

Potential changes in feeding behavior of Antarctic fish, *Pseudotrematomus bernacchii* (Boulenger, 1902) on the East Ongul Island, Antarctica



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ABSTRACT

The feeding habits of the Antarctic fish *Pseudotrematomus bernacchii* (Previous name: *Trematomus bernacchii*) under the fast ice around Japanese Syowa Station were investigated in the summers of 2004/2005 and 2009/2010. The results showed that amphipods and krill were the major prey. However, there was a significant difference in the proportions of larger invertebrates such as squids, octopus and other crustaceans found in the fish stomachs between 2009/2010 and the previous years. Moreover, the percentage of amphipods and krill in fish stomachs declined over the 5-year period in all fish size classes. Several factors including sea ice melting, habitat and environmental changes might have influenced the pattern of feeding behavior.

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1. Introduction

The emerald notothen, *Pseudotrematomus bernacchii* (Boulenger, 1902) (Previous name: *Trematomus bernacchii* Boulenger, 1902) is the dominant fish species in the coastal waters of the Antarctic continent (Kiest, 1993). The family Nototheniidae has extensive habitat radiation (MacDonald et al., 1987), ranging from shallow to deeper zones as deep as 600 m (MacDonald et al., 1987). Previous studies indicated that this fish is a generalist, opportunistic consumer, and specialized benthic feeders (Kock, 1992; Montgomery et al., 1993; Vacchi et al., 1994). However, Moreno (1980) reported that this fish consumed more on pelagic food items. Many previous studies that addressed feeding behaviors of *Pseudotrematomus bernacchii* were conducted in the Weddell Sea, Ross Sea, and the western part of the Antarctic region (Kock et al., 1984; Montgomery et al., 1993; Vacchi et al., 1994, 2000; La Mesa et al., 2004). However, there is little information on temporal changes in the diet of *P. bernacchii* under the fast ice in the northeastern part of Antarctica, particular around the Japanese Syowa Station. The

purpose of this study was therefore to determine the diet composition of *P. bernacchii* living under the fast ice and to investigate any change in feeding behavior of *P. bernacchii* during the five-year period from 2004/2005–2009/2010 under the influence of changing climate.

2. Materials and methods

Fish samples were collected during the 46th and 51st Japanese Antarctic Research Expedition in 2004/2005 and 2009/2010. The study site was located on the East Ongul Island near the Japanese Syowa Station (69°00' S, 39°35' E). Fish under the fast ice were caught by hook and line and SCUBA diving using a trap from less than 10 m depth to 50 m depth of water during the summer months of December 2004 and January 2005 and the months of December 2009 and January 2010. To make holes for fishing and SCUBA diving, first, snow on the sea ice was removed using a snow shovel, and then the holes were drilled. Following collection, the fish samples were brought back to the laboratory and frozen for further stomach content analysis to determine food composition. In the laboratory, the stomach content of each fish was removed from the digestive tract, fixed in 10% formalin, transferred to 40% isopropyl alcohol, and sorted under a dissecting microscope into major taxonomic

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groups. Fish samples were divided into 3 size classes based on a total length: small (15–19 cm), medium (20–25 cm), and large (>25 cm). A total of 72 individuals were collected.

The percentage of different foods was determined by spreading the stomach content evenly on a 100-point grid using a dissecting microscope to identify diet types of each point. Diet types were categorized into six main groups: amphipods/krill, other crustaceans, fish, squids/octopus/other molluscs, polychaetes, and digested matters (small particle that could not be identified). One-way-ANOVA was performed to examine difference in the percentage of each diet type among years. In addition, the diets were also expressed as percentage of total number (%N), percentage of total weight (%W), and percentage frequency of occurrence (%F), and then, the index of importance were calculated (Hannah, 1980; Gray et al., 1997).

