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Juvenile *Trematomus bernacchii* and *Pagothenia brachysoma* (Pisces, *Nototheniidae*) within krill concentrations off Balleny Islands (Antarctic)*

ABSTRACT: Juvenile fishes of the family *Nototheniidae* were recorded during fishing for krill eastwards of the Balleny Islands. The paper describes juveniles of the most abundant species. *Trematomus bernacchii* and *Pagothenia brachysoma*, their distribution and abundance. Also the correctness of assigning of some juveniles to the species *T. bernacchii* is discussed.

Key words: Antarctic, juvenile nototheniid fish

1. Introduction

Following DeWitt (1970) the dominant group of demersal *Nototheniidae* of the Ross Sea are fishes belonging to the genus *Trematomus*. Among them *T. bernacchii* is considered as one of the most frequent and widely distributed species (Andrjašev 1964). *Pagothenia brachysoma* belongs to the cryopelagic fauna of that region (Andrjašev 1968, 1970 — cited as *Trematomus brachysoma*). The literature dealing with juvenile *Nototheniidae* of the Ross Sea is rather scarce. Some reference to the juveniles of species mentioned above is given by Miller (1961), Andrjašev (1967, 1970), DeWitt (1970), Andrjašev and Jakubowski (1971) and Baluškin (1976a). Apart from the Ross Sea, only nine species, out of 51 *Nototheniids* living in the Antarctic, have been described in the developmental stages (Regan 1916, Everson 1968, Hureau 1970, Efremenko 1979).

Investigations of juvenile ichthyofauna within the krill concentrations off the Balleny Islands were carried out in 1978, during the circumantarctic expedition of the r/v "Profesor Bogucki". One of the objectives of the study

*) This work was performed as part of the problem MR-II-16

was to draw attention to the necessity of protecting juvenile fish under the conditions of a rapidly developing krill fishery.

2. Material and method

The material for the paper was collected between January 24 and February 2, 1978. Fish for investigations were taken during exploratory fishing for krill. It was carried out with a commercial pelagic trawl 63/57 × 4, with a head-rope of 63 m and with a fine-meshed inset (mesh size 12 mm) in the terminal part of the belly and in the codend. The vessel's speed ranged from 2.8 to 3.3 knots. Depending on the speed of trawling, the vertical opening of the trawl mouth (at a place where the fine-meshed inset began) ranged from 8.7 to 9.2 m while the horizontal opening ranged from 9.8 to 10.4 m.

The collected fish were preserved in 4% buffered formalin or frozen. Enzymatically cleared (transparent) individuals, stained with alizarine (by the Taylor (1967) method) were used for species identification. The investigation of cephalic canals, serving also species identification, were carried out after they had been discoloured with Delafield's hematoxylin by the Jakubowski's (1967) method.

In order to estimate the abundance of juvenile fish in krill concentrations, random samples of krill and fish weighing 9–70 kg (depending on the size of krill catch and the number of fish) were taken from 15 hauls. Each sample was examined in detail and juveniles were sorted out.

Two measures of abundance, comparable with each other, were used: the number of individuals in 100 kg of krill and the number of individuals taken in 1 hour of fishing, (one haul fishes determined by the abundance of fish in the samples and the yield of krill catch).

3. Investigation area

The Balleny Islands are situated in the south-western part of the Pacific Ocean between 66° and 68° S and 162° and 165° E. The distance between the islands and Victoria Land is 300 km (Fig. 1). From an ichthyogeographic point of view, they are considered by Hureau (1973) to be part of the Antarctic (continental) Province. The fauna off the islands is poorly known and there is little information concerning its composition in the literature (Korabelnikov 1975). The islands lie within the area of the Antarctic convergence. According to Beklemišev (Korabelnikov 1975), the upwelling bottom waters favour the formation of concentrations of *Euphausiidae*. Naumov (1962) writes about the abundance of krill off the islands, estimating its biomass at 300 g/m³.

