JOINT POLISH/AMERICAN HYDROACOUSTIC SURVEY OF ELEPHANT ISLAND AND THE VICINITY OF KING GEORGE ISLAND, 1988

M.C. Macaulay

Abstract

The hydroacoustic survey found a low krill abundance in most areas covered by last years survey. The total biomass in the vicinity of Elephant Island was estimated from 120 kHz data to be 260k tonnes and that in the Bransfield Strait south of King George Island was 39k tonnes for a total of 299k tonnes in the combined areas. The estimated 200 kHz survey data were higher, giving 715k tonnes near Elephant Island and 83k tonnes in the Bransfield Strait. The survey results apply to 7 453 n miles^2 near Elephant Island and 2 894 n miles^2 in the Bransfield Strait. The full survey found (120 kHz data) 385k tonnes (in 7 787 n miles^2) in the Bransfield Strait and the area north of King George Island and 309k tonnes (in 8 836 n m^2) in the expanded area around Elephant Island.

Résumé

Une campagne d'étude hydroacoustique a permis de détecter un niveau d'abondance de krill peu élevé dans la plupart des régions ayant fait l'objet d'une prospection l'année passée. D'après les données établies sur 120 kHz, la biomasse totale aux alentours de l'île de l'Eléphant a été estimée à 260 kilotonnes. Dans le détroit de Bransfield, au sud de l'île du Roi George, elle a été estimée à 39 kilotonnes, soit un total de 299 kilotonnes pour les deux régions. Les données d'étude estimées sur 200 kHz étaient plus élevées, indiquant une biomasse de 715 kilotonnes près de l'île de l'Eléphant et 83 kilotonnes dans le détroit de Bransfield. Les résultats de l'étude s'appliquent à 7453 milles marins carrés près de l'île de l'Eléphant et 2894 mille marins carrés dans le détroit de Bransfield. L'ensemble de l'étude (données obtenues sur 120 kHz) indiquait la présence de 385 kilotonnes (sur 7787 milles marins carrés) dans le détroit de Bransfield et la région au nord de l'île du Roi George, et de 309 kilotonnes (sur 8836 milles marins carrés) dans la région qui s'étend autour de l'île de l'Eléphant.

Резюме

Результаты гидроакустических съемок показали наличие небольшого количества криля в большинстве районов, охваченных съемкой предыдущего года. По данным, полученным при работе на частоте в 120 кГц, общая биомасса в районе острова Элефант была оценена в 260 тысяч тонн, а в проливе Брансфилда, к югу от острова Кинг-Джордж, - в 39 тысяч тонн, что по обоим районам вместе дает 299 тысяч тонн. При работе на частоте 200 кГц оценки были выше: 715 тысяч тонн около острова Элефант и

83 тысячи тонн в проливе Брансфилда. Результаты съемки применимы к акватории в 7453 кв. морских мили у острова Элефант и 2894 кв. морских мили - в проливе Брансфилда. Общие результаты съемок (по данным при работе на частоте в 120 кГц): 385 тысяч тонн (акватория в 7787 кв. морских миль) в проливе Брансфильда и районе к северу от острова Кинг-Джордж и 309 тысяч тонн (акватория в 8836 кв. морских миль) в большем районе вокруг острова Элефант.

Resumen

La prospección hidroacústica encontró una baja abundancia de krill en la mayoría de las áreas cubiertas por la prospección del año pasado. La biomasa total en las proximidades de la isla Elefante estimada a partir de los datos correspondientes a los 120 kHz, resultó ser de 260k toneladas mientras que en el estrecho de Bransfield al sur de la isla Rey Jorge fue de 39k toneladas dando un total de 299k toneladas en las áreas combinadas. Los datos estimados de la prospección en 200 kHz fueron mayores, dando unas 715k toneladas cerca de la isla Elefante y unos 83k toneladas en el estrecho de Bransfield. Los resultados de la prospección corresponden a 7 453 nm^2 cerca de la isla Elefante y a 2 894 nm^2 en el estrecho de Bransfield. La prospección completa (datos correspondientes a 120 kHz) encontró 385k toneladas (en 7 787 nm^2) en el estrecho de Bransfield y en el área al norte de la isla Rey Jorge, y 309k toneladas (en 8 836 nm^2) en el área extendida en los alrededores de la isla Elefante.

1.   INTRODUCTION

The joint Polish/American hydroacoustic cruise was conducted as a response to provide input for the CCAMLR Ecosystem Monitoring Program and for providing guidance to the US delegation to the CCAMLR concerning krill and other prey species. This research involves an annual Antarctic field program, analysis and interpretation of data, and preparation of scientific papers. This was the second of a series of similar cruises.

The principal objectives of the cruise focus on priorities identified by the CCAMLR Ecosystem Monitoring Working Group. These include:

(1)   Establishment of a standard survey encompassing Elephant Island and King George Island.

(2)   Establishment of baseline studies coordinated with predator (e.g. seal and penguin) populations within the survey area.

(3)   Establish a longterm monitoring effort for a statistically-based evaluation of net and acoustic sampling gear bias.

The last topic has not been done in a consistent or systematic manner and needs to be addressed to validate the results of any survey effort and to assist with determination of statistical confidence limits about hyrdroacoustic and net estimates of abundance. The survey and baseline studies will permit evaluation of interannual variation in population of krill and other prey as well as monitor distribution. These topics directly respond to identified CCAMLR data needs and will be closely coordinated with us and other nations' research efforts.

