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*Electrona carlsbergi* (Tåning, 1932),  
the principal component of a deep  
scattering layer in the Pacific  
sector of the Antarctic Ocean

**ABSTRACT:** During a cruise of the fishing vessel m/t "Sagitta" around the Antarctic, the occurrence of *DSL* was noted in a small area of the Pacific sector of the Antarctic waters. The layers were found at depths of 50–150 m. Their main component was *E. carlsbergi* (family *Myctophidae*), whose maximum density was within the range of  $219-437 \times 10^{-4}$  fish/m<sup>3</sup>.

Key words: Antarctic, *Myctophidae*, *DSL*

## 1. Introduction

The occurrence of water layers with sound-scattering properties (the so-called deep scattering layers, *DSL*) is typical for most areas of the open ocean (Marshall 1951).

The absence of *DSL* in the Antarctic waters south of the Antarctic Convergence was noted by Dietz (1948) and Bätzler and Vent (1967). Deep scattering layers were first observed in Antarctic waters by Nuñez and Novarini (1976) who investigated the Drake Passage area by means of a 12 kHz echosounder.

It was noted that myctophids are often the main component of deep scattering layers (Pearcy and Laurs 1966, Barham 1966, Backus et al. 1968, Backus et al. 1970, Baird et al. 1974, Taylor 1968, Gjøsaeter 1981, and others).

## 2. Material and methods

Materials for the present paper were collected during a research cruise of a commercial trawler m/t "Sagitta", taking part in the 3rd Polish Marine

Antarctic Expedition in the 1977/1978 season\*).

Hydroacoustic observations were carried out by means of a 33 kHz Atlas-Krupp 790 DS echosounder. The echosounder operated within the basic range of 0—500 m and 0—200 m during hauls. The effect of the transducer was 4 kW. Standard recording amplification of 4 was used.

The hydroacoustic recordings were checked against hauls made with a pelagic line-trawl, type 112/146 × 103/90. Lines were used in the front part of the trawl, segments of the belly up to the tunnel were made of knotless net with 400 and 200 mm mesh size, while the tunnel was made of a 60 mm net with a krill inset with a 15 mm mesh size (Korpys, unpublished date). An inset of the same kind was placed in the codend. During trawling, the horizontal opening of the trawl was 30—35 m and the vertical opening 18—20 m. The fishing depth as well as the parameters of the trawl vertical opening were determined with a net sonde.

The volume of filtered water was calculated on the basis of the trawl opening parameters measured in the belly. A satellite navigation system was used for the determination of geographical positions. Detailed data concerning trawl sites of the "Sagitta" in the area of *DSL* occurrence are quoted after Liwoch, Barthelke and Korpys (unpublished data) in Table I.

Table I

Hauls made from the "Sagitta" in the area of occurrence of *DSL*

Haul No.	Date	Trawling speed (knots)	Geographical position	Average depth of head line (m)	Time of shooting trawl (LT)	Duration of haul		Volume of filtered water (1000 of m <sup>3</sup> )	
						Total (kg)	kg/h		
25	13Jan. 1978	3,8	61°46'S 124°32'W	65	10 <sup>55</sup>	70	500	420	5682
26	13Jan. 1978	4,2	59°42'S 126°01'W	110	22 <sup>20</sup>	120	100	50	9909
27	14Jan. 1978	4,2	59°36'S 131°45'W	50	22 <sup>05</sup>	60	600	600	4426

Material for biological analysis was deep-frozen on board and analysed in the laboratory on shore. Standard length was measured to nearest mm. Weight was recorded to nearest 0.05 g. The length of 414 specimens was measured. Weight measurements, the analyses of gonads' maturity and the stomach fullness were made for a sample consisting of 100 specimens.

\*) Overall results of this expedition were collected in an unpublished report: "Report on investigations of III Polish Marine Antarctic Expedition in the 1977/78 season", vol. I—IV, Sea Fisheries Institute, Gdynia, 1978 (in Polish).

### 3. Results

Within the Pacific sector of the Antarctic Ocean, the occurrence of deep scattering layers was noted at depths from 50 to 150 m. These layers were observed on 13–14 January 1978 between 61°46'S, 124°32'W and 59°36'S, 131°45'W. Any clear tendencies of the layers to move vertically in the water were observed.

