THE STATUS OF KRILL (*EUPHAUSIA SUPERBA* DANA) RESOURCES IN CCAMLR STATISTICAL DIVISIONS 58.4.2 AND 58.4.3 FROM 1988 TO 1990. RESULTS OF ACOUSTIC SURVEYS

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Abstract

Since 1977 the YugNIRO Research Institute (Kerch, USSR) has carried out biological and ecological monitoring of krill resources in the central part of the Indian Ocean sector of the Antarctic (CCAMLR Statistical Divisions 58.4.2 and 58.4.3). Results of surveys conducted from 1988 to 1990 are discussed in the paper. It was found that the increase in krill biomass observed in the area in 1990 is linked with the abundant 1986 and 1987 year-classes and with a diminished rate of emigration of krill of these year-classes from the area in 1989/1990.

Résumé

Depuis 1977, l'Institut de recherche YugNIRO (Kerch, URSS) a effectué le contrôle biologique et écologique des ressources de krill dans la partie centrale du secteur de l'océan Indien de l'Antarctique (divisions statistiques 58.4.2 et 58.4.3 de la CCAMLR). Les résultats des campagnes d'évaluation menées de 1988 à 1990 sont discutés dans ce document. Ils révèlent que l'augmentation de la biomasse du krill observée dans cette zone en 1990 est liée à l'abondance des classes d'âge de 1986 et 1987 et de la diminution du taux d'émigration du krill de ces classes dans cette zone en 1989/1990.

Резюме

Начиная с 1977 г. ЮгНИРО (Керчь, СССР) выполняет мониторинг биологических и экологических параметров ресурсов криля в центральной части индоокеанского сектора Антарктики (Статистические участки АНТКОМа 58.4.2 и 58.4.3). В настоящем документе рассматриваются результаты съемок, выполненных в 1988-1990 гг. Было установлено, что отмеченное повышение биомассы криля в этом районе в 1990 г. связано с вступлением в запас мощных годовых классов 1986 и 1987 гг., а также с пониженными темпами миграции криля этих годовых классов из данного района в 1989/1990 г.

Resumen

Desde 1977 el instituto de investigación YugNIRO ha realizado estudios ecológicos y biológicos de seguimiento del krill en la parte central del océano Indico Antártico (Divisiones Estadísticas 58.4.2 y 58.4.3 de la CCRVMA). Este trabajo presenta los resultados de las prospecciones realizadas entre 1988 y 1990. Se ha visto que el aumento de la biomasa del krill en la zona durante 1990 está relacionada con la abundancia de las clases anuales de 1986 y 1987 y con un índice de emigración de krill menor de estas clases en la zona durante 1989/90.

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1. INTRODUCTION

Since 1977 the YugNIRO Research Institute (Kerch, USSR) has carried out biological and ecological monitoring of krill resources in the central part of the Indian Ocean sector of the Antarctic (CCAMLR Statistical Divisions 58.4.2 and 58.4.3). Integrated trawl/acoustic krill census surveys have been carried out over the whole area (south of 60°S between 60 and 80° E) and, in particular, in the southern coastal waters of the area (south of 65°30'S). Until 1988 krill biomass was determined by a technique based on the processing of echosounder records and trawl catch data, but after this, only acoustic survey techniques were used. Results of acoustic surveys conducted from 1988 to 1990 are presented in the paper.

2. MATERIALS AND METHODS

Data on survey areas, spacing of survey tacks and integrated intervals are given in Table 1. The boundaries of survey areas were not fixed from year to year. Therefore, data in Table 1 covers only areas where the same level of detail and accuracy in biomass assessment was obtained during the period under consideration. In the open ocean this area falls between 60° and 75°E; near the coast - between 60° and 69°E.

The following set of hydroacoustic equipment was used: a "Sargan" sonar, a "SIORS" echo-integrator and a "USOD" sonar-integrator bridge device with a working frequency of 136 kHz. A copper ball, 26 mm in diameter, was used to determine the acoustic constant. Krill target strength was calculated using the formula:

$$TS = -97.2+20.01 \text{ LogL}$$

Two types of trawls were used for krill sampling: an Isaacs-Kidd midwater trawl with a 6.0 sq. m opening and a Samyshev-Yevdokomov scientific trawl with a 30 sq. m opening. Trawling speed was 2.5 to 3.0 knots. During the night when krill migrates to the surface, the surface layer was regularly sampled in order to validate results of the hydroacoustic survey. The results obtained were used to map krill density distribution.

