

Remarks on horizontal and vertical distribution of family Gadidae, Lotidae and Phycidae representatives in the eastern Adriatic

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*The presence of four genera, four species and one subspecies of family Gadidae, two genera and four species of family Lotidae and two genera and two species of family Phycidae was established with certainty for the Adriatic. These families include species of different distribution in the Adriatic and of different ecological preferences. Some of these species are common and abundant fishes in the Adriatic Sea while some are rare with a very restricted distribution area. The species *Trisopterus minutus* is most widespread in the Adriatic, followed by *Merlangius merlangus* found in all shallower areas (particularly the northern Adriatic area), and *Micromesistius poutassou*, *Phycis phycis*, *Phycis blennoides* and *Gaidropsarus mediterraneus* mainly in the middle and southern Adriatic. *Molva macrophthalma* is however distributed only in the southern Adriatic. Of all concerned species, six show bathyphilous trend, distributed mainly in the area of continental slope or bathyal (below 200 m depth) and four species occur almost exclusively in the area of continental shelf that is down to 200 m. As to the substratum, most of the species prefer muddy bottoms rather than sandy and muddy-sandy bottoms.*

Key words: Gadidae, Lotidae, Phycidae, horizontal distribution, depth distribution, bottom type distribution, eastern Adriatic

INTRODUCTION

All representatives of the family Gadidae are marine fishes (Arctic, Atlantic and Pacific) with greatest diversity in northern Atlantic. According to COHEN *et al.* (1990) and NELSON (1994) a total of 14 genera and check 22 species live in seas all over the world, 12 genera, 17 species and two subspecies are recorded in the Atlantic (BINI, 1970; SVETOVIDOV, 1986; COHEN *et al.*, 1990) and four genera, five species and two subspecies in the Mediterranean (TORTONESE, 1970; SVETOVIDOV, 1986; BAUCHOT, 1987; COHEN *et al.*, 1990). The Lotidae species are marine fishes occurring in Arctic, Atlantic and Pacific (only one Holarctic freshwater species) with six genera and 21

species (NELSON, 1994). Five genera and 15 species are recorded in the northern part of Atlantic and two genera and five species in the Mediterranean (BAUCHOT, 1987; COHEN *et al.*, 1990). The Phycidae species are marine, primarily northern Atlantic fishes but also off Gulf of Mexico, Brazil and Argentina. There are two genera and eleven species in the whole Atlantic, two genera and three species occur in the north-eastern Atlantic area (SVETOVIDOV, 1964; BINI, 1970), one genus with two species in the Mediterranean (SVETOVIDOV, 1986; BAUCHOT, 1987).

The Adriatic ichthyofauna includes four genera and four species of the family Gadidae, two genera and four species of the family

Lotidae and one genus and two species of the family Phycidae (JARDAS, 1996). Concerning to their biogeography they all belong to the North Atlantic - Mediterranean species or the West Mediterranean subspecies. Recent revisions of these three families are given by SVETOVIDOV (1948, 1953), MARKLE (1982, 1989), COHEN (1984), DUNN and MATARESE (1984), DUNN (1989) and COHEN *et al.*, (1990).

With respect to their history and ecology the Gadidae, Lotiidae and Phycidae species are predominant benthic or benthopelagic forms (only few species are pelagic) above muddy and sandy substrata and some species above hard bottoms. Concerning to their depth distribution they inhabit the continental shelf and the upper part of the continental slope or bathyal (i.e. the epi-, meso- and bathypelagic zones).

Most of the Gadidae and Lothidae species are sympatric (COHEN *et al.*, 1990; JARDAS, 1996). They are of little commercial importance in the Adriatic Sea - half of the species are rare in the Adriatic, more or less locally distributed or not exploited at all.

This paper presents the distribution with respect to the depth and bottom type of the representatives of Gadidae, Lotidae and Phycidae families in the Adriatic Sea.

MATERIAL AND METHODS

The study of the horizontal and vertical distribution and relationship of Gadidae, Lotidae and Phycidae species to substratum was based on unpublished data from trawl and trammel bottom set surveys in the channels and inshore waters of the northern, middle and southern Adriatic.

The used trammel bottom sets (NÉDÉLEC, 1975) had the following construction characteristics: length 32 m, height 1.6 - 1.8 m, external netting panels ("popon") with 110 - 120 mm and internal netting panel ("maha") with 28, 32, 36 and 40 mm mesh size. The operating net surface was on average 54 m². Experimental trammel bottom set catches made between 1960 and 1999 were the subject of analyses. The unpublished and published data (MOROVIĆ, 1965) for the Mid-Dalmatia was also used for the 1960 - 1964 period. The remainder of the data was obtained by the author's fieldwork (JARDAS, 1999) (Table 1). Experimental fishing was carried out with different number of nets tied together. Usually 10 or 11 nets were used together (90% of the catches). Nets were commonly set at the bottom at the depth between 2 and 30 m, rarely at great depths, but most frequently down to 15 m (80% of the catches). Fishing activities were performed on different bottom types: rocky, sandy and muddy, overgrown by algae or marine phanerogam *Posidonia oceanica*. Fishing operations were performed exclusively at night that is nets were set on the bottom in the evening and hauled in the morning next day. Four species of the Gadidae, Lothidae and Phycidae families were found in the trammel bottom set catches.

