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Seasonal aspects of the biology and diet of nearshore nototheniid fish at Potter Cove, South Shetland Islands, Antarctica

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Summary. Approximately 1000 specimens belonging to eight fish species were collected at Potter Cove, King George Island, South Shetland Islands, from August 1985 to May 1986. This study deals with the dominant species *Notothenia neglecta*, *Notothenia gibberifrons*, *Trematomus newnesi* and *Notothenia rossii marmorata.* Age and size structure of the fish were analyzed using scale and otolith readings. *Notothenia neglecta* was the most abundant species. It spawns in the austral autumn. Juvenile *N. rossii marmorata* migrate offshore when sexually mature. Over eight hundred stomach contents were analyzed. The four species studied were generally benthophagous. However, in summer *T. newnesi* and *N. rossii marmorata*, carried out vertical migrations, feeding on pelagic organisms. Gammarid amphipods constituted the main food in all four species. Algae were consumed regularly throughout the year and we suggest that they are intentially eaten by the fish, rather than by accident. Two 48 hour sampling periods, carried out in summer of 1987, showed that *N. neglecta* was more active during the day.

Introduction

Nototheniids are widespread in the Antarctic Ocean. Several species are almost entirely neritic. In the last two decades, papers on the trophic ecology of these coastal fishes have dealt mainly with samples taken in offshore waters (Permitin and Tarverdiyeva 1972, 1978; Linkowski and Rembiszewski 1978; Tarverdiyeva and Pinskaya 1980; Targett 1981; Daniels 1982; Duhamel and Hureau 1985; Kock 1985; Williams 1985). Only a few nearshore studies were done by means of small trawlers, trammel nets, hooks and lines or traps (Moreno and Bahamonde 1975; Richardson 1975; Moreno and Osorio 1977; Moreno and Zamorano 1980; Linkowski et al. 1983; Daniels 1982; Burchett 1982, 1983a). Most of these samples were collected in summer and only a few studies were done year round.

Potter Cove, in King George Island, South Shetland Islands, is a convenient locality for nearshore community studies because it is usually calm and drift ice is seldom encountered. With the exception of some winter months, when the cove remains frozen, samples can be obtained throughout the year.

This paper presents an analysis of the stomach contents of four nearshore nototheniids (*Notothenia neglecta*, *Notothenia gibberifrons*, *Trematomus newnesi* and *Notothenia rossii marmorata*) collected throughout a year.

Study site, material and methods

Samples were collected in Potter Cove, King George I., South Shetland Is., close to the Scientific Station Jubany (62° 14'S and 58°40'O) (Fig. 1).

The cove has an approximate area of 6.3 km^2. Its profile is V-shaped and the maximum depth is 130 m. The cove can be divided into two zones. The internal or zone I (Fig. 1), bordered by a glacier, has the bottom covered with glacial sediments and is devoid of algae. The external or zone II (Fig. 1), is the entrance to the cove and constitutes the area sampled during this study. It has a rocky bottom covered mainly with Rodophyceaen (Gigartina sp.) and Phaeophyceaen (Desmarestia sp.) algae. Algal densities increase gradually from zone I to zone II.

The fauna associated with algal beds in the sampling area is rich and diverse. It includes: polychaetes, gammarid amphipods (*Eurimera monticulosa, Bovallia gigantea, Valettia coheres*), isopods (*Serolis* sp., *Glyptonotus antarcticus*), cephalopods, gastropods (*Laevilacunaria bransfieldensis, Margarita antarctica, Patinigera polaris, Eatoniela caliginosa*), chitons (Quiton sp.), bivalves (*Mysella charcoti, Laternula eliptica*), ophiuroids (*Amphiura deficiens*), asteroids (*Odontaster validus, Labidiaster annulatus, Cuenotaster involutus, Lysasterias* spp., *Porania antarctica glabra*), echinoids (*Ctenocidaris speciosa, Sterechinus neumayeri*), tunicates (*Salpa thompsoni*), and fish.

Surface water temperature varied from $-1.4°$ to $+1.9°C$ during the year.

For the stomach content analysis and the study of reproductive aspects, sampling was carried out from August 1985 to May 1986 (the cove was frozen during June and July). Trammel-nets of 25 and 50 m length, 1.5 m width and 25 mm mesh size were used. The nets were fastened to a rock at the entrance to the cove and cast in various directions and depths from 8 to 48 m. During January and February 1987, two 48-h periods of sampling were undertaken. The nets were examined every 6 hours in order to obtain information on activity rates.

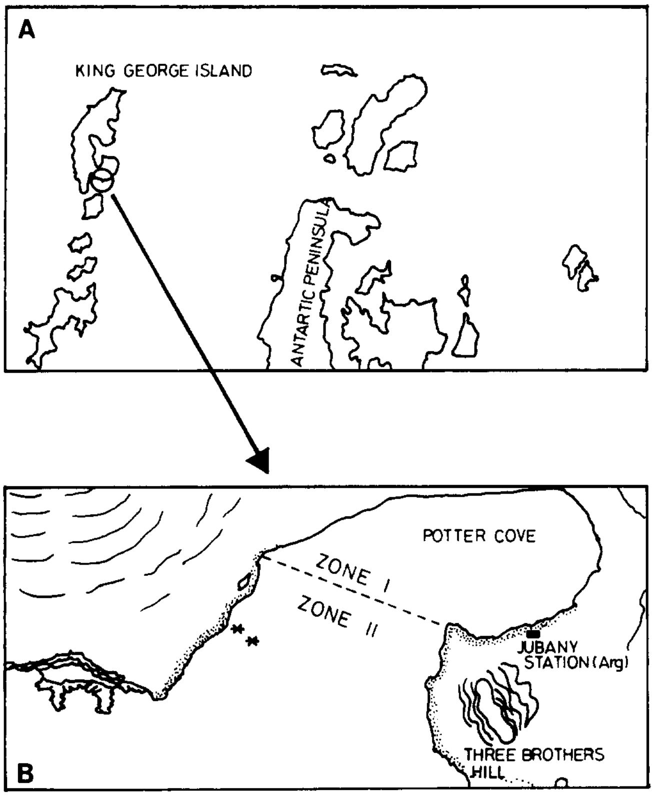


Fig. 1. A General view of King George Island, South Shetland Islands; **B** Map of Potter Cove showing zones I, II and catch place *

