Mem. Natl Inst. Polar Res., Spec. Issue, 40, 289–298, 1986

OBSERVATION OF THE MARINE BENTHIC ORGANISMS AT SYOWA STATION IN ANTARCTICA USING A REMOTELY OPERATED VEHICLE

Etuyuki HAMADA[1], Hideki NUMANAMI[2], Yasuhiko NAITO[3] and Akira TANIGUCHI[4]

[1]*Tokyo University of Fisheries, 5–7, Konan 4-chome, Minato-ku, Tokyo 108*
[2]*Faculty of Marine Science and Technology, Tokai University, 20–1, Orido 3-chome, Shimizu 424*
[3]*National Institute of Polar Research, 9–10, Kaga 1-chome, Itabashi-ku, Tokyo 173*
[4]*Faculty of Agriculture, Tohoku University, 1–1, Tsutsumidôri-Amamiyamachi, Sendai 980*

Abstract: The authors participated in the 25th Japanese Antarctic Research Expedition and conducted observation of benthos near Syowa Station in Antarctica using a remotely operated vehicle. In addition to a TV camera, the vehicle was equipped with two still cameras for "stereographic" photographs.

As a result of analysis of those photographs, the authors were able to determine the distribution density of benthos. In shallow waters (10 and 16 m), motile animals such as urchins (*Sterechinus neumayeri*) were plentiful, while as the water got deeper (40 and 80 m), sessile animals such as tubeworms increased. At the deepest location observed in this study, 200 m, Bryozoa were dominant; areas existed where Bryozoa covered the entire seabed.

1. Introduction

The seabed along the coast of the Antarctic continent is inhabited by many organisms, as revealed by scuba diving observations (DAYTON *et al.*, 1970; PROPP, 1970; WATANABE *et al.*, 1982), by beam trawl net (BULLIVANT, 1967a), by grab sampling (BULLIVANT, 1967a, b) and by trap net (HOSHINO, 1976; HOSHIAI, 1978; MURANO *et al.*, 1982; NUMANAMI *et al.*, 1984).

By scuba diving in shallow sea waters, direct observation of benthos can be made and an estimation of the biomass is possible. However, conversely, there are limits of depths reached by diving and the cold water temperature makes a long-time work difficult. Collection by trap net is restricted to carnivorous organisms and therefore obtaining a total picture of the benthos community is not possible. Gathering by beam trawl net is limited to open water. Although the biomass is estimated by the catch volume and the area swept, the method does not allow observation of the benthos in an intact habitat. As this study sought to observe organisms alive on the seabed in waters too deep for scuba diving, and to conduct quantitative observation which would allow for an estimate of the biomass, a remotely operated vehicle was used.

2. The Remotely Operated Vehicle System

The remotely operated vehicle used throughout this study was the DLT-300 manufactured by QI Co., Ltd. (Tokyo). An underwater still stereo camera had been attached (Fig. 1).

