POLISH POLAR RESEARCH (POL. POLAR RES.) POLSKIE BADANIA POLARNE	6	1—2	31—41	1985

Alfred GRELOWSKI[1] and Ryszard TOKARCZYK[2]
[1] Sea Fisheries Institute, al. Zjednoczenia 1, 81—345 Gdynia
[2] Department of Polar Research, Institute of Ecology, Polish Academy of Sciences, Dziekanów Leśny 05-092 Łomianki, Poland.

Hydrological conditions in the region of Bransfield Strait and southern part of Drake Passage in the period from December 10, 1983 and January 8, 1984 (BIOMASS-SIBEX)*)

ABSTRACT: On the basis of T/S measurements water masses were differentiated and geostrophic currents were drawn. It was stated, that the Weddell Sea waters filled a major part of Bransfield Strait from the southeast to Trinity Island on the west. Waters originating from Bellingshausen Sea occurred in the western and northern part of the research area and along the southern coasts of Shetlands. The direction of the geostrophic current is from the southwest to the northeast with a branch in the south at the top of the Antarctic Peninsula.

1. Introduction

The Bransfield Strait is situated between the Antarctic Peninsula and South Shetland Islands, and is influenced, in accordance with Clowes (1934) and Gordon, Nowlin (1978) by the waters flowing from Bellingshausen and Weddell Seas. The Bellingshausen Sea waters penetrate into the Strait between Low, Smith and Snow Islands. In the vicinity of Deception Island a branch of the current forming a characteristic bend (Clowes 1934) may be encountered. This part of the current may reach as far as Trinity and Hoseason Island (Stein and Rakusa-Suszczewski 1983) where it is turned back and directed towards the South Shetlands, forming a strong, north-eastern flow along their southern shores. Generally the same, north-eastern

*) This research was a part of the MR-I-29A Project and was supported by a grant from the Polish Academy of Sciences.

direction of the flow is present on the northern side of the archipelago (Nowlin, Whitworth and Pillsbury 1977), but in the close vicinity of the northern shores of South Shetlands an opposite northwestern direction of the current may be observed (Clowes ibid.). Along the shores of the Antarctic Peninsula the surface waters of Weddell Sea may penetrate into the Strait from the east to the southwest. Mixing of water masses, which originate from different sources and local factors modify the temperature and salinity what caused, that no less than a few water masses have been differentiated in this area (First Post FIBEX 1982, Stein and Rakusa-Suszczewski 1984).

A region of Weddell-Scotia Confluence or rather (Patterson and Sievers 1980) its northern boundary stretches between the South Shetlands and Elephant Island and farther to the South Orkneys. This boundary separetes the Weddell Sea Deep Water from those of the southeastern pacific origin (Gordon 1967) is sharply defined by a specific vertical distribution of temperature (Stein 1981, Second Post FIBEX 1983). Its position is traced in the area between the South Shetlands and South Sandwich Islands indicates at an connection with the bottom topography (Gordon 1967, Patterson and Sievers 1980).

During the SIBEX r/v "Profesor Siedlecki" completed 73 hydrographic stations in the region of South Shetlands. On the basis of these data the distribution of the water masses and geostrophic currents in December 1983 — January 1984 is discussed.

2. Material and method

In the period from 10 December to 8 January 1984 measurements of water temperature and salinity in the function of depth were conducted on 73 oceanographic stations (Fig. 1) from on board r/v "Profesor Siedlecki". The measurements were taken with Bisset-Berman TSDDO model 9040, usually from the surface to the depth of 500 meters. The data obtained were then compute with computer Elliot 905. Differentiation of water masses was based on analyses of T-S diagrams drawn for each of the stations (Fig. 2). The boundaries of water masses with different T/S in the layers 0 — 200 m and 0 — 500 m are presented (Figs. 3, 4). Geostrophic currents were calculated with the method of the dynamic heights in relation to the layer 500 db. On the basis of the values obtained the isolines of dynamic heights have been drawn (Fig. 5) in order to find the relative motion and direction of the current.

