

A SEASONAL PATTERN OF OCCURRENCE OF GOBIID FISH (GOBIIDAE) IN THE SHALLOW LITTORAL ZONE (0-1 M DEPTH) OF PUCK BAY.

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Key words: Baltic Sea, Puck Bay, *Gobiidae*, shallow littoral zone, seasonal variations

Abstract

In the years 1993-1995, investigations of the variability in occurrence of gobiids in the shallowest part of Puck Bay (0-1 m depth) were conducted. Three species of gobiids, *Pomatoschistus minutus*, *Pomatoschistus microps* and *Neogobius melanostomus* were identified. Abundance, biomass and species distribution varied with time and sampling location. *P. microps* was a dominant species all year round and accounted for over 80% of all fish caught. An apparent preference of *P. microps* for inhabiting the internal part of Puck Bay was observed while *P. minutus* was found more frequently in the external part of Bay. In the coastal zone, fish from genus *Pomatoschistus* showed seasonality of occurrence with the abundance peak in the fall.

INTRODUCTION

In general, gobies (*Gobiidae*) are not commercially exploited because of their small size. Commercial gobiid fisheries exist only in the Caspian and Black Seas (Svetovidov 1964). As a result of the lack of commercial interest in other areas, gobiids are relatively poorly characterized.

Six species from family *Gobiidae* were found in Polish zone of the Baltic. The presence of five species, namely, the sand goby *Pomatoschistus minutus* (Pallas 1770), the common goby *Pomatoschistus microps* (Kroyer 1838), the black goby *Gobius niger* (Linnaeus 1758), the two-spotted goby *Gobiusculus flavescens* (Fabricius 1779) and the transparent goby *Aphya minuta* (Risso 1810) was confirmed by many authors. However, the latter two species are relatively rare in the Polish coastal area (Demel 1924, Gasowska 1962, Lawacz 1965, Rembiszewski and Rolik 1975, Morawski 1978, Miller 1986). The sixth species the round goby, *Neogobius melanostomus* (Pallas 1811) is not native to the Baltic but originates from Ponto-Caspian

Sea. Its presence was observed for the first time in 1990 near Hel (Skóra and Stolarski 1993). Since then, the species spread to the entire area of the Gulf of Gdańsk (Skóra 1996) and the first specimens were found beyond the Gulf near Dębki (Kuczyński 1995 after Grygiel 1995) and offshore Lithuania (Maksimov personal communication). Because of the fast rate of colonization, it became essential to survey the habitats of native gobiids and to establish its distribution in the locations of gobiid occurrence. Such measures will allow to monitor the rate and intensity of expansion by *N. melanostomus*.

Gobiids inhabit the eulitoral, however, their occurrence pattern in this zone shows high variability throughout the year. The seasonal fluctuations of the gobiid occurrence in the coastal waters were observed by, among the others, Healey (1971), Fonds (1973), Hesthagen (1975), Jansson *et al.* (1985) and Doornbos and Twisk (1987). A similar phenomenon was noted in the Gulf of Gdańsk by Morawski (1978), although the investigated area did not include the shallowest part of eulitoral from 0 to 1 metre of depth. This shallow zone is inhabited by the large numbers of fish from genus *Pomatoschistus* (Ławacz 1965).

P. minutus and *P. microps* are morphologically very similar, therefore, these two species are quite often treated as one category (Anner and Nellbring 1977, Morawski 1978, Nellbring 1988). The literature describing ichthyofauna communities in the Polish coastal waters lacks information about the two separate species from genus *Pomatoschistus*, except for the work by Ławacz (1965). A better knowledge about the present abundance and distribution of gobiid species will allow the evaluation of their potential role as a food item for commercial fish, *i.e.* for young cod (Chrzan 1962, Ciegiewicz *et al.* 1972).

MATERIALS AND METHODS

The area of investigations covered the littoral zone of Puck Bay and the southern part of the Gulf of Gdańsk. Sampling stations were located nearby the following towns and villages: Gdańsk, Sopot, Gdynia, Rewa, Puck, Chałupy, Jurata and Hel (Map. 1). Sampling was always performed during one night at the end of each month, for the same of sequence sampling sites each time. Specimens collection started always after sunset in Gdańsk and ended before sunrise in Hel. The timetable of performed catches is presented in Table 1.