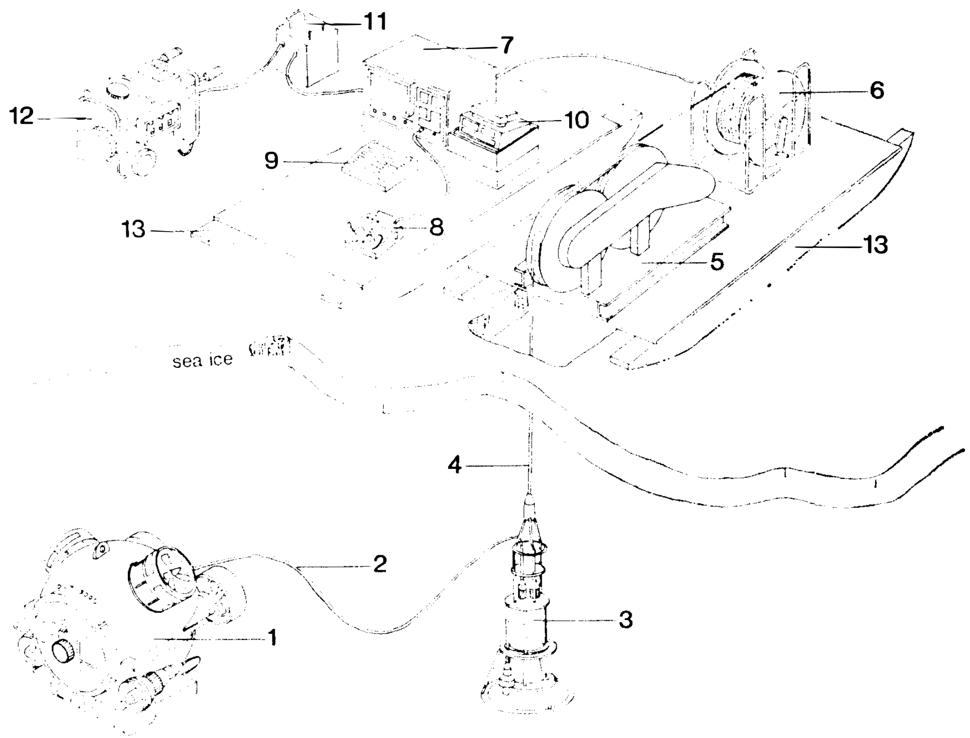

Fig. 1. Showing a remotely operated vehicle system.
1: vehicle, 2: tether cable (30 m long), 3: transformer, 4: main cable, 5: electric winch, 6: cable spooling drum, 7: control/monitor, 8: joystick, 9: microcomputer, 10: video tape deck, 11: transformer, 12: gasoline-powered generator, 13: sleds.

The remotely operated vehicle has four thrusters which provide vertical, forward and reverse, lateral and rotational motions. The vehicle is nearly spherical in shape and 430mm in diameter. The weight is about 51 kg in air and nearly 0 kg in water. The vehicle was pressure-tested and the confirmed operational water depth was down to 350 m. The maximum speed of the vehicle was 0.8 m/s. A magnetic compass and a depth sensor were installed in the vehicle and functioned as the navigational system. The vehicle utilizes a CMOS color TV camera with a resolutoin of 260 lines, automatic iris control and remote tilt and focus.

The underwater still photo cameras used were two full automatic cameras (Autoboy, Cannon Ltd.), but the automatic focus was not functioned, because the cameras used the focus fixed at the minimum distance (1.2 m in water). The cameras were placed along with a strobo light in a watertight case. The watertight case was fixed to the bottom front of the vehicle. While the TV camera monitored approximately the same scenes as the cameras, photographs were taken by sending down shutter release signals at the appropriate times from above the ice.

The vehicle was connected to a transformer by a flexible tether cable of 30 m in length. The tether cable had slight buoyancy so as not to become entangled with objects under investigation.

The transformer changed the 220 V AC current from the surface power source through the main cable to the 100 V AC which was supplied to the vehicle. Once the transformer had been settled on the seabed, it was fixed by its weight in water (30 kg). Therefore, the vehicle's movements were restricted within a circle around the transformer with a radius equal to the length of the tether cable (30 m).

The transformer was lowered to the seabed by the main cable. As the length of the main cable was 300 m, in order to send electricity to the vehicle through such a long cable, it was necessary to raise the voltage and reduce the current thereby necessitating the use of a transformer. The main cable was 16 mm in diameter and the maximum allowable tensile strength was 400 kg. This made it possible to raise and lower the transformer using the main cable alone.

The vehicle and transformer were raised and lowered by an electric winch through an 80 cm square hole cut into the ice. The electric winch, along with the cable spooling drum, was loaded onto a sled. The sled was positioned over the hole in the ice.

The main cable was spooled on the cable spooling drum which was maneuvered by man power. The control/monitor and the joystick were situated on a second sled. This sled had a covering and was of the type called "caboose". The control/monitor has a TV monitor, a depth indicator and a compass. These devices provided necessary information for operating the vehicle. The control/monitor was linked to a microcomputer and a video tape deck. The distance that the vehicle moved was estimated by the operation time of the thrusters. From that figure and the direction obtained from the compass, the position of the vehicle was calculated and displayed by the microcomputer. In addition to recording images on the video tape deck, verbal comments were recorded on the main sound track and data (such as maneuvering data from the joystick and information data regarding depth sensor and direction of compass from the vehicle) were recorded on the auxiliary sound track in digital signals.