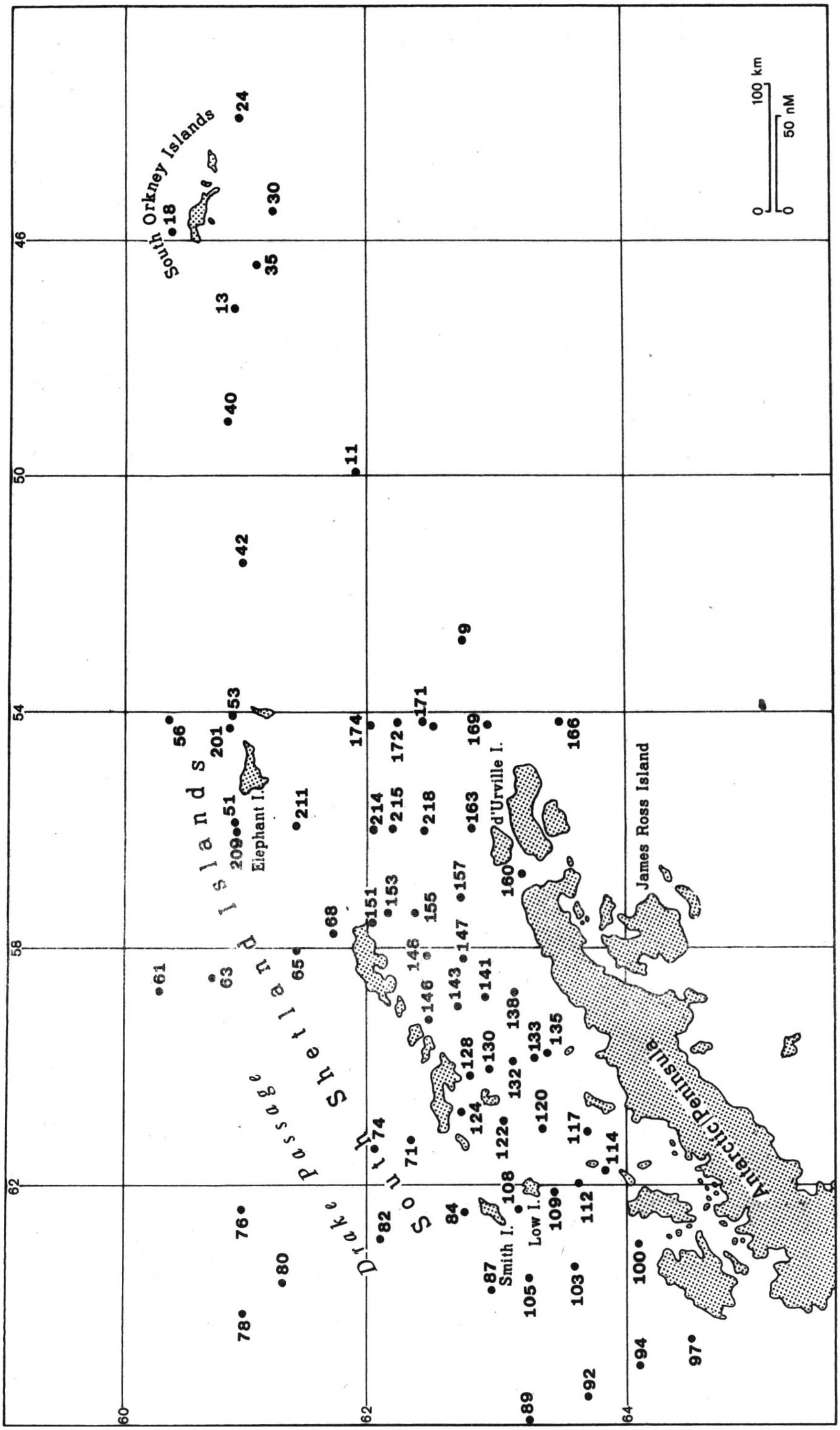
