ISSN: 0001-5113
AADRAY

ACTA ADRIAT.
35 (1/2): 69 - 82, 1994

UDC: 597 (262.35)
Original scientific paper

Ichthyological analysis of catches from the Mirna Estuary - eastern Adriatic

Miro KRALJEVIĆ, Jakov DULČIĆ, Ivo KAČIĆ, Armin PALLAORO and Ivan JARDAS

Institute of Oceanography and Fisheries, Split, Croatia

Mirna Estuary has been fished once per year for more than 900 years. Ichthyological analyzes started in 1989. Material was collected by special constructed big seine net for this area. Twelve species were captured, though 4 of these are of commercial point. Family Mugilidae was numerically dominant and constituted 93.6% of total catch (8 year period) while Liza aurata *and* Liza ramada *constituted 89.0 and 6.6% of that procent, respectively. All other species were represented in very small numbers of which* Lithognathus mormyrus *(4.1%) and* Dicentrarchus labrax *(1.7 %) were mostly abundant. Total length-weight relationship and condition factor were calculated for these comercial species. On the basis of age, maturity of individuals, length frequency distribution according to first maturity, mean total length of analyzed specimens and exploitation ratio (E), we concluded that the fishing pressure exerted on the golden and thin-lipped mullet were light (underfished stock), while the population of the sea bass (E=0.554) and striped sea bream (E=0.499) in a sufficient fishing condition in the area under study.*

INTRODUCTION

The Mirna Estuary is specific and productively rich habitat of a large number of commercial fish species. Traditionally, estuary has been fished once or twice a year for more than 900 years (PLANČIĆ, 1952).

The Mirna Estuary has for centuries been either the property of different owners or rented as a place of very profitable fishing. German - Roman king Otto III, by his Chart of the year 983 AD confirmed the rights of Poreč Diocease to fish in Mirna Estuary. These rights were later confirmed by Henry, the king of Franks and Lombards, in 1060 AD and the emperor Rudolph Habsburg in 1291 AD. The beginning of the proper management of this area may be traced back to the year 1760 and in 1792 the Poreč Diocese authorized the Poreč - Rovinj municipalities for fishing in this area (ZJAČIĆ, 1973).

The Mirna Estuary is situated on the western coast of the Istrian penninsula, Eastern Adriatic (13°30'N, 45°20'E) (Fig.1).

Depth at the estuary entrance reaches 23 m to be reduced in its inner parts to 8 m in the Tar Cove, somewhere not exceeding 3 m. The Mirna River discharges into Mirna Bay northeast of the small town Novigrad, the easternmost and shallowest part of the bay called Tar Cove. Delta-like end of the Mirna River mouth, flooded plains, shoal belt and gradual increase of depth from the eastern bay part (Tar Cove) westward and offshore show that settling of particles carried by the river is going on pointing to the fact that Tar Cove is the residue of sub-

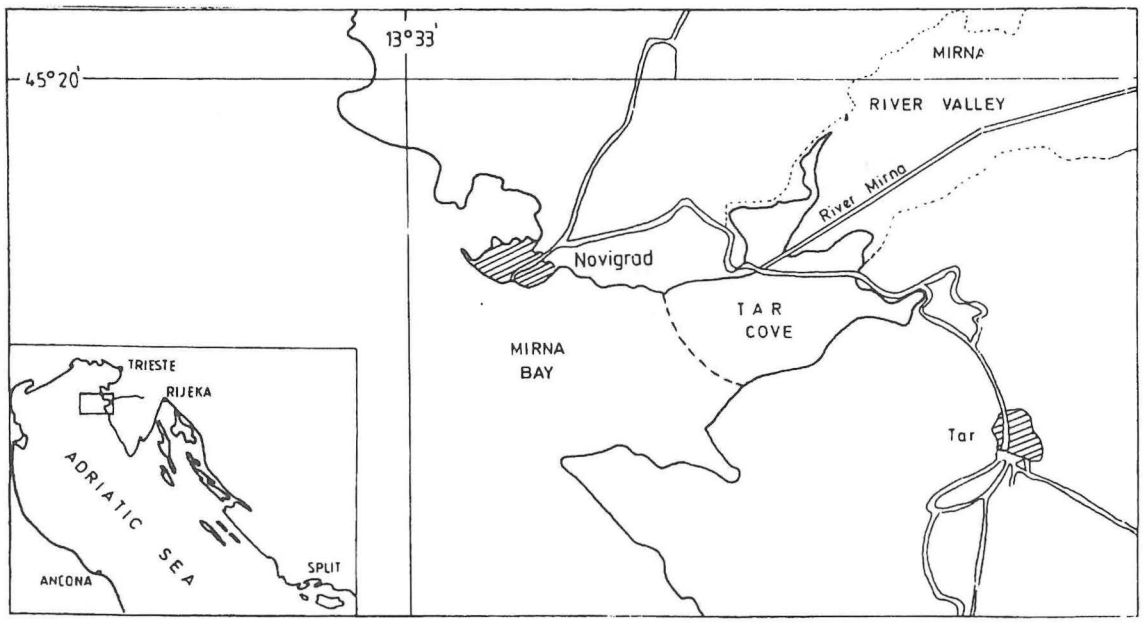

Fig. 1. The map of the study area, Mirna Estuary.

merged Mirna River valley (VESNAVER, 1905; BASIOLI, 1956).

We started a preliminary fishery-biology research of Mirna estuary in 1989. The scope of this work was to study quantitative-qualitative, length-weight catch structure and to establish the percentage of immature specimens with a final goal of fish species protection and developement of appropriate management practices in this peculiar environment.

MATERIAL AND METHODS

Material was collected in winter (December 1989, 1990, 1991) by specially constructed tow nets with beg - "ciplarice" (mullet nets). These nets are used only in the area of the Mirna Estuary. The total length of a net is 1450 m. They are set so as to enclose the whole bay from one side to the other (north-south) at a length of 1300 to 1350 m (see Fig. 1 - dashed line). Net is deep from 15 to 30 m. Mesh diameter is 22 mm. Prior to fishing operations the entrance of a larger quantities of fish into the estuary, or in fact into the Tar Cove is observed. Upon the entrance of the fish the nets are set one after another. Since the enclosed area is very large, fish could be impounded for several days. In the end, fish is pulled out in the Tar Cove. Random samples were taken for ichthyological analyses out of the total catch. Analyzed fish quantities expressed in percentages by years are given in Table 1.

Table 1. Analyzed catch quantities from Mirna Estuary.