A 100 V 1.2 kW gasoline powered generator was used to supply the necessary power.

3. Result of TV and Still Photography Observation

Observations were carried out from January 6 to 20, 1984 at five stations near Syowa Station (Fig. 2). In the first observation conducted at the Nisi-no-ura Cove, one of the stereo still cameras malfunctioned allowing only monaural photographs to be taken. At the other stations, a total of 130 pairs of stereo photographs were taken. In addition, at least 30 min of visual recording by TV camera was done at all stations.

3.1. Nisi-no-ura Cove (water depth 10 m)

The bottom condition was divided into two areas, one is sandy with partially exposed rocks and the other is rocky bottom. Urchins (*Sterechinus neumayeri*), motile animals, were quite frequently observed. Furthermore, organisms like tubeworms and Ascidiacea, which use the rocks as their adhesion base, were noticed in small numbers. However, compared with the past diving studies (WATANABE *et al.*, 1982), fewer different

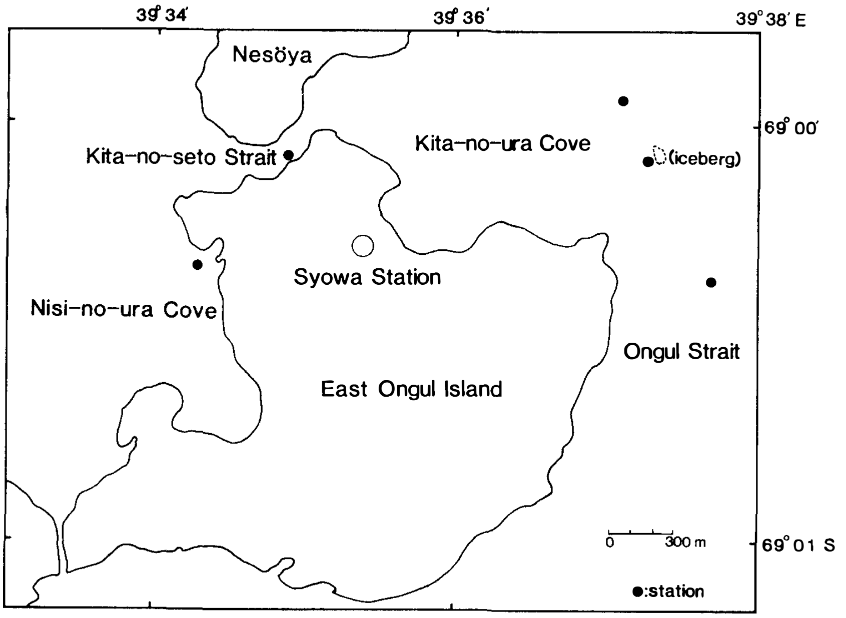

Fig. 2. A map showing five observational stations near Syowa Station.

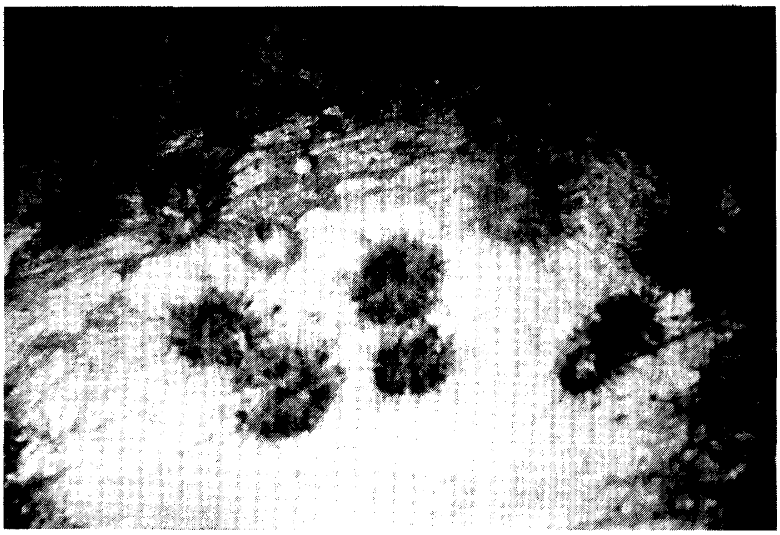

Fig. 3. Benthic fauna in Nisi-no-ura Cove (water depth 10m).

species of organisms were observed (Fig. 3).

