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Some observations on the growth of juvenile amberjack (*Seriola dumerili*, RISSO, 1810) in cage rearing from the southern Adriatic Sea

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The growth rate of the few months old Mediterranean amberjack (Seriola dumerili) *was studied throughout a period of one year (from Sept'95 to Sept'96) in the Bay of Mali Ston (South Adriatic). Sixty nine fish with an average weight of 183±57.5g and total length of 25.2±2.8cm were settled in rearing cages (5x5x5m) on September 27. 1995 for the purpose of studying growth in weight and length. The fish were usually fed frozen sardines once a day, every other day. The first month of rearing the fish showed considerable growth in weight (328±92.7g) and length (28±2.5cm). At the end of the one-year period, the reared fish averaged 1239±129.8g in weight and 47.8±1.7cm in length. The condition factor throughout the entire period of rearing was relatively homogenous, at 1.38±0.15. Significant gains in the weight and length of fish can be noticed during the warmer periods of the year (June, July, August, September and October), while less are for the colder months (January, February, March, April). The fish preferred frozen sardines. During this experiment, we noted the mortality of 7 fish (10.1%). Moreover, the sudden oscillations in the basic hydrographic parameters for this relatively enclosed bay can be attributed to the influence of the river Neretva.*

Key words: *Seriola dumerili*, cage rearing, growth, Adriatic Sea

INTRODUCTION

The Mediterranean amberjack (*Seriola dumerili*, RISSO, 1810) species is a potential candidate for aquaculture in Mediterranean countries for three important reasons: a rapid growth rate, easy adjustment to captivity and a high market price (CAVALIERE *et al.*, 1989; GIOVANARDI *et al.*, 1984; PORRELLO *et al.*, 1993; SKARAMUCA *et al.*, in press). This is a pelagic and migratory Carangidae species, widespread in temperate and sub-tropical waters, from the Mediterranean to the Gulf of Biscay, from Nova Scotia to Brazil, South Africa, the Arabian Gulf, Australia, Japan and Hawaii (SMITH-VANIZ, 1986; BAUCHOT, 1987; ANDALORO *et al.*, 1992). The amberjack is a numerous species in the South Adriatic and along the shores of the mid-Dalmatian islands, while rare in the Northern Adriatic

(GRUBIŠIĆ, 1982; SKARAMUCA *et al.*, 1995).

Growth rate is an important parameter in the commercial rearing of fish. There are really not enough exact data on the growth of the Mediterranean amberjack, neither in the wild nor under conditions of cultivation. At the public aquarium in Dubrovnik, we have successfully maintained this species for over 30 years. It eats frozen fish well and grows over 25 kg in weight (GAMULIN and MARCHI, 1972). The Mediterranean amberjack, so far, is still not being commercially reared, as a solution has still not been found to the problem of spawning under captive conditions and also wild juveniles are not always available (MARINO *et al.*, 1995). This is the first time cage rearing of the Mediterranean amberjack in the Adriatic Sea has been carried out. A similar species, the Japanese Yellowtail (*Seriola quinqueradiata*), has been widely reared in Japan since 1928, and stocking is based on catches of wild juveniles (FUJIYA, 1976). Today, the amberjack is one of the most important commercial marine fish used in aquaculture in Japan (PIILLAY, 1995; NISHIMURA *et al.*, 1995).

This paper presents, for the first time in the Adriatic Sea, the influence of basic hydrographic factors on the growth of caged, juvenile amberjack.

MATERIAL AND METHODS

The fish used for the growth studies were collected during September 1995, in the cove of Molunat (Fig.1a). This is a small bay, 40 km south-east of Dubrovnik, a traditional fishing area for the Mediterranean amberjack (SKARAMUCA *et al.*, 1997). We collected juvenile fish (a few months old) using a modified dragnet ("šabaka") 350 m in length and 5 m in height, with lead weights at the bottom and floaters at the top. The net consists of a framework of individual squares 50-80 mm wide, ending in a 10-12 mm mesh size bag. We stored the undamaged fish in small net cages, 1x1x1 m, constructed for this purpose, until an adequate number was collected. The fish (69) were transported to our laboratory in Dubrovnik in 50 l plastic bags, filled with 30 l of seawater, in which 1 ml of an anesthetic was added (Aethylis Aminobenzoas). We placed 7 fishes in a bag and filled the rest of the volume with oxygen. In the laboratory, the fish were placed in a cement tank, 3 m^3 in volume. At the beginning of the experiment (September 27, 1995), with the same procedure described above, we transported 69 fishes, averaging 183±57.5 g in weight and 25.2±2.8 cm in length, to the fish hatchery of Sea bass located in the Bay of Mali Ston, 100 km north-west of Dubrovnik (Fig.1b). The dimensions of the two cages used in rearing are 5 x 5 x 5 m, at a sea-depth of 18 m. The experiment finished on September 2, 1996, after a one-year period of rearing.