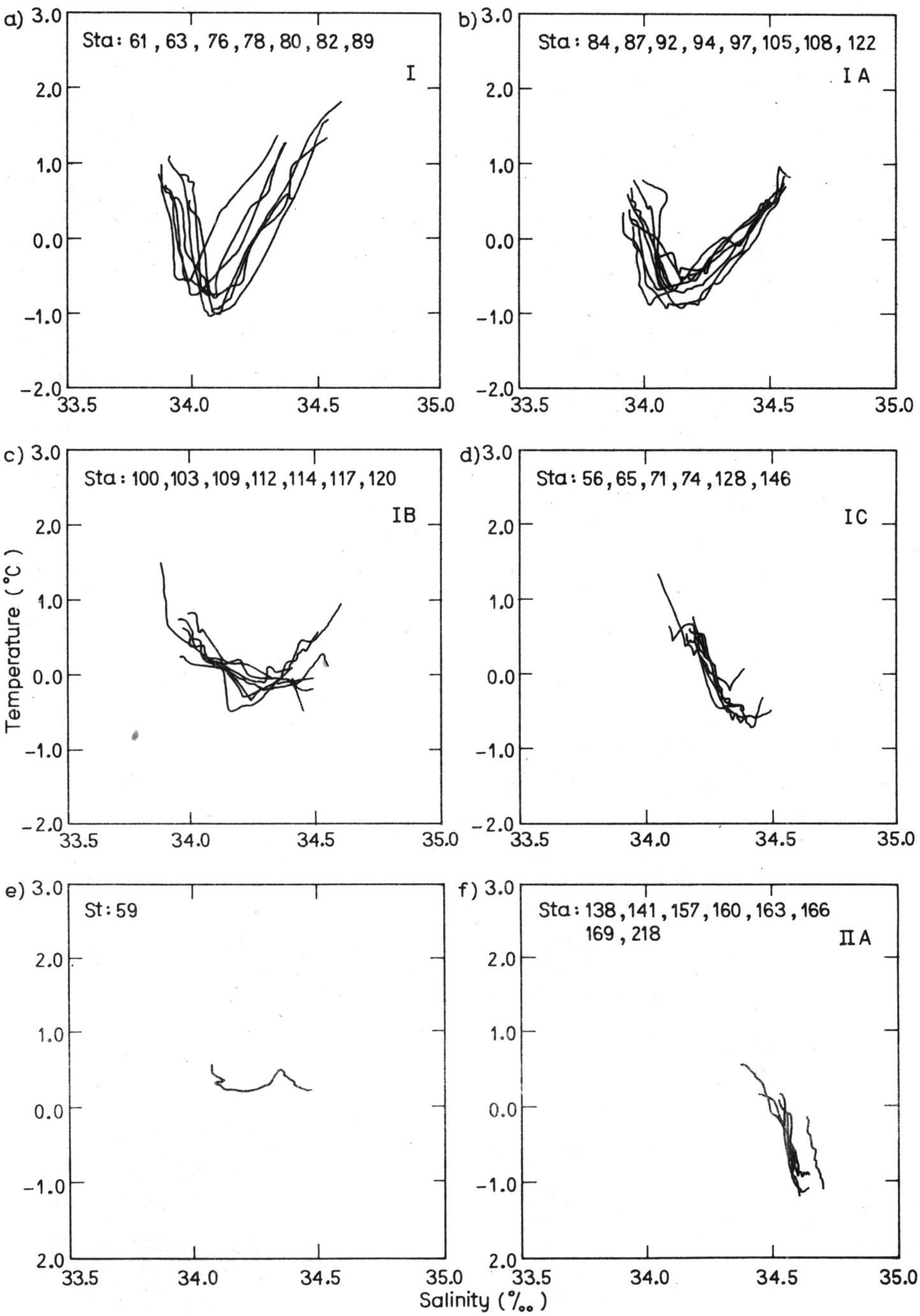