3. DISCUSSION OF THE RESULTS

In 1988 no macro-scale survey was conducted in the Sodruzhestva Sea, although a survey of its southern part (to the south of 65°50'S between 59° and 80°E) was made. The total biomass of krill in the surface layer of the area was $3.5\pm0.6 \times 10^3$ tonnes, and mean density was 41 g/m^2. In the eastern part of the area, krill was found in loose aggregations with a mean density of 34 g/m^2. Dispersed aggregations and separate shoals of krill were most frequently observed on echo-records. The higher krill density was observed in the western part between 60° and 69°E, which was designated the standard survey area (Figure 1). Mean density in the area was 48 g/m^2 (Table 1). Dense but unstable concentrations of krill in the form of shoals and aggregations of about 0.5 miles in length were observed over the continental slope between 61° and 62°30'E. Daily catches by scientific survey vessels varied within a range of 10 to 35 tonnes. The biomass of exploitable krill concentrations (high density concentrations) was $0.3\pm0.05 \times 10^3$ tonnes.

In 1989 the macro-scale survey was carried out in February and the meso-scale survey was carried out during the first ten days of March (Figure 2). Krill biomass over the whole of the survey area (540×10^3 square miles) was 12.0±4.0. In the coastal waters of the area (53×10^3 square miles) it was $4.0\pm0.7 \times 10^3$ tonnes. In the waters between 60° and 69°E of the survey area total krill biomass was $3.5\pm0.6 \times 10^3$ tonnes, and the biomass of the exploitable krill concentrations was $0.5\pm0.09 \times 10^3$ tonnes. Krill density in the surface layer was 92 g/m^2

(Table 1). In contrast to 1988, dense krill concentrations were observed not only over the continental slope, but also in the waters between 68° and 69°E, which is an area where krill concentrations in the Sodruzhestva Sea are most frequently observed .

In 1990 the macro-scale survey indicated an increase in the observed frequency of dense krill concentrations, mainly in the western part of the area between 60° and 75°E (Figure 3). Echo-records of a group of shoals (5 to 6 shoals per mile) of up to 200 m in length and 15 m deep were most frequent. Dispersed concentrations up to 20 miles in length were also observed. Mean density was 47 g/m^2 (Table 1). Echo-records of krill to the east of 75°E were not frequent; shoals were usually 5 to 7 m deep, spaced wide apart. Mean density was 12 g/m^2. Mean density for the whole of the area surveyed (60° to 80°E, 760x10^3 square miles) was 39 g/m^2.

A considerable spatial variation in krill density was also a characteristic feature of coastal waters (Figure 4). In the east of the area, krill density was about 32 g/m^2, whereas in the west it was 167 g/m^2. Krill biomass in concentrations having a density of 850 g/m^2 and more, was estimated to be 0.8±0.15 g/m^2. The most stable concentrations of krill (5 500 g/m^2 maximum) were observed over the continental slope between 65° and 66°E. These concentrations were repeatedly recorded on a micro-scale during the summer.

The abovementioned data on krill biomass and density demonstrated that in 1990 there was a considerable increase in both parameters as compared with 1988 and 1989, mainly in the west of the area surveyed (60° to 70°E). Krill density in the surface layer of the "standard" survey area (south of 60°S between 60° and 75°E) in 1990 was close to its average value for the period from 1977 to 1987, considerably less (1.5 to 2.0 times) than in 1977 to 1979, but considerably higher (3 to 4 times) than in 1986/1987.

On the basis of many years of observations, it is considered that variations in krill biomass in the area are mainly dependent on annual variations in circulations of the atmosphere and the hydrosphere. These environmental parameters determine conditions for reproduction and the replenishment of the "local" krill population. Since 1988, a remarkable growth in atmospheric circulation activity has been observed over the area surveyed, leading to an increase in meandering of current fields to the south of the Antarctic Divergence. Such conditions were responsible for a reduction in the emigration rate of krill from the Sodruzhestva Sea in comparison with the previous period (1986 to 1988) and for an increase in krill biomass in the area.

The data in Table 2 show that an increase in biomass is mainly observed in length groups 38.1 to 45.0 and 45.1 to 52.0 mm (identified as 1987 and 1988 year-classes), i.e. the size groups mostly retained in the area in 1989/1990.

4. CONCLUSION

Results of the integrated census surveys of krill from 1988 to 1990 confirmed earlier findings of the YugNIRO Research Institute that a high natural variability of krill biomass is observed in the Sodruzhestva Sea.