The presence of ice cover in Puck Bay and stormy weather in the fall and winter rendered the sampling impossible from November 1993 to March 1994. The results for this period came from the corresponding season in the subsequent year. From 96 planned sampling catches only 4 were not performed. Catches were taken with a small mesh-size trawl net (opening 2.8 m, mesh diameter 5 mm, mesh diameter of cod end 1 mm). This fishing gear was used in the immediate vicinity of

fish from genus *Pomatoschistus* based on morphology became questionable. The species biomass in a tow was calculated by adding the weights of individual fish. The variability of abundance, biomass and length distribution for particular gobiid species in a given area were estimated from the collected material.

RESULTS

Three species of gobies, *P. minutus*, *P. microps* and *N. melanostomus*, were found in the collected material. Overall, 2060 fish were caught. In this number 320 individuals of *P. minutus* (15.5% of the total catch), 1695 of *P. microps* (82.3%) and 28 of *N. melanostomus* (1.4%) were found. The species of 17 individuals from family *Gobiidae* remained unidentified (0.8% of the total catch). The largest individual from the species *P. minutus* measured 68 mm, the smallest one was 5 mm long. The respective values for *P. microps* were 43 and 11 mm and for *N. melanostomus* 116 and 26 mm.

The values of fishing efficiency by gobiid species for each station throughout the year are shown in Table 2. It became clear that the occurrence, total abundance, per cent abundance and species biomass varied depending on time and location (Figs. 1 and 2).

P. Microps

In winter, the sand goby (*P. microps*) was absent or sporadically present in the shallow littoral of Puck Bay (Fig. 1). A slight increase of its abundance was noted in spring. In June, the abundance dropped again and fish caught in this period highest length-classes (Fig. 3). In July, another increase of abundance began which was much more pronounced than the spring one and belonged to the reached its maximum in September. The September peak was caused by the massive appearance of younger fish from lower length-classes (Fig. 3). In October, the next decrease in abundance occurred. During the year, the length distribution was usually unimodal. Only in July this pattern was slightly different. From August until the following year, the mean length of fish caught increases.

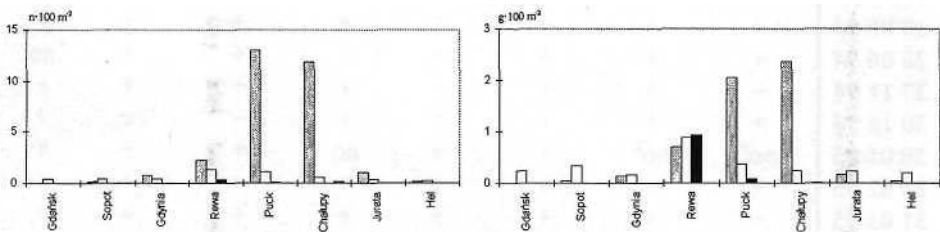


Fig. 1. Monthly mean abundance and biomass of gobiid species

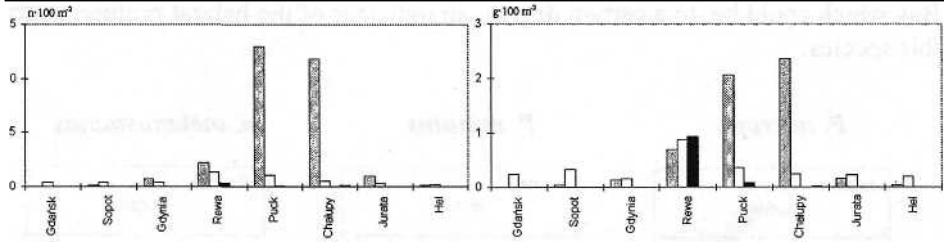


Fig. 2. Annual mean abundance and biomass of gobiid species at particular stations

Locations and frequency of abundance and particularly high fishing efficiency values for *P. microps* observed near Rewa, Puck and Chałupy (Fig. 2), specifically in the late summer, indicate that this species apparently prefers the habitats in the internal lagoonal part of Puck Bay.

