The polygonal area about 30 km across, centered at the ship's position, was taken as to the studies of ice field deformation. This area was represented by connecting the outer icebergs far from the ship. As it seemed that icebergs were also beset in the pack ice, deformations of this area showed the contraction and the relaxation of the ice field. The ice field was contracted by north-east or east by north-east wind, and was relaxed by south or west wind. In the period of Jan. 14–25 during which the east by north-east wind was most frequent, the ice area was contracted to about 64% of the initial area. When the ice field was relaxed by south or west wind between Jan. 25 and Feb. 1, the ice area increased about 34% of the area observed on Jan. 25. This fairly large value of ice area increment might be resulted from the motion of icebergs which drifted independently from surrounding pack ice, especially during the latter stage when the ice field became loose.

The ratios of contraction in all directions within the ice field were obtained from the contraction period of Jan. 18–22. The circle within the initial ice field deformed to the ellipse at the last stage during the considered period. The maximum contraction appeared in the direction of east by north-east to west by south-west. This contraction was observed from the ship as the formation of hummocks and pressure ridges. The ratios of expansion in all direction were obtained from the relaxation period of Jan. 26–Feb. 1. The maximum expansion appeared in the direction of north-west to south-east. This expansion was recognized from the airplane as the formation of cracks and leads in the direction of north-east to south-west which was perpendicular to the above-mentioned direction.

PACK ICE IN THE LÜTZOW-HOLMBUKTA OF THE ANTARCTIC*

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昭和基地沖の流氷帯移動について*

熊凝武晴**・宝谷英生***・柳川三郎***

Introduction Pack ice in the Antarctic late in summer (from January to February) begins to thaw out and disunite. The Antarctic pack is composed of sea ice frozen in the open sea, detached fragments of fast ice formed along the coastline, and disintegrated particles of land ice. This conglomeration drifts northward and north-westward under the influence of the wind, the current and the anticlockwise component due to the earths rotation. This drift to lower latitude impeded between 40°S. and 60°S. by the " Westerlies " prevailing in those latitudes, with the result that a belt of somewhat consolidated ice is produced through which vessels must pass in order to reach the shores of the continent. The north limit of the pack is variable and the location of the extreme edge varies also with the season. During the late winter and spring the edge extends to most northern limit, the edge lying in much the same position during July, August, September and

