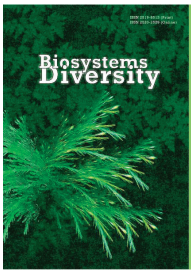

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Allocation of the diet of the Argentine Islands' inshore ichthyofauna

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Fish diets are important indicators of ecosystem change. This aspect of the ichthyofauna of the coast of the Argentine Islands has been insufficiently studied in comparison with other regions. This article presents the results of comparison of dietary and somatic parameters of the dominant species *Notothenia coriiceps* depending on the point, depth and season of catch. The sample was collected between February 2006 and February 2007. In the year of study, *N. coriiceps*, *Trematomus bernacchii*, *Chaenocephalus aceratus* (common species), Harpagifer antarcticus and *Pagothenia borchgrevinki* (rare species in this region) were caught. The average fish size in this region does not differ from other places in the Southern Ocean. In Cornice Channel and Stella Creek, *N. coriiceps* was smaller than at other points due to the narrowness and shallow depth of these places. In winter, large individuals apparently migrated from the coast. The diet of *N. coriiceps* consisted mainly of crustaceans and seaweeds, with a small number of mollusks (especially limpets), which are common. The number of fish in the diet of *N. coriiceps* is relatively low for this region. Access to food was relatively the same at different points and depths of the catch. The lowest amount of food was in the fall, the highest amount of food was in the spring and summer. The condition and hepatosomatic index also did not change depending on the point and depth of the catch, but they were low in spring and high in summer. Perhaps this is due to the low energy value of food, which is not compensated by the amount. It is necessary to conduct studies of the diet of *N. coriiceps* in other years to clarify the specificity of fish in the diet and phenological changes in somatic parameters. Similar studies are needed for other species in the region if catches are sufficient to collect a representative sample.

Keywords: South Ocean; Antarctic Peninsula; Antarctic fish fauna; *Notothenia coriiceps*; Notothenioidei.

Introduction

The dominant group of demersal fish in the Southern Ocean is the suborder Notothenioidei (order Perciformes) (Gon & Heemstra, 1990; Eastman, 2005). The coastal waters of the Argentine Islands (Wilhelm Archipelago, West Coast of Antarctic Peninsula) are no exception. Of the 35 species recorded in this region, 31 belong to this group. Of these, 18 species belong to the family Nototheniidae, 2 to the family Artedidraconidae, 4 to the family Harpagiferidae, 5 to the family Channichthyidae and 1 to the family Bovichthidae (Manilo, 2006). However, only 16 out of 35 species are more or less regularly found; all of them are in the suborder Notothenioidei (Manilo et al., 2009; Trokhymets et al., 2010).

Climate change is one of the most important reasons for studying the ecosystems of the Southern Ocean (Griffiths, 2010). This phenomenon can cause a variety of effects on the Antarctic ichthyofauna. So, over the past three decades, due to the melting of the Fourcade Glacier, there has been a clear change in the general physiognomy of Potter Cove. However, this did not seem to affect the diet of *Notothenia rossii* Richardson, 1844 and *N. coriiceps* Richardson, 1844 (Barrera-Oro et al., 2018). Due to their wide diet, these two fish species, like some other organisms, stabilize the ecosystem of the Potter Cove inshore (Marina et al., 2018), and this may be typical for all ecosystems in the region. The increase in the average body size of fish in populations over time, especially in juveniles, is also an indicator of climate change. Indeed, an increase in temperature critically increases the metabolic level of polar fish (Raga et al., 2015). On the other hand, commercial fishing directly leads to strong changes in fish fauna. There are already cases of prohibition of fishing of *N. rossii* and *Gobionotothen gibberifrons* (Lönnberg, 1905) in the South Shetland area, as these two species have begun to be supplanted by the non-commercial species *N. coriiceps* (Marschoff et al., 2012; Ferreira et al., 2017). Apparently, *N. coriiceps* has greatly expanded its ecological niche in the ecosystems of the Antarctic Peninsula coastline due to the impact of overfishing on other species (Barrera-Oro et al., 2017). In addition, commercial catches tie the main applied research to depths greater than 100 m, although it is very important to study the Seasonal Pack Ice Zone being the Antarctic's most productive ecological zone (Jurajda, 2016). Thus, *N. coriiceps* can be used both as an indicator of climate change and the level of harvesting impact. One of the most important aspects of the study of ichthyofauna is the study of the diet of fish. This allows one to assess the overall state of the ecosystem and predict its state in the future (Moreira et al., 2014; Barrera-Oro et al., 2018).