Fig. 1. — Position of oceanographic stations with r/v "Profesor Siedlecki" during SIBEX, 10 December 83 — 8 January 84


a)
Sta: 61, 63, 76, 78, 80, 82, 89
I
b)
Sta: 84, 87, 92, 94, 97, 105, 108, 122
I A
c)
Sta: 100, 103, 109, 112, 114, 117, 120
IB
d)
Sta: 56, 65, 71, 74, 128, 146
IC
e)
St: 59
f)
Sta: 138, 141, 157, 160, 163, 166
169, 218
II A
3.0
2.0
1.0
0.0
-1.0
-2.0
33.5
34.0
34.5
35.0
Temperature (°C)
Salinity (‰)

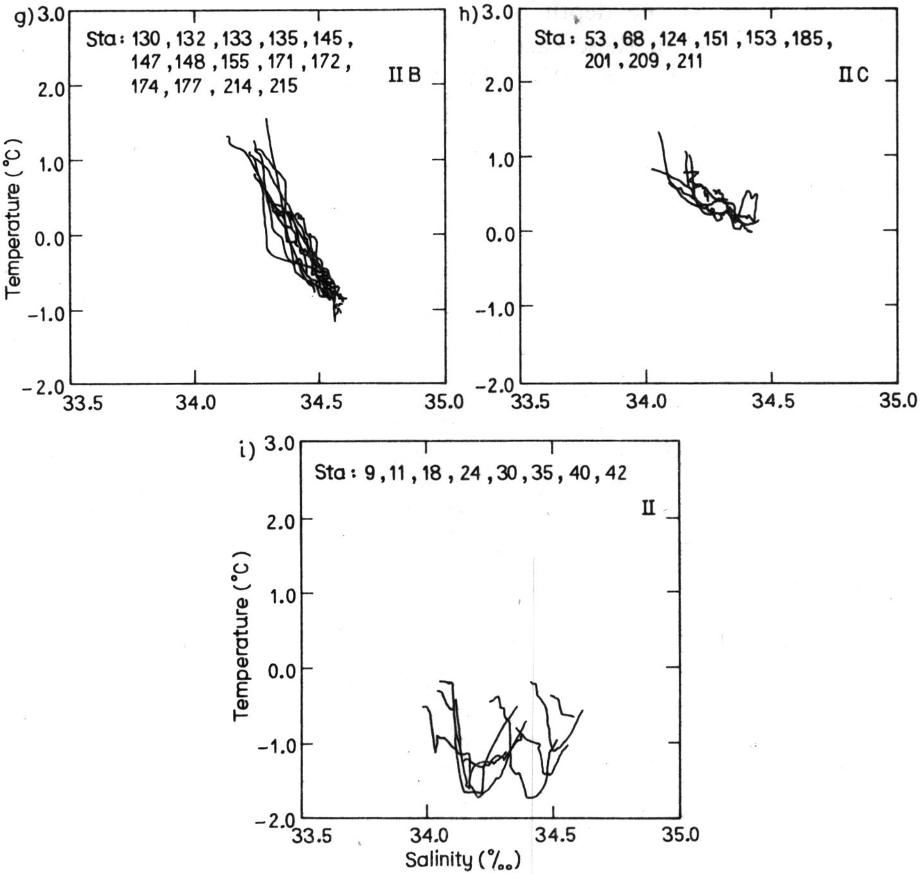


Fig. 2. — T-S diagrams of oceanographic stations grouped in accordance with their characteristics
— class I — waters connected with Bellingshausen Sea,
— clase II — waters connected with Weddell Sea.

3. Results

On the basis of the analysis of T-S diagrams two main categories of water masses were differentiated: warmer, somewhat less saline waters originating from Bellingshausen sea were icluded in class I (Fig. 2 — Ia, b, c); colder and saline waters with a characteristic similar to Weddell Sea water were included in class II (Fig. 2 — IIa, b, c). The cleary marked presence of Warm Deep Water occuring in the layer 0—200 m is common feature of the waters belonging to class I, the temperature and salinity of which indicate at connection with the Bellingshausen Sea. On the T-S diagrams (Fig. 2) the presence of this layer can be observed in the form of the distinct temperature maximum and usually from the salinity 34.2‰. At the depth of a few tenths of meters the temperature growth reaches 2°C in these case of the waters I, Ia found in the western part of the research area (Fig. 3). To the northeast this temperature