Year	Total catch (kg)	Analyzed catch kg	%
1989	27 428	103	0.37
1990	75 006	156	0.21
1991	18 445	216	1.17

Fish were determined by the key for species identification (ŠOLJAN, 1975). Total length (TL) and weight (W) were taken from each analyzed specimen to the nearest 0.1 cm and 1 g, respectively.

Total length-weight relationship was expressed as:

$$W=aL^b,$$

where W=the weight, L=the length and a and b are constants, commonly used by fishery biolo-

Table 2. Total quantity (kg, %) of catches for the 1983-1991 by the best represented species

Familiae / Species	Market size	YEAR																	
		1983		1984		1985		1986		1987		1989		1990		1991		Total	
	kg	kg	%	kg	%	kg	%	kg	%	kg	%	kg	%	kg	%	kg	%	kg	%
Mugilidae		6216	98.71	19802	96.87	37934	96.29	4350	83.52	3220	81.27	22100	80.58	72000	95.99	17990	97.51	183612	93.59
L. mormyrus	> 0.25	-	-	-	-	161	0.42	-	-	156	3.94	3000	10.94	642	0.86	68	0.36	4027	2.05
L. mormyrus	0.25-0.10	-	-	102	0.50	220	0.56	32	0.61	202	5.10	1300	4.74	1300	1.73	103	0.55	3259	1.66
L. mormyrus	< 0.10	21	0.33	-	-	266	0.67	-	-	-	-	171	0.62	235	0.31	21	0.11	714	0.36
D. labrax	> 0.25	34	0.54	420	2.05	788	2.00	52	1.00	230	5.81	840	3.06	755	1.01	220	1.19	3339	1.70
S. salpa	> 0.20	-	-	36	0.18	-	-	22	0.42	117	2.95	-	-	-	-	10	0.05	185	0.09
S. salpa	0.20-0.10	-	-	-	-	-	-	510	9.79	-	-	-	-	-	-	-	-	510	0.26
S. aurata	> 0.25	-	-	-	-	-	-	5	0.10	-	-	-	-	-	-	2	0.01	7	0.00
S. aurata	< 0.25	26	0.42	8	0.04	-	-	17	0.33	10	0.25	3	0.01	47	0.06	6	0.03	117	0.06
L. amia		-	-	-	-	-	-	67	1.29	-	-	2	0.01	11	0.02	10	0.05	90	0.05
T. mediterraneus		-	-	-	-	-	-	20	0.38	-	-	-	-	-	-	3	0.02	23	0.01
U. cirrosa		-	-	-	-	25	0.06	-	-	-	-	-	-	6	0.01	10	0.05	41	0.02
D. annularis		-	-	36	0.18	-	-	-	-	-	-	-	-	-	-	-	-	36	0.02
M. mustelus		-	-	-	-	-	-	133	2.56	-	-	-	-	-	-	12	0.07	145	0.07
Others		-	-	38	0.18	-	-	-	-	27	0.68	12	0.04	10	0.01	-	-	87	0.04
Total		**6297**	**100.0**	**20442**	**100.0**	**39394**	**100.0**	**5208**	**100.0**	**3962**	**100.0**	**27428**	**100.0**	**75006**	**100.0**	**18455**	**100.0**	**196192**	**99.98**

* 1988 cove was not fished

gist (RICKER, 1975), was calculated by program FB 1 (PAULY, 1984). Condition factor (CF) was also calculated as:

$$CF = \frac{W}{L^3} \times 100 .$$

The stage of maturity of their reproductive organs and the percentage of immature individuals of fish species caught in the largest quantities (*Liza aurata, Liza ramada, Lithognathus mormyrus* and *Dicentrarchus labrax*) during fishing operations were determined (ŽUPANOVIĆ, 1958; after MOROVIĆ, 1960).

Age was determined on the basis of reading scale rings under stereo-microscope at 400-fold magnification.

Scales have been taken always from the back of the belly fin, at the height of the lateral line. For estimation of L_∞ and K we used the program ELEFAN II. We used this program also for estimation of natural mortality (M) using estimates of L_∞, K and mean temperature based on PAULY's (1983) empirical equation and estimation of $F = Z - M$, where F is fishing mortality and Z is total instantaneous mortality rate.

Exploitation ratio was calculated by equation:

$$E = F / Z .$$

Method of annual fish growth studies by scale readings proved suitable for Mugilidae family since the scales are big enough to be easily read. We also used this method since it is common in fishery-biology practice and was used also by JACOT (1920), HELDT (1948) and MOROVIĆ (1960).

RESULTS

Family Mugilidae has been the best represented (93.59%; 183612 kg) (Table 2) in the Mirna Estuary catches for the past eight years, that is ever since the weight proportion of fish in catches by species began to be observed. Earlier data refered only to the total catch quantities (Table 3).

Table 3. Total catch quantities for period 1978 to 1982

Year	Catch quantities (kg)
1978	13 182
1979	12 166
1980	32 038
1981	33 338
1982	54 840

Of other fish species Striped sea bream (*Lithognathus mormyrus* L.) provided 4.1% (8000 kg) of the total catches and Sea bass (*Dicentrarchus labrax* L.) 1.7% (3339 kg). The quantities of all the other fish species (Table 3) were quite insignificant (> 1.0%) with the dominance of *Sarpa salpa* with 0.4%. Quantities of fish species were variable from one year to another. For example, the quantity of Mugilidae family had fallen from a maximum of 98.7% (1983) to a minimum of 80.6% (1989). Even the species the percentage of which did not exceed 1% of the total catch showed quantity variations. Salema (*Sarpa salpa* L.), for example, in some years mounted up to 10.2% (1986) whereas they were completely absent in some years (1983, 1985, 1989, 1990).

Tables 2 and 3 show marked differences in annual catch quantities (from 75006 to 3962 kg) with the mean 26288 ± 20924 kg. Of six mullet species in the Adriatic (*Liza aurata, Liza ramada, Liza saliens, Mugil cephalus, Chelon labrosus* and *Oedalechilus labeo*), five were recorded from the Tar Cove. Table 4 demonstrate quantitative-qualitative structure of analyzed individuals.

As shown by Table 4, golden mullet (*L. aurata*) dominated the catches providing 89.0% whereas the quantities of other species were rather small (6.6 - 0.9%).

Annual means of total length and weight of *L. aurata* are shown in Table 5. Length frequency distribution is shown in Fig. 2 and length-weight relationship in Fig. 3.