2.   MATERIALS AND METHODS

The hydroacoustic survey was conducted from 22 January 1988 to 5 February 1988 and covered 1 693 n miles. The area surveyed is shown on the cruise track map (Figure 1). The cruise departed Punta Arenas, Chile on 18 January 1988 and returned to Rio de Janeiro, Brazil on 27 February 1988. The survey of Elephant Island began on 22 January and ended on 31 January. The survey of King George Island and Bransfield Strait began on 31 January and was completed on 5 February. Additional special studies were done north of Elephant Island from 21 January until 22 January and from 5 February until 14 February when the return to Rio was begun. All sampling was done from the R/V *Professor Siedlecki*, a 300 ft stern trawler equipped for fisheries and oceanographic research. The vessel consistently maintained speeds greater than 6 knots (day and night) in all sea states encountered (including force 8 winds and fog).

This joint survey was conducted using simultaneously operated acoustic systems utilizing a towed system (American) and the hull mounted system (Polish) in the R/V *Professor Siedlecki*. There were no indications of interference between systems due to the operating frequencies having no common multiple (50 kHz and 200 kHz, American; 120 kHz Polish). The coverage by frequency/depth/method of integration is as follows: 120 kHz/6-180 m/analog; 50 kHz/6-250 m/digital; 200 kHz/6-250 m/digital. Echo data were processed by analog integrator (120 kHz) or processed using the software and hardware developed at NWAFC (50 kHz and 200 kHz). The methods, constants and target-strengths used for processing the 120 kHz and 200 kHz data presented in this report are included in Appendix.

The areas surveyed were Bransfield Strait in proximity to King George Island (7 787 n miles² including 2 894 n miles² of areas surveyed in 1987) including the area

north of King George Island and the vicinity of Elephant Island (8 836 n miles^2 including 7 453 n miles^2 in areas surveyed in 1987; Figure 1). The survey was conducted 24 hours a day, incorporating minimal interruption of survey mode. These breaks were limited to bongo-net hauls (reduced speed from 6-8 knots to 3 knots for 45 min) spaced approximately every 30 n miles and RMT-8 hauls taken at several locations for length-frequency of ensonified populations. Noon productivity stations incorporating a hydrocast and STD cast were taken daily. The methods used to calculate abundance and biomass are included as an appendix.

3.   RESULTS

The results of the analog integration (120 kHz data) gave an estimate of 39k tonnes (in 2 894 n miles^2) in the Bransfield Strait and 260k tonnes (in 7 453 n miles^2) in the Elephant Island area for a total of 299k tonnes in the areas surveyed last year. The full survey found (120 kHz data) 385k tonnes (in 7 787 n miles^2) in the Bransfield Strait and the area north of King George Island and 309k tonnes (in 8 836 n miles^2) in the expanded area around Elephant Island. This is probably a minimum figure because the 120 kHz system had a higher threshold of detection than the 200 kHz system. It is, however, much lower than last year and closer to the estimates observed in 1984 in this area, i.e. a low density. The results from the 50 kHz and 200 kHz systems were stratified to compare with the 120 kHz system and to provide additional independent estimates of abundance and biomass. The areas and statistics for sub-blocks are shown in Table 1 (the geographic boundaries for these areas and sub-blocks are shown in Figure 1). The mean density in each block is shown under the column labelled "Actual Mean, 120 kHz" and is in tonnes per n miles^2. The biomass for each block estimated from 120 kHz data is given under the column labelled "Est. Total, 120 kHz" and is in thousand tonnes. Similar columns are presented for 200 kHz data estimated from the 120 kHz data based on ratios established last year. The 200 kHz data will be presented in the final cruise report as well as the 50 kHz data. Table II presents a complete listing of survey data including the areas not surveyed last year. Table III presents the electrical and acoustic parameters of the systems used.

4.   DISCUSSION

The survey in areas covered last year were very comparable (2 894 n miles^2 in 1988 vs 3 000 n miles^2 in 1987 for the Bransfield Strait; 7 453 n miles^2 in 1988 vs 7 346 n miles^2 in 1987 for Elephant Island) (Figure 2). The additional areas covered were to the west of Elephant Island (1 383 n miles^2) and east of Elephant Island (336 n miles^2), and the area north of King George Island (3 239 n miles^2) so that the total survey represents 16 623 n miles^2 in 1988 vs 10 346 n miles^2 in 1987. The mean abundance (tonnes/n miles^2) by block for 120 kHz data and estimated 200 kHz data (Figure 3) is about half that of 1987 as is the total biomass (Figure 4). The distribution of abundance and biomass was much more even between blocks in 1988 instead of highly variable as it was in 1987. The mean abundance and total biomass for 1987 is shown in Figure 5 and the comparison of total biomass in the survey area in 1987 and 1988 (120 kHz data) is shown in Figure 6. A joint scientific paper will report the results of the full comparison of these data.

REFERENCES CITED

JOHANNESSON, K.A. and R.B. MITSON. 1983. Fisheries Acoustics. A practical manual for aquatic biomass estimation. FAO Fisheries Tech. Paper 240. FIRM/t240. 249 PP. FAO Rome.

KRISTENSEN, A. and J. DALEN. 1986. Acoustic estimation of size distribution and abundance of zooplankton. J. Acoust. Soc. Am 80: 601-611.

MACAULAY, M.C., T.S. ENGLISH and O.A. MATHISEN. 1984. Acoustic Characterization of Antarctic krill (*Euphausia superba*) swarms from Elephant Island and Bransfield Strait. J. of Crustacean Biology. Vol 4 (Special No. 1) 16-44 pp.

