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BENTHOS AND FISH COMMUNITY ASSOCIATED WITH CLUMPS OF SUBMERGED DRIFTING ALGAE IN FILDES BAY, KING GEORGE ISLAND, ANTARCTICA

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Abstract: We conducted a quantitative study of an animal community associated with clumps of submerged drifting algae on a sand/mud bottom at Fildes Bay, King George Island. The algae clumps were found at depths between 5 and 20 m in the inner part of the bay. The clumps mainly consisted of *Desmarestia anceps* covering about 5% of the bottom. A large number of a nemertinean (0–220 individuals/m^2), *Nacella concinna* (0–65 individuals/m^2), *Glyptonotus antarcticus* (adults 0–8 individuals/m^2, juvenile 0–80 individuals/m^2) and gammaridean amphipods (490–25020 individuals/m^2) were found associated with the clumps. Schools of *Trematomus newnesi* young (0–18 individuals/m^2) hovered over the clumps. Stomach contents of *T. newnesi* consisted mainly of gammaridean amphipods. The algae clump seemed to be an important habitat as a nursery ground for *G. antarcticus* and *T. newnesi*.

1. Introduction

Detailed descriptions of animal communities and their habitats are of great importance to understand the community structures and their maintenance mechanisms. By virtue of recent advances in SCUBA diving techniques, knowledge about the habitats and species compositions of fishes and benthic animals have been accumulated by underwater observations in the coastal waters of Antarctica (PECKHEM, 1964; PROPP, 1970; NAKAJIMA *et al.*, 1982; TUCKER, 1988; SATO *et al.*, 1992). However, there have been few studies that quantitatively describe an animal community utilizing a specific habitat in detail.

SATO *et al.* (1992) summarized a marine fauna shallower than 15 m depth at the innermost part of Fildes Bay, King George Island, South Shetland Islands. They reported the existence of clumps of submerged drifting algae, mainly consisting of *Desmarestia anceps* and *Ascoseira milabilis*, on the sand/mud bottom around 10 m depth, where they found *Glyptonotus antarcticus* (order Isopoda), *Trematomus newnesi* (family Nototheniidae) and other benthic animals specifically associated with the clumps. As a distinctive animal community is expected to be formed at this unusual habitat on the monotonous sand/mud bottom, a detailed study will significantly contribute to the understanding of animal communities in the coastal waters of Antarctica.

We conducted a quantitative survey of the occurrence of algae clumps, species compositions of the algae, and densities of animals associated with them by underwater observation at Fildes Bay, in November 1993. In this paper, we describe the results and discuss the significance of the clumps of submerged drifting algae as a habitat for fishes and benthos on monotonous sand/mud bottoms.

2. Methods

This study was conducted at Ardley Inlet, Fildes Bay, King George Island, South Shetland Islands (62° 12′ S, 58° 54′ W), from November 10 to 24, 1993 (Fig. 1). Ardley Inlet is located in the innermost part of the bay, and we did not encounter strong currents or swells. However, strong incoming waves in stormy weather sometimes caused perturbations at the bottom at about 10 m depth. Water temperature at the surface in the study site ranged from 0.3 to 1.8°C in summer. Salinity in the bay in summer was reported to be from 33.5 to 34.6‰ (CHANG *et al.*, 1990).

A study area (100 m×200 m) was set up using ropes on the bottom at the same place where we had observed algae clumps during previous expeditions in January and November 1992 (S. TADA and H. ARAI, unpublished). The bottom of the study area was mostly sandy and muddy, and gradually sloped down from 2 to 20 m depth. Underwater observations were made by three divers using SCUBA. Divers were equipped with dry suits made of 5 mm thick neoprene (Nippon Scuba Co., Ltd.), Blizzard regulators (Sherwood Scuba) and 12 *l*, 200 atm. diving tanks.

