Oceanographic conditions on the Weddell Sea Shelf during the German Antarctic Expedition 1979/80

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Hydrographic (CTD), current and water level measurements obtained in the vicinity of the floating Ronne and Filchner Ice Shelves are presented. The distribution of Western Shelf Water (S > 34.7) and Ice Shelf Water (T<-1.9°C) are discussed. The general circulation in the area seems to consist of two large cyclonic gyres, one in the Filchner Depression and one north of the Ronne Ice Shelf. Each gyre shows a 'warm' (T ~ −1°C) southgoing flow of Modified Weddell Deep Water and a cold northward flow of Ice Shelf Water. The mean surface current was found to be 8 cm/s towards the north-west along the barrier. The mean flow below the ice shelf shows significant components normal to the barrier, and mixing seems to be very efficient here. Well mixed layers down to more than 150 m were observed. North of Berkner Island the water level shows a typical mixed tide with tidal range ~3 m. In the tidal currents the semidiurnal constituents dominate (~30 cm/s) and with the largest current components normal to the barrier.

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The first German Antarctic Expedition to the Filchner and Ronne Ice Shelves with the ice-breaker 'Polarsirkel' took place in 1979/80 (Kohnen 1981). The Geophysical Institute, University of Bergen, was kindly invited by the Alfred-Wegener Institut für Polarforschung, Bremerhaven, to carry out the physical oceanography programme. This provided an opportunity to follow up investigations made in the same area by the Norwegian Antarctic Research Expeditions in 1977 and 1979 (see Foldvik et al. 1985a and 1985b, hereafter referred to as Pol-77 and Pol 79).

The shallow shelves in the southern Weddell Sea are of very special interest to global oceanography. Dense water is known to be produced near the floating Filchner and Ronne Ice Shelves (Foster 1972; Gill 1973) and the favourable ice conditions in 1980 provided us with the opportunity to study the oceanic conditions near these shelves all the way to the Antarctic Peninsula (Fig. 1). A preliminary report on the physical oceanography programme has been given by Gammelsrød & Slotsvik (1981). For convenience, some of their results are reproduced here.

Most of our observations consist of CTD and current measurements. The observation techniques are described in the next paragraph. Typical water masses and water mass distributions are defined in 'Water masses on the Weddell Sea Shelf'. Current measurements obtained from moorings are presented in 'Results from the instrument moorings', and studies of the variability near the barrier (seaward extent of the ice shelf) on time scales of a few tidal cycles are given in 'Time series'. In 'Transformation of water masses', we discuss the origin and circulation of the most dominant water masses observed in the southern Weddel Sea.

Instruments and methods

During the cruise, 179 CTD stations were obtained with a Neil Brown CTD. On-line computer facilities provided data quality control and possibilities for preliminary analysis. The CTD salinities were standardized against water samples obtained with a Niskin bottle triggered by a bottom feeler. The results presented here are based on 2 m averages of the original data. The CTD

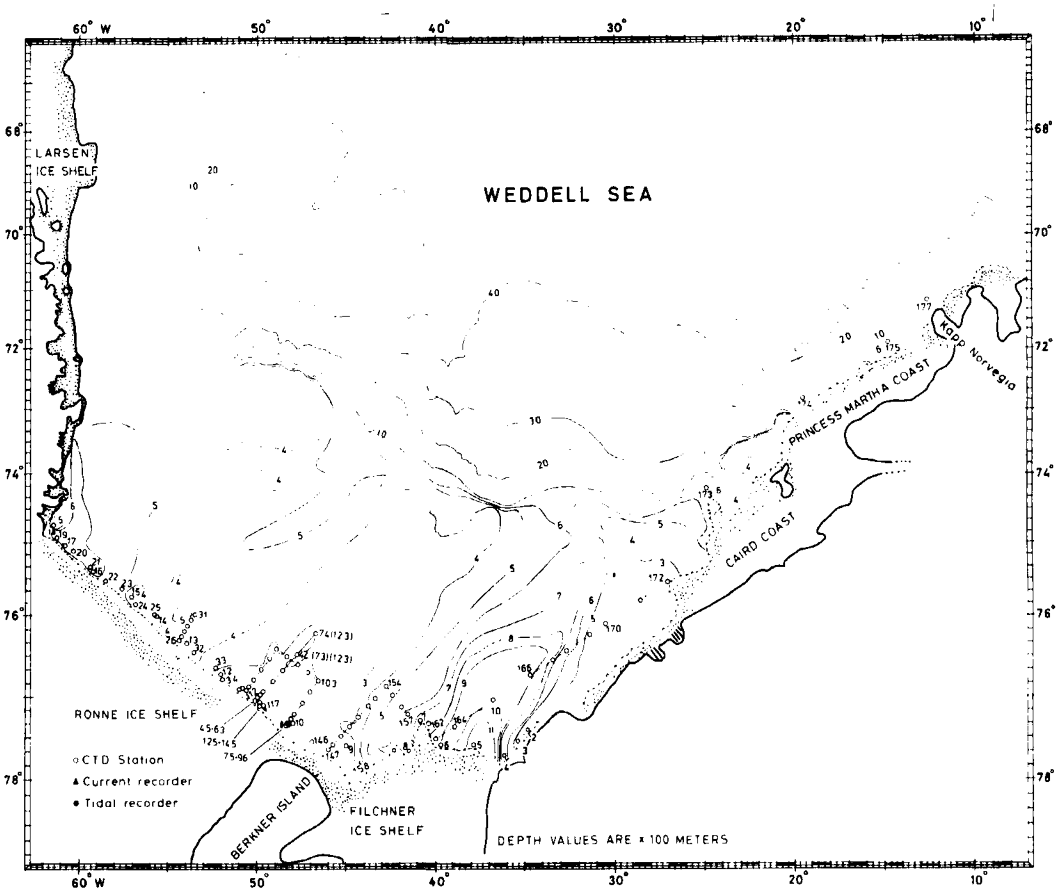

Fig. 1. Map of the southern Weddell Sea. The floating ice shelves are shaded. The CTD stations are marked with circles, and the moorings are marked with solid triangles. Sections are indicated with solid lines.

programme by Røyset & Bjerke (1982) was applied for the computer analysis.

Two current meters (Aanderaa RCM-4) and one pressure recorder (Aanderaa WLR-1) were deployed for 4.5 days on a mooring anchored to the bottom. Data were recorded every ten minutes. The same two current meters were later deployed for a 10-day period, moored to the barrier on a 75 m long wire with a weight underneath.

Current profiles down to 90 m were obtained with a Braystoke meter. Due to leakage in the cable, only a few measurements were made.

Two Sensor Data (SD-2) current meters were used on the CTD cable to obtain current values at two levels when the ship was moored to the ice. These meters give one data point for each cast.

Water masses on the Weddell Sea Shelf

Three station curves showing typical water masses on the southern Weddell Sea Shelf are shown in Figs. 2a, b, c. In Fig. 2d the same stations are plotted in a potential temperature *v.* salinity diagram where the water mass definitions by Carmack & Foster (1975a, b; 1977), Foster & Carmack (1976a, b), and Gordon (1982) are indicated. For a discussion of water masses, see Pol-77.

The relatively fresh Winter Water and Eastern Shelf Water (Fig. 2d) are commonly found in the upper 300–400 m near the coast (Pol-79). The surface layer is often warmer and fresher during summer. This is demonstrated below where most of our CTD data are presented in the form of vertical sections.

