Indian Expedition to Weddell Sea, Antarctica, Scientific Report, 1995
Department of Ocean Development, Technical Publication No. 7, pp. 15-24

Pack Ice Condition in Weddell Sea, 1989-90

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Introduction

Weddell Sea is famous for its treacherous and unpredictable ice conditions. There have been years when even the most powerful ice breakers have not been able to reach its southern limits. The blockade of the westward drifting pack ice and icebergs by the peninsular arm which, per force, concentrates the drifting ice floes within the higher latitudes of Weddell Sea, is apparently the main cause. During the summer months when, all around the Antarctic continent, open sea exists, major part of the Weddell Sea is usually covered by pack ice. This

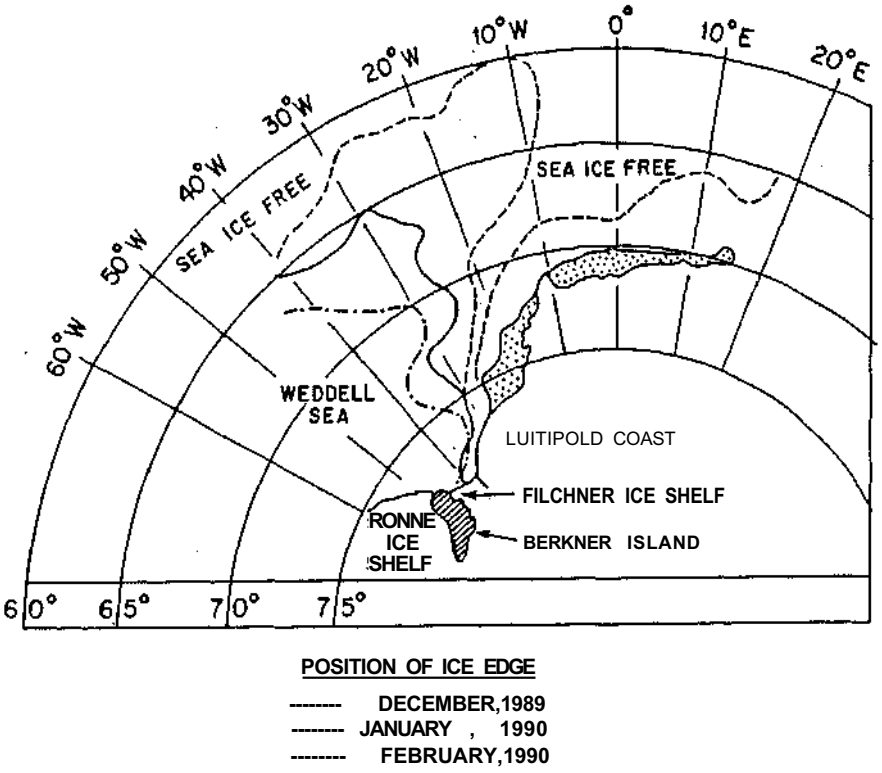

Fig.1. Retreating pack ice-edge in Weddell Sea during Antarctic Summer (Based on ice charts released by NOAA and observations made at site).

sea which is supposed to be the home of the world's climate and the ocean bottom cold waters, is also the home of the world's largest icebergs often referred to as the "ice islands" which make navigation even more hazardous. During our stay in the Weddell Sea three such icebergs each covering areas of 40 x 15 kms at about 77°00'S: 41 °W were noted, which were apparently the frontal part of the Filchner Ice Shelf reportedly broken in 1986.

Within the pack ice cover a number of leads are, however, always present and so are the polynyas along the coastal front. One of the most important leads, from the navigational point of view, is the one which extends from about 10°W at 60°S to 35°W at 75°S in almost NE-SW direction. This lead, possibly the result of a sub-oceanic warm water current which flows from the Indian Ocean into the Weddell Sea, has been observed to remain practically open, at times, from early December, as during the current season, till upto the second week of March (Fig. 1). It is often linked with the coastal polynyas enabling the ice breakers to cruise upto the shelf front. However, a change in the wind direction may lead to the closure of the polynyas, at short notice, thus entrapping the ships with a dire consequence. Nature of the open leads and the polynyas is now-a-days being regularly monitored with the help of satellites and the resultant ice charts are beamed, every week by the United States National Oceanic and Navy (NOAA) joint ice centre, Suitland, USA.

