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DISTRIBUTION AND STOCK OF KRILL, EUPHAUSIA SUPERBA DANA, IN DECEMBER 1983 AND JANUARY 1984 BEFORE AND DURING THE SECOND INTERNATIONAL BIOMASS EXPERIMENT I (SIBEX I)

Abstract

The preliminary results of hydroacoustic investigations conducted aboard the Polish vessel "Professor Siedlecki" (8.XII.1983 - 8.I.1984) are presented. In the first leg of the cruise (8-20.XII.1983) the area between Joinville Is., South Orkney Is., Elephant Is. was covered. The second leg covered the area of the Drake Passage and Bransfield Strait as a part of participation in SIBEX. It was found that total krill stock was much lower than during FIBEX (1981), especially in the Bransfield Strait. Large concentrations of krill were observed only to the north and south-west and south of Elephant Is. and to the north of King George Is.

REPARTITION GEOGRAPHIQUE ET STOCK DE KRILL EUPHAUSIA SUPERBA DANA EN DECEMBRE 1983 ET JANVIER 1984 AVANT ET PENDANT LA DEUXIEME EXPERIENCE INTERNATIONALE BIOMASS I (SIBEX I)

Résumé

Les résultats préliminaires des études hydroacoustiques effectuées à bord du navire polonais, "Professor Siedlecki" du 8 décembre 1983 au 8 janvier 1984 sont présentés. Au cours de la première étape de l'expédition en mer du 8 au 20 décembre 1983, les études ont été menées dans la zone se trouvant entre l'île Joinville, les Orcades du Sud, et l'île Eléphant. Au cours de la deuxième étape, appelée Deuxième Expérience Internationale BIOMASS, les études ont été effectuées dans la zone située entre le Passage de Drake et le Détroit de Bransfield. Les résultats de ces études ont démontré que le stock total de krill était beaucoup moins élevé qu'en 1981, lors de la Première Expérience Internationale BIOMASS, notamment dans le Détroit de Bransfield. Des concentrations importantes de krill ont été observées uniquement au nord et au sud-ouest et au sud de l'île Eléphant ainsi qu'au nord de l'île du Roi George.

РАСПРЕДЕЛЕНИЕ И ЗАПАСЫ КРИЛЯ ВИДА EUPHAUSIA SUPERBA DANA
В ДЕКАБРЕ 1983 г. И В ЯНВАРЕ 1984 г., ДО И ВО ВРЕМЯ
ВТОРОГО МЕЖДУНАРОДНОГО ЭКСПЕРИМЕНТА БИОМАСС I/СИБЕКС 1/

Краткий обзор

В документе представлены предварительные результаты гидроакустических исследований, проведенных с борта польского судна "Профессор Седлецки" с 8/XII/1983 по 8/I/1984 г. На первом этапе плавания (с 8 по 20 декабря 1983 г.) был пройден участок между о-вом Джойнвилль, Кжньми Оркнейскими о-вами и о-вом Элефант. Второй этап, получивший название Второго международного эксперимента БИОМАСС, проводился в районе пролива Дрейка и пролива Брансфилда. Было обнаружено, что общие запасы криля были намного ниже, чем во время Первого международного эксперимента БИОМАСС (1981 г.), особенно в проливе Брансфилда. Большие скопления криля наблюдались только северу, к юго-западу и к югу от о-ва Элефант и к северу от о-ва Короля Георга.

DISTRIBUCION Y RESERVA DE KRILL EUPHAUSIA SUPERBA DANA EN DICIEMBRE DE 1983
Y ENERO DE 1984 ANTES Y DURANTE EL SEGUNDO EXPERIMENTO INTERNACIONAL DE
BIOMASS I (SIBEX I)

Resumen

Presentamos los resultados preliminares de las investigaciones hidroacústicas llevadas a cabo a bordo de la nave polaco "Profesor Siedlecki" (8.XII.1983 - 8.I.1984). Durante la primera etapa del crucero (8-20.XII.1983) se cubrió el área entre la Isla Joinville, Islas Orcadas del Sur e Isla Elefante. La segunda etapa, llamada el Segundo Experimento Internacional de BIOMASS, cubrió el área del Pasaje Drake y Estrecho de Bransfield. Se descubrió que la reserva total de krill era mucho menor que la observada durante el Primer Experimento Internacional de BIOMASS (1981), especialmente en el Estrecho de Bransfield. Se observaron grandes concentraciones de krill únicamente al norte, al sudoeste y al sur de la Isla Elefante y al norte de la isla King George.