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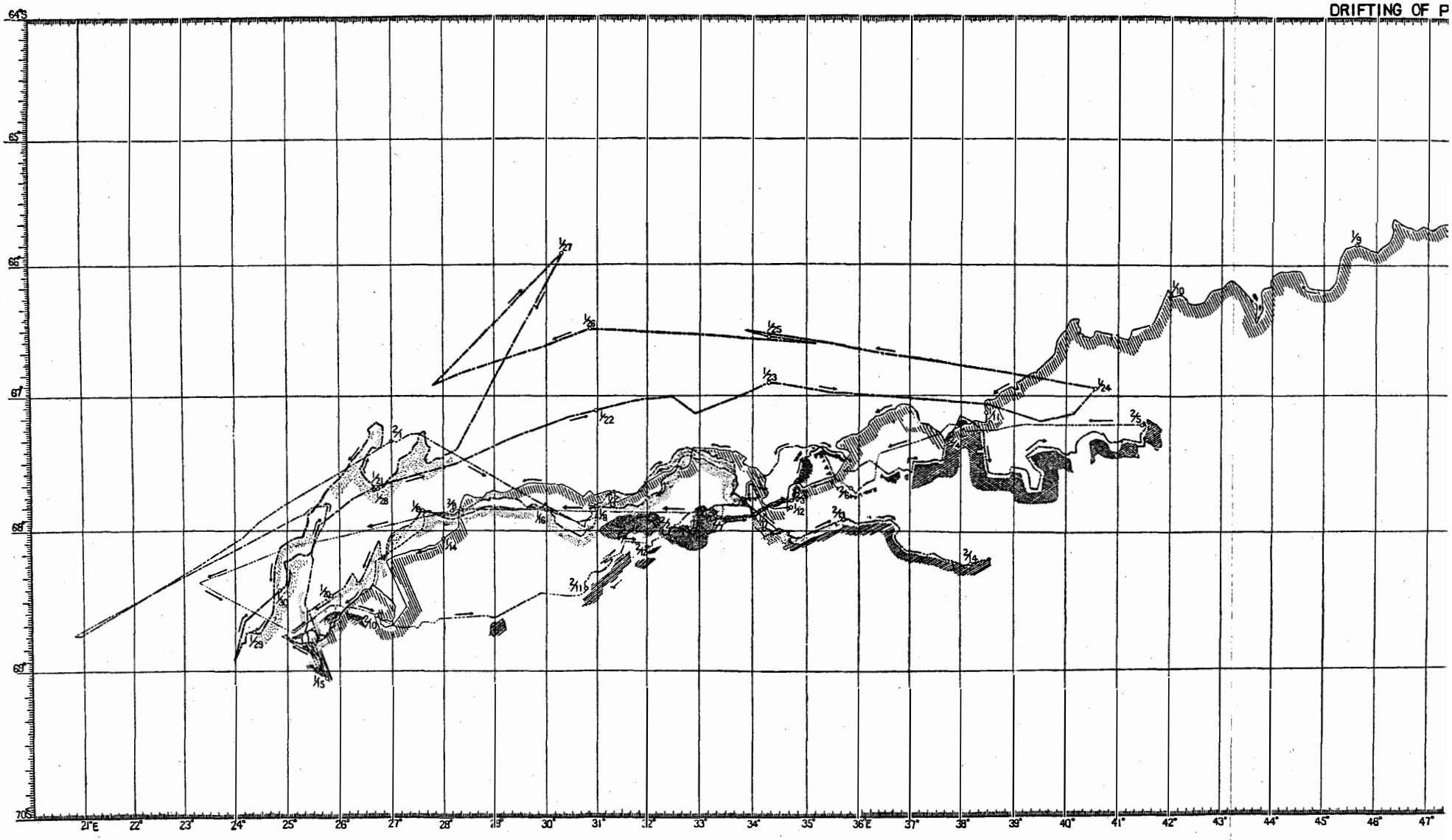

Fig. 1. Chart showing the change of pack line from Enderby land to Princess Ragnhild Coast in the Antarctic Coast. (From early January to the end of February, 1957.)

