

The Average Pack Ice Conditions in the Southern Weddell Sea and the Actual Situation during the Summer of 1979/80

By H. Kohnen and J. Schwarz*

Summary: The highest concentration of pack ice around the perimeter of Antarctica is met in the Weddell Sea which, even in summer, does not become ice-free. Satellite techniques have tremendously facilitated the pack ice investigations during the past decade. Satellite images show that a shore lead develops during the summer months along the Filchner Ice Shelf. This shore lead is caused by the catabatic winds which drive the ice away from the ice front towards north or northwest respectively. Ships sometimes make use of this feature. The shore lead is a long-term characteristic of the summer season. Its width and ice coverage, however, is subject to annual fluctuations. During the 1979/80 summer the shore lead was extremely wide. The pack ice had retreated far north and open water was met until the Antarctic Peninsula. The situation was entirely different during January 1981. The shore lead was closed from the Gould Bay to the Peninsula. A crucial point for shipping in the lead is the horn at 41 °W near the Russian station Druzhnaya where the pack ice is often highly concentrated.

It can be generally stated, that ship operations are possible along the front of the Filchner Ice Shelf during the summer. The operations may, however, be temporarily jeopardized by strong pack ice fluctuations.

Zusammenfassung: Die Weddell-See ist die packeisreichste See der Antarktis, die auch während des Sommers nicht eisfrei wird. Satellitenbeobachtungen des letzten Jahrzehnts, durch die Schiffsoperationen heute wesentlich erleichtert werden, haben gezeigt, daß jedoch während der Sommermonate eine eisfreie Rinne von einigen Meilen Breite entlang dem Filchner-Ronne-Schelfeis ausgebildet ist. Diese Rinne entsteht durch die Wirkung der katabatischen Winde, die das Packeis von der Schelfeiskante weg nach Norden bzw. Nordwesten treiben. Schiffsexpeditionen in die südliche Weddell-See und zum Ronne-Schelfeis machen sich diese Rinne zu Nutze. Die Ausbildung der Rinne ist im langjährigen Mittel ein Charakteristikum der Sommermonate. Ihre Breite und Eisbedeckung ist jedoch jährlichen Schwankungen unterworfen. Im Südsommer 1979/80 war die Rinne extrem weit ausgebildet. Das Packeis war stellenweise bis zu 180 Meilen nach Norden zurückgewichen, so daß bis zur Halbinsel weit offenes Wasser angetroffen wurde. Während des Januars 1981 war diese Rinne beispielsweise ab der Gould Bay nach Westen völlig geschlossen. Ein besonders kritischer Punkt ist der Schelfeisevorsprung bei Druzhnaya, wo sich sehr häufig Packeis staut und die Durchfahrt behindert. Generell kann gesagt werden, daß während der Sommermonate Schiffsoperationen entlang der Kante des Filchner-Ronne-Schelfeises möglich sind, temporär aber von starken Packeiskonzentrationen behindert werden können.

INTRODUCTION

In contrast to the Arctic basin the pack ice cover around the Antarctic continent is subject to large fluctuations. Its areal extent varies from about 4 Mill. km² at the end of the summer to about 20 Mill. km² at maximum winter extent. Most coastal regions become ice free during the summer except the Weddell Sea. Its western and southern portion is covered by heavy pack ice even through January and February jeopardizing ship operations also during this season. Until the development of modern and powerful icebreakers the pack ice has prevented almost any scientific operation in the central or southern Weddell Sea as documented by the history of Antarctic exploration. Yet in our times ship-borne expeditions in the Weddell Sea are tied to careful ice observations to avoid unexpected hazards. The pack ice conditions in the Weddell Sea have been studied intensively now over more than one decade. Compared with earlier studies the recent investigations are greatly helped by satellite observation techniques. Images from satellites in polar orbits are, for instance, compiled to give weekly ice charts (Fleet Weather Facility) reflecting the seasonal ice variations in the Weddell Sea. Satellite images of different resolution and with different coverage are available for detailed studies.