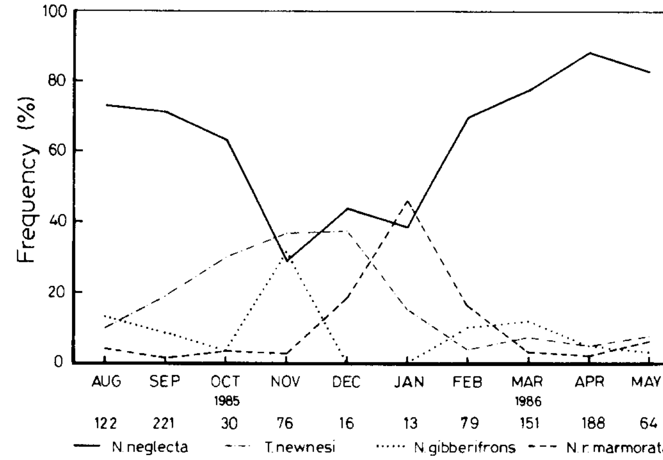


Fig. 2. Monthly frequency distribution of capture of the fish species studied in Potter Cove. The number below each month indicates the number of fish caught

The weight of the fish was recorded to the nearest gram below. Size measured as total length (TL) to the nearest millimeter below. Scales and otoliths were examined to determine age. Scales of *N. neglecta*, *N. gibberifrons* and *N. rossii marmorata* were prepared according to Barrera-Oro (1989). Otolith sections of *N. gibberifrons* were obtained using the method described by Tomo and Barrera-Oro (1986). Otoliths of *N. neglecta* and *N. rossii marmorata* were examined in their entirety. The ages were interpreted by E.B.-O.

Nine hundred and ninety three fish belonging to 8 species were collected. Only the four most abundant species are analyzed in this study. These are *N. neglecta* (690), *N. gibberifrons* (127), *T. newnesi* (97) and *N. rossii marmorata* (46), representing 97% of all the fish caught. *Chaenocephalus aceratus* (19), *Champsocephalus gunnari* (8), *Parachaenichthys charcoti* (5) and *Nototheniops nudifrons* (1) are not included.

Eight hundred and sixty nine stomach contents were examined according to the mixed method of Hureau (1970), following the recommendation of the BIOMASS Program (Anonymous 1981). Six hundred and seventy one stomachs belonged to *N. neglecta*, 89 to *N. gibberifrons*, 63 to *T. newnesi* and 46 to *N. rossii marmorata*. Data are expressed in terms of the dietary coefficient (Q), which is the product of the percentage by number and the percentage by weight of each prey type. This reduces biases due to the use of numeric or weight methods. A total "Q" value was calculated as the sum of the annual "Q" indices "An" corresponding to each item. For graphic representation of each component of the diet, a fraction of the total "Q" was used as "Q%".

The relationship between the ingestion of algae and gammarid amphipods in *N. neglecta* throughout the year was analyzed by testing the null hypothesis of independence using the "G" statistic.

Gonad development was determined according to the scale of Everson (1977).

Results

Notothenia neglecta was the dominant fish species both in numbers (69%), and weight (88%). However, the frequency in the catches relative to the remaining species decreased during November, December and January (Fig. 2).

Populational aspects

The size-range of the specimens caught was as follows: *N. neglecta*, 163–552 mm; *N. gibberifrons*, 143–355 mm; *T. newnesi*, 123–233 mm, and *N. rossii marmorata*, 223–440 mm. Figure 3 shows the length distribution of the four species by sex as well as the age-range of *N. neglecta*, *N. gibberifrons* and *N. rossii marmorata*.

To examine the annual variation, the data were combined into three periods: August to October (1); November to February (2); March to May (3). The length distribution of *N. neglecta* by sex throughout these periods is shown in Fig. 4.

Figure 5 shows the monthly frequency of occurrence of gonad stages in *N. neglecta*. Only this species yielded the five stages. The smallest mature females (stage IV) were 345 mm long while males matured at 320 mm. The age at sexual maturity was 6 years in both sexes.

All specimens of *N. gibberifrons* were at stages I and II with the exception of five individuals (both sexes) which were in stage III.

In *T. newnesi*, stage IV was only found in females, the smallest of which measured 160 mm. The males were in stage I and II only.

Most of the males of *N. rossii marmorata* were of stages I and II. Four were of stage III, and one (6 years; 443 mm) of stage IV. Females of this species were of stages I and II only. This agrees with the age ranges found.