The trawl - surveys were carried out between 1965 - 1989 mainly on the stations which had been analysed during the fishery - biological expedition HVAR in 1948 - 1949 (KARLOVAC, 1959). Fish samples were collected with different types of bottom trawl nets, but the most used was the Italian bottom trawl net, called "tartana" (JUKIĆ, 1975). Geographic positions, depths and type of bottom of the investigated stations were the same as of the

Table 1. Time series of data on the trammel bottom set catches in the coastal eastern Adriatic

Study area	Time series of data		
North Adriatic (Istra peninsula)	-	-	1995 - 1997
North Adriatic (Velebit channel area)	-	-	1995 - 1999
Kornati Islands	1960 - 1964	1977 - 1987	1990 - 1994
Split	1960 - 1964	1977 - 1979	1990 - 1999
Mid-Dalmatia Islands	1960 - 1964	1971 - 1987	1990 - 1999
Palagruža Islands	1961	1970 - 1971	1987 - 1997
South Adriatic	-	1972	1987 - 1999

mentioned expedition HVAR (KARLOVAC, *op. cit.*).

In purpose of estimating the abundance of the Gadidae, Lotidae and Phycidae species in trawl catches at different depth ranges (every 50 or 100 m) and different types of bottom (muddy and sandy bottoms) "the number of specimens per trawl haul" (number of caught specimens/number of trawl haul) have been used. For the trammel bottom set catches which had been taken mainly on hard rocky bottoms, lesser on soft bottoms, abundance of each species was estimated according to the number of specimens occurring in the catches: > 10 specimens very common (+++); 5 - 10 common (++); < 5 positive finding (+).

Besides the unpublished author's data, all relevant published data for the same areas were used in this study. For northern Adriatic channels (KOTHAUS and ZEI, 1938; CRNKOVIĆ, 1970), middle Adriatic - channels and open part (ŽUPANOVIĆ, 1961; JUKIĆ, 1975; ŽUPANOVIĆ and JARDAS, 1989), southern Adriatic - including Boka Kotorska (KIRINČIĆ and LEPETIĆ, 1955; LEPETIĆ, 1965; MERKER and NINČIĆ, 1973; BELLO and RIZZI, 1988), as well as from published results of the fishery - biology HVAR expedition 1948/49 (KARLOVAC, 1959).

Since the statistical distribution of analysed values (number of specimens per trawl haul) are not known, it is not possible to use parametric

tests to compare these values for different depth ranges and bottom types. Also there weren't sufficient available data regarding depth, bottom type characteristics and number of caught specimens per trawl for each analyzed station. Consequently, the multivariate analyses (e.g. combination of cluster and multidimensional scaling) applied to the matrix (abundance per species x depth zone per Adriatic area) couldn't be done. Thus, to complement the analyses of changes in trawl catches, chi - square (χ^2) comparison of different number of specimens caught per trawl haul were made on the three different bottom types (sandy, loamy and clayey) and different depth ranges: for *Merlangius merlangus* on every 50 m and other species on every 100 m.

RESULTS AND DISCUSSION

Family Gadidae

Gadidae species of the Adriatic Sea belonged to four genera: *Gadiculus*, *Micromesitius*, *Merlangius* and *Trisopterus*. Their horizontal and vertical distribution is stated below:

Gadiculus argenteus argenteus GUICHENOT, 1859

It's pelagic species of the temperate seas (from 24°N - 74°N) distributed in the Atlantic around the Straits of Gibraltar and to the south

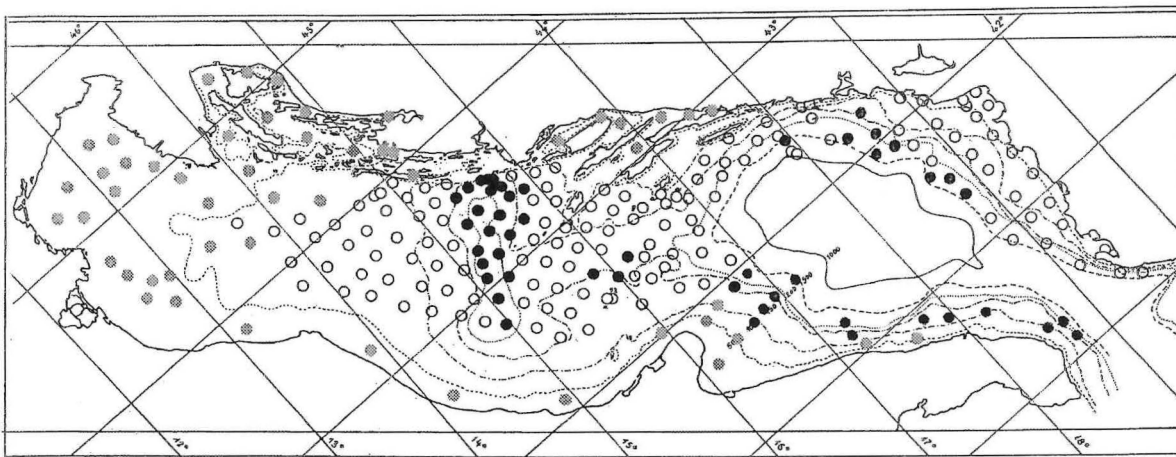


Fig. 1. *Gadiculus argenteus argenteus* ● and *Merlangius merlangus* ○: Horizontal distribution in the Adriatic Sea

Table 2. The Adriatic Gadidae, Lothidae and Phycidae relations to the bottom substratum (Numbers denote average number of specimens per trawl haul: + species present; ++ common species; +++ very common species; - absent)