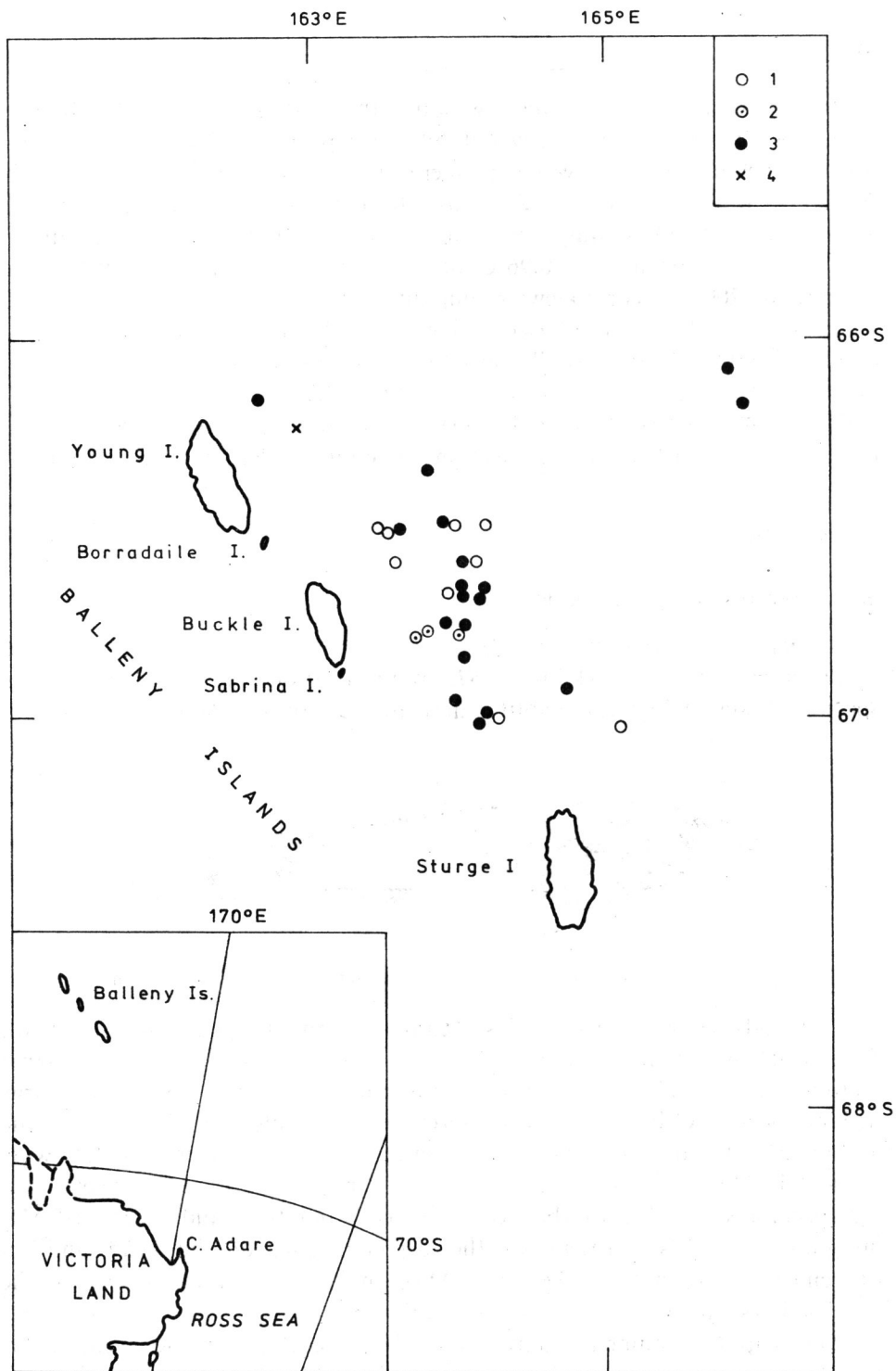


Fig. 1. The occurrence of juvenile *Trematomus bernacchii* and *Pagothenia brachysoma* within krill concentrations off Balleny Islands, January—February 1978
 1 — *Trematomus bernacchii*, 2 — *Pagothenia brachysoma*, 3 — *T. bernacchii* and *P. brachysoma*, 4 — no juveniles

In the course of our investigations, the waters east of the Balleny Islands were free of ice or covered by loose pack ice. Numerous icebergs floated around. Average water temperature at the surface was -0.37°C . A drop in water temperature with depth to a mean temperature of -1.48°C at a depth of 40 m was observed. Below 40 m temperature gradually increased to a mean of -0.96°C at a depth of 100 m and $+0.11^{\circ}\text{C}$ at a depth of 200 m (Koronkiewicz, unpublished).