In our opinion, the primary cause for the krill biomass variability is inter-annual variability in atmospheric circulation which determines the level of isolation of the area from adjacent waters. If this level increases, the biomass of krill grows only gradually, because of the inertia of biological processes. If the level of isolation decreases and immigration of krill from adjacent areas is limited, a reduction of krill biomass occurs. It is this tendency which has apparently been observed during recent years.

Table 1: Results of acoustic census surveys in the Sodruzhestva Sea in 1988 to 1990.

Survey Number	Survey Period	Scale	Survey Area Boundaries	Survey Area (square km)	Tack Spacing (miles)	Integrated Distance (miles)	Mean Surface Krill Density (g/m^2)	Biomass x 10^6 tonnes	
								Total	Exploitable Concentrations
1	1988 (February to early March)	Meso	66° to 67°S 60° to 69°E	42 000	25	4	48	2.0±0.3	0.3±0.05
2	1989 (February)	Macro	60° to 60°40S 60° to 75°E	540 000	125	30	22	12±4	-
3	1989 (1 to 10 March)	Meso	65°50' to 60°55'S 60° to 69°E	37 800	28	4	92	3.5±0.6	0.5±0.09
4	1990 (January)	Macro	60°67°S 60° to 75°E	590 000	125	30	47	28±9	-
5	1990 (February to early March)	Meso	65°30' to 67°08'S 60° to 69°E	53 800	25	4	167	9.0±1.5	0.8±0.15

Table 2: Length composition of krill (%) in the Sodruzhestva Sea (65°30' to 68°00'S, 60° to 80°E) from 1988 to 1990. (Sampling by Isaacs-Kidd trawl).

Year	Length Class (mm)				
	≤30.0	30.1 to 38. 0	38.1 to 46.0	46.1 to 54.0	>54.0
1988	18.9	24.2	37.3	18.8	0.8
1989	8.0	27.9	46.0	17.5	0.6
1990	3.0	9.4	50.1	35.0	2.5