Nature of the Open Lead and Pack Ice Condition during 1989-90

During the austral summer of December, 1989, an open lead (Fig. 1) was encountered by the Indian team at and around 60°S and 20°W and the ship, ice breaker Polarbjorn, chartered by the expedition, taking the advantage of this open lead was able to move, without any ice

Fig.2. Pack ice at 77^0 S: 35° W, Weddell Sea.

Fig. 3 Pack ice/Fast ice close to Filchner Shelf (seen in the background) 78° 10 'S. 39° W, Weddell Sea

breaking upto 76°S: 30°W (28th December, 1989). Beyond this, however, considerable ice breaking had to be done on 29th and 30th December, 1989 as a wide body of pack ice was blocking the southward route (Fig. 2) at and around 77°S. Further south, the sea was again free of any major pack ice till very close to the Filchner ice shelf front at 78°S. There a drifting pack ice body (Fig. 3) per force made the ship to take an eastward detour till the open sea was observed to be linked with a polynya, developed parallel to the shelf front. The polynya was navigable, along the shelf front, upto 40°W along 78°10'S beyond which i e. westward, high concentration of fast ice conditions were encountered — too thick for any effort being made by the ship to proceed further. Incidentally, this happened to be the only *in situ* observation of pack ice/fast ice condition which did not match the NOAA picture of December, 1989. The latter had shown an open polynya all along the shelf front extending upto and linking with the polynya flanking the peninsular arm. The general pack ice condition during the period December, 1989 to February, 1990 was such that the ship could navigate easily along the shelf front and as such, was clear of drifting ice. In between, i.e. from 26th to 28th January, 1990, it, however, showed a remarkable change, which was so rapid that the ship was caught unawares with the possibility of serious consequences. A continuous snowfall during the day on 26th January, 1990 followed, by what appeared at the time, the freezing of the sea all around, led to fall of temperature which had gone down to minus 9°C. By the evening the frozen sea ice was found to have developed circular patterns; the circular margins being marked by low level pressure ridges almost soapy in texture. These circular ice floes, not *sensu stricto* "pancakes" started coalescing with each other and gave rise to a continuous white sheet; the coalescing boundary of the floes being

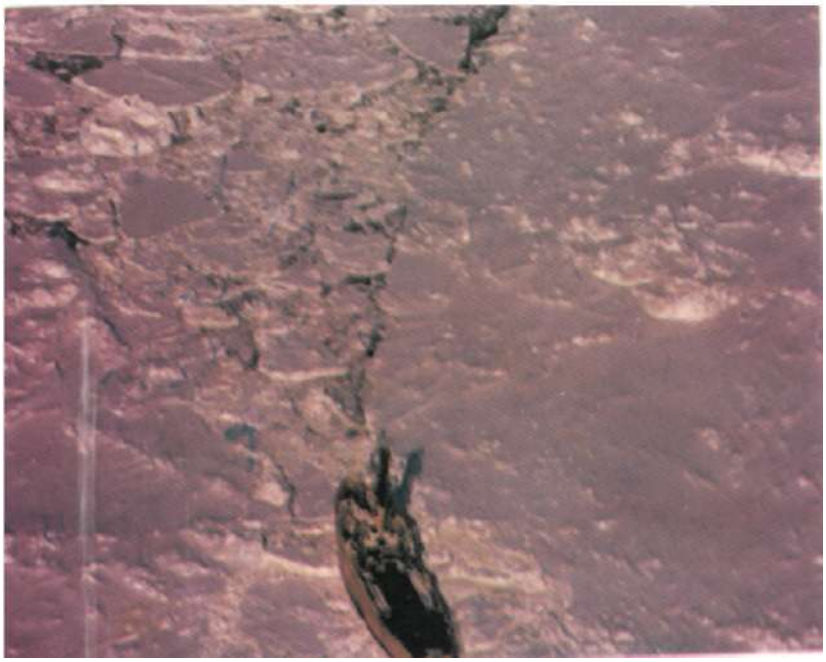

Fig.4. Coalescing icefloes, Weddell Sea.

Fig.5. Pressure ice ridges, Weddell Sea.

Fig.6. Rafted ice blocks marking, the pressure ice ridges, Weddell Sea.