P. minutus

Similarly to *P. microps*, *P. minutus* showed fluctuations of abundance and variability in length distribution. The duration of decreased abundance of *P. minutus* in the spring was somewhat longer (May-July), while the decrease in October was not as pronounced as for *P. microps*.

Fishing efficiency values obtained for *P. minutus* were much lower than for *P. microps* for the majority of the stations for all the months (Table 2, Fig. 2). The fluctuations of abundance throughout the year were not as extreme as for *P. microps* whereas the seasonal changes of biomass were more pronounced (Fig. 1).

For *P. minutus*, no noticeable habitat preference was observed in the investigated area of Puck Bay. However, it should be emphasized that this species was either dominant or the only gobiid present at the stations most remote from the lagoonal part of Puck Bay, such as Hel, Sopot and Gdańsk.

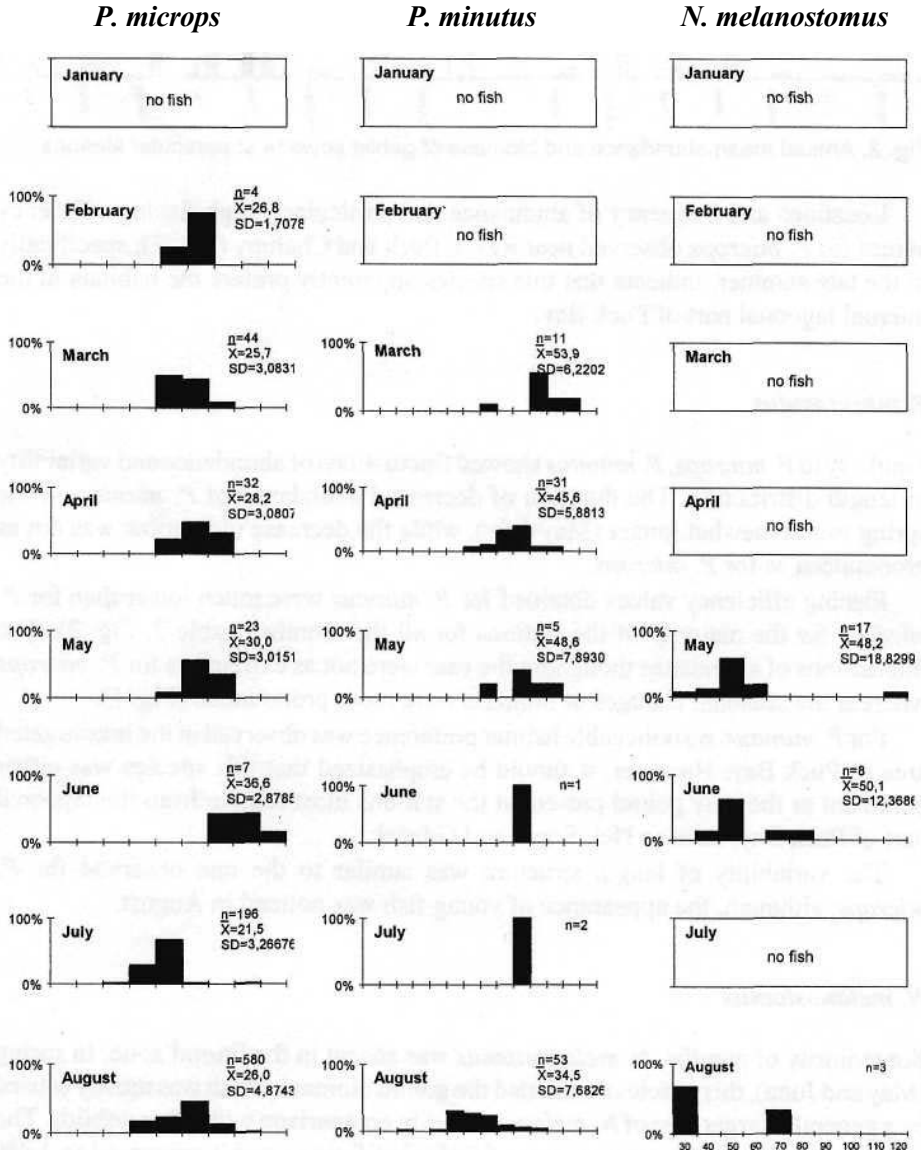
The variability of length structure was similar to the one observed for *P. microps*, although, the appearance of young fish was noticed in August.

