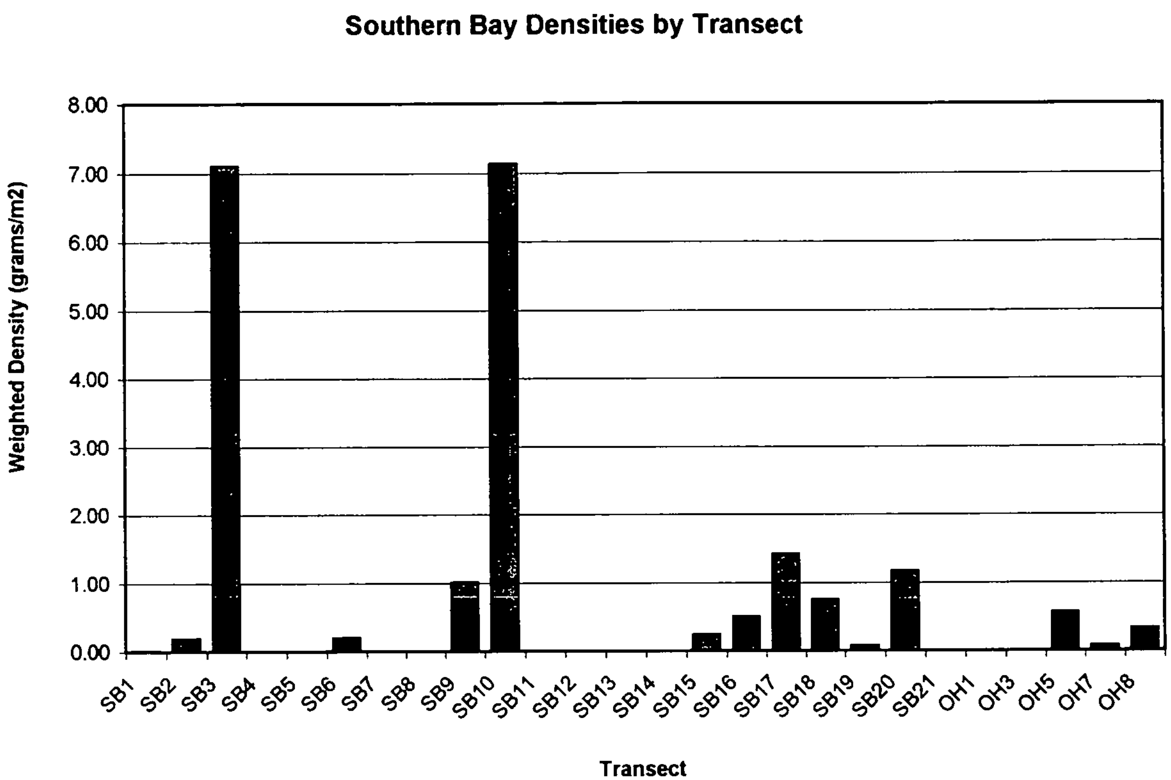

Clode Sound Densities by Transect
60.00
50.00
40.00
30.00
20.00
10.00
0.00
Weighted Density (grs per m2)
CS1
CS2
CS3
CS4
CS5
CS6
CS8
CS10
CS12
CS14
transect

Fig. 11

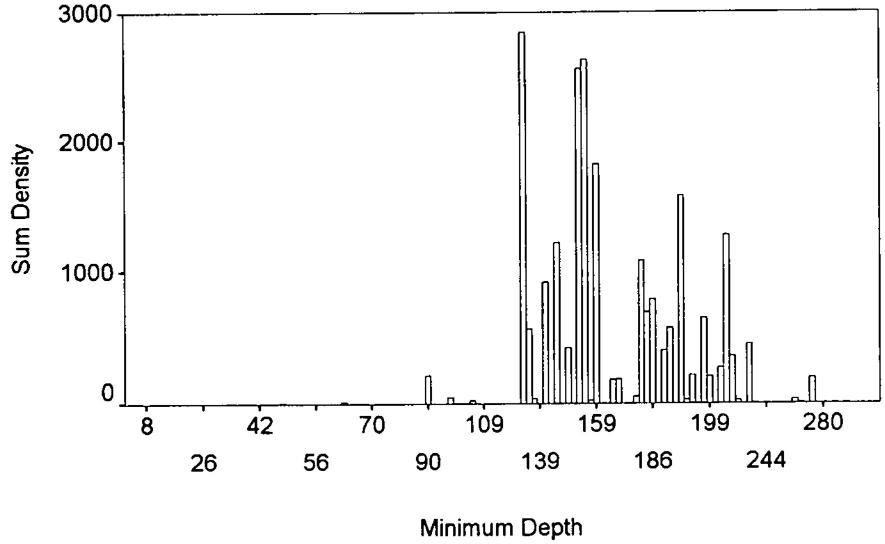


Southern Bay Densities by Transect
Weighted Density (grams/m2)
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
SB1
SB2
SB3
SB4
SB5
SB6
SB7
SB8
SB9
SB10
SB11
SB12
SB13
SB14
SB15
SB16
SB17
SB18
SB19
SB20
SB21
OH1
OH3
OH5
OH7
OH8
Transect

Smith Sound (strata 38)