The study of the ichthyofauna of the coast of the Argentine Islands is limited to a general overview from 2002 to 2006 and 2008 without a detailed study of the diet (Manilo et al., 2009), and several publications on 2007 catches (Trokhymets et al., 2010; Trokhymets & Zinkovskyi, 2017). The closest area for which the fish fauna and its diet is well-studied is the Danco Coast, Antarctic Peninsula (Casaux et al., 2003; Casaux & Barrera-Oro, 2013). However, despite the proximity, the different ecological conditions of these places can cause a difference in the feeding habits of the fish. Also available research in the area indicates that the diet of the dominant species *N. coriiceps* may vary over the years (Trokhymets & Zinkovskyi, 2017; Zinkovskyi et al., 2019). We believe that this may indicate a strong change in the ecological conditions of the Argentine Islands. Therefore, our goal was to study the contents of the gastrointestinal tracts of fish caught between February 2006 and February 2007 and compare them with the available knowledge.

Material and methods

Fishes for this study were caught during 9th Ukrainian Antarctic Expedition from February 2006 to February 2007. This and other materials were collected in accordance with the tasks of State Research Program of Ukraine in Antarctica for 2002–2010 (Order of the Cabinet of Ministers of Ukraine on September 13, 2001 № 422-р).

Catching of samples was carried out by hook tools such as "bottom fishing tackle". Trawling was performed with a fishing rod in cases where the fish did not react to the bait for a long time. Catching was also carried out by grids, but only 13 individuals (1 *Ch. aceratus* and 12 *N. coriiceps*) were caught in this way. Nets (immovable and trawls) cannot be used due to the rocky bottom, floating ice and narrow straits with strong currents between the islands in this area. Pieces of fresh meat were used as bait.

All of fish were collected in the Argentine Islands area (Fig. 1). Cornice Channel (S 65°15′05″ W 64°15′14″), Meek Channel (S 65°14′38″ W 64°15′18″), Stella Creek Channel (corner of Emergency Bay, S 65°14′49″ W 64°15′17″) and Marina Point (S 65°14′42″ W 64°15′25″) were the main catch points. There were also small numbers of catches near the Barchans Islands (S 65°14′33″ W 64°17′15″).

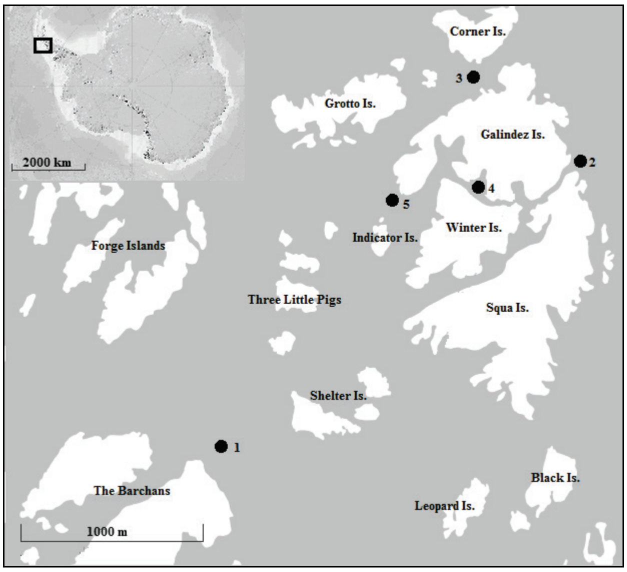

Fig. 1. The map of catch points: *1* – Barchans Islands, *2* – Cornice Channel, *3* – Meek Channel, *4* – Stella Creek Channel, *5* – Marina Point

The collective monograph "Fishes of the Southern Ocean" (Gon & Heemstra, 1990), the species identification sheet of the FAO "Southern Ocean (fishing areas 48, 58, 88) (CCAMLR Convention Area)" (Fischer & Hureau, 1985) and guide for fishermen "Bottom and subbottom fish of Antarctica and adjacent waters" (Solyanik, 1975) were used to determine the species of fish.

Comparisons were made mainly among *N. coriiceps*, as only individuals of this species were sufficient for statistical analysis. Individuals were compared by point, depth and season. Seasons were named according to the Southern Hemisphere so as to match seasonal weather conditions. So, summer includes December, January and February etc.

The statistical analysis of the following indicators was carried out: hepatosomatic index (liver to body weight ratio), Fulton's (KF) and Clark's (KC) body condition factor, index of food (gastrointestinal tract contents to body weight ratio), total (TL) and standard (SL) body lengths, total body weight and body weight without entrails (Aleksienko & Podobailo, 1998; Raga et al., 2015; Plotnikov et al., 2018). Total and standard lengths were measured with an accuracy of 0.1 cm; body, organs and food weights were measured with an accuracy of 1 g.