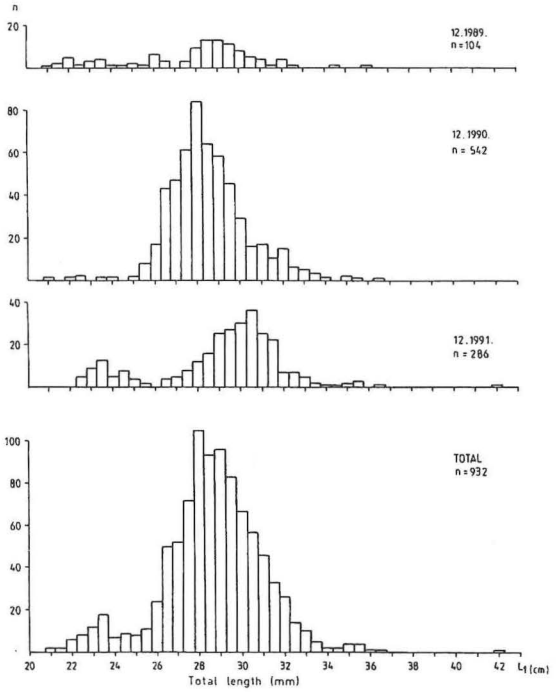

Fig. 2. Length-frequency distribution of *L. aurata* in three winter samples (1989, 1990, 1991) and in total

Table 4. Presence of analyzed individuals of the family Mugilidae as reported by earlier studies of Mirna Estuary (1989, 1990, 1991)

Species	Year 1989	1990 N	1991	N	%
Liza aurata (golden mullet)	104	541	286	931	89.0
Liza ramada (thin-lipped mullet)	5	2	62	69	6.6
Mugil cephalus (flathead mullet)	9	1	14	24	2.3
Chelon labrosus (thick-lipped mullet)	-	-	13	13	1.2
Liza saliens (leapping mullet)	-	9	-	9	0.9
Total	118	553	375	1046	100.0

Table 5. Annual mean lengths $\overline{XL}$ (cm), weights $\overline{XW}$ (g), and their ranges for analyzed individuals (N) of recorded species

Species	Year	$\overline{XL}$ (cm) ±SD	Range (cm)	$\overline{XW}$ (g) ±SD	Range (g)	N	Total N
Liza aurata	1989	27.9±3.02	21.0-36.0	167±55.1	40-430	104	
	1990	29.1±2.21	26.1-41.8	186±57.9	90-541	542	
	1991	29.1±2.84	22.3-36.6	205±58.9	85-358	286	931
Liza ramada	1989	39.5±4.56	33.5-45.0	521±186.0	280-770	5	
	1990	39.3±3.54	36.8-41.8	485±91.9	420-550	2	
	1991	37.7±7.44	29.0-62.0	485±349.8	188-2050	62	69
Mugil cephalus	1989	31.16±6.78	25.0-43.5	311±237.3	130-805	9	
	1990	52.8	-	1510	-	1	
	1991	42.8±7.79	32.0-56.0	824±449.3	348- 1680	14	24
Liza saliens	1990	37.1±4.68	31.6-42.7	474±186.4	245-776	9	9
Chelon labrosus	1991	37.5±4.01	33.5-44.0	569±199.5	357-1016	13	13
Lithognathus mormyrus	1989	24.5±3.32	18.5-31.5	191±82.4	70-395	47	
	1990	26.2±3.29	18.0-35.0	215±85.4	70-493	42	
	1991	25.9±3.75	15.7-32.7	224±92.8	48-502	108	197
Dicentrarchus labrax	1989	35.3±4.44	29.0-39.5	448±172.7	240-660	4	
	1990	47.6±15.47	31.2-80.0	1377±1445.7	297-5268	21	
	1991	41.2±10.10	30.5-88.0	888±1092.1	275-7300	68	93
Sparus aurata	1989	20.0±1.89	17.5-23.5	109±39.9	70- 190	10	
	1990	20.8±3.35	17.4-28.0	125±73.3	66-307	13	
	1991	20.7±2.53	18.3-30.2	123±65.5	79-431	49	72
Lichia amia	1989	31.5	-	280	-	1	
	1990	37.5±51.77	35.6-40.1	456±46.4	395-505	6	
	1991	33.7±2.62	27.5-39.0	360±85.2	190-561	27	34
Umbrina cirrosa	1990	45.9±11.35	36.2-61.1	1110±735.4	514-2130	4	
	1991	40.3±3.54	36.5-45.5	691±149.5	508-922	11	15
Alosa fallax nilotica	1990	35.0±4.12	28.0-40.0	348±133.2	197-537	5	
	1991	31.0±5.37	28.0-40.6	217±180.0	121-539	5	10
Sarpa salpa	1991	34.7±2.76	30.4-37.7	532±106.8	367-669	8	8
Trachurus mediterraneus	1989	27.0±1.41	26.0-28.0	145±35.4	120-170	2	2
Loligo vulgaris	1991	29.2±7.39	17.7-40.8	480±280.9	162-1010	6	6

Annual means of total length and weight of *L. aurata* point to a course of slight increase (see Table 5 and Fig. 2). Analyzed specimens of 21.0 to 41.8 cm length range belong from 3^+ to 8^+ and 11^+ year classes.

The growth coefficients of *L. aurata* showed negative allometric growth in 1989, but positive one in 1990 and 1991. The value of b (2.95) in 1989 was not significantly different from 3 ($p > 0.05$) while the values of b in 1990

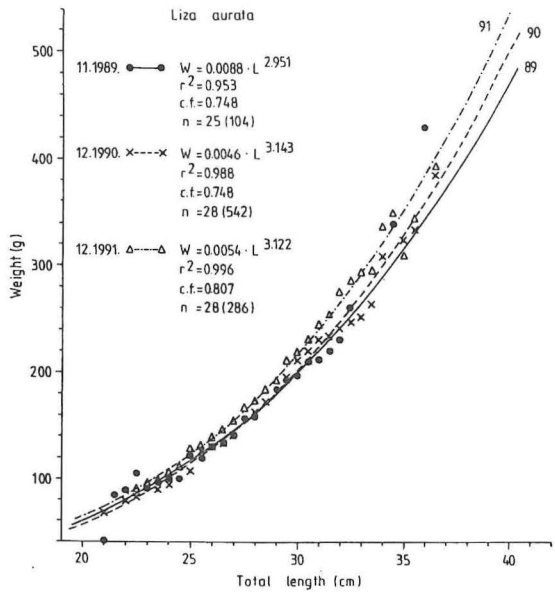

Fig. 3. Length-weight relationship of *L. aurata* from Mirna Estuary

(3.14) and 1991 (3.12) were significantly different from ($p < 0.05$). The value of condition factor was considerably higher in 1991 than in the 1989 and 1990 (see Fig. 3).