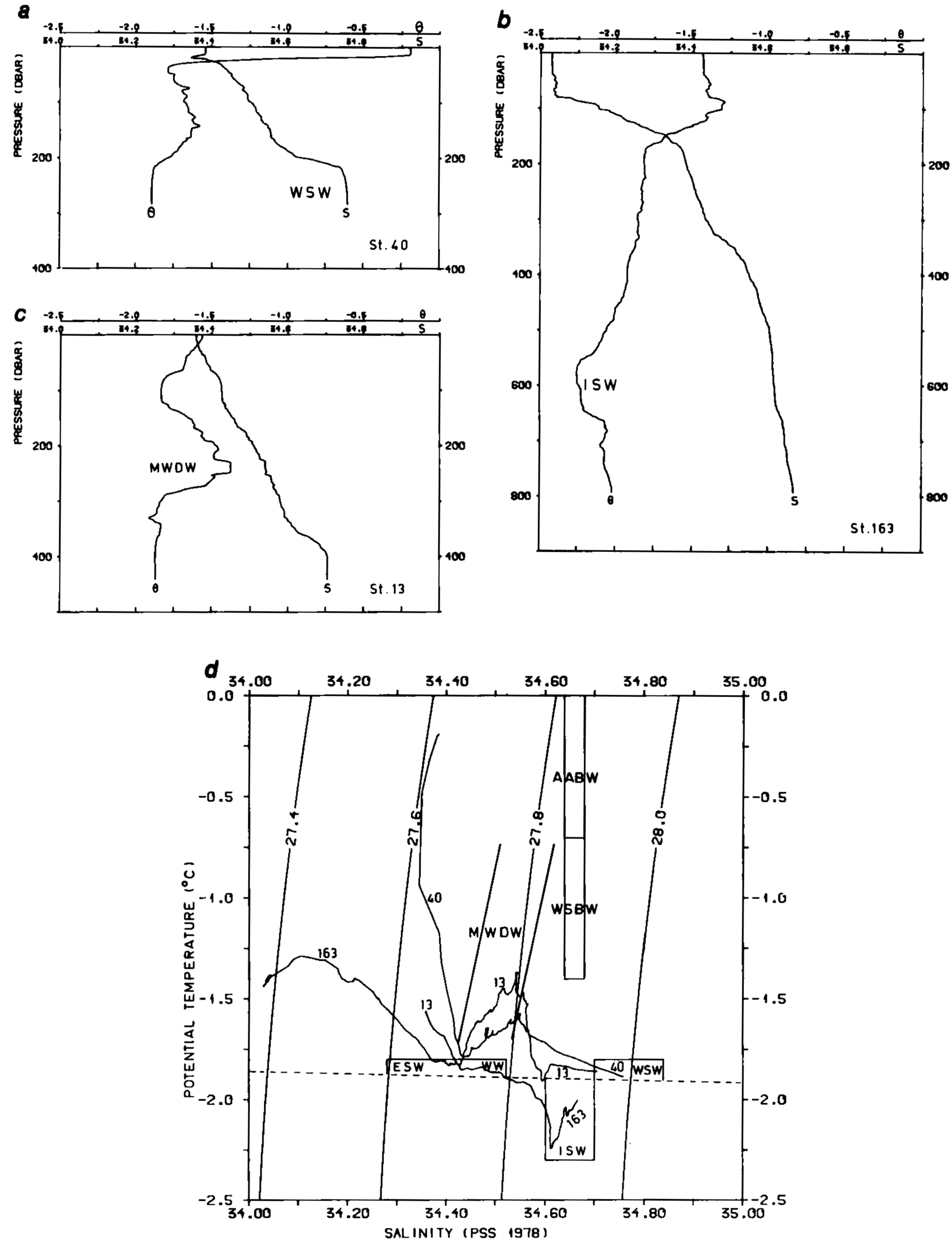

Fig. 2 a. Vertical profiles of potential temperature (θ) and salinity (S) for station 40. Western Shelf Water (WSW) is indicated. b. Vertical profiles of potential temperature (θ) and salinity (S) for station 163. Ice Shelf Water (ISW) is indicated. c. Vertical profiles of potential temperature (θ) and salinity (S) for station 13. Modified Weddell Deep Water (MWDW) is indicated. d. Potential temperature v. salinity diagram for stations 40, 163 and 13. The main Weddell Sea water masses are also shown (from Fig. 5, Pol-77).

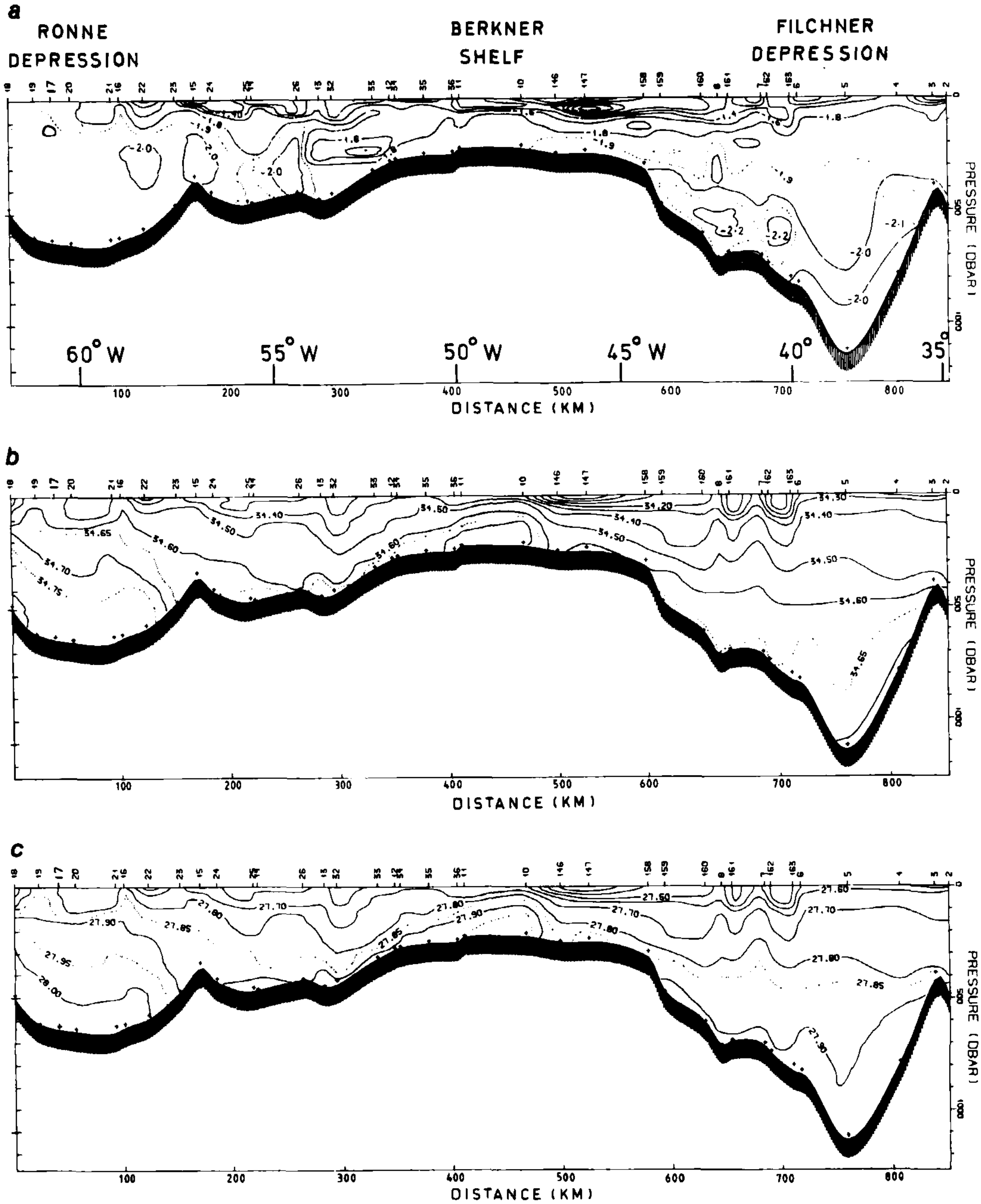

Fig. 3. Section along the barrier from the Filchner Depression to the Ronne Depression. All the stations close to the barrier are used. Crosses denote deepest observations. a. Potential temperature (°C); b. Salinity; and c. Potential density.

Three water masses are of special interest for the deep circulation: Western Shelf Water (WSW, T~−1.9°C, S>34.70) is formed by brine rejection due to freezing on the shelves in the southern Weddell Sea (Mosby 1934; Foster 1972; Gill 1973). WSW appears for example as a saline layer near the bottom at station 40 (Fig. 2a, d) on the shallow shelf north of Berkner Island, which we will refer to as the Berkner Shelf.