Fishing for krill was carried out east of the Balleny Islands over the depths of 1100–2750 m. Krill concentrations, usually scattered, were found in the near-surface waters, most frequently at depths of 10–60 m. Czykieta and Koronkiewicz (unpublished data) found out that juvenile (64.5%) and immature (34.3%) krill, on the average 31.6 mm in length, predominated.

4. Results

4.1. Description of the species

Trematomus bernacchii (Fig. 2)

Juveniles of 33.5–44.4 mm *SL* were recorded in catches. Sixteen specimens were taken for identification and description of the species.

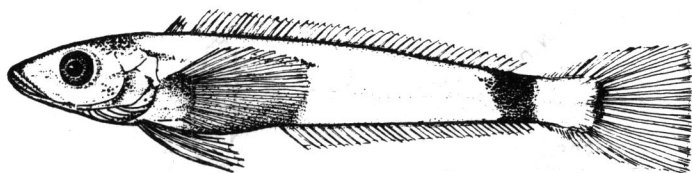


Fig. 2. Juvenile *Trematomus bernacchii*, 42.7 mm *SL* (preserved in alcohol)

The body of a juvenile fish is cream -- coloured, semi-translucent with a vertical bar of melanophores on the posterior part of the post-anal section. The dorsal surface of the peritoneum is nearly covered by large melanophores. Additional melanophores are distributed on the sides of the abdomen and sometimes above it, forming in some specimens the following vertical bar. In the larger juveniles three further bars, made up of small melanophores, are located between the head and the caudal section. Melanophores are also present on the occipital part of the head and on opercular bones; in the larger specimens small melanophores occur on the cheeks, jaws and at the base of pectoral fin.

The scapular foramen is almost completely situated on the dyed, superficially ossifying hypercoracoid, which was observed in 8 individuals, examined after dyeing and clearing. The relatively small foramen is usually ovaly shaped. It is highly improbable that the foramen can extend behind the lower margin of the hypercoracoid which, at this stage of development, is not

yet clearly marked. Also the skeletal structure of the caudal fin is not most likely, finally developed: some specimens show patterns of type 2+2+1 (when counting from the ventral: hypurals 1 and 2,3 and 4 are joined, hypural 5 is free), while other specimens (not too numerous) show the commencing partition of hypurals 3 and 4 or hypurals of the pattern 2+1+1+1. The infraorbital space is quite broad, being 15.2 to 16.1% of head length. Meristic counts are as follows: 52—53 vertebrae (18 truncal); V—VI, 35—37 dorsal fin spines and soft rays; 31—33 anal fin rays, 15—16 principal and 19—21 marginal caudal fin rays; (24) 25—26 (27) pectoral fin rays; 12—13 gill rakers on the lower part of first arch. In spite of the early development stage the system of cephalic canals of some specimens has already the characteristic features of mature fish of *T. bernacchii*: the infraorbital canal marked by at least one disjunction under the eyesocket, two disjunctions of the supratemporal canal and separated preopercular and mandibular canals. The individually varying topography of the cephalic canals of this species (Jakubowski, 1970) and the covering of some disjunctions at this stage of development, precludes the explicit formulation of canal patterns for all of the investigated specimens.

Pagothenia brachysoma (Fig. 3)

Juveniles of standard length 51—88 mm were captured. Description of some characteristic features of the species is based on 7 specimens.

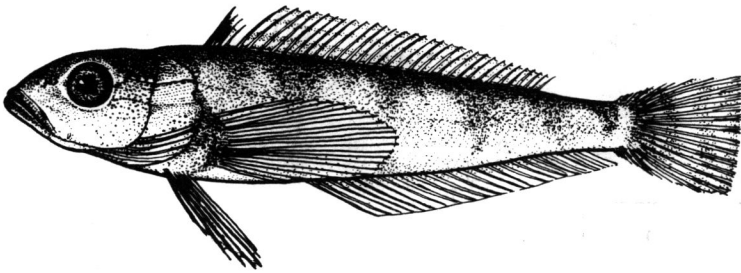


Fig. 3. Juvenile *Pagothenia brachysoma*, 64.0 mm SL (preserved in formaline)

The body of juveniles is brownish grey with silvery-blue hue of the head and on the anterior part. Two series of dark spots occur on the body: 5 to 6 in the dorsal part and 4 in the ventral part. A big black spot is located on spinous dorsal and at the base of pectoral fin. Soft dorsal fin is strongly pigmented, caudal fin has a series of melanophores forming cross-bars. Other fins are whitish, semitranslucent.