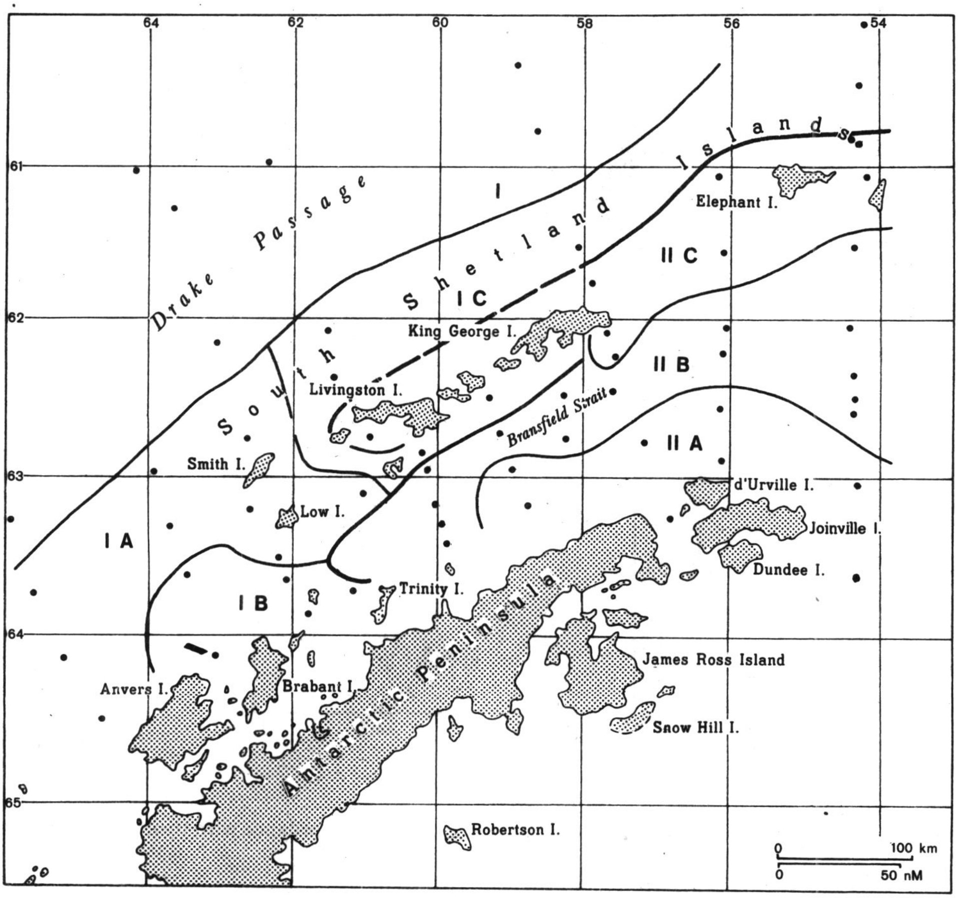


Fig. 3. — Distribution of water masses in the layer 0 — 200 m in the period 10 December 83 — 8 January 84

difference diminishes, nevertheless the characteristic temperature minimum delimiting the boundary between surface and deep waters is always visible (Figs. 2, 3, type Ib, Ic).

Characteristic for the waters adjoining the Bransfield Strait and belonging to the class II is the lack of Warm Deep Water in the discussed layer (Fig. 2 — IIa, b, c). In the case of the stations situated in the vicinity of the Antarctic Peninsula it means that practically it is absent from the whole water column, from the surface to the bottom. High salinity and low temperature of waters of this category indicates at an influence the Weddell Sea. This waters spread from the Trinity Island in the east through the major part of the Bransfield Strait and reach to the eastern