Fisher's Exact Test (F-test) for Count Data (Fisher, 1935) was used to compare the frequency of occurrence of diet components. F-test was also used to compare 3 or more manifestations of the factor. To reduce the possible effect of random distribution, Monte Carlo simulated of P-values with the number of repetitions of simulation cycles 10,000 was used (Mundform, 2012). F-test reporting is P-value. The Shapiro-Wilk Normality Test (Shapiro & Wilk, 1965) showed that most indicators were not distributed according to the normal distribution, so non-parametric tests were used. To compare the dimensional and weight characteristics, the Kruskal-Wallis Rank Sum Test (H-test, or KW) (Kruskal & Wallis, 1952) with the notation form (the value of χ^2 H (the value of degrees of freedom), the P-value of the test) was used. In the case of statistically significant influence of the factor according to the result of Kruskal-Wallis, for pairwise analysis the Pairwise Test for Multiple Comparisons of Mean Rank Sums (Dunn's Test) was used with the Benjamini & Hochberg correction (Dunn, 1964; Benjamini & Hochberg, 1995; Dinno, 2015). Dunn's-Test reporting is shown as P-values. R 3.6.2 language and environment for statistical computing with RStudio 1.2.5033 interface (R Core Team, Austria, 2019) included packages "PMCMR" version 4.3 (Thorsten Pohlert, 2014) and "readxl" version 1.3.1 (Hadley Wickham and Jennifer Bryan, 2019) were used for statistical analysis.

Results

Frequency of occurrence. During the expedition the following species of fish were caught: *Notothenia coriiceps* Richardson, 1844 – 86.1% (149 individuals), *Trematomus bernacchii* Boulenger, 1902 – 6.4% (11 individuals), *Chaenocephalus aceratus* (Lönnberg, 1906) – 6.4% (11 individuals), *Harpagifer antarcticus* Nybelin, 1947 – 0.6% (1 individual), *Pagothenia borchgrevinki* (Boulenger, 1902) – 0.6% (1 individual).

N. coriiceps was the most numerous species and it occupied 86.1% in individuals or 81.8% by weight of the total fish catch. Insufficient numbers of the other species were caught to speak about their presence as being statistically significant. The F-test showed strong (P < 0.0100) difference between each point of catch except Cornice Channel and Stella Creek Channel (P = 0.4322), Meek Channel and Marina Point (P = 0.4846), and Stella Creek Channel and Marina Point (P = 0.0734). *T. bernacchii* was relatively often met in Cornice Channel and Stella-Creek catches (Table 1). The Meek Channel and Marina Point catches showed similarity in the large number of *N. coriiceps*. Also, there was a big difference between depths of catches. The difference was not only between < 10 m and 11–20 m catches (P = 0.1539); these catch groups have the same ratio of *N. coriiceps* and *T. bernacchii* (Table 1). Catches in winter were strongly different from those of summer (P < 0.0001), weakly different from those of spring (P = 0.0194) and almost different from autumn catches (P = 0.0687). There is not any statistically significant difference between other seasons. 8 of 11 *T. bernacchii* individuals were caught in winter, which is a reason for such results (Table 1).

Size. The only *P. borchgrevinki* caught had total length 24.6 cm (standard length 21.0 cm) and total body weight 158 g (body weight without entrails 145 g), and *H. antarcticus* had total length 8.8 cm (standard length 7.4 cm) and total body weight 9 g (body weight without entrails was not measured). Size characteristics of *Ch. aceratus*, *N. coriiceps* and *T. bernacchii* are shown in Table 2.

Lengths of *N. coriiceps* were strongly different depending on the point (TL H(4) = 31.567, P < 0.0001; SL H(4) = 32.22, P < 0.0001), depth (TL H(3) = 16.652, P = 0.0008; SL H(3) = 16.151, P = 0.0011) and season (TL H(3) = 24.745, P < 0.0001; SL H(3) = 25.948, P < 0.0001) of catching. Pairwise comparison shows strong difference between Cornice Channel and 3 points: Barchans Islands (P = 0.0011), Meek Channel (P < 0.0001) and Marina Point (P = 0.0023). Fish from Cornice Channel had the smallest length (Table 3). Fish from Stella Creek Channel also were quite small, so there was weak difference with the Barchans Islands (P = 0.0108) and strong difference with Meek Channel (P = 0.0073). Average length increased with depth: the smallest individuals were caught on < 10 m, the biggest – on > 31 m. Accordingly, differences were between < 10 m and 21–30 m (P = 0.0021), and < 10 m and > 31 m (P = 0.0314). Fish caught in winter had the smallest length compared with the other three seasons (Table 3). Pairwise comparison showed strong differences with spring (P = 0.0001), summer (P < 0.0001) and autumn (P < 0.0011). Wherein there are not significant differences between other seasons.

In this description P-values are given for total length, but standard length has completely the same distribution characteristic. The exception is the absence of difference between < 10 m and > 31 m (P = 0.0514). Weights of *N. coriiceps* had exactly the same differences as the SL (Table 3).