N. melanostomus

For majority of months, *N. melanostomus* was absent in the littoral zone. In spring (May and June), this species dominated the gobiid biomass which was mostly caused by a generally larger size of *N. melanostomus* in comparison with other gobiids. The abundance of *N. melanostomus* was of little significance and it amounted to 1.4% per year. Mainly smaller individuals were caught (Fig. 3).

The occurrence of *N. melanostomus* was limited to the lagoonal part of Puck

Bay which could be, to a certain degree, an indicator of the habitat preference for this species.



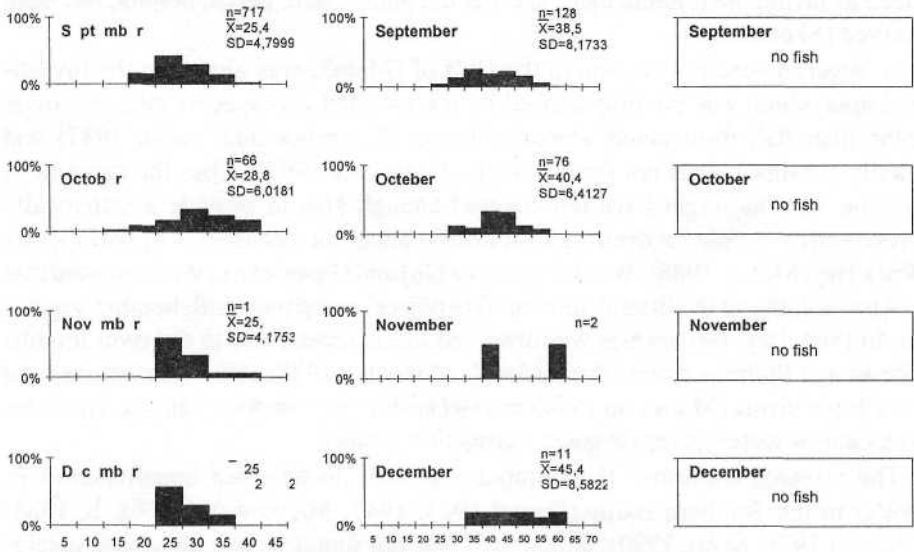


Fig. 3. Distribution of gobiids among length-classes: n, number offish; \bar{x} , mean length (L.) [mm]; SD, standard deviation

DISCUSSION

Only three out of six gobiid species observed in the Polish area of the southern Baltic (Demel 1924, Gařowska 1962, Rembiszewski and Rolik 1975, Morawski 1978, Miller 1986, Skóra and Stolarski 1993) were caught in the investigated area at depths from 0 to 1 m.

The transparent goby, *A. minuta*, which is considered a rare species inhabiting the western part of the Baltic (Gařowska 1962, Rembiszewski and Rolik 1975) and also occurring in the Gulf of Gdańsk (Morawski 1978), was never caught. The two-spotted goby, *G. flavescens*, which was earlier present in Puck Bay (Demel 1933, 1947), however rather rare (Demel 1924), was not found either. Its presence in the Gulf of Gdańsk was confirmed by the findings of larvae (Mańkowski 1950a) and the reports by Morawski (1978). The current absence of this species might be caused by changes in the species composition of macroalgae community in Puck Bay (Kruk-Dowgiałło 1991, Pliński and Florczyk 1993). The vegetation covering the sea bottom constitutes a substrate on which this species lays its eggs (Russell 1976). The disappearance of benthic algae and increased predatory pressure of the three-spined stickleback were probably the cause of extinction of other fish linked to the macroalgae community. There are no recent observations of the fifteen-spined stickleback, *Spinachia spinachia* and also the pipefish, *Syngnatus typhle*, is disappearing (Margoński 1994). A considerable reduction of commercially-exploited fish, charac-

terized as laying phytophilic eggs, such as the pike, roach, perch, belona, has been observed (Skóra 1993).