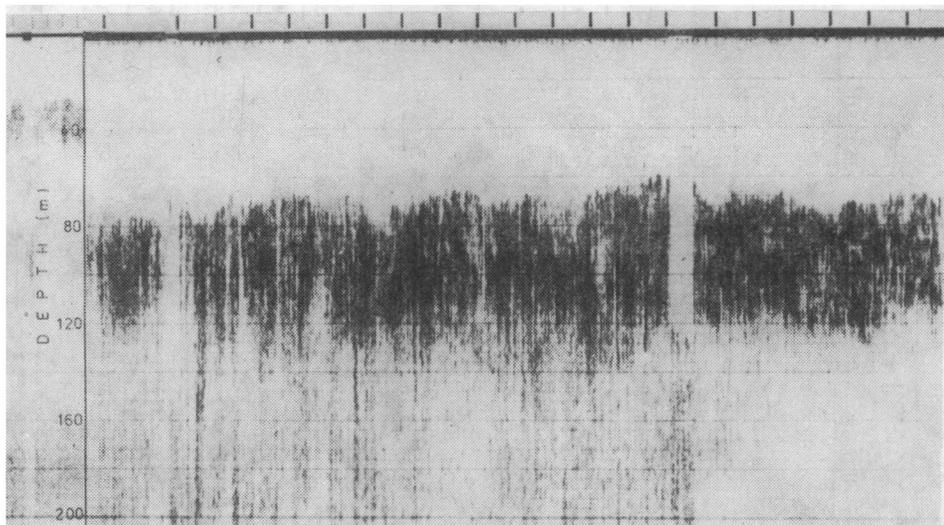


Fig. 1. Echo recordings obtained at trawl site No. 25

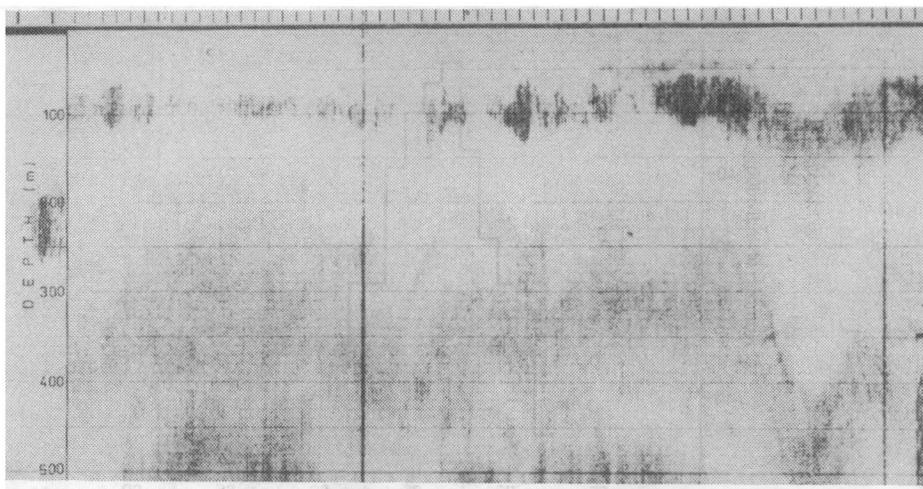


Fig. 2. Recordings of *DSL* 61°37'S, 124°38'W — 60°36'S, 125°26'W (Jan. 13, 1978: 13<sup>15</sup>—18<sup>15</sup> hours LT), vessel's speed 12.3 knots

Three experimental hauls were made in order to identify the composition of DSL. The examples of concentrations on which hauls no. 25 and 27 were made and the echo recordings obtained at the vessel searching speed are presented in echograms in Figs 1—3. In all three hauls, fishes belonging to the species *Electrona carlsbergi* (Tåning, 1932), family *Myctophidae*, constituted almost 100% of the catch. The presence of individual specimens of *Krefflichthys anderssoni* (Lönnberg, 1905) was also noted.