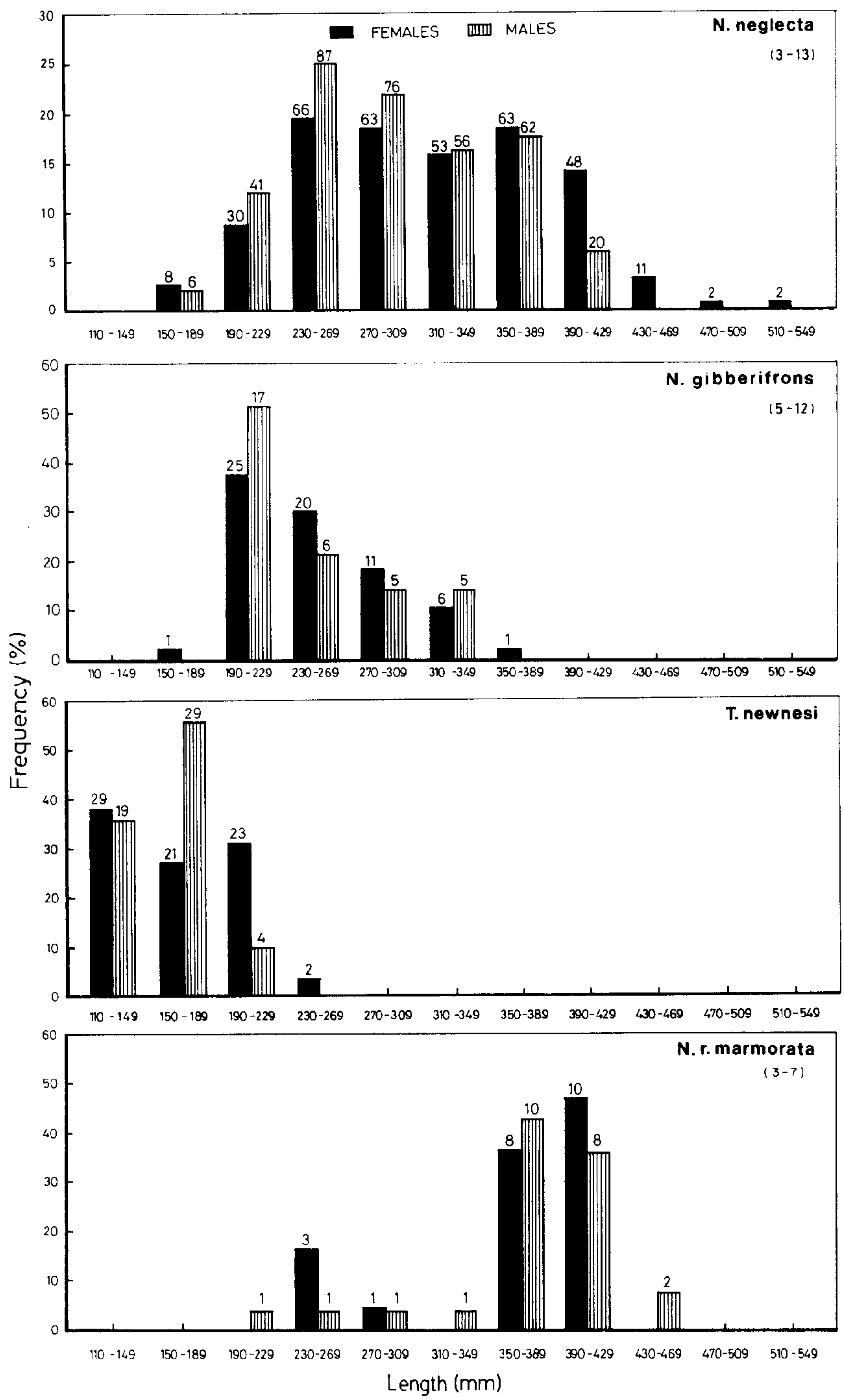


Fig. 3. Distribution of length frequency in male and female specimens of the fish species studied. The number above each histogram indicates the number of fish caught. Numbers between brackets indicate the age range in years, when estimated

Diet

Table 1 shows the total trophic spectrum observed for each species throughout the year and during each of the three periods. Figure 6 only shows the main ($Q > 200$) and secondary ($200 > Q > 20$) diatary items of each species.

N. neglecta. Together with *N. gibberifrons* this species had a wide variety of dietary items, which suggests an euriphagous behaviour (Table 1). However, gammarid amphipods were the main prey during all periods. Algae, fish and hyperiid amphipods were secondary food items. Other prey taxa were only important during certain periods, e.g. the euphausiids during the summer.

Figure 7 shows the size of *N. neglecta* and its prey. Gammarid amphipods and opistobranch gastropods were eaten by small and medium-sized fish, but were found less often in the diet of larger individuals. Fish (mainly *Harpag-*