The scapular foramen is located inside the hypercoracoid. The skeletal structure of the caudal fin has a pattern 2+2+1. Two segments of the infraorbital canal are absent. The vertebral count of two dyed and cleared specimens is 46—47, including 31 caudal and 15 to 16 truncal vertebrae.

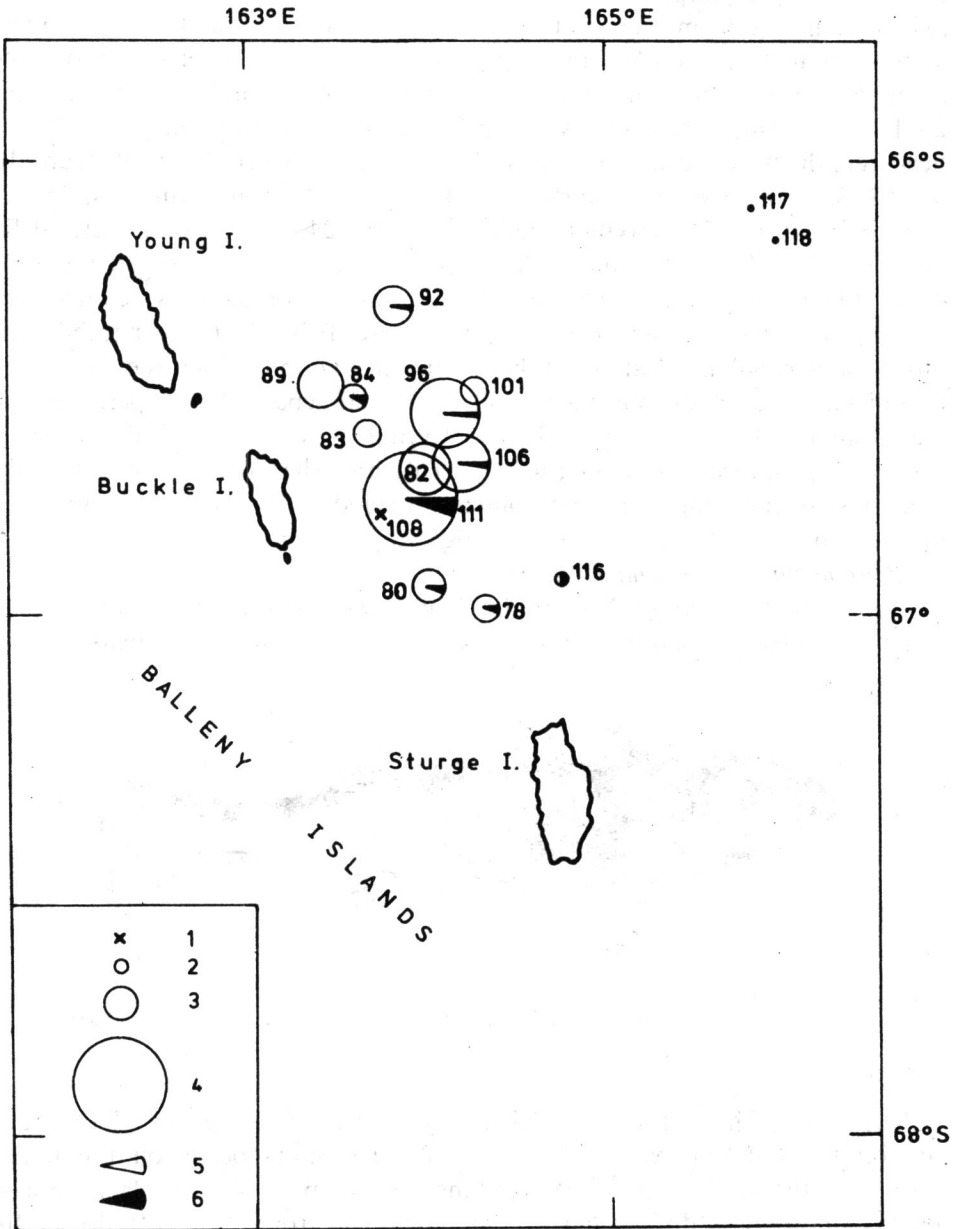


Fig. 4. The distribution and abundance of juvenile *Trematomus bernacchii* and *Pagothenia brachysoma* within krill concentrations off the Balleny Islands, January—February 1978
 1 — no juveniles, 2 — 100 per 1 hour fished, 3 — 1000/1 hf, 4 — 10000/1 hf, 5 — *Trematomus bernacchii*, 6 — *Pagothenia brachysoma*

The fin-ray counts are as follows: dorsal V, 30—33, anal 29—31, pectoral 23.

4.2. Distribution and abundance

Trematomus bernacchii and *Pagothenia brachysoma* occurred almost within the whole investigation area, *T. bernacchii* being the most frequent and abundant (Fig. 1). The distribution of fish was uneven (Fig. 4). This is especially true for *T. bernacchii*; its abundance indices fluctuated from 1 to 9,421 individuals per hour of fishing. To some extent, changes in abundance of this fish could have depended on the density of krill concentrations; *T. bernacchii* was more abundant in catches with low yield of krill (Table I).

Table I

Indices of abundance of juvenile *Trematomus bernacchii* and *Pagothenia brachysoma* within krill concentrations off Balleny Islands (January — February 1978)

Hául No	Time**)	Sampling depth (m)	Yield of krill (kg per 1 h)	<i>Trematomus bernacchii</i>		<i>Pagothenia brachysoma</i>	
				N/1 hf	N/0. 1T	N/1 hf	N/0. 1T
78	L	20— 35	77	806	1047.4	4	4.7
80	D	11— 29	351	1108	315.8	31	8.8
82	D	16— 54	1267	2802	221.2	—	—
83	L	12— 21	14700	750	5.1	—	—
84	L	17— 31	1059	691	65.2	46	4.3
89	L	24— 56	178	1829	1104.9	+	+
92	D	14— 59	75	1553	2070.7	23	30.3
96	L	10— 30	800	4548	568.5	41	5.1
101	N	9— 26	1104	845	125.6	—	—
106	L	20— 49	66	2879	4438.2	29	44.9
108	N	12— 22	7000	—	—	+	+
111	L	16— 29	1600	9421	588.8	449	28.0
116	L	22— 59	417	31	5.5	31	5.5
117*)	N	105—189	—	1	—	3	—
