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## The effect of the state of the sea on the occurrence of krill swarms in the region of the South Orkney Islands \*)

**ABSTRACT:** Recording of krill swarms and the observations of the state of the sea and the force of wind were conducted on the M/T "Gemini" from 6 to 26 February, 1978, eastwards of the South Orkneys Archipelago. It has been found that a heavy sea and strong winds disperse krill swarms. At night krill swarms occur much more frequently than during the day.

**Key words:** Antarctic, krill swarm

### 1. Introduction

In accordance with the concurrent statements of Deacon (1937) and Bogdanov et al. (1969) the flow of a part of the water masses from the Weddell Sea northwards occurs on the eastern side of the South Orkneys. These waters mix with the waters of the West Winds Drift forming a frontal zone (Bogdanov et al. 1969). This is the area of the formation of krill swarms (Sevcov and Makarov 1969).

In 1976, Jażdżewski et al. (1978) observed near the South Orkney Islands the occurrence of krill swarms, in which the predominant age-group consisted of specimens of 40 to 50 mm body length. Mohr (1976), using an echo-sounder, observed during six days and nights in April 1976 the appearance of krill swarms near the South Shetland Islands, in the upper water layer (downwards to the depth of 20 metres), in the middle of the night.

Shust (1969), on the basis of visual observations, suggests that hydrometeorological agents are of great consequence in the formation of krill swarms.

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Hydro-acoustic studies of vertical distribution of krill were not conducted hitherto simultaneously with the observations of the hydrometeorological parameters. The aim of this study was the analysis of the occurrence of krill swarms dependent on the state of the sea and the force of wind.

## 2. Methods

Investigations were conducted in the region of the shelf region of the South Orkneys Archipelago, 15–75 km east and south east from the shores of Laurie Island, between 6–26 February, 1978 (Fig. 1).

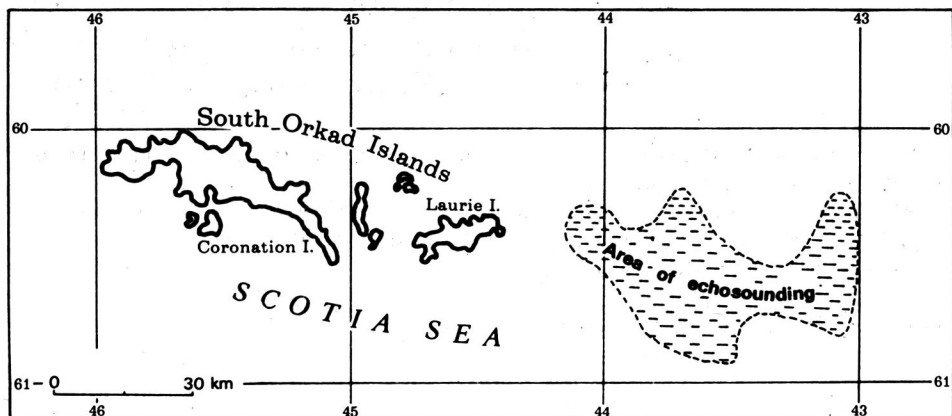


Fig. 1. Region of fisheries of the M/T "Gemini" in the shelf waters off the South Orkneys Archipelago (6–26 February, 1978)

Hydro-acoustic recording of krill (*Euphausia superba* Dana) swarms was conducted in the course of industrial fisheries of *Champocephalus gunnari* Lönnberg fishes. Soundings were carried out during 264 hours along about 1000 nautical miles. For the investigations an Atlas Echograph 420 (Krupp Atlas-Elektronik) echo-sounder was used. The parameters of the echo-sounder in operation were as follows:

- working range 0–50 m or 0–100 m
- beam width  $14^\circ$
- range amplifying control
- recorder amplification 5, 6, 7
- pulse length 0.28 m/s
- speed of the recording paper 338 mm/h
- transmission level 110 dB rel. 1 mbar
- output power 120 W
- working frequency 200 kHz
- scale 2.5 mm = 1 m depth

The transducer of the echo-sounder was installed in the bottom of the M/T "Gemini" at the depth of 5 m. Thus the soundings of the deep sea were made from the depth of 5 m deep downwards. Due to the high frequency of the transmitter the range of detection of krill aggregations was probably not more than 100 m (Elminowicz 1976). The relative density of krill swarms was determined on the basis of the surface of krill aggregations recorded in echograms in  $\text{mm}^2$ .

