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MESOSCALE STRUCTURE OF TEMPERATURE AND SALINITY IN SOUTHERN PART OF THE SCOTIA SEA

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The paper deals with results of hydrophysical investigations carried out at 43 cruise of r/v "Akademik Kurchatov" in mesoscale study area near the Elephant Island (Southern Shetland Islands) from December, 1st, 1985 until December, 6th, 1985. The study area with dimensions of 60 x 60 nautic miles and with center situated 60°35'S and 53°40'W, consisted of 42 hydrological stations distributed at distances of 10 miles. The work involved the data obtained with vertical sounding using STD–sound and standard bathometers.

Macroscale hydrophysical and hydrobiological investigations of this region were carried out during recent years in connection with learning about conditions of forming, maintaining and dynamics of biological communities (Bogdanov et al. 1980, Rakusa-Suszczewski et al. 1985, Grelowski, Tokarczyk 1985). In the literature often were mentioned suggestions on regular dependence of spatial distribution of populations on peculiarities of distribution of hydrophysical factors and on rotatory character of water circulation (Makarov et al. 1980).

The aim of the present paper was detailed investigation of mesoscale structure of hydrophysical factors in a relatively small area, forming a separate interest for hydrobiological investigations. Most important feature of the water dynamics in this region was that an intense Antarctic Circumpolar Current (ACC) which penetrates into deeper waters has no countercurrent and is closely related to the bottom relief (Bogdanov et al. 1980). The presence of Secondary Frontal Zone* (SFZ) separating waters of the Weddell Sea, permits to conclude that there are active hydrophysical processes of synoptic and subsynoptic scales in the spots of krill aggregations north of the Elephant Island, bringing to the corresponding spatial distribution of hydrophysical factors. Evaluations based on theory of synoptic eddies (Kamenkovich et al. 1982) show that typical horizontal scale of possible

*In English papers the term Weddell–Scotia Confluence is used (the Editor).

anomalies of temperature and salinity in the region amounts to 15–30 km, therefore the distance between stations was chosen as 10 miles i.e. 2–3 times less than in oceanographic practice.

In vertical distribution of temperature in the study area two-layer structure of water was observed (Fig. 1, 2). The upper layer 100–150 m thick, was taken by Surface Antarctic Water. The water temperature on the surface ranged slightly from –0.21°C in south-east to +0.48°C in north-west. At the 100 m horizon the amplitude of water temperature change was somewhat higher, from –0.55°C to +0.82°C. In horizons from 0 to 50 m the synoptic variability of temperature regime was poorly expressed and its scale amounted to 36–50 km.

Typical temperatures in the centers of relatively warm patches was from +0.4°C to +0.6°C and in cold ones from –0.1°C to –0.2°C. The scale of temperature ununiformity along vertical direction amounted to 50–70 m.

In deeper layers (200-800 m) which are usually taken by Deep Antarctic Water the temperature anomaly is much more clearly expressed and acquire more organized shape. The range of temperature variation is also larger. So, at a depth of 300 m (Fig. 3) the temperature ranged from –0.7°C to +2.0°C. In maps of temperature distribution at horizons from 200 to 500 m four main structures can be distinguished. The most important one is clearly expressed, subsurfacial Secondary Frontal Zone (SFZ) which is delineated with isotherms from 0.3 to 1.2°C and it stretches generally from south-west to north-east. On the surface the Secondary Frontal Zone practically is not observed. At horizon of 300 m cyclonic meandering (SFZ) is well observed about 50 km in size, which covers a patch of cold water with minimum temperature –0.4°C (Fig. 3). The temperature decrease through the Frontal Zone in the region of cyclonic meandering amounts to 2.2°C along a distance of 25 km. The depth of cold patch reaches 800 m (Fig. 2).

