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HABITATS OF FISH AND EPIBENTHIC INVERTEBRATES IN FILDES BAY, KING GEORGE ISLAND, ANTARCTICA

Hiroshi SAKURAI, Tetsu SATO, Hiroshi ARAI, Akinori TAKASAKI, Satoshi TADA, Hidemasa HORI, Isao KIMPARA, Toshiki MATSUYAMA and Masaaki KODAMA

Tokyo Sea Life Park, 2–3, Rinkaicho 6-chome, Edogawa-ku, Tokyo 134

Abstract: From 1991 to 1993 we conducted underwater observations on communities of fish and epibenthic invertebrates four times during the austral summer in Fildes Bay, King George Island Antarctica. We defined eight distinctive habitat types in the inshore areas (depths between 0 and 40 m), each having a characteristic community of fish and epibenthic invertebrates. Species compositions of animal communities varied according to the bottom substrates, depths and the presence or absence of macroalgal colonies. The habitat types of the major animal species are described, and characteristics of each habitat type and its faunal composition are noted.

1. Introduction

A considerable amount of knowledge on the fauna, habitat and ecology of marine organisms in the Southern Ocean has been accumulated by virtue of recent advances in underwater observation techniques such as SCUBA diving and underwater photography (PROPP, 1970; DAYTON *et al.*, 1970; TUCKER, 1981; DANIELS and LIPPS, 1982; NAKAJIMA *et al.*, 1982; NUMANAMI *et al.*, 1986; EKAU and GUTT, 1991; SATO *et al.*, 1992; TADA *et al.*, 1996).

King George Island, at the tip of the Antarctic Peninsula, is located at the lowest latitude (about 62°S) within the Antarctic Convergence and has a different physical condition from other areas in higher latitudes. For example, the water in Fildes Bay on the south coast of the island does not freeze even in winter in some years. Although ARNAUD *et al.* (1986) published a faunal list of benthic invertebrates on this island, there have been only a few studies of the habitats of fish and benthos based on underwater observation. SATO *et al.* (1992) described inshore habitats of fish and benthic invertebrates on sand/mud and rocky bottoms in Ardely Inlet, the innermost part of Fildes Bay, and TADA *et al.* (1996) conducted a quantitative survey of a distinctive animal community associated with clumps of submerged drifting algae in the same area. Although Fildes Bay has various habitats from inter-tidal zone to muddy bottoms deeper than 40 m, the previous reports covered only a part of the diverse habitats of the Bay.

We conducted underwater observations covering wider areas of Fildes Bay, and found distinguishable communities of fish and epibenthic invertebrates according to bottom types and water depths. In this paper, we describe the inshore faunas of Fildes Bay in relation to the substrate types, water depths, and the presence of large brown algae.

2. Methods

We conducted underwater observations and collections in the western part of Fildes Bay (Fig. 1) using SCUBA at depths between 0 and 40 m in four summer seasons (13–19 March 1991, 12–21 January 1992, 20 November–3 December 1992, and 11–23 November 1993). A total of 12 dives were made by three divers in 1991, 22 dives by two divers in January 1992, 32 dives by three divers in November 1992 and 43 dives by three divers in 1993. Most dives were conducted in the areas surrounding the schematic lines 1 to 4 in Fig. 1. Water temperature at the surface varied between 0.5 and 1.8°C during the study period.

All species observed during these dives except a species of actiniarian (tribe Thenaria) were collected by hand or hand-net. These specimens were transported to Tokyo Sea Life Park either alive or preserved in 10% formalin solution, and identified into species or higher taxa. Details of methods for diving, collecting and transportation of live organisms heve been given elsewhere (SATO *et al.*, 1992).

The habitat types of fish and epibenthic invertebrates were categorized using depth