Ice Shelf Water (ISW) is formed under the

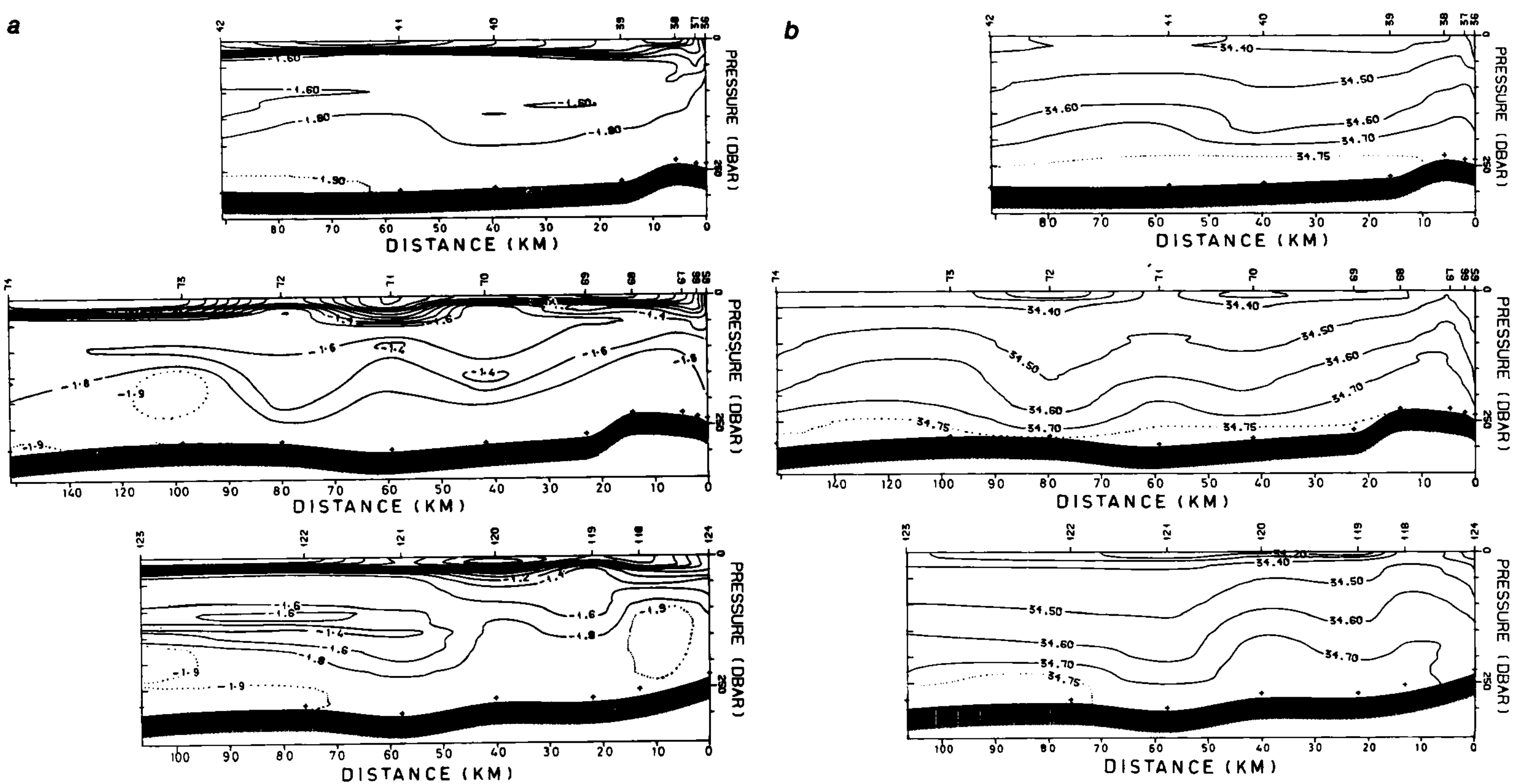

Fig. 4. Leg 1, stations 36–42, 7–8 January 1980; Leg 2, stations 65–74, 15–16 January 1980; and Leg 3, stations 118–124, 31 January to 1 February 1980. Sections normal to the barrier at 50°W. a. Potential temperature (°C); b. Salinity.

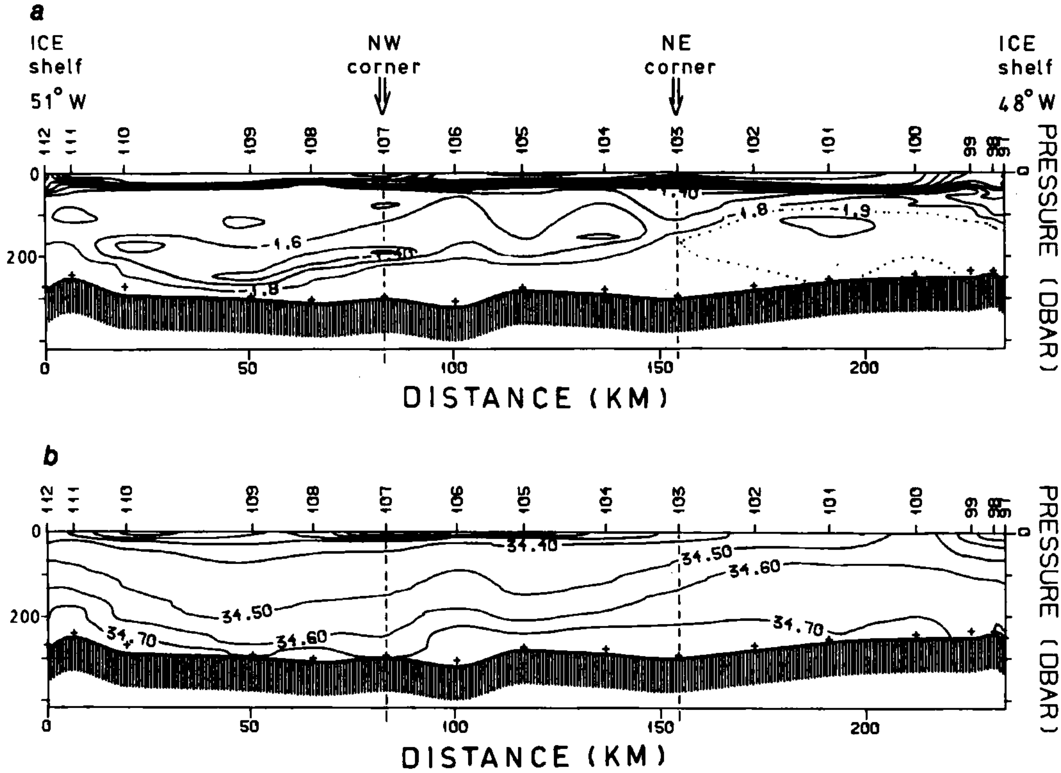

Fig. 5. Section on the 'Berkner Shelf' which forms a 'box' with the ice shelf as one of the sides. Stations 97–103 and 107–112 are the eastern and western sides, respectively, and stations 103–107 are parallel to the barrier (Fig. 1). The section is shown folded out with the NW and NE corners indicated. a. Potential temperature (°C); b. Salinity.

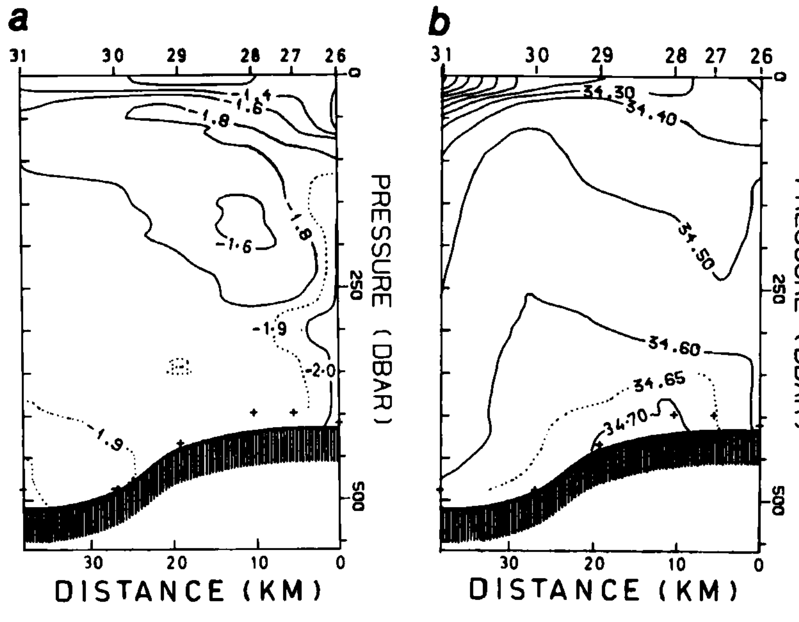

Fig. 6. Leg West, stations 26–31, 6 January 1980. Section normal to the barrier at 54°W. a. Potential temperature (°C); b. Salinity.