Eight census lines, each 100 m long with intervals of 20 to 60 m, were set on the bottom of the study area. The divers recorded the proportions of the areas covered by the algae clumps within the rectangular areas 1 m bilateral to the lines for each 5 m section along the lines (5×2 m²), with a unit of 5%. The total area covered by divers was 1600 m². The estimations were done by two divers and the average values were used

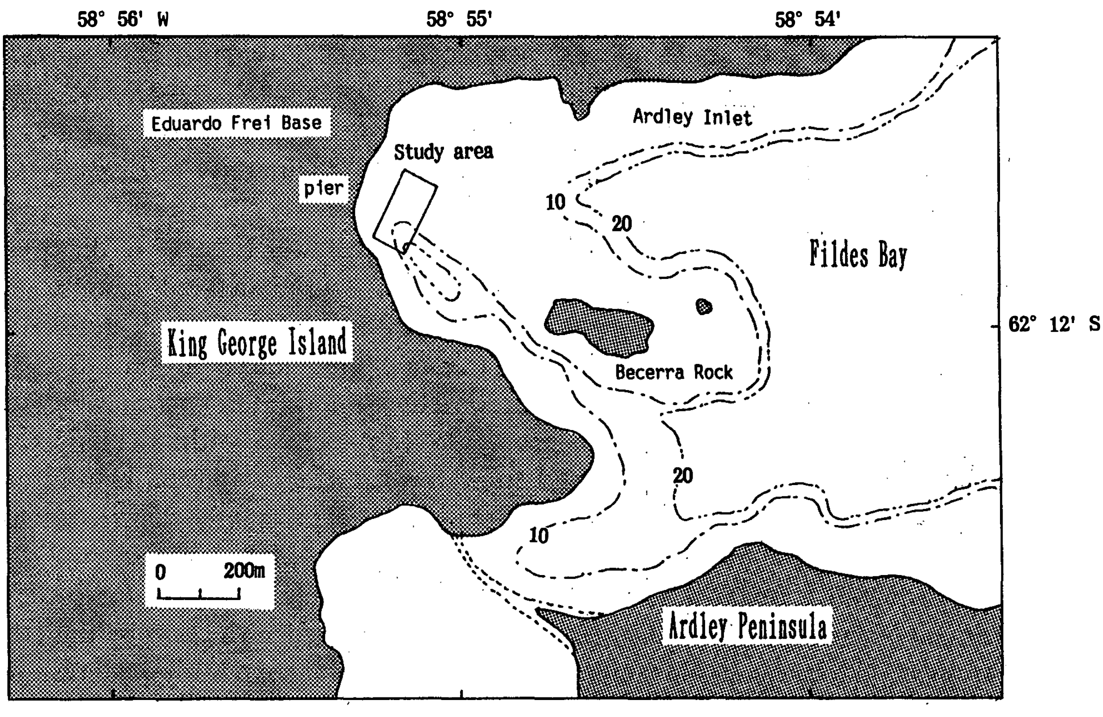

Fig. 1. The study area at Ardley Inlet, Fildes Bay, King George Island, South Shetland Islands.