The fish were generally fed with frozen sardines (*Sardina pilchardus*), and rarely with frozen anchovy (*Engraulis encrasicolus*), horse mackerel (*Trachurus trachurus*), and occasionally with bogue (*Boops boops*). During the first two months, prior to distribution, we cut the frozen fish into smaller pieces; later whole fish were provided. Food was distributed once, every other day, always in the morning, at a level of approximately 10-15% of the fish weight in the beginning to about 5% later, depending on the size of fish and the temperature in the cage.

Biometric parameters: during the experiment, once a month, fish were anaesthetized and their weight measured to the nearest 0.5 g and total length to the closest 0.1 cm. Ecological parameters (temperature, oxygen and salinity) were measured in each cage every 15 days, always in the morning, at a depth of 4m. Weight (W), weight gain (WG), total length (TL), length gain (LG) and the condition factor (K) were presented with average and standard deviation (SD).

In this paper, our main attention focused on studying growth in weight and length of fishes, with respect to ecological parameters throughout the year, especially temperature, as

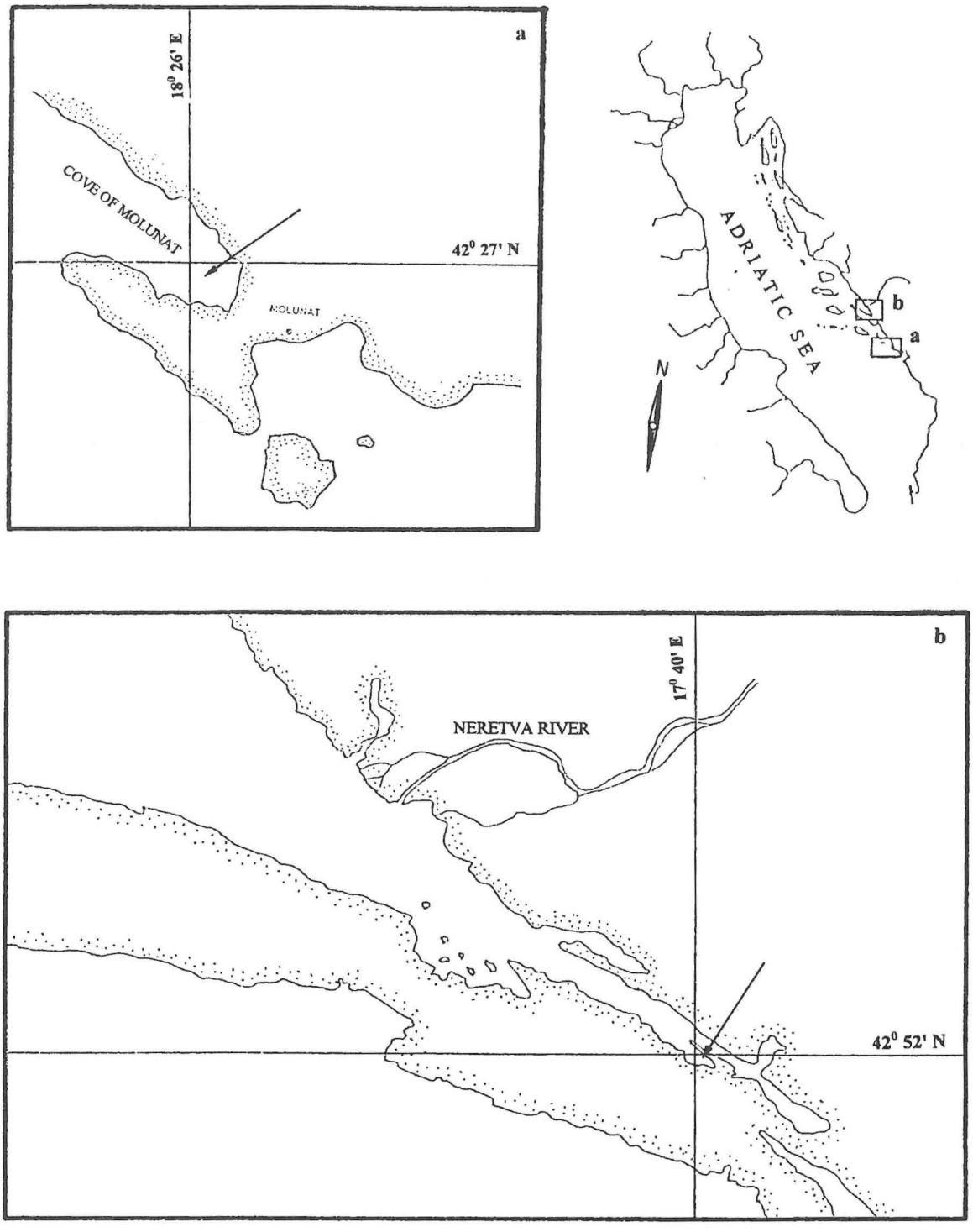

Fig. 1. Study area. a) Donji Molunat Cove, traditional fishing grounds for the Mediterranean amberjack , b) Hatchery site in the Bay of Mali Ston

well as population homogenity expressed in relations to length/weight, shown through change the condition factor (K) of individual fish for each month.

The condition factor (K) was defined as follows:

$$K = 100 \times W L^{-b}$$

where K is the condition factor, W the weight (g), L the total length (cm) of the fish, and b constant.

The difference in the condition factor was calculated by month using the WILCOXON signed rank test in Systat 5.01.