Fig.7. Mounds of rafted ice slabs, pressure ridges, Weddell Sea.

marked by a slightly uplifted row of rafted ice blocks. Individual floes varied in size from 10 m to 15 m across. It was observed that the concentration of the ice floes was faster on the northern side of the ship (open sea side) as compared to the side closer to the ice shelf (Fig. 4). Within hours-the entire sea had vanished and the surface was marked by a thick white sheet prominently exhibiting rows'of rafted ice blocks and pressure ridges (Fig. 5). With the advent of time, shear fractures were observed to have developed along the western boundary of individual floes with each eastern floe moving over the western floe. This was followed by the development of much larger pressure ridges along the contact with piling of the rectangular rafted ice blocks - almost in a series of layers one upon the other though often haphazardly (Fig. 6). By the morning of 27th January, 1990, concentration of pack ice all around the ship had become very heavy and the pressure ridges had attained a definite form and shape and had even risen to more than a metre in height at some of the places. No perceptible change could be seen either at the high tide or at the low tide time. Density/concentration and the thickness of the pack ice within just 24 hours had attained the strength to bear the weight of a helicopter and one could stroll over the pack ice surface at ease. By late afternoon of 27th January, 1990, the pressure ridges along the contact of the original colliding ice floes had at places given rise to huge ice mounds rising to a height of upto 2 metres, formed of steeply inclined large.rafted ice slabs (Fig. 7). This activity of sea ice continued with gradual increase throughout the 27th, with the ship entrapped and drifting westward along with the pack ice. During the previous 24 hours, i.e. midnight of 26th to midnight of 27th, the ship had drifted WNW from its original position, by about 2.5 nautical miles. By the midnight of 27th some of the pressure ice ridge mounds had attained frightening size and had in fact, in one case risen above the height of the helo deck of the ship. This mound had developed icicles on its front (Fig. 8). Apparently the rising air temperature during the day had caused melting of superficial ice layers which had by evening frozen to form icicles as no other explanation appears to be forthcoming; unless it is presumed that along the colliding margins, sea water got squeezed and sprouted along the ridge surface which froze to form icicles. Pack ice by now had started putting pressure on the ship's bulkhead and screeching sound, with ice under pressure gliding along the ship's side, could be clearly heard.

Towards the morning of 28th January, 1990, the sky cleared and perceptible katabatic winds, down the polar ice cap, started blowing which brought to halt the movement of the entrapping pack ice all around the ship. Within hours the pressure on the ship's bulkhead reduced; the pressure ridge mounds started collapsing and series of meandering cracks and fissures developed in the pack ice. These meandering cracks, which at places exhibited a rectilinear nature (Fig. 9) gradually opened up and sea water could be seen after a lapse of more than 48 hours. The widening gap continued to enlarge every hour and by the afternoon of 28th, large open leads of sea water had developed throughout the pack and a polynya of about half a kilometre width developed along the ice front. This polynya linked eastward with the open sea way beyond the Vahsel Bay.

These spot observations made have not only thrown some light on the fluctuating sea ice conditions in the Weddell Sea, but have also substantiated some of the observations made earlier by Wordie (1921):

1. Formation of pack ice is basically a phenomenon of lowering of temperature and freezing of sea water, the drifting and concentration, however, is direct conse-

Fig. 8. Large ice mounds with icicles marking. Vie pressure ridges. Weddell Sea.