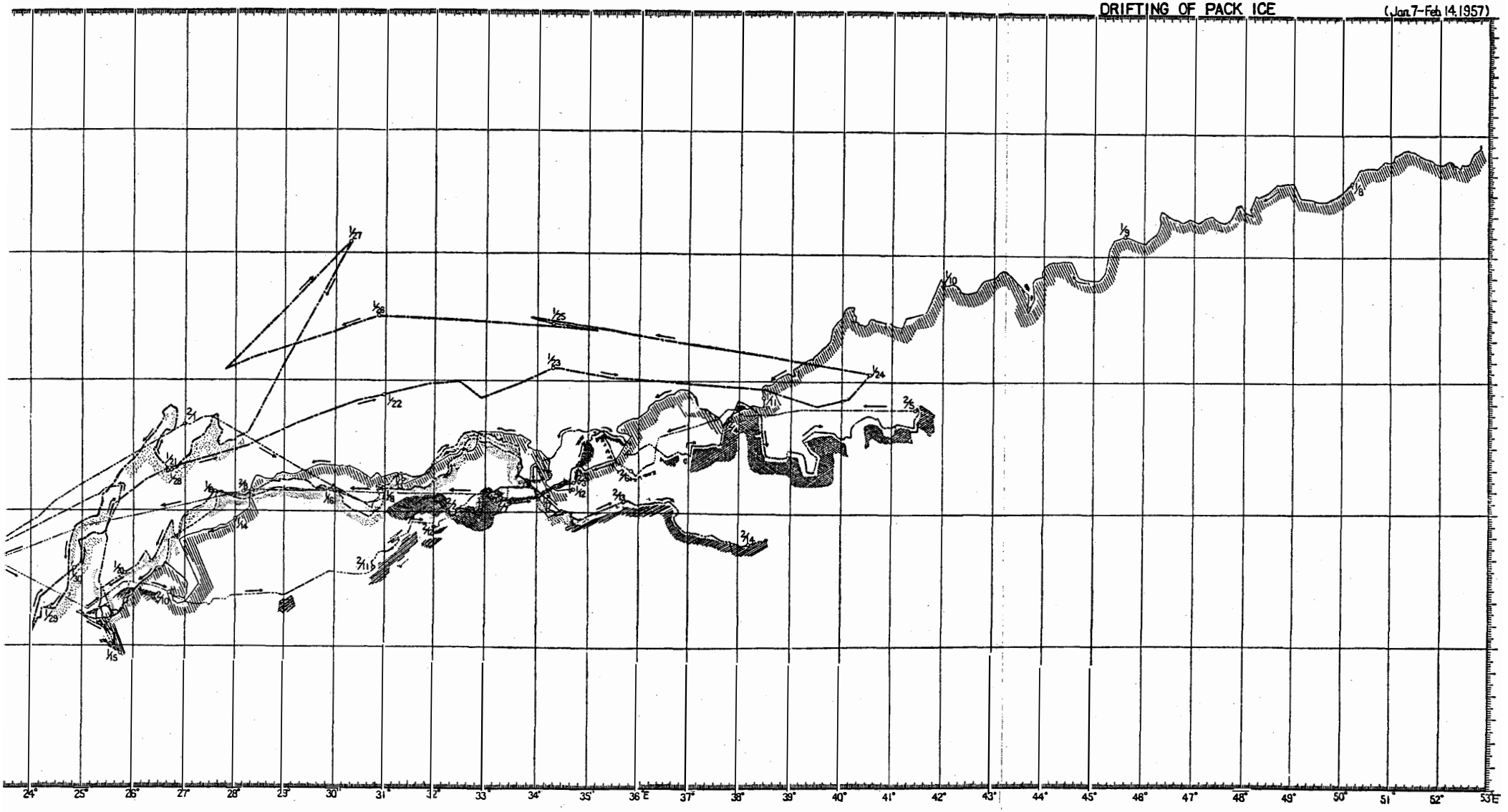

Fig. 1. Chart showing the change of pack line from Enderby land to Princess Ragnhild Coast in the Antarctic Coast. (From early January to the end of February, 1957.)

October. But during summer the edge retreats to a southern limit during the autumn months of February and March, when it is considerably south of the spring position.

Indian Ocean: From 20°E to 50°E, 1957, in December the edge usually lies in about 63°S. By January the ice has dissipated considerably and open water is generally found very close to the continental coast. In February and March the edge of the pack retreats to a southern limit 68°-69°S. In the off sea of the Princess Ragnhild retreats to the edge to about 69°-10°S (southern limit). In January the wind force is comparatively weak, the edge of pack-ice retreat to the continent by the drift of 1.5-7 miles per day.

The ratio at which the different floes travel is not so much dependent upon the size and depth of the floe as upon the nature of its surface. Since the pack is made up of a conglomeration of young-ice, old floes which have been subjected to pressure, and ice-bergs, each of these elements presents radically different resistance to the wind and the current. Surface irregularities, such as hummocks and pressure ridges, act in said areas, and the rate of movement of a floe depends on a certain extent on the amount of hummocking in proportion to the area and weight of the floe.

A progeny of previous pressure, hummocked floes in turn becomes the cause of stiff further pressure when two floes are moving at different rates, either the distance between them is increased and a lead or lane produced or the distance between them is decreased through in physical contact. In gaining the momentum, larger floes will take longer to reach gain speed, but, once underway, they will under their way long after smaller floes have stopped moving. In the early stages, therefore, the large heavy floe will be broken up into smaller ones overtaking it; in the later stages, it will itself be the attackes of smaller floes in its path.