MACAULAY, M.C., K.L. DALY and O.A. MATHISEN (in prep.) Inter-year variation in the abundance and distribution of Antarctic krill (*Euphausia superba*) near Elephant Island and the South Orkney Islands.

Post-FIBEX Acoustic Workshop. Frankfurt/Mein, FRG 3-14 September 1984. BIOMASS Report Series No. 40: 106 pp.

CALCULATION OF TARGET STRENGTH AND SYSTEM CONSTANTS

The R/V *Professor Siedlecki* hull mounted system consisted of Simrad[*] EK-120 sounder coupled to a Simrad QM MK II analog echo integrator. A Simrad EK-38 sounder was used for auxiliary observation of targets outside the range of the EK-120 (i.e. below 130 m). Before the cruise, the equipment was calibrated in acoustic and electrical units. These values are presented in Table 2. Echo integration was done for the depths of 6 to 180 m. Because the range of the EK-120 TVG is limited to 110 m, during calculations the results from 110 to 180 m were corrected. The basis for the estimation of krill biomass was the calculation of the mean value of volume back-scattering-strength S_v for each 1 n mile of vessel track following the method described in BIOMASS Report Series No. 40. Mean volume back-scattering is here defined as:

$$\overline{S}_v = -75.81 + 10 \log \overline{I} \qquad\qquad 1.0$$

where $\overline{S}_v$ is mean volume back-scattering-strength; $\overline{I}$ is echo integrator deflection for 1 n mile segment (in n miles). The mean abundance of krill per unit of surface area was calculated using:

$$\overline{\sigma} = 10^{\,0.1(S_v + 10 \log R - TS)} \qquad\qquad 1.1$$

where $\overline{\sigma}$ is mean abundance of krill (number/m^2); R is width of integration layer (110 m value was assumed) and TS is mean target strength of ensonified krill. The target strength to length relation used was:

$$\overline{TS} = 19.9 \log \overline{L} - 95.7 \text{ (db)} \qquad\qquad 1.2$$

where $\overline{L}$ is the length of krill in mm. Mean surface density or abundance (tonnes/nm^2) was calculated from the following formula:

$$\overline{B} = 3.43 * \overline{\sigma} * \overline{w} \qquad\qquad 1.3$$

where $\overline{B}$ is mean surface abundance of biomass; $\overline{w}$ is the mean weight of krill (in g) and is mean density of krill from 1.1 above mean weight of krill was calculated from the relation:

$$\overline{w} = 0.000925 * \overline{L}^{3.55} \qquad\qquad 1.4$$

where $\overline{w}$ is weight of krill (mg) and $\overline{L}$ is length of krill (mm).

The towed acoustic systems used from R/V *Professor Siedlecki* consisted of a BIOSONICS Inc. Model 101 sounder operating at 200 kHz and coupled to a Hewlett Packard A900 computer for real-time digital integration of the data. A BIOSONICS Inc. Model 101 sounder operating at 50 kHz was also used. The 50 kHz envelope detected signal was recorded in FM mode on an instrument recorder for post cruise analysis. Before the cruise, the

---

[*] Reference to trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service (NMFS), NOAA.

equipment was calibrated in acoustic and electrical units. These values are presented in Table 2. Analysis of the 200 kHz acoustic data follows the methods of Johanneson and Mitson, 1983 and Macaulay et al, 1984. Measurements of envelope detected voltage for each ping were made every 0.1 m (a digitizing rate of 7.5 kHz), then squared and summed into 1 m depth intervals and averaged for 60 pings (1 min). The estimate of average density in each depth interval and for the total column selected (6-250 m) was then calculated. One-min estimates then were recorded on magnetic disk files for further analyses. Estimates of average density were determined for intervals down to 250 m or bottom whichever occurred first. Provision for elimination of the bottom signal is made in the system by means of a combination software and hardware bottom detection methods. For comparison with 120 kHz data, the data were stratified for the depth bin 6-180 m. The target strength (1.2 above) and length-weight (1.4 above) relations were used for calculations of density and biomass. This was done on the basis of Kristensen and Dalen (1986) which indicates no correction for frequency is necessary between 120 kHz and 200 kHz, unlike that proposed in BIOMASS Report No. 40.

Table 1: Comparative mean abundance and total biomass for blocks also surveyed in 1987.

BLOCK	DIST. n miles	AREA	ACTUAL MEAN 120 kHz	EST. MEAN* 200 kHz	ACTUAL TOTAL 120 kHz tonnes/1000	EST. TOTAL* 200 kHz tonnes/1000
BRANSFIELD STRAIT (BS)						
A5	37.00	567.00	11.02	47.84	6.25	27.13
B5	44.00	811.00	7.06	11.72	5.73	9.50
A6	34.00	826.00	21.27	35.06	17.57	28.96
B6	27.00	690.00	13.12	25.37	9.05	17.51
SUBTOT (BS)	142.00	2894.00	52.47	119.99	38.60	83.10
Avg. (BS)	35.50	723.50	13.12	30.00	9.65	20.77
ELEPHANT ISLAND (EI)						
C1	9.00	223.00	18.70	52.08	4.17	11.61
D1	61.00	446.00	66.98	167.70	29.87	74.79
E1	42.00	446.00	35.89	176.38	16.01	78.67
C2	63.00	734.00	48.64	135.47	35.70	99.43
D2	274.00	881.00	42.25	124.10	37.22	109.33
E2	149.00	882.00	29.50	108.49	26.02	95.69
C3	132.00	1013.00	39.26	89.06	39.77	90.22
D3	109.00	742.00	21.74	34.77	16.13	25.80
E3	99.00	803.00	33.03	83.26	26.52	66.86
C4	62.00	142.00	65.07	80.68	9.24	11.46
D4	25.00	570.00	26.47	66.96	15.09	38.17
E4	56.00	571.00	7.47	22.41	4.27	12.80
SUBTOT (EI)	1081.00	7453.00	435.00	1141.36	260.01	714.82
Avg. (EI)	90.08	621.08	36.25	95.11	21.67	59.57
G. TOTAL	1223.00	10347.00			298.61	797.92