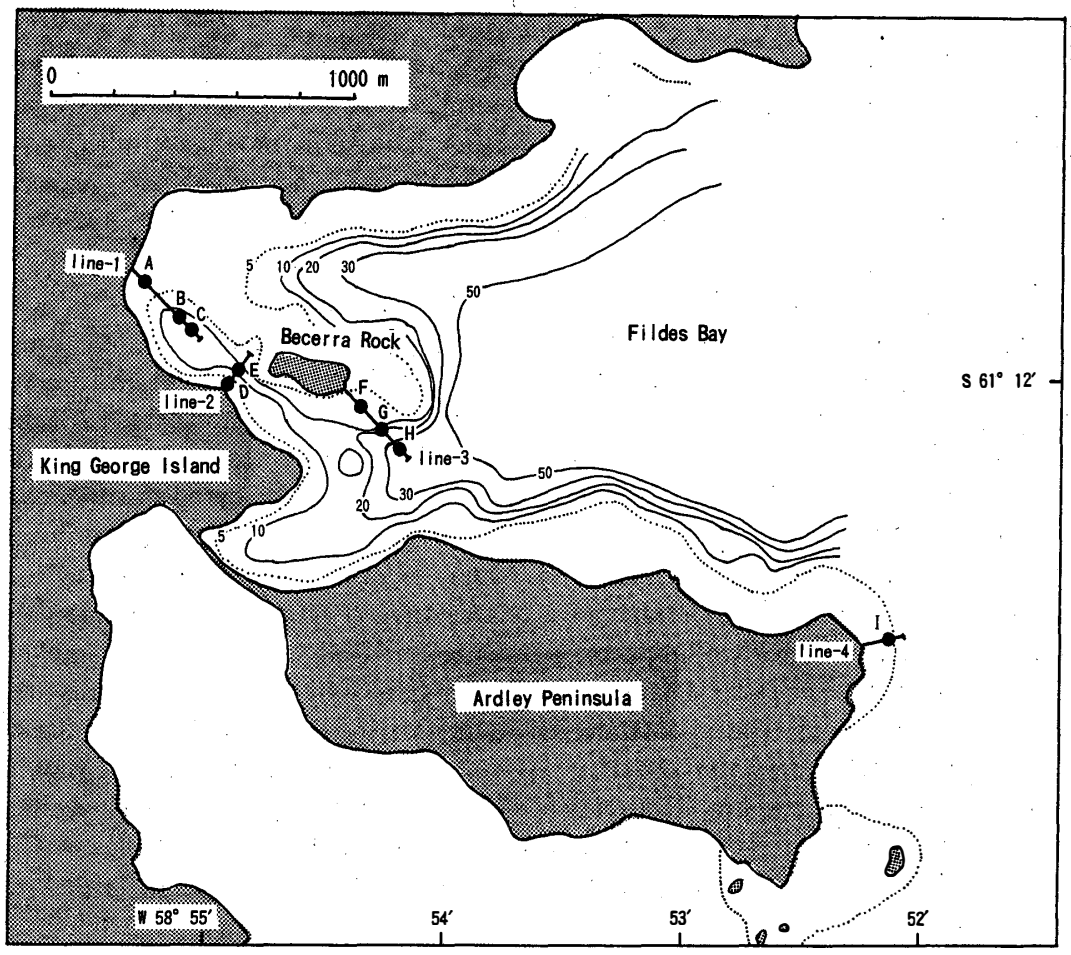

Fig. 1. Schematic map of the study area in Fildes Bay. Underwater observations and collections were conducted mainly in the areas surrounding lines 1 to 4.

ranges, types of bottom substrates and the presence or absence of colonies of large brown algae. Depth ranges were divided into shallow (s; 0 to 3 m), middle (m; 3–20 m) and deep (d; 20 to 40 m), and substrate types were divided into sandy or muddy (sand/mud bottoms; M) and boulders, rocks, stones or pebbles (rocky bottoms; R).

We defined six distinctive habitats by combining depth ranges (s, m, d) and substrate types (M, R). (1) sand/mud bottoms in tidal zones (habitat A; sM), (2) sand/mud bottoms at middle depths (habitats B and C; mM), (3) rocky bottoms in tidal zones (habitat D; sR), (4) rocky bottoms at middle depths (habitats E, F and I; mR), (5) deep rocky bottoms (habitat G; dR), (6) deep muddy bottoms (habitat H; dM) (Fig 1). The rocky bottoms at middle depths (mR) were further divided into those with (habitat I; mRA) and without (habitats E and F; mR) colonies of large brown algae, *Desmarestia anceps*. The sand/mud bottoms at middle depths were divided into those with (habitat C; mMA) and without (habitat B; mM) clumps of submerged drifting algae (SATO *et al.*, 1992; TADA *et al.*, 1996).

Relative abundance of each species of fishes and epibenthic invertebrates was categorized by direct observations into very common (cc), common (c), rare (r) and very rare (rr). The typical microhabitats of each species were recorded, and represented schematically in cross-sectional drawings of each habitat.

3. Results

3.1. Habitats of fishes and benthic invertebrates

Five species of fishes, 31 taxa of invertebrates and three species of macroalgae were observed and/or collected in the study area (Table 1).