Species:	Bottom substratum			
	Rocky	Sandy	Loamy	Muddy Clayey
<i>Gadiculus argenteus argenteus</i>	-	9.2	202.4	241.5
<i>Merlangius merlangus</i>	-	27.8	16.7	
<i>Micromesistius poutassou</i>	-	90.9		29.8
<i>Trisopterus minutus</i>	-	64.0	101.7	125.5
<i>Molva macrophthalma</i>	-	-	+	++
<i>Phycis phycis</i>	+++	-	-	
<i>Phycis blennioides</i>	-	0.8	77.7	12.9
<i>Gaidropsarus biscayensis</i>	-	0.3	3.3	1.9
<i>Gaidropsarus mediterraneus</i>	++	-	+	+
<i>Gaidropsarus vulgaris</i>	+	-	+	+

along the Moroccan coast, also in the western Mediterranean and Adriatic (SVETOVIDOV, 1986; BAUCHOT, 1987; COHEN *et al.*, 1990). They are abundant in the Adriatic, but don't enter the shallower northern Adriatic, northward of the Jabuka Pit (middle Adriatic) where they are common and numerous fish (Fig. 1). Occur in large schools over mud, muddy sand, gravel and rock bottoms (SVETOVIDOV, 1986; BAUCHOT, 1987; COHEN *et al.*, 1990), preferring in Adriatic mainly muddy (202.4 - 241.5 specimens per trawl haul), more rarely fine muddy-sandy bottoms ($\chi^2=204.8$; $d.f=2$; $P > 0.05$) (Table 2). It's bathyphilous species recorded from the Adriatic trawl catches at 70 up to 660 m, presumably reach greater depths. Commonly inhabits depths between 200 and 400 m (238.7 - 281.8 specimens per trawl haul) ($\chi^2=267.7$; $d.f=3$; $P > 0.05$ (Table 3, Fig. 2).

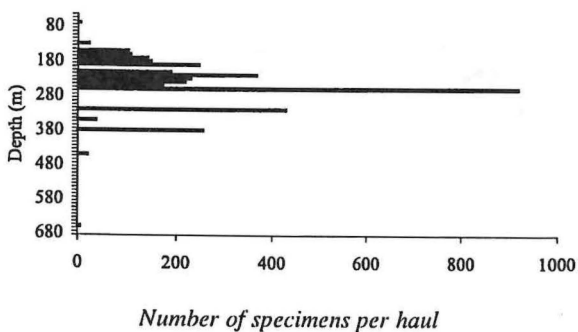


Fig. 2. Vertical distribution of *Gadiculus argenteus argenteus* in the eastern Adriatic

Merlangius merlangus (LINNAEUS, 1758)

It's benthopelagic temperate (35°N - 72°N) species, from near the bottom to the surface, distributed in northeast Atlantic from the southern Barents Sea and Iceland to Portugal, also in the Black Sea, Aegean and Adriatic Sea; rare in the northwestern Mediterranean (SVETOVIDOV, 1986; BAUCHOT, 1987; COHEN *et al.*, 1990). They are found mainly in the shallow and open part of the northern Adriatic, less in the channel area, and more rare along the Italian coast (Fig. 1). They are also rare in the middle Adriatic channels. Inhabit equally fine sandy and muddy bottoms (16.7 - 27.8 specimens per trawl haul) (Table 2) ($\chi^2=2.8$; $d.f=1$; $P > 0.05$), but also were found on gravel, hard sand and rock (COHEN *et al.*, 1990). Their most common habitat is the continental shelf. It is caught at depths from 20 to 120 m, particularly between 20 and

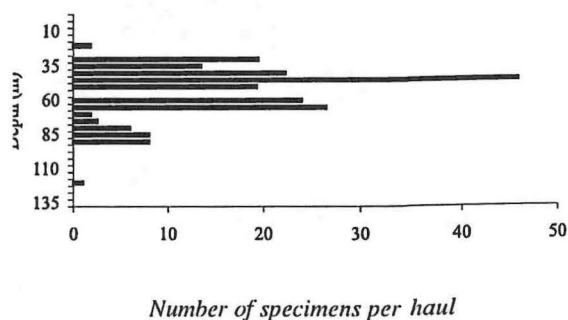


Fig. 3. Vertical distribution of *Merlangius merlangus* in the eastern Adriatic

Table 3. The Adriatic Gadidae, Lotidae and Phycidae - relations to the depth (numbers denote average number of specimens per trawl haul + species present; ++ common species; +++ very common species, - absent)

Species:	Depth (m)						
	< 50	50-100	100-200	200-300	300-400	400-500	> 500
<i>Gadiculus argenteus argenteus</i>	-	-	118.2	281.8	238.7	14.6	up to 660 m
<i>Merlangius merlangus</i>	26.1	11.7	3.2	-	-	-	-
<i>Micromesistius poutassou</i>	0.5	2.8	25.1	68.2	219.5	7.1	up to 660 m
<i>Trisopterus minutus</i>	8.6	49.1	102.6	101.1	10.4	+	-
<i>Molva macrophthalma</i>	-	+	+	++	++	++	up to 700 m
<i>Phycis phycis</i>	++	++	+	+	+	-	-
<i>Phycis blennioides</i>	+	0.3	3.0	3.7	7.4	8.7	up to 1100 m
<i>Gaidropsarus bysacensis</i>	0.1	0.3	1.8	4.0	+	+	up to 590 m
<i>Gaidropsarus mediterraneus</i>	++	+	+	+	+	-	-
<i>Gaidropsarus vulgaris</i>	+	+	+	-	-	-	-