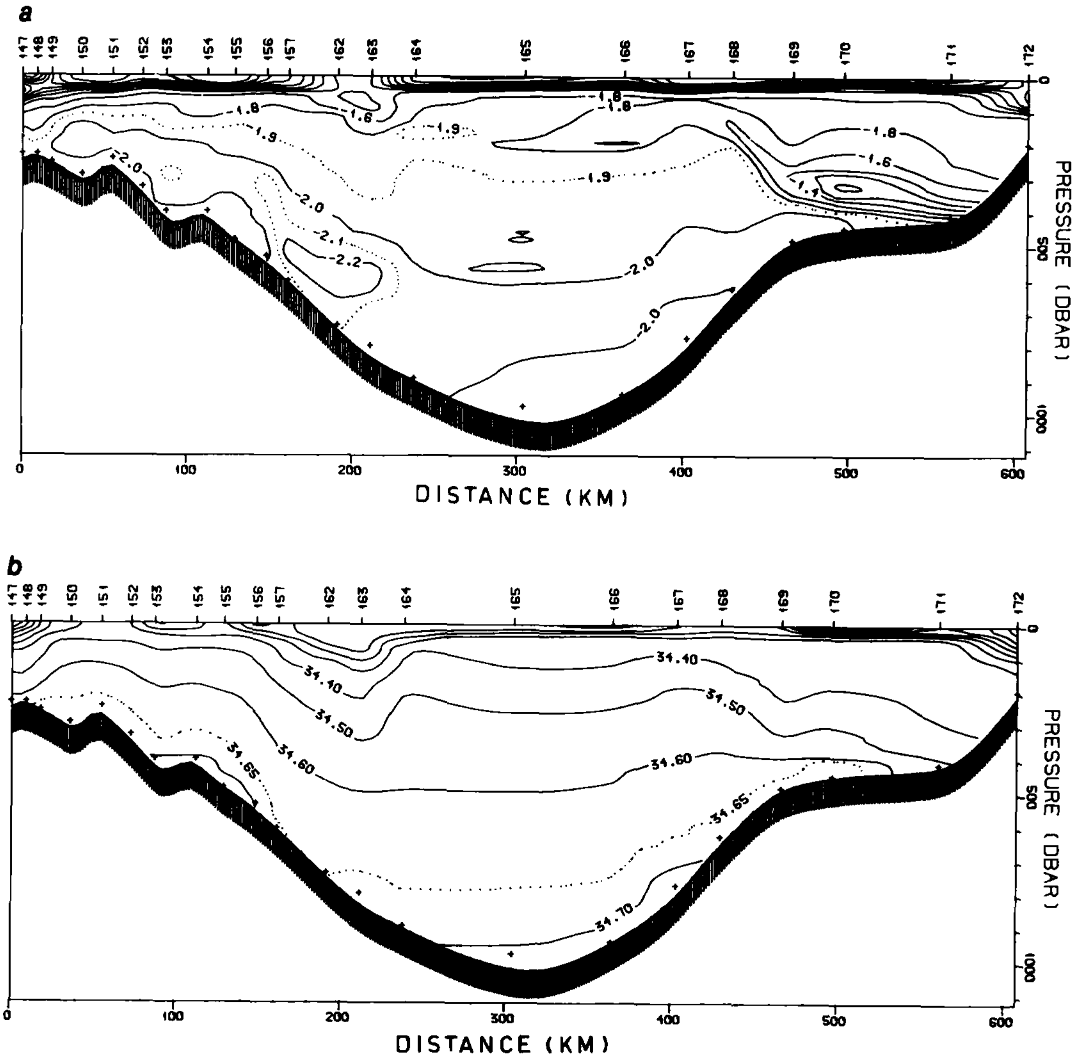

Fig. 7. Zig-zag section with one leg north-east from Berkner Island (stations 147–154), one leg crossing the western slope of the Filchner Depression (stations 154–163) and one leg from the Filchner Ice Shelf north-east across the Filchner Depression (stations 163–172). See Fig. 1 for location. a. Potential temperature (°C); b. Salinity.

floating ice shelves by cooling at high pressure (Sverdrup 1940; Lusquinos 1963). ISW is by definition potentially supercooled, i.e. has a potential temperature lower than the surface freezing point, T∼−1.9°C. This water is for instance seen below 450 m at station 163 in the Filchner Depression (Fig. 2b, d) where the core is found at 600 m depth.

Finally we draw attention to a water mass which is a mixture of Winter Water (WW) and warm and saline Weddell Deep Water (WDW). This Modified Weddell Deep Water (MWDW) appears as a warm layer at about 230 m depth at station 13 on the western slope of the Berkner Shelf (Fig. 2c).

A section including all stations in the vicinity of the floating Filchner and Ronne Ice Shelves is presented in Fig. 3. WSW with salinity higher than 34.74 is found near the bottom on the Berkner Shelf. However, sections normal to the barrier show that even more saline water is found at a distance from the ice shelf (see Figs. 4, 5 and 6).

ISW fills up the Filchner Depression below 300 m (Figs. 3 and 7). The cores of the ISW, which appear as minimum temperatures below −2°C, are usually found some distance above the bottom. Fig. 3 indicates separate cores of ISW at the two sides of the Filchner Depression, with the western core(s) colder and deeper than the eastern core. On the western slope of the Filchner Depression ISW penetrates up on the shelf in a thin layer near the bottom close to the barrier (Fig. 3), while further north (Fig. 7) the ISW core is forced up by the more saline water near the bottom (see also Pol-77). Also note that a lens of cold saline water (S > 34.70) appears on the eastern slope (Figs. 3 and 7). Patches of ISW are also seen on the Berkner Shelf in the sections normal to the barrier (Figs. 4 and 5).

West of the Berkner Shelf separate cores of cold water are found centred around stations 26, 15 and 22 (see Fig. 3). In the depression near the Antarctic Peninsula, which will be referred to as the Ronne Depression, very saline ISW dominates. Near the bottom the salinity exceeds 34.80 and this is the most dense water (σ_t = 28.05) encountered on the cruise.

In the Filchner Depression MWDW is observed at 330 m depth on the eastern slope (station 170, Fig. 7) as a distinct temperature maximum (T∼−1.0°C). A corresponding temperature maximum is not seen at the slope further south of the Filchner Depression (Fig. 3).

Another core of MWDW is found west of the Berkner Shelf. The highest temperature (T∼ −1.1°C) occurs in the north-west corner of the 'box' section (Fig. 5), and near the barrier (Fig. 3) the core is found at station 33 at about 200 m depth. The section which was repeated three times on the Berkner Shelf (Fig. 4) indicates that both the temperature and the volume of MWDW increased during January.

Results from the Instrument moorings

Two time series from moored instruments were obtained on the Berkner Shelf. The first mooring was anchored at the bottom (260 m) with two Aanderaa current meters at 100 m and 224 m depths and with an Aanderaa pressure recorder at the bottom. It was launched on January 17 near station 10 (see Fig. 3), and attached to the fast ice some 10 km from the barrier. The rig was recovered after four days because the ice started to break up.

The second mooring was attached to the barrier. It consisted of the two Aanderaa current meters at 25 m and 75 m depths and was deployed from 27 January to 7 February near station 11 (see Fig. 3). The draught of the barrier at the observation site was 25 m.

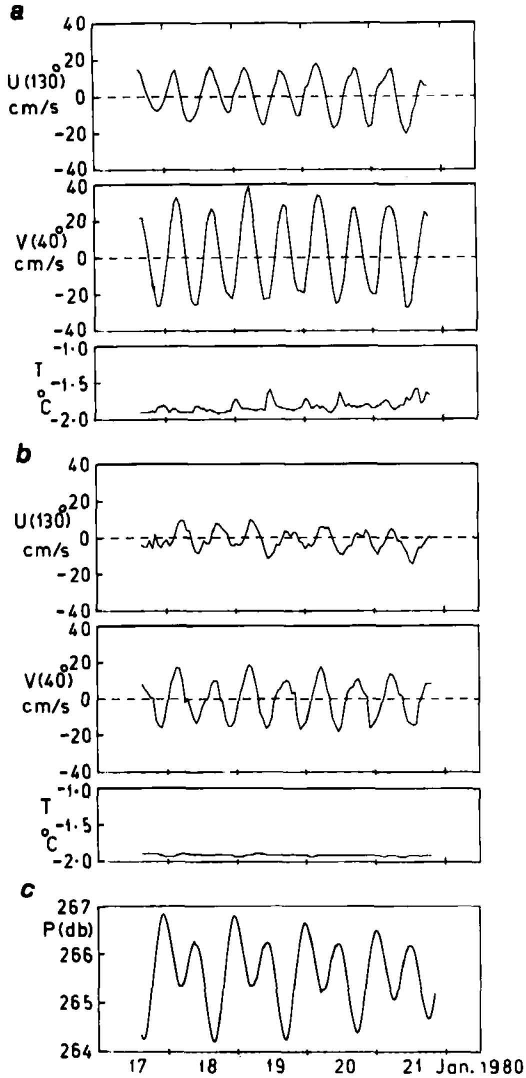

Fig. 8. Results from the first instrument mooring, 17–21 January 1980. The coordinate system is rotated 40° clockwise so that the U component is parallel to the mean direction of the barrier and the V component normal to the barrier. a. U, V, and temperature from the instrument at 100 m depth; b. U. V. and temperature from the instrument at 224 m depth; c. Pressure in decibars.