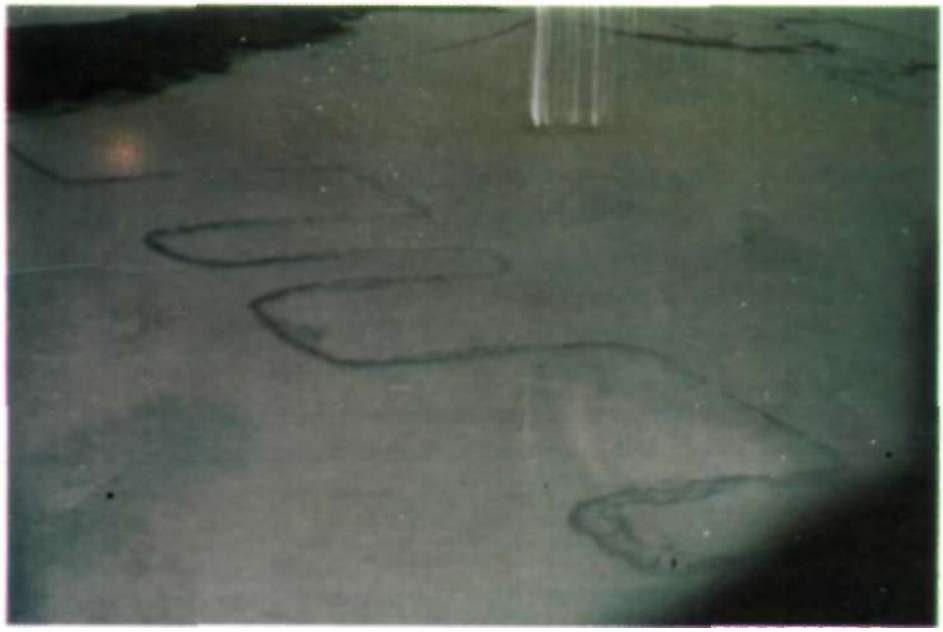

Fig. 9. Rectilinear meandering cracks in pack ice, Weddell Sea.

quence of sea water currents aided by surface winds prevailing in the vicinity of landmass.

2. Pack ice in the southern part of the Weddell Sea shows high pressure nature giving rise to huge pressure ridges and mounds.
3. Drift movement in this part of the Weddell Sea — around 78°S is rather fast and westward.

Fluctuation of the Ice Edge

The northern limits of the pack ice of varying concentration in the Weddell Sea area shows a regular fluctuation. During the austral summer of 1989-90 ice edge was still existing at 60°S towards the third week of December with its western margin running almost parallel to the 10°W longitude practically marking the eastern limits of the Weddell Sea. Further south it had taken a southwesterly swing upto 75°S giving rise to an open lead (Fig. 1). Along the eastern margin of the lead, the ice edge ran almost parallel to the coastal features

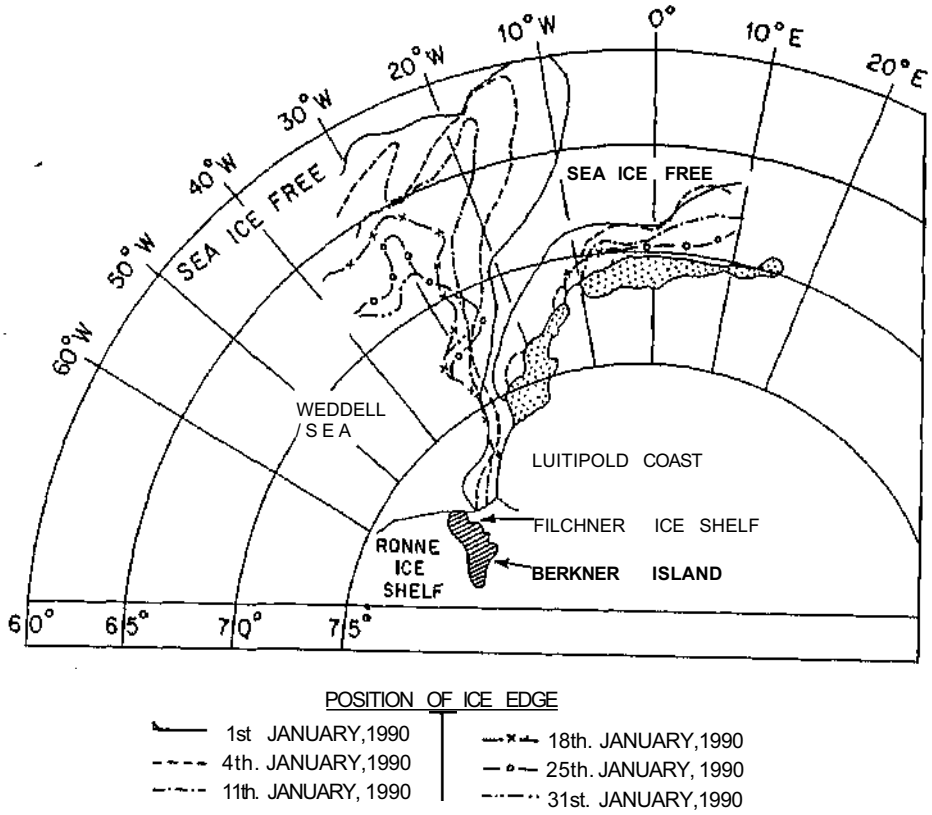

Fig.10. Retreating pack ice-edge in Weddell Sea — January, 1990 (Based on ice charts released NOAA and observation at site).