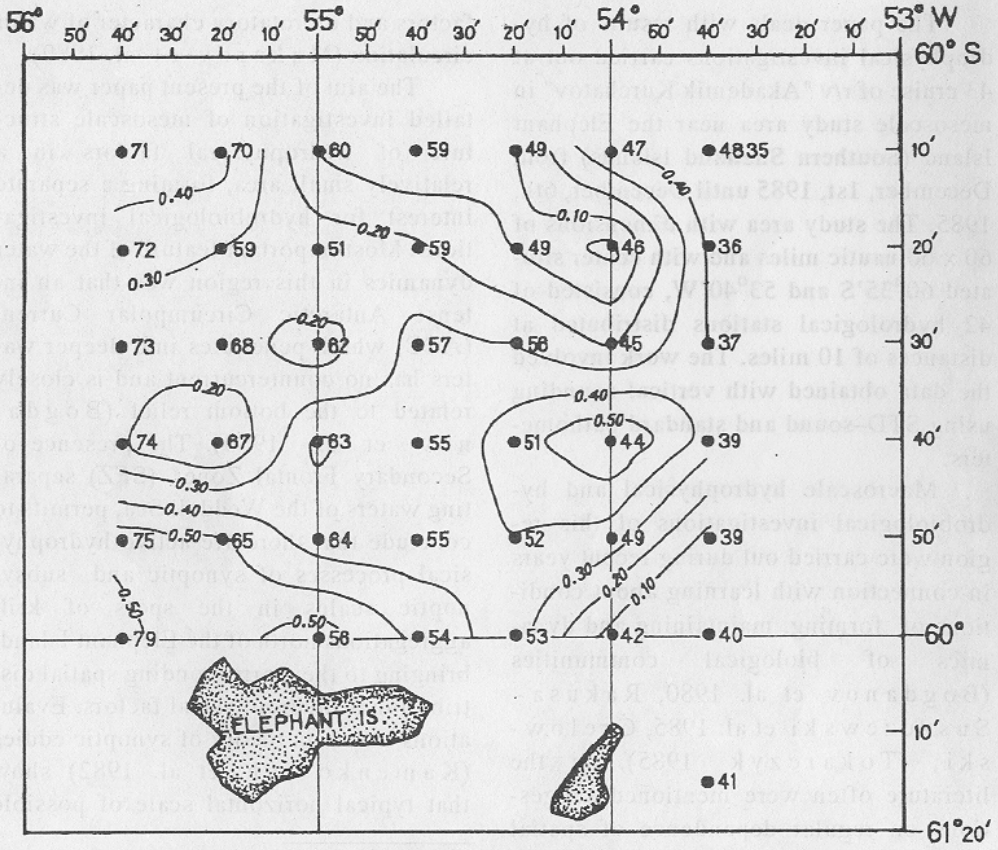

Fig. 1. Scotia Sea, north off Elephant Island. Temperature (in °C) distribution at sea surface. Points and numbers indicate hydrological stations