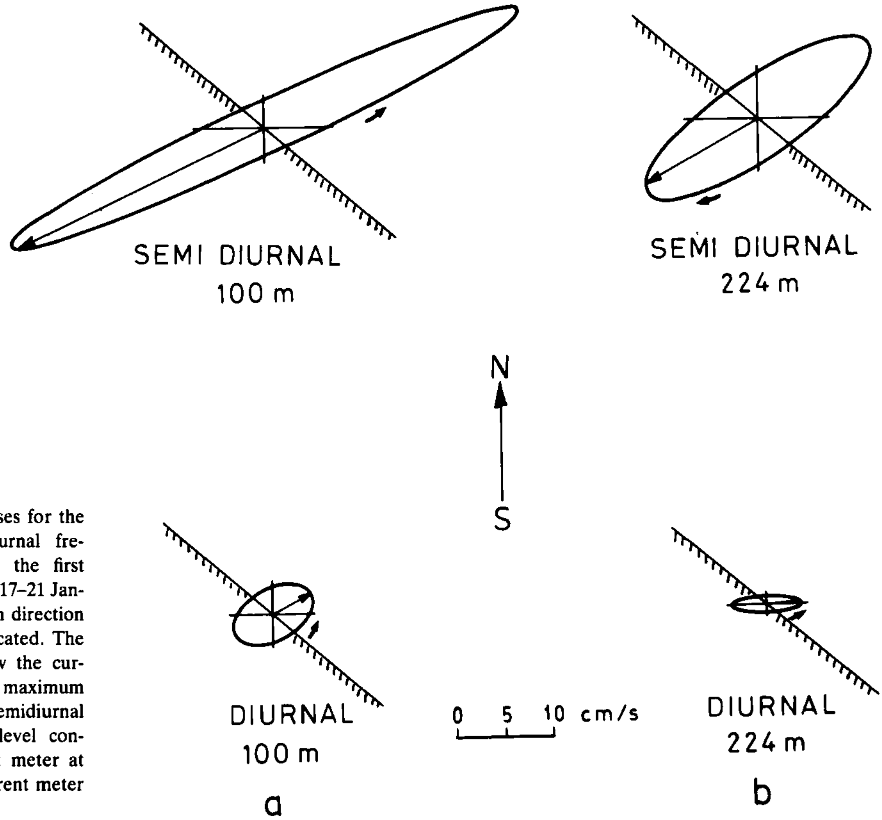

Fig. 9. Current ellipses for the semidiurnal and diurnal frequency bands from the first instrument mooring, 17–21 January 1980. The mean direction of the barrier is indicated. The current vectors show the current at the time of maximum amplitude for the semidiurnal and diurnal water level constituents. a. Current meter at 100 m depth; b. Current meter at 224 m depth.

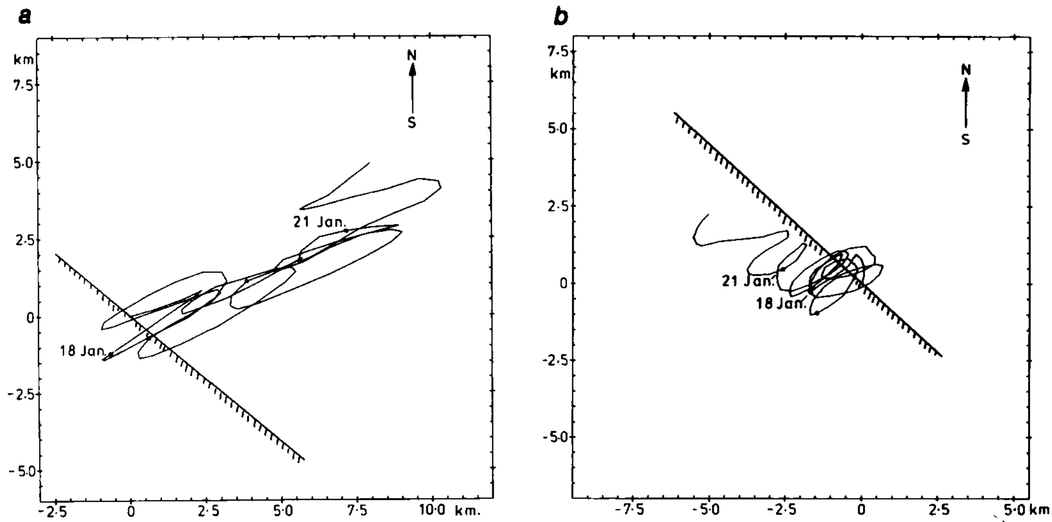

Fig. 10. Progressive vector diagrams for the first instrument mooring, 17–21 January 1980. The data are unfiltered. a. Current meter at 100 m depth; b. Current meter at 224 m depth.

Registrations from 17 to 21 January

The current measurements are shown in Fig. 8 with the coordinate system rotated 40° such that the U component is parallel to the mean orientation of the barrier and the V component is normal to the barrier. The semidiurnal tidal period is dominant with an amplitude around 30 cm/s at 100 m depth and somewhat smaller at 224 m depth. At both levels the component normal to the barrier is the largest.

The pressure registrations show a typical mixed tide where the difference between high and low water is almost 3 m (see Fig. 8c). The diurnal signal is more readily seen here than in the current registrations.

The current records are too short for a good tidal analysis, but we have drawn the current ellipses for the diurnal and semidiurnal frequency bands (Fig. 9) and indicated the currents at the time of high water. For the dominating semidiurnal tidal currents high water coincides with

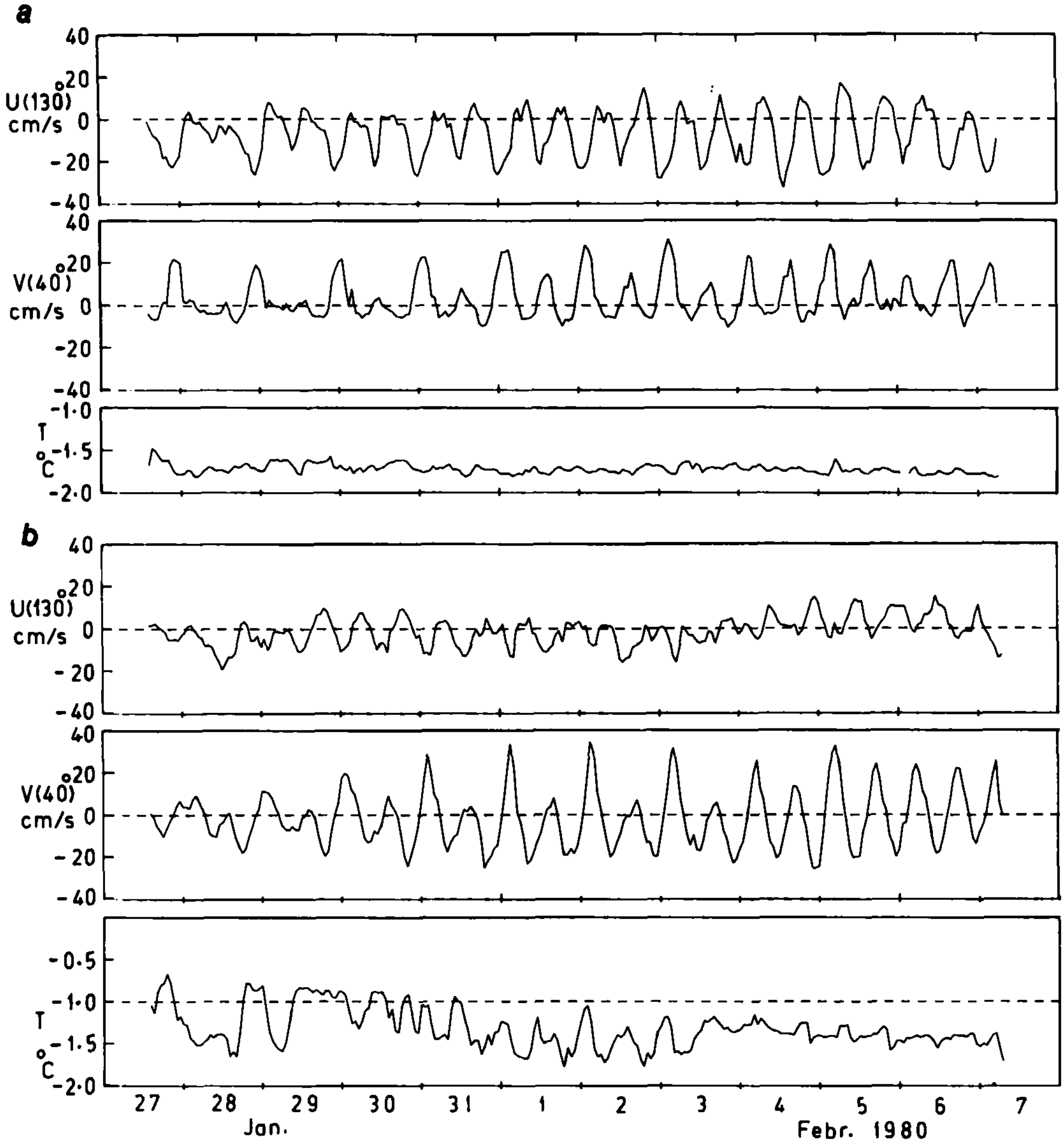

Fig. 11. Results from the second instrument mooring, 27 January to 7 February 1980. The coordinate system is rotated 40° clockwise so that the U component is parallel to the mean direction of the barrier and the V component normal to the barrier. a. U, V, and temperature from the instrument at 25 m depth; b. U, V, and temperature from the instrument at 75 m depth.

maximum inflow. This component behaves as a long progressive wave and with good agreement between the pressure and current amplitudes. The relatively small amplitude of the diurnal current component may indicate a more standing type diurnal oscillation.