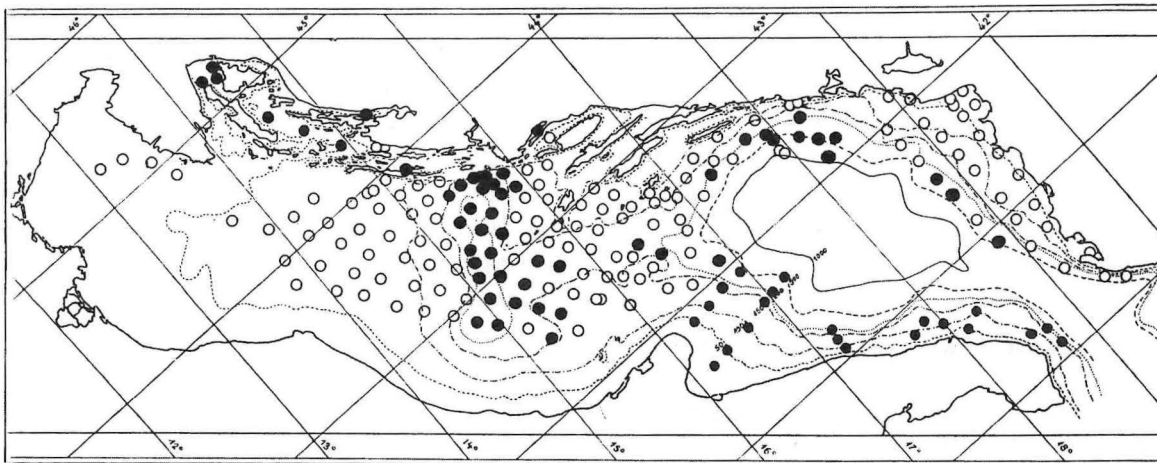


Fig. 4. *Micromesistius poutassou* ●: Horizontal distribution in the Adriatic Sea

40 m (26.1 specimens per trawl haul) ($\chi^2 = 19.6$; $d.f = 2$; $P > 0.05$) (Table 3, Fig. 3). Whole depth range of this species is from 10 to 200 m (SVETOVIDOV, 1986; BAUCHOT, 1987; COHEN *et al.*, 1990).

Micromesistius poutassou (RISSO, 1827)

It's also pelagic species of the temperate seas (26°N - 79°N) which makes daily vertical migrations: in surface waters at night and near the bottom during the day. They inhabit the northwest Atlantic, northeast Atlantic (Barents Sea, eastern Norwegian Sea, around Iceland), western Mediterranean and Adriatic (SVETOVIDOV, 1986; BAUCHOT, 1987; COHEN *et al.*, 1990). It's distributed in the channels of the northeastern Adriatic and in the middle and

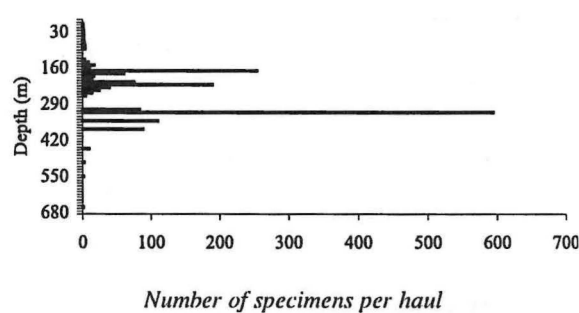


Fig. 5. Vertical distribution of *Micromesistius poutassou* in the eastern Adriatic

southern Adriatic (Fig. 4). The species is abundant in the southern Adriatic. Reside sandy and muddy bottoms of coarser granulometric structure (90.9 - 101.7 specimens per trawl haul) (Table 2) ($\chi^2 = 40.5$; $d.f = 2$; $P > 0.05$). Abound

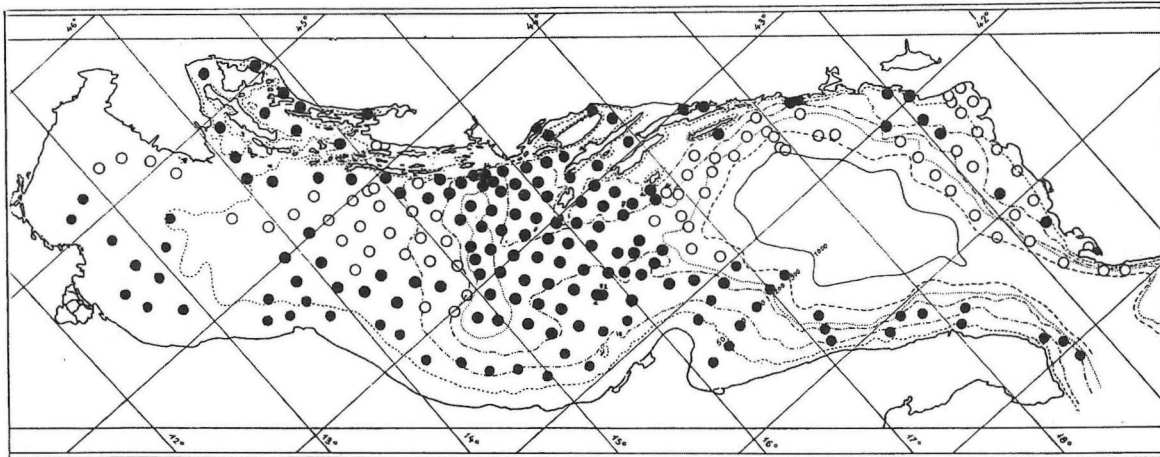


Fig. 6. *Trisopterus minutus* ●: Horizontal distribution in the Adriatic Sea

over the continental slope and shelf to more than 1000 m, but more common at 300 - 400 m. In Adriatic it was found between 5 and 660 m depths, mainly deeper than 100 m, the most numerous was between 300 and 400 m (219.5 specimens per trawl haul) ($\chi^2=669.9$; $df=5$; $P > 0.05$) (Table 3, Fig. 5).