Relative abundances of fishes, epibenthic invertebrates and macroalgae in each habitat are summarized in Table 1. Almost all of the observed species were associated with one to a few particular habitat types, except for a ubiquitous *Lineus corrugatus*. Two species of actiniarians (*Uticinopsis antarctica* and a species of the tribe Thenaria), a nudibranch (suborder Nudibranchia), a brachiopod (order Telotremata), a black colored holothuroid (sp. 1, order Dendrochirotida), a pink colored holothuroid (sp. 2, order Dendrochirotida), an orange and small asteroid (sp. 1, class Euasteroidea) and a brown colored asteroid (sp. 2, class Euasteroidea) were found only on rock, stone and pebble bottoms. *Laternula elliptica* widely occurred on sand/mud bottoms. *Neobuccinum eatoni* also occurred widely on sand/mud bottoms in deeper areas but rare in shallow areas. A large number of *Glyptonotus antarcticus,* as well as *Nacella concinna* which was a rocky area inhabitant, were found in the clumps of algae on sand/mud bottoms. Two species of poriferans, possibly belonging to genera *Dendrilla* and *Ciocalypta,* two species of pennanthulaceans (sp. 1 and sp. 2, order Pennathulacea), a brown colored holothuroid (sp. 3, order Dendrochirotida) half buried in the muddy bottom, a spatangoid echinoid (order Spatangoida), an ophiuroid (class Ophiuroidea) and *Distaplia cylindrica* were found only on muddy bottoms deeper than 20 m. Although *Sterechinus neumayeri* and *Odontaster validus* lived mainly on rocky bottoms, they were also found on deep muddy bottoms. *Margarites antarctica* was mainly found on the surface of macrophytes.

Among fishes, *Notothenia coriiceps* occurred in various habitats, while *Lepidonoto-*

Table 1. A list of fishes, epibenthic invertebrates and macroalgae recorded in the study area. Relative abundances of each species are represented by cc (very commom), c (commom), r (rare) and rr (very rare). The blanks mean that we did not find the species in the habitat.

	Species	Habitat								
		A (sM)	B (mM)	C (mMA)	D (sR)	E (mR)	F (mR)	G (dR)	H (dM)	I (mRA)
Fishes	*Lepidonotothen nudifrons*					c	c	c		c
	Notothenia coriiceps			r		r	r	r		r
	Pagothenia borchgrevinki					c				
	Trematomus newnesi			cc		c				cc
	Harpagifer antarcticus				c	c	c			cc
	H. antarcticus (juvenile)	c								
Porifera	Porifera (cf. *Dendrilla* sp.)								rr	
	Porifera (cf. *Ciocalypta* sp.)								rr	
	Porifera (yellow)									c
Cnidaria	Pennatulacea sp. 1								cc	
	Pennatulacea sp. 2 (slender)								cc	
	Uticinopsis antarcticus			c		cc	cc	c		
	Thenaria sp. (large)							c		
Nemertinea	*Lineus corrugatus*	r	r	cc	c	cc	cc	c	c	c
Mollusca	*Nacella concinna*		c	cc	c	cc	cc			cc
	Margarites antarctica			c	r	c		r		cc
	Neobuccinum eatoni		r	r					cc	
	Nudibranchia sp.					rr		r		
	Laternula elliptica	r	cc	cc					cc	
Arthropoda	Pycnogonida sp.							c	c	
	Serolis sp.		cc	c					cc	
	Glyptonotus antarcticus	c	cc	cc		c				
	Paraceradocus sp.					cc	cc	c		c
	Gammaridea spp.	c	cc	cc	cc	cc	cc	cc	cc	cc
Brachiopoda	Telotremata sp.						r	c		
Echinodermata	Dendrochirotida sp. 1 (brown)					r	c	cc		
	Dendrochirotida sp. 2 (pink)		r	c		r	r	cc		c
	Dendrochirotida sp. 3 (in mud)								cc	
	Sterechinus neumayeri				rr	cc	cc	cc	cc	c
	Spatangonida sp.								c	
	Odontaster validus				rr	c	c	c	c	cc
	Euasteroidea sp. 1 (orange, small)			c		c	cc	c		c
	Euasteroidea sp. 2 (brown)						c	c		c
	Ophiuroidea sp.								c	
Prochordata	*Distaplia cylindrica*								c	
	Pleurogona sp. (brown)						r	r	c	
Algae	*Desmarestia anceps*					c		r		cc
	Ascoseira mirabilis							cc		
	Adenocystis utricularis					c	c			

then nudifrons and *Harpagifer antarcticus* were found only on rocky bottoms. The latter two species were always observed under stones during day time. *Trematomus newnesi* and *Pagothenia borchgrevinki* occurred only in the habitats where algal colonies or clumps of submerged drifting algae were found. These two species seemed to have a strong association with the three-dimensional structures of macroalgae (DANIELS and LIPPS, 1982; SATO *et al.*, 1992; TADA *et al.*, 1996).

3.2. Sand/mud bottoms in tidal zones (habitat A; sM) (Fig. 2)

This habitat type corresponded to inter-tidal and upper sub-tidal zones at depths between 0 and 3 m. Epibenthic animals were scarcely observed, except for small numbers of *G. antarcticus* larvae and *L. elliptica*. However, many *G. antarcticus* and gammaridean amphipods were sometimes found under pieces of drifting algae on the bottom. Pelagic larvae of *H. antarcticus* were often found hovering on the sandy floor.

3.3. Sand/mud bottoms in middle depths (habitat B; mM) (Fig. 2)

This habitat type was a sand/mud bottom at the inner part of the bay at depths between 5 and 20 m. Live individuals and dead shells of *L. elliptica* were found with a high density. *G. antarcticus* and *Serolis* sp. were found commonly on the bottom. Dendrochirotida sp. 2 and *N. eatoni* were rare.