The species *L. ramada* of the family Mugilidae followed by 6.6%. The annual means of total length in 1991 was lower than in the two preceeding years. This may be explained by a small number of caught individuals (n=5, n=2 respectively) (see Table 5). Length-frequency distribution shows that almost all caught individuals (n=69) exceeded 30 cm in total length (Fig. 4). Length-weight relationship (calculated for all analyzed specimens) points to a positive allometric growth. The value of b (3.05) was not significantly different from 3 ($p > 0.05$) while the value of condition factor was similar with the value for L. aurata (Fig. 5).

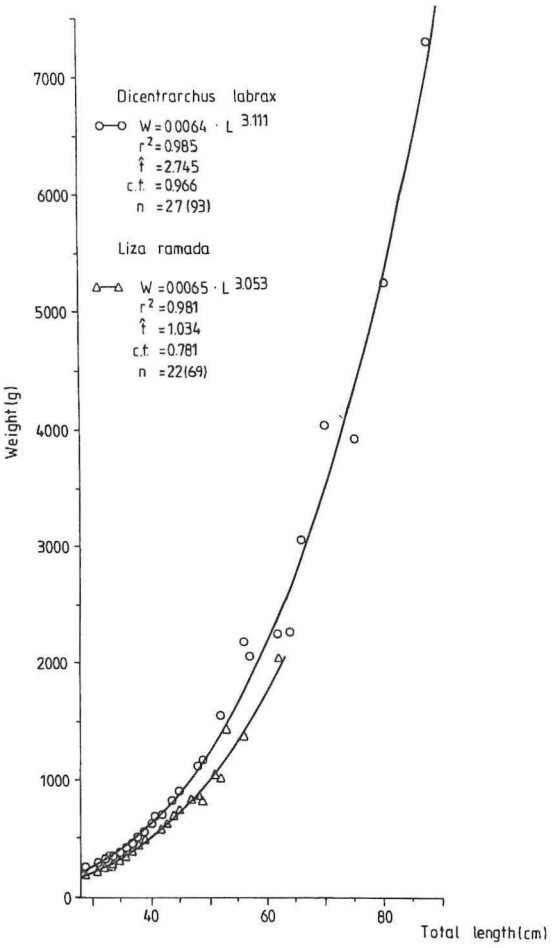

Fig. 5. Length-weight relationship of *L. ramada and D. labrax* from Mirna Estuary

A comparison ot annual mean total lengths and weights of *L. mormyrus* (Table 5) shows their slight and limited increase.

Analyzed specimens caught during all three seasons in Mirna Estuary ranged from 15.5 cm to 35.0 cm in total length (Fig. 6). The growth coefficients showed positive allometric growth of striped sea bream at the beginning of

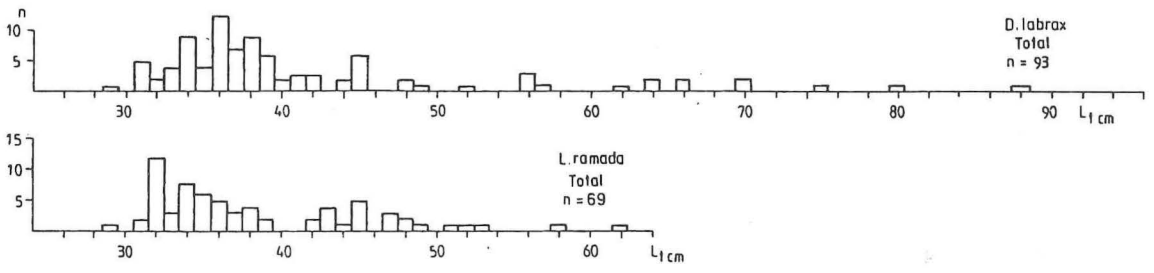

Fig. 4. Length-frequency distribution of L. ramada and D. labrax (total for three years of estimation)

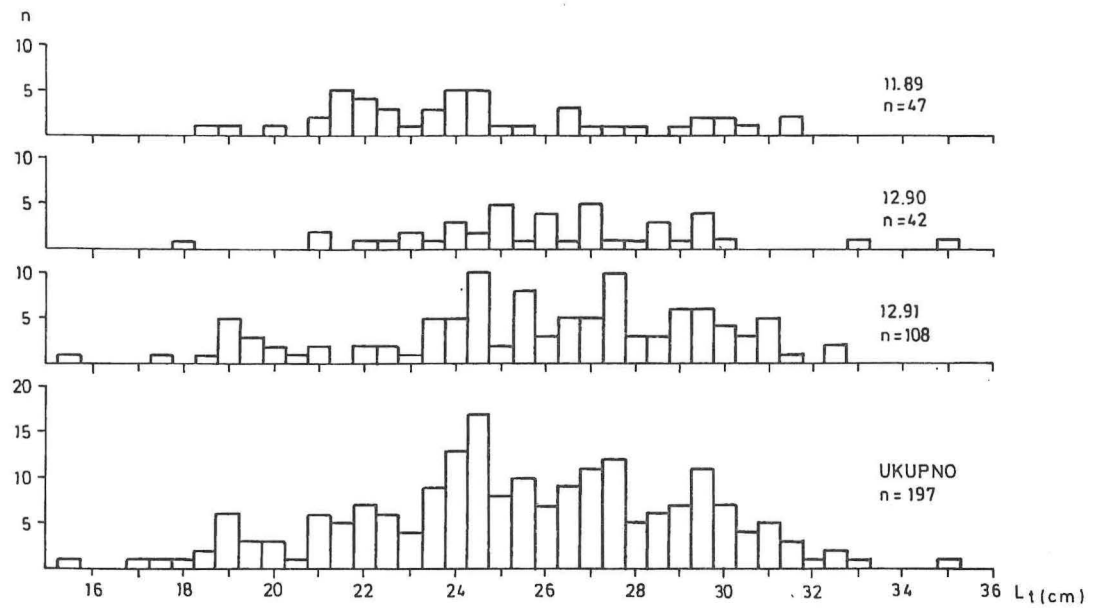

Fig. 6. Length-frequency distribution of L. mormyrus for three winter samples (1989, 1990, 1991) and in total

winter. The values of b in 1989 (3.09) and 1991 (3.03) were not significantly different from 3 ($p > 0.05$), while the value of b (3.25) in 1990 was different from 3 ($p < 0.05$). The value of condition factor (CF) oscillated from 1.164 to 1.238 (Fig. 7).