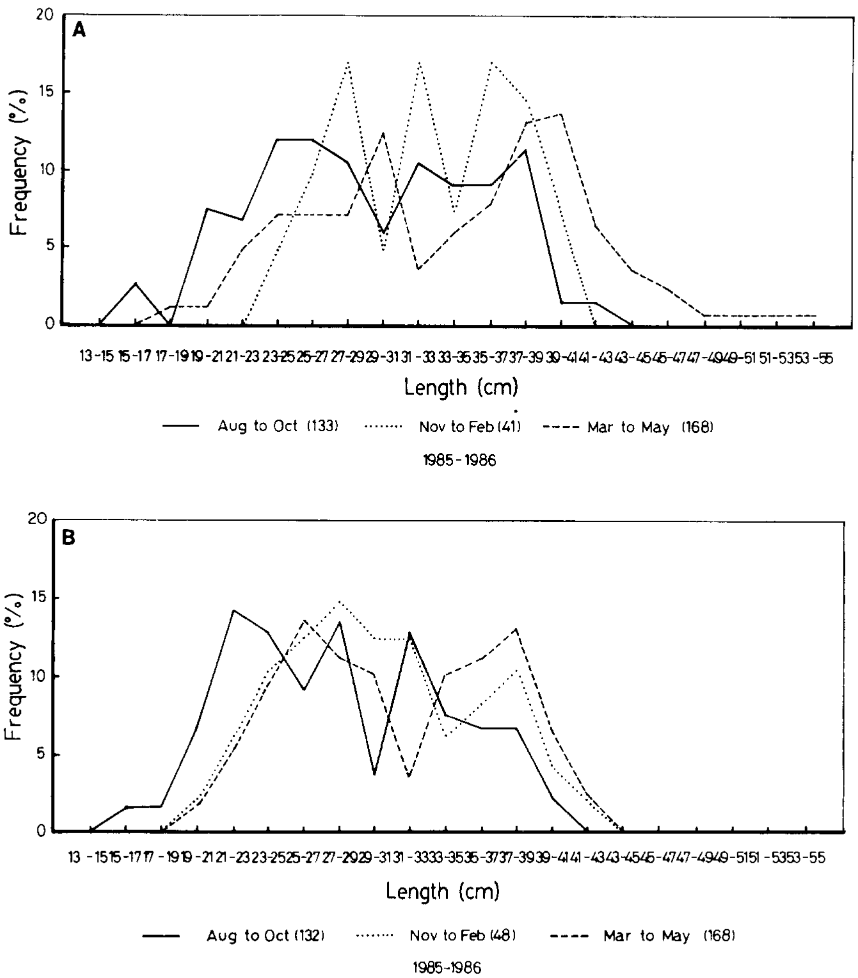


Fig. 4A, B. Distribution of the length frequency in *Notothenia neglecta* for each period of capture. A) Females; B) Males. The number between brackets indicates the number of fish caught

ifer antarcticus and *T. newnesi*) were consumed by intermediate and especially by the larger *N. neglecta*. Gastropods, archaeogastropoda (limpets) and cephalopods were only eaten by the largest fish.

N. gibberifrons. Gammarid amphipods were the main prey (Q% = 99) (Table 1). Algae and polychaetes were the secondary prey. There was no significant variation in diet throughout the year, except for a limited consumption of hyperiid amphipods during the first period only, and an increase in polychaetes during the second period (Table 1). In the third period a more diverse diet (accidental food) was recorded: number of prey items increased by 63% with respect to the first period, and 116% with respect to the second.

T. newnesi. This species showed the least diverse diet, with gammarid amphipods being the main prey (Q% = 95) (Table 1). Secondary prey were hyperiid amphipods and euphausiids, whose importance increased in the third period (Fig. 6).

N. rossii marmorata. Gammarid amphipods were the main prey, but were not as dominant as in the other species. Algae, hyperiid amphipods and euphausiids were secondary components of the diet (Fig. 6). Other taxa became the main food during specific periods. Bivalves and euphausiids in the first one; algae in the second, and hyperiid amphipods in the third (Table 1).

Results of the 48-h sampling indicates that *N. neglecta* is more active during the day (Fig. 8).

Table 2 shows the relationship between the ingestion of algae and gammarid amphipods in *N. neglecta* throughout the year.

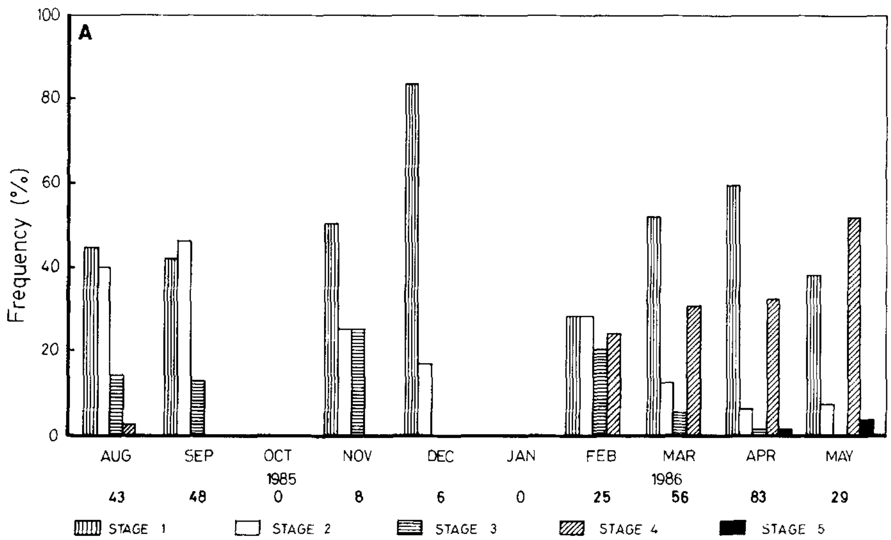
Discussion

Several authors have indicated that areas with high macroalgae diversity show greater fish activity (Richardson 1975, for Signy Island, South Orkney Islands; Zukowski 1980; King George I.; Duhamel 1982; Kerguelen Island; Burchett 1983b, South Georgia Islands; among others). In Potter Cove this was confirmed by diving observations in the inner part of the cove or zone I (Fig. 1) where the seabed was barren of algae, and where fish were not found. Macroalgal environments offer a diversity in prey and shelter from potential predators such as penguins and mammals.