Diet and somatic indexes. Remains of subphylum Crustacea (orders Euphausiacea, Amphipoda and Isopoda of class Malacostraca), superclass Pisces, phylum Mollusca (class Gastropoda, especially Limpet, and class Bivalvia) and phylum Polychaeta representatives were found in the fishes' gastrointestinal tracts. The order Euphausiacea was represented predominantly by *Eupausia superba*. Among the order Amphipoda representatives remains of *Paraceradocus gibber* were defined authentically. The study of zoobenthos shows that *Patinigera polaris* was the most frequent Limpet species in the research area. Materials collected in 2008 showed that contents of *N. coriiceps* gastrointestinal tract consisted of classes Phaeophyceae (*Desmarestia* spp.) and Florideophyceae (*Mazzaella* spp., *Leptosomia* spp. and *Kallymenia* spp.) in this region.

Table 1
Number of fish in catches during February, 2006 – February, 2007 depending of point, depth and season of catching

Factor	Group	Species				
		N. coriiceps	*Ch. aceratus*	*T. bernacchii*	*P. borchgrevinki*	*H. antarcticus*
Point	Barchans Islands	3	4	–	–	–
	Cornice Channel	12	–	5	–	–
	Meek Channel	91	7	3	1	–
	Stella Creek Channel	17	–	3	–	–
	Marina Point	26	–	–	–	1
Depth	< 10 m	35	–	3	–	1
	11–20 m	22	–	6	–	–
	21–30 m	82	7	1	–	–
	> 31 m	5	4	–	1	–
Season	Winter	37	–	8	–	–
	Spring	27	4	2	1	1
	Summer	57	6	–	–	–
	Autumn	26	1	1	–	–

Table 2
Mean annual values of the main biological characteristics of fish caught during February, 2006 – February, 2007 (x ± SE)

Species	Total body length, cm	Standard body length, cm	Total body weight, g	Body weight without entrails, g	Index of food	Clark's condition factor	Fulton's condition factor	Index of liver
N. coriiceps	30.5 ± 0.4	26.9 ± 0.4	417 ± 18	354 ± 14	1.92 ± 0.05	1.68 ± 0.01	1.95 ± 0.02	1.92 ± 0.05
Ch. aceratus	53.5 ± 1.3	48.6 ± 1.2	1148 ± 79	816 ± 55	0.48 ± 0.36	0.70 ± 0.02	0.94 ± 0.03	6.22 ± 0.61
T. bernacchii	20.6 ± 1.5	18.4 ± 1.4	176 ± 33	142 ± 29	0.80 ± 0.41	1.55 ± 0.05	1.89 ± 0.07	3.55 ± 0.29

Table 3
Mean annual values of the main biological characteristics of *N. coriiceps* caught during February, 2006 – February, 2007 depending of point, depth and season of catching (x ± SE)