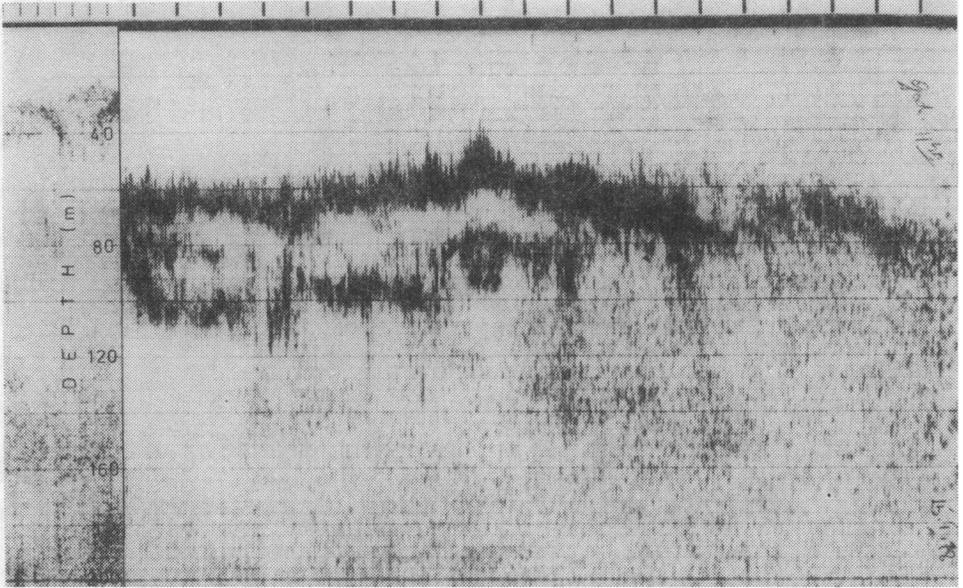


Fig. 3. Echo recordings obtained at trawl site No. 27

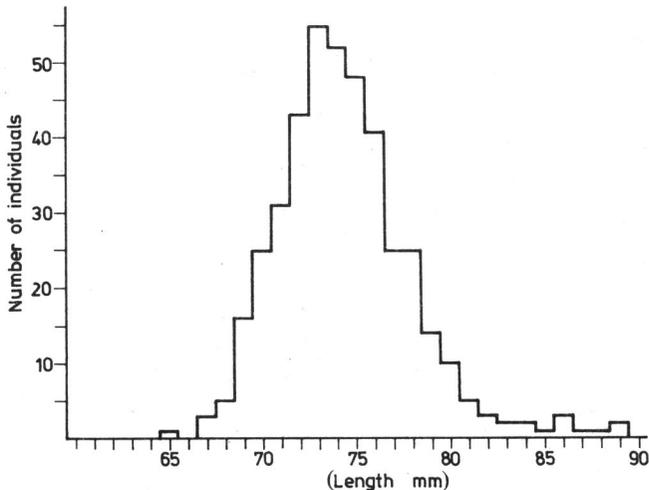


Fig. 4. Length distribution of *Electrona calisbergi* (trawl site No. 25)

The length range of *E. carlsbergi* taken was 65–89 mm, their weight 4.7–10.3 g (mean weight 6.2 g). The length distribution of *E. carlsbergi* is shown in Fig. 4.

Females constituted 62% of the analysed material. No sexually mature individuals were found. The stomachs of all analysed fishes contained food.

On the basis of the catch obtained and the volume of water filtered by the trawl, the density of fish in the investigated layer was calculated. The density values were calculated for three assumed magnitudes of the trawl catchability coefficient:  $F = 0.50$ ;  $F = 0.75$ ;  $F = 1.00$ . The density values calculated in this way are presented in Table II.

Table II

Values of density of *Electrona carlsbergi* in observed DSL

Haul No.	Penetrated layer (m)	Density at assumed values of catchability coefficient $F$					
		$10^{-4} \cdot \text{g/m}^3$			$10^{-4} \cdot \text{fish/m}^3$		
		$F = 0.50$	$F = 0.75$	$F = 1.00$	$F = 0.50$	$F = 0.75$	$F = 1.00$
25	65—85	1760	1320	800	284	213	142
26	110—128	242	182	121	39	29	19
27	50—68	2710	2034	1356	437	328	219
average	50—128	1199	899	599	193	145	97

#### 4. Discussion

Unfortunately, no hydrological investigations were carried out alongside the hydroacoustic investigations and hauls. However, on the basis of the location of the Antarctic Convergence in this area (Deacon 1937, McGinnis 1974b), it can be seen that the occurrence of observed DSL is connected with the waters of this front.

Species composition of experimental catches confirms earlier observations concerning the geographical distribution of *E. carlsbergi* (McGinnis 1974a, Krefft 1974, Hulley 1981).