RESULTS

Hydrographic Data

The average sea temperature throughout the one-year period at the hatchery was 17.8 ± 4.3 °C, fluctuating from the lowest at 10.8 °C,

Table 1. Basic hydrographic values at the hatchery during the study

Time of examination	Temperature (°C)	Salinity ($Sx10^{-3}$)	Dissolved oxygen ($mg\ l^{-1}$)	Saturation (%)
1995.				
September 9.	22.2	36.8	4.06	82.67
October 2.	21.0	38.1	4.06	81.53
October 6.	20.3	34.9	4.13	80.36
October 27.	20.3	36.7	3.43	67.45
November 15.	17.0	34.0	3.78	68.73
November 30.	15.0	35.0	3.92	68.93
December 16.	15.9	35.8	4.62	82.95
December 28.	15.0	36.5	6.30	111.80
1996.				
January 16.	14.0	35.0	7.0	120.62
February 1.	14.0	36.0	7.28	126.22
February 15.	11.8	37.0	6.44	107.33
March 4.	10.8	35.5	6.86	110.85
March 16.	13.1	38.0	6.37	108.41
April 1.	13.0	36.3	7.07	120.30
April 16.	12.3	33.8	7.0	115.56
May 2.	16.2	37.0	6.51	118.67
May 15.	17.8	24.8	7.56	132.11
June 3.	19.7	34.8	7.14	137.32
June 12.	27.0	27.9	5.60	117.77
June 20.	19.5	36.4	6.44	124.57
July 1.	18.5	37.0	6.02	114.70
July 13.	21.9	36.9	5.25	106.40
August 6.	25.8	33.1	5.46	115.86
August 16	21.0	35.0	5.11	100.77
September 2.	21.7	38.7	4.83	97.42
average during the study	17.8±4.3	35.2±3.0	5.69±1.28	104.77±20.52

noted on March 04, 1996, to the highest at 27.0 °C on June 12, 1996. Throughout the year, temperatures lower than 13°C were noted only three times, in February, March and April, but not continuously (Table 1, Fig. 2).

The average salinity values throughout the year were 35.2±3.0 x 10^{-3}. A minimum salinity value (24.8 x 10^{-3}) was noted in the month of May and a maximum (38.7 x Sal 10^{-3}) in September 1996. A salinity lower than 30 x 10^{-3} was noted only once more on June 12, 1996 (Table 1).