The pack ice seldom forms a closed cover and open leads are always present. These leads represent an ice-free area of 3% to 5% in relation to the total area covered by sea ice even during the winter (KUKLA, 1977). Other estimates amount to 20% of open water during winter, which are however questionable.

* Dr. Heinz Kohnen, Institut für Geophysik der Universität, Corrensstr. 24, D-4400 Münster (Westf.)
Dr.-Ing. Joachim Schwarz, Hamburgische Schiffbau-Versuchsanstalt, Bramfelder Str. 164, D-2000 Hamburg 60

PACK ICE OBSERVATIONS

Besides extent and variation of the pack ice cover and the existence of open water in the inner Weddell Sea, the most striking feature is the presence of a shore lead along the Filchner and Ronne Ice Shelves. This polynya shows up clearly on satellite pictures and seems to be a characteristic feature of the southern Weddell Sea. The polynya is well expressed during the austral summer when it extends from the Antarctic Peninsula along the ice shelves eastwards. East of the Filchner Ice Shelf the polynya begins to widen steadily, merging finally into the ice-free open waters of the southern ocean. This situation can be traced on satellite pictures extending over many years and is obviously the common situation during January and February. The satellite image (Tiros N) of January 1, 1979 (Fig. 1) and the ice chart (Fleet Weather Facility) of January 09—11, 1979 (Fig. 2) represent typical examples of this situation. The reason for the occurrence of the shore lead is well understood. The predominant southerly to southeasterly winds of katabatic origin exert a considerable shear stress on the pack ice cover and drive the ice to north-east and north respectively. This trend is enforced by the dominant ocean current which follows the barrier of the Filchner/Ronne Ice Shelf westward.

The classical shipping routes to the southern Weddell Sea have used this strip of open water with its northern entrance between 10° W and 30° W. The stations Halley (U. K.) and Belgrano (Argentina) have been supplied on this way since two decades. Along the Ronne Ice Shelf, the polynya becomes 20 to 30 km wide during the summer. Sometimes it breaks up even along the eastern coast line of the Antarctic Peninsula. The crucial point for shipping in the shore lead is a horn at about 41° W where the Russian