* 200 kHz data estimated from 120 kHz data using 1987 ratios.

Table 2:   Mean abundance and total biomass in blocks surveyed in 1988.

BLOCK	DIST. n miles	AREA	ACTUAL MEAN 120 kHz	EST. MEAN* 200 kHz	ACTUAL TOTAL 120 kHz tonnes/1000	EST. TOTAL* 200 kHz tonnes/1000
BRANSFIELD STRAIT (BS)						
AA34	122.00	997.00	86.71	207.75	86.45	207.13
A3	19.00	432.00	91.39	218.96	39.48	94.59
B3	20.00	289.00	57.96	138.85	16.75	40.13
A4	73.00	803.00	139.63	334.53	112.12	268.63
B4	35.00	576.00	38.78	92.90	22.33	53.51
C4	11.00	142.00	65.07	155.88	9.24	22.13
AA5	35.00	579.00	33.05	79.19	19.14	45.85
A5	37.00	567.00	11.02	47.84	6.25	27.13
B5	44.00	811.00	7.06	11.72	5.73	9.50
C5	30.00	420.00	26.13	62.60	10.97	26.29
AA6	18.00	413.00	48.76	116.82	20.14	48.25
A6	34.00	826.00	21.27	35.06	17.57	28.96
B6	27.00	690.00	13.12	25.37	9.05	17.51
C6	20.00	242.00	41.64	99.75	10.08	24.14
SUBTOT (BS)	525.00	7787.00	681.58	1627.22	385.30	913.74
Avg. (BS)	37.50	556.21	48.68	116.23	27.52	65.27
ELEPHANT ISLAND (EI)						
C1	9.00	223.00	18.70	52.08	4.17	11.61
D1	61.00	446.00	66.98	167.70	29.87	74.79
E1	42.00	446.00	35.89	176.38	16.01	78.67
F1	10.00	223.00	46.77	140.32	10.43	31.29
BC2	63.00	734.00	48.64	135.47	35.70	99.43
D2	274.00	881.00	42.25	124.10	37.22	109.33
E2	149.00	882.00	29.50	108.49	26.02	95.69
F2	30.00	441.00	45.77	137.31	20.19	60.55
BC3	132.00	1013.00	39.26	89.06	39.77	90.22
D3	109.00	742.00	21.74	34.77	16.13	25.80
E3	99.00	803.00	33.03	83.26	26.52	66.86
F3	29.00	434.00	27.01	81.04	11.72	35.17
BC4	62.00	142.00	65.07	80.68	9.24	11.46
D4	25.00	570.00	26.47	66.96	15.09	38.17
E4	56.00	571.00	7.47	22.41	4.27	12.80
F4	18.00	285.00	24.58	73.73	7.00	21.01
SUBTOT (EI)	1168.00	8836.00	579.14	1573.76	309.35	862.85
Avg. (EI)	73.00	552.25	36.20	98.36	19.33	63.93
G. TOTAL	1693.00	16623.00			694.65	1776.59