The state of the sea and the force of wind were determined every hours — 00, 04, 08, 12, 16, 20 L.M.T. (local mean time) on the Beaufort scale (°B). The mean daily and periodic values of the parameters were determined on the basis of the every-four-hour data.

### 3. Results and discussion

During the period of the investigations the largest krill swarms occurred between 6 and 12 February (Fig. 2). The analysis of the facsimile weather charts showed that in the time before 6 February moderate winds from the south prevailed in the region under investigations. From 6 to 12 February the winds were blowing exclusively from northwest, the mean wind force was 4.7 B.

On 13 February the mean wind force was 7.6°B and the mean state of sea — 6.8°B. On that day and in the following four days krill swarms

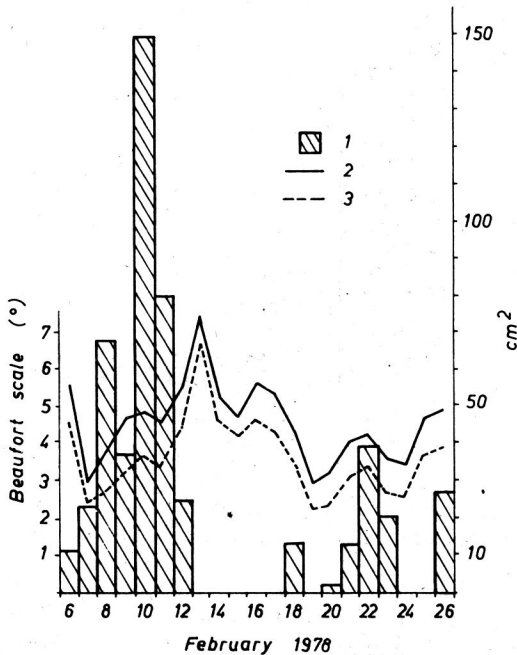


Fig. 2. Total surface of the day-and-night records of *Euphausia superba* swarms, in  $\text{mm}^2$  (1) and the mean daily values of the wind force (2) and the state of the sea (3)

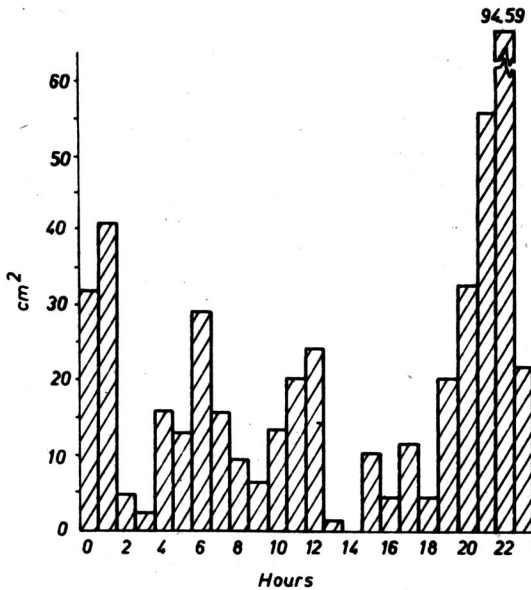


Fig. 3. Total surface of the records of *Euphausia superba* swarms noted at various hours of the day and night (6—26 February, 1978)

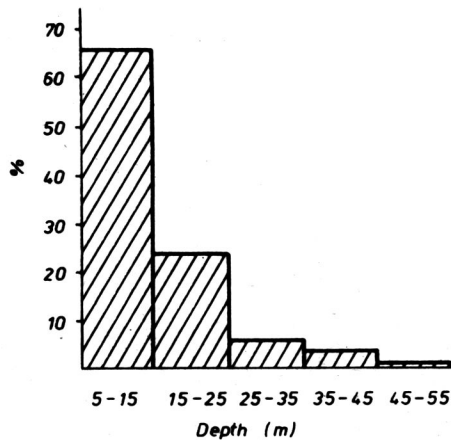


Fig. 4. The surface of the records of *Euphausia superba* swarms at various depths, expressed in percent of the total surface of the records

were not observed (Fig. 2). On 18 February fishing grounds were changed moving to another area nearer to the island (east border of the area is marked out in Fig. 1). Krill swarms were recorded again. The total surface of the records was at that time smaller than in the period previous to 13 February (Fig. 2). This indicates that krill aggregations observed

between 6 and 12 February were dispersed by a strong westerly wind. Krill swarms appeared again 5 days later in the region situated at a somewhat shorter distance from Laurie Island.