3. Results and discussion

The diet of *Pseudotrematomus bernacchii* during the summer seasons 2004/2005 and 2009/2010 are shown in Fig. 1. Amphipods and krill were the major preys comprising between 28% and 62% of the total diets followed by other crustaceans (11.7%–21%) (Fig. 1). During the summer 2004/2005, only three types of diets were

found; however, in the summer of 2009/2010, molluscs including squids, octopus and polychaetes were found in the stomach contents. There was a significant difference ($p < 0.05$) in the percentage of molluscs and polychaetes found in the fish stomachs between the years studied. The whole body of small octopus and squids were observed either in the stomach contents or in the fish mounts after they were collected. The 2009/2010 samples also showed high proportions of larger invertebrates such as squids, octopus, and other crustaceans in all fish size classes. In addition, there was a statistically significant difference ($p < 0.05$) between years in the percentage of amphipods and krill, with lower percentages of amphipods and krill found in the stomachs in 2009/2010 than in 2004/2005 (Fig. 1). However, based on the index of importance, amphipods and krill were the most important prey groups both in the year 2004/2005 and 2009/2010 (Table 1). It is interesting to note that molluscs and polychaetes became more important as prey, and were more frequently consumed in 2009/2010 than in 2004/2005 (Table 1).

An Antarctic scallop, *Adamussium colbecki* was considered to be the main food item of *Pseudotrematomus bernacchii* (Vacchi et al., 2000; La Mesa et al., 2004). Sedentary and burrowing prey species were also reported to be consumed by *P. bernacchii* (Kiest,

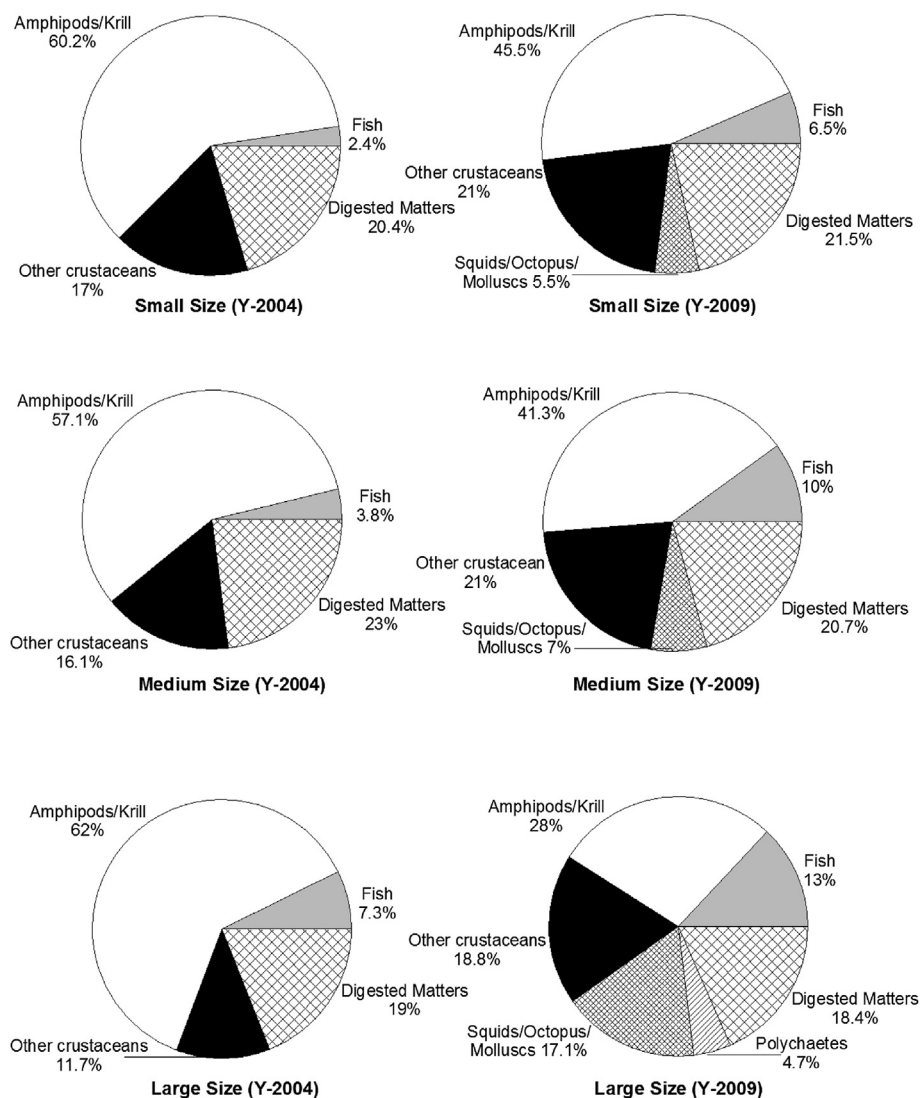


Fig. 1. Stomach contents of *Pseudotrematomus bernacchii* in 3 size classes collected in the summers of 2004/2005 and 2009/2010.