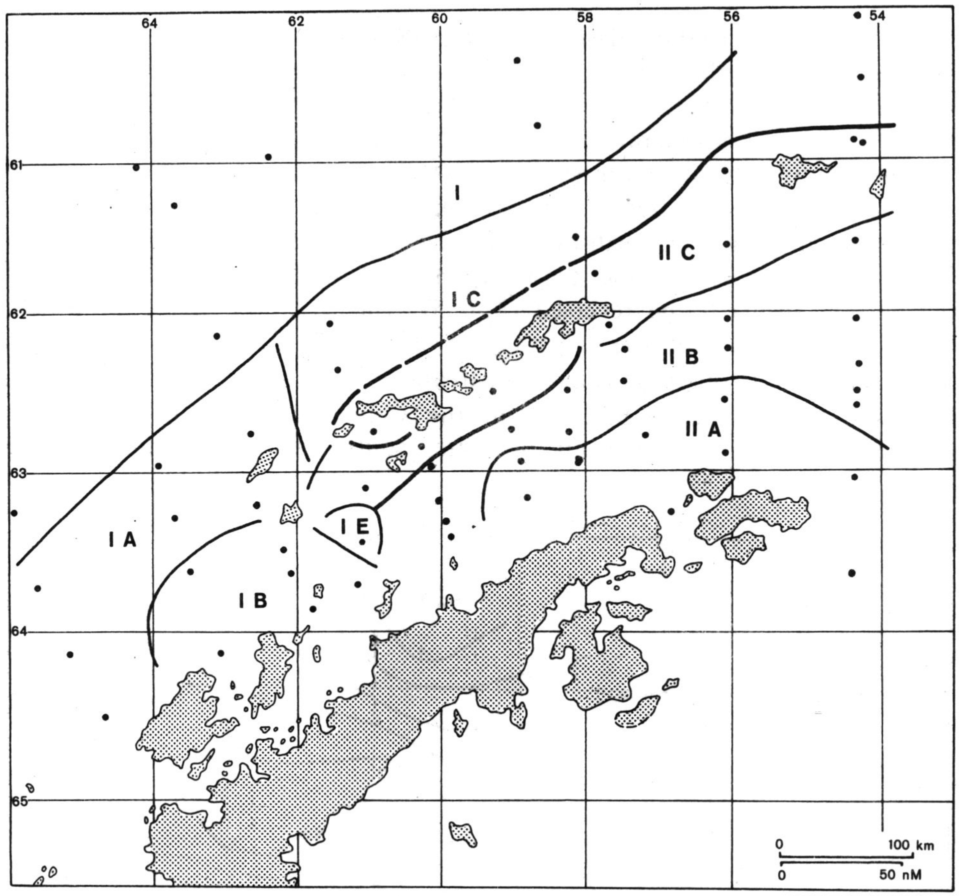


Fig. 4. — Distribution of water masses in the layer 0 — 500 m in the period 10 December 83 — 8 January 84

end of King George Island (Fig. 3). The temperature and salinity of these waters changes gradually from the south to the north. Waters found in the vicinity of the Antarctic Peninsula are colder and more saline, the more northern ones (Figs. 2, 3).

The structure of the T-S diagram of the northenmost station no 59 (Fig. 1) differs from the remaining ones (Fig. 2). Water salinity is visibly different but the temperature remains practically unchanged in the whole of the discussed layer. This station was belong to the boundary region of the Weddell-Scotia Confluence. Its position is in accordance with the boundary reported earlier (Second Post FIBEX — 1983).

To the east of the line Clarence — Joinville Islands stretched the typical Weddell Sea waters, designated with the symbol II, with the presence of Warm Deep Water marked in the layer 0 — 200 m. Their characteristics

(Fig. 2) are similar to those described earlier (Second Post FIBEX — 1983), but since the number of stations made in this region was low (Fig. 1), and the changes of temperature and salinity were gradual, no detailed analysis of the T-S diagrams has been carried out.

The relative dynamic topography 500 db — surface (Fig. 5) correlative with the presented pattern of water masses. The current flow north of the South Shetlands is north-estward, however close to the eastern shores of King George Island and between Smith, Low Island the direction of the current seems to be reversed (Fig. 5). The situation in the Bransfield Strait is similar. In the vicinity of the southern shores of South Shetlands there is observed a narrow stream of north-eastern current flowing from the Bellingshausen Sea, but in the vicinity of the northern shores of the Antarctic Peninsula an opposite, south western current carrying