G. niger, a species common in the Gulf of Gdańsk, was absent in the investigated area which was possibly caused by the fact that this species inhabits lower depths than fish from genus *Pomatoschistus* (Doornbos and Twisk 1987) and partially because it does not form schools (Gašowska 1962). Also, the network of sampling stations might have not covered enough area to provide a statistically representative sample for drawing conclusions about the occurrence of fish species in Puck Bay. Miller (1986), Wiederholm (1987a) and Gašowska (1962) reported that *G. niger* residing in the littoral zone prefers places overgrown with benthic vegetation. In Puck Bay, this species was observed in the areas close to the river mouths of Rewa and Plutnica rivers (Demel 1947, Morawski 1978, own observations) and seawalls in Gdynia (Morawski 1978) and Hel harbours (own observation). The latter two locations were not investigated during this project.

The research confirmed the common and well documented occurrence of *P. minutus* in the Southern Baltic (Demel 1933, 1947; Mankowski 1950a, b, 1951; Morawski 1978, Skóra 1990), although, it was not found to be a dominant species in Puck Bay. This role was assigned to *P. microps* whose abundance amounted to 82% of all *Gobiidae* caught. Ławacz (1965) has already pointed to a very numerous occurrence of *P. microps* (not estimated quantitatively) at depths from 0 to 1 m in Puck Bay in summer. Quite different results were obtained by Morawski (1978) who observed a "profuse excess" of *P. minutus* in the coastal zone of the Gulf of Gdansk. This discrepancy was probably caused by the fact that Morawski conducted his research at depths from 2 to 10 m. Based on the findings of Ławacz (1965), these two different conclusions could be explained by dissimilar depth preference of *P. microps* and *P. minutus*.

N. melanostomus was a new species found in the shallow littoral zone. Its occurrence in Puck Bay was noticed for the first time in 1990 (Skóra and Stolarski 1993). At present, this species is spreading relatively fast over the entire area of the Gulf of Gdansk (Skóra and Stolarski 1995, Skóra 1996, Kuczyński 1995); a significant number of individuals caught confirms a non-incident character of its occurrence. While the first observations of *N. melanostomus* concerned adults from larger depths, in this study younger individuals (Fig. 3), probably from the previous year's spawning, were noted.

The spatial variability of occurrence of the specific gobiid species was probably influenced by the lagoonal character of the habitat. Sandy bottom of the open sea coastline of the Gulf of Gdańsk, seems to be preferred by *P. minutus*. At stations displaying such a bottom type, *i.e.* Hel, Sopot and Gdansk, *P. minutus* dominated or was the only representative from family *Gobiidae*. The described preferences for inhabiting sandy bottom in the open sea coastal zone were confirmed by Horackie-

wicz and Skóra (1996). Sand-muddy and muddy bottom in the lagoonal part of Puck Bay was mostly occupied by *P. microps*. During the entire year, *N. melanostomus* appeared most frequently in Rewa where bottom is of a sand-gravel character.

During the year, stations located in the internal part of Puck Bay had higher fishing efficiency values for gobiids than the stations in the external part of Bay. Morawski (1978) obtained quite different results for the same area of investigation, with the highest fishing efficiency values for the area outside or at the borders of Puck Bay. The possible reasons for this could be differences in sampling design such as, different range of depths or non-representative sample collection sites.

The dominance of *P. microps* in relation to *P. minutus*, expressed as high fishing efficiency values of the former species in Puck Bay, probably resulted from its better acclimatization to the environmental conditions of littoral.