*   200 kHz data estimated from 120 kHz data using 1987 ratios

Table 3: Electro-acoustic characteristics of sounder systems

Manufacturer	BIOSONICS Model 101	BIOSONICS Model 101	SIMRAD EK120
Frequency	50 kHz	200 kHz	120 kHz
Source Level dB//1 uPa ref 1 m	205.4	224.4	219.0
Receiving Sensitivity dB//lV per uPa	-115.7	-132.9	-109.0
Beam pattern (directivity)	12.9	29.5	
Pulse Length (msec)	0.6	0.6	0.6
Time Varied Gain (TVG)	digital	digital	analog
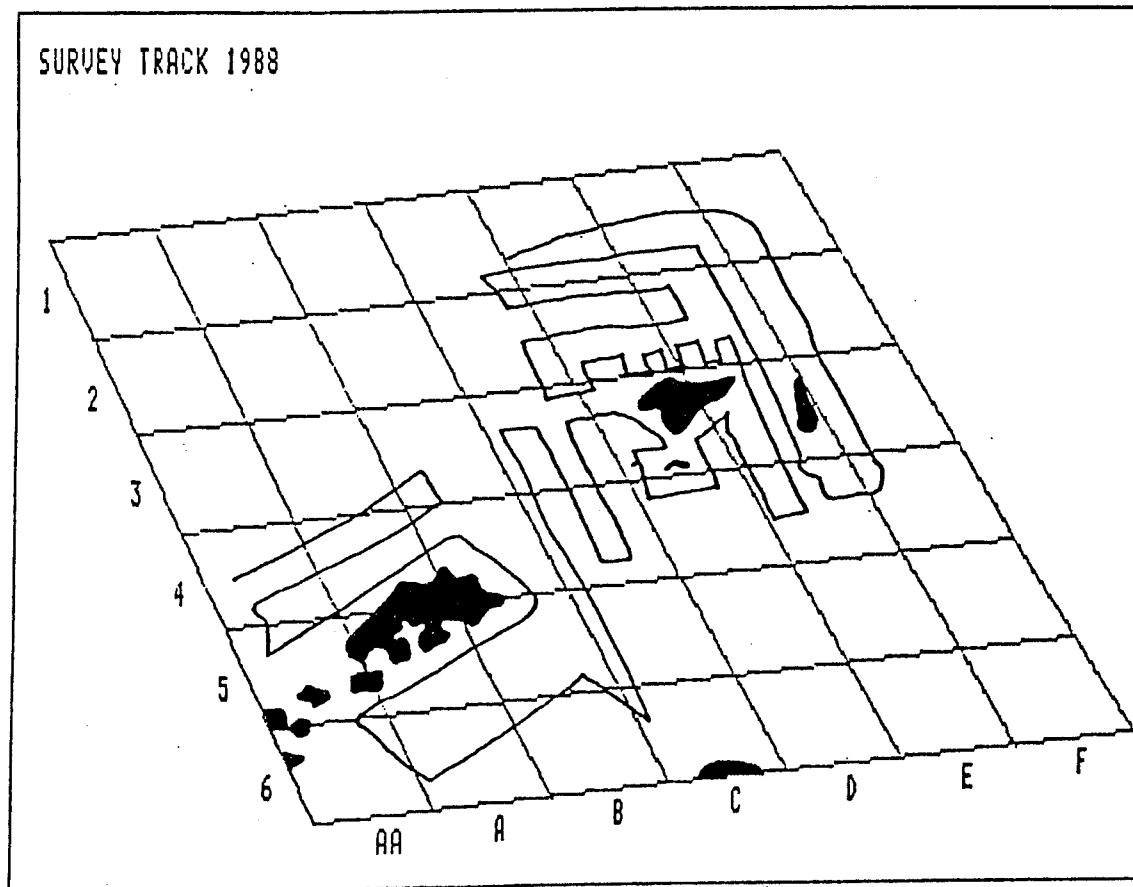