The size and age ranges of *N. neglecta* indicate that demersal juvenile and adult specimens co-exist in Potter

Table 1. Diet composition of the fish species studied. 1 = August to October; 2 = November to February; 3 = March to May; An = annual period; Q = dietary coefficient

Food item	Frequency of occurrence (%)				Q			
	1	2	3	An	1	2	3	An
N. neglecta								
Sediments	29.27	4.44	8.63	15.64	2.16	1.06	0.24	1.17
Algae	80.45	70.00	63.14	70.73	77.06	106.16	36.48	59.97
Polychaetes	33.65	4.44	3.92	15.09	15.68	6.59	0.19	1.09
Gastropods	34.15	20.00	24.71	27.45	16.75	4.97	12.50	12.77
Limpets	11.71	2.22	5.49	7.27	5.05	3.03	1.98	2.98
Clams	0.00	0.00	0.78	0.36	0.00	0.00	0.00	0.00
Siphons	2.93	0.00	0.00	1.09	0.87	0.00	0.00	0.09
Cephalopods	1.46	6.67	3.14	3.09	0.05	1.15	0.31	0.31
Euphausiids	0.00	11.11	4.31	3.82	0.00	188.67	13.09	14.53
Gammarids	51.22	44.44	50.99	50.00	1104.28	724.13	751.30	870.39
Hyperiids	0.49	4.44	9.02	5.09	0.00	27.94	147.94	51.83
Isopods	0.98	5.56	6.27	4.18	0.02	5.22	1.28	1.06
Copepods	0.00	1.11	0.00	0.18	0.00	0.00	0.00	0.00
Salps	0.00	12.22	23.14	12.73	0.00	9.66	9.66	13.37
Asciids	0.98	0.00	0.00	0.36	0.06	0.00	0.00	0.00
Fish	41.46	15.56	16.86	25.82	139.38	19.52	25.50	53.18
No. observed					261	74	336	671
N. gibberifrons								
Sediments	79.16	32.14	29.62	40.44	2.65	14.28	2.87	3.55
Algae	79.41	67.86	70.37	74.15	9.10	105.86	57.95	29.12
Oligochaetes	5.88	0.00	0.00	2.24	0.27	0.00	0.00	0.09
Polychaetes	35.29	53.57	22.22	37.07	5.91	721.44	4.15	26.11
Priapulids	0.00	0.00	7.40	2.24	0.00	0.00	3.05	0.25
Gastropods	14.70	3.57	11.11	10.11	0.32	0.22	0.07	0.23
Limpets	0.00	7.14	3.70	3.37	0.00	2.64	0.01	0.05
Clams	0.00	7.14	11.11	5.61	0.00	5.80	3.14	0.69
Siphons	0.00	0.00	3.70	1.12	0.00	0.00	0.03	0.00
Euphausiids	0.00	0.00	3.70	1.12	0.00	0.00	0.56	0.65
Gammarids	91.17	39.28	59.25	65.16	7187.14	2066.31	3262.58	5165.70
Hyperiids	11.76	0.00	0.00	4.49	43.03	0.00	0.00	0.09
Isopods	11.76	0.00	14.81	8.98	0.55	0.00	3.82	1.00
Ophiuroids	0.00	0.00	7.40	2.24	0.00	0.00	1.19	0.10
Salps	0.00	0.00	7.40	2.24	0.00	0.00	0.34	0.03
Fish	2.94	0.00	3.70	2.24	0.02	0.00	0.61	0.11
No. observed					34	28	27	89
T. newnesi								
Algae		2.56	12.50	6.35		0.32	9.26	2.79
Gastropods		5.13	0.00	3.17		10.67	0.00	2.99
Euphausiids		0.00	8.33	3.17		0.00	436.84	86.15
Gammarids		28.20	25.00	26.98		7370.12	2802.29	4787.57
Hyperiids		5.13	16.66	9.52		100.31	241.79	152.85
No. observed						39	24	63
N. rossii marmorata								
Sediments	11.11	8.33	0.00	7.14	0.36	0.08	0.00	0.02
Algae	44.44	58.33	41.66	54.76	73.13	343.98	773.00	63.82
Polychaetes	11.11	4.16	0.00	4.76	7.82	0.40	0.00	0.24
Siphons	22.22	0.00	0.00	4.76	647.79	0.00	0.00	6.65
Octopus	0.00	4.16	0.00	2.38	0.00	1.07	0.00	0.10
Squids	11.11	0.00	0.00	2.38	0.30	0.00	0.00	0.00
Euphausiids	11.11	25.00	16.66	21.42	209.37	105.23	28.12	46.23
Gammarids	11.11	29.16	41.66	30.95	16.04	721.84	781.83	421.13
Hyperiids	0.00	0.00	8.33	2.38	0.00	0.00	914.98	147.00
Isopods	0.00	4.16	0.00	4.76	0.00	0.26	0.00	0.00
Fish	11.11	4.16	25.00	11.90	19.53	1.22	16.58	5.90
No. observed					9	24	13	46



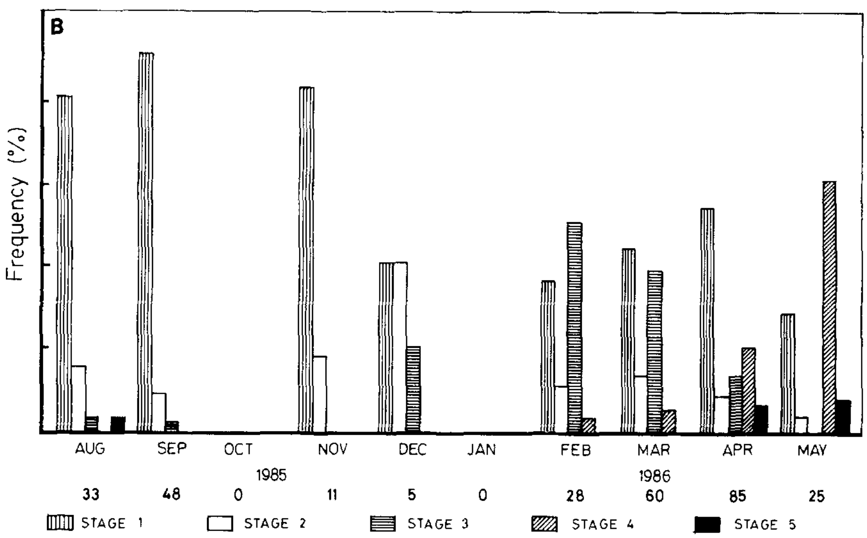


Fig. 5A, B. Monthly frequency distribution of the gonad maturation stages for *Notothenia neglecta* from August 1985 to May 1986. **A** Females; **B** Males. The number below each month indicates the number of fish examined