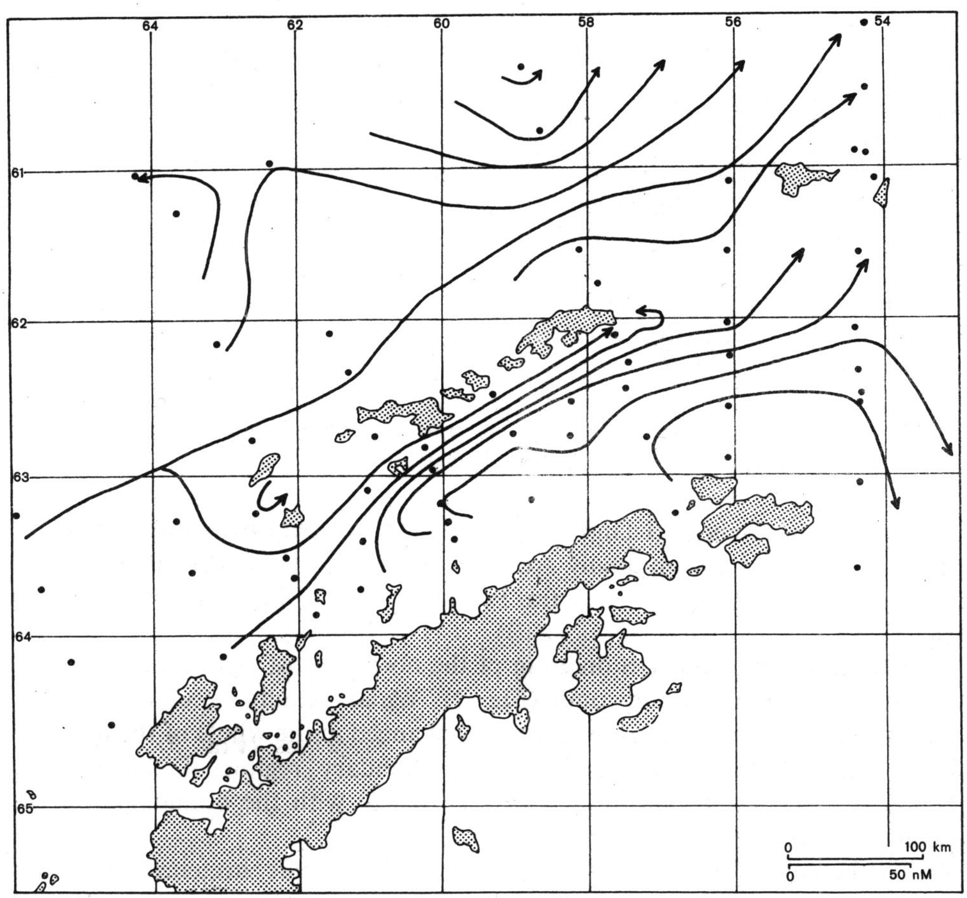


Fig. 5 — Relative dynamic topography 500 db — surface 10 December 83 — 8 January 84

the Weddell Sea waters can be observed. This current reaches as far as Trinity Island, where it seems to be turned back by the waters flowing from the southwest (Fig. 5).

4. Discussion

The separated classes of water masses demarcate the border ranges of the Bellingshausen and Weddell Seas in the region of the South Shetlands, in the period of 10 December 83 — 8 January 84 The system of geostrophic currents is similar to that one observed during FIBEX (Stein and Rakusa-Suszczewski 1983, First Post FIBEX — 1982). The specific meander of current flowing out from Bellingshausen Sea, situated usually between Low, Smith and Deception Islands (Clowes 1934, Stein and Rakusa-Suszczewski ibid.) has not been observed similary as it had place with r/v "Itzumi" (Sievers 1982). It is probable that distribution of the oceanographic stations was too scattered to demonstrate this phenomenon. In comparison with FIBEX expedition, more stations in neighbourhood of Antarctic Peninsula and Joinville Island were established. It make possible the observation of separation of Weddell current, turning back in vicinity of Trinity Island and flowing through Bransfield Strait into two arms (Fig. 5); one driving towards north to Elephand Island, the other directed to the south at 56°W. This splitting of the current is probably connected with the mentioned earlier whirl (Stein and Rakusa-Suszczewski 1983) situated at the southeast from Clarence I.

The system of water masses analysed in the recommended layer 0 — 500 m (Fig. 4) is so similar to that one found in FIBEX (First Post FIBEX 1982) and to the mentioned earlier pattern (Clowes 1934, Gordon and Nowlin 1978) that it seems to be the permanent feature of this region is more connected with the bottom topography than with any other factor. However, such a very stable system of water masses ceases to be useful for biological analyses. The comparison between the T-S diagrams from the deep stations inside the straits with the shallow stations of continental shelf seems also to be not quite regular. Due to the above reservations, T-S diagrams were cut at the depth of 200 m and the system of water masses was analysed in the layer of equal thickness (Fig. 3). After this modification, the obtained system of water masses was slightly simplified. Firstly, the specific waters observed in the area between Low, Trinity and Deception Islands (Fig. 4 — type Ic, corresponding approximately to type B_1W — First Post FIBEX 1982) disappeared, secondly the differentiation of waters type Id (Fig. 4) corresponding approximately to type B_{rs} (First Post FIBEX 1982) on the south side of South Shetlands became unnecesary. Those waters were revealed as identical with the expanding waters type Ic on the north side of the isles (Figs. 3, 4) The scope of waters type IIc (Fig. 3) remains unclear. From the station no 68 (Fig. 1), in vicinity of north coasts of King George Island, it is demarcated with the broken line to the station no 124 situated between Snow and Livingston Islands where the waters with similar characteristics were found. It should be stressed that T-S characteristics of waters type IIc are similar to those ones of waters type Ib (Fig. 2 c, h) found near Anvers and Brabant Islands. It may be perhaps caused by the fact that in both regions we have to deal with the similar mixing of waters coming from Weddell and Bellingshausen Seas, taking part in surfacial layer. The visible meander of current (Fig. 5) near the east coasts of King George Island as well as mentioned south-west direction of the current observed on the north side of islands (Clowes 1934) suggest the posssibility of spreading out of waters type IIc alongside the north shores of South Shetlands.