Sum Density by Minimum Depth

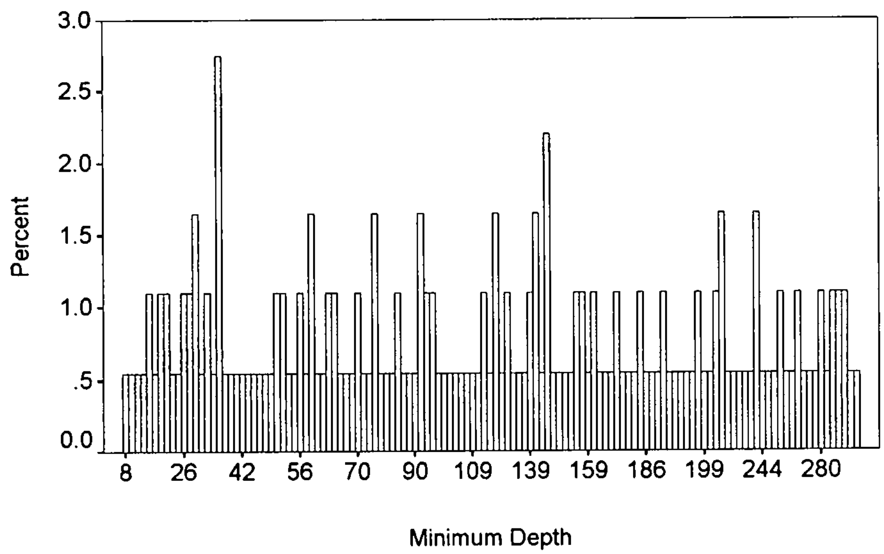
Fig. 12A



Smith Sound (strata 38)

Percent by Minimum Depth

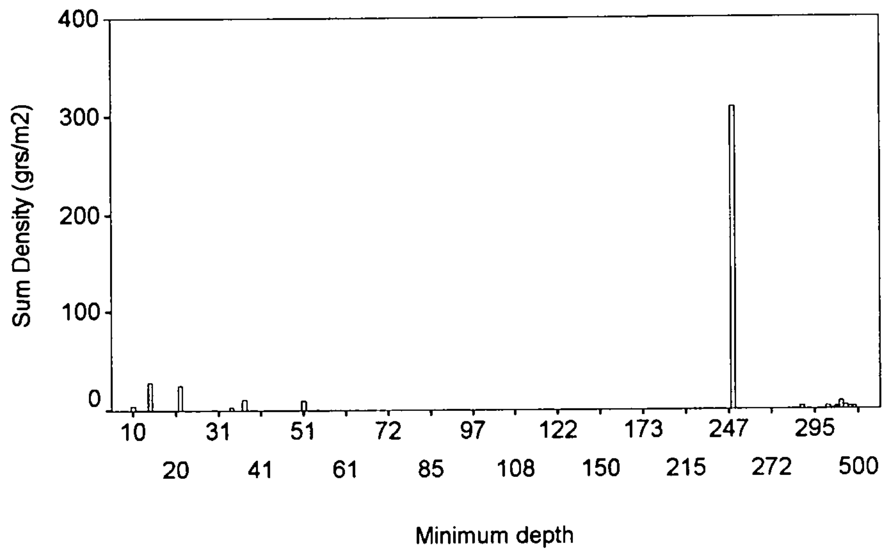
Fig. 12B



Newman Sound (strata 31)

Sum Density by Minimum Depth

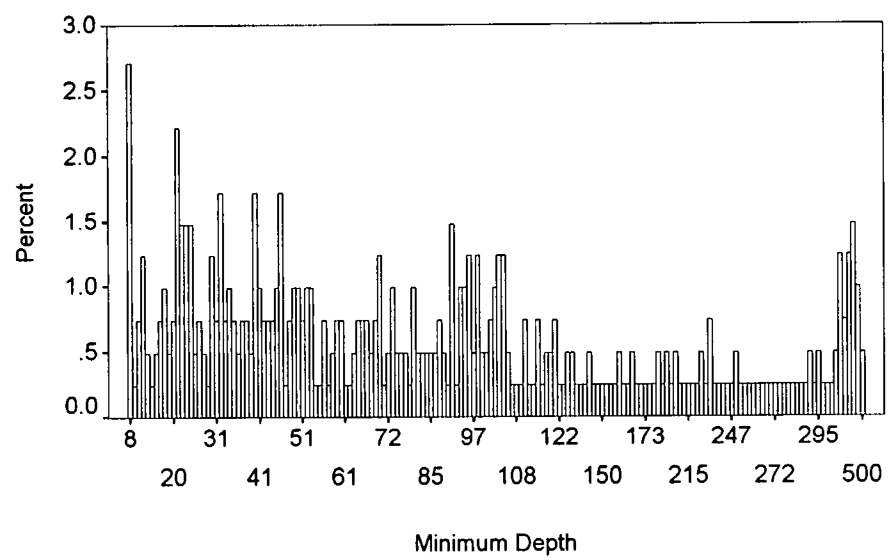
Fig. 13A



Newman Sound (strata 31)

Percent by Minimum Depth

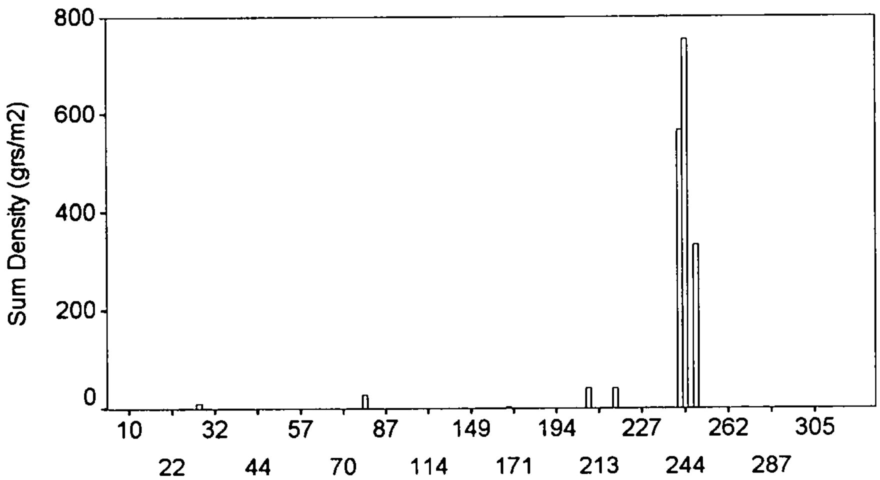
Fig. 13B



Goose Bay (strata 32)