Introduction

The international research programme BIOMASS (Biological Investigations of Marine Antarctic Systems and Stocks) was initiated in 1976. Its objectives included comprehensive investigations of the Antarctic marine ecosystem, with special emphasis on krill Euphausia superba Dana. Two research experiments were made within the framework of the BIOMASS programme : FIBEX (the first International BIOMASS Experiment) which took place in January-March 1981 with the objective of estimating krill stocks in all of the Antarctic (Hampton 1983) and SIBEX I (the Second International BIOMASS Experiment). The second experiment took place in two subsequent Antarctic summers. The first stage was conducted in October 1983-February 1984 in the area of the South Shetland Islands and Elephant Island. The Polish vessel "Professor Siedlecki" took part in this expedition. The investigations covered not only the area within the SIBEX I project but also included the South Orkney Islands. Part of the project included hydroacoustic investigations whose main goal was to prepare maps of krill distribution and estimate its stocks. The objectives were thus the same as those realised during the FIBEX 81 expedition (Kalinowski 1982).

The aim of this paper is to present the preliminary results of hydroacoustic investigations covering the distribution of krill in the area of Joinville Is., the South Orkney Is., and Elephant Is. as well as in the area covered by the SIBEX project, i.e. Elephant Is., the Drake Passage and the Bransfield Strait.

Materials and Method

Hydroacoustic investigations were conducted in a 24-hour watch system. The following equipment was used :

- Simrad EK-120 (basic) vertical echosounder,
- Simrad QMMM II analog echo integrator coupled with the EK-120 echosounder,
- Simrad EK 38 vertical echosounder (as auxiliary, for observation of water layers outside the range of the EK-120, i.e. below 130 m).

Before the investigations, the equipment was calibrated in acoustic and electrical units. For the EK-120 echosounder, the following working parameters were obtained :

- frequency $f = 120,000$ Hz,
- source level $SL = 219$ dB $1\mu\text{Pa}$ ref. 1 m,
- voltage response $VR = 97.4$ dB // 1 Volt per μPa ,
- length of sounding pulse $\tau = 0.0006$ s.

Echo integration was carried out in a continuous manner in the layer between 10 and 130 m.

The basis for the estimation of krill biomass was the calculation of mean value of volume back scattering strength S_v for each segment of 1 NM of the vessel route. The calculations of S_v were made on the basis of the echo integrator readings. After proper transformations, the following was obtained :

$$\bar{S}_v = -81.31 + 4.34 \ln I \quad (1)$$

where :

\bar{S}_v - mean volume back scattering strength (dB),

I - echo integrator reading for 1 NM segment mm. Mean abundance of krill per unit of surface area (mean biomass density) was calculated according to the following dependence :

$$\bar{b} = 10^{0.1[\bar{S}_v + 10 \log \Delta R - \overline{TS}]} \quad (2)$$

where :

\bar{b} = mean biomass density (no. of krill/m²)

\bar{S}_v = mean volume back scattering strength [dB],

ΔR = width of integration layer [m],

\overline{TS} = mean target strength of krill [dB].

In order to compare these results with those of the FIBEX experiment, the following dependence was used for the calculation of TS :

$$TS = -97.1 + 20 \log L \quad (3)$$

where :

TS = target strength of krill [dB],

L = length of krill [mm].

Mean surface density of krill biomass in t/NM^2 was calculated from the following formula :

$$\bar{B} = 3.43 \cdot \bar{w}^0 \quad (4)$$

where :

\bar{B} = mean surface density of biomass [t/NM^2],

\bar{w} = mean weight of krill [g].