The average values for dissolved oxygen were 5.69±1.28mg per litre (104.77± 20.52 % saturation). The lowest value for dissolved oxygen (3.43 mg per litre and a saturation of 67.45 %) was noted on October 27, 1995. Low values were constant for both dissolved oxygen and saturation levels throughout the month of November 1995. A maximum value for dissolved oxygen (7.56 mg per litre) was noted on May 15th and for saturation 137.32 %) on June 03, 1996 (Table 1).

Survival and Growth of Fish

From the original 69 fishes caged, 31 fishes survived to the end of the experiment. During the year, we registered 7 dead fishes (10.1%), 2 fishes were damaged (2.8%) by cormorans and

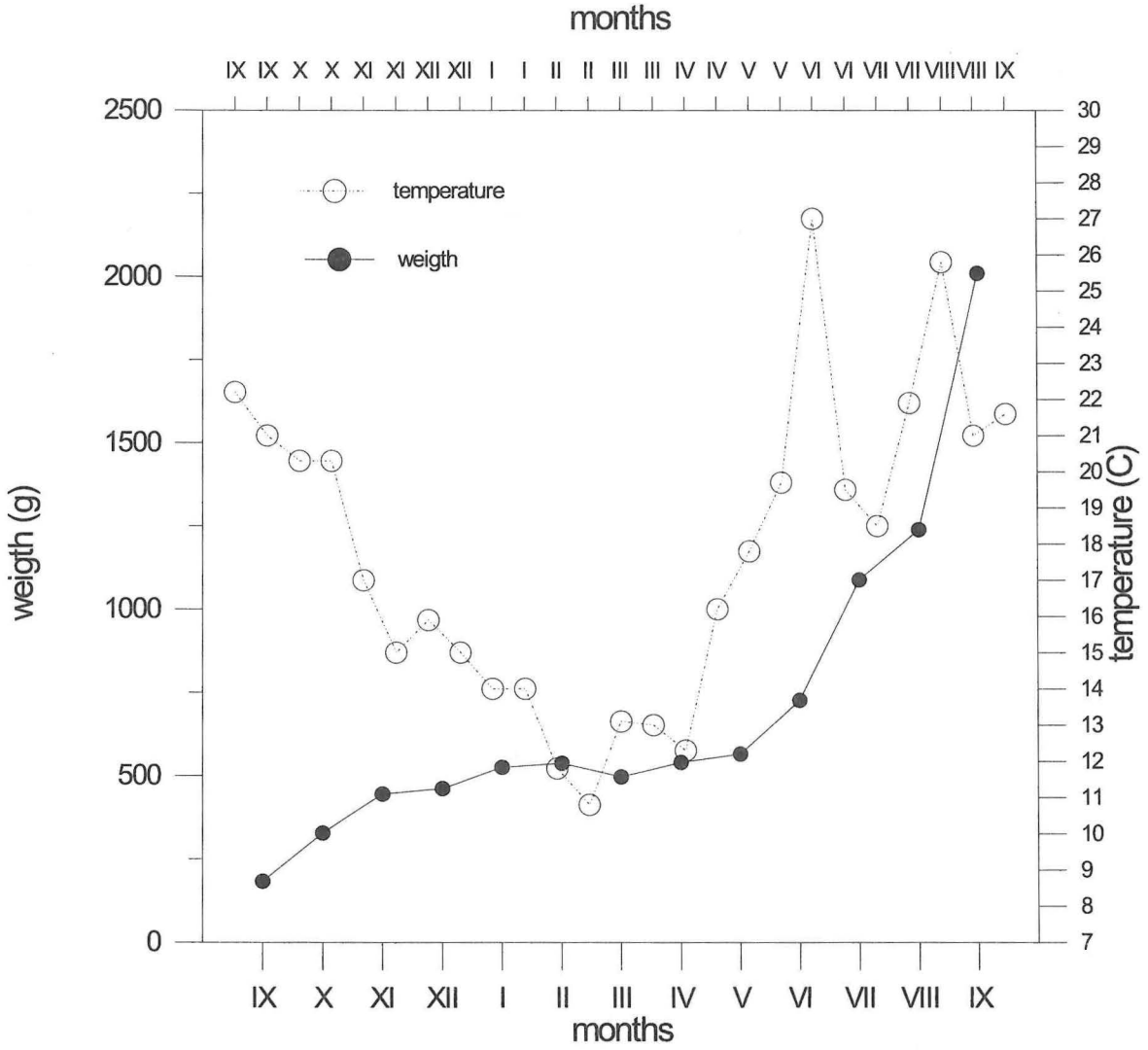

Fig. 2. Relationship between average body weight of the cage-reared Mediterranean amberjack and water temperature