Sum Density by Minimum Depth

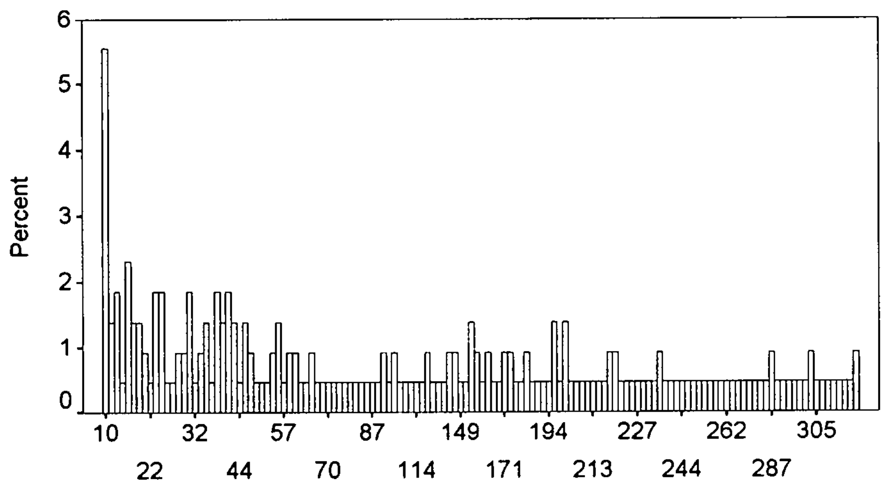
Fig. 14A



Goose Bay (strata 32)

Percent by Minimum Depth

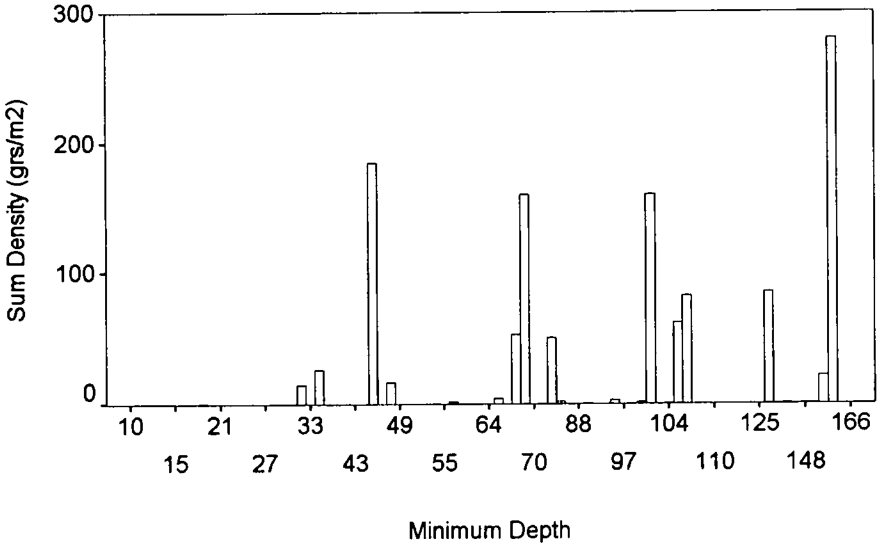
Fig. 14B



Clode Sound (strata 33)

Sum Density by Minimum Depth

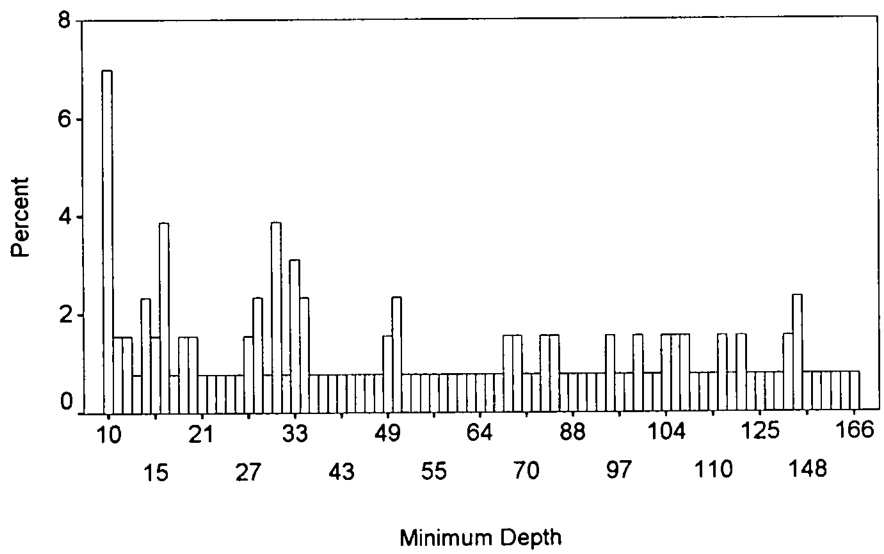
Fig. 15A



Clode Sound (strata 33)

Percent By Minimum Depth

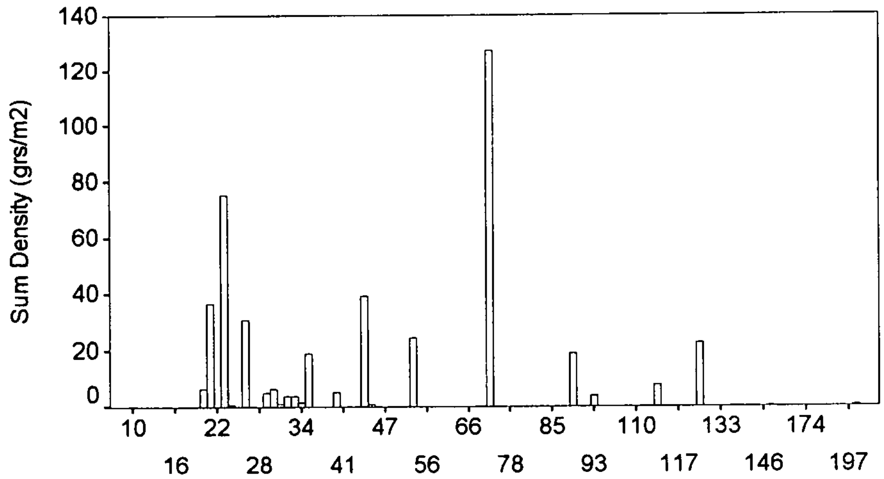
Fig. 15B



Southern Bay/ Sweet Bay (strata 34)