Larvae of two unidentified nototheniid fishes were observed swarming around stranded icebergs, one in crevasses and on surfaces of the icebergs, and the other beneath them.

3.4. Sand/mud bottoms with clumps of submerged drifting algae (habitat C; mMA) (Fig. 2)

Many clumps of submerged drifting algae, mainly consisting of *D. anceps* and *Ascoseira mirabilis* were found in depths between 9 and 20 m (SATO *et al.*, 1992; TADA *et al.*, 1996). Many individuals of *N. concinna* and *G. antarcticus* were found on and inside the clump. *U. antarctica, M. antarctica,* Euasteroidea sp. 1, *N. coriiceps* and another unidentified nototheniid fish also occurred in this habitat. *L. corrugatus* and a large number of gammaridean amphipods gathered under the clumps. *T. newnesi* hovered in water columns over the algal clumps 1 to 1.5 m from the bottom in small schools. As the divers approached, they quickly retreated into the clumps and rarely left them.

3.5. Rocky bottoms in tidal zones (habitat D; sR) (Fig. 3)

This habitat corresponded to inter-tidal and upper sub-tidal zones at depths between 0 to 3 m. Fishes and benthic animals were generally less abundant. *N. concinna* was common among pebbles and stones and *L. corrugatus* and *H. antarcticus* were also common under pebbles and stones. *S. neumayeri* and *O. validus* were very rare. A large number of gammaridean amphipods lived under pebbles and stones.

3.6. Rocky bottoms at middle depths (habitat E and F; mR) (Fig. 3 and 4)

Habitat E was a rock, pebble or stone bottom at depths between 3 and 10 m with small colonies of *D. anceps. U. antarctica, N. concinna, S. neumayeri, O. validus* and Euasteroidea sp. 1 were common on pebbles and stones. Nudibranchia sp. and Dendrochirotida sp. 1 were also found, but were rare. *N. coriiceps* was found among pebbles and stones. *L. corrugatus, Paraceradocus* sp., *H. antarcticus* and *L. nudifrons* were abundant in this habitat. *M. antarctica* was found in small colonies of *D. anceps. T. newnesi* and *P. borchgrevinki* hovered in water columns over the colonies. A brown algae *Adenocystis utricularis* occurred specifically on the shells of alive *N. concinna.*