3.2. Kita-no-seto Strait (water depth 16m)

The seabed here was primarily sand with rocks exposed in some places. An extremely large number of urchins (*S. neumayeri*) were observed throughout the seabed. Also, while few in number, organisms such as brittle-stars and starfish were also observed. As to sessile animals, tubeworms abounded, while only few sponges, Ascidacea, Actiniaria and Hydrozoa inhabited the strait. As to fish, both adult and juvenile of *Trematomus bernacchii*, which have in the past been frequently collected in the Syowa

Fig. 4. Benthic fauna in Kita-no-seto Strait (water detph 16 m).

Station area, were observed. While algae were not found on the rock, 78% of the urchins (*S. neumayeri*) observed in the photographs had algae on their body surfaces (Fig. 4).

At this station, Gastropods (*Neobuccinum eatoni*) and Nemertinea (*Lineus corrugatus*) both of which had high frequency of trap collections in the past (HOSHIAI, 1978). were not photographed.

3.3. Kita-no-ura Cove (water depth 40m)

At the Kita-no-ura Cove, organism distribution has been noted in prior trap collections (HOSHIAI, 1978; NAITO and IWAMI, 1982; NUMANAMI *et al.*, 1984) as well as observed during scuba divings in water depths down to 18 m (WATANABE *et al.*, 1982).

The present observational station was rocky with sediment accumulation in some

Fig. 5. Benthic fauna in Kita-no-ura Cove (water depth 40 m).

spots. Filter feeders, such as tubeworms, Ascidiacea, sponges and Bryozoa, which use the rocks as an adhesion base, were observed in great numbers (Fig. 5).

While there numbers were not as great as those observed at the shallower Nisi-no-ura Cove and Kita-no-seto Strait, urchins (*S. neumayeri*) were observed here, too, in numbers and Holothuroidea (*Cucumaria* sp.), Crinoidea, Mysidacea, Pycnogonida, fish (*T. bernacchii*) etc. were distributed. Holothuroidea (*Cucumaria* sp.) and Chrinoidea thriving above sponges were observed in particularly large numbers.

3.4. Kita-no-ura Cove (water depth 80m)

A hole was opened in the ice approximately 10m distant from an iceberg and observations were undertaken. On the face of the iceberg, at a depth of 20m, Bivalvia (*Adamussium colbecki*), fish larva and Amphipods were observed.

The distribution of organisms on the seabed here was nearly identical to that of the station where the water depth was 40m, although the habitation of juvenile fish (*Trematomus* sp.) on the seabed at a water depth of 80m was confirmed (Fig. 6). Furthermore, traces of detachment of organisms over a rather large segment of the seabed was observed. This is thought to be destruction caused by movements of icebergs. Hitherto trap-collected *N. eatoni* (NUMANAMI *et al.*, 1984) were not observed.