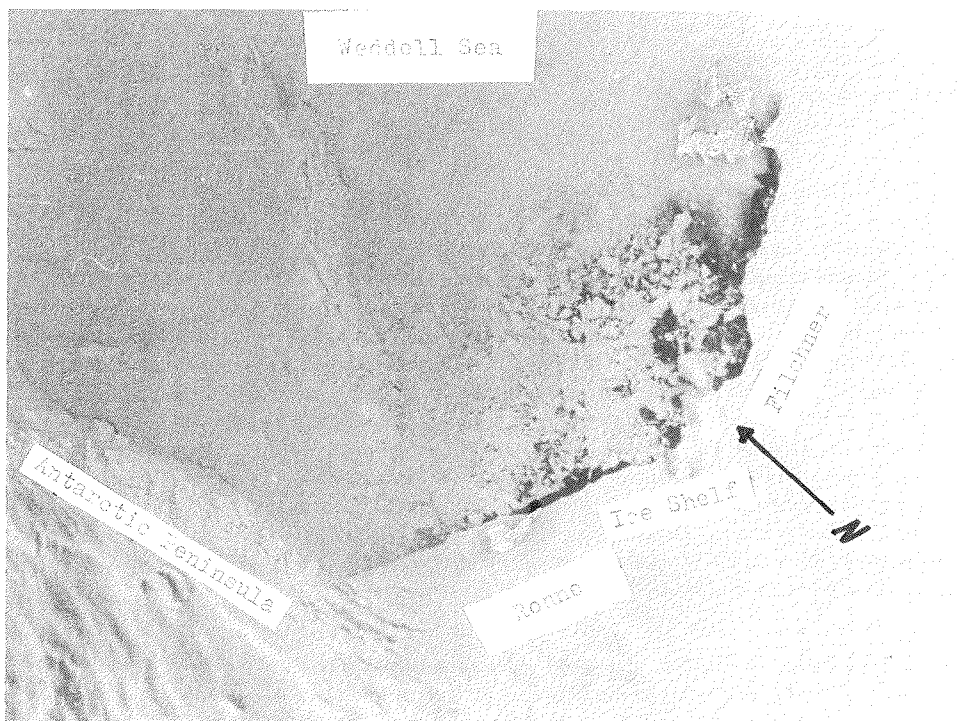


Fig. 1: Satellite image from Tiros N of 1 January 1979 (USGS). Black areas indicate open water whereas the greyish white areas indicate ice as well as clouds. Pack ice can be distinguished from clouds by its characteristic floe-like structure.

Abb. 1: Satellitenaufnahme von Tiros N vom 1. 1. 1979 (USGS). Schwarze Regionen bedeuten offenes Wasser, grauweiße Gebiete Packeis oder Wolken. Packeis ist von den Wolken durch seine floßähnliche Struktur zu unterscheiden.