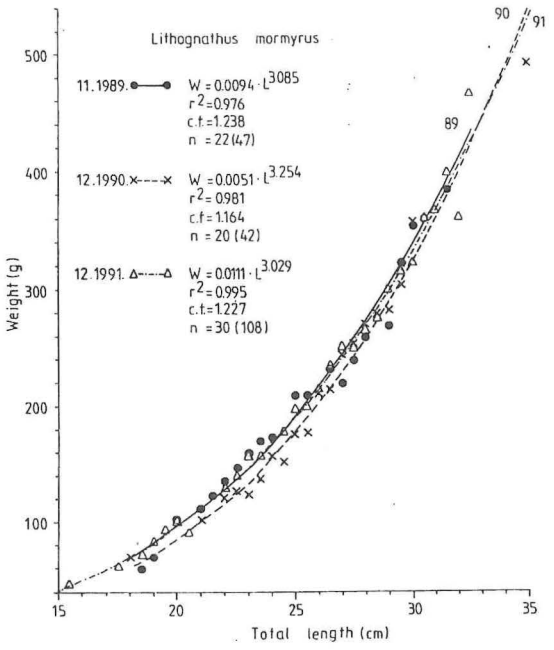

Fig. 7. Length-weight relationship of *L. mormyrus* from Mirna Estuary

Sea bass (*Dicentrarchus labrax*) showed greater variability of annual mean total length and weight (Table 5). These oscillations are likely due to a small number of analyzed specimens in 1989 (n=4) and 1990 (n=21). Most of the catch contained specimens of 30 to 46 cm in total length, with only one specimen not exceeding 30 cm (29.0 cm) (Fig. 4). Length-weight relationship (calculated for all analyzed specimens, n=93) shows positive allometric growth. The value of b (3.11) was not significantly different from 3 ($p < 0.05$) . Condition factor was 0.966 (Fig. 5).

The total (Z), natural (M), fishing (F) mortality and exploitation rate (E) were also calculated for these species (Table 6).

Table 6. The total (Z), natural (M), fishing (F) mortality and exploitation rate (E) for L. aurata, L. ramada, L. mormyrus and D. labrax from Mirna Bay for the period 1989-1991.

Species	Z	M	F	E
L. aurata	0.649	0.387	0.262	0.404
L. ramada	0.627	0.432	0.195	0.311
L. mormyrus	1.030	0.516	0.514	0.499
D. labrax	0.567	0.253	0.314	0.554

The exploitation rates indicate that the fishing pressure exerted on the golden and thin-lipped mullet left them underfished, while the populations of the sea bass (E=0.554) and striped sea bream (E=0.499) were a sufficient fishing condition in the area under study.

DISCUSSION

Family Mugilidae is widely distributed throughout the Mediterranean and Atlantic from British to Canarian islands (BINI, 1968; BEN-TUVIA, 1986; FISHER *et al.*, 1987). As distincly euryhaline (1-90 ppt) and eurythermal (2-37°C) organisms all mullets usually are found in the coastal shallow waters (0-30 m), river estuaries and harbours where there is some freshwater influence.

According to this investigations family Mugilidae was dominant (93.5%) in the Mirna Estuary. *L. mormyrus* (4.1 %) and *D. labrax* (1.7%) were also important from commercial stand point. Of a total of six species of Mugilidae family, five (*L. aurata, L. ramada, M. cephalus, C. labrosus* and *L. saliens*) were recorded from the Mirna Estuary. All six species, both juvenile and adult, including *O. labeo*, were found in the Krka River Estuary (MODRUŠAN *et al.*, 1988; JUG-DUJAKOVIĆ, 1988) and in the shallow coastal waters of the eastern Adriatic (MOROVIĆ, 1960). However, only four of them (*L. aurata, L. saliens, C. labrosus* and *O. labeo*) were recorded from the shallow coves of Kornati Islands (KRALJEVIĆ and JUG-DUJAKOVIĆ, 1988; KRALJEVIĆ and PALLAORO, 1991). Of this family only *O. labeo* was present with a few individuals (0.3-0.8%) since it is very rare in estuaries and brackish waters along the Adriatic coast. *O. labeo* closes its life cycle in open waters (BOGRAD, 1961).

Of all fish species caught in the Mirna Estuary, the species *L. aurata* (89.0%) is best represented. Coastal waters of the eastern Adriatic are best inhabited by the species of the family Mugilidae of which *M. cephalus* and *C. labrosus* dominate constituting 33.8% and 24.8% respectively (MOROVIĆ, 1960). MOROVIĆ (1960) also reported an almost equal presence of other three species, *L. ramada* (14.3%), *L. aurata* (13.6%) and *L. saliens* (12.8%). Analyzing fish fry of this family in the waters of the western coast of Istrian Peninsula, the same author confirmed the dominance of *L. aurata* (29.8%) and *M. cephalus* (28.1%). Our records and the records of VATOVA (1948) prove the dominance of *L. aurata* in the waters of the western coast of Istrian Peninsula.

The Mugilidae species *C. labrosus* were dominant in the Krka River Estuary (middle Adriatic) whereas other species of this family were moderately present (MODRUŠAN *et al.*, 1988). The analysis of fish fry of Mugilidae from the coastal area of the Krka Estuary also showed the dominance of *L. saliens* (37.8%) and *L. aurata* (22.6%) (JUG-DUJAKOVIĆ, 1988). However, the records from the shallow waters of Kornati Islands coves (middle Adriatic) in 1984-1985, showed the highest contribution of *C. labrosus* (47.5%) and *O. labeo* (25.2%) (KRALJEVIĆ and JUG-DUJAKOVIĆ, 1988) and in 1989-1990 the dominance of *O. labeo* (87.2%) and moderate presence of other three species (*L. aurata* - 6.6%; *C. labrosus* - 5.4% and *L. saliens* - 0.8%) (KRALJEVIĆ and PALLAORO, 1991).

As reported, in several estuaries of Israel *L. saliens* constituted 38.1% and *L. ramada* 24.7%, but others were only present *L. aurata* (9.5%), *C. labrosus* (13.6%) and *M. cephalus* (14.1%) (BOGRAD, 1961). *L. ramada* is relatively much more abundant (98.4%) than *C. labrosus* (1.6%) in the Severn Estuary and Bristol Channel (British coastal waters) while no *L. aurata* were taken (CLARIDGE and POTTER, 1985). Eurythermal and euryhaline species of Mugilidae family (except for *O. labeo*) inhabit physically and chemically very diverse habitats and localities (THOMSON, 1966; FARRUGIO, 1975). In spite of the non-variable timing of the incidence of concentrations of this family, everything brought out shows wide and diverse distribution of its species.