Factor	Group	Total body length, cm	Standard body length, cm	Total body weight, g	Body weight without entrails, g	Index of food	Clark's condition factor	Fulton's condition factor	Index of liver
Point	Barchans Islands	36.2 ± 2.0^{a}	32.2 ± 1.9^{a}	647 ± 151^{a}	547 ± 119^{a}	1.44 ± 0.26^{a}	1.58 ± 0.08^{a}	1.86 ± 0.12^{a}	1.94 ± 0.35^{ab}
	Cornice Channel	24.9 ± 0.7^{b}	21.7 ± 0.6^{b}	204 ± 18^{b}	174 ± 16^{b}	1.20 ± 0.27^{a}	1.65 ± 0.04^{a}	1.94 ± 0.05^{a}	2.34 ± 0.16^{a}
	Meek Channel	31.6 ± 0.5^{a}	27.9 ± 0.4^{a}	460 ± 23^{a}	394 ± 18^{a}	1.99 ± 0.17^{a}	1.71 ± 0.02^{a}	1.98 ± 0.02^{a}	1.97 ± 0.06^{ab}
	Stella Creek Channel	28.0 ± 1.0^{ab}	24.8 ± 0.9^{ab}	306 ± 39^{ab}	264 ± 34^{ab}	1.76 ± 0.26^{a}	1.61 ± 0.04^{a}	1.87 ± 0.04^{a}	1.83 ± 0.12^{ab}
	Marina Point	30.1 ± 0.9^{a}	26.6 ± 0.8^{a}	408 ± 41^{a}	333 ± 29^{a}	1.36 ± 0.39^{a}	1.66 ± 0.03^{a}	1.86 ± 0.05^{a}	1.69 ± 0.11^{b}
Depth	< 10 m	27.8 ± 0.7^{a}	24.5 ± 0.7^{a}	296 ± 26^{a}	254 ± 20^{a}	1.79 ± 0.23^{a}	1.62 ± 0.03^{a}	1.84 ± 0.03^{a}	1.93 ± 0.12^{a}
	11–20 m	29.3 ± 1.1^{ab}	25.8 ± 0.9^{ab}	368 ± 44^{ab}	317 ± 37^{ab}	1.18 ± 0.29^{a}	1.68 ± 0.04^{ab}	1.94 ± 0.04^{ab}	1.85 ± 0.09^{a}
	21–30 m	31.5 ± 0.5^{b}	27.8 ± 0.5^{b}	458 ± 24^{b}	392 ± 20^{b}	1.83 ± 0.17^{a}	1.71 ± 0.02^{b}	1.98 ± 0.02^{b}	1.99 ± 0.06^{a}
	> 31 m	33.7 ± 2.0^{ab}	29.7 ± 1.9^{ab}	529 ± 114^{ab}	449 ± 93^{ab}	2.01 ± 0.40^{a}	1.62 ± 0.03^{ab}	1.89 ± 0.08^{ab}	1.95 ± 0.23^{a}
Season	Spring	31.8 ± 0.7^{a}	28.1 ± 0.7^{a}	440 ± 34^{a}	381 ± 29^{a}	2.38 ± 0.33^{a}	1.63 ± 0.04^{a}	1.88 ± 0.04^{ab}	1.65 ± 0.08^{a}
	Summer	31.5 ± 0.6^{a}	27.8 ± 0.5^{a}	488 ± 31^{a}	395 ± 24^{a}	2.64 ± 0.18^{a}	1.73 ± 0.02^{b}	2.04 ± 0.03^{c}	2.02 ± 0.09^{b}
	Autumn	31.3 ± 1.0^{a}	28.0 ± 0.9^{a}	424 ± 39^{a}	376 ± 33^{a}	0.24 ± 0.08^{b}	1.61 ± 0.02^{a}	1.81 ± 0.03^{a}	1.91 ± 0.10^{ab}
	Winter	27.1 ± 0.8^{b}	23.9 ± 0.7^{b}	292 ± 29^{b}	253 ± 24^{b}	1.28 ± 0.19^{c}	1.70 ± 0.03^{ab}	1.96 ± 0.03^{bc}	2.06 ± 0.09^{b}

Note: the same letters of one column values within boundaries of a factor indicate statistically insignificant differences in the compared pair according to Dunn's test.

Ch. aceratus gastrointestinal tracts contained crustaceans in 2 cases (one was representative of the order Euphausiacea) and fish in 3 cases. 7 fish had empty gastrointestinal tracts. Only remains of crustaceans were found in *T. bernacchii* gastrointestinal tracts in 4 cases (representatives of orders Euphausiacea in 1 fish and Isopoda in 2 fish); 6 fish had empty gastrointestinal tract. The only caught individual of *H. antarcticus* had an empty gastrointestinal tract. Remains of Amphipoda representatives were found in the only *P. borchgrevinki*.

Gastrointestinal tracts of *N. coriiceps* were filled with representatives of: order Euphausiacea – 27.6% (34 cases), order Amphipoda – 37.4% (46 cases), order Isopoda – 17.9% (22 cases), subphylum Crustacea total – 77.2% (95 cases), superclass Pisces – 13.0% (16 cases), Limpet – 21.1% (26 cases), class Gastropoda total – 34.2% (42 cases), class Bivalvia – 0.8% (1 case), phylum Mollusca total – 35.0% (43 cases), phylum Polichaeta – 5.7% (7 cases) and Algae – 61.0% (75 cases). 26 individuals of *N. coriiceps* had empty gastrointestinal tracts. Further, the representation of the food component was calculated by the number of individuals with a full gastrointestinal tract (123 fish). Details about the diet components are shown in Table 4. Three fish caught near the Barchan Islands had remains of crustaceans in their gastrointestinal tracts (representatives of Amphipoda in 1 case, and Euphausiacea and Isopoda in 2 cases). Also, there were found remains of a Limpet representative (1 case) and seaweeds (1 case). Crustaceans were the most numerous diet components among all of points (except Meek Channel, where seaweeds were more prevalent) and there isn't any difference between these groups (Table 4). Also, no difference was for representation of the order Isopoda : they were not numerous food items, indeed no fish from Cornice Channel had Isopoda in their gastrointestinal tract. Representatives of the order Euphausiacea were found more often in the Meek Channel catch than at other points, especially the Stella Creek Channel (P = 0.0307). The biggest difference among subphylum Crustacea representatives was in the order Amphipoda: in the Cornice Channel catch group representatives of the order Amphipoda were found in most individuals. This is much more than at other points, especially Meek Channel (P = 0.0024) and Marina Point (P = 0.0080). However, there are not differences in Amphipoda representation between depths of catching, just as with crustaceans. The number of fish with remains of representatives of the order Euphausiacea increased with depth, but the only statistically significant difference is between < 10 m and 21–30 m (P = 0.0023). Representatives of the order Isopoda were more unevenly distributed among depths. There are differences between < 10 m and 11–