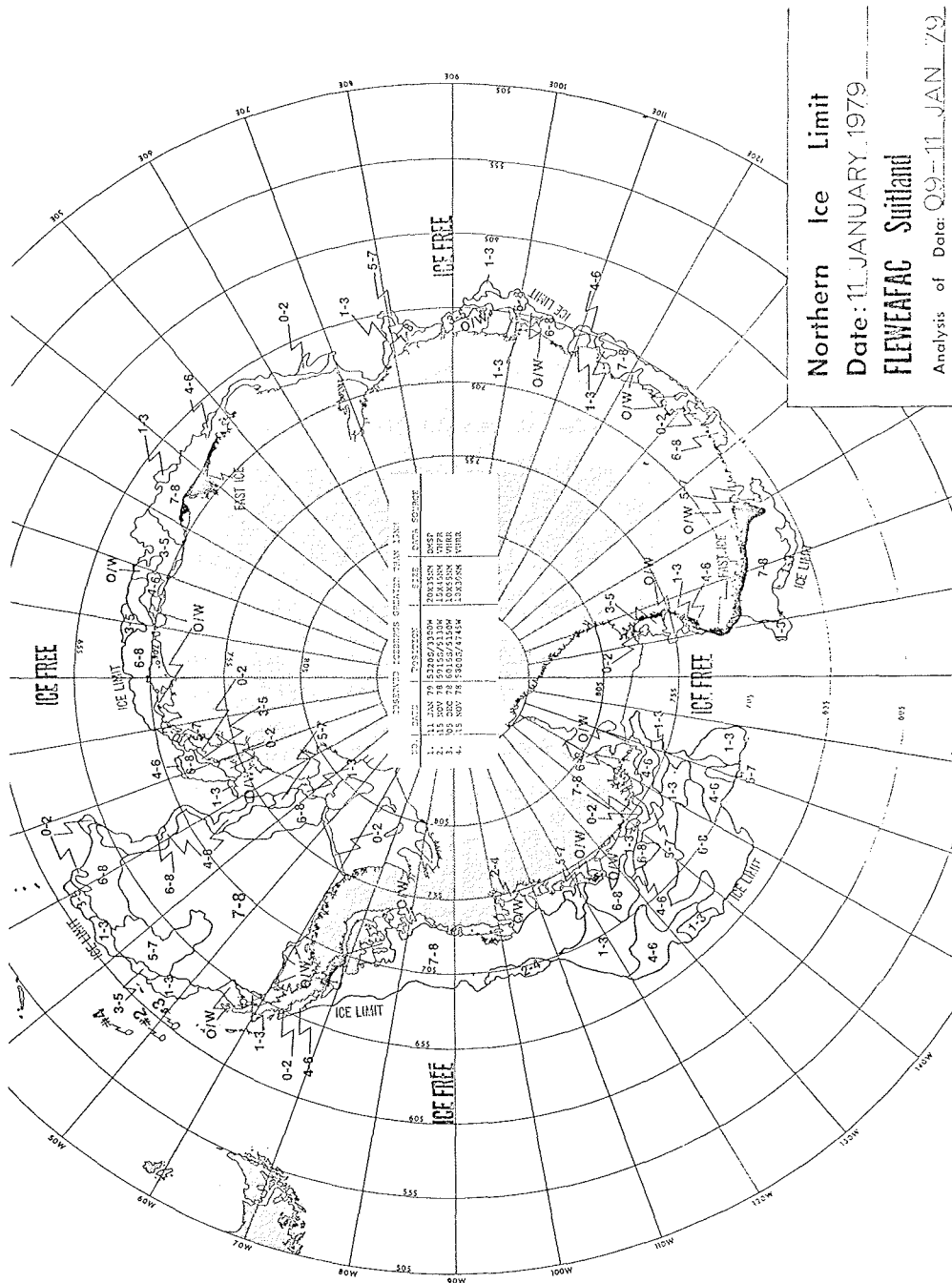


Fig. 2: Ice chart of the Antarctic seas during the summer of 1979 (11 January 1979; Fleet Weather Facility, Suitland). The pack ice concentration is given in eighths; 0: open water, 8: closed ice cover. The shore lead along the Filchner/Ronne Ice Shelf is open (0—2) except west of the horn (Druzhnaya) and in the Gould Bay (6—8).

Abb. 2: Eiskarte der Fleet Weather Facility vom 11. 1. 1979. Die Packeiskonzentration ist in Achteln angegeben. 0: offenes Wasser, 8: geschlossene Eisdecke. Die Rinne entlang dem Filchner-Ronne-Schelfeis ist offen (0—2) bis auf die Region von Druzhnaya und der Gould Bay (6—8).

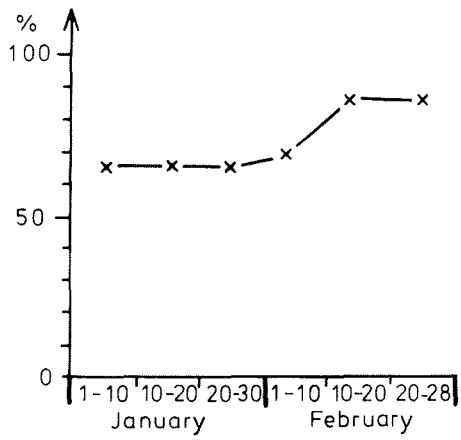


Fig. 3: Probability (in percent) for free access to the Berkner Island and Gould Bay area during January and February after T. VINJE (pers. communication). The compilation is based on satellite images of the last decade.

Abb. 3: Wahrscheinlichkeit in Prozent für freien Zugang zum Filchner-Schelfeis während des Januars und Februars nach T. VINJE (pers. Mitteilung). Die Darstellung beruht auf Satellitenbildauswertungen der siebziger Jahre.