For protection of commercially important fish species it is necessary to leave fish to spawn freely in a marine environment for one or two seasons. It is common to most commercial-

ly important fish species (Sparidae, Serranidae) that they are not mature during the first or second year of age (1^0 - 2^0). Usually, in their second year (2^0) some species mature as males and in the third (3^0) as females. Some authors (MOROVIĆ, 1961) reported the same for Mugilidae with only a year lag. For the purpose of protection of commercially important fish species, the time of spawning and total length at first maturity (at least 50% mature males and females respectively) should be known so as to allow normal species reproduction. MOROVIĆ (1961) stated that, theoretically, for most of the fish species, 10.0% of sexually mature individuals spawned in wild marine environment would be quite sufficient for normal reproduction.

After the same author (1961) the Mugilidae family spawns mainly in the open sea waters. So it would be necessary to make possible for at least 20.0% of the population to reach safely the spawning grounds to keep approximately unchanged state of population of an area. Following the Book of Regulations of the Republic of Croatia on Fish Fry in Catches, the fishing is allowed provided the percentage of immature specimens of the catch does not exceed 20.0%. Many authors held that in this way every commercially important fish species could be normally reproduced in the open sea and freely recruited in the area it inhabits.

The family Mugilidae shows significant variance in growth rates, weight and spawning time due to its heterobiotic way of life.

The data of a series of authors on the spawning season of *L. aurata* differ considerably (Table 7).

Table 7. Spawning season of *L. aurata* given by other authors

Author Study area	Month J J A S O N D J F M A M
GRAEFFE, 1888 Gulf of Trieste - NE Adriatic	
ROULE, 1917 (after VIALLI, 1937) Gulf of Napoli - W. Mediterranean	
SANZO, 1936 Gulf of Messina - W. Mediterranean	
MOROVIĆ, 1960 Eastern Adriatic Sea	
BANARESCU, 1964 Black Sea	
BINI, 1968 Italian coastal waters	
ALBERTINI-BERHAUT, 1978 Gulf of Marseille	
GRUBIŠIĆ, 1982 Eastern Adriatic Sea	
CAMBRONY, 1984 Lion's Gulf - W. Mediterranean	
BEN-TUVIA, 1986 E. Mediterranean & Red Sea	
JUG-DUJAKOVIĆ, 1988 Eastern Adriatic Sea	
Present work	

After our data *L. aurata* spawns from the end of September to the end of November which is in agreement with most of the reports (see Table 6) since we recorded all adult species already spent (I and II gonad stages). *L. aurata* are of separate sex. Their individuals mature at 22.0 to 27.0 cm (3° and 4°). Calculated annual means of total length of total catches of *L. aurata* from the Mirna Estuary (see Table 5) exceed minimum total lengths at first maturity of 26.0 cm as reported by MOROVIĆ (1961) and 27.0 cm as we obtained. The percentage of adolescent specimens in analyzed sample was 8.9% (min. L_t = 26.0 cm) and 16.8 % (min L_t = 27.0 cm). Thus it may be concluded that this species normally reproduces and therefore is not yet threatened to be overfished in the natural reservoir of the Mirna Estuary.

Thin-lipped mullet (*L. ramada*) leaves shallow estuaries for spawning in the open waters of the Adriatic (MODRUŠAN *et al.*, 1991) just at the time of the Mirna Estuary fishing operations. Therefore they were poorly represented in the total catch not exceeding 6.6%. This confirms that these fish spawn between the end of October and the end of December.

As suggested by the other authors, the spawning season of *L. ramada*, dependently on the area they inhabit in the Mediterranean, extends from October to January. So in the coastal waters of Tunisia (HELDT, 1948; FARRUGIO, 1975), Egypt (ZAKY-RAFAIL, 1968; EL-MAGHRABY *et al.*, 1974) and Israel (BOGRAD, 1961; BEN-TUVIA, 1986) this species matures from October to the end of December. In the coastal waters of the Adriatic it matures from November to the first half of January (MOROVIĆ, 1961; SINOVČIĆ *et al.*, 1986; MODRUŠAN et al., 1991). FISCHER *et al.*, (1987) reported its first maturity at 25.0-27.0 cm and 25.0-30.0 cm total lengths respectively for males and females. The first maturity of *L. ramada* from the Gulf of Tunis occurs at the total length of 25.5-28.0 cm (males) and 25.5-30.5 cm (females) (FARRUGIO and QUIGNARD, 1973). The same authors reported males of this fish to be fully mature (100.0% of mature males in the population) at total length of 28.0 cm, and females (100.0% mature females in the population) at 30.5 cm. MOROVIĆ (1961) believed that this species is completely mature at total length of 30.0 cm (4°). As distinct from mentioned authors, MODRUŠAN *et al.* (1991) reported the first mature male specimens at total length of 21.5 cm at the end of the second year of age (2°), and the first mature females at 24.5 cm during the fourth year (3^+) what is not in agreement with the reports of other authors. Calculated annual means of total length for total catches from the Mirna Estuary considerably exceed minimum total length at first maturity (L_t = 30.0 cm) (Table 5). The proportion of immature specimens of this species in total catches is quite insignificant not exceeding 1.5% (a single specimen). Accordingly, this species also normally reproduces and is not threatened to be overfished in the Mirna Estuary. This is also confirmed by the value of the exploitation rate (E=0.311).

Striped sea bream, *L. mormyrus*, is best represented by 4.1% of Sparidae family. This species is hermaphroditic protandrous. The first mature males of this species were recorded at 19.0 cm total length and females at 20.5 cm. Within total length ranges of 19.5-24.5 cm 77% males and 23% females are present at spawning (KRALJEVIĆ *et al.*, 1995).

With respect to the percentage of mature females and the fact that 10.0% of sexually mature population spawned in a free marine environment is sufficient for normal reproduction, the total length of 25.0 cm, which is probably the length which allows normal reproduction. Of the total (197) of analyzed striped sea bream specimens 85 did not reach that minimum length, that is there were 43.1% immature specimens in the catch. So, striped sea bream appears to be least protected species in the Mirna Estuary. However, even though the value of exploitation rate was relatively high (E=0.499) it makes up not more than 4.1% of the total catch and it is not presumably threatened by overfishing by the present catch course.