Table 2. Growth performance of Mediterranean amberjack during one-year rearing. Means and standard deviation

Time of examination	Fish N°	Average body weight	Average weight gain	Average length	Average length gain	K
1995.						
September 27.	69	183±57.5		25.2±2.3		1.12±0.27
October 27.	51	328±92.7	145	28.0±2.5	2.8	1.45±0.13
November 30.	50	445±101.1	117	30.7±2.5	2.7	1.54±0.28
December 28.	48	461±89.3	25	31.7±2.4	1.0	1.47±0.47
1996.						
January 31.	36	525±80.7	64	32.7±1.6	1.0	1.48±0.10
March 4.	39	537±77.0	12	32.6±1.5	-0.1	1.53±0.13
April 1.	38	498±79.5	-41	32.9±1.6	0.2	1.39±0.15
May 2.	36	540±78.8	42	33.1±1.8	0.8	1.48±0.11
June 3.	36	565±100.9	25	33.9±1.7	3.8	1.43±0.11
July 1.	32	726±100.1	161	37.7±1.8	7.7	1.34±0.10
August 6.	32	1088±125.6	362	45.4±2.5	2.4	1.16±0.12
September 2.	31	1239±129.8	151	47.8±1.7	4.1	1.12±0.08

Table 3. Comparison of average monthly values in condition factors (K) for the Mediterranean amberjack during one year of cage-rearing (WILCOXON signed rank test)

months	IX	X	XI	XII	I	II	III	IV	V	VI	VII	VIII
IX	1.000											
X	<0.001	1.000										
XI	<0.001	0.001	1.000									
XII	<0.001	0.194	0.002	1.000								
I	<0.001	0.176	0.002	0.012	1.000							
II	<0.001	0.010	0.200	0.010	0.230	1.000						
III	<0.001	0.324	0.003	1.000	0.030	0.018	1.000					
IV	<0.001	0.417	0.015	0.144	0.296	0.144	0.188	1.000				
V	<0.001	0.617	0.030	0.243	0.405	0.005	0.405	0.405	1.000			
VI	<0.001	0.022	<0.001	0.216	<0.001	<0.001	0.377	0.003	0.052	1.000		
VII	0.022	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	1.000	
VIII	0.151	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.072	1.0

the remaining 29 (42%) were stolen by unidentified persons during the year. No signs of illness were noticed among the reared fish.

We observed that the amberjack prefered to eat sardines rather than other small fish. This was especially evident during the colder periods of the year, when the fish usually eat less.

We noted a considerable gain in fish biomass throughout the year-long rearing. The final average weight of fish was 1239 ±129.8 g, and the average length 47.8 ±1.7 cm (Table 2). The average WG was 1056 g, and LG 22.6 cm. The average monthly WG was 96.6±109.8g,

with the largest gain at 362g noted in the month of June 1996. A negative WG was noted in February 1995. Similar results were observed by month for LG. The average LG was 2.0±2.3 cm. The fishes showed the highest gains in length in June '95 and the lowest in January '96.

Using the WILCOXON rank test we determined two groups of values for the condition factor (K), which can be differentiated as follows: the first group shows values for the months of July, August, September, and the second group, for the months of October, November, December, January, February, March, April and May. The values for the month of June are different from those previously noted (Table 3).

DISCUSSION

The research results are similar to those achieved by PORRELLO (1992), and somewhat greater than those noted in tank-rearing (CAVALIERE *et al.*, 1989; SKARAMUCA *et al.*, (in press). The average weight of our fish at the end of one year of rearing was 1239 ±129.8 g (WG was 1056g), and the average length was 47.8cm±1.7 (LG 22.6cm).