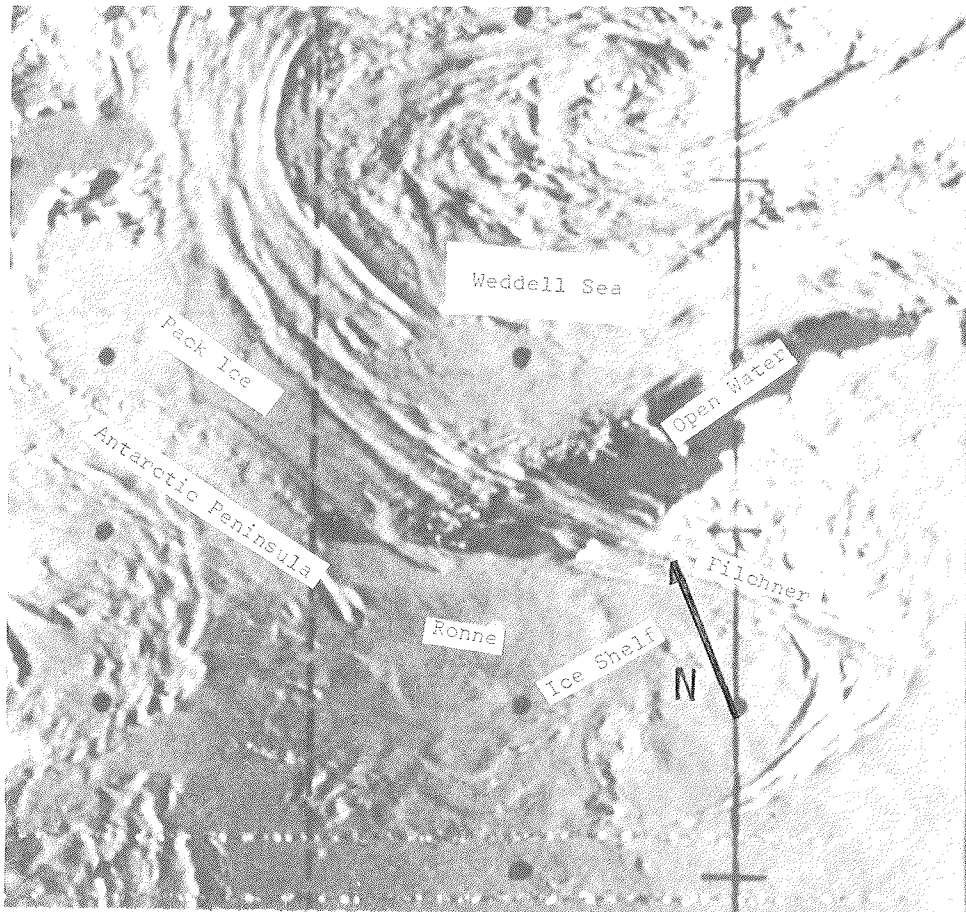


Fig. 4: Satellite image from NOAA 6 (24 January 1980) received on board with the Skyeceiver.

Abb. 4: Satellitenaufnahme von NOAA 6 (24. 1. 1980), aufgenommen mit einem Skyeivergerät an Bord der POLARSIRKEL.

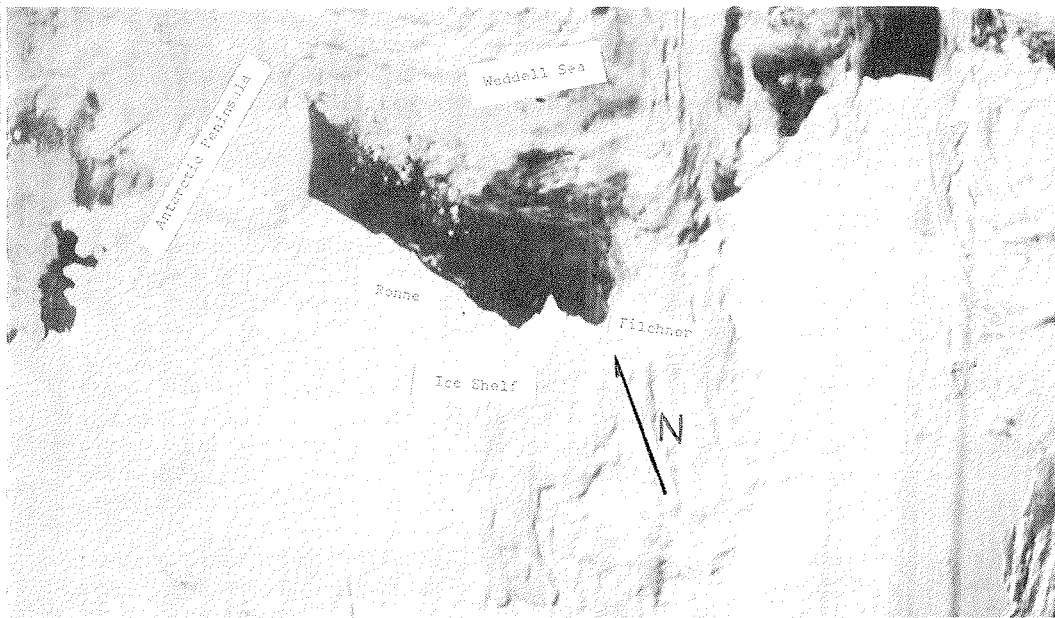


Fig. 5: Satellite image from Meteor V (6 February 1980) obtained from the Russian station Druzhnaya. The image shows the extreme situation during the summer of 1980. The pack ice has retreated from the ice shelf nearly 180 nM to northeast.