Mean weight of krill was calculated from dependence (Jazdzewski et al. 1978) :

$$\bar{w} = 0.0018 \cdot L^{3.3831} \quad (5)$$

where :

w = mean weight of krill [mg].

Marking the calculated values of mean surface density of biomass every 1 NM along the vessel route, maps of krill distribution in the investigated areas were obtained (Figs 1,2,3). The width of the belt equal to 4 NM was assumed arbitrarily in order to present biomass distribution graphically. In places where these belts overlapped, certain areas with different densities were obtained. In the area covered by the SIBEX project, the grid of echosoundings was regular so it was possible to make an attempt at krill estimation. To do this, the whole area was divided into squares 30 NM x 30 NM (Fig. 4). Mean surface density of biomass was calculated for each square on the basis of echosoundings made in these squares. The sum of all the results gave the krill biomass in the whole investigated area.

All investigations which were carried out may be divided into two main parts. The goal of the first was to look for fish concentrations, which in advance limited the area of investigations to the shelves of islands (Figs 1,2,3).

In the area of Joinville Is. (Fig. 1), the vessel conducted investigations on 9-11 December, 1983, in the area of South Orkney Is. (Fig. 2) on 12-16 December, 1983, in the area of Elephant Is. (Fig. 3) on 19-20 December, 1983. A total of 2,000 NM was sounded in this area. Then, according to the plan, the SIBEX I part of the expedition was carried out (21 December - 9 January, 1984) along preselected transects (Fig. 4). These investigations were begun in the Elephant Is. area, continued in the Drake Passage and Bransfield Strait, back to Elephant Is. where, after three days of catches, the last of the planned transects was made to King George Is. A total of about 2,100 NM was covered by echosoundings.

Results

When discussing the results of the first leg of the cruise, an objection may be made that, because the soundings were limited to shelf areas, the picture of krill distribution obtained does not correspond to the actual situation. There is some truth to it but a series of earlier publications (e.g. Kalinowski and Witek 1983, Orłowski 1984) points out that the basic biomass of krill is found in just such areas. Because the methods used were the same, the results discussed here will be compared with those obtained earlier during the "Professor Siedlecki's" cruises. The vessel took part in five Antarctic expeditions in 1975-1981, during which hydroacoustic investigations of krill distribution and stock estimates were conducted.

In the Joinville Is. area, investigations were conducted in January and March 1979, when the density of krill often exceeded 100 t/NM^2 ; in the cruise under discussion such a result was obtained only once, north-east of the island (Fig. 1).

The "Professor Siedlecki" was in the South Orkney Islands area several times ; in March 1977, December, 1978 and January 1979. The area was always characterized by surface densities exceeding $1,000 \text{ t/NM}^2$. In 1983, there was less krill but biomass densities often exceeded 100 t/NM^2 which was not such a small figure related to the situation in the whole of the investigated area (Fig. 2).

The Elephant Is. area was sounded in each cruise of the "Professor Siedlecki", i.e. in 1976, 1977, 1979 and 1981. The area was characterized by large krill concentrations, exceeding 1000 t/NM^2 . The situation in the cruise under discussion was similar (Fig. 3). The area was an exceptional one, Biomass density reached 500 t/NM^2 and krill concentrations (patches) encountered had dimensions exceeding 1 NM and densities in the order of several hundred g/m^3 ; no similar concentrations were encountered elsewhere. It should be noted, however, that when observations were only at the assigned SIBEX transect, a different picture of biomass distribution was obtained and the values of biomass density were lower (Fig. 4).