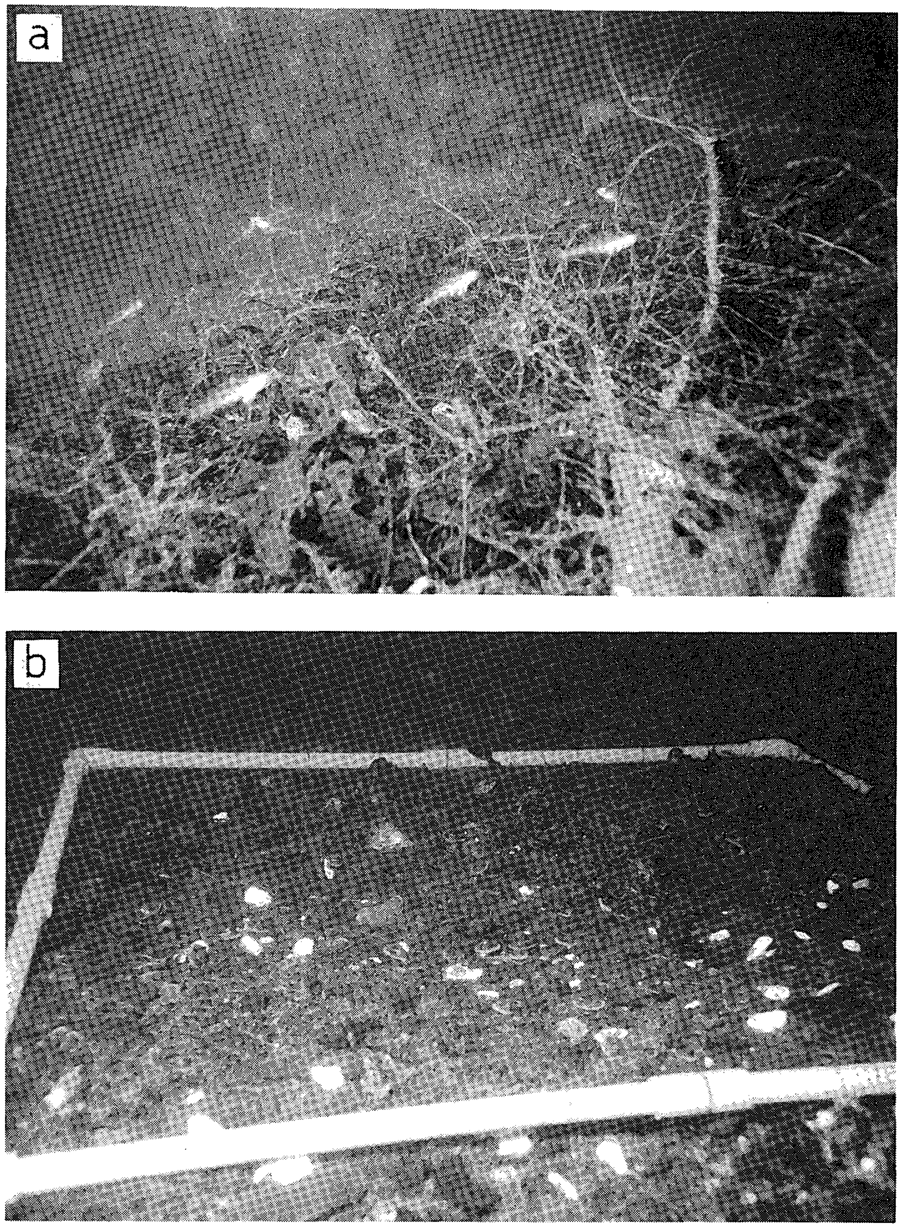

Fig. 2. Characteristic algae clumps in the study area. (a) An algae clump categorized as "new". The algae, especially Desmarestia anceps, *were preserved well. A small school of* Trematomus newnesi *hovered over the algae. (b) An algae clump categorized as "old". The algae were in decay and fragmented into pieces.*

for the further analysis.

We chose eight algae clumps in the study area and estimated their sizes to the nearest 0.5 m^2 area visually. The freshness of the algae in the clumps were categorized into three classes: "new", "medium" and "old". The "new" clumps were those in which the algae, especially *D. anceps,* were preserved well, the stems and leaves still being connected. The clumps had thick three-dimensional structures on the bottom, and there were numerous hiding spaces inside the clumps (Fig. 2a). The "old" clumps were those in which the algae were in decay and fragmented into pieces. The clumps were spread flat on the bottom, with less space inside them (Fig. 2b). The "medium" clumps were intermediate between the two cases.

A 1×1 m^2 quadrat was set ad libitum on each of the eight algae clumps. *T. newnesi* hovering over the algae inside the quadrat were counted, and some of them were collected with a hand net. Then, all algae inside the quadrat were collected by a hand net (35 cm in diameter, 5 mm mesh), together with benthic animals among them. These were put in a plastic bag (about 50 *l* capacity) in the water and brought to land. Collected organisms, such as *T. newnesi,* adult *G. antarcticus* and *Nacella concinna,* were classified into species or a higher taxa, counted and weighed (wet weight). Then we weighed the algae, took from 5 to 100% of them, and sorted out small animals from the algae. The animals were classified into species or higher taxa, counted and weighed to estimate their density in each algae clump. All individuals of *T. newnesi* were preserved in 5% formaldehyde solution immediately after the collection. We measured standard length and body weight of *T. newnesi,* and analyzed stomach contents later in the laboratory at Tokyo Sea Life Park.