Trisopterus minutus (LINNAEUS, 1758)

It's benthopelagic species of the temperate seas (28°N - 66°N) found in eastern Atlantic from the Trondheim Fjord and the Faeroe Islands to Portugal and along the Atlantic coast of Morocco; also in the Mediterranean and Adriatic Sea (SVETOVIDOV, 1986; BAUCHOT, 1987; COHEN *et al.*, 1990). It's one of the most abundant and widely distributed Gadidae in the Adriatic. They are distributed all over the Adriatic, except the northernmost part and deep southern Adriatic Pit (Fig. 6), better in the open

sea than in the channel area. It inhabits all types of bottoms in deeper sea, predominantly muddy ones (125.5 specimens per trawl haul) ($\chi^2=23.4$; $df=2$; $P > 0.05$) (Table 2). It's caught in the Adriatic between 8 and 500 m, mainly between 100 and 300 m depth (101.1 - 102.6 specimens per trawl haul) ($\chi^2=158.1$; $df=4$; $P > 0.05$) (Table 3, Fig. 7).

Family Lotidae

Adriatic Lotidae fishes belong to two genera: *Molva* and *Gaidropsarus* and four species. Horizontal and vertical distribution of these genera is stated below:

Molva macrophthalma (RAFINESQUE, 1810)

It's bathyphilous and demersal species of the temperate marine zone (28°N - 57°N) known in the eastern Atlantic from the Irish Atlantic slope south, including the western Mediterranean and Adriatic Sea (SVETOVIDOV, 1986; BAUCHOT, 1987; COHEN, 1984; COHEN *et al.*, 1990). In the Adriatic it's distributed almost exclusively in the area of the south Adriatic, where they are rather numerous and common (BELLO and RIZZI, 1988) (Fig. 8). Caught in the Adriatic on muddy bottoms (Table 2) between 70 and 700 m depth (in high significances). They are the most abundant at 200 to 500 m i.e. in the upper part of the continental slope or bathyal (Table 3). According to

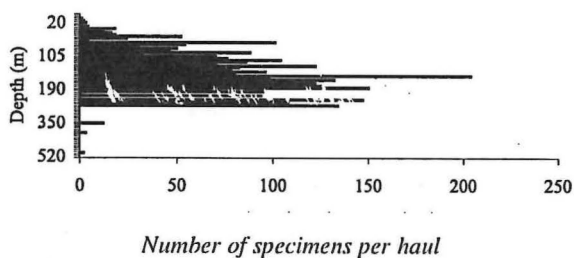


Fig. 7. Vertical distribution of *Trisopterus minutus* in the eastern Adriatic

BAUCHOT (1987) and COHEN *et al.* (1990) they occur on upper slope and reach 1000 m depth.

***Gaidropsarus biscayensis* (COLLETT, 1890)**

It's demersal and benthopelagic species of the temperate seas (46°N - 31°N) distributed in eastern central Atlantic from Spain and Portugal to Morocco and Madeira Islands, also in western Mediterranean, northern part of central Mediterranean and Adriatic (SVETOVIDOV, 1986; BAUCHOT, 1987; COHEN *et al.*, 1990). It's distributed in the middle Adriatic including the channel area and southern Adriatic (Fig. 8), and are also numerous in the open sea area. Resides both muddy and sandy bottoms ($\chi^2 = 1.49$; $df = 2$; $P > 0.05$) (Table 2). According to SVETOVIDOV (1986) and COHEN *et al.*, (1990) it's found in offshore waters on mud, shelly and coral bottoms at depth range between 80 and 600 m. Caught in the Adriatic between 20 and 600 m, probably reach greater depths ($\chi^2 = 6.37$; $df = 3$; $P > 0.05$). More frequently resides the upper part of the continental slope or bathyal, which is between 200 and 300 m depth (Table 3).

***Gaidropsarus mediterraneus* (LINNAEUS, 1758)**

It's demersal, temperate (in seawater between 5° and 18° C) and shallow water species found in eastern Atlantic, from Norway to

southwest and south coasts of Europe, along the northwest African coast, in Black Sea and Adriatic (SVETOVIDOV, 1986; BAUCHOT, 1987; COHEN *et al.*, 1990). Lives generally at shallow waters near the shores on rocky bottom with aquatic vegetation down to 60 m depth (COHEN *et al.*, 1990). In the Adriatic Sea it's distributed in the channel and open areas, recorded from catches of the middle and southern Adriatic. Only one specimen has been found in channels of northern Adriatic (Fig. 8). It isn't numerous, but it's more abundant in the land coastal area than in island area. Occurs at different substrata, from markedly rocky to sandy and muddy bottoms, although it seems to prefer mixed rocky - muddy bottoms (Table 2). It's vertical distribution ranges between 1 and 450 m, more numerous at depths less than 30 m (Table 3). They were mainly caught with trammel nets rather than trawlers.