The investigations carried out within the framework of the BIOMASS-SIBEX I venture were part of a multi-stage experiment which is to end in 1985. At the same time it was a continuation of the FIBEX experiment carried out in 1981. That is why the results of these two cruises will be compared. During the FIBEX 81 expedition, large krill concentrations in the Bransfield Strait were estimated at 1.32 million tons (Hampton 1983) and at 2.27 million tons according to the method employed on the "Professor Siedlecki" (Kalinowski 1982). The stocks in the Drake Passage were estimated at 0.06 million tons (Kalinowski 1982). The differences between the figures quoted are, among other, a result of the different delineation of these two areas. In the Elephant Is. area West German scientists estimated the stock at 3.26 million tons (Hampton 1983).

During the SIBEX I expedition, the situation was diametrically different (Fig. 4). No larger concentrations in the Bransfield Strait and Drake Passage were observed ; only at a transect north of King George Is. certain larger concentrations were recorded - at a segment of several nautical miles they exceeded 100 t/NM^2 . Small concentrations were also

present west of Low and Smith Islands. The area of Elephant Is. turned out to be richer in krill : concentrations with biomass densities exceeding 100 t/NM^2 were observed north, south and south-west of the island. The results obtained served as a basis for krill biomass estimate. In a paper forthcoming in Polish Polar Research (Kalinowski, Godlewska, Klusek, Matuszak), a figure of 70 thousand was given for the Bransfield Strait and 122 thousand for the Drake Passage. The calculations were based on mean arithmetic biomass density from all the results obtained multiplied by the investigated area. The method used in the present paper is different and enables also the drawing of biomass distribution in the whole of the investigated area. Taking the results from the following squares : L1, K1, J1, I1, H1, G1, L2, K2, J2, I2, H2, G2, F2, E2, J3, I3, H3, G3, F3, E3, D3, C3, I4, H4, G4, F4, E4, D4, C4, G5, E5, D5, D6, C6, B7, A7, as belonging to the Drake Passage, the biomass was estimated at 100,565 tons. The remaining squares were assumed as belonging to the Bransfield Strait - the stocks there were estimated at 157,095 tons. However, if we separate squares L2, K2, J3, K3, L3, J4, K4, L4 from the Bransfield Strait and Drake Passage as belonging to the Elephant Is. area then 120,281 tons should be subtracted from the total figure. As regards the results obtained during the FIBEX cruise, it should be noted that the figures obtained are smaller by one order of magnitude. Instead of concluding, let me quote a statement by a Chilean scientist, Mr Oscar Guzman, contained in the protocol from the Acoustic Working Party Meeting, Hamburg 1984 : "during Sibex I the distribution of krill in the West Atlantic sector was distinctly anomalous, with krill density in the Bransfield Strait area being abnormally low".