3. Results

3.1. The algae clumps

The algae clumps were mainly found at depths between 10 and 20 m in the innermost part of the bay, and their distribution was patchy. The proportion of the bottom covered with the algae clumps was 0–13% (median 3%). The clumps consisted mainly of three algae species, *Desmarestia anceps, Ascoseira milabilis* and *Adenocystis utricularis,* each representing 22–97%, 0–38% and 0–30% of the algae in the clumps in wet weight (Table 1). The sizes of algae clumps ranged from 1.5 to 60.0 m^2 with height ranging from a few cm to 70 cm from the bottom. Three among eight clumps were classified as "new", four as "medium" and one as "old". There were some shallow hollows on the bottom of the study area in which the "old" algae clumps were found. These hollows seemed to be made by drifting icebergs. Generally, large clumps on the flat bottom were the "new" ones.

3.2. Animal communities in the clumps

A turbellarian (class Turbellaria), a nemertinean (class Nemertinea), *Nacella concinna* (family Patellidae), *Margarites antarctica* (family Trochidae), *Laevilitorina antarctica, Laevilacunaria bransfieldensis* (family Littorinidae), *Yoldia (Aequiyoldia) eightsi* (family Sareptidae), *Lasaea consanguinea* (family Erycinidae), *Cyamiomactra laminifera* (family Cyamiidae), a sedentary polychaete (order Sedentaria), a pycnogonid (order Pantopoda), *Glyptonotus antarcticus* (family Chaetiliidae), an isopod (order Isopoda), several species of gammaridean amphipods (suborder Gammaridea), a brachiopod (order Telotremata) and *Trematomus newnesi* (family Nototheniidae) were found from the algae clumps (Table 2). Among these, a nemertinean, *N. concinna, G. antarcticus,* gammaridean amphipods and *T. newnesi* were found from most clumps collected. SATO *et al.* (1992) reported a holothuroid, an actiniarian, an ascidian, *Notothenia coriiceps* and *Lepidonotothen nudifrons* from the algae clumps. But we did

Table 1. Size, freshness and species composition of each algae clump. The amounts of each algae species and the total amount of algae are represented by g/m². Numbers in parenthesis represent the percentages of each algae species.

Clump number	1	2	3	4	5	6	7	8	Median	Range
Area (m^2)	5.0	20.0	60.0	3.0	1.5	7.0	2.0	2.0	4.0	1.5–60.0
Depth (m)	unknown	unknown	12.0	unknown	17.0	17.2	13.0	11.9	—	—
Freshness of algae	medium	new	medium	new	medium	new	old	medium	—	—
Algae species										
Desmarestia anceps	1904(39)	1533(51)	3760(60)	3623(98)	1856(59)	2939(97)	3100(72)	1035(22)	2398	1035–3760
Ascoseira mirabilis	1240(25)	1158(38)	1380(22)	22(1)	758(24)	0	418(10)	1620(34)	958	0–1620
Adenocystis utricularis	1478(30)	92(3)	920(15)	30(1)	200(6)	0	810(19)	1110(23)	505	0–1478
Chromophyta	110(2)	140(5)	0	0	180(6)	0	0	470(10)	55	0– 470
Rhodophyta	160(3)	105(3)	232(4)	0	135(4)	90(3)	0	500(11)	120	0– 500
Total	4892	3028	6292	3675	3129	3029	4328	4735	4002	3028–6292

Table 2. Species composition and abundance of animals associated with algae clumps. Number of individuals and total weight in grams (in parenthesis) of each species found in 1 m^2 area in the clumps were represented. Stars in parenthesis represents the cases where weight data were not available.