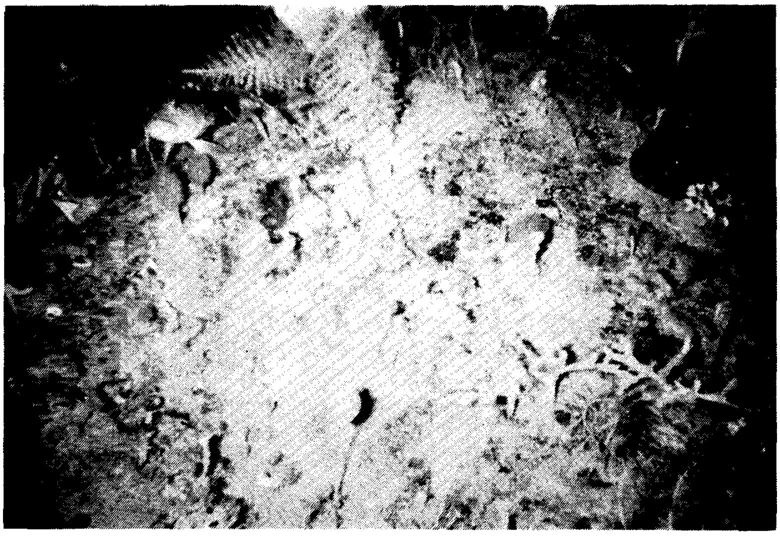

Fig. 6. Benthic fauna in Kita-no-ura Cove (water depth 80m).

3.5. Ongul Strait (water depth 200m)

The seabed here was covered with fine sediment. When the vehicle hit the bottom, clouds of sediment rose obstructing visibility. The biota here, unlike the shallower stations, showed no urchins and few motile animals such as brittle-stars. Colonies of Bryozoa were present on the seabed, among which large sponges, Holothuroidea (*Cucumaria* sp.), Crinoidea and tubeworms were seen (Fig. 7).

In observations made from the video recordings and still photographs, the shift from a motile animal biota to a sessile biota became pronounced with increases in depth.

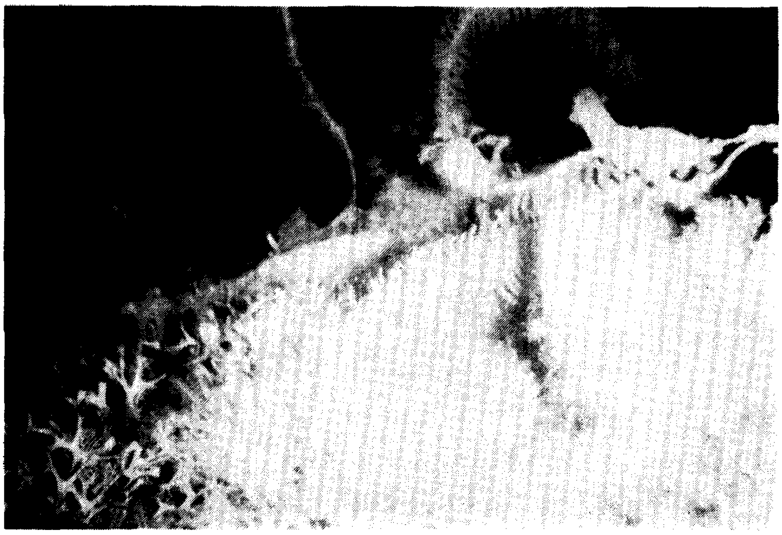

Fig. 7. Benthic fauna in Ongul Strait (water depth 200m).

4. Density of Individual Benthic Organisms as Observed from Stereo Photographs

The stereo photographs obtained from both the left and right cameras were enlarged 8 times and prints made. Using a digitalizer, the positions of organisms photographed in the still shots were converted into values which were fed into the microcomputer (Fig. 8).

Method of obtaining the 3-dimensional location of objects from their respective left and right photograph positions by using stereo photography has been elaborated by LONG *et al.* (1985). In our study, the same method was used to obtain the 3-dimensional location—the x, y and z values—of the photographed organisms. Here, the center point between the two cameras was set as the origin of the coordinate axes. Rising straight up was the z-axis, the area straight ahead of the camera on the horizontal plane was the y-axis and directly perpendicular to that, the x-axis.

The area of the seabed in the photographs was estimated as follows: The width was set as the difference between the x value of the organism farthest to the left and the x value of the organism farthest to the right. In the same fashion, the depth was set as the difference in the y value of the nearest organism and the y value of the farthest organism. The number of organisms within this area was then counted, regardless of the z value, and the distribution density per 1 m^2 was obtained.

38 pairs of clear stereo photographs were analyzed. 1763 individual organisms were counted over a total of 18.3 m^2 of the seabed at four stations (Table 1). As organism identification was insufficient, the organisms were classified here at the class level.