20 m (P = 0.0446), < 10 m and > 31 m (P = 0.0015), and 21–30 m and > 31 m (P = 0.0026). In autumn remains of crustaceans were found less often than in other seasons, but there is not a statistically significant difference. Representatives of the order Isopoda were not found in autumn, but the difference was only between spring and summer (P = 0.0322). Representatives of the order Euphausiacea were more often found in summer, there are differences with winter (P = 0.0002) and spring (P = 0.0257). In their turn, representatives of the order Amphipoda were found more often in winter, and differences are with summer (P = 0.0003) and spring (P = 0.0006).

Table 4
Diet components occurrence of *N. coriiceps* caught during February, 2006 – February, 2007
(numbers in the table shows amounts in % of fish in whose gastrointestinal tracts the remains were found depending of point, depth and season of catching)

Diet component	Point				Depth				Season			
	Cornice Channel	Meek Channel	Stella Creek Channel	Marina Point	< 10 m	11–20 m	21–30 m	> 31 m	winter	spring	summer	autumn
Crustacea	90.9	73.6	80.0	81.0	79.3	89.5	70.3	100.0	85.3	85.2	73.1	55.6
Euphausiacea	9.1	36.1	6.7	19.1	6.9	21.1	37.5	40.0	8.8	18.5	46.2	22.2
Amphipoda	81.8	31.9	46.7	28.6	41.4	57.9	32.8	20.0	67.7	22.2	26.9	33.3
Isopoda	0.0	18.1	20.0	19.1	6.9	31.6	12.5	80.0	20.6	33.3	11.5	0.0
Pisces	0.0	18.1	0.0	14.3	6.9	5.3	15.6	20.0	2.9	18.5	19.2	0.0
Molusca	36.4	34.7	33.3	38.1	44.8	21.1	37.5	20.0	32.4	40.7	32.7	44.4
Gastropoda	36.4	34.7	26.7	38.1	41.4	21.1	37.5	20.0	32.4	37.0	32.7	44.4
Limpet	18.2	25.0	6.7	19.1	24.1	0.0	26.6	20.0	14.7	25.9	23.1	22.2
Polichaeta	9.1	5.6	6.7	4.8	6.9	5.3	3.1	0.0	8.8	14.8	0.0	0.0
Algae	27.3	77.8	26.7	52.4	34.5	47.4	76.6	60.0	44.1	48.2	75.0	88.9

Remains of fish were found equally rarely among all the points, depth and seasons; in Cornice Channel and Meek Channel, and also in autumn there were no fish in the gastrointestinal tracts. There was a very weak difference (P = 0.0439) between winter and summer catches, and that appears to be more like a random feature than a regularity (Table 4).

Representatives of the phylum Mollusca included class Gastropoda (especially Limpet) found everywhere with the same frequency. There was a weak difference in Limpet frequency between < 10 m and 11–20 m (P = 0.0326) only. However, this type of food was encountered more often than fish (Table 4).

Representatives of the phylum Polychaeta were found less often than fish and other types of food and there is no statistically significant difference among groups, except spring and summer (P = 0.0117).

Remains of seaweeds were especially often found in the gastrointestinal tracts of fish from Meek Channel (Table 4). This greatly exceeds their frequency in fish caught in the Cornice Channel (P = 0.0016), Stella Creek Channel (P = 0.0003), and Marina Point (P = 0.0294). There is no difference between the other three points. Among depths Algae representatives were found more often at 21–30 m, and there are differences between < 10 m (P = 0.0002) and with 11–20 m (P = 0.0224). Fish gastrointestinal tracts from summer and autumn contained more remains of seaweeds than contents of tracts of fish caught in spring and winter. There are statistically significant differences between winter and summer (P = 0.0059), winter and autumn (P = 0.0224), and spring and summer (P = 0.0244).

Mass index of food is slightly different from scoring system (Table 3). There is no statistically significant difference among point (H(4) = 4.7131, P = 0.3180) and depth (H(3) = 5.0638, P = 0.1672) of catching. However, the high value of food in summer and spring are very different from winter and, especially, autumn. So, there is not a strong difference between spring and summer (P = 0.2578) only.