	Clump number	1	2	3	4	5	6	7	8	Median	Range
Invertebrates											
Platyhelminthes	Turbellaria sp.	0	1 (*)	0	0	0	0	0	0	—	—
Nemertinea		4 (32)	2 (0.8)	0	1 (*)	66 (220)	0	220 (7.6)	3 (*)	2.5	0–220
Mollusca	*Nacella concinna*	65 (84)	19 (28)	28 (71)	1 (*)	4 (30)	0	58 (110)	18 (30)	18.5	0–65
	Margarites antarctica	0	5 (0.1)	0	0	0	3 (0.1)	0	0	—	0–5 (0–0.1)
	Laevilitorina antarctica	0	0	0	0	0	4 (<0.1)	40 (0.4)	0	—	0–40 (0–0.4)
	Laevilacunaria bransfieldensis	0	0	0	0	0	43 (0.3)	0	0	—	0–43 (0–0.3)
	Yoldia (Aequiyoldia) eightsi	0	0	0	0	0	0	20 (*)	0	—	0–20
	Lasaea consanguinea	0	0	0	0	0	0	120 (*)	0	—	0–120
	Cyamiomactra laminifera	0	0	0	0	0	0	100 (*)	0	—	0–100
Annelida	Sedentaria sp.	0	0	0	0	1 (<0.1)	0	61 (13.4)	0	—	0–61 (0–13.4)
Arthropoda	Pycnogonida sp.	0	0	0	1 (<0.1)	0	0	0	20 (0.5)	—	0–20 (0–0.5)
	Glyptonotus antarcticus (adult)	4 (95)	0	0	1 (22)	4 (80)	2 (40)	8 (118)	4 (92)	3.0 (60)	0–8 (0–118)
	G. antarcticus (juvenile)	80 (1.5)	0	40 (0.7)	0	1 (<0.1)	0	60 (1.0)	30 (0.5)	15.5	0–80 (0–1.5)
	Isopoda sp.	0	0	0	0	0	13 (0.1)	0	10 (<0.1)	—	0–13 (0–0.1)
	Gammaridea spp.	5200 (280)	4320 (101)	8200 (200)	12140 (139)	490 (37)	25020 (172)	2160 (100)	3160 (150)	4760 (144.5)	490–25020 (37–280)
Brachiopoda		0	1 (<0.1)	0	0	0	0	0	0	—	0–1
Fish	*Trematomus newnesi*	8 (*)	8 (12.5)	1 (1.8)	10 (*)	10 (*)	18 (*)	0	15 (22.4)	9.0	0–18

not find these animals in the present study.

We saw few *N. concinna,* gammaridean amphipods or *T. newnesi* on the sand/mud bottom out of the clumps at least during the daytime, although they were abundant in the clumps. Among other habitats in Fildes Bay, *T. newnesi* was found associated with *D. anceps* in rocky areas. *N. concinna* was a common inhabitant of shallow rocky areas, usually found on the surfaces of rocks and macrophytes. Gammaridean amphipods were commonly found under stones. Large individuals of *G. antarcticus* were often found crawling on the sand/mud bottom, but their density was obviously higher in the algae clumps. The majority of *G. antarcticus* found in the clumps were juveniles smaller than 8 mm in total length. The density of *G. antarcticus* in the "old" and "medium" clumps was significantly higher than that in the "new" clumps (Table 2. $n=5$ for "old" and "medium", $n=3$ for "new", Mann-Whitney Test, $U=0.0$, $p<0.05$).

3.3. *Size distribution and stomach contents of* T. newnesi

We collected 49 individuals of *T. newnesi,* ranging from 48 to 90 mm in standard length and from 1.1 to 9.5 g in wet weight. Figure 3 shows the size frequency distribution of the collected individuals. Although the sample size was small, two year classes seemed to be included (Radtke *et al.,* 1989). The results of stomach content