Comparing the total measured organism count obtained at each station, it is found that the Kita-no-seto Strait (water depth 16m) and Kita-no-ura Cove (water depth 40m) had counts of 100.5 and 103.9 individ./m^2 respectively, nearly identical values. The deeper Kita-no-ura Cove (water depth 80m) had the highest count of 155.7 individ./m^2. At the Ongul Strait (water depth 200m), the index drops noticeably to 55.5 individ./m^2; the reason for this is that the seabed photographed was covered with

Fig. 8. A result analyzed stereo photographs, using the microcomputer. a: number of photograph, b: number of object, c: name of object, d: size of object (mm), e: x-axis (mm), f: y-axis (mm), g: z-axis (mm), h: range (mm), i: Comatlid, j: Holothuroida, k: Echinoid. l: Bryozoa

Table 1. Individual number of benthic organisms as observed from stereo photographs.

Station	Kita-no-seto	Kita-no-ura	Kita-no-ura	Ongul Strait
Water depth (m)	16	40	80	200
Observed area (m²)	4.4	8.2	1.2	4.0
Porifera	2(0.5)	77(8.8)	18(14.8)	32(8.0)
Hydrozoa	—	9(1.0)	9(7.4)	3(0.7)
Octocorallia	4(0.9)	3(0.3)	1(0.8)	2(0.5)
Actiniaria	1(0.2)	—	1(0.8)	—
Polychaeta	103(23.3)	244(28.4)	47(38.5)	42(10.5)
Bryozoa	—	59(6.8)	11(9.0)	76(19.0)
Pycnogonida	—	2(0.2)	—	1(0.2)
Mysidacea	—	11(1.3)	—	—
Crinoidea	—	54(6.2)	6(4.9)	5(1.2)
Asteroidea	1(0.2)	—	—	1(0.2)
Ophiuroidea	10(2.3)	19(2.2)	3(2.5)	6(1.5)
Echinoida	306(69.1)	195(22.4)	26(21.3)	—
Holothuroidea	—	56(6.4)	6(4.9)	6(1.5)
Ascidiacea	10(2.3)	78(8.9)	10(8.9)	8(2.0)
Fish	3(0.7)	—	1(0.8)	—
Fish juvenile	2(0.5)	—	1(0.8)	—
Unidentified	2(0.5)	99(11.4)	50(41.0)	41(10.2)
Total	444(100.5)	906(103.9)	190(155.7)	223(55.5)
Range	(35.7-200.2)	(32.9-337.9)	(95.4-593.3)	(27.0-309.7)

Values in parentheses reflect number of individ./m².

Bryozoa, which could not be counted. Therefore, the actual distribution density is higher than the density shown in Table 1.

Concerning organism density for each station, the dominant species at the Kita-no-seto Strait (water depth 16m) was the urchin (*S. neumayeri*), a motile animal having a density of 69.1 individ./m^2. At the Kita-no-ura Cove (water depth 40m) the number of urchins was comparatively less than that of the Kita-no-seto Strait, while the number of sessile animals such as tubeworms, sponges, Bryozoa and Ascidiacea increased. At the Kita-no-ura Cove (water depth 80m) the number of sessile animals, namely tubeworms, sponges and Bryozoa was even greater than the 40m level. At the Ongul Strait (water depth 200m), Bryozoa were dominant.

5. Discussion

As described earlier, observations made from video tape recordings and still photographs show a trend for the motile biota to shift to a sessile biota with an increase in depth. This was further quantitatively confirmed by the analysis of stereo photographs.

A diving study of the McMurdo Sound area reported that motile animals were populous in shallow areas (0–30m) due to the influence of the anchor ice, while at greater depths (33–60m) sponges were dominant (DAYTON *et al.*, 1970). Comparing this with our observations obtained, even though the existence of anchor ice cannot be considered, an identical trend existed, motile animals being numerous in shallow areas and sessile animals being plentiful in deep areas. However, according to this study, sponges cannot be termed the dominant organism in deep areas; this point differs from the McMurdo Sound study.

These changes in biota with changes in depth have also been reported at Mirny Station (GRUZOV *et al.*, 1967).