Sum Density by minimum Depth

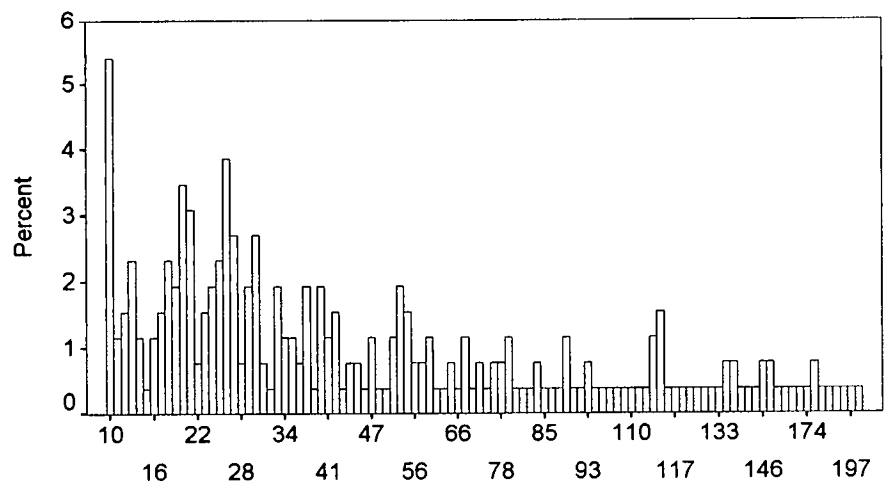
Fig. 16A



Southern Bay/Sweet Bay (strata 34)

Percent By Minimum Depth

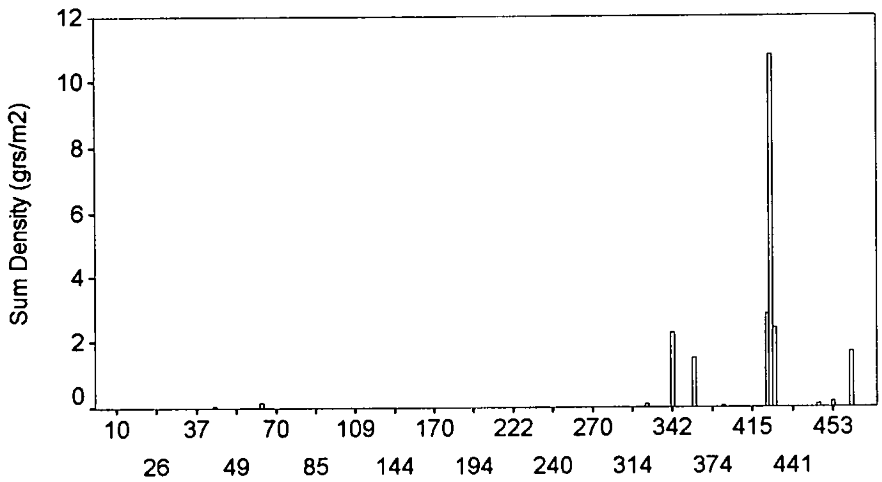
Fig. 16B



Western Head (strata 34)

Sum Density by Minimum Depth

Fig. 17A.



Western Head (strata 34)