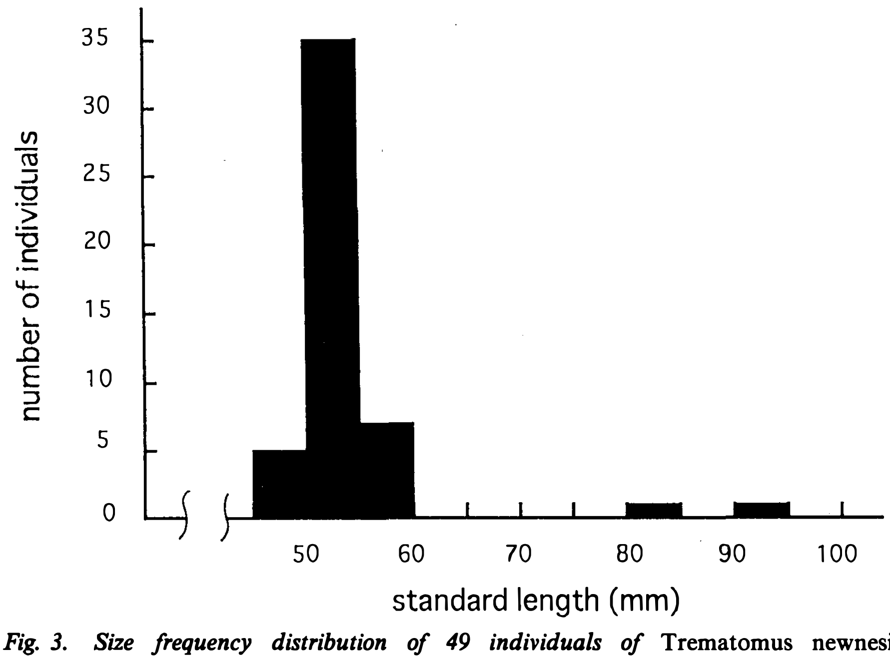

Fig. 3. Size frequency distribution of 49 individuals of Trematomus newnesi *collected from the algae clumps.*

Table 3. Stomach contents of Trematomus newnesi. *The occurrence of each food item is represented by the number of individuals which had each food item in their stomachs. Numbers in parenthesis represent percentages in 49 individuals examined.*

Food items	Gammaridea spp.	Decapoda spp.	Fish larva	*G. antarcticus*	Algae	Empty
Number of individuals	47(96)	8(16)	1(2)	1(2)	1(2)	1(2)

analyses are summarized in Table 3. Most individuals fed on gammaridean amphipods; eight fed on unidentified decapods. Other food items included an unidentified fish larva from a large individual, a juvenile *G. antarcticus* and pieces of algae.

4. Discussion

The present results demonstrate that the clumps of submerged drifting algae on the sand/mud bottom harbor a characteristic animal community. The coexistence of animals of rocky and sandy area origin such as *N. concinna, G. antarcticus* and *T. newnesi* at a high density is a unique feature of the algae clumps compared with other habitats in Fildes Bay (SAKURAI *et al.*, 1996). As most individuals of *G. antarcticus* and *T. newnesi* in algae clumps were immature young, it is likely that the clumps played a role as a nursery ground for these species. The clumps also functioned as a habitat for animals of rocky area origin such as *N. concinna* and *T. newnesi* on a sandy or muddy substrate.

Young individuals of *T. newnesi* are known to be associated with large brown algae in rocky areas (DANIELS and LIPPS, 1982; DHARGALKAR *et al.*, 1988). They mainly fed on gammaridean amphipods that are also associated with brown algae (CASAUX *et al.*, 1990; RICHARDSON, 1975). The present study also showed that *T. newnesi* young in the algae clumps on the sand/mud bottom fed mainly on gammaridean amphipods. As gammaridean amphipods in the stomach of *T. newnesi* were generally smaller than those found in the algae clumps, *T. newnesi* seemed to feed selectively on the smaller individuals or species. We also observed that *T. newnesi* hovering over the algae clumps retreated quickly into the algae when divers approached. These facts strongly suggest that the association of *T. newnesi* young with the algae clumps is based on their requirements for food and refuge on the sand/mud bottom.