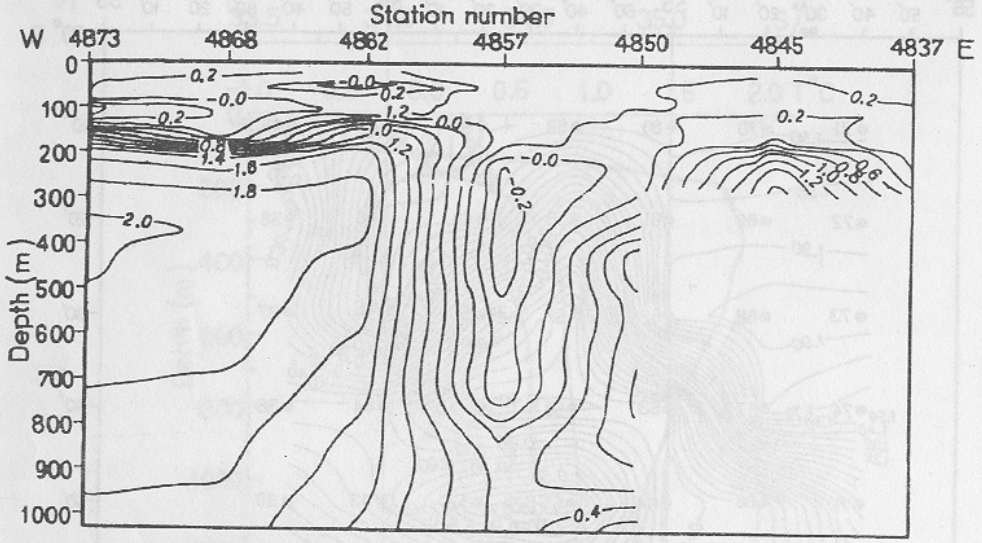

Fig. 2. Scotia Sea, north off Elephant Island. Vertical distribution of temperature in West-East section (stations positions – see Fig. 1)

In north-eastern part of the study area there is a deep anticyclonic meandering SFZ, covering a patch of warm water with temperature in the center of about 1.6°C. The temperature drop between this warm meander and surrounding cold water is approximately 1.6°C. Directly under the warm patch in the layer 0–150 m there is weaker cold patch with temperature of an order –0.2°C and with temperature difference with background of 0.3°C.

In southern part of the study area there is an isolated subsurfacial lense with temperature of 1.5°C, with horizontal size of 30–40 km and vertical one 350–400 m. The difference from the background temperature amounts to 2°C (at horizon of 400 m).

Vertical profiles of temperature in the study area can be split into three types. To the first type belong to typical for Antarctic waters profiles with cold water in the surfacial part and with warmer deep interlayer (Fig. 4). Such profiles of temperature were found northwest off SFZ and in warm patch to the

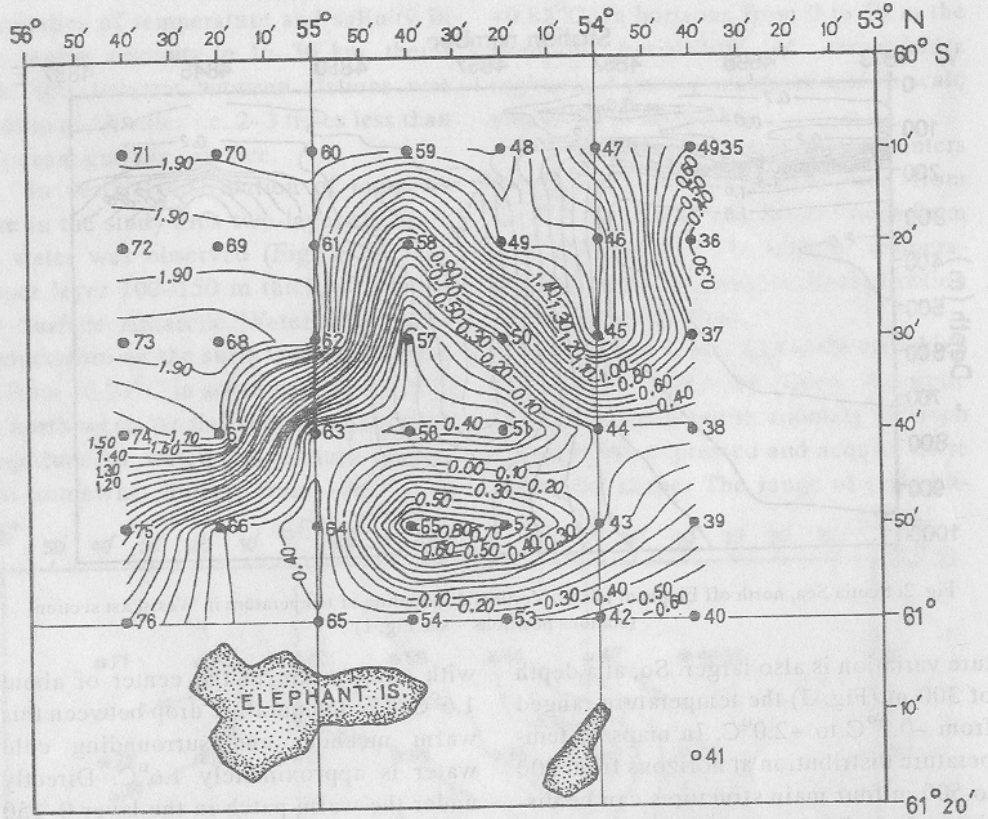

Fig. 3. Scotia Sea, north off Elephant Island. Temperature distribution at depth of 300 m

south of the study area, 19 stations in total. Anomal profiles of temperature with warmer waters in upper parts and cold – in lowering layers (Fig. 4) were observed in 12 stations. Vertical profiles on last stations should be classified as intermediate type.