The sea bass, *Dicentrarchus labrax*, is the most sought and highly priced species of the Mirna Estuary. During three year samplings, a total of 93 individuals of 29.0-88.0 cm L_t range

Table 8. Total length and age of sea bass (*Dicentrarchus labrax*) at first maturity in different areas (BOUAIN, 1977; after BARNABE, 1980)

Study area and authors	Males		Females	
	L_t (cm)	Age	L_t (cm)	Age
KENNEDY and FITZMAURICE, 1972 British Islands	33.7	4-7	37.7	5-8
STÉQUERT, 1972 Arcachon-Atlantic	31.9 - 37.2	4	42.5	6
BARNABÉ, 1973 Lion's Gulf - W. Mediterranean	28.0 - 30.0	2	37.1 - 40.0	3
BOUAIN, 1977 Tunisian coast	23.1 - 25.5	2-3	31.4 - 32.6	4-5
FISHER *et al.*, 1987 Mediterranean Sea	23.0 - 30.0	2	31.0 - 40.0	3

were analyzed. Even though, for the time being, we do not have available any data on its length and age at first maturity, we made use of the reports of other authors to get some conclusions. Total length and age at first maturity of sea bass, *Dicentrarchus labrax*, in different regions (BOUAIN, 1977; after BARNABE, 1980) are listed in Table 8.

The first mature male sea bass specimens in aquaria were found to be of 23.0 cm (2°) total length, and females of 26.0 cm (2° - 3°). The first maturity (at least 50% of males and females mature in the population respectively) was recorded at both male and female total length of 31.0 cm (KATAVIĆ, 1984). After the same author, most males (60.0%-70.0%) in the population were of 28.0-30.0 cm total length, and females (60.0%-70.0%) of 32.0 cm on. Analyzed mature male sea bass specimens from the Mirna Estuary were of 31.0-34.0 cm total length. Available data point to the fact that first maturity of this species in the Mirna Estuary occurs at 31.0 cm total length or at even smaller length. However, we could not establish it with certainty since of the total of 93 analyzed specimens only one fish was less than 31.0 cm long.

Annual mean total lengths of sea bass (Table 5) show significant oscillations, due presumably to a too small number of analyzed specimens in 1989 (n=4) and 1990 (n=2). In 1991 L_t mean was 41.2 cm exceeding considerably minimum total length of sea bass at first maturity (L_t = 31.0 cm). The percentage of immature specimens was not greater than 1.0% in the analyzed sample. So it may be concluded that this species is relatively protected in the Mirna Estuary, even though the value of exploitation rate was high (E=0.554).

The growth coefficients (allometric factors) estimated for *L. aurata, L. ramada, L. mormyrus* and *D. labrax* varied within species and among species for the 1989-1991 period. The changes in the body shape, physiological changes, hydrology of the environment, differently accessible food during the life and biological cycle, increase or hinderance of growth rate affect the variations in allometric factors (FROST, 1945). It was also found that allometric factors vary with the locality inhabited by a species, with respect to its sex, length, age and gonad maturity. The values of the condition factor also varied and seemed to be affected by the factors such as sex, time of the year (season) and maturity stage.

ACKNOWLEDGEMENTS

The authors express their gratitude to the Ministry of Science, Technology and Informatics of the Republic of Croatia for financial sup-

port (Project 1-08-174) and also to Mrs. Marta Marušić for her kind assistance in preparing the manuscript.

REFERENCES

ALBERTINI-BERHAUT, J. 1978. Croissance linéaire et pondérale de *Mugil auratus* comparée a celle de *Mugil capito*. Cybium 4: 51-60.

BANARESCU, P. 1964. Fauna Republicii Populare Romine (Pisces-Osteichthyes). Editura Academiei Republicii populare Romine, Bucuresti, Vol 13, 960 p.

BARNABE, G. 1980. Expose synoptique des donnes biologiques sur le loup ou bar, *Dicentrarchus labrax* (LINNE, 1758). Synop. FAO Peches, 126: 70p.

BASIOLI, J. 1956. Ribolov u Tarskoj uvali. Morsko ribarstvo. 9: 29-39.

BEN-TUVIA, A. 1986. Mugilidae, p. 1197-1204. In P. J. P. WHITEHEAD (ed.), Fishes of the North-Eastern Atlantic and the Mediterranean, Vol. 3. Paris, UNESCO.

BINI, G. 1968. Mugilidae, p. 27-42. In: Atlante dei pesci delle coste italiane, Vol. 4. Milano, Mondo Sommerso.

BOGRAD, L. 1961. Occurence of Mugil in the Rivers of Israel. Bull. Res. Counc. of Israel. 9B: 169-190.

CAMBRONY, M. 1984. Identification et périodicité du recrutement des juveniles de Mugilidae dans les etangs litoraux du Languedoc-Roussillon. Vie et Millieu. 34: 221-227.

CLARIDGE, P. N. and I. C. POTTER. 1985. Distribution, abundance and size composition of mullet populations in the Severn Estuary and Bristol Channel. J. mar. biol. Ass. U. K. 65: 325-335.

EL-MAGHRABY, A. M., M. T. HASHEM and H. M. EL SEDFY. 1974. Sexual, spawning migration and fecundity of *Mugil capito* (Cuv.) in lake Borollus. Bull. Inst. Ocean. Fish. A. R. E. 4: 33-56.

FARRUGIO, H. and J. P. QUIGNARD. 1973. Biologie de *Mugil (Liza) ramada* RISSO, 1826 et de *Mugil (Chelon) labrosus* RISSO, 1826 (Poissons, Téléostéens, Mugilidés) du lac de Tunis. Taille de première maturité sexuelle, cycle de fecondite. Bull. Inst. Océanogr. Pêche, Salambó. 4: 545-578.

FARRUGIO, H. 1975. Les Muges (Poissons, Téléostéens) de Tunisiee. Répartition et pêche, contribution à leur étude sistématique et biologique. Thése, Languedoc, 201 p.

FISCHER, W., M. SCHNEIDER, and M. L. BAUCHOT. 1987. Fiches FAO d' identification des especes pour ves besoins de la peche. Mediterranee et mer Noire zone de peche 37. Revision 1. Vol. 2 Vertebres. Organization des Nations Unies pour l'alimentation et l' agriculture, Rome, 1599 p.

FROST, W. E. 1945. The age and growth of eels (*Anguilla anguilla*) from the Windermere catchment area. Part 2. J. Anim. Ecol. 14: 106-124.

GRAEFFE, E. 1888. Übersicht der Seethierfauna des Golfes von Triest nebst Notizen über Vorkommen, Lebensweise, Erscheinungs und Fortpflanzungszeit der einzelnen Arten. Pisces 4. Arb. Zool. Inst. 7: 445-470.

GRUBIŠIĆ, F. 1982. Ribe, rakovi i školjke Jadrana. ITRO Naprijed, Zagreb - GRO Liburnija, Rijeka, 240 p.

HELDT, H. 1948. Contribution à l' etude de la biologie des Muges des lass tunisiens. Bull. Station oceanographique de Salambó, Tunis. 41.