On the basis of rich materials Hulley (1981) has found that the females of this species reach sexual maturity at a minimum length of 83 mm (SL). The population found in the investigated layers consisted mostly of smaller, immature specimens.

The catchability of large pelagic trawls used for fishing for mesopelagic fishes is difficult to determine (Taylor 1968, Gjøsæter 1981). Czubek (1981) noted that the catchability of a krill trawl used on r/v "Profesor Siedlecki" to catch *Euphausia superba* Dana was 0.86. Unfortunately, the trawl investigated by that author differed substantially from the line-trawl with a small-meshed inset used during the cruise described here. The objects of the fishery differed as well. It can be expected that the catchability of the

latter gear was much lower. Taking the above qualifications into account, it should be emphasized that the density calculations presented here illustrate only the order of magnitude of the phenomenon, and not its real value.

Comparing the obtained population density estimates in the observed *DSL* with the results of earlier papers on the subject, it may be said that there were no such investigations in the Antarctic. An exception is the paper by Kaškin (1967), who analysed the abundance of myctophids in the Atlantic Ocean. The magnitudes given by that author for the Drake Passage ( $57 \times 10^{-4} \text{ g/m}^3$  and  $21 \times 10^{-4} \text{ fish/m}^3$ ) are based on the results of five hauls made with small *IKMT* gear, not connected with the occurrence of *DSL*.

Lower values of fish density in *DSL* than those listed here are given by Baird et al. (1974). On the basis of catch rates they estimated the density of *Diaphus taaningi* in Cariaco Trench at  $20 \times 10^{-4} \text{ fish/m}^3$ . Gjøsæter (1981), who investigated the abundance of myctophids in western and northern Arabian Sea, reported the density reaching up to  $6.3 \text{ g/m}^3$  (about  $8 \text{ fish/m}^3$ ). However, he admitted that those values were calculated on the assumption that catchability coefficient of the krill trawl was 1.00 (100%), thus they are underestimated in practice.

The examples quoted above (Baird et al. 1974, Gjøsæter 1981) referred to *DSL*s occurring above or near the shelves, while this paper deals with layers in the waters of the open ocean, far from the shelves and ocean banks.

I would like to thank Mr M. Liwoch (Sea Fisheries Institute, Gdynia) for supplying me with the materials collected during the "Sagitta's" cruise, as well as Dr. J. Kalinowski (SFI) for critical comments on the manuscript.

## 6. Резюме

Во время рейса рыбацкого судна м/т „Сагитта” вокруг Антарктиды на небольшой территории пацифического сектора антарктических вод было установлено присутствие *ДСЛ* (глубоководные звукорассеивающие слои). Эти слои были определены на глубине 50—150 м (рис. 1—3) в районе  $61^{\circ}46'$  ю.ш. и  $124^{\circ}32'$  з.д.— $59^{\circ}36'$  ю.ш. и  $131^{\circ}45'$  з.д.

На основании 3 контрольных тралений, проведенных с помощью большого пелагического трала с крилевой рубашкой, было установлено, что главным компонентом *ДСЛ* является *E. carlsbergi* (семейство *Myctophidae*). В контрольных уловах обнаружены рыбы, в пределах длины 65—89 мм (рис. 4).

Исходя из эффективности выловов была вычислена плотность рыб, приходящаяся на единицу объема профильтрованной воды из исследуемого слоя. Результаты представлены с учетом вариантного значения коэффициента эффективности трала (таблица II).

## 7. Streszczenie

Podczas rejsu wokół Antarktydy statku rybackiego m/t „Sagitta” na niewielkim obszarze pacyficznego sektora wód antarktycznych stwierdzono występowanie *DSL*. Warstwy te zloka-

lizowano na głębokościach od 50 do 150 m (rys. 1—3) w rejonie pozycji 61°46'S 124°32'W—59°36'S 131°45'W.

Na podstawie 3 zaciągów kontrolnych wykonanych przy pomocy dużego włoka pelagicznego z wkładką krylową stwierdzono, że główny składnik *DSL* stanowiła *E. carlsbergi* (rodzina *Myctophidae*). Zakres długości ryb występujących w połowach kontrolnych wynosił od 65 do 89 mm (rys. 4).

W oparciu o wydajności połowów obliczono zagęszczenie ryb na jednostkę objętości prze-filtrowanej wody badanej warstwy. Wyniki przedstawiono przy wariantowym założeniu wartości współczynnika łowności włoka (tabela II).

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