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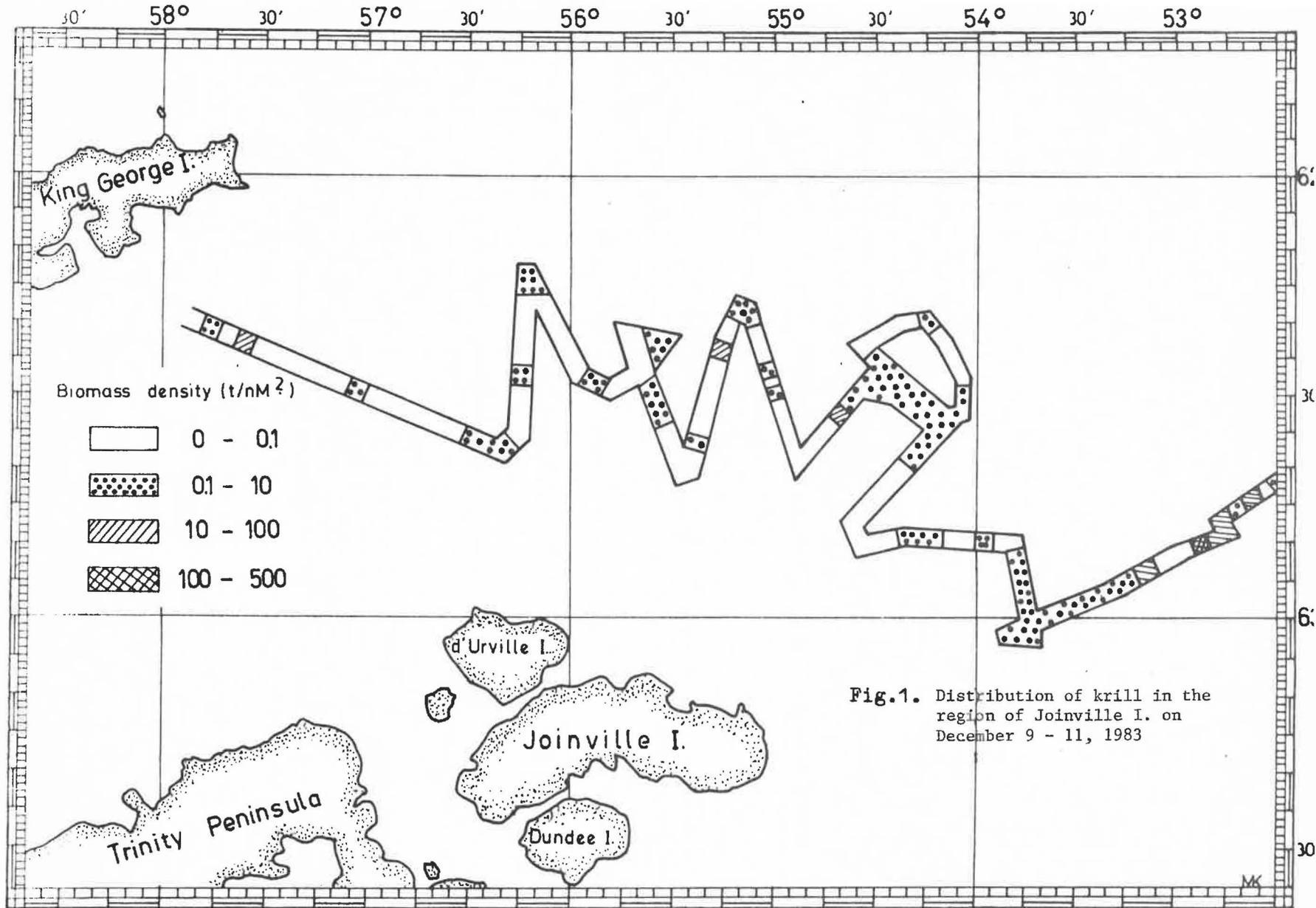


Fig.1. Distribution of krill in the region of Joinville I. on December 9 - 11, 1983