The temperature registrations at 224 m show negligible variations (Fig. 8) while at 100 m maximum temperatures coincide with the culmination of the inflow. This result conforms with the vertical temperature distribution near station 10 (see Figs. 3 and 15).

The progressive vector diagrams (Fig. 10) show that the water moves about 5 km during ½ tidal cycle at 100 m and about half the distance at 224 m. At both levels the mean currents are weak (~2 cm/s).

Registrations from 27 January to 7 February

The tide is dominant also at this location near station 11 (see Fig. 3), but here both the diurnal and the semidiurnal periods are clearly revealed in the current measurements (see Fig. 11). The current ellipses (Fig. 12a) and the progressive vector diagrams (Fig. 13a) indicate that the current at 25 m is steered by the barrier and with a strong mean current (8 cm/s) toward the northwest.

At 75 m the water is obviously free to move under the ice shelf. Both the orientation of the current ellipses (Fig. 12b) and the progressive vector diagram (Fig. 13b) indicate significant tidal and mean current components normal to the barrier.

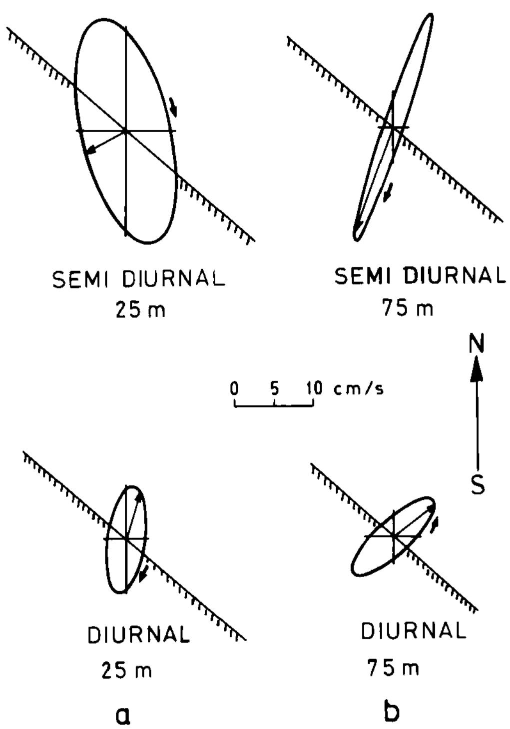

Fig. 12. Current ellipses for the semidiurnal and diurnal frequency bands from the second instrument mooring, 27 January to 7 February 1980. The mean direction of the barrier is indicated. The current vectors show the current at the time of maximum amplitude for the semidiurnal and diurnal water level constituents. a. Current meter at 25 m depth; b. Current meter at 75 m depth.

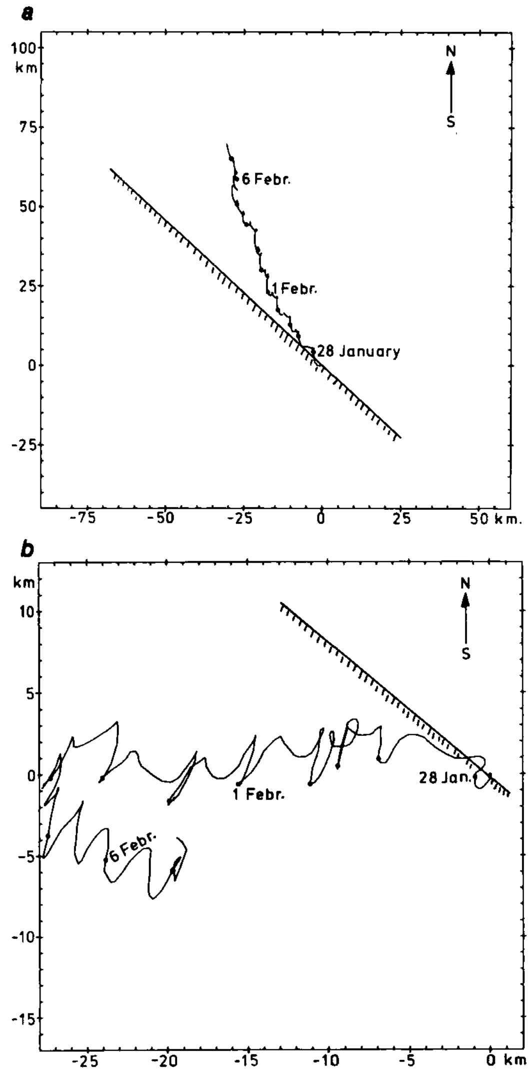

Fig. 13. Progressive vector diagrams for the second instrument mooring 27 January to 7 February 1980. a. Current meter at 25 m depth; b. Current meter at 75 m depth.

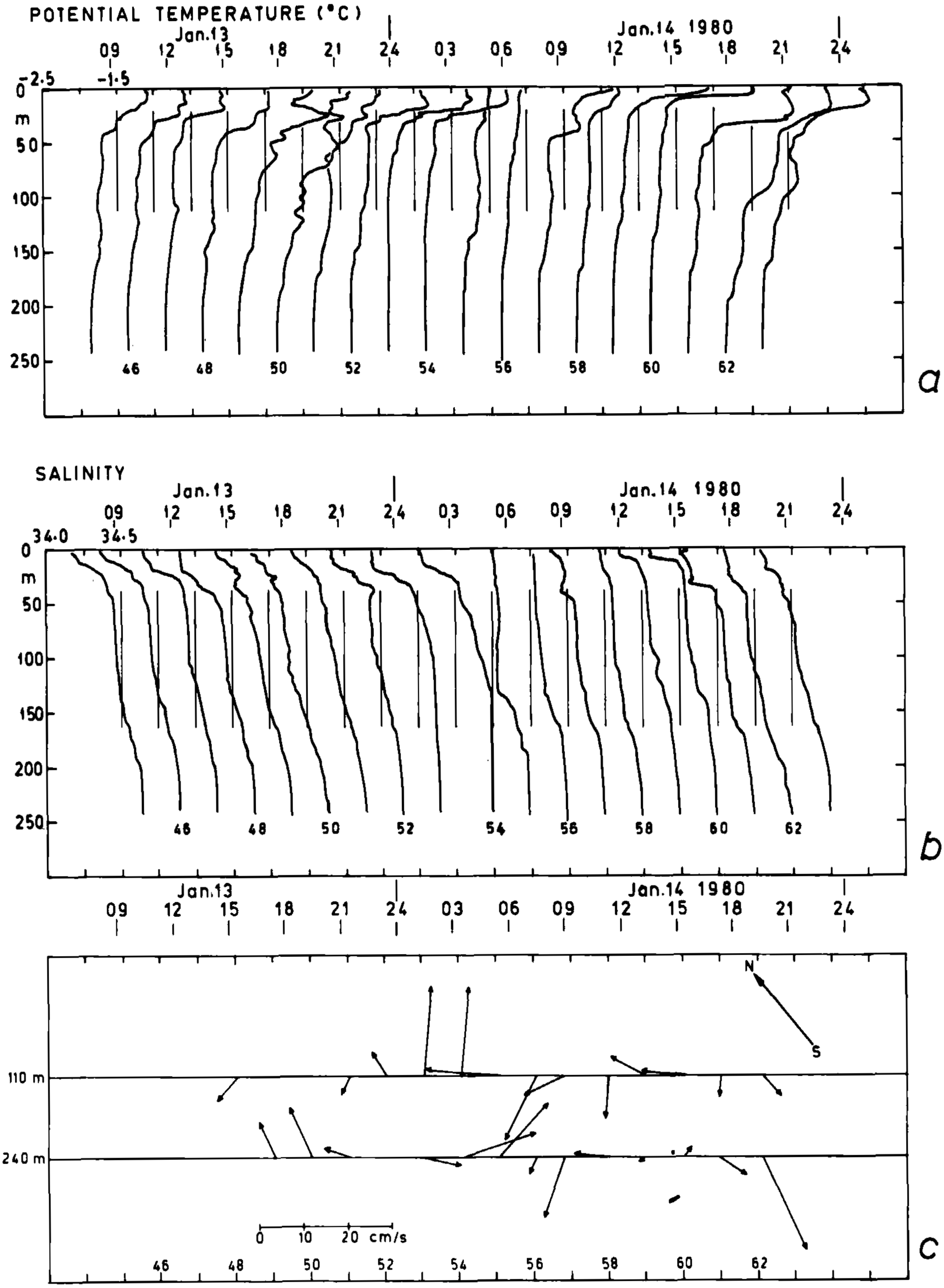

Fig. 14. CTD Yo-Yo No. 1, 13–15 January 1980, stations 45–63, showing a. Potential temperature (°C); b. Salinity; and c. Current at 110 m and 240 m depth. The time interval between each station is 2 hours. The scale refers to the first profile, and successive profiles are set off by 0.5°C and 0.25 for a. and b., respectively. Also on a. and b. the −1.5°C isotherms and the 34.5 isohalines are indicated. The time scale refers to these marks.