The biota of the Ongul Strait (water depth 200m), the deepest station observed in this study, was similar to that of the Ross Sea and the Pennell Bank Assemblage (BULLIVANT, 1967a).

In the future, the authors wish to continue further analysis, obtain the size of organisms photographed, include the individual weight of specimens obtained from collection methods such as trapping and thereby obtain the biomass.

Acknowledgments

The authors wish to express their grateful thanks to Dr. T. HIRASAWA, the leader of the 25th Japanese Antarctic Research Expedition (JARE-25), and his staff, particularly to Mr. S. FUTATSUMACHI and Mr. K. IWANAMI of Japan Maritime Safety Agency, for their helpful cooperation. The authors are indebted to Prof. T. HOSHIAI and Mr. K. WATANABE of National Institute of Polar Research, for their invaluable advice. The authors thank Dr. T. IWAMI, Institute of Biological Science, University of Tsukuba, for identification of fishes. Thanks are also due to Mr. M. SATO, captain of the icebreaker SHIRASE, and his crew for their great help.

References

BULLIVANT, J. S. (1967a): The fauna of the Ross Sea. Part 5. New Zealand oeeanographic institute Ross Sea investigations, 1958–60; General account and station list. N. Z. Oceanogr. Inst. Mem., **32**, 9–29.

BULLIVANT, J. S. (1967b): The fauna of the Ross Sea. Part 5. Ecology of the Ross Sea benthos. N. Z. Oceanogr. Inst. Mem., **32**, 49–75.

DAYTON, P. K., ROBILLIARD, G. A. and PAINE, R. T. (1970): Benthic faunal zonation as a result of anchor ice at McMurdo Sound, Antarctica. Antarctic Ecology, Vol. 1, ed. by M. W. HOLDGATE. London, Academic Press, 244–258.

GRUZOV, E. N., PROPP, M. V. and PUSHKIN, A. F. (1967): Biological association of coastal areas of the Davis Sea (based on the observations of divers). Sov. Antarct. Exped. Inf. Bull., **6**, 523–533.

HOSHIAI, T. (1978): Torappu saishû ni yoru Syowa Kiti no teisei dôbutsu (Benthic animals collected with a trap at Syowa Station, Antarctica). Bentosu Kenren Shi, **15/16**, 1–9.

HOSHINO, K. (1976): Nankyoku-iki (15-ji) de saishû shita hyôhon no gaiyô (1) (An epitome of the zoological collections obtained from the Antarctic in the 15th Japanese Antarctic Research Expedition (1)). Nankyoku Shiryô (Antarct. Rec.), **57**, 123–128.

LONG, L. V., AOYAMA, T. and INAGAKI, T. (1985): A stereo photographic method for measuring the spatial position of fish. Bull. Jpn. Soc. Sci. Fish., **51**, 183–190.

MURANO, M., INOUE, K. and MARUYAMA, T. (1982): Benthic fauna in the vicinity of Balleny Islands. Trans. Tokyo Univ. Fish., **5**, 197–201.

NAITO, Y. and IWAMI, T. (1982): Fish fauna in the northeastern parts of Lützow-Holm Bay with some notes on the stomach contents. Mem. Natl Inst. Polar Res., Spec. Issue, **23**, 64–72.

NUMANAMI, H., KOSAKA, M., NAITO, Y. and HOSHIAI, T. (1984): Distribution of carnivorous benthic invertebrate in the northeastern part of Lützow-Holm Bay, Antarctica. Mem. Natl Inst. Polar Res., Spec. Issue, **32**, 105–111.

PROPP, M. V. (1970): The study of bottom fauna at Haswell Island by SCUBA diving. Antarctic Ecology, Vol. 1, ed. by M. W. HOLDGATE. London, Academic Press, 239–241.

WATANABE, K., NAKAJIMA, Y. and NAITO, Y. (1982): Higashi Onguru-to engan de no hyôka sensui chôsa hôkoku (SCUBA ice diving along the coast of East Ongul Island, Antarctica). Nankyoku Shiryô (Antarct. Rec.), **75**, 75–92.

(Received August 17, 1985; Revised manuscript received September 12, 1985)