SURVEY TRACK 1988

Figure 1: Survey track and block locations in the area of Bransfield Strait and Elephant Island.

SURVEY TRACK 1987

SURVEY TRACK 1988
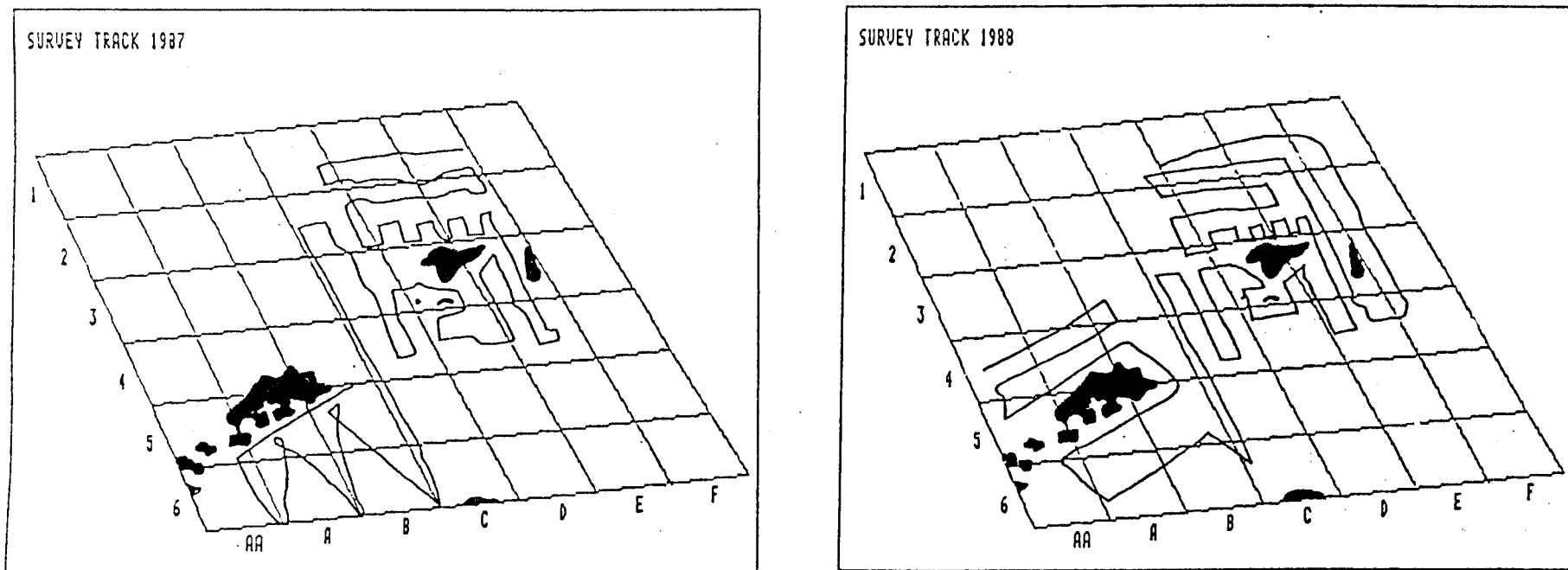
Figure 2: Comparison of cruise tracks in areas surveyed in 1987 and 1988
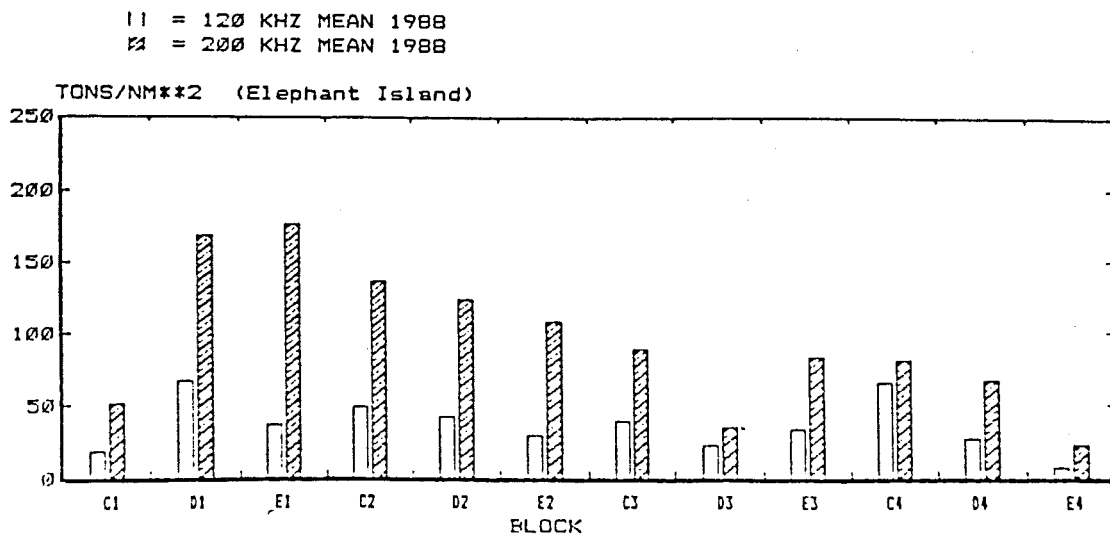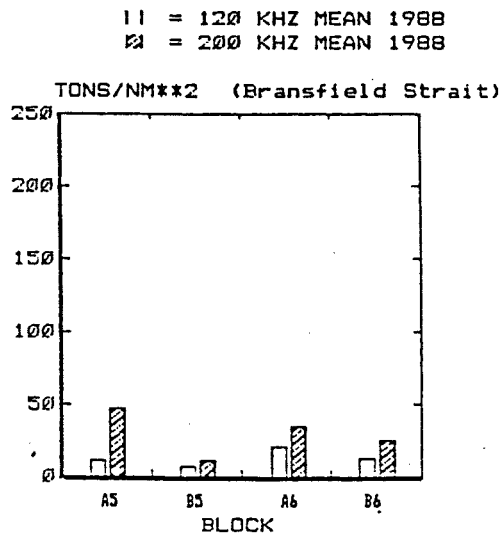
Figure 3: Mean biomass (abundance in tonnes/ n miles²) for Bransfield Strait and Elephant Island by frequency and block.