The maximum records of krill aggregations during the day and night watch from 6 to 26 February were noted at 2200 L.M.T. (Fig. 3). During twelve hours of the night, counted from 1900 to 0600 L.M.T. the total surface of the records of krill swarms was three times greater than during twelve hours of the day-time. The difference between the night-time and day-time records of the surface of krill swarms was noted as well within the total range (5—55 m depths) of echo-sounding as in each particular sub-range (Table I). Below the depth of 55 m deep krill swarms were not observed. The major part of the recorded krill swarms occurred in the water-layers at the depth of 5 to 15 m deep, i.e. 65% of the total area of the records (Fig. 4).

Table I.

Total surface (mm<sup>2</sup>) of the records of krill swarms at various hours and various depths, noted during the echo-sounding on the M/T "Gemini" (6—26 February 1978)  
 $\Sigma h$ —number of hours during which the recording was carried out at a given hour throughout the period of the observations

	Hour	$\Sigma h$	Depth of layer (m)				
			5—15	15—25	25—35	35—45	45—55
Night	0	6	3184	—	—	—	—
	1	9	2577	785	474	201	20
	2	8	160	261	29	15	—
	3	8	5	152	50	—	—
	4	8	1376	128	72	10	—
	5	10	609	666	27	—	—
	6	13	1354	1400	168	43	—
Day	7	15	1238	293	46	32	—
	8	13	670	295	—	—	—
	9	8	444	93	60	12	—
	10	12	975	320	12	90	—
	11	13	515	451	494	587	—
	12	14	2157	120	20	187	—
	13	16	—	20	83	11	—
	14	13	—	—	—	—	—
	15	15	318	170	143	123	299
	16	13	395	55	—	—	—
	17	14	988	182	93	18	—
	18	15	142	285	—	—	—
Night	19	17	1261	307	150	236	81
	20	9	785	1986	484	56	—
	21	6	4125	1417	80	—	—
	22	4	7455	1999	5	—	—
	23	5	2895	460	618	321	142

## 4. Summary

In the period between 6—26 February 1978 hydro-acoustic recording of krill swarms (*Euphausia superba*) and observations of wind force and the state of sea were carried out. A complete disappearance of krill swarms was noted after the storm on 13 February and their reappearance after 5 days in an area closer to Laurie Island. In the night-time the records of krill swarms were three times higher than during the day. The maximum of the swarms occurrence was noted at 2200 L.M.T. The majority of the recorded swarms was noted in the upper layer of the echo-sounding range (from 5 to 15 m depth — 65% of the total surface of the records).

## 5. Резюме

В днях 6—26 февраля 1978 г проведено гидроакустическую регистрацию скоплений (*Euphausia superba*) а также наблюдения силы ветра и состояния моря. Констатировано полное исчезновение скоплений крыла после шторма 13 февраля и повторное их появление через пять дней в ближайшем соседстве Острова Лори, Южные Оркады. В ночное время зарегистрировано в три раза больше записей чем днём. Максимум появления скоплений крыла замечено в 10 часов ночи. Самое большое количество скоплений зарегистрировано в верхнем слое зондированного диапазона (с 5 до 15 м — 65% всей поверхности записей).

## 6. Streszczenie

W okresie 6—26 lutego 1978 roku przeprowadzono hydroakustyczną rejestrację skupień kryla (*Euphausia superba*) oraz obserwacje siły wiatru i stanu morza. Stwierdzono całkowity zanik skupień kryla po sztormie z dnia 13 lutego i ponowne ich pojawienie się po 5 dniach w bliższym sąsiedztwie wyspy Laurie. W godzinach nocnych zarejestrowano trzykrotnie więcej zapisów skupień niż w ciągu dnia. Maksimum występowania skupień przypadało na godz. 22<sup>00</sup>. Najwięcej skupień zarejestrowano w górnej warstwie sondowanego zakresu (od 5 do 15 m — 65% całości powierzchni zapisów).

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