Ławacz (1965) had already observed that *P. microps* in Puck Bay occurred in large numbers at depths from 0 to 1 m, less frequently at depths 1 -5 m and sporadically below 5 m depth. *P. minutus* showed a reversed depth-specific distribution. Similar preferences, that is, for inhabiting very shallow waters by the common goby and deeper waters by the sand goby, were noted by Doornbos and Twisk (1987) in Lake Grevelingen, and by Fonds (1973) in the Wadden Sea. The same preferences apply to the choice of spawning grounds (Boucheraeu *et al.* 1993, Nellbring 1993). Lebour (1919) reported that *P. microps* was a relatively warm-water species. Fonds and Veldhuis (1973), while conducting research on oxygen consumption among gobiids under different thermal conditions, found out that *P. microps* had better capability to live in high temperatures than *P. minutus*. Also, *P. microps* required a higher temperature for spawning than *P. minutus* (Fonds 1973, Wiederholm 1987b).

A wide range of salinity tolerated by these two euryhaline species, namely, from 0.9 to over 30.0, and spawning capabilities in salinities below 5.0 (Wiederholm 1987b) prove that salinity is of no significance as a factor influencing the spatial distribution of gobies.

Gobies from Puck Bay showed seasonal fluctuations of occurrence which was also observed by Morawski (1978). Jones and Miller (1966) reported similar changes. They stated that the absence of *P. microps* in the littoral in winter was caused by migration into deeper parts of the water body. According to these authors, the migration was induced by cooling of the habitats in the littoral down to below 5°C. When the water temperature in winter did not fall below 7°C then the migration was not taking place. A similar decrease in fish abundance in winter was observed by Healey (1971) in the estuary of Ythan River, where *P. minutus* was disappearing in January at temperatures 3-5°C. Healey also reported that winter migrations of this species were not induced by salinity or searching for food and these findings had been confirmed by Morawski (1978). In Puck Bay, thermal fluctuations in the littoral exceed the levels described above. The temperatures below 5°C usually occur from

December through March and in some locations even from November through April (Nowacki 1993). This thermal pattern coincides with the period of almost total absence of the gobiid species between November and February. During this interval, fish from genus *Pomatoschistus* amass in the Gulf of Gdańsk at a depth of 50-100 m (Morawski 1978, 1979). Fonds (1973) observed a winter decrease in abundance of *P. minutus* in the Wadden Sea in response to the drop of temperature below 2°C. He hypothesized that the decrease in abundance was caused by the migration of fish to the warmer waters of the North Sea where fish distribution showed a correlation with increasing depth. According to Fonds, *P. microps* is not able to perform such long migrations as *P. minutus*. The migrations of *P. microps* in the Wadden Sea resulted from avoiding low temperatures, however, fish searched only for deeper sites in this water body. A similar strategy may also apply to Puck Bay.

In spring, when water temperature rises to above 3°C, both species reappear in the littoral zone (Doornbos and Twisk 1987, Hesthagen 1977). The incoming fish prepare for spawning (Hesthagen 1977) which in *P. minutus* in the Gulf of Gdansk takes place from mid-April until mid-June (Morawski 1978) while in *P. microps* starts later. Nellbring (1985) reported the beginning of spawning season for *P. minutus* in the Central Baltic as ranging from May until August and for *P. microps* from June until September.

The number of gobiids in the 0-1 m depth zone is much lower in spring than in the fall. Morawski (1978) suggested that the spring decrease in fish abundance may be caused by predation during winter. Cieglewicz *et al.* (1972) reported that gobiids are the most important food item in cod's diet during the fall-winter period. Miller (1975) also remarked about the possible role of predation in relation to the decreased population size of *P. microps* in winter. Healey (1971) suggested a similar explanation in the case of *P. minutus*. Another factor possibly controlling the population size, particularly of *P. microps*, is low temperature. A temperature decrease below -1°C results in death of fish. Cold winter in 1962-1963 caused a decrease of gobiid abundance during the two subsequent productive seasons in the Wadden Sea (Fonds 1973).

It is characteristic that after a short increase of gobiid abundance in spring, there is a decrease in fish number. Such a decrease was observed by many researchers. Fonds (1973) claimed that spawned gobiids experience higher mortality rates in the post-spawning period. Miller (1975) suggested that a decrease could have resulted from natural mortality caused by aging. The experiments conducted by Healey (1971) showed that in this time of the year, *P. minutus* had the lowest values of condition factor. Some role could be assigned to predation. Lindstrom and Ranta (1992) demonstrated that during spawning, the male gobiids are very vulnerable to predation by birds. Hesthagen (1977), on the other hand, suggested that in the case of *P. minutus* the decrease in abundance resulted from the avoidance of high temperatures (above 19°C) in the littoral zone. It seems, however, that it is a natural

process. Fish from genus *Pomatoschistus* are short-lived and their maximum life span ranges, depending on species, from 1.3 to 2 years (Miller 1986).