TONS/1000. (Bransfield Strait)

BLOCK

I I = 120 KHZ BIOMASS 1988
⊠ = 200 KHZ BIOMASS. 1988

TONS/1000 (Elephant Island)
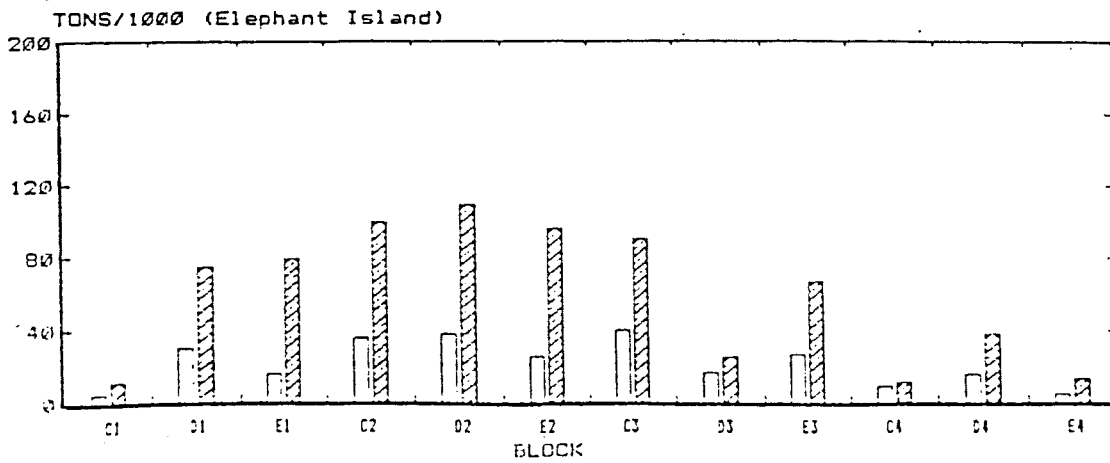
BLOCK

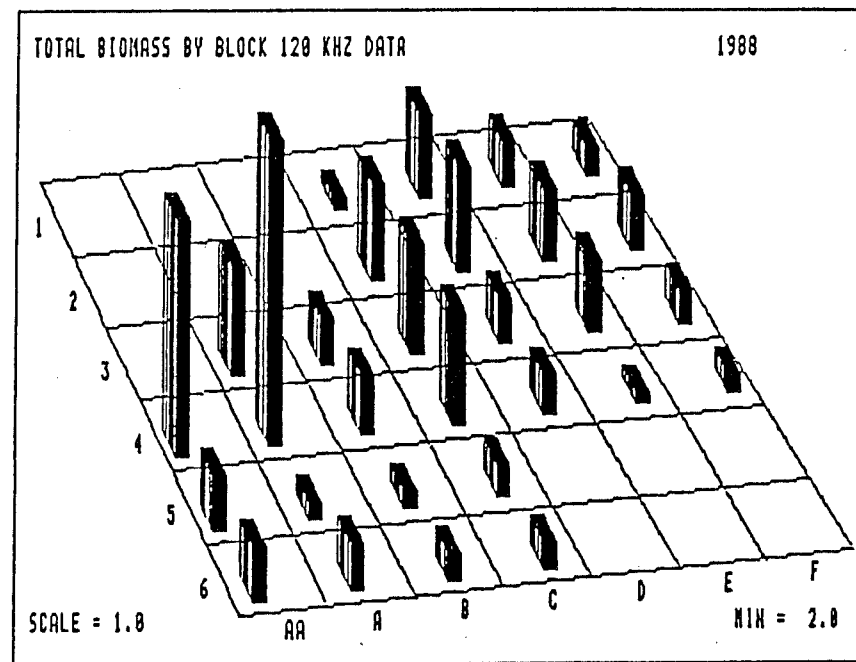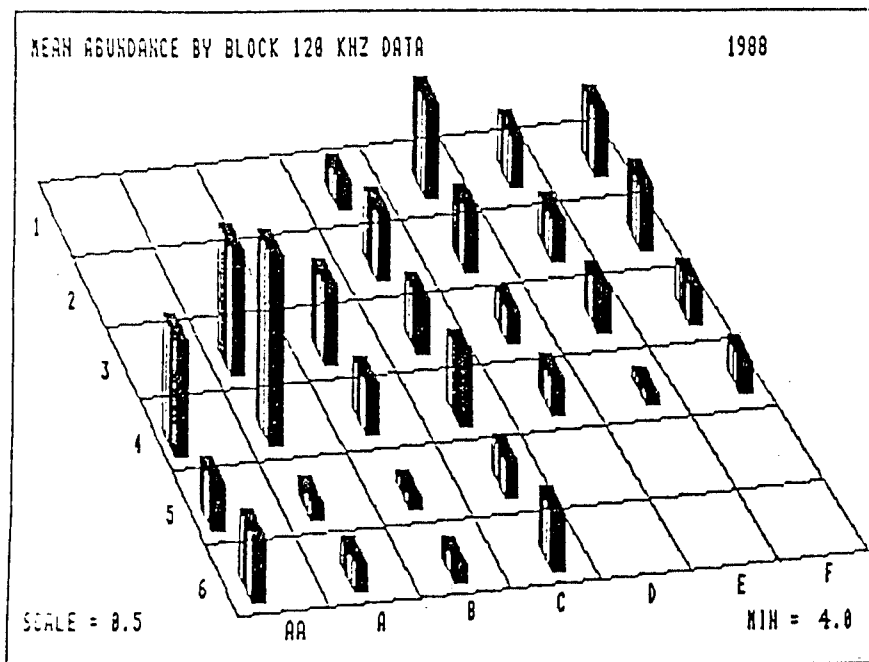Figure 4:   Total biomass (tonnes/1 000) for Bransfield Strait and Elephant Island by frequency and block.

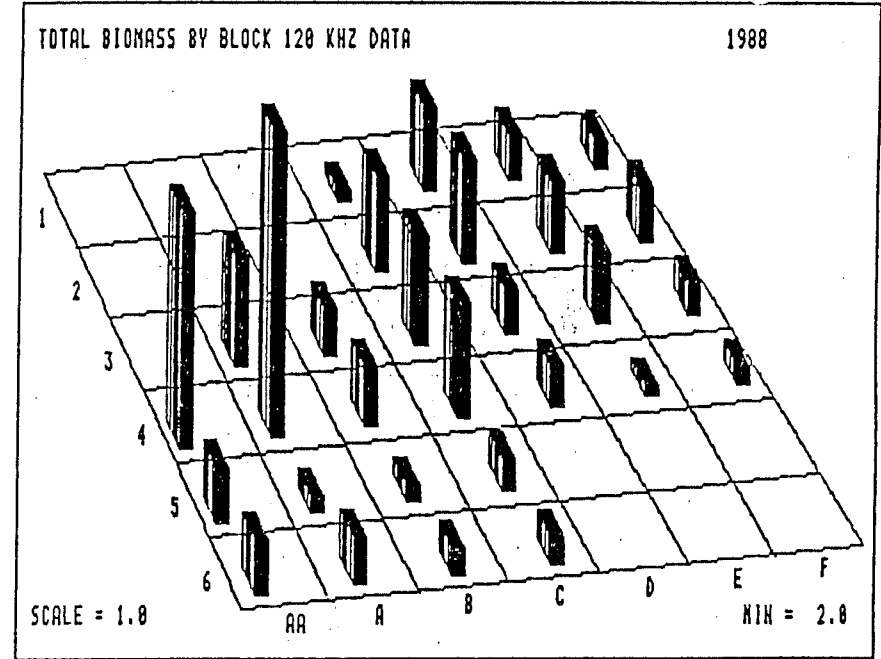Figure 5:   Mean abundance (tonnes/ n miles²) and total biomass (tonnes/1 000) for 120 kHz data by block.
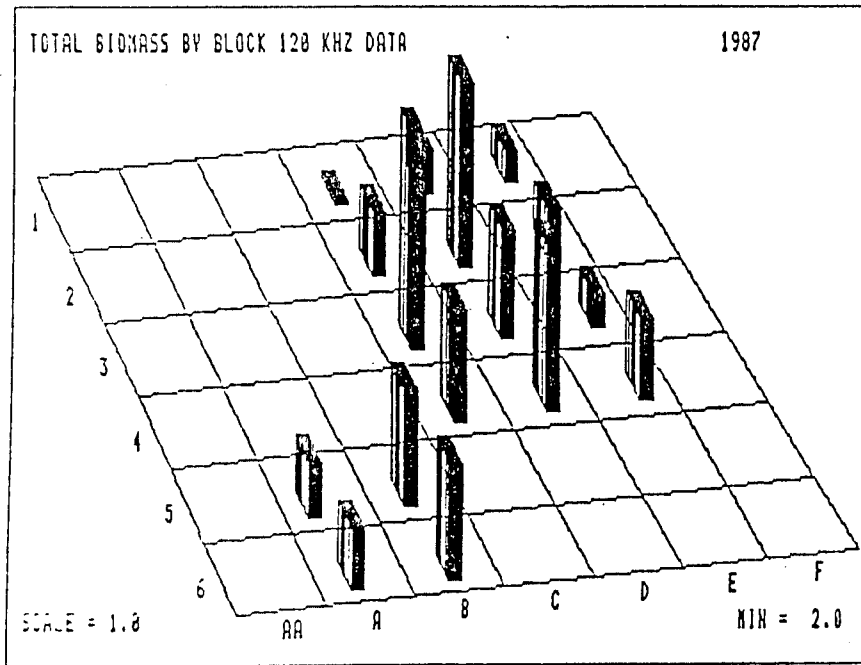
Figure 6: Comparison of total biomass by block for 120 kHz data between 1987 and 1988.