118*)	D	20— 30	—	9	—	+	+
Mean index per haul sampled				1818.2	812.1	43.8	10.1

+ juveniles found outside the sample (abundance not estimated)

— no juveniles in krill catch

*) haul outside the concentration of krill (index: N/0. 1T not estimated)

***) L — daylight, D — dawn and dusk, N — night

The highest values of abundance indices for the two species were observed east of Buckle Island. For instance, the number of individuals in 100 kG of krill in the case of *T. bernacchii* was 4,438.2 (Table I). The small number of investigated samples, limited by the short stay of the vessel on the fishing ground, does not allow to explain on what other factors (apart from density of krill) the distribution and changes in abundance of these fish in krill concentrations could have depended.

5. Discussion

The identification keys of *Nototheniidae* are based, among other features, on the scaling of fish. Such keys are of limited application in the case of juveniles, because their body is mostly free of scales or at most the presence of first, undeveloped scales is sometimes noted. In consequence, it was found difficult to identify juveniles, determined in this paper as *Trematomus bernacchii* (Boulenger).

The meristic features of juveniles revealed in that development stage are in good accordance with descriptions of the species *T. bernacchii* given by several sources. The observed number of vertebrae conforms with those mentioned by Andrjašev (1959), Gosse (1968) and Hureau (1970) for this species from the coastal zone of the East Antarctic. The fin-ray patterns are in general also similar to the meristic characteristics of the species given by DeWitt and Tyler (1960), Blanc (1961) and Hureau (1962), based of fish samples taken from the Ross Sea and coastal waters of the Adelie Land. The topography of cephalic canals observed in juveniles, specific for *T. bernacchii* and unique among the remaining species of this genus, is in good accordance with descriptions of Jakubowski (1970) and Andrjašev and Jakubowski (1971).