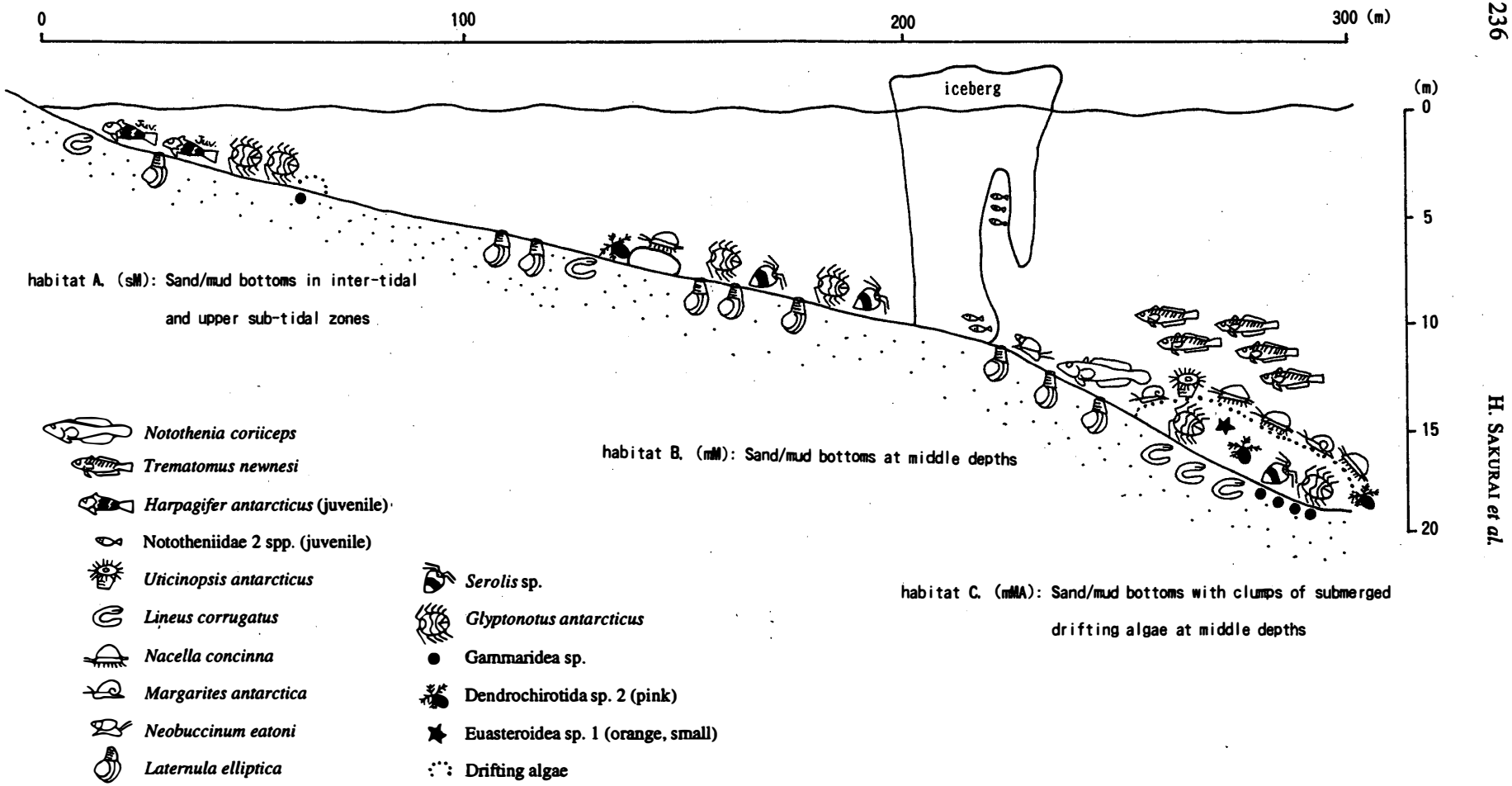

Fig. 2. Typical microhabitats of fish and epibenthos in a schematic cross-section along line-1 in Fig. 1. Most was a sand/mud bottom and clumps of submerged drifting algae occurred in some deeper areas. Scales represent the approximate distance from the shore and depths, respectively.