***Gaidropsarus vulgaris* (CLOQUET, 1824)**

This demersal and temperate (64°N - 34°N) species is distributed in northeast Atlantic from the central Norwegian coast and Island to the region around the Strait of Gibraltartar, also in the western and northern coasts of the Mediterranean and in the Adriatic Sea (SVETOVIDOV, 1986; BAUCHOT, 1987; COHEN *et al.*, 1990). It's generally rare, the rarest of all Lotidae representatives in the Adriatic. Probably allopathic

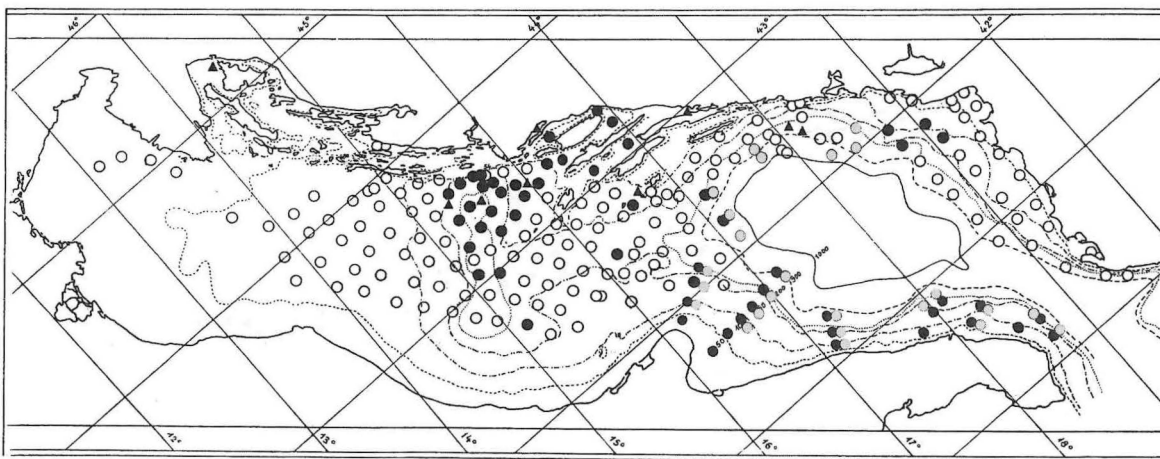


Fig. 8. *Gaidropsarus biscayensis* ●, *Gaidropsarus mediterraneus* ▲ and *Molva macrophthalmus* ○ : Horizontal distribution in the Adriatic Sea

with relative species *Gaidropsarus mediterraneus*, and seems to prefer deeper areas. In the last four years four specimens have been found in trawl catches from the islands of Lastovo and Mljet area and from the southern Adriatic area (Dubrovnik, Split fish market), Depth of trawl hauls ranged from 80 to 200 m (Table 2), whereas there were no available data of bottom structure characteristics (Table 3). It was generally reported to occur in the inshore waters, on rocky bottoms, but also on mud, sand and gravel, and between 10 and 120 m depth. (COHEN *et al.*, 1990).

Family Phycidae

Adriatic Phycidae fishes belong to one genus: *Phycis* and two species. Horizontal and vertical distribution of these genera is stated below:

Phycis blennoides (BRÜNNICH, 1768)

It's benthopelagic, bathyphilous species of the temperate areas (between 30°N and 69°N) inhabiting in the Adriatic mainly the open sea and rarely channels (Fig. 9). It's the most abundant in the southern Adriatic, inhabit the sandy and muddy bottoms and preferring finer muddy sediments ($\chi^2 = 15.51$; $d.f. = 2$; $P > 0.05$) (Table 2). It's caught at depth ranging from 18 to 1100 m, facts indicate their eurybathyal character, mainly at depths deeper than 300 m ($\chi^2 = 10.12$;

$d.f. = 4$; $P > 0.05$) (Table 3; Fig. 10). They were recorded at 600, 660, 700, 800 and 1100 m depth. This species is distributed in eastern Atlantic, from Norway and Iceland to Cape Blanc, West Africa, also in the Mediterranean and Adriatic (SVETOVIDOV, 1986; BAUCHOT, 1987; COHEN *et al.*, 1990). It was found over sand and mud bottoms. Young are more coastal and found on the continental shelf, while adults migrate along the slope.

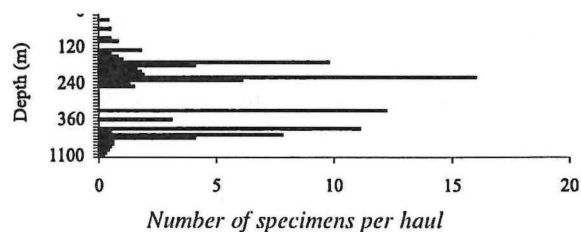


Fig. 10. Vertical distribution of *Phycis blennoides* in the eastern Adriatic

Phycis phycis (LINNAEUS, 1758)

This benthopelagic and subtropical (45°N - 13°N) species is distributed in northeast Atlantic from Bay of Biscay to Morocco south to Cape Verde, also in the Mediterranean and Adriatic (SVETOVIDOV, 1986; BAUCHOT, 1987; COHEN *et al.*, 1990). It was found mainly in shallow water on hard rocky bottoms along the all eastern Adriatic coast and western Adriatic