Abb. 5: Satellitenaufnahme von Meteor V (6. 2. 1980) aus Druzhnaya. Das Bild zeigt deutlich die extreme Situation des Südsommers 1979/80. Das Packeis hat sich zu diesem Zeitpunkt fast 180 Meilen nach Norden zurückgezogen.

station Druzhnaya is located. Here, the Filchner Ice Shelf has a prominent wedge-like northern extremity. At the horn the ice is often highly concentrated (Fig. 2). This constraint more or less controls the passage to the west and hence reduces the probability of an unhampered passage through the polynya. T. VINJE from the Norsk Polarinstitut has compiled the probability for free access to the area east of Berkner Island from satellite pictures of various years. According to his compilations, the probability for free access is close to 100% during January and February in the region of Cape Norvegia (pers. communication). The accessibility reduces to about 70% to 80% along the Filchner Ice Shelf at the same time (Fig. 3). According to this figure, the highest probability (85%) is given here during the second half of February. The chance of unrestrained access reduces rapidly in March due to decreasing temperatures and ice formation. K. STRÜBING has averaged the pack ice conditions over the last six decades between 0° to 60° W. He shows (pers. communication) that the pack ice concentration along the Antarctic coast line from 10° to 30° W varies between 0 and 6/10 from late December until the end of February. Such conditions allow free access to the continent. Similar conditions are met between 30° and 40° W until the second half of February. From this time onward, the ice concentration may increase up to 8/10 reducing the accessibility to these waters, at least temporarily. West of the 'horn', i. e. west of 41° W, the average situation is worse. Pack ice concentration 6/10 to 8/10 may be encountered during the austral summer constraining the passage to the coast west of Berkner Island. Such risks have consequently to be taken into account for all ship operations in this area. The pack ice conditions during 1979/80 season were entirely different from the average situation. The ice distribution was surveyed by satellite techniques using the Skyceiver equipment. With the aid of this instrument we were able to receive images of the Weddell Sea and total West Antarctica from the satellites Tiros N and NOAA 6. Figs. 4 and 5 present a satellite image (NOAA 6) of 24 January 1980 and of Meteor V of 9 February 1980 received from the Russian station Druzhnaya. There is open water all along the coast of West Antarctica and of the East Antarctica section encompassed by Fig. 5. The pack ice of the Weddell Sea had retreated far west to about 35° to 40° W. The funnel-like entrance between 10° and 30° W, which is usually ice free, giving access only to the area

between Cap Norvegia and Halley, had widened extraordinarily. During this time, ships could have sailed straight south from S. Georgia to the Filchner Ice Shelf.

The polynya along the Filchner/Ronne Ice Shelf was at this time no longer a small shore lead. The ice had retreated north leaving a wide area of open water. Ice free water extended all along the ice shelf to the Antarctic Peninsula and also up to 180 nautical miles northeast. These conditions allowed free operations in the southern Weddell-Sea and an unhampered passage to the Antarctic Peninsula.

The ice conditions have been compiled in an ice chart by STRÜBING (1980). Fig. 6 shows this chart with the maximum and minimum ice extent during January. The map comprises almost the same Antarctic section as the NOAA 6 image and also contains the ice extent averaged over the period 1973—1979. Despite a minor error — the shore lead extended until the Antarctic Peninsula during all January — Fig. 6 gives a good impression of the anomalous situation in 1979/80.

The pack ice distribution in the Weddell Sea is not only subject to seasonal fluctuations but its extent and concentration vary also from year to year. Such fluctuations are manifested, for instance, in the pack ice conditions during January 1979, 1980 and 1981. During January 1981, the Ronne shore lead was closed at all until the end of the month as experienced by the German ships operating in these waters at that time.