Percent by Minimum Depth

Fig. 17B

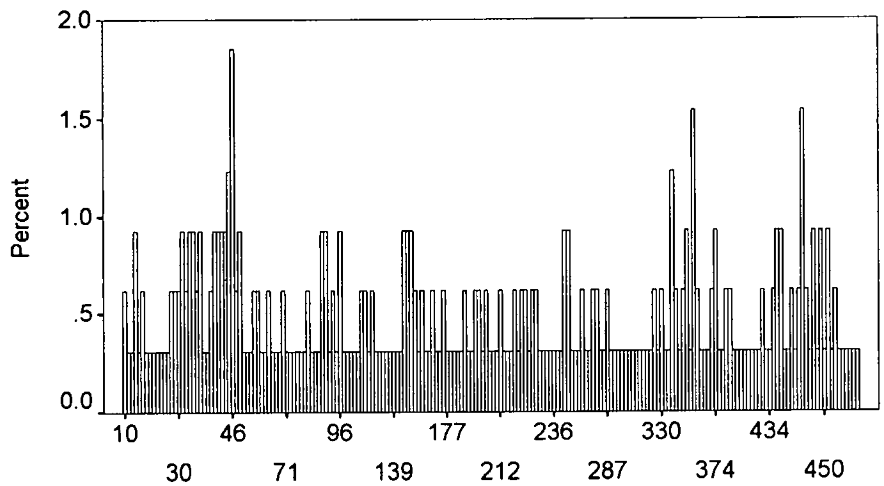
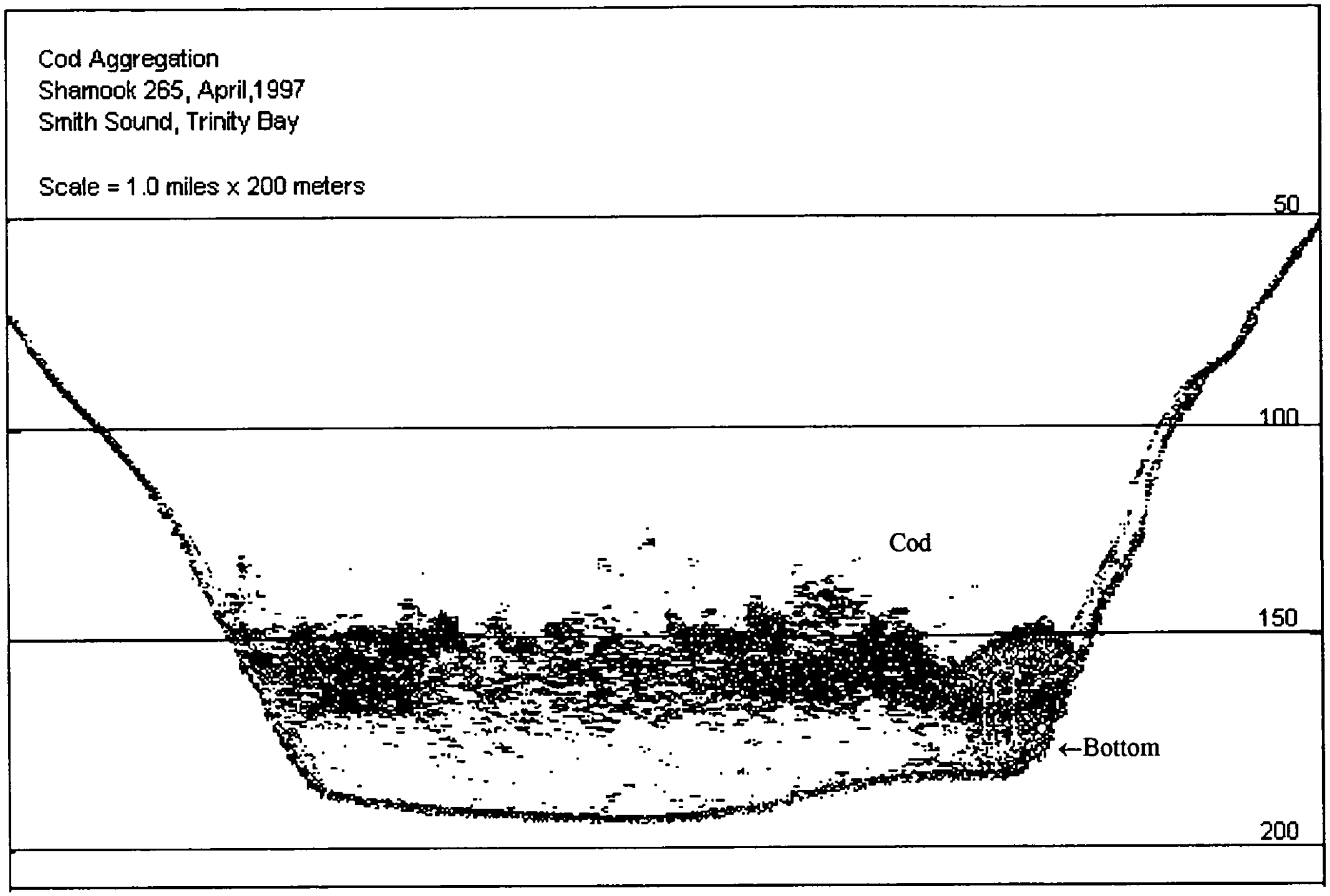
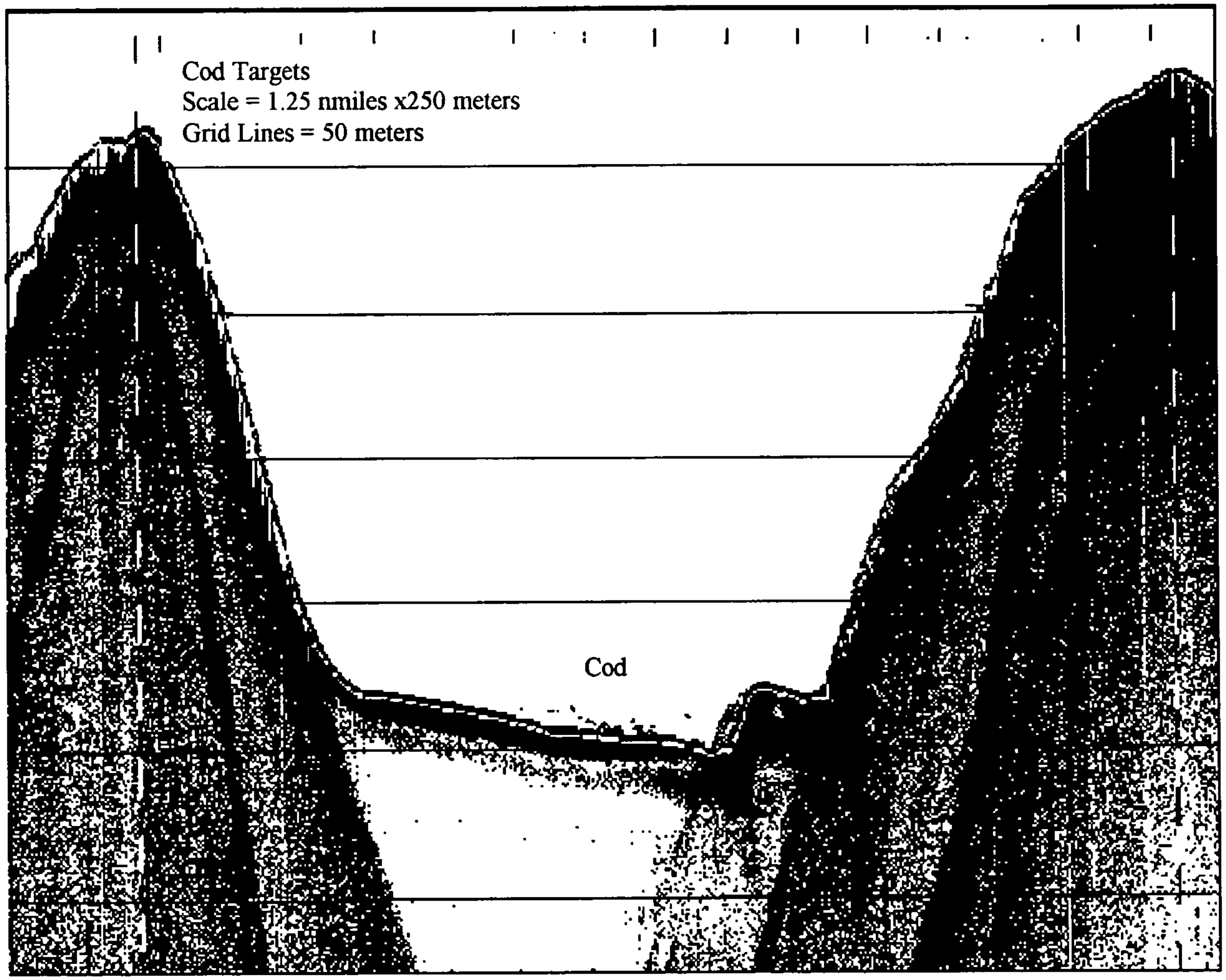