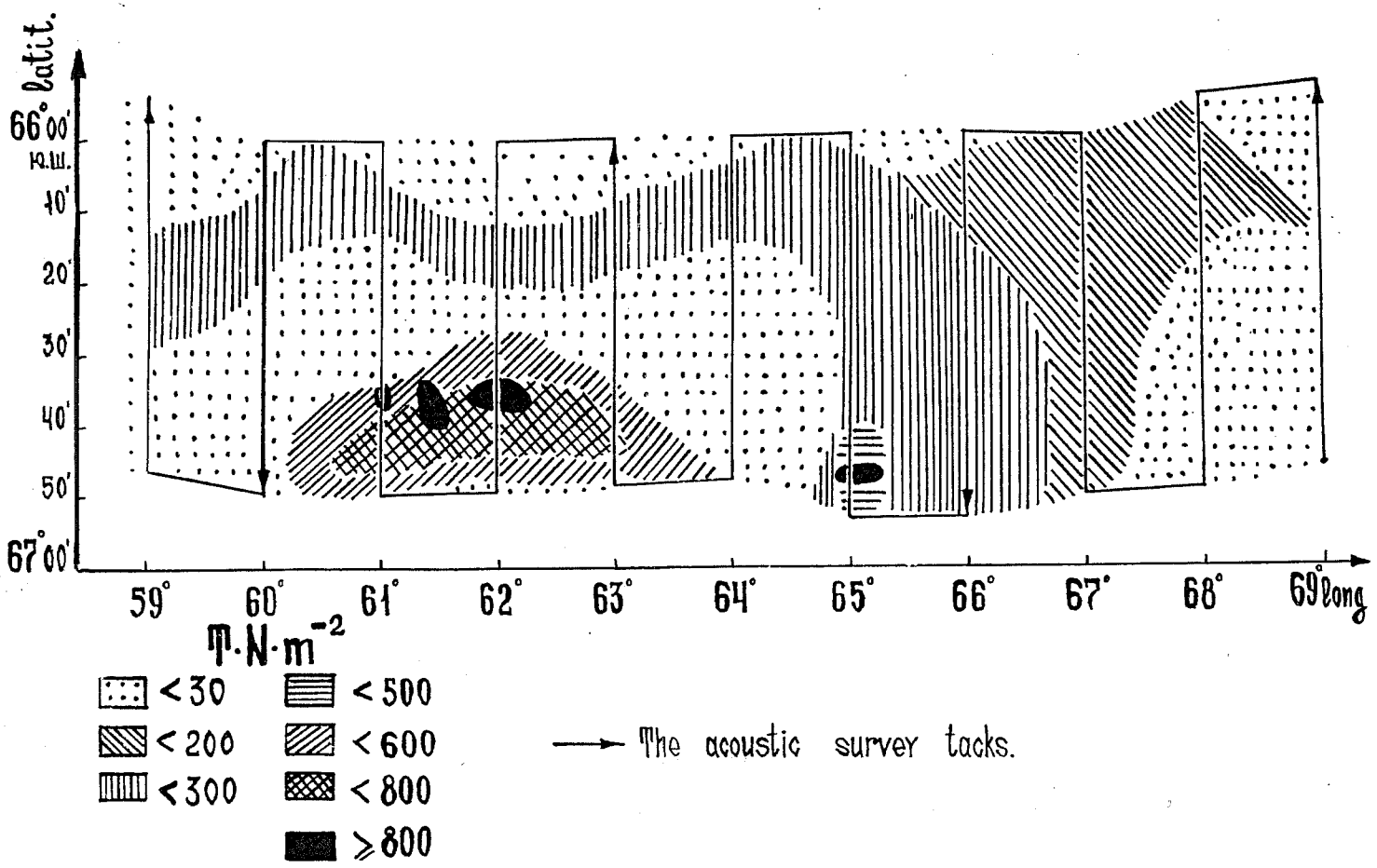


Figure 1: Density of krill in the surface layer (tonnes per square mile) in late February/early March 1988 (meso-scale survey).