Assigning of these juveniles to the species *T. bernacchii* raises some doubts however, when some osteological observations and the descriptions of pigment design of juveniles are compared with the results of other authors. After Andersen and Hureau (1979), a characteristic feature of the species belonging to the genus *Notothenia* (genus *Trematomus* is considered as a junior synonym of this genus) is among others, the pattern of the skeletal structure of the caudal fin described as 2+2+1. The skeletal framework of the caudal fin of juveniles studied seems not to be completely developed; however, the pattern of the type 2+1+1+1, observed in a small number of specimens, suggested their affinity to the genus *Patagonotothen* which, according to Andersen and Hureau (1979), distinguishes that feature from the genus *Notothenia*.

According to the available sources, only a single species belonging to the genus *Patagonotothen* — *P. loesha* — occurs in the waters off the Balleny Islands (Andrjašev 1964, DeVries 1970 — cited as *Notothenia larseni* and Baluškin 1976 a, b — cited as *N. loesha* or *Nototheniops larseni*). However, the features of this species, differ from these of juveniles presented in the paper. The infraorbital space of *P. loesha* is narrow (5.9 to 7.2% of *HL*, according to Baluškin) but was found to be much wider in the juveniles investigated (15.2 to 16.1% of *HL*). The variable width of this space (14.9 to 28.7% of *HL*) was observed by DeWitt and Tyler (1960) for *T. bernacchii* from the Ross Sea. Following Baluškin (1976 a, b), the number of the fin-rays of *P. loesha* varies from 34 to 36 in the anal fin and from 24 to 27 marginal rays in case of the caudal one, while in the

juveniles examined counts were distinctly lower (31 to 33 and 19 to 21 respectively).

The pigmentation of juveniles studied differs from that in the sketch of larvae, collected off the Adelie Land and identified by Hureau (1970) as *T. bernacchii*. On the other hand this pigmentation resembles the pigment design of juvenile *Notothenia kempfi* (41.5—47.5 mm *SL*) from the Scotia Sea (Efremenko 1979). In the case of the latter also other diagnostic characters (fin-rays, vertebrae) given by Efremenko are close to the features of juvenile *T. bernacchii* from the Balleny Islands. It should be noted that these characters, according to Norman (1938), Andrjašev (1959), Hureau (1970) and Baluškin (1976 a, b), are similar in the adults of both species as well. There is however one distinct difference between them, the location of the scapular foramen, which concerns also *P. loesha*, discussed formerly.

The classic systematics of the family *Nototheniidae* (Regan 1913, Norman 1937, 1938) distinguishes the genera *Trematomus* and *Notothenia* by the location of the scapular foramen in pectoral fin skeleton. Since the shape and position of the foramen is not described by Baluškin (1976 a, b) and Efremenko (1979), this problem was investigated additionally on several score of specimens of *Patagonotothen larseni*, *P. nybelini* and *Notothenia kempfi* (11.5—31 cm *SL*), collected by the author in the Scotia Sea. The presence of the large triangular foramen, clearly margined below by the hypocoracoid, was observed in these species. The foramen in the examined juveniles from Balleny Islands differs considerably from that observed in the above mentioned species, being close however to the sketch drawn for adult *T. bernacchii* by Hureau (1970). In spite of exceptions to the rule of Regan (1913), found by Hureau (1962, 1970) in genus *Trematomus*, the framework of the pectoral fin skeleton settles finally — in opinion of the author — question of affiliation of examined juveniles to the species *T. bernacchii*, excluding their affinity with *P. loesha* (*P. larseni*) and *N. kempfi*.

The apertures of the partially disjoined hypurals 3 and 4, which were a basis for some doubts, will probably close during advancing ossification of the skeleton. In view of this, the complete partition of the partly ossified hypural plate is rather questionable. At the same time, the presence of disjoined hypurals 3 and 4, observed in a few specimens, can serve as a tentative proof of individual variability of the described features and/or, probably, of a high plasticity of this widely distributed species (Jakubowski — pers. comm.).