Despite the high level of difference in size characteristics (length and weight), their ratio as Clark's and Fulton's conditions factors is distributed more evenly (Table 3). Clark's factor does not show difference among points of catch (H(4) = 6.4207, P = 0.1699). There is a weak statistical significant test result in Fulton's factor (H(4) = 9.5015, P = 0.0497), but pairwise comparison give no confirmation of this. There were differences among depths (KC H(3) = 8.0343, P = 0.0453 and KF H(3) = 10.306, P = 0.0161), but this is connected with difference between < 10 m (the lowest value) and 21–30 m (the highest value) catch groups (KC P = 0.0350 and KF P = 0.0086) only. Seasonal changes of condition were more pronounced (KC H(3) = 13.932, P = 0.0030 and KF H(3) = 24.157, P < 0.0001). In summer the condition factor had the highest value, so there are differences with spring (KC P = 0.0110 and KF P = 0.0028), and with autumn (KC P = 0.0110 and KF P < 0.0001). Also, there is difference of Fulton's factor between autumn and winter (P = 0.0093).

There is difference in hepatosomatic index among poinst of catch (H(4) = 12.197, P = 0.0159) only between Cornice Channel (the highest value, Table 3) and Marina Point (P = 0.0084). There was no difference among the depths of the catch (H(3) = 1.3720, P = 0.7121). The lowest value of hepatosomatic index was in autumn and spring (H(3) = 10.924, P = 0.0121). However, there are differences between spring and summer (P = 0.0099), and spring and winter (P = 0.0099) only (Table 3).

Discussion

Frequency of occurrence. N. coriiceps is a common coastal species throughout the Southern Ocean, including the Antarctic Peninsula (Casaux & Barrera-Oro, 2013; Raga et al., 2015). This species always takes up the majority of the catches (Manilo et al., 2009; Trokhymets et al., 2010). The Argentine Islands are within the range of *Ch. aceratus* (Reid et al., 2007), so the catch of this species was not an accident. 3 years before this study, *Ch. aceratus* was about 2%, and in 2007–2008 – 4% of the catch (quantity) in the study area. In the year of study the relative amount of the catch of this species was about the same – 6% (Manilo et al., 2009; Trokhymets et al., 2010). This frequency of occurrence is normal for this species. In the Danco Coast area the relative catch of this species was less than 1% in 2000 (Casaux et al., 2003).

The relative amount of catch of *T. bernacchii* 6% in 2006–2007 was very small compared to the previous three years of research in this area (Manilo et al., 2009). However, in 2007–2008, its proportion was already about 2% (Trokhymets et al., 2010). There was a similar catch from the Danco Coast (Casaux et al., 2003; Casaux & Barrera-Oro, 2013). Overall, *T. bernacchii* is circumpolar and is found almost everywhere in the Southern Ocean (Moreno, 1980).

H. antarcticus had already been seen in catches in the area and also in very small numbers (Manilo et al., 2009; Trokhymets et al., 2010). But between 2002 and 2008 *P. borchgrevinki* was caught only in the year of study (Manilo et al., 2009; Trokhymets et al., 2010). *H. antarcticus* and *P. borchgrevinki* did not occur off the Danco Coast even in single cases (Casaux et al., 2003; Casaux & Barrera-Oro, 2013). Sufficient numbers of adults and larvae of *H. antarcticus* have been found in the South Shetland Islands for it to be considered a common species in the West Antarctic (Piacentino et al., 2018). The catch of *P. borchgrevinki* in the Antarctic Peninsula is rarely mentioned. However, this species is part of the diet of seals (Casaux et al., 2011) and shags (Casaux et al., 2002).

Size. The caught individuals of the *Ch. aceratus*, *T. bernacchii*, *H. antarcticus* and *P. borchgrevinki* were typical in size relative to this area and their range in general (Casaux et al., 2002; La Mesa et al., 2004; Reid et al., 2007; Riginella et al., 2016; Piacentino et al., 2018).

N. coriiceps at the Cornice Channel and Stella Creek Channel were significantly smaller than the rest of the total catch. These places are located in the narrowest and shallowest places among other points in this research. It appears that *N. coriiceps* either leaves these areas as it grows or does not reach the same size as elsewhere. The average size increased with depth, but the general trend has little confirmation. The fact that smaller individuals were caught in winter can be explained by the possible migration of large individuals during this period. Studies in Admiralty Bay, Antarctic Peninsula (Raga et al., 2015) indicate that larger individuals of this species are more common in warm water. The water temperature directly depends on the season, so the migration of large individuals to a warm place in winter is an acceptable explanation. However, this phenomenon requires additional research.

Diet and somatic indexes. The numbers of caught and analyzed *Ch. aceratus*, *Tr. bernacchii*, *H. antarcticus*, and *P. borchgrevinki* were too few for dietary analysis and conclusions to be drawn. Gastrointestinal tracts of these species were generally poorly filled, especially *Ch. aceratus*. Diet remains found are not unique to these species and are common (Casaux et al., 2003; La Mesa et al., 2004; Reid et al., 2007).

