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Spatial and temporal variations in the diet of nototheniid fish in McMurdo Sound, Antarctica

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Abstract. Specimens of 4 species of Antarctic fish were captured at different locations in McMurdo Sound during the early summer, and for one species also during late winter. Stomach contents were analysed to examine resource utilization across species, at different locations, and between late winter and early summer. The results are consistent with earlier findings that there is a gradation in resource utilization across these species. *T. pennelli* and *T. bernacchii* tend to take predominantly benthic crawling prey, though they also take prey from the water column. *T. hansoni* and *T. nicolai* tend to take more prey from the water column, a tendency which can be related to the visual feeding vector of these species. Substantial differences in diet for the same species captured in different locations indicated significant flexibility in prey selection which would allow utilization of spatial and temporal fluctuations in prey availability. Successful feeding by *T. bernacchii* in late winter is a further indication that this species can feed non-visually and supports the notion that non-visual feeding mechanisms are likely to be of importance in the biology of the Antarctic fishes.

The marine environment of McMurdo Sound, although extreme, is thermally stable. The ecosystem may thus be less complicated than in more temperate regimes. The relationships among the 1000 or so species recorded from the Ross Sea (unpublished Fauna compiled from the literature) are understood at a general level, whereby the penguins and seals depend on the summer-time primary productivity, with zooplankton and fish as intermediaries. However, beyond these broad generalizations, our understanding of the contribution of fish to the McMurdo Sound ecosystem is still fragmentary. Our past investigations of the prey of nothothenioid fish species that live in McMurdo Sound have revealed grades of planktivory, piscivory and benthic feeding (Foster et al. 1987; Montgomery et al. 1989; Foster and Montgomery 1992, Janssen et al 1992). However, these studies have focused on particular locations at particular times, and details of spatial and temporal variations in feeding are largely lacking.

This paper reports on further dietary analysis of specimens taken over a wider area within McMurdo Sound and shows that there is considerable spatial and temporal flexibility in prey species. Comparisons are made between species (slight differences), between sites (strong differences) and between seasons (slight differences).

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Materials and methods

All fish were caught with baited lines, and no a priori effort was made to catch different species.

The bulk of the fish were caught during the early 1990/91 NZARP season, from 31 October to 27 November 1990, on a number of occasions at the following 3 localities:

(i) southern end of Hut Point Peninsula (from fish huts at Cape Armitage, McMurdo Bay, Danger Slopes);
(ii) midway into McMurdo Sound at Cape Evans;
(iii) at the entrance to the Sound at Cape Bird.

Samples of *T. bernacchii*, *T. pennelli* and *T. hansoni* were caught at Hut Point sites. Two lots of *T. bernacchii* were caught at Cape Evans. (two *T. hansoni* were caught at Cape Evans, but these were insufficient for analysis.) At Cape Bird, *T. bernacchii* and *T. nicolai* were caught. The numbers of fish caught are given in the results table; sample sizes for each species and locality ranged from 12 to 36.

A second set of fish were collected at Cape Evans over the August to October dark-to-light transition 1989, as part of the Greenpeace World Park Base scientific programme. These fish were all *T. bernacchii*, except for one *T. hansoni*.

Each fish had its stomach removed and the stomach contents washed out and preserved for identification and counting of prey items. Some fish had no items in their stomachs. Those prey taxa present were categorised as swimmers (planktonic, or demersal), or crawling (normally intimately associated with the sea bottom).

Table 1. Dietary analysis for McMurdo Sound nototheniids

	A	B	C	D	E	F	G
Fish species	bernach	pennelli	hansoni	bernach	bernach	nicolai	bernach
Locality	Hut Pt	Hut Pt	Hut Pt	C. Evans	C. Evans	C. Bird	C. Bird
Date: day/month	31/10–11/11/	31/10–12/11/	13/11–24/11/	2/11–13/11/	11/8–7/10/	27/11/	27/11/
Year	1990	1990	1990	1990	1989	1990	1990
No. occasions	3	7	3	2	16	1	1
No. caught-no. empty	32-5	30-6	14-7	36-19	35-8	16-1	12-0
swimmers							
copepods	–	–	–	–	10	–	–
Limacina	49	1	–	22	2	–	–
limacosphaera	–	1	–	–	1	5	7
Hyperiella	3	5	2	3	29	–	–
Orchomene	4	4	–	23	5	1	–
Paramoera	1	1	2	2	–	59	284
other gammarids	–	–	–	–	17	–	–
fish	1	2	4	2	5	12	4
crawlers							
Nototanais	3	19	–	–	24	–	–
Munna	–	–	–	–	25	–	–
Gnathia	2	1	–	3	–	–	–
Antarcturus	–	6	–	–	–	–	–
Glyptonotus	–	–	–	–	2	–	–
Harmothoe	35	23	3	6	5	–	1

Results

The total numbers of prey items identified in stomachs of each of the fish species from each area are given in Table 1. The swimming prey ranged in size from planktonic copepods through amphipods and fish; and benthic prey ranged in size from tanaiids (several mm) through isopods and polynoid polychaetes (10s of mm) that crawl over and burrow into benthic marine growth.