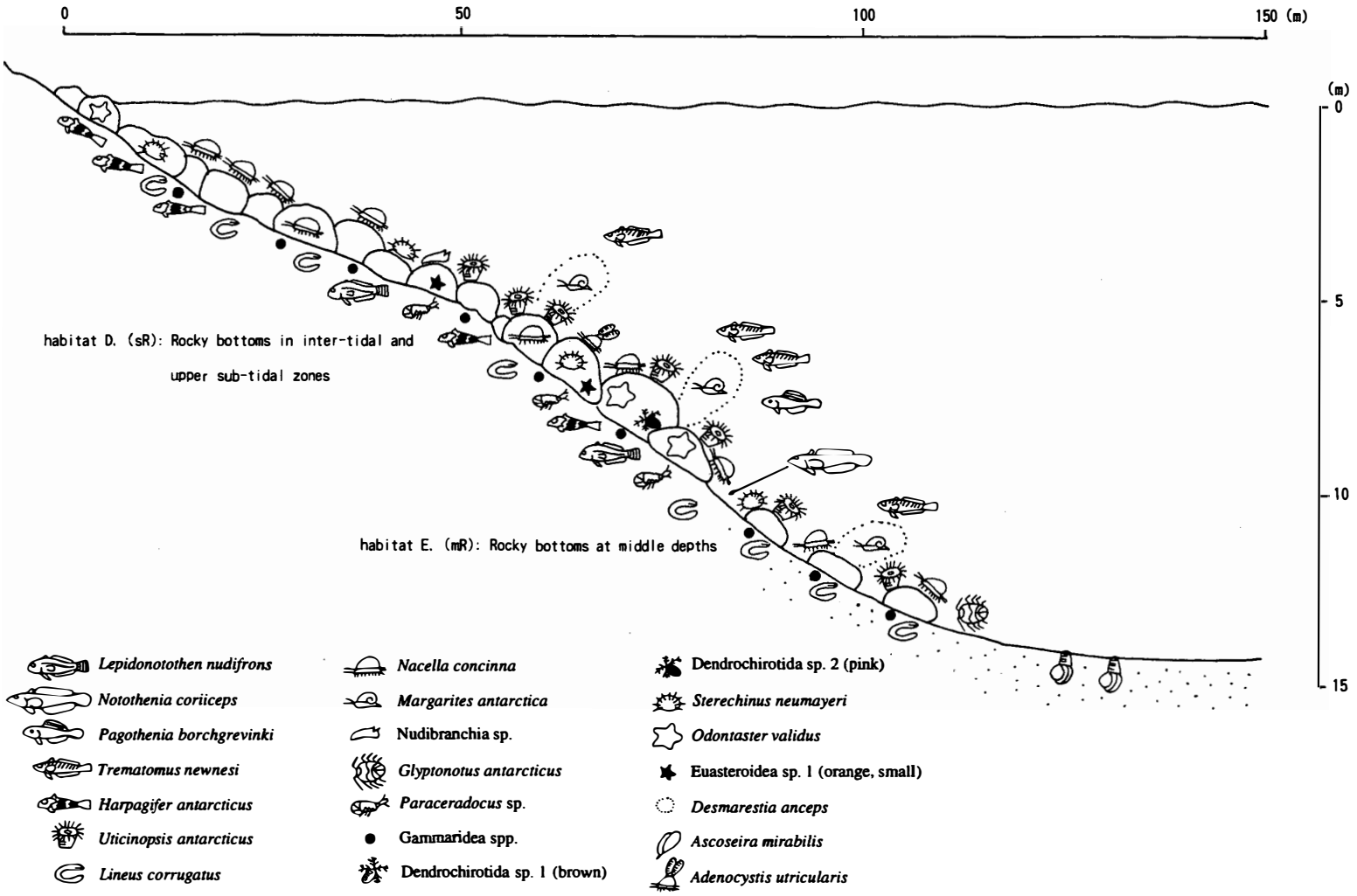

Fig. 3. Typical microhabitats of fish and epibenthos in a schematic cross-section along line-2 in Fig. 1. The bottomgradually sloped along most of the line. The substrate was rocks, pebbles or stones. Sacales represent an approximate distance from the shore and depths, respectively.

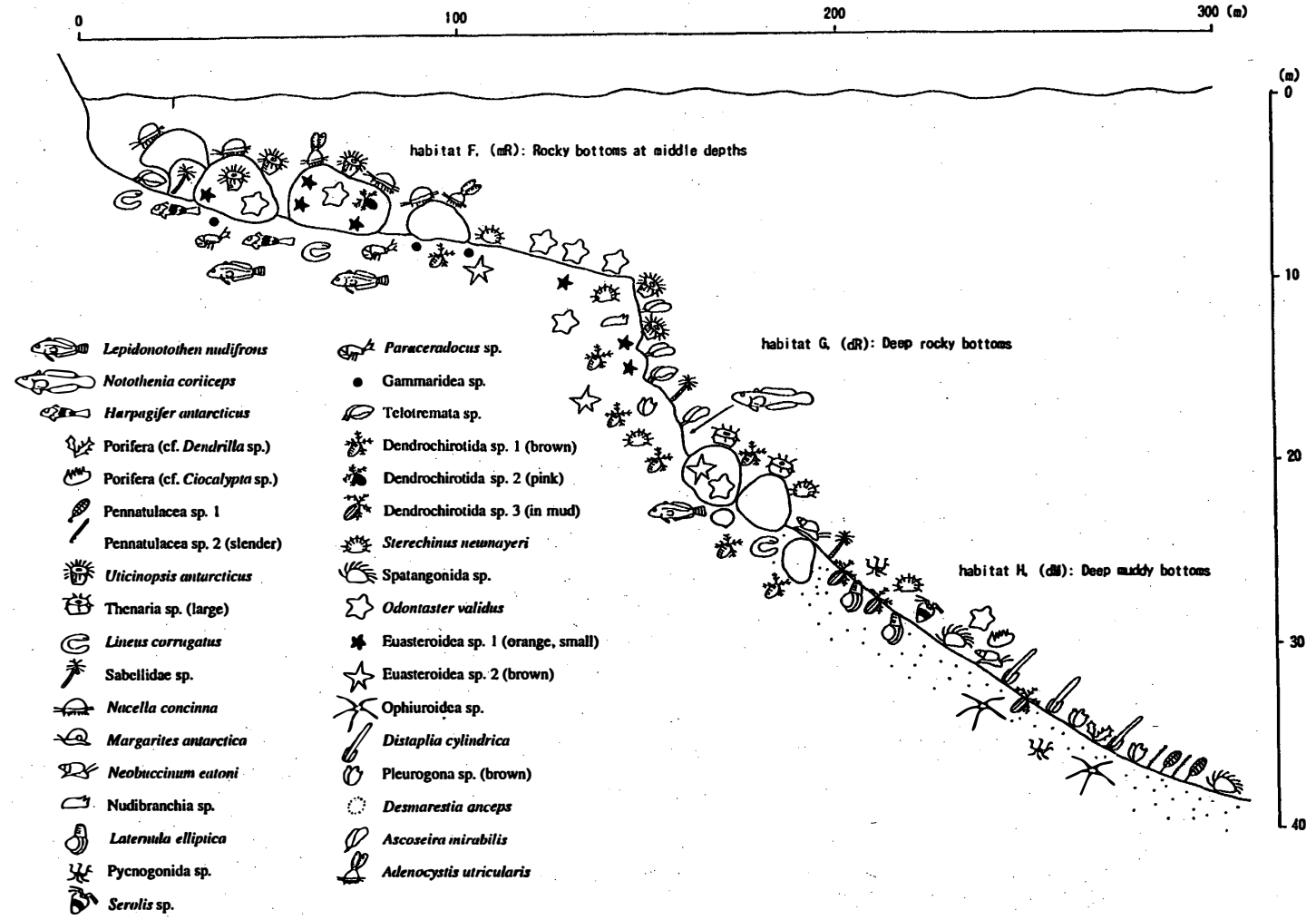

Fig. 4. Typical microhabitats of fish and epibenthos in a schematic cross-section along line-3 in Fig. 1. The bottom consisted of three substrates types. A relatively flat rocky bottom in shallow areas followed by a rock cliff and a mud bottom in deeper areas. Sacales represent the approximate distance from the shore and depths, respectively.