Fig. 18



Smith Sound Transect 6
Shamook 265,Trinity Bay

Fig. 19



Goose Bay Transect 8,
Shamook 266, Bonavista Bay

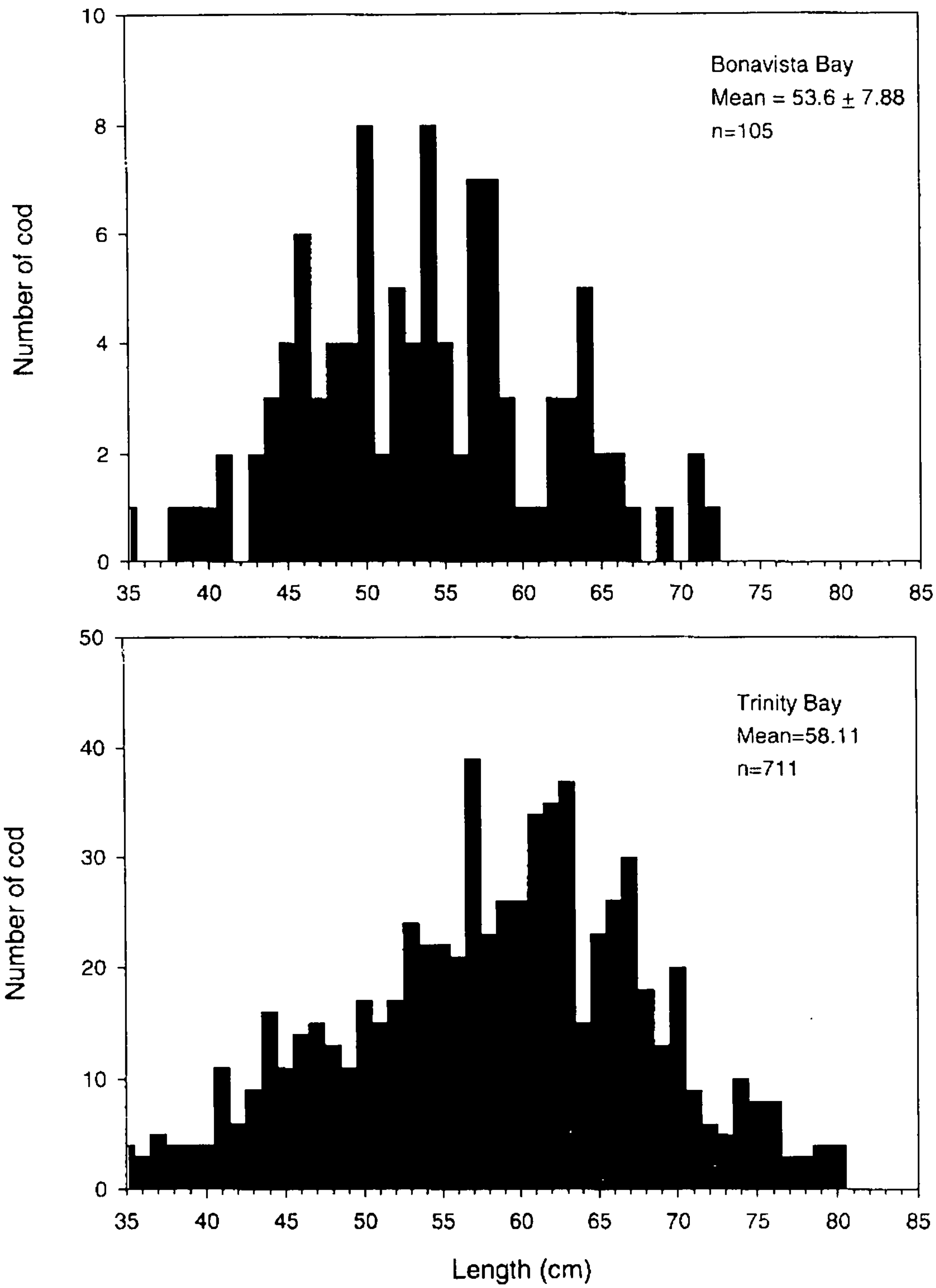


Fig. 20. Length frequencies of cod sampled during inshore acoustic surveys in Trinity Bay and Bonavista Bay during spring 1997.