The juveniles of *P. brachysoma* had developed a completely scaled head, a skeleton of the caudal fin and coloration typical for adults which facilitates their identification. Moreover, the meristic features and observations on skeletal structures of the tail were in accordance with the specific characteristics given by Norman (1938), Andrjašev and Jakubowski (1971) and Andersen and Hureau (1979).

The high abundance of juvenile fish of the above-mentioned species off the Balleny Islands is not an exceptional phenomenon in the Antarctic. Numerous larvae (mean *SL* of 25 mm) and juvenile stages (40–50 mm *SL*) of *T. bernacchii* were found by Hureau (1970) in the near-surface waters off Adelie Land. Juvenile and adult fishes of the genus *Pagothenia* were found to be quite abundant in very cold near-surface waters or under permanent ice (Pappenheim 1912, Andrijašev 1967, 1970, DeVries 1970). Antarctic juvenile fishes within krill concentrations equally abundant as those of the Balleny Islands, were observed near West Ice Shelf (Ślósarczyk, unpublished data) and on South Georgia fishing grounds (Kompowski 1980, Wolnomiejski and Boberski, unpublished data). In the vicinity of West Ice Shelf (Princess Elizabeth Land), the author observed mass-occurrence of juvenile *Pleuragramma antarcticum* Boulenger, estimated at 61.000 ind./hf (11,500 ind./t of krill). Kompowski (1980) noted similar occurrence of juvenile (18–23 cm *SL*) *Champocephalus gunnari*: in several hauls off Clerke Rocks this fish constituted about 20% of the catch weight (amounting to 2 tons in a haul). Wolnomiejski and Boberski (unpublished data) observed during fishing for krill off South Georgia mass-occurrence of juvenile stages of the species *Patagonotothen larseni* (Lönnerberg) (41–48 mm *SL*).

During the investigations carried out over a much longer period than those carried out off the Balleny Islands, Wolnomiejski and Boberski (unpublished data) observed a some relationship between the occurrence of juvenile fish and environmental conditions. These authors noted that *P. larseni* was found more frequently in catches made at depths of 50–70 m while *Chaenocephalus aceratus* (8–10 cm *SL*) was found below a depth of 100 m. According to them, in most cases young fishes were caught at night, in scattered krill concentrations. They also noted that *P. larseni*, unlike *Ch. aceratus*, was more frequently found outside krill concentrations of high density, that resembles our observations for *Trematomus bernacchii*.

6. Conclusions

Juvenile nototheniids: *Trematomus bernacchii* (Boulenger) and *Pagothenia brachysoma* (Pappenheim) were recorded in great numbers within krill concentrations off the Balleny Islands.

A short description of the species is given in the paper because juvenile *T. bernacchii* remained undescribed yet. The correctness of assigning of some juveniles studied to this species is discussed.

Investigations were carried out in the course of exploratory fishing for krill with a commercial pelagic trawl. The mean number of juveniles per hour fished in by-catch of krill was estimated to be 1818 individuals of *T. bernacchii* and 44 individuals of *P. brachysoma*.

The area off the Balleny Islands have become traditional krill fishing grounds. The relatively high abundance of juvenile fish observed there within krill swarms indicates, that the intensive krill fishery may waste a considerable amount of fish fry, which could results in a decline of mature fish populations.

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7. Резюме

Среди скоплений антарктического криля вблизи островов Баллени наблюдалось массовое присутствие молоди двух видов рыб из семейства *Nototheniidae*: *Trematomus bernacchii* (Boulenger, 1902) (рис. 2) и *Pagothenia brachysoma* (Pappenheim, 1912) (рис. 3). Исследования этих видов проводились с судна „Профессор Богуцки“, с 24 января по 2 февраль 1978 года, во время исследовательного рейса вокруг Антарктиды. Материалы для исследований собирались при промысле антарктического криля, проводимого пелагическим тралом с длиной верхней подборы в 63 м и величиной ячеи мантии мешка в 12 мм.

В период исследований поверхность моря восточнее островов Баллени покрыта была шугой или полностью свободна ото льда. Средняя температура воды у поверхности составляла — 0,37°С. Небольшие по плотности скопления криля встречались в приповерхностном слое воды, преимущественно на глубине 10—60 м. В уловах выступал главным образом криль ювенальный и неполовозрелый.