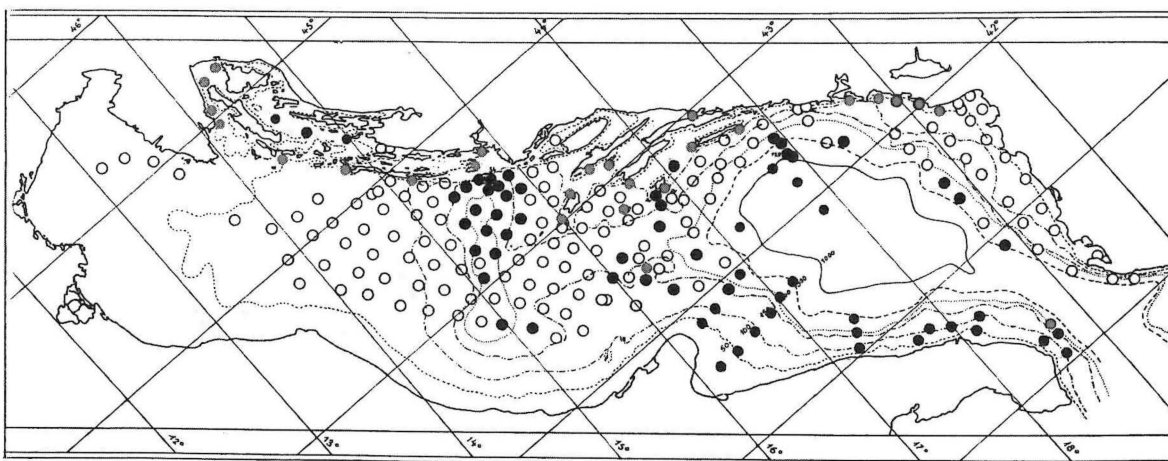


Fig. 9. *Phycis phycis* ● and *Phycis blennoides* ●: Horizontal distribution in the Adriatic Sea

coast south from Monte Gargano Cape (Fig. 9). Most abundant and very common species around outer middle and south Adriatic islands: (Sv. Andrija, Biševo, Vis, Sušac, Palagruža, Mljet, Lastovo). Resides predominantly hard (rocky bottoms) but also (much scarcely) were found on trawling grounds (Table 2). It was recorded from 5 - 370 m depth range, mainly between 20 and 70 m (Table 3; Fig. 11). According to COHEN *et al.* (1990), *Ph. phycis* was found on hard and sandy-muddy bottoms near rocks at 100 - 600 m, but sometimes taken at greater depths.

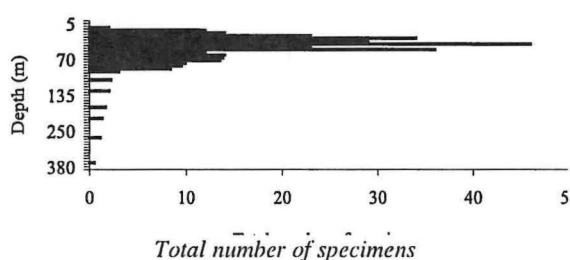


Fig. 11. Vertical distribution of *Phycis phycis* in the eastern Adriatic

The data about horizontal distribution and some basic ecological requirements (including bathymetric distribution as well as relation to sea bottom sediments) of fish species of Gadidae, Lotidae and Phycidae families in the Adriatic Sea and in the neighbouring Ionian and Aegean Sea are rather numerous in available literature, primarily due to fisheries importance of some their representatives and many researches of trawl settlements in the mentioned sea areas over the last ten years (VASSILOPOULOU *et al.*, 1998; VACCARELLA *et al.*, 1992; UNGARO *et al.*, 1998; TURSÌ *et al.*, 1992; RELINI, 1998; PAOLINI *et al.*, 1995; MARANO *et al.*, 1994, 1998; D'ONGIA *et al.*, 1989, 1998; VRGOČ, 2000).

In FAO Fishery Statistics (2000) for the Mediterranean, landings for five fish species of mentioned families are separately listed, while other species are probably included in the "other Gadiformes" category. However, recent statistical data for the eastern Adriatic Sea are not available. *Micromesistius poutassou* is currently

the most exploited gadiform species in the Mediterranean, and its catches show a trend of constant increase: 17,929 mt (1995) to 32,516 mt (1998). The reason for this probably lies in the fact that deeper areas of the sea (deeper than 200 m) are subjected to exploitation, where this species is far more abundant. According to author's data, the most abundant population in the Adriatic Sea was established between 300 and 400 m depth, ranges from 5 to 660 m, while in the Taranto Bay it was caught even at 715 m depth (D'ONGIA *et al.*, 1998). According to MEDITS Programme data (VRGOČ, 2000) this species in the Adriatic Sea was found in depths ranged between isobate from 50 to 100 m, 100 to 200 m and over 200 m, although it was the most abundant in the area deeper than 200 m (Table 4). It was also far more abundant above muddy than above sandy bottoms (VRGOČ, *op. cit.*). It is interesting to note that UNGARO *et al.* (1998) do not mention it at all in the SW Adriatic area between 19 and 654 m depth. For now, its catches along the eastern Adriatic Sea coast does not exceed above 4 mt per year (JARDAS, 1996).

The catches of *Merlangius merlangus* species show in the Mediterranean a slight decrease in recent year: 18,675 mt (1995) to 14,030 mt (1998), which can be explained by over fishing of shallow trawl fishing areas inhabited by this species (Table 4). According to the available data, vertical distribution of this species hardly exceeds 200 m depth (author's data; GIOVANARDI and RIZZOLI, 1983; COHEN *et al.*, 1990; VRGOČ, 2000) (Table 4). Due to its limited distribution, mostly in the open northern Adriatic, annual catches along the eastern Adriatic coast don't exceed about 5 mt (JARDAS, 1996).