WG and LG gains occurred immediately during the first month of rearing, at the end of September and during October of 1995, when temperature conditions were better (more than 20°C). The slow growth from November 1995 to April 1996 can be attributed to a sea temperature drop at the hatchery. The most pronounced WG, at 362 g, was noted at the end of June and during the month of July in 1996, at an average temperature of 27°C, the highest temperature noted throughout rearing. The more pronounced growth of these fish during the warmer months of the year, when the sea temperature at the hatchery was above 15°C (end of spring, summer and autumn), confirms the dispersion of amberjack to warmer seas, where the temperature does not generally fall below 13°C. Low temperatures are a limiting factor in maintaining these fish under aquarium conditions. At a temperature of 12°C or less, the amberjack stops eating, at 11°C movements are slow, and at below 10°C, death occurs within a few days (BENOVIĆ, 1980).

The condition factor values calculated according to the WILCOXON signed rank method are divided into two groups: periods of increased temperatures and growth and periods of low temperatures, when food consumption and growth are slowed down. The condition factor value for the month of June 1996 varies from these two groups and is similar to the values noted for October and December 1995 and for March and May 1996. Possibly, this can be the result of inequality in the feeding activity of individual fish at the beginning of the warm season in the month of June and the continuing effects of weight loss occuring during the colder, winter months.

The relatively high mortality rate during the one-year period of rearing showed that our hatchery location was not the most suitable. For this experiment, we used equipment already installed for the rearing of Sea bass in the Bay of Mali Ston, near the mouth of the River Neretva. We avoided costs in this manner, however because for the rearing of the Mediterranean amberjack, locations outside the river's influence would have been better thus avoiding stress caused by oscillations in salinity and low winter temperatures. The sudden penetration of waters from the River Neretva on May 15, 1996 into the Bay of Mali Ston resulted in a salinity drop (24.8×10^{-3}), in the highest values noted for dissolved oxygen (7.56 mg l^{-1}), in saturation 15 days later (137.32 %); furthermore, the fish did not eat for 3 days.

These research results have shown that the Mediterranean amberjack could become a potential species for mariculture in the Adriatic Sea, especially in aquatic regions outside the reach of river mouths, where winter temperatures are not below 13°C. Such temperatures and salinity can be found throughout the entire South Adriatic and throughout most of the

Middle Adriatic (BULJAN and ZORE-ARMANDA, 1979; VUČAK, *et al.*, 1982, ZORE-ARMANDA *et al.*, 1991; SKARAMUCA and KOŽUL, 1995).

It will be necessary to invest greater efforts into research on the possibility of controlled spawning, in order that an adequate number of fingerlings can be supplied for the commercial rearing of this species. The very fast growth rates of this fish up to the time of harvestry would justify all the efforts made.

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Neka opažanja o rastu mlađi gofa (*Seriola dumerili* RISSO, 1810) u kaveznom uzgoju iz južnog Jadrana

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SAŽETAK

Praćen je rast nekoliko mjeseci starog gofa (*Seriola dumerili*) kroz godinu dana (od rujna '95 do rujna '96) u Malostonskom zaljevu (južni Jadran). Šestdeset devet riba sa prosječnom masom 183±57 g i ukupne dužine 25.2±2.8 cm smješteno je u uzgojni kavez (5x5x5) u svrhu promatranja rasta mase i dužine. Riba je hranjena smrznutom srdelom jedanput dnevno, svaki drugi dan. Prvi mjesec uzgoja riba je pokazala znatan rast mase (328±29.7 g) i dužine (28±2.5 cm). Na kraju jednogodišnjeg razdoblja riba je bila prosječne mase 1239±129.8 g i prosječne dužine 47.8±1.7 cm. Čimbenik kondicije kroz istraživano razdoblje bio je relativno ujednačen i iznosio je 1.38±0.15. Značajno povećanje mase i dužine ribe karakteristično je za topliji period godine (lipanj, srpanj, kolovoz, rujan i listopad), dok je manji rast zabilježen u hladnim mjesecima (siječanj, veljača, ožujak, travanj). Za vrijeme ovog eksperimenta zabilježen je mortalitet od 7 riba (10.1%). Nenadane osilacije osnovnih hidrografskih parametara u ovom relativno zatvorenom zaljevu vjerovatno su posljedica utjecaja rijeke Neretve.