In order to describe more precisely the structure and dynamics of water masses in this region, distribution of greater number of stations at the north side of shallow shelf of South Shetlands and Antarctic Peninsula seems to be purposeful.

We would like to thank chief our expedition Prof. dr. hab. S. Rakusa-Suszczewski for his indications given before and after the research.

5. Резюме

На основе измерений температуры и солености из 73 океанографических станци был выполнен анализ гидрологического режима района Пролива Брансфилда и островов Южных Шетландов в периоде с 10 Декабря до 8 Января 1984. Из детального анализа Т-С графиков два гловных класса поверхностных вод были найдены: один связан с морем Белингсгаузена, второй с морем Ведделла. В каждом из классов выделено несколько типов вод (рис. 2). Воды происхождения М. Ведделла занимали большую часть Пролива Брансфилда (рис. 3) достигая берегов острова Книг Джордж на севере и острова Триниты на западе. Западную и северо-западную часть рацона занимали воды натекающие из Моря Белингсгаусена, в проливе Брансфилда эти воды протекали узким потоком вдоль берегов Южных Шетландов (рис. 3). Расположение геострофических течений показывает полностью северо-восточное направление течения в рассматриваемом районе (рис. 5), только вблизи северных берегов Антарктического Полуострова и северных берегов островов Южных Шетландов это направление является противположным.

6. Streszczenie

W oparciu o pomiary temperatury i zasolenia przeprowadzone na 73 stacjach, w okresie of 10 grudnia 83 do 8 stycznia 84, została wykonana analiza systuacji hydrologicznej

w rejonie Południowych Szetlandów. Na podstawie analizy T-S diagramów wyodrębniono dwie główne klasy wód: jedną pochodzenia z Morza Bellingshausena, drugą związaną z Morzem Weddella. W obrębie każdej z klas wyróżniono kilka typów mas wodnych (rys. 2). Wody pochodzące z Morza Weddella wypełniały większą część Cieśniniy Bransfielda (rys. 3) sięgając południowo-wschodnich brzegów Wyspy Króla Jerzego — na północy i Wyspy Trinity na zachodzie.

Zachodnią i północno-zachodnią część badanego obszaru wypełniały wody napływające z Morza Bellingshausena — wewnątrz Cieśniny obecne wąskim pasem wzdłuż wybrzeży Szetlandów Południowych (rys. 3). Układ prądów geostroficznych wskazuje na generalnie północno-wschodni kierunek przepływu wód w badanym obszarze (rys. 5). Jedynie w pobliżu północnych brzegach Półwyspu Antarktycznego i północnych brzegach Szetlandów Południowych kierunek ten wydaje się być odwrócony.

7. References

1. Clowes A. J. 1934 — Hydrology of the Bransfield Strait — Discovery Rep. 9: 1—64.
2. First Post FIBEX Hydrographic Data Interpretation Workshop 1983 — Hamburg 20—26 September 1983 — Pol. Polar Res., 4. 155—162.
3. Gordon A. L. 1967 — Structure of Antarctic Waters between 20°W and 170°W — Antarctic Map Folio Series, Fol 6.
4. Gordon A. L., Nowlin W. D. 1978 — The basin waters of the Bransfield Strait — J. Phys. Oceanogr. 8: 258—264.
5. Nowlin W. D., Whitworth T., Pillsbury R. D. 1977 — Structure and transport of the Antarctic Circumpolar Current at Drake Passage from short-term measurements — J. Phys. Oceanogr. 7: 788-802.
6. Patterson S.L., Sievers H. A. 1980 — The Weddell-Scotia Confluence — J. Phys. Oceanogr. 10: 1584—1610.
7. Second Post FIBEX Hydrographic Data Interpretation Workshop — Hamburg 16—20 May 1983, Biomass Rep. Ser. 31.
8. Sievers H. A. 1982 — Description of the physical oceanographic conditions, in support of the study on the distribution and behaviour of krill. — INACH Scientific Ser. 28: 87—136.
9. Stein M. 1981 — Thermal structure of the Weddell-Scotia Confluence — Meeresforsch. 29: 47—52.
10. Stein M., Rakusa-Suszczewski S. 1983 — Geostrophic currents in the South Shetlands Islands area during FIBEX — Mem. Nat. Inst. Polar Res. Tokyo 27: 24—34.

Paper received 23 January 1985