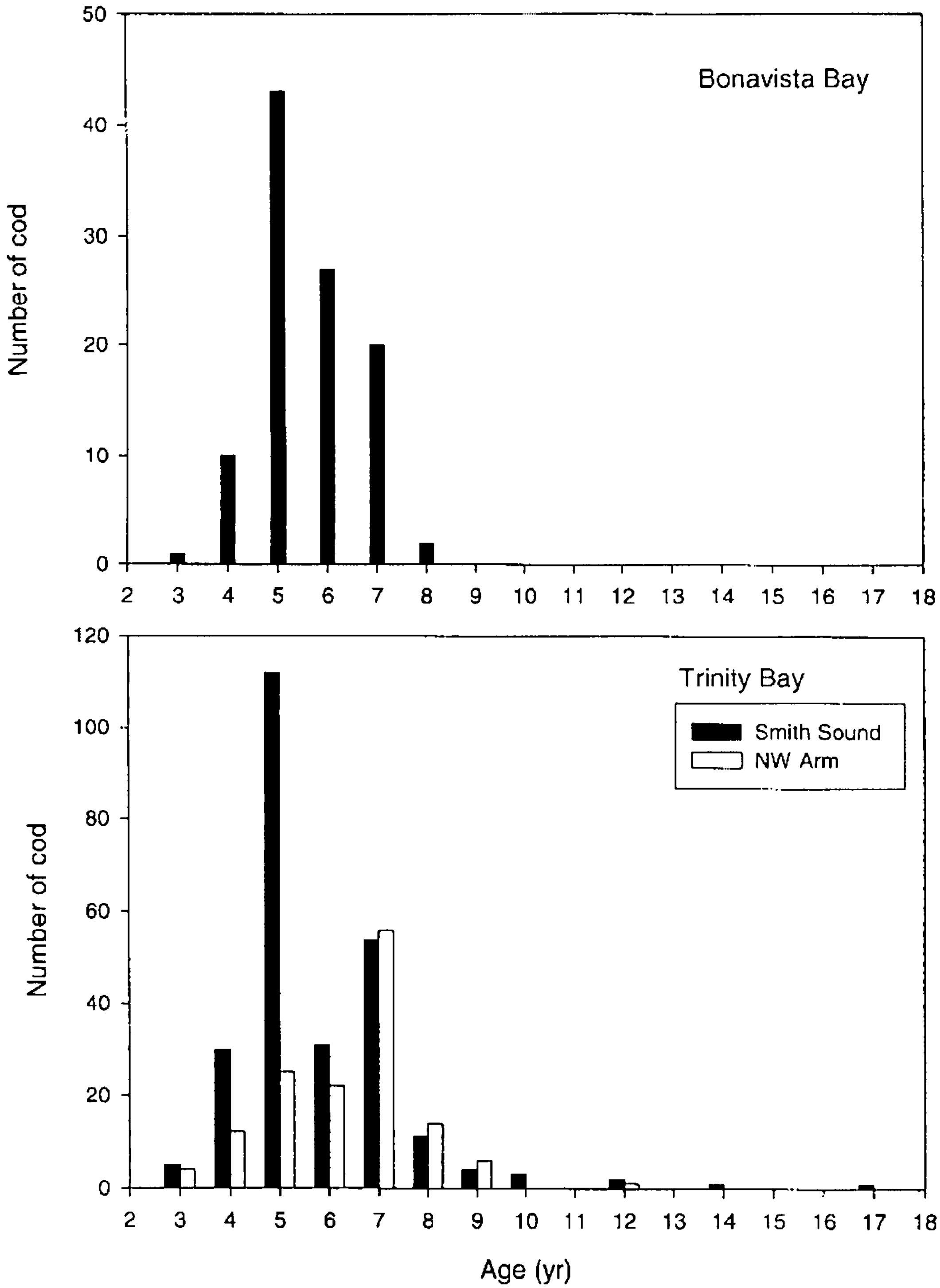
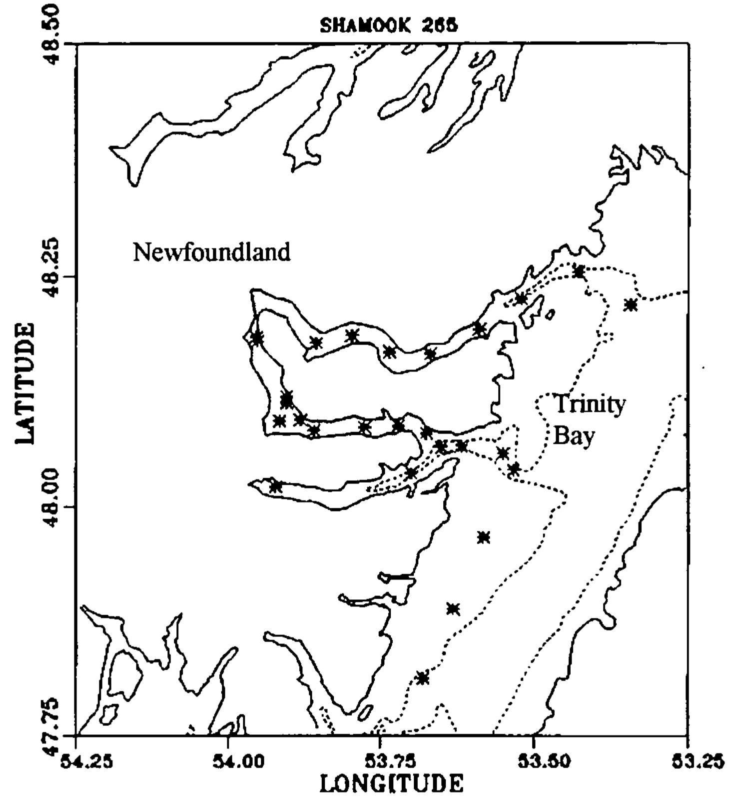
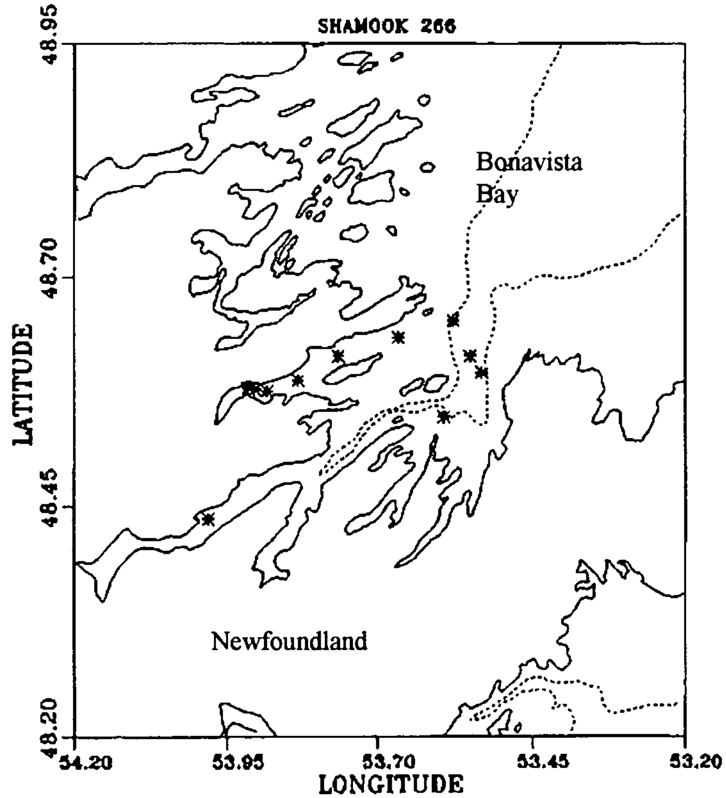