Attempts have been made to quantify the annual fluctuation. KUKLA (1977), for instance has found a seemingly periodic fluctuation in the ice coverage between 1967 and 1977 with a wave length of about 8

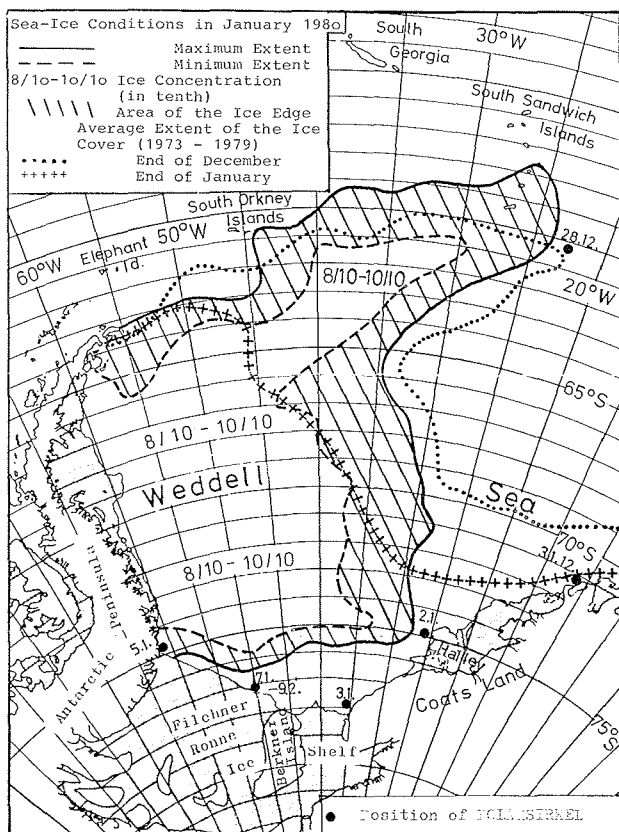


Fig. 6: Ice chart of the Weddell Sea (STRÜBING, 1980) showing the pack ice extent in the Weddell Sea at different times in the summer of 1979/80.

Abb. 6: Die Eiskarte der Weddell-See von STRÜBING (1980) zeigt die Packeisbedeckung in der Weddell-See zu verschiedenen Zeiten während des Südsommers 1979/80.

years. Such behaviour, if generally valid, would also allow prediction of the ice extent for the following seasons. We are, however, still far from any reliable prediction of this kind, particularly when it comes to detailed ice concentrations as the experiences of the last seasons have drastically shown, as KUKLA & GAVIN (1981) have pointed out recently.

CONCLUSIONS

The Weddell Sea is covered by sea ice throughout the year. During the summer season the ice retreats to the south and also to the west opening up an ice-free entrance to the continent between roughly 10° and 30° W. At the same time, a shore lead develops along the Filchner/Ronne Ice Shelf giving access to the southern most parts of the Weddell Sea. This shore lead is 20 to 30 km wide on the average, usually exhibiting a relatively low pack ice concentration. The appearance of the shore lead is subject to seasonal as well as annual variations. It may be exceptionally wide and ice free during one summer season and nearly closed in the following. The situation may also alter during one season from week to week as can be seen from the weekly ice charts. Open water may be followed by high ice concentration within a few days and vice versa depending on the regional weather conditions. Consequently, no reliable prediction is possible for the accessibility to the Filchner/Ronne Ice Shelf. It can only be expected from the average situation that the shore lead is open within the summer season with the highest probability at the second half of February.

References

- Ackley, S. F. & T. E. Kelihier (1976): Antarctic sea ice dynamics and its possible climatic effects. — *Aidjex Bull.* 33: 53—76
Kukla, G. (1977): Antarctic pack ice cover variations. — *US Antarctic J.* XII (4): 138—140
Kukla, G. & J. Gavin (1981): Summer ice and carbon dioxide. — *Science* 214 (4520): 497—503
Strübing, K. (1980): Wetterkarte des Deutschen Wetterdienstes, 1980, Nr. 38