В работе описывается пигментация молоди и некоторые характерные черты двух выше перечисленных видов, а также общее строение каналов головы и скелетов грудных и хвостовых плавников рыб этой возрастной стадии. В обсуждении широко рассматривается вопрос определения видовой принадлежности молоди *T. bernacchii*. Видовое определение вызывает некоторые сомнения, в связи с наблюдаемым у отдельных экземпляров строением скелета хвостового плавника, характерным для рода *Patagonotothen* (Болушкин, 1976), а также в связи с встреченным в литературе описанием молоди *Notothenia kempfi* из моря Скоша, напоминающей молодь рыб определенную в настоящей работе как *T. bernacchii*.

Молодь *T. bernacchii* и *P. brachysoma* встречалась, почти во всем районе исследований (рис. 1 и 4). Средняя численность рыб в прилове промысла криля оценивалась в 1818 особей/час траления для вида *T. bernacchii* и 44 особи рыб/час траления для вида *P. brachysoma* (таблица I). Воды вблизи островов Баллени считаются традиционным районом промысла криля. Наблюдаемая большая численность рыб в прилове промысла криля в этом районе указывает на возможность уничтожения при интенсивном его промысле значительного количества молоди названных видов рыб, что отрицательно повлияет на величину пополнения их основных популяций в районе островов.

8. Streszczenie

W koncentracjach krylowych w okolicy Wysp Balleny stwierdzono masową obecność dwóch gatunków młodocianych ryb z rodziny *Nototheniidae*: *Trematomus bernacchii* (Boulenger, 1902) (rys. 2) i *Pagothenia brachysoma* (Pappenheim, 1912) (rys. 3). Badania nad nimi

przeprowadzono ze statku „Profesor Bogucki”, w okresie od 24 stycznia do 2 lutego 1978 r., w czasie rejsu badawczego dookoła Antarktydy. Materiał do badań zebrano w trakcie połowów kryla, prowadzonych włokiem pelagicznym o długości nadbory 63 m i wielkości oczka 12 mm w gardzieli i w worku.

W okresie naszych badań powierzchnia akwenu na wschód od Wysp Balleny była pokryta luźną krą lub była wolna od lodu. Średnia temperatura wody przy powierzchni wynosiła $-0,37^{\circ}\text{C}$. Rozrzedzone zwykle skupienia kryla występowały pod powierzchnią wody, przeważnie na głębokości 10–60 m. W połowach notowano głównie kryla juvenilnego i nie-dojrzałego.

Opisano pigmentację w stadium młodocianym i wybrane cechy merystyczne obu wymienionych wyżej gatunków. Opisano również ogólnie budowę kanałów głowy oraz szkieletu pasa barkowego i ogona ryb w tym stadium rozwoju. W dyskusji omówiono szerzej problem identyfikacji młodocianych ryb z gatunku *T. bernacchii*. Oznaczenie gatunku pozostawia pewne wątpliwości z uwagi na obserwowaną u niektórych osobników strukturę szkieletu płetwy ogonowej, charakterystyczną dla rodzaju *Patagonotothen* (Baluškin 1979), a także istnienie w literaturze opisu młodocianej *Notothenia kempii* z Morza Scotia, przypominającego w dużym stopniu młodociane ryby, określone w tej pracy jako *T. bernacchii*.

Ryby z gatunków *T. bernacchii* i *P. brachysoma* występowały niemal w całym rejonie badań (rys. 1). Najwyższe wartości wskaźników liczebności tych ryb zanotowano na wschód od Wyspy Buckle (rys. 4). Średnią liczebność ryb w przyłowie krylowym oszacowano na poziomie 1818 osobn./1h w przypadku *T. bernacchii* i 44 osobn./1h w przypadku *P. brachysoma* (tabela 1).

Okolice Wysp Balleny należą do tradycyjnych łowisk krylowych. Obserwowana tam wysoka liczebność ryb w przyłowie kryla, świadczy o możliwości niszczenia przez intensywne połowy tego skorupiaka znacznej ilości narybku wymienionych wyżej gatunków, co wpłynąć może ujemnie na wielkość stad ryb dorosłych.

9. References

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