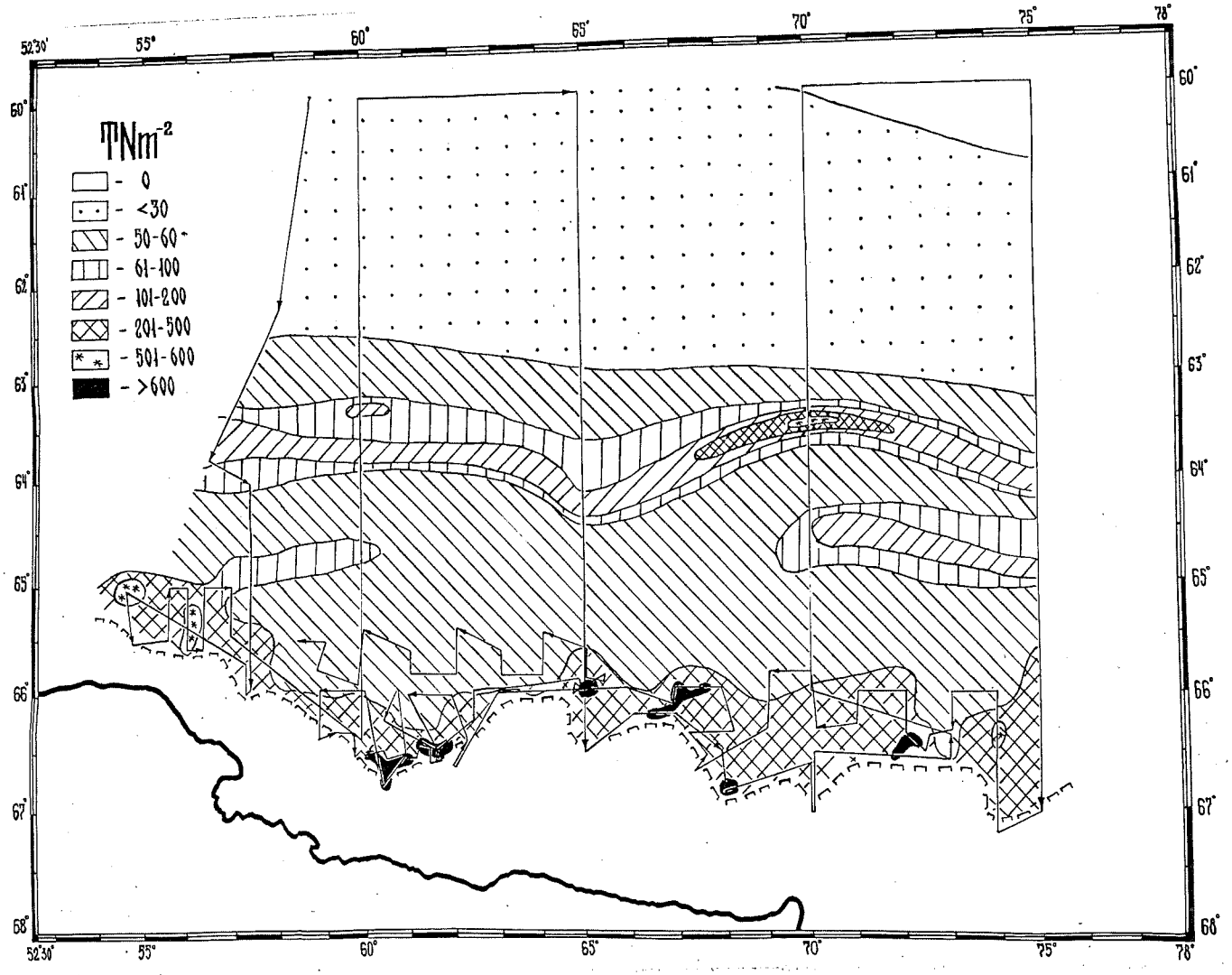


Figure 2: Density of krill in February/early March 1989 (macro- and meso-scale surveys).