At a depth of 0-1 m, spring decrease of abundance of *P. minutus* lasted from May until the end of July. In the case of *P. microps* the decrease was insignificant and limited only to June. The possible explanation of this difference is probably a preference of a particular spawning depth. *P. microps* chooses shallower sites (Nellbring 1993) and it was present in the shallow littoral throughout the entire spawning season. *P. minutus* spawns most intensively in deeper places than the ones investigated in this study.

Starting in July for the sand goby and in August for the small goby, there is observed an increase of both species' abundance which peaks in September. This peak results from the appearance of the individuals which have moved into the near-bottom habitats (Morawski 1977). The changes in length distribution found in this study (Fig. 3) confirm this hypothesis. During the abundance peak of gobiids, both species from genus *Pomatoschistus* were present in the entire investigated area. The September increase is followed by a decrease in abundance in October.

Hesthagen (1975), while investigating changes in population age structure of *P. minutus*, found that only a small proportion of fish is capable of second spawning. According to Fond (1973), second-time spawners amount to 1-2% of a year-class. After the first spawning, most of the individuals disappear while fish which had survived through their second winter vanish at the beginning of the reproductive season. Doornbos and Twisk (1987) observed that *P. minutus* in Lake Grevelingen never survives to its second spawning season, and the spawned individuals disappear right after spawning.

The variability of length distribution in *P. minutus* from the Gulf of Gdansk are confirmed by the following observations. Fish from the higher length-classes, probably at age +1, were very infrequent at the beginning of spawning in April and during the appearance of young-of-year in August. It is possible that some survive until the second spawning. Certain indications of such a situation are prompted by the length distribution in August where, besides young fish, one finds individuals from high length-classes. However, because the data on fish age are lacking, it is not possible to confirm this hypothesis. By analysing the variability of frequency in length-classes, an evident shift of the mean length towards lower values (Fig. 3) can be noted. It occurs in August as a result of recruitment. Until November, the mean fish length increases, whereas in winter only large fish are present.

In the case of *P. microps*, Miller (1975) observed that, similarly to the sand goby, a big number of fish dies after the first spawning and only a small proportion of them become second-time spawners. The maximum age ranges from 1.6 to 2 years (Miller 1986). The variability of length distribution in the investigated area is in agreement with these observations. As in the former species, fish from the higher

length-classes (probable age class +1) begin to disappear when young-of-year show up in July. High length-class fish disappear totally in December.

N. melanostomus appeared only during three months. It is a very expansive species in this area and its range has been increasing year after year (Skóra unpublished, Kuczynski 1995). The relatively apparent presence of this species, particularly as biomass in May and June 1994, is probably caused by the fact that these two months were the last time period of sample collection. It is very likely that the round goby in the Gulf of Gdansk may display similar fluctuations of abundance as other fish from genus *Pomatoschistus*. Seasonal migrations of *N. melanostomus* were observed in its natural environment, the Black Sea (Svetovidov 1964). The observations of young fish of this species indicate a possibility of their permanent or seasonal presence in the shallow littoral and competition with the indigenous gobiids.

CONCLUSIONS

P. microps is a dominant species among the gobiids of the shallow littoral in Puck Bay and it is particularly abundant in the internal part of Bay. *P. minutus* rather prefers the external part of Bay. Fish from genus *Pomatoschistus* show fluctuations of abundance in this zone. Maximum values of biomass and abundance were obtained in the fall. In the remaining time of the year, the values were low or equalled 0, except for spring when a slight increase of values was observed. The presence of small individuals of *N. melanostomus* indicates that a possibility of competition between this species and the native gobiids in the littoral exists. Although, this phenomenon requires further and more detailed investigation.

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