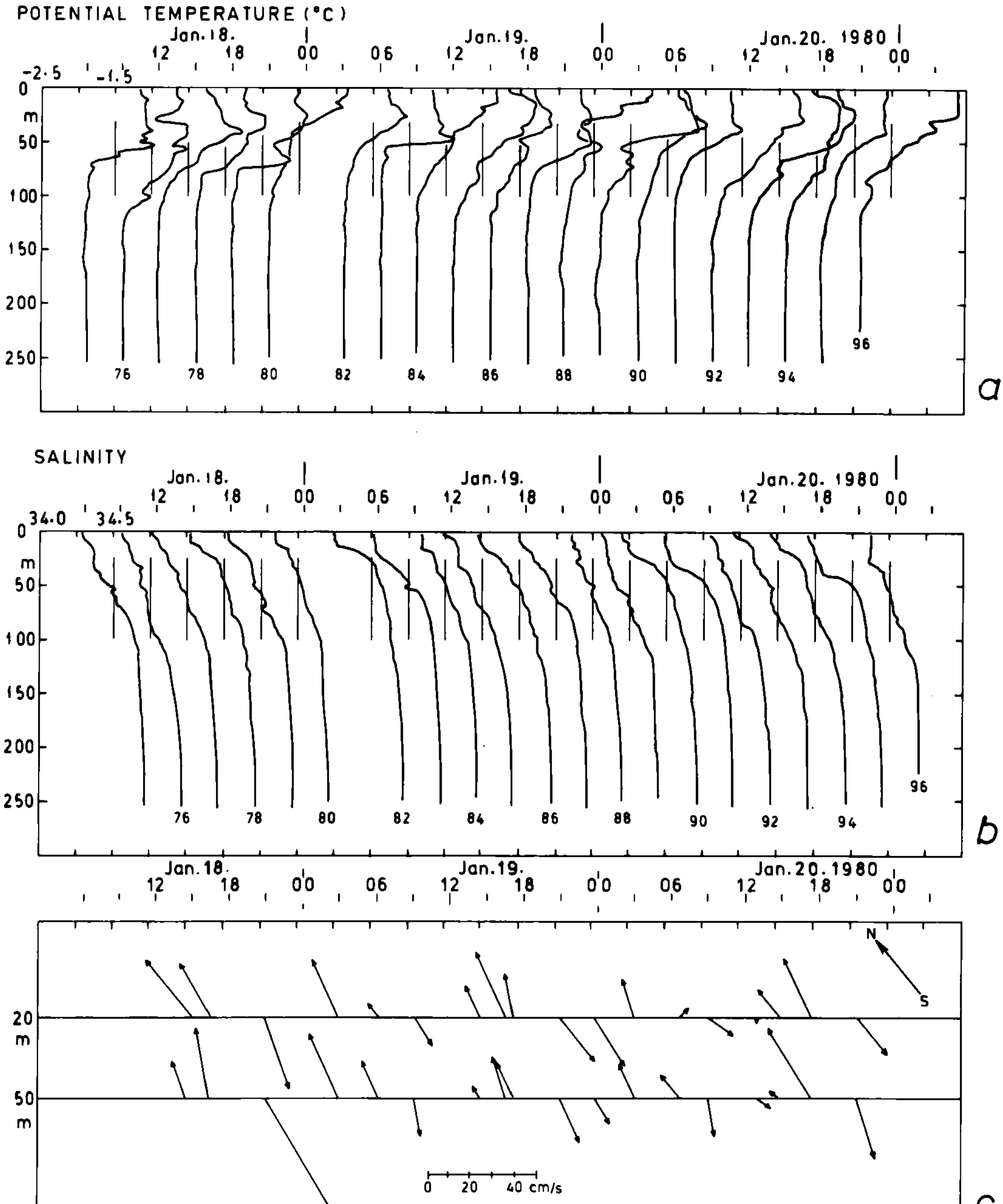

Fig. 15. CTD Yo-Yo No. 2, 18–21 January 1980, stations 75–96, showing a. Potential temperature (°C); b. Salinity; and c. Current at 20 m and 50 m depth. The time interval between each station is approximately 3 hours. The scale refers to the first profile, and successive profiles are set off by 0.5°C and 0.25 for a. and b. respectively. Also on a. and b. the −1.5°C isotherms and the 34.5 isohalines are indicated. The time scale refers to these marks.

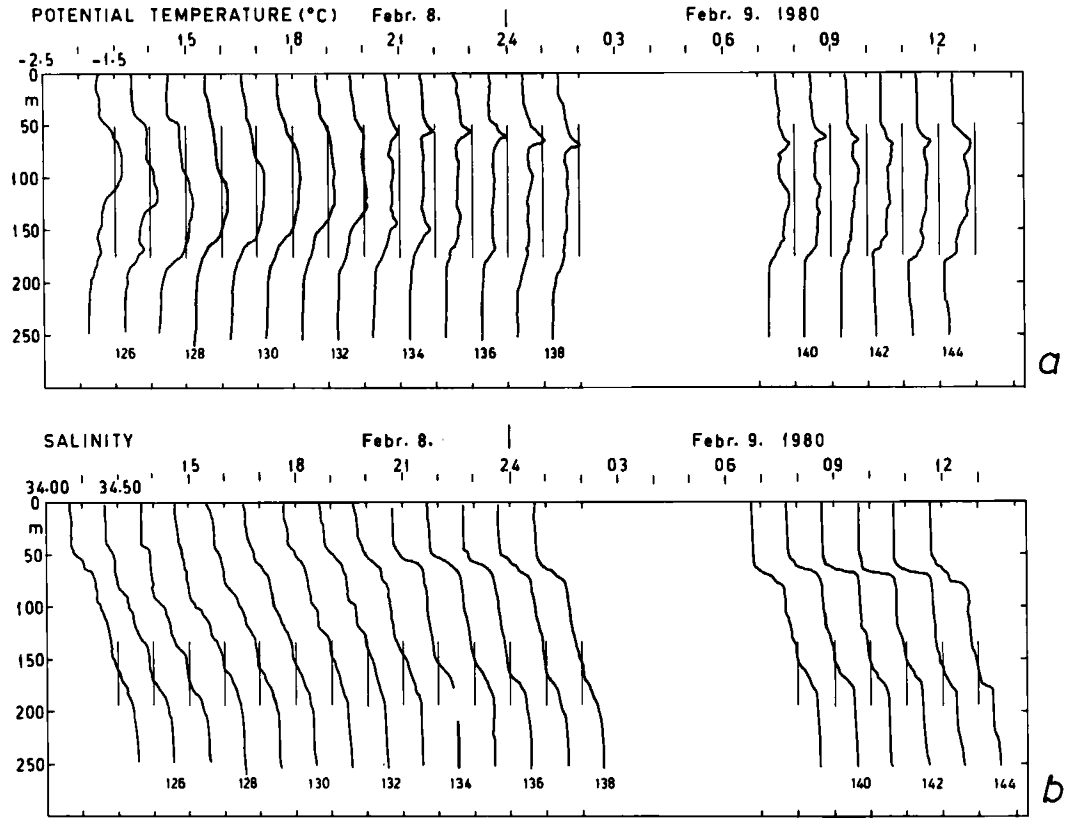

Fig. 16. CTD Yo-Yo No. 3, 8–9 February 1980, stations 125–144, showing a. Potential temperature (°C); and b. salinity. The time interval between each station is 1 hour with a 6-hour gap between stations 138 and 139. The scale refers to the first profile, and successive profiles are set off by 0.5°C and 0.25 for a. and b. respectively. Also on a. and b. the −1.5°C isotherms and the 34.5 isohalines are indicated. The time scale refers to these marks.

Table 1. Two current profiles to 50 m and 90 m obtained with a Braystoke meter. The currents at 100 m and 224 m are from Aanderaa current meters on a mooring nearby.

	18 Jan. 1980, 15.00 GMT		18 Jan. 1980, 16.00 GMT	
Depth (m)	Speed (cm/s)	Dir. (deg.)	Speed (cm/s)	Dir. (deg.)
5	21	360	10	350
10	26	360	16	360
15	31	360		
20	33	360	27	10
30	30	10	29	20
40	27	20	27	20
50	23	20	31	30
60			36	50
70			35	60
80			33	50
90			29	50
100	12	75	26	69
224	8	353	9	29

The water at 25 m shows small temperature variations, but a general cooling seems to take place at 75 m. The warm water (T~ −.7°C) which appears at the beginning of this record must have been formed at the surface during summer (cf. Fig. 16). A semidiurnal period can be seen in the temperature variations where again the maximum temperature seems to be related to maximum inflow, although this phase relationship varies somewhat during the record.

Time series

Three CTD Yo-Yo series were obtained while the ship was moored to the ice. The first series lasted 36 hours with stations taken every second hour. Current measurements were also obtained in connection with these CTD casts.