Cove. In coastal waters of Admiralty Bay, (near Potter Cove), Linkowski and Zukowski (1980) reported that *N. neglecta* from 4 to 12 years old, were caught, which agrees with our findings. Demersal juveniles develop in coastal areas and sexual maturity is first reached at 6–9 years. At Signy Island Everson (1970) found that precocious *N. neglecta* were mature at 4–5 years, although most did not become mature until they were 8–11 years old (about 30 cm SL). At Potter Cove the youngest mature male and female *N. neglecta* were 6 years old, at 320 mm and 345 mm, respectively. Similarly, Burchet et al. (1983) observed at South Georgia, that females were larger than males. The presence of all five stages in the gonad cycle suggests that spawning occurs in coastal waters of the island.

In *N. neglecta* at Potter Cove, the mature stage (IV) appeared in both sexes from February to May, therefore spawning probably occurs during these months. The spawning period of this species shows a wide variation (up to 6 months) with different localities and conditions (Everson 1970). However, the period established for Potter Cove coincides with that found at other localities by several authors: late March/April in Deception Island, South Shetland Is. (Nybelin 1951); May/June in Elephant Island, South Shetland Is. (Kock 1989); late May in Signy Island (Everson 1970); April/May in South Georgia I. (Burchett et al. 1983). During this period a high number of larger specimens predominated in the catches (Fig. 4), and again decreased in number after spawning. This appears to indicate that mature specimens migrate to the sampling area to spawn, as was also described by Burchett (1983c) for shallow waters off South Georgia Island. A different result was found by Kock (1989), who reported a maximum abundance of *N. neglecta*, outside the spawning season, in shallower waters off Elephant I. Furthermore, during the spawning season, small groups of prespawning/spent fishes were caught down to a depth of 450 m. This supports the view of Everson (1970) and Hureau (1970) who maintained that *N. neglecta* migrate to deeper waters to spawn.

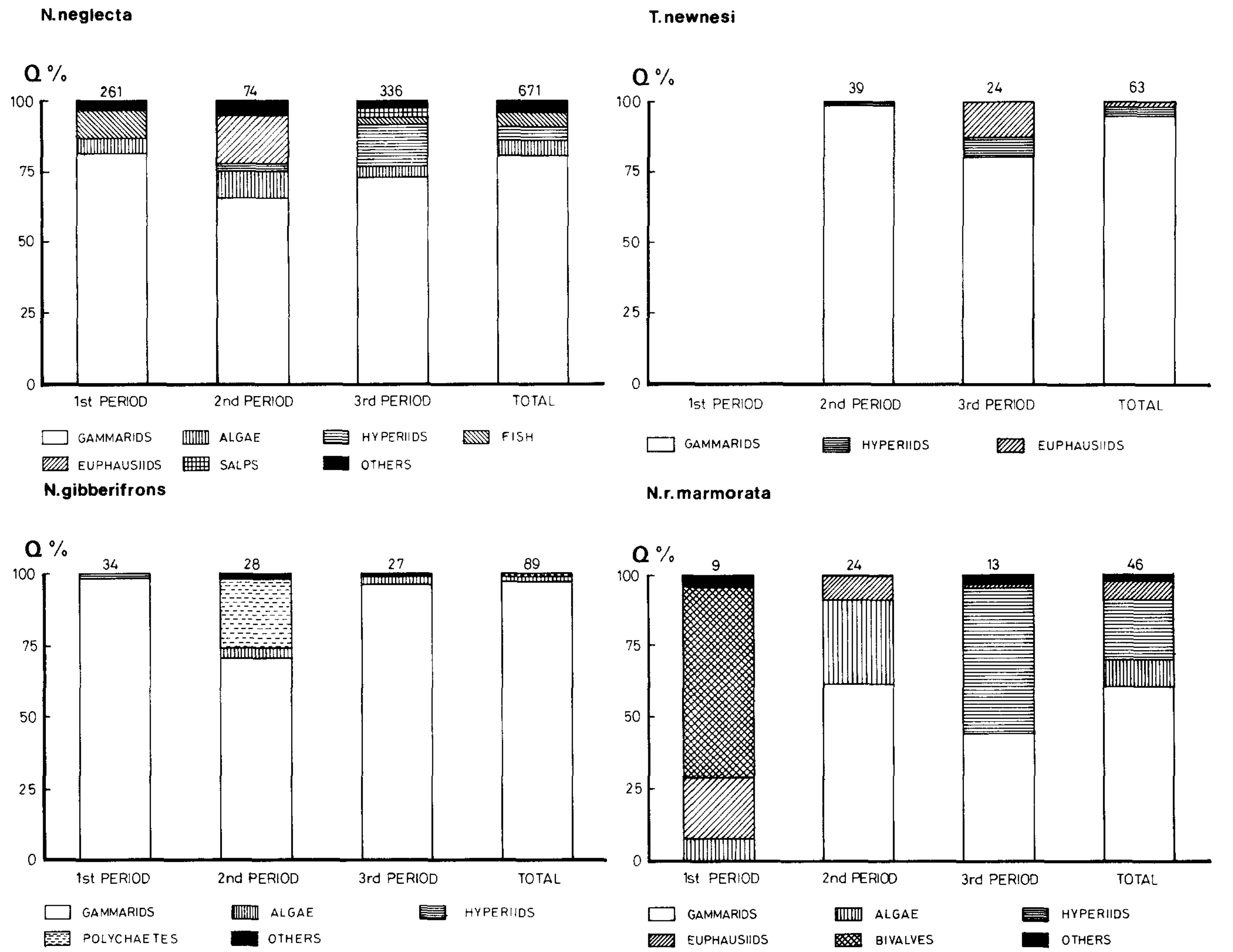


Fig. 6. Main and secondary food of the fish species studied expressed as Q%. Data are presented for total and each period of capture. The number above each histogram indicates the number of stomachs examined