The catches of *Trisopterus minutus* species are also in a slight decrease in the Mediterranean: 586 mt (1995) to 428 mt (1998), probably due to the same reason as for the previously mentioned species. Due to its widespread distribution in the Adriatic Sea (FROGLIA, 1981; TANGERINI and ARNERI, 1983; UNGARO *et al.*, 1998; author's data) (Table 4) its catches in

Table 4. Range and optimal depth of Gadidae, Lotidae and Phycidae species in the Adriatic and whole distribution area

Authors	Present study	Jardas, 1996	Cohen <i>et al.</i> , 1990	Ungaro <i>et al.</i> , 1998	Vrgoč, 2000
Study area	Adriatic	Adriatic	Whole area	SW Adriatic	Adriatic
Depth (m)	Range (optimal)	Range (optimal)	Range (optimal)	Range (optimal)	Range (optimal)
<i>Gadiculus argenteus argenteus</i>	70 – 660 (200 – 400)	50 – 1100 (100 – 1000)	110 – 1000 (200 – 600)	– –	50 – >200 (>200)
<i>Micromesistius poutassou</i>	5 – 660 (300 – 400)	50 – 1100 (200 – 400)	150 – 1000 (300- 400)	– –	50 – >200 (> 200)
<i>Trisopterus minutus</i>	8 – 500 (100 – 300)	20 – 400 (< 300)	15 – 400 (15 – 200)	38 – 181 (78 – 135)	<50 – >200 (100 – 200)
<i>Merlangius merlangus</i>	20 – 120 (20 – 40)	5 – 200 (30 – 100)	5 – 200 (30 – 100)	– –	<50 – >200 (< 50)
<i>Molva macrophthalma</i>	70 – 700 (200 – 500)	200 – 1000 (350 – 500)	150 – 1000 (350 – 500)	225 – 527 (225 – 424)	100 – >200 (> 200)
<i>Gaidropsarus biscayensis</i>	20 – 600 (200 – 300)	120 – 600 –	80 – 600 –	38 – 654 (79 – 354)	<50 – >200 (100 – >200)
<i>Gaidropsarus mediterraneus</i>	1 – 450 (< 30)	1 – 400 (< 50)	1 – 450 (1 – 60)	– –	>200 (> 200)
<i>Gaidropsarus vulgaris</i>	80 – 200 –	10 – 120 –	10 – 120 –	– –	– –
<i>Phycis blenniodes</i>	18 – 1100 (200 – 400)	60 – 1100 (< 400)	10 – 800 (100 – 450)	127 – 654 (225 – 527)	50 – >200 (> 200)
<i>Phycis phycis</i>	5 – 370 (20 – 70)	5 – 270 (20 – 70)	100 – 650 (100 – 200)	– –	50 – 100 (50 – 100)

the eastern part reach the amounts to approximately 30 mt (JARDAS, 1996).

Gadiculus argenteus argenteus, the fourth species of the Gadidae family, is not of fisheries importance at all, although it is abundant in the Adriatic Sea (ŽUPANOVIĆ and JARDAS, 1989; VRGOČ, 2000) (Table 4). The fishes of Lotidae family (*Gaidropsarus* genus) also haven't any fishery importance, except *Molva macrophthalma*, but its catches in the Mediterranean hardly reach about 1 mt (1997-1998). According to the latest investigations (UNGARO *et al.*, 1998; VRGOČ, 2000) this species is relatively abundant in deeper areas (> 200 m) of the South Adriatic Pit (Table 4). Species as *Gaidropsarus mediterraneus* and *G. vulgaris* are allopatric, the former of which inhabits shallow waters, and the later inhabits deeper waters. The same can be said for the *Phycis phycis* and *Ph. blenniodes*

species (Table 4) (D'ONGIA *et al.*, 1989, 1998; COHEN, *et al.*, 1990; UNGARO *et al.*, 1998; VASSILOPOULOU *et al.*, 1998; VRGOČ, 2000). According to FAO Fisheries Statistics data (2000) the catches of *Ph. blenniodes* species in the Mediterranean are in slight increase: from 246 mt (1995) to 310 mt (1998), due to exploitation of deeper trawl fishing areas (deeper than 300 m). Along the eastern Adriatic coast its fisheries importance is insignificant (JARDAS, 1996), because trawl fishing is not performed in the areas deeper than 300 m. Other allopatric species, i.e. *Ph. phycis*, which mostly inhabit rocky coastal area of the eastern Adriatic Sea is more abundant, so its presence in the catches from that parts of the Adriatic Sea is more considerable - about several tones per year (JARDAS, 1996).

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Horizontalna i vertikalna rasprostranjenost predstavnika porodica Gadidae, Lotidae i Phycidae u istočnom Jadranu

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SAŽETAK

U Jadranu je sa sigurnošću utvrđena prisutnost četiriju rodova, četiri vrste i jedne podvrste porodice Gadidae, dva roda i četiri vrste porodice Lotidae, te dva roda i dvije vrste porodice Phycidae. Ove porodice obuhvaćaju vrste različitih ekoloških preferencija i vrlo raznolike zastupljenosti u Jadranu. Neke su od ovih vrsta uobičajene i dobro rasprostranjene ribe u Jadranskom moru, dok su neke vrlo rijetke i nalaze se samo u određenim područjima. Vrsta *Trisopterus minutus* je vrlo rasprostranjena u Jadranu, a po raširenosti nakon nje slijedi vrsta *Merlangius merlangus* koja je pronađena samo u plićim područjima (posebno u sjevernom Jadranu). Vrste *Micromesistius poutassou*, *Phycis phycis*, *Phycis blennoides* i *Gaidropsarus mediterraneus* su pronađene pretežito u srednjem i južnom Jadranu, dok je vrsta *Molva macrophthalma* zastupljena samo u južnom Jadranu. Od svih proučavanih vrsta šest ih pokazuje batifilna svojstva, a rasprostranjene su pretežito na kontinentalnom slazu ili batijalu (ispod 200 m dubine). Četiri vrste se pojavljuju skoro isključivo na području kontinentalnog šelfa do 200 m. Većina vrsta preferira muljevita (pretežito glinasta) dna.

Ključne riječi: Gadidae, Lotidae, Phycidae, horizontalna distribucija, rasprostranjenost na dnu, raspodjela dubine, rasprostranjenost prema vrsti dna, istočni Jadran