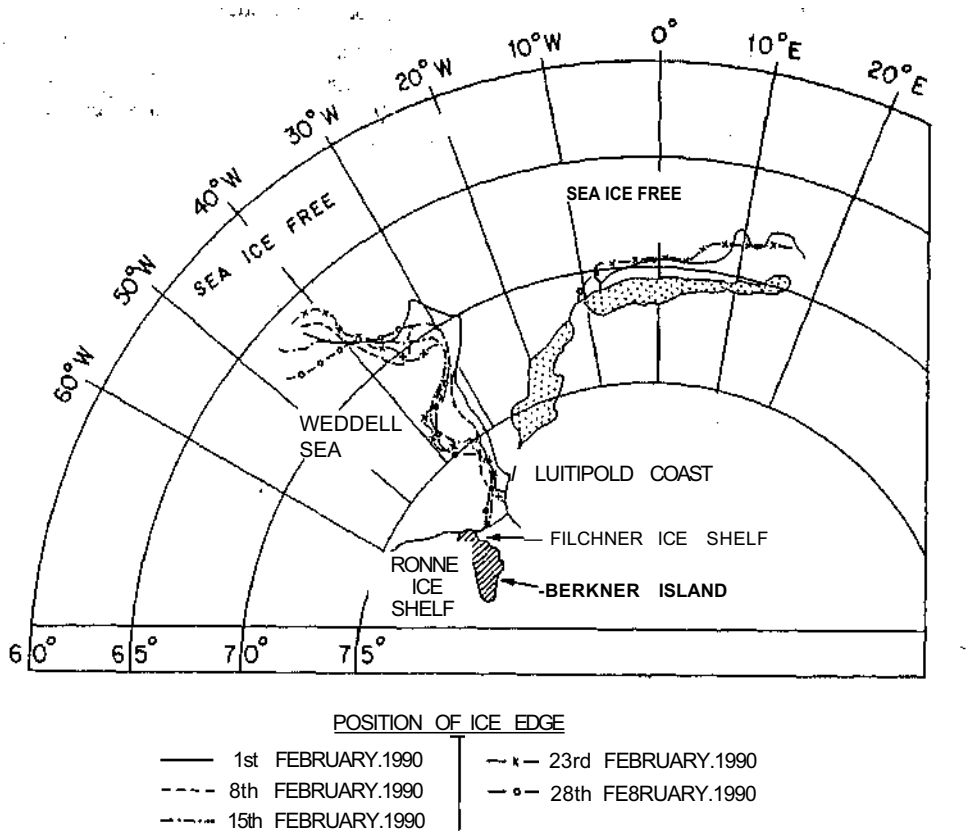

Fig 11 *Retreating pack ice-edge i n WeddellSea — February, 1990 (Based on ice charts released by NOAA)*

being restncted northward to a maximum of 68°S upto 0° meridian, east of which it still continued to exist upto 65°S

During the month of January, this pack ice edge showed a continuous retreat along its northern limit, retreating to 68°S with 25°W longitude marking its eastern margin (Fig. 10) It had simultaneously completely drifted away by the end of January, 1990 from the sea surrounding the Luitipold Coast and the Brunt ice shelf

The open lead had widened considerably and along the northern limits had practically become an open sea Towards the end of January — 26th to 29th to be precise, heavy snowfall which lashed the area for more than 48 hours coupled with the lowering of temperatures and northerly winds, led to freezing of the southern limits of the open lead and the polynya with pack ice concentration increasing to the extent of 9/10 Pressure ridges which started as low amplitude ridges of fractured ice cubes slowly grew to'large size — upto 3 metres — comprising huge ice blocks. Ice breaker Polarbjorn was engulfed on all sides and could not make any progress. "Almirante Inzar", the Argentinian ice breaker of

10,000 H.P. capacity, which was in this area at the time, tried to come to our help but found negotiating the pack ice a tough proposition on 27th - 28th January, 1990.

During the month of February, 1990 (Fig. 11) the pack ice edge continued to retreat further south and west and at the end of the month, ice edge in Weddell Sea, had almost retreated to 70°S with 30°W meridian marking its eastern limits. Open lead had become an open sea extending almost upto 77°S. A well developed polynya marked the Filchner ice shelf front upto 41°W, west of which, however, ice concentration of 7/10 to 9/10 continued.

Reference

Wordie, J.M. (1921): Shackleton Antarctic Expedition, 1914-1917. Geological observations in the Weddell Sea area. *Trans. Roy. Soc.* Edin., 53(1) 17-27.