Overall, the most important parts of the *N. coriiceps* diet were representatives of the phyla Crustacea and Algae for this region in 2006–2007. This is common for this species both in this area (Manilo et al., 2009; Trokhymets & Zinkovskyi, 2017; Zinkovskyi et al., 2019) and in the West Antarctic in general (Casaux et al., 2003; Barrera-Oro et al., 2018). Also common is a low but stable amount of representatives of the phylum Mollusca (especially Limpet) and a very small number of representatives of the phylum Polychaeta. But such a low quantity of the representatives of the superclass Pisces in the diet is unusual – it is low even in comparison with 2008, when fish were found in about 30% of *N. coriiceps* (Zinkovskyi et al., 2019). And this is much lower in comparison with 2007, when there were more fish than crustaceans (Trokhymets & Zinkovskyi, 2017). In 2000, about 15% of *N. coriiceps* analyzed caught from the Danco Coast contained fish (Casaux et al., 2003). However, recalculation of the relative mass of the component indicates the predominance of fish over crustaceans and its formation as the main component of the diet at the level with seaweeds (Casaux & Barrera-Oro, 2013). So far, we have no hypotheses to explain such a wavelike change in the amount of fish as a component of the diet of *N. coriiceps*.

The differences in diet in relation to the place of capture was not large. The main difference was the high number of the order Amphipoda representatives at Cornice Channel and Algae representatives at Meek Channel. Most likely, this is simply a reflection of the presence of these organisms at these points. Cornice Channel is the most closed and calm water of the points represented, which clearly favours the reproduction of Amphipoda representatives there. Meek Channel has the strongest current that would interfere with hunting for common prey in the water column. Only among the seaweeds can *N. coriiceps* find the necessary prey, therefore it swallows a large amount of algae.

The diet was more uneven in terms of depth. Representatives of the order Isopoda at depths < 10 and 21–30 m were much less common than at depths of 11–20 and > 31 m. At the moment, this fact is difficult to explain. Algae representatives were more common at a depth of 21–30 and quite often at a depth of > 31 m. This can be explained by the fact that algae grow at these depths.

The diet was distributed relatively unevenly over the seasons. There were more representatives of the order Isopoda in spring, but fewer Euphausiacea and algae representatives compared to summer. There were also fewer Amphipoda representatives in spring than in winter. There were fewer order Euphausiacea representatives in winter and fewer order Amphipoda representatives in summer.

The condition of *N. coriiceps* did not depend on the place of catch, although weight and length were dependent, as indicated above. Condition was the same among different fishing depths. However, as with size, there was only a significant difference between > 10 m and 21–30 m. The high weight-to-length ratio in summer is due to the availability of food and the ability to eat better than in autumn. The low level of this indicator in the spring can be explained by the peculiarities of the diet, which will be discussed below. The fact that the condition in this region varied seasonally differs from the results of the study at Admiralty Bay (Raga et al., 2015). This confirms the seasonal heterogeneity of the diet and possibly other factors currently unknown in this region.

The hepatosomatic index was the same for all fish, regardless of point (except for the difference between the highest value in Cornice Channel and the smallest in Marina Point) and the depth of catch.. The relative weight of the liver is undoubtedly directly proportional to the availability of food. Such a low indicator of the hepatosomatic index (like the condition) in the spring, provided there is a high level of food availability, is possible because the food this season was not so high in calories. Thus, in comparison with summer, far fewer Euphausiacea and algae representatives were encountered in spring, and fewer Amphipoda representatives than in winter. The relatively high number of representatives of the order Isopoda did not seem to compensate for the lack of other components. In the summer, the amount of food was sufficient, so the hepatosomatic index was high. Despite the small amount of food in the autumn, the relative weight of the liver can be high due to fattening in the summer. In winter, the average level of food availability was the same as in summer, therefore the hepatosomatic index was high. The average hepatosomatic index in the year of study was similar to 2007 (Trokhymets & Zinkovskyi, 2017) and slightly lower than in 2008 (Zinkovskyi et al., 2019). The distribution of this indicator is similar to the distribution in Admiralty Bay (Raga et al., 2015).

Conclusions

Mostly the diet and changes in somatic indices in *N. coriiceps* are characteristic both for this region and for the Antarctic Peninsula as a whole. This also applies to the species composition of the catch of the studied year. This indicates that despite the geographical differences of the Argentine Islands, the ichthyofauna as part of the local ecosystem does not differ from other ecosystems on the West Coast of the Antarctic Peninsula. An exception is the number of fish in the diet, which varies greatly from year to year in this region. This was not the case in other regions. Also, there are seasonal changes of the condition that are not similar to other areas researched. These facts need to be studied by doing more research in other years.

Unfortunately, the numbers of the other 4 species caught were too small for a representative sample to be collected and, therefore, to perform similar research. Obtained data on the size and diet of *Ch. aceratus* and *T. bernacchii* do not differ from other regions. Accordingly, in the subsequent studies, one should try to recruit the required number of representatives of these species to conduct a similar study.

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