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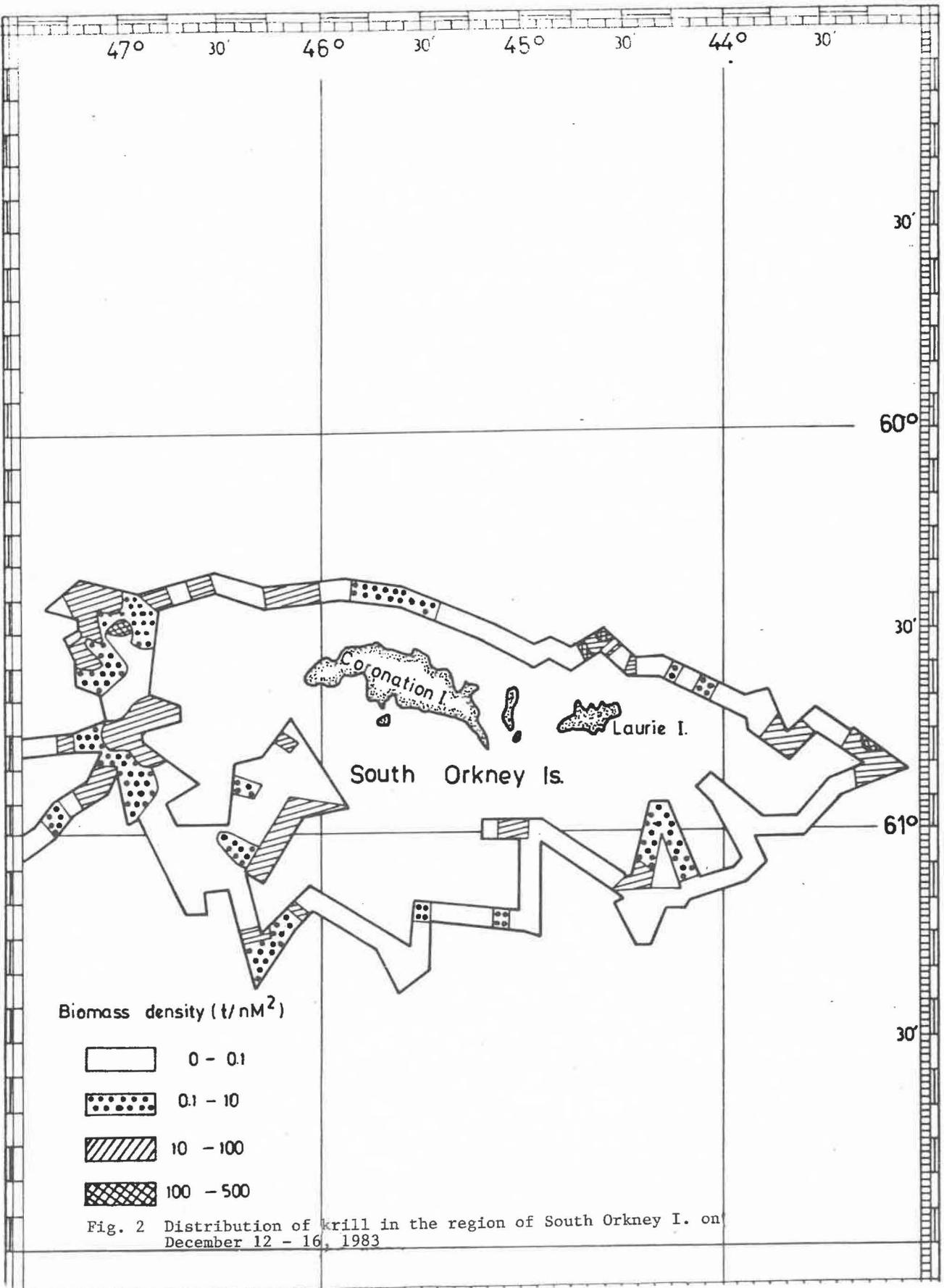
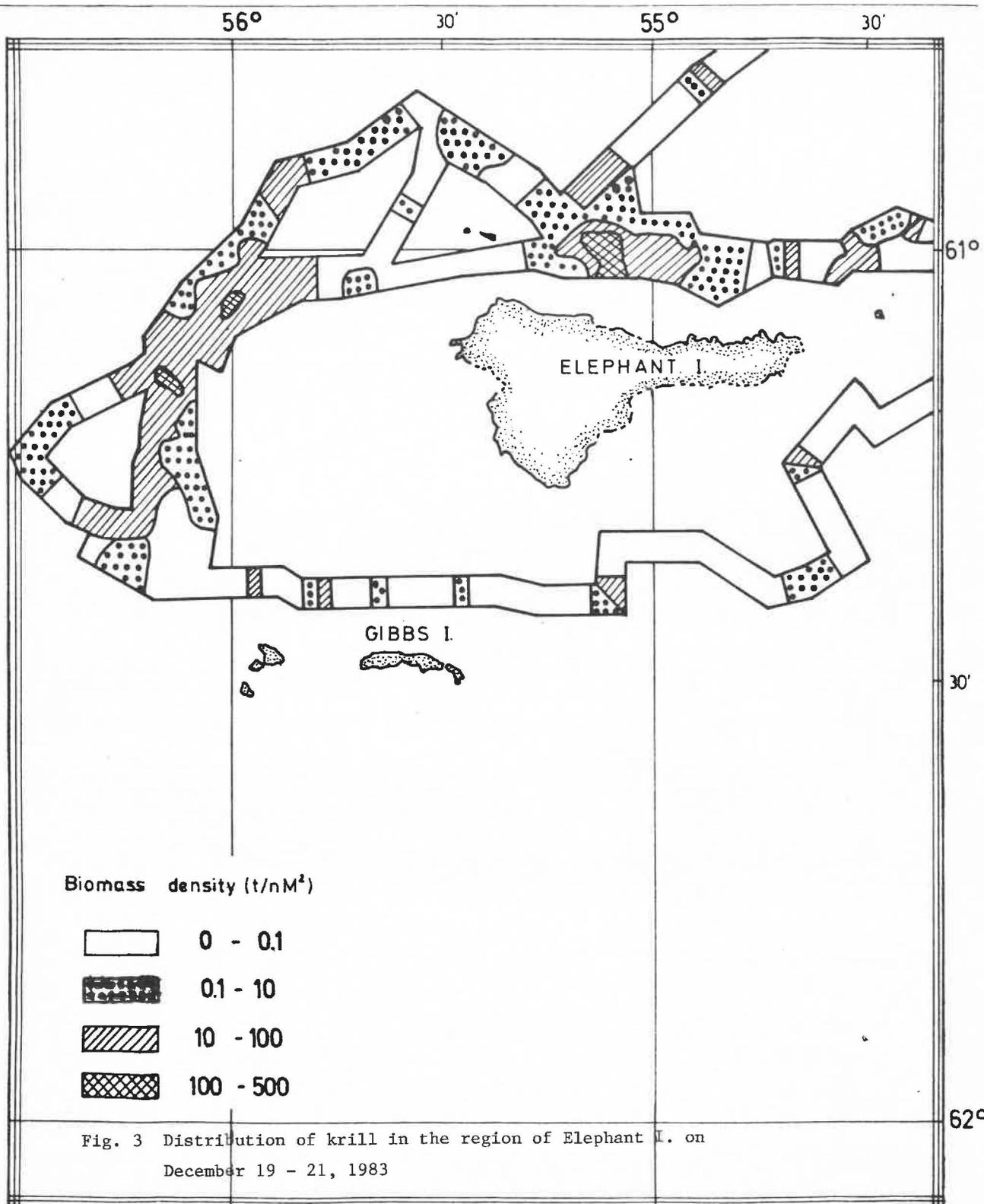