Table 2. Relationship between the occurrence of algae and gammarid amphipods in the stomach contents of *Notothenia neglecta*

		Gammarid amphipods	
		Presence	Absence
Algae	Presence	241	234
	Absence	69	79
Annual period			

		Gammarid amphipods	
		Presence	Absence
Algae	Presence	84	112
	Absence	22	29
Dec. – Jan. – Feb.			

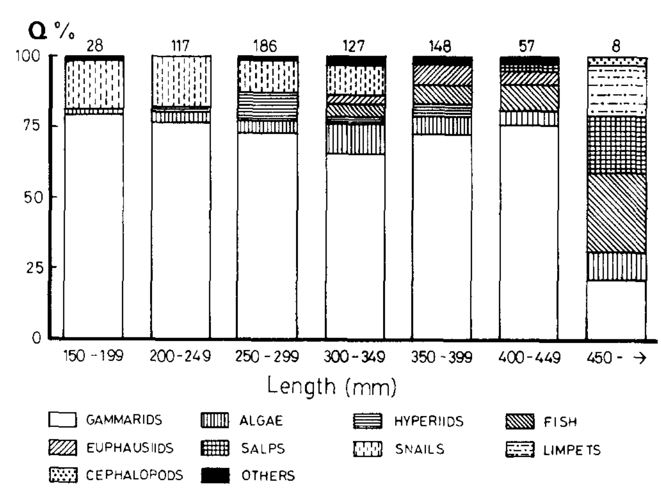


Fig. 7. Main and secondary food prey expressed as Q% in relation to the length of *Notothenia neglecta*. Data are presented for the total period of catches. The number above each histogram indicates the number of stomach examined

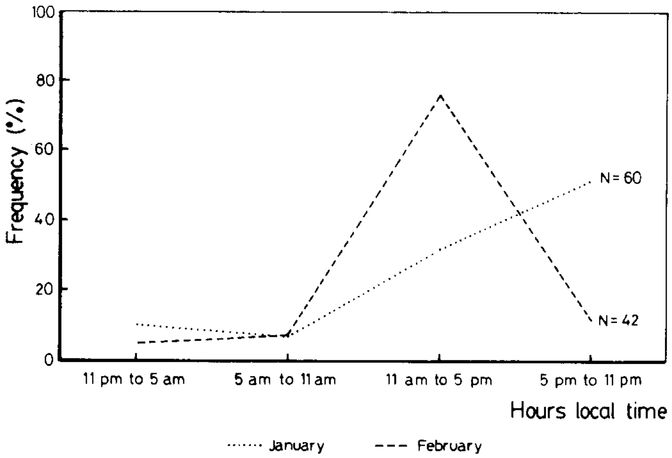


Fig. 8. Percentage of *Notothenia neglecta* specimens caught every 6 h in two 48-h samplings

The ranges of age and size indicate that mainly juvenile and a part of the adult population of *N. gibberifrons* coexist in the sampling area. Kock (1989) found August/September to be the spawning time for this species at Elephant I. According to Clasing et al. (1985), this species becomes sexually mature at 6–7 years near South Bay (Palmer Archipelago) as well as at South Georgia Is. Since South Bay and Elephant I. are close to King George, we assume that the same occurs in this area. Analyses of the gonads revealed that mature adult specimens (stage IV) were absent from Potter Cove indicating that they may be migrated to deeper water.

Only demersal juvenile individuals of *N. rossii marmorata* were caught. Linkowski and Zukowski (1980) found the same age range in the inshore waters of Admiralty Bay. According to Burchett (1983a) and Linkowski and Rembiszewski (1978), at South Georgia juvenile *N. rossii marmorata* become sexually mature at 5–6 years, at an approximate length of 41 cm. They leave the inshore waters and migrate offshore to join the adult population (Burchett 1982, 1983a). Additional data on length at first spawning for *N. rossii marmorata* from Elephant I, was given by Kock (1989): 45.2, males; 52.6, females.

Notothenia neglecta, *N. gibberifrons* and *N. rossii marmorata* show greater activity during the dark, presumably due to the greater night time activity of the prey (Richardson 1975; Moreno and Zamorano 1980; Burchett 1982, 1983c). Observation by divers confirm that fish hide during the day. However, during our 48-h sampling sequence, *N. neglecta* was caught mainly during the day time (Fig. 8). A possible explanation for this is that if the benthic prey show greater night activity, the fish will adopt an ambush behaviour during this period. On the contrary, the capture of preys during the day would require of them greater mobility. Diving observations could be unreliable to evaluate this type of behaviour, since the fish in the presence of the diver would seek refuge, which could be erroneously interpreted as a passive behaviour.