Fig 21. Age Composition of cod sampled in Trinity Bay and Bonavista Bay during acoustic surveys in April-June, 1997.

Fig. 22.



CTD cast positions. Shamook 265, Trinity Bay



CTD cast positions. Shamook 266. Bonavista Bay

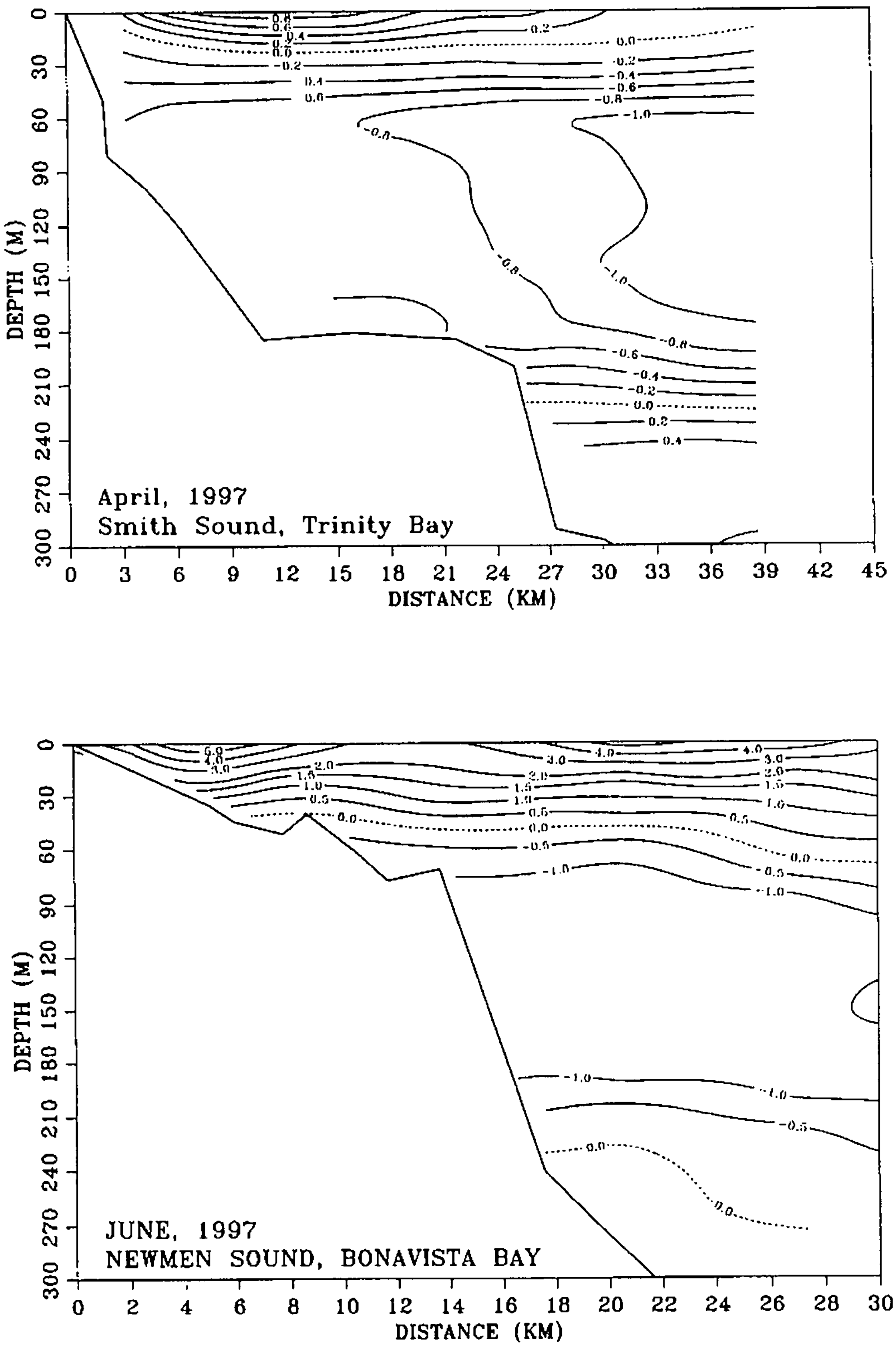


Fig. 23. Temperature profiles for Smith Sound, Trinity Bay and Newman Sound, Bonavista Bay