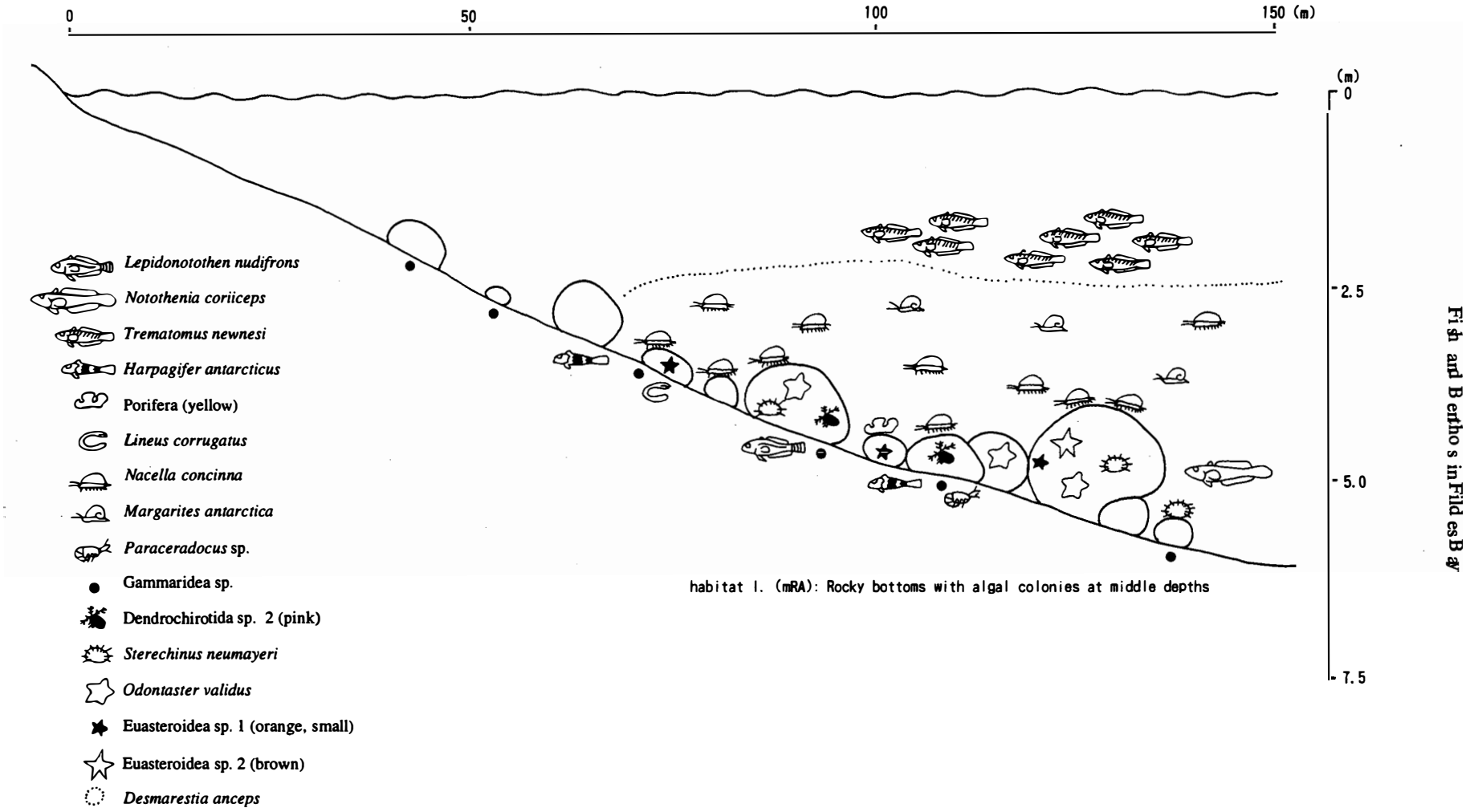

Fig. 5. Typical microhabitats of fish and epibenthos in a schematic cross-section along line-4 in Fig. 1. A large colony of D. anceps *occupied most of tnis area. Sacales represent the approximate distance from the shore and depths, respectively.*

G. antarcticus and *L. elliptica* occurred in a deeper transitional zone between rocky and muddy bottoms.

Habitat F off Becerra Rock was a relatively flat rocky bottom at depths between 5 and 10 m. *U. antarctica, N. concinna,* Dendrochirotida sp. 1, *S. neumayeri,* Euasteroidea sp. 1 and Euasteroidea sp. 2 were found at high densities. A species of the family Sabellidae and Telotremata sp. were found only in a small concavity at a base of a large rock. *L. corrugatus, Paraceradocus* sp., *H. antarcticus* and *L. nudifrons* were abundant under pebbles and stones.