Table 1

Dietary composition of *Pseudotrematomus bernacchii* under the fast ice, East Ongul Island in 2004/2005 and 2009/2010 (%N = percentage of total number, %W = percentage of total weight, %F = percentage frequency of occurrence, IOI = index of importance).

Diet types	%N		%W		%F		IOI	
	2004	2009	2004	2009	2004	2009	2004	2009
Fish	15.6	8.3	24.6	19.1	29.2	35.4	21.3	17.6
Amphipods/krill	56.7	31.7	51.3	26.8	79.2	83.3	51.6	35.5
Other crustaceans	27.8	27.5	20.5	22.6	47.9	54.2	27.1	24.8
Squids/octopus and other molluscs	0	24.2	0	20.4	0	29.2	0	16
Polychaetes	0	8.3	0	8.4	0	10.4	0	6.1

1993). However, in this study, crustaceans such as amphipods, krill, and others were found to be the major prey. Even though, molluscs were found in the stomach contents, there was no *A. colbecki* (Fig. 1). The feeding habitats and the food availability can influence prey types of *P. bernacchii* (Eastman, 1985; Kiest, 1993; Casaux et al., 2003). The Antarctic krill, *Euphausia superba*, were commonly found under the fast ice off the Ongul Island (Kawaguchi et al., 1986). Thus, they were an important food source for *P. bernacchii* occurring around the Lützow-Holm Bay and Ongul Island (Naito and Iwami, 1982; Kawaguchi et al., 1986). Antarctic krill have a wide vertical distribution, and can be found near the sea bottom (Kawaguchi et al., 1986; Martin et al., 1991). In the past (Nakajima et al., 1982), live specimens of mollusc, *Adamussium colbecki* were reported around the Japanese Syowa station. During the subsequent years, many dead shells of *A. colbecki* caused by the occurrence of hyposaline water were observed (Numanami et al., 1996), and only a small specimen of *A. colbecki* was found in stomach contents of *P. bernacchii* (Numanami et al., 1996). In addition, Takahashi and Iwami (1997) reported that demersal fish around Antarctic peninsula could be classified as fish feeder, krill feeder, and benthic feeder. Thus, this could explain why *P. bernacchii* found around the Japanese Syowa Station consumed more amphipods and krill than those living in other coastal areas of the Antarctic continent.

From this study, high proportions of molluscs and polychaetes fed by *P. bernacchii* were observed around the East Ongul Island near the Japanese Syowa Station when compared to the previous years. Several factors including changes in habitat and environment could lead to changes in fish feeding habits. The effect of sea ice melting due to climate change has becoming an increasing concern (Stroeve et al., 2007; Nomura et al., 2012), since it can influence water stratification, biogeochemical processes, and the entire food web (Arrigo et al., 1999; Steele et al., 2010; Nomura et al., 2012). Consequently, it can change the phytoplankton community by favoring growth of diatoms (Arrigo et al., 1999). In addition, climate change through increasing water temperatures and pCO₂ and reducing water salinity can threaten the Antarctic fish (Mintenbeck et al., 2012). Yet, the mechanisms linking sea ice melting and shifting diets of *P. bernacchii* living under the fast ice around the Japanese Syowa Station remain unclear, and further studies are needed to investigate the linkages among changing climate/environment, benthic community, and feeding habits of Antarctic fish.

4. Conclusions

Changes in feeding behavior of Antarctic fish, *P. bernacchii* were observed through the stomach contents from samples collected in the summer seasons of 2004/2005 and 2009/2010. Lower proportions of amphipods and krill were observed in fish stomachs when compared to the previous years. Several factors such as sea ice melting, habitat, and environmental changes might have influenced the changes in fish feeding behaviors. However, the

linkage between feeding behaviors and changes of environment are needed for further investigation.

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