Due to their size and weight the smaller floes will be disrupted and the floe surface materially modified, thereby creating new possibilities of yet further difference in speed.

The movement of the pack-ice Soya closed The position of Soya in pack ice was 68°—22′S, 38°—42′E by the radio bearing from Umitaka-maru on February 22.

We found a big ice-berg (67°57′.5S, 37°49.0′E) having a wide cave in the vicinity of Soya and sailed from the point to prevent storm. After 4 stormy days Soya reached 68°08.5′S, 35°43.2′E in the pack-ice (165°, 12 miles from Umitaka-maru). The position of Umitaka-maru was 68°25′S, 25°47′.0E on February 25th.

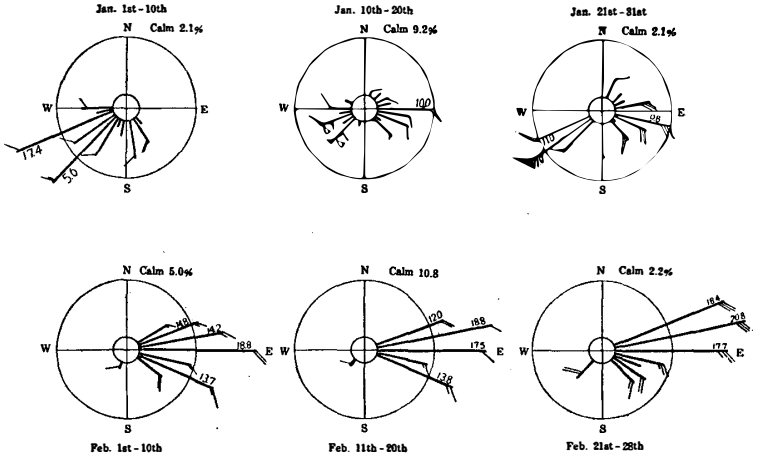

Fig. 2. Chart showing the distribution of wind directions and force on each ten days of January and February, 1957 off the Antarctic coast. (Lützow-Holm Bay)

The ice-berg, when we started from the large ice-berg on February 22 at noon, lies 2 miles east from Umitaka-maru on February 25th and drifted 225°,42 miles for 4 days. The current streamed with 0.6 knot per hour to the w/s (w/s≒260°). There is known that the drifting of the large ice-berg is not caused by the wind, but chiefly moved by the current. And therefore, we can consider this ice-berg drifted by the only 0.6 knot current. We found the ice-berg in the Antarctic have been drifting with 70% of the velocity of the current toward the current direction. The pack-ice around the Soya included many ice-bergs and fast hummocked ice on account of this. The pack-ice drifted chiefly by the wind; the ice-berg is considered to have drifted by the current without the influence of the wind.

The drifting velocity of the ice-berg and the pack-ice is different and the latter was sooner than the former. Because of the pack-ice was streamed by the wind, there was 19 miles open sea at the lee side of the big ice-berg. We considered this 19 miles open sea is the difference between the drifting velocity of the ice-berg by the current and that of the pack-ice by the wind or the current.

Drifting distance of Soya 63 miles

Drifting distance of the ice-berg in the pack-ice

63 miles−19 miles=44 miles

Drifting of current per day

0.6 knot×24=14.4 miles

Drifting velocity of ice-berg per day

11 miles $\left(\frac{44\times100}{14.4}=75\%\right)$

Drifting rates 76%

The drifting velocity of pack-ice is almost approximate value, because it is difficult to separate the current and the other fact. Cook peninsula lay down at the lee side and the current has a tendency to stream toward the northern direction along the peninsula.