N. concinna usually live in shallow rocky areas on a surface of rocks and macrophytes. In the aquarium, we did not observe them feeding on animal diet, but they grazed on surfaces of rocks and glass walls, possibly feeding on attached algae (H. ARAI, unpublished). In the algae clumps, they may feed on epiphytes on the algae or the algae themselves. *N. concinna* may be associated with the algae clumps mainly because of their food habits.

The algae clumps seemed to function as a refuge for a slowly moving *G. antarcticus.* This species is known to be a carnivore, mainly feeding on ophiuroids and gastropods (DEARBORN, 1967). The association of young *G. antarcticus* with old clumps found in the present study suggests that they may also feed on pieces of decayed algae.

On the sand/mud bottom of the innermost part of Fildes Bay, the clumps of submerged drifting algae had been observed every year during the Antarctic summer (from November to March) since 1991 (unpublished observations). In the present study area, the water only freezes down to several meters from the surface in winter, and it does not freeze at all in some years. Therefore, freezing in winter does not have destructive effects on the algae clumps. As drifting algae decay very slowly in cold water, it is likely that the algae clumps are stable habitats for fishes and benthic animals. On the monotonous sand/mud bottom where refuges for fishes and macrobenthos are rare, the three-demensional structures of the algae clumps play an important role as a refuge, nursery ground and feeding site.

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References

CASAUX, R.J., MAZZOTTA, A.S. and BARRERA-ORO, E.R. (1990): Seasonal aspects of the biology and diet of nearshore nototheniid fish at Potter Cove, South Shetland Islands, Antarctica. Polar Biol., **11**, 63–72.

CHANG, K.I., JUN, H.K., PARK, G.T. and EO, Y.S. (1990): Oceanographic conditions of Maxwell Bay, King George Island, Antarctica (Austral summer 1989). Korean J. Polar Res., **1**(1), 27–46.

DHARGALKAR, V.K., BURTON, H.R. and KIRKWOOD, J.M. (1988): Animal associations with the dominant species of shallow water macrophytes along the coastline of the Vestfold Hills, Antarctica. Hydrobiologia, **165**, 141–150.

DANIELS, R.A. and LIPPS, J.H. (1982): Distribution and ecology of fishes of the Antarctic Peninsula. J. Biogeogr., **9**, 1–9.

DEARBORN, J.H. (1967): Food and reproduction of *Glyptonotus antarcticus* (Crustacea: Isopoda) at McMurdo Sound, Antarctica. Trans. R. Soc. N. Z., Zool., **8**(15), 163–168.

NAKAJIMA, Y., WATANABE, K. and NAITO, Y. (1982): Diving observation of the marine benthos at Syowa Station, Antarctica. Mem. Natl Inst. Polar Res., Spec. Issue, **23**, 44–54.

PECKHAM, V. (1964): Year-round scuba diving in the Antarctic. Polar Rec., **12**, 143–146.

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

RADTKE, R.L., TARGETT, T.E., KELLERMANN, A., BELL, J.L. and HILL, K.T. (1989): Antarctic fish growth: Profile of *Trematomus newnesi.* Mar. Ecol. Prog. Ser., **57**, 103–117.

RICHARDSON, M. G. (1975): The dietary composition of some Antarctic fish. Br. Antarct. Surv. Bull., **41&42**, 113–120.

SAKURAI, H., SATO, T., ARAI, H., TAKASAKI, A., TADA, S., HORI, H., KIMPARA, I., MATSUYAMA, T. and KODAMA, M. (1996): Habitats of fish and epibenthic invertebrates in Fildes Bay, King George Island, Antarctica. Proc. NIPR Symp. Polar Biol., **9**, 231–242.

SATO, T., SAKURAI, H., TAKASAKI, A., WATANABE, K., and HIRANO, Y. (1992): Underwater observation of Antarctic fishes and invertebrates with a note on collection and transportation techniques for research and exhibition in the aquarium. Ser. Cient. INACH, **42**, 95–103.

TUCKER, M. J. (1988): Temporal distribution and brooding behavior of selected benthic species from the shallow marine waters off the Vestfold Hills, Antarctica. Hydrobiologia **165**, 151–159.

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