There are three main comparisons that can be made. Firstly between different fish species at the same locality. At Hut point (column A, B & C) there is a general consistency between the diets of *T. bernacchii* and *T. pennelli* with the latter taking more crawlers. Despite the fewer numbers of *T. hansoni* taken there is a tendency for them to take larger swimmers and fewer crawlers. An example of this tendency is the percent occurrence of the scale worm *Harmothoe spinosa*, in *T. bernacchii*, *T. pennelli* and *T. hansoni* its percent occurrence was 73%, 61% and 33% respectively. At Cape Bird (columns F & G) there was a local abundance of the amphipod *Paramoera* which were observed swimming in the water column and resting on the fast-ice and on the bottom. This local abundance was reflected in high numbers of this prey item in both species of fish. *T. nicolai* also contained considerable numbers of fish larvae indicating a strong component of feeding from the water column.

The second comparison is for the same fish species at different localities. *T. bernacchii* was caught at Hut Point, Cape Evans and Cape Bird (columns A, D & G). At the inner McMurdo Sound localities the diet is much the same, with more polynoid polychaetes at Hut Point and more *Orchomene* amphipods at Cape Evans, but at Cape Bird the diet is dominated by the amphipod *Paramoera*.

Finally there is a comparison to make between the same fish species captured at the same location, but at different seasons. *T. bernacchii* were captured at Cape Evans in late winter (mid August to mid October, column E) and in early summer (column D), albeit in different years. The dark-to-light transition diet is dominated by more smaller swimmers and crawlers. Of interest are the copepods (*Metridia gerlachei*, *Ctenocalanus citer*, *Euchaeta antarctica* and *Stephos longipes*) which were not in evidence in the other gut samples taken.

Discussion

Fish were caught on baited lines which could potentially bias the results, however given the logistic limitations of obtaining fish from beneath ice cover it represents the best available option. Using traps to catch fish for the study of gut contents can lead to problems with amphipods attracted to the baits being consumed by fish in the trap.

The samples taken in the region of Hut Point broadly agree with earlier dietary studies from this area as to the importance of errant polychaetes in diet of benthic nototheniids (Dayton et al. 1970; Eastman 1985; Foster and Montgomery 1992). In particular this study found that the scale worm *Harmothoe spinosa* was an especially important component in the diets of *T. pennelli* and *T. bernacchii* and to lesser extent *T. hansoni* (73%, 61% and 33% occurrence respectively). Given the large size of *Harmothoe* the percent occurrence figures underestimate the importance of this dietary component which often occupied a large proportion of gut space, up to one case of 100% where a *T. bernacchii* individual of 135 mm was found to contain a *H. spinosa* worm of 60 mm.

This study also agrees with the previous finding of Foster and Montgomery (1992) as to the presence of a degree of planktivorous feeding in even the most benthic species. There is a general trend across these species in benthic to water column feeding from *T. pennelli* and *T. bernacchii* to *T. hansoni* and *T. nicolai*. This trend is not tightly correlated to density measures where the density indices for the 4 species are 3.04, 3.37, 2.91 and 3.13 respectively (Eastman and DeVries 1982). However, *T. hansoni* is the least dense, and may be expected to spend some time in the water column hunting as opposed to sitting on the substrate waiting for prey to pass overhead. There is, however, a clear correlation with visual feeding vectors. As discussed by Pankhurst and Montgomery (1989), *T. pennelli* and *T. bernacchii* have a lateral visual axis and a corneal iridescence which screen out down-welling light. *T. hansoni* has dorso-laterally directed eyes, as does *T. nicolai* to an even greater extent (Macdonald and Montgomery 1991) but neither of these species has corneal iridescence.

Consumption of the small sea anemone *Edwardsia meridionalis* and the burrowing amphipods *Heterophoxus videns* and *Monoculodes scabriulosus* by *Trematomus* sp. in 1976 (Oliver and Slattery 1985), but not in this study perhaps indicates locality and/or annual differences of either predator or prey species. Targett (1981) and Daniels (1982) noted both locality and year differences in nototheniid feeding. The locality differences between Cape Bird and the other two sites are particularly marked. At the time the samples were taken the amphipod *Paramoera* was particularly abundant and this is reflected in the diets of both fish species. It is clear that feeding strategies in these species are sufficiently flexible to take advantage of fluctuations in abundance of prey.

Finally, the late winter samples were collected in the attempt to answer the question as to whether these high latitude fishes continue to successfully feed through the winter darkness. Samples could not be obtained through the period of total darkness due to ice conditions, but the earliest samples obtained clearly indicated that the fish are feeding as successfully, and on much the same mix of prey species, as they are during early summer. The presence of smaller prey items, particularly the copepods, may simply be an indication of their greater availability at this time of year. Concurrent plankton samples indicate that the copepod species in question all peak in abundance over the winter period, and that the numbers begin to fall around August–September, to almost zero during the summer (Foster, Schmidt and Carr unpublished). Successful feeding during the period of late winter when there are only a few hours of daylight suggests that these fish are able to feed non-visually probably using their mechanosensory lateral line system. The potentiality for lateral line feeding is clearly shown in laboratory studies which reveal that blinded *T. bernacchii* can locate moving prey, and that in behavioural conditions where conflicting visual and lateral line cues are available to determine food localization, lateral line cues dominate (Janssen, unpublished). If the water column feeding in *T. hansoni* and *T. nicolai* is directly related to the dorsal visual axis of these species it would be interesting to know if there is a change in the composition of their diet during winter darkness. Unfortunately these species were not represented in the late winter samples.

The late winter dietary samples for *T. bernacchii* show that this species feeds successfully despite long hours of darkness, and support the notion that non-visual feeding mechanisms are likely to be of importance in the biology of the Antarctic fishes.

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