The second series lasted for 63 hours with three hours between the stations. This series coincided in time with the first mooring (see 'Registrations from 17 to 21 January'). In addition, current meters were attached to the CTD wire and a few profiles with a Braystoke current meter were obtained.

The third series lasted for 24 hours and started when the last mooring ('Registrations from 27 January to 7 February) was recovered.

CTD Yo-Yo stations 13–15 January

This series (stations 45–63, see Fig. 1 for location) was obtained while the ship was moored at the barrier. The draught of the ice shelf here was around 75 m. The individual temperature and salinity profiles are shown in Fig. 14 together with the current measurements obtained at 110 m and 240 m depths.

Extrapolation of the bottom pressure series (Fig. 8c) shows that the maximum outflow (stations 53–54) coincides with low tide.

The upper 50 m are dominated by a relatively warm, fresh layer, the thickness of which seems to have a diurnal period. After the period with maximum outflow, the upper 150 m are well mixed (c/f profiles 55 and 56), indicating that the tidal mixing is extremely effective below the ice shelf. Note also the rapid re-establishment of the surface layer after the outflow.

CTD Yo-Yo stations 18–21 January

During this period the ship was moored to the fast ice some 10 km from the barrier. These Yo-Yo stations (stations 75–96, see Fig. 1) were taken near the first instrument mooring.

Again a well defined warm, fresh surface layer is observed (Fig. 15a, b). The surface layer remains warm and fresh indicating less influence of the barrier than in the previous series, but note the sporadic occurrence of a sharp temperature interface around 60 m depth. The progressive vector diagram from the nearby rig (Fig. 10) shows that typical displacements during one tidal cycle are about half the distance to the barrier.

The current measurements at 20 m and 50 m (Fig. 15c) indicate a rather unidirectional current of semidiurnal period. The current profiles obtained down to 90 m and the simultaneous results from the mooring (Table 1) also give the general impression of a barotropic current.

CTD Yo-Yo stations 8–9 February

During this period the ship was again moored to the barrier and stations 125–145 were obtained. The warm surface layer has disappeared (Fig. 16a) indicating that the summer is over. A temperature maximum (T> −1.5°C) occurs between 60 m and 150 m at the beginning of the series, but after about eight hours this warm layer disappears except for a remnant at about 60 m. The salinity of this warm layer is too low to be MWDW, and we therefore believe it to be surface water which has been mixed down to 180 m.

Transformation of water masses

Eastern Shelf Water flows westwards along the barrier towards the Berkner Shelf. Here high bottom salinities are produced in the winter season due to freezing and brine rejection, especially in shallow water. This saline Western Shelf Water is seen in the observations from the shallow Berkner Shelf (Fig. 3). The warm, fresh surface layer shows that the active brine induced convection has temporarily ceased during summer and that the WSW found below has been formed earlier, presumably during the preceding winter. The salinity of the WSW was observed to decrease by approximately 0.05 in one month (Fig. 4).

Studies of satellite pictures (Kohnen & Schwarz 1981) show that narrow leads open near the barrier, making the conditions for freezing favourable there. The observed strong tidal currents will be very efficient in keeping these leads open by crushing and packing newly formed ice during onshore tidal flow. The prevailing offshore winds enhance this effect (Gill 1973), the expected net effect being a salinity maximum near the barrier. Thus the minimum bottom salinity observed near the barrier in the austral summer (Figs. 4, 5 and 6) must be due to tidal mixing of glacial meltwater and/or weak currents off the barrier.

Western Shelf Water formed on the Berkner Shelf drains into the deeper parts of the Filchner Depression (Carmack & Foster 1975b) as a thin, saline layer near the bottom (see Fig. 7). This flow is trapped below 600 m by the sill at about 75°S and recirculates in the Filchner Depression where it is observed as a lens of saline water below 600 m on the eastern slope (Figs. 3 and 7). During its journey below the Filchner Ice Shelf the WSW is transformed to Ice Shelf Water which is lighter than WSW. The cores of outflowing ISW are therefore found above the WSW (Figs. 3 and 7).

On its way north ISW can be traced along the isobaths on the western slope of the Filchner Depression (Pol-77, Carmack & Foster 1975b). A substantial part of the ISW flows over the sill and down towards the deep ocean (Pol-77, Pol-79), but some recirculates in the Filchner Depression and appears at the eastern slope (see Figs 3 and 7).

The most saline water, however, is found in the Ronne Depression (Fig. 3). Very saline water (S~34.84) was also observed further north in the Ronne Depression in 1968 (Elder & Seabrooke 1970). It is not clear whether this water is produced locally by brine rejection and trapped by a sill to the north, or whether it has been formed on the Berkner Shelf and has circulated below the Ronne Ice Shelf in a large cyclonic gyre (Robin et al. 1983). The latter idea is supported by the fact that the deep water in the Ronne Depression is potentially supercooled, showing that it has been modified under the ice shelf. Also, from Figs. 3 and 6, some of the WSW formed on the Berkner Shelf appears to have moved westwards, and the slope of the isopycnals indicates a southward flow under the ice shelf. West of station 13 (Fig. 3) ISW is the dominant water mass, and the slope of the isopycnals indicates a deep flow out from the barrier (Fig. 3). The isolated cores of ISW observed here are not related to alternating tidal currents, because the stations taken both on our way to and from the Antarctic Peninsula are consistent. Besides, stations occupied by GLACIER in 1968 (Elder & Seabrooke 1970) close to stations 15 and 23, also showed ISW.

Table 2. The table gives the lateral heat exchange normal to the barrier for the records shown in Figs. 8 and 11. Negative values indicate heat transports towards the ice shelf.

Record length (days)	4.5	4.5	10	10
Instrument depth (m)	100	224	25	75
Distance from barrier (km)	10	10	~0	~0
Lateral heat exchange Q (kw/m^2)	−190	41	−260	105

We have calculated the lateral heat exchange normal to the barrier due to the fluctuating tides for the records shown in Figs. 8 and 11. The net heat flux Q through an area A parallel to the barrier is

$$Q = \rho c \overline{\theta v} A$$

where ρ, c, θ denote the density, heat capacity and potential temperature of the water, respectively, and v the velocity component normal to the barrier. The bar denotes the arithmetic mean over the period of observation. The computed heat transport is presented in Table 2.

The records are short and the locations of the current meters are probably not representative of larger areas. Also the thermal structure is not representative of the winter season. Therefore it is not permissible from these records to draw conclusions about the net heat transport towards the barrier in the area. However, the numbers are interesting as indicators of the order of magnitude to expect for the heat flux. For comparison, the large southward heat fluxes in Table 2 would accommodate as much heat through a 100 m deep and 500 km long section as the entire northward heat transported by the West Spitsbergen Current (Aagaard & Greisman 1975).

The Weddell Deep Water is observed to intrude on the shelf at about 400 m depth (Pol-77, Pol-79) where it mixes with Winter Water to form Modified Weddell Deep Water (Foster & Carmack 1976a). This intrusion seems to take place both east and west of the sill north of the Filchner Depression and these two locations are the origin of two separate branches of MWDW which extend southwards towards the barrier. The eastern branch is found above the 400 m isobath on the eastern side of the Filchner Depression (Fig. 7a); the western branch seems to coincide with the 400 m isobath west of the Berkner Shelf (Fig. 3a, Gammelsrød & Slotsvik 1981). The modified Weddell Deep Water above the ISW on the eastern shelf (Fig. 7) supports the idea of a strong southward flow there. MWDW was observed near the Filchner Ice Shelf in 1979, but is absent in Fig. 3, which indicates that the current is intermittent. The occurrence of MWDW on the western slope of the Berkner Shelf (Figs. 3, 4 and 5) indicates a strong flow towards the barrier.

Summary

The favourable ice conditions in 1980 provided an opportunity to study the water masses near the Filchner and Ronne Ice Shelves. Most observations were taken on the shallow shelf of Berkner Island, here referred to as the Berkner Shelf.

The formation of the saline (S>34.7) Western Shelf Water due to brine release is believed to be very effective on the Berkner Shelf, and our data indicate that WSW was formed here earlier in the season.

The tides on the Berkner Shelf are considerable with a range of almost 3 m between high and low water and with semidiurnal current amplitudes up to 30 cm/s.

The floating ice shelves have important influence on the water masses. Strong tidal currents normal to the barrier provide effective flushing of the outer area of the ice shelf and the cooling effect is seen as large volumes of Ice Shelf Water with temperatures below the surface freezing point. Current meter records near the barrier show that the tidal currents are systematically colder flowing out from the barrier, the difference being typically a few tenths of a degree, in extreme cases up to 1°C (Figs. 8 and 11).

The general circulation seems to consist of two large cyclonic cells, one in the Filchner Depression (Carmack & Foster 1975b), and one west of the Berkner Shelf. In both circulation cells the northward flow is cold ISW which originates below the ice shelves, while the southward flow is 'warm' (T~−1°C) Modified Weddell Deep Water.

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