3.7. Deep rocky bottoms (habitat G; dR) (Fig. 4)

Habitat G off Becerra Rock consisted of large boulders, rocks, pebbles and stones at depths between 10 and 25 m, with a steep rock cliff occupying the major part of the habitat. A large brown algae *A. mirabilis* scattered on the boulders and rocks. Epibenthic invertebrates were abundant. Thenaria sp. was observed only in this habitat. Widely distributed species such as *U. antarctica, N. concinna,* Dendrochirotida sp.1, Dendrochirotida sp. 2, *S. neumayeri, O. validus,* Euasteroidea sp. 1 and sp. 2 occurred in this habitat, as well as Sabellidae sp., Telotremata sp. and Nudibranchia sp. which were rare in the other habitat types. *L. nudifrons* occurred under pebbles and stones and *N. coriiceps* was found among rocks, while *H. antarcticus* was not found.

3.8. Deep mud bottoms (habitat H; dM) (Fig. 4)

Habitat H off Becerra Rock was a muddy bottom in depths between 20 and 40 m. *L. elliptica, N. eatoni* and *Serolis* sp. were common. *S. neumayeri* and *O. validus* which were common on the rocky bottom. Pennathulacea sp. 1, Pennathulacea sp. 2, Dendrochirotida sp. 3, Spatangoida sp. and Ophiuroidea sp. lived on the muddy bottom. A huge ascidian *D. cylindrica* attaining about 5 m in colony length, an unidentified ascidian of brown color (order Pleurogona) and Sabellidae sp. were found only on hard substrates such as pebbles or shells. Sabellidae sp. was not abundant in Fildes Bay but was observed on rocky bottoms. Two poriferans (cf. *Dendrilla* sp. and cf. *Ciocalypta* sp.), Pennathulacea sp. 1, Pennathulacea sp. 2, Dendrochirotida sp. 3, Spatangoida sp., Ophiuroidea sp., *D. cylindrica* were observed only in this habitat.

3.9. Algal colonies on rocky bottoms (habitat I; mRA) (Fig. 5)

Habitat I at the eastern end of the Ardely Peninsula was a rocky bottom at depths between 3 and 6 m, and seemed to be influenced by open sea water. This habitat had large colonies of macroalgae dominated by *D. anceps. N. concinna* and *M. antarctica* were abundant in the algal colonies. *N. concinna, S. neumayeri,* an unidentified poriferan (yellow colored), Dendrochirotida sp. 3, and three species of asteroids (*O. validus,* Phanerozonia sp. 1 and Phanerozonia sp. 2) were common on pebbles and stones, and *Paraceradocus* sp. were found under them. *T. newnesi* hovered over the algal colonies and *N. coriiceps* was in and around the colonies. *H. antarcticus* was commonly found under pebbles and stones.

4. Discussion

In the present study, we observed diverse animal communities in all habitat types except for shallow water areas where animals might suffer from drifting ice blocks, freezing and hyper cooling of water in winter. DAYTON *et al.* (1970) showed that motile animals were abundant in shallow areas (from 0 to 30 m), while sponges were dominant at greater depths between 33 and 60 m in the McMurdo Sound area. They argued that such distribution patterns of benthic animals were caused by the effects of anchor ice. HAMADA *et al.* (1986) studied benthic animals around Syowa Station where the effect of anchor ice was negligible, and found that motile animals dominated in shallow areas while sessile animals did so in deeper areas. WATANABE *et al.* (1982) briefly commented that few sessile benthos were observed shallower than 3–4 m deep. The present results also confirmed that motile animals were found at wider depth ranges but sessile animals such as two species of poriferans (cf. *Dendrilla* sp. and cf. *Ciocalypta* sp.), two species of Pennathulacea, Sabellidae sp., Telotremata sp., *D. cylindrica* and Pleurogona sp. mainly occurred in deeper areas. Sabellidae sp. and Telotremata sp. also occurred in shallower areas, but their microhabitats were limited to a concavity at a base of a large rock where they seemed to be protected from crushing by ice blocks.

The inshore areas of the Antarctic Peninsula at low latitude are thought to have more rich marine faunas and floras than higher latitude areas. In the present study, diverse habitats of fishes and invertebrates were recognized even within a limited area inside Fildes Bay, each having different animal communities. Furthermore, many species were found associated with specific microhabitats. These results suggest that many fishes and invertebrates have specific patterns of microhabitat utilization. Further quantitative studies on habitat utilization and food webs are needed to clarify the structure and characteristics of the Antarctic inshore animal communities.

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