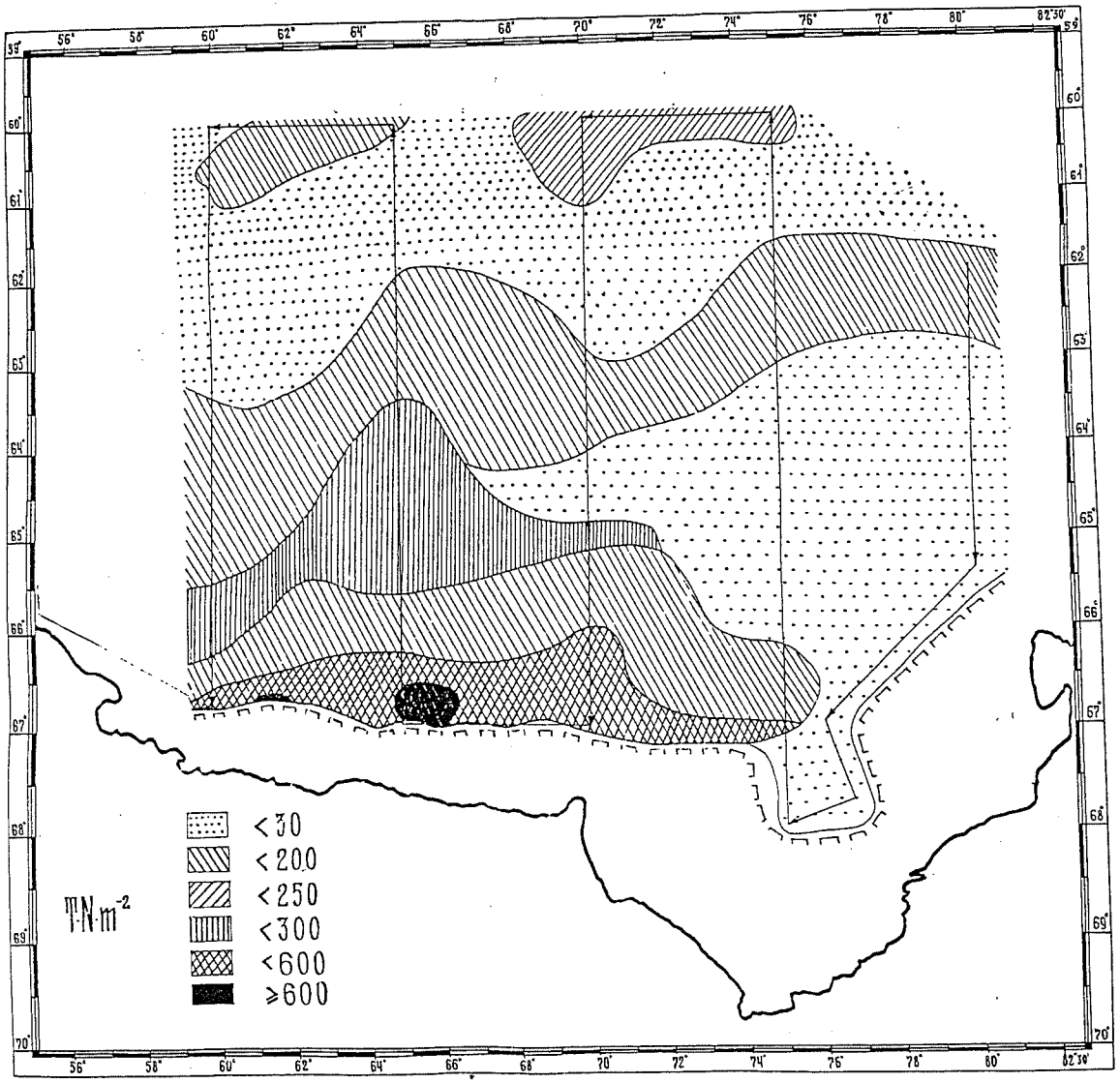
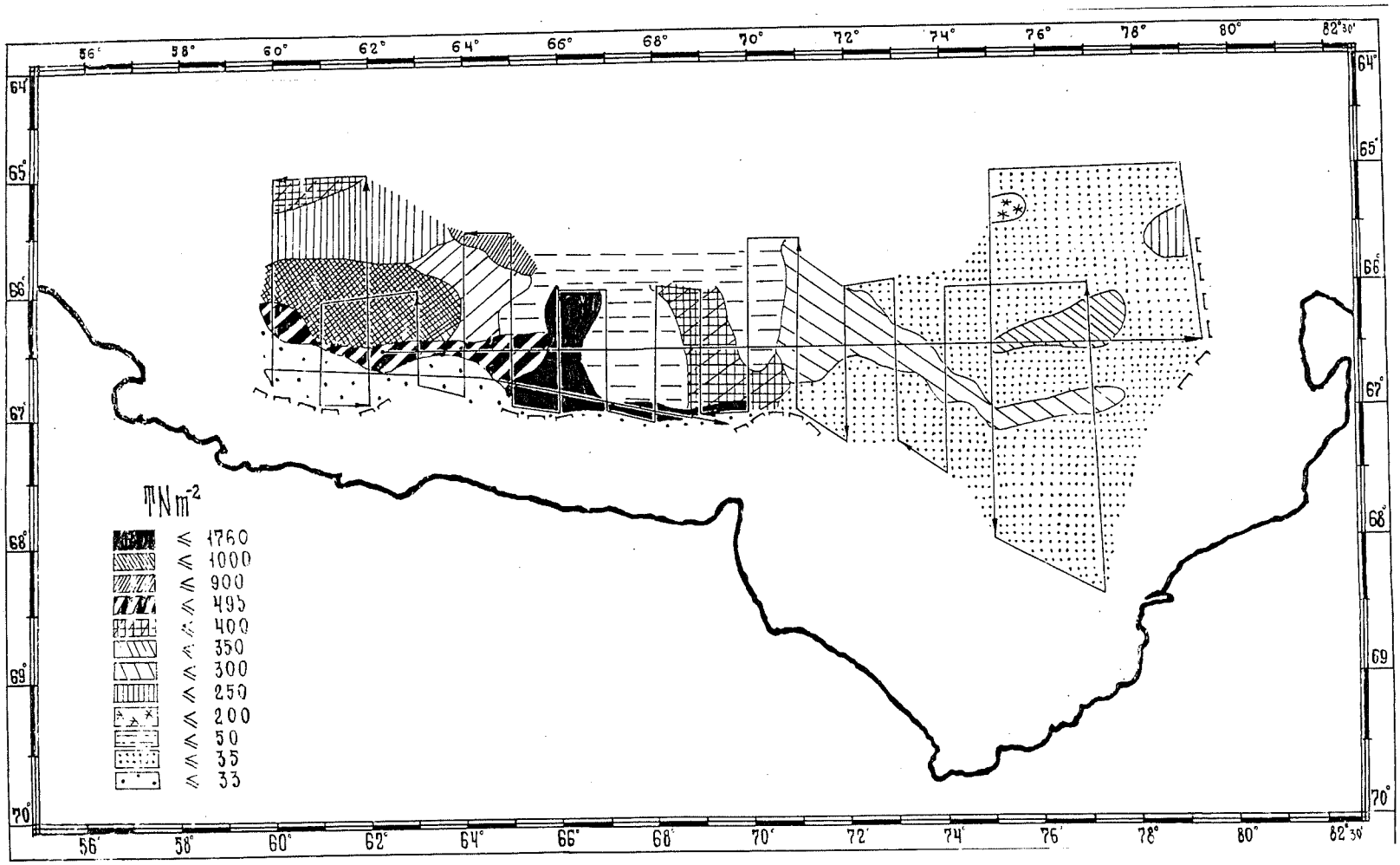


Figure 3: Density of krill in January 1990 (macro-scale survey).



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