This data contains an element of estimation, and is to so referent as it does not deduced from a direct observation. The streamed direction of pack-ice is caused by the wind and the current. In the Antarctic the direction has been streamed to left from the direction of the wind. The drifting velocity of pack-ice have been determined by the wind, current and the open sea. If we ignore the resistance of ice, as the drifting theory by Ekman, actually the ice streams about 30° left than the wind direction. As the current influences to the drifting of pack ice makes recurrent movement. We can not find the large difference if we calculate by the wind only in the drifting of pack-ice near the shore. In the calculation (1), (2), (3), (4), (5). (1) separate from pack-ice lasting to the continent and stream out to offshore and has a tendency to stream toward the northwest with the influence of the westerly wind and the earth rotation.

Drifting velocity of pack-ice If we ignore the influence of the current as the next table shows.

In Lat. 20°E–50°E on January-February 1957, pack-ice streamed with 1.9–2.4% of the wind velocity and drifted about 30° left from the wind direction.

It is agreed with the drifting theory by Ekman.

Drifting of pack-ice Pack-ice began to drift in the case of the separation from the shelf ice of the continent by the wind and current. Pack-ice has been drifted generally toward northwest by the influence of the wind, westerly drifting current and earth rotation with 2.7 m/day for 10 days from January 18th to 28th as Figure 3 (1 and 2). Unless the pack-ice does not thaw out, probably it will be reach to near the limit of the westerly wind (Lat. 66°S).

Change of the pack-ice The wind in the middle of January is weak as Figure 6 shows. The retirement of pack-ice to the continent is chiefly caused by the solvent, especially in Long. 34°E off the Cook peninsula. Pack ice has 42 miles wide on January 12th decreased to 28 miles on

January 17th and showed 2 miles retirement average per day. The storm with blizzard began to attack from the late of January. According to the easterly wind and the west drifting current in the west of Cook peninsula, the drift of west or northwest getting stronger and caused open sea near the Cook peninsula and showed the retirement to pack line on February 10th as Figure 3. In the early of February, as Figures 2 (February 4th to 6th), 3 (February 4th–13th) and 4 (February 4th to 13th) shows.

Pack-ice drifted with over 5 miles per day.

There continued the drifting of pack-ice toward west and northwest on the west seas of the Cook peninsula and caused open sea between Cook peninsula and the groups of pack-ice. In the Lützow-Holmbukta pack ice from Enderby land has been continued drifting toward WSW by the easterly wind and westerly drifting current. At February 3rd Lützow-Holmbukta was filled with these pack-ice and began to hummocking. In the middle of February; the number of the storm attack is increasing and easterly wind grow stronger and stronger, these pack-ice is constructed and began to refreeze with the low temperature and became a strong pack-ice zone. As Figure 3 shows in February 22nd to 27th the movement of pack-ice is violent because of a heavy storm continued for 6 days and showed the big drift with about 16 miles for 7 days.

Drifting and solvent of pack ice around the Antarctic continent is influenced by 3 elements of the wind, current and temperature, and the amount of these shall not be constant every year.

Distribution of pack-ice In the state of Lützow-Holmbukta in Lat. 65°–69°S. from Enderby land to prince Ragunhild; the average sea temperature in January, 1957 was −0.13°C and the lowest (temperature) was −1.50°C, in February showed −0.85°C and the lowest was −1.7°C.

Antarctic surface water with lowest temperature and lowest salinity is found on near the surface; and considered it was influenced by the pack-ice and the polar front. We found the different character in the east and west region of the Cook peninsula; in January the surface sea temperature in the east was −0.5°C and lowest water (−1.5°C) laid between 100m and 150 m; in the west, the surface sea temperature was −1.0°C and lowest water (−1.5°C) laid between 40 m and 210 m depth.

In February atmospheric temperature suddenly fell down at the east region of its Cook peninsula. Surface sea temperature at the region run down to −1.0°C and filled with very cold water (−1.7°C) from surface to 150 meter depth. On the contrary in the west region of the peninsula, the sea condition showed the same as in annuary, and we could not observe any difference, the frozen of sea water began on February 4th and new pack-ice has been growing on February 18th in 1957.

Conclusion This is the examination of pack-ice in the Antarctic around Syowa Base covering in the period from January to March in 1957.