Fig. 2 Distribution of krill in the region of South Orkney I. on December 12 - 16, 1983



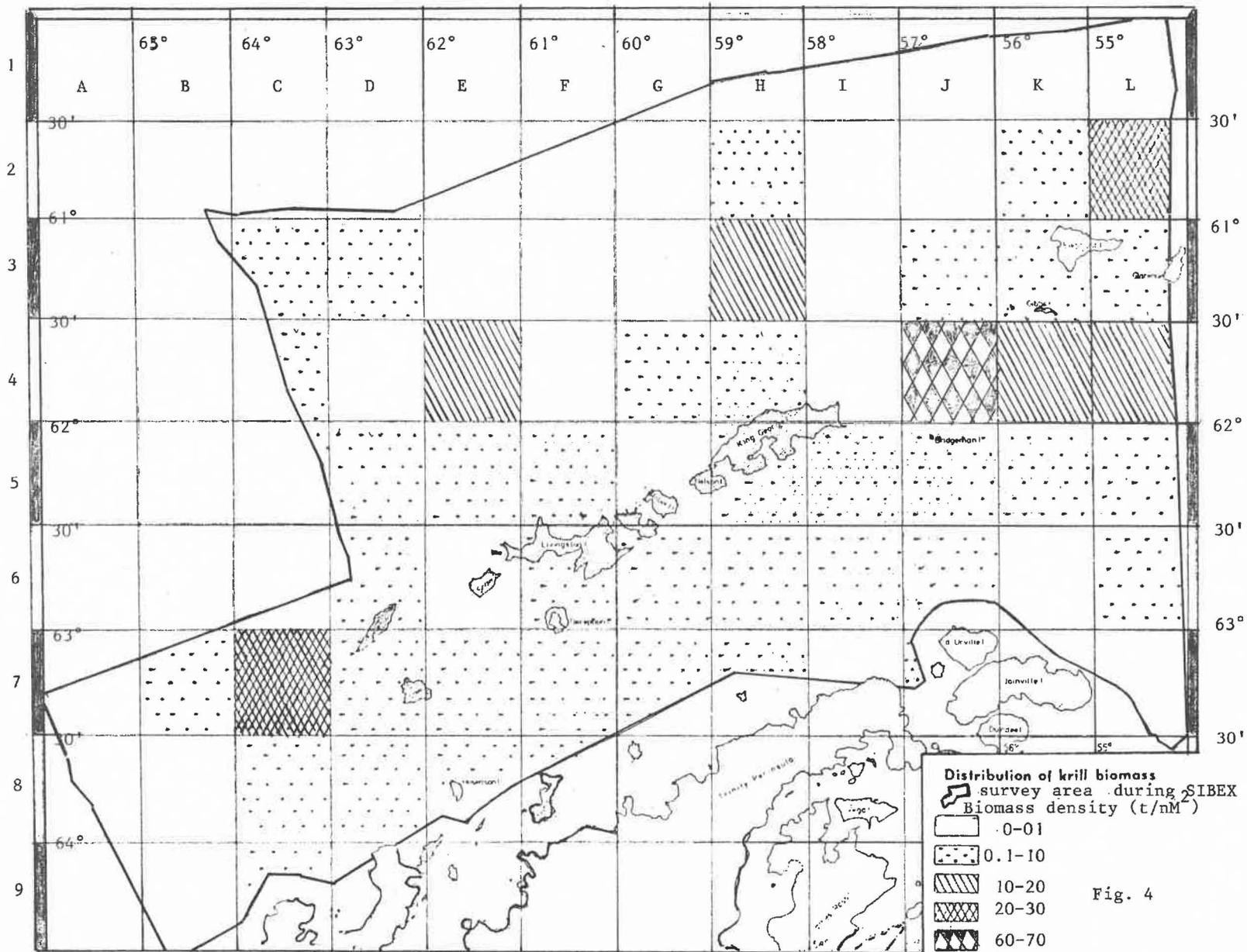


Fig. 4

Figure 1. Distribution of krill in the region of Joinville I. on December 9 - 11, 1983.

Figure 2. Distribution of krill in the region of South Orkney Is. on December 12 - 16, 1983.

Figure 3. Distribution of krill in the region of Elephant I. on December 19 - 21, 1983.

Figure 4. Distribution of krill biomass(during SIBEX).

Figure 1. Répartition géographique du krill dans la région de l'Ile Joinville du 9 au 11 décembre 1983.

Figure 2. Répartition géographique du krill dans la région des Iles Orcades du Sud du 12 au 16 décembre 1983.

Figure 3. Répartition géographique du krill dans la région de l'Ile Eléphant, du 19 au 21 décembre 1983.

Figure 4. Répartition géographique de la biomasse du krill (au cours de l'expérience SIBEX).

Рис. 1. Распределение криля в районе о-ва Джойнвилл на 9-11 декабря 1983 г.

Рис. 2. Распределение криля в районе Южных Оркнейских о-вов на 12-16 декабря 1983 г.

Рис. 3. Распределение криля в районе о-ва Элефант на 19-21 декабря 1983 г.

Рис. 4. Распределение биомассы криля (во время проведения СИБЕКС).

Ilustración 1. Distribución del krill en la región de la Isla Joinville del 9 al 11 de diciembre de 1983.

Ilustración 2. Distribución del krill en la región de las Islas Orcadas del Sur del 12 al 16 de diciembre de 1983.

Ilustración 3. Distribución del krill en la región de la Isla Elefante del 19 al 21 de diciembre de 1983.

Ilustración 4. Distribución de la Biomasa de krill (durante SIBEX).