The salinity regime in the study area has a clearer character than the temperature regime. The salinity on the surface ranged from 33.97‰ in north-west to 34.5‰ in south-east. Isohalines in the upper 15 m layer are elongated especially in direction of SFZ. In subsurfacial layer salinity ranges from 34.42‰ to 34.75‰.

Analysis of temperature–salinity (T–S) characteristics in the region of study area and their comparison with achieved data yield possibility to determine occurrence of main structure forming elements of the study area. North-west part of the study area covers water of south branch of ACC characterized by minimum temperature (about –0.5°C) at salinity of 34.1‰ and flat maximum of temperature (about +2.0°C) at salinity of 34.6‰. These waters form a nucleus of warm patch in Antarctic meandering of SFZ.

The cold patch in the center of study area is formed by waters of continental

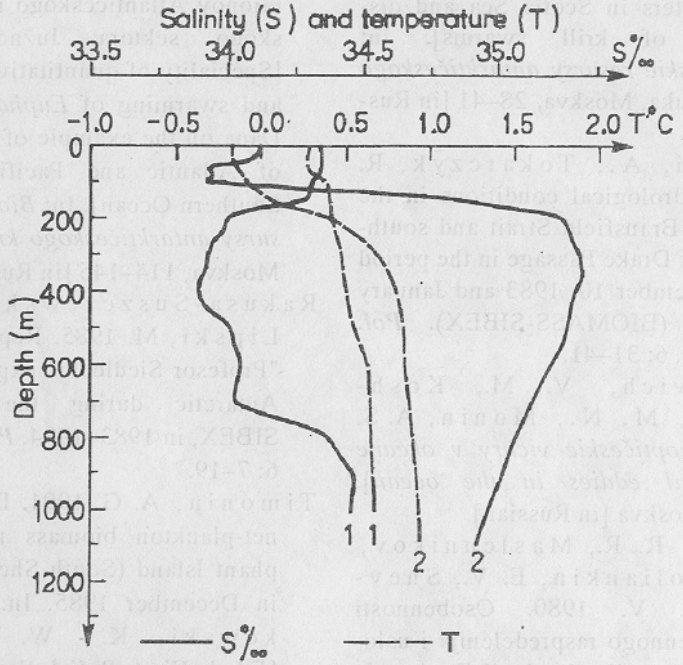

Fig. 4. Scotia Sea, north off Elephant Island. Vertical profiles of temperature and salinity at the stations No. 4857 (lines marked 1) and 4857 (lines marked 2) in the central part of study area (see also Fig. 1)

shelf of northern part of Antarctic Peninsula.

The nucleus of isolated rotation in southern part of the study area is formed by slightly modified waters of southern branch of ACC. Similarity of T–S characteristic in warm lense and in warm meander of SFZ allows to postulate that the lense was formed as a result of separation from anticyclonic meander of SFZ, analogously as forming of Golf Stream.

The study area was characterized by weak, vertical stability and small vertical gradients of potential temperature as well as potential density, what proves that the period of cold convection in this region was not ended yet. This is also suggested by above mentioned patchy structure of the thermocline. Probably penetration of surfacial waters of Antarctic Shelf to the depth of 800 m in the region of station No. 4857 was a result of convective processes complicated by the presence of upbringing current (Fig. 2). In favour of this speaks also augmented concentration of phytoplankton at depth down to 700 m as observed in this station (Timonin 1991).

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