Stomach contents showed that nearshore demersal fish from Potter Cove feed mainly on gammarid amphipods. The diet of *N. neglecta* was more or less constant throughout the year (Table 1). There were no great differences, except for a more benthic diet during winter and early spring (period 1). In that period *N. neglecta* preyed on the bottom and vertical trophic migration was limited. Planktonic organisms were seldom consumed, while polychaetes and sediments were eaten more frequently (f% = 33 and 29 respectively). Vertical movements were evident during the rest of the year. In the second period pelagic organisms such as euphausiids and hyperiid amphipods were important items of the diet, as were hyperiid amphipods and salps in the third one. This was accompanied by a decrease in the ingestion of polychaetes. The diet varied according to the size of the predator. As the fish grow larger, their trophic spectrum increases because the prey they are able to capture is larger (Fig. 7). It is a non-selective feeder with a wide trophic spectrum.

Notothenia gibberifrons may be classified as benthophagous, which is indicated by the high frequency of occurrence of polychaetes and sediments in the stomach contents, and by the subterminal position of its mouth. Planktonic organisms were rarely consumed. Although gammarid amphipods were preyed intensively (Q% = 99), *N. gibberifrons* has a wide trophic spectrum.

The diet of *T. newnesi* did not change substantially throughout the year. It preyed principally amongst the algae and made vertical migrations to feed on plankton, mainly at the end of the summer and autumn (period 3). Of the four species analyzed, *T. newnesi* and *N. rossii marmorata* were more planktivorous. Planktivory is also indicated in *T. newnesi* by the supraterminal position of its mouth. In Potter Cove it is a specialized predator, with a limited trophic spectrum (5 taxa only).

The main food of *N. rossii marmorata* varied considerably throughout the year. Although the greater part of the diet was composed of benthic groups, we consider this species to be bentho- and plankto-phagous, due to the ingestion of hyperiid amphipods and euphausiids. In Potter Cove, as was observed by Moreno and Bahamonde (1975) in Chile Bay and Fildes Bay, the trophic spectrum of this species is narrower than that of *N. neglecta.*

Due to the importance of gammarid amphipods as prey of the four species analyzed, food competition would seem to be high. However, we suggest that the different species of gammarid amphipods in the area may well be the prey of different fish species. Thus, *N. neglecta* could feed primarily on amphipods living amongst the algae, whereas *N. gibberifrons* could ingest mainly epibenthic gammarids. Therefore prey overlap would be limited.

Moreno and Bahamonde 1975; Showers et al. 1977; Moreno and Zamorano 1980; Burchett 1982, 1983b, among others dealt with the presence of algae in the diet of nearshore Antarctic fish. At potter Cove, algae were often found in the diet of the fish. If the dietary coefficients (Q) are taken into account it is evident that the algae are secondary food, except in *T. newnesi.*

The method proposed by Hureau (1970) underestimates algae because when the percentage by number is calculated, all the algae present in each stomach are counted as one individual. It should be noted that several stomachs contained more than one species of algae and different pieces of algae consumed at different times will be counted only once. Taking this into account, the dietary coefficients for algae should be higher and the algae may become a main component of diet.

Are the algae taken accidentally or deliberately?, i.e. are the algae associated with the ingestion of other prey? Given the type of prey found, this association could only occur with the gammarid amphipods. The frequency of occurrence of algae in *N. neglecta*, *N. gibberifrons* and *N. rossii marmorata* is higher than that of these crustaceans. If the algae are eaten accidentally, the efficiency for capturing gammarid amphipods (which are the main food), would be very low. *Trematomus newnesi* consumed mainly gammarids and only occasionally algae. This species is a more effective predator of gammarid amphipods, perhaps because of the supraterminal position of its mouth or the algae were eaten intentionally. On the other hand, the two more benthophagous species, *N. neglecta* and *N. gibberifrons*, ingested algae more frequently. Consumption of algae is thus probably related to the feeding habit rather than to the ingestion of gammarid amphipods.

Application of the "G" statistic in a model I test of independence as described in Sokal and Rohlf (1981) to the monthly observations on the relationship between the ingestion of algae and gammarid amphipods for *N. neglecta*, showed little association (Table 2). This was more evident in summer and disagrees with findings of Moreno and Zamorano (1980) at South Bay. Algal consumption shows little variation during the year while that of gammarid amphipods fluctuates. We suggest that the association between them in the diet is because both are frequent prey of fish. Therefore, if algae are sought as food it is to be expected that the fish can digest them. Targett and Radtke (1984) analyzed the gastric and intestinal pH in *N. neglecta*. They concluded that gastric pH appears to be sufficient to lyse algal cell walls and that macroalgae can be assimilated by the fish. We suggest that the algae are actively selected and consumed deliberately by the fish, and that its diet should be considered to be omnivorous.

Diet may change with ontogeny. For example *N. neglecta*, of increasing size, shows a greater tendency to piscivory and preys less on gammarid amphipods. Demersal juvenile *N. rossii marmorata* prey mainly on benthic organisms, whereas adult specimens have a planktonic diet (Permitin 1970; Tarverdiyeva 1972; Linkowski and Rembiszewski 1978; Tarverdiyeva and Pinskaya 1980; Burchett 1983b). Richardson (1975) and Targett (1981) found variations in the diet with respect to the body length for *T. newnesi* from South Orkney Is.. For *Nototheniops larseni* from the Scotia Arc, Barrera-Oro and Tomo (1987) observed that growth in size is correlated with a decrease in the consumption of copepods and an increase in that of krill.

Seasonal variations in the diets were observed at Potter Cove. This has also been noted by other authors for other localities. Daniels (1982) concluded that *N. neglecta* from Arthur Harbor, Anvers Island, has a carnivorous diet in autum and winter, and an omnivorous one in spring and summer. These changes can be explained by the variable resource availability expressed through changes in the main food, enlargement of the trophic spectrum and or the use of another trophic level.

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