JACOT, A. P. 1920. Age, growth and scale characters of the Mullets *Mugil cephalus* and *Mugil curema*. Trans. Amer. Microsc. Soc. Vol. 39, 199p.

JUG-DUJAKOVIĆ, J. 1988. Prilog poznavanju ekologije mladi gospodarski interesantnih vrsta riba u šibenskom priobalju. M.Sc. Thesis, University of Zagreb, 84p (mimeo).

KATAVIĆ, I. 1984. Inducirano mriješćenje i uzgoj ranih stadija lubina, *Dicentrarchus labrax* (Linnaeus, 1758) i komarče, *Sparus aurata* (Linnaeus, 1758). Ph.D. Thesis, University of Zagreb, 231p (mimeo).

KRALJEVIĆ, M. and J. JUG-DUJAKOVIĆ. 1988. Preliminary ecological and biological studies of juvenile fish species of commercial interest in the National Park "Kornati". FAO Fish. Rep., 394: 291-299.

KRALJEVIĆ, M. and A. PALLAORO. 1991. Ihtiocenoze plitkih uvala nacionalnog parka "Kornati". Morsko ribarstvo, 3: 81-90.

KRALJEVIĆ, M., J. DULČIĆ, A. PALLAORO, P. CETINIĆ and J. JUG-DUJAKOVIĆ. 1995. Sexual maturation, age and growth of striped sea bream *Lithognathus mormyrus* L. on the Eastern Coast of Adriatic Sea. J. Appl. Ichtyol., 11: 1-8.

MODRUŠAN, Z., E. TESKEREDŽIĆ and S. JUKIĆ. 1988. Biology and ecology of Mugilidae species on the Eastern Adriatic coast (Šibenik Bay). FAO Fish. Rap., 394: 159-167.

MODRUŠAN, Z., E. TESKEREDŽIĆ and D. MARGUŠ. 1991. First maturity, seasonal variations of gonadosomatic index, spawning time and annual migrations of grey mullets *Liza (Liza) ramada* Rissop 1826 and Chelon labrosus RISSO, 1826 from the Eastern Adriatic. Oebalia. 17: 145-157.

MOROVIĆ, D. and S. ŽUPANOVIĆ. 1958. Osnovi ribarstvene biologije. Priručnik za ribarske škole. Ribarska biblioteka Udruženja morskog ribarstva, sv. 3, Rijeka.

MOROVIĆ, D. 1960. Mugilids of the Adriatic with a special review of *Mugil cephalus* L. and *Mugil chelo* Cuv. Ph. D. Thesis, Univ. Of Zagreb. 131p, (mimeo).

PAULY, D. 1983. Some simple methods for the assessment of tropical fish stocks. FAO Fish. Tech. Rap. 234: 52 p.

PAULY, D. 1984. Fish population dynamics in tropical waters: a manual for use with programmable calculators. ICLARM Stud. Rev. 8: 325p.

PLANČIĆ, J. 1952. Rijeka Mirna, mogućnosti iskorištavanja u ribarske svrhe. Ribarstvo Jugoslavije, 6: 21-53.

RICKER, W. E. 1975. Computation and interpretation of biological statistics of fish populations, Bull. Fish. Res. Bd. Can., 191: 382p.

SANZO, L. 1936. Contributi alla conoscenza dello sviluppo embrionario e post-embrionario nei Mugilidi. I *Mugil cephalus* Cuv. II *Mugil chelo* Cuv. Mem. R. Com. Talassogr. Ital., 230: 1-11.

SINOVČIĆ, G., V. ALEGRIA-HERNANDEZ, J. JUG- DUJAKOVIĆ, S. JUKIĆ, I. KAČIĆ, S. REGNER and M. TONKOVIĆ. 1986. Contribution to the knowledge of ecology of grey mullet *Liza (Liza) ramada* (RISSO, 1826) from the middle Adriatic (Šibenik area). Acta Adriat. 27: 147-162.

ŠOLJAN, T. 1975. I pesci dell'Adriatico. Mondadori (ed.), Verona. 522 p.

THOMSON, J. M. 1966. The grey mullets. Oceanog. Mar. Biol. Ann. Rev. 4: 301-335.

VATOVA, A. 1948. Su di una particolare zoogenesi delle stagne del Palu presse Rovigno. Boll. pesca e idrobiol. XXIII, Vol.II (N.S.) no.2.

VESNAVER, G. 1905. Notizie storiche di Grisignana. Pagine istriane, 1.

VIALLI, M. 1937. Mugilidae. Fauna e flora del Golfo di Napoli. 38 Monografia, uova, larvae e studi giovanili di Teleostei. 3a puntata, I parte: 433-456.

ZAKY-RAFAIL, S. 1968. Investigations of mullet fisheries by beach seine on the UAR Mediterranean coasts. Stud. Rev. Gen. Count. Medit. 35: 1-19.

ZJAČIĆ, M. 1973. Posjedovni odnosi porečke crkve od VI do XVI stoljeća. Jadranski zbornik, 8: 25-38.

Accepted: July 4, 1995

Ihtiološke analize lovina iz ušća rijeke Mirne - istočni Jadran

Miro KRALJEVIĆ, Jakov DULČIĆ, Ivo KAČIĆ, Armin PALLAORO i Ivan JARDAS

Institut za oceanografiju i ribarstvo, Split, Hrvatska

KRATKI SADRŽAJ

Ušće rijeke Mirne izlovljavano je jednom godišnje više od 900 godina. Ihtiološka istraživanja počinju 1989. Materijal je bio sakupljan posebno napravljenom mrežom za izlov riba u prirodnom staništu Tarske vale. Dvanaest vrsta je ulovljeno od čega su četiri od gospodarstvenog značaja. Porodica Mugilidae brojčano je prevladavala s 93.6% od ukupnog ulova u razdoblju od 1983. do 1991. U toj porodici prevladavajuće vrste su cipal zlatac, *Liza aurata* (89.0%) i cipal balavac *Liza*

ramada (6.6%). Sve ostale vrste bile su nazočne u manjim količinama od kojih su najzastupljenije bile ovčica *Lithognathus mormyrus* (4.1%) i lubin *Dicentrarchus labrax* (1.7%). Dužinsko-maseni odnos i indeks kondicije bili su izračunati za sve gospodarski značajne vrste. Na temelju starosti, zrelosti, raspodjele dužinskih učestalosti i indeksa eksploatacije (E) zaključeno je da populacijama cipla zlatca i cipla balavca ne prijeti opasnost od prelova, dok se populacije lubina (E=0.554) i ovčice (E=0.499) nalaze u nedovoljnim količinama za gospodarsko iskorištavanje u dozvoljenim granicama za sada.