Légendes des tableaux

Tableau 1	Abondance moyenne comparative et biomasse totale pour les aires délimitées étudiées aussi en 1987.
Tableau 2	Abondance moyenne et biomasse totale dans les aires étudiées en 1988.
Tableau 3	Caractéristiques électro-acoustiques des systèmes de sondage.

Légendes des figures

Figure 1	Tracé d'étude et emplacements des aires délimitées dans la zone du détroit de Bransfield et de l'île de l'Eléphant.
Figure 2	Comparaison des trajets de la campagne dans les zone étudiées en 1987 et en 1988.
Figure 3	Biomasse moyenne (tonnes/milles nautiques^2) pour le détroit de Bransfield et l'île de l'Eléphant par fréquence et aire délimitée.
Figure 4	Biomasse totale (tonnes/1 000) pour le détroit de Bransfield et l'île de l'Eléphant par fréquence et aire délimitée.
Figure 5	Abondance moyenne (tonnes/milles nautiques^2) et biomasse totale (1 000 tonnes) pour les données relatives à 120 kHz, par aire délimitée.
Figure 6	Comparaison de la biomasse totale par aire délimitée pour les données à 120 kHz entre 1987 et 1988.

Заголовки к таблицам

Таблица 1	Сравнительная средняя численность и общая биомасса по квадратам, изученным также в 1987 г.
Таблица 2	Средняя численность и общая биомасса по квадратам, изученным также в 1988 г.
Таблица 3	Электроакустические характеристики звуковых систем.

Подписи к рисункам

Рисунок 1	Маршрут съемки и расположения квадратов в районе пролива Брансфилда и острова Элефант.
Рисунок 2	Сравнение маршрутов судов в районах, изученных в 1987 и 1988 гг.
Рисунок 3	Средняя биомасса, измеренная по частоте и квадратам (численность выражена в тоннах/кв.морские мили) для пролива Брансфилда и острова Элефант.
Рисунок 4	Общая биомасса, измеренная по частоте и квадратам (тонны/1000) для пролива Брансфилда и острова Элефант.

Рисунок 5   Средняя численность, (тонны/кв. морские мили) и общая биомасса (1000 тонны), измеренные по квадратам (частота 120кГц).

Рисунок 6   Сравнение общей биомассы, измеренной по квадратам, за 1987 и 1988 гг. (частота 120 кГц).

Encabezamientos de las Tablas

Tabla 1   Abundancia media comparativa y biomasa total para los bloques que fueron también prospeccionados en 1987.

Tabla 2   Abundancia media y biomasa total en los bloques prospeccionados en 1988.

Tabla 3   Características electro-acústicas de los sistemas de sondeo.

Leyendas de las Figuras

Figura 1   Trayectoria de la prospección y localización de los bloques en el área del estrecho de Bransfield y la isla Elefante.

Figura 2   Comparación de las trayectorias del crucero en zonas prospeccionadas en 1987 y 1988.

Figura 3   Biomasa media (abundancia en toneladas/millas náuticas^2) para el estrecho de Bransfield y la isla Elefante por frequencia y bloque.

Figura 4   Biomasa total (toneladas/1 000) para el estrecho de Bransfield y la isla Elefante por frequencia y bloque.

Figura 5   Abundancia media (toneladas/millas náuticas^2) y biomasa total (1 000 toneladas) para los datos de 120 kHz por bloque.

Figura 6   Comparación de la biomasa total por bloque para los datos de 120 kHz entre 1987 y 1988.