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THE LARVAL STAGES OF FISH IN THE KAŠTELA BAY

LARVALNI STADIJI RIBA NA PODRUČJU KAŠTELANSKOG ZALJEVA

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The paper gives the results of the analysis of annual distribution and long-term fluctuations of the qualitative and quantitative composition of the larval fish stages in the plankton of the Kaštela Bay.

INTRODUCTION

A number of studies and a variety of authors have studied the planktonic stages of individual fish species, particularly those of sardine *(Sardina pilchardus* Walb.) and anchovy *(Engraulis encrasicolus* L.) in the Adriatic. However, there is far less papers dealing with the composition and dynamics of individual groups or even of the ichtyoplankton community as a whole.

First joint data on the planktonic stages of the Adriatic fishes were given by Graeffe (1888), Steuer (1910), Stiasny (1910) and Vatova (1928) for the northern Adriatic. Karlovac (1953) provided the data on distribution, numerousness and the time of occurrence of planktonic stages of fish from the families *Sternoptychidae, Stomiatidae* and *Scopelidae* for the whole Adriatic. Varagnolo (1964) studied the period of the occurrence and seasonal dynamics of the numerousness of larval stages of twentyone fish species in the northern Adriatic in 1962—1963. The same author Varagnolo, 1964a) after the observations of the time of occurrence of individual embrionic stages of fish eggs in the same area during 1963, determined approximately the duration of eggs development and the time of spawning in the course of the day for the six fish species. In the course of investigations of the planktonic stages of sardine carried out in the central Adriatic in 1952—1953 period Karlovac (1967) recorded the larval stages of 68 fish species from the plankton. On that occasion this author studied their distibution and dynamics of numerousness. Studying the pelagial of the northern Adriatic, Štirn (1969) worked out the time of occurrence, spatial and seasonal dynamics of the number of eggs of twentyone fish species in 1965. The data on the qualitative and quantitative distribution of the larval fish stages in the central Adriatic in 1973 (Regner, 1976) are also available. Finaly, Vučetić (1965, 1970 and 1971) reported the seasonal and long-term distribution of the total numbers of the larval fish stages in the central Adriatic.

The given review of the investigations of the composition of the ichthyoplankton comunity in the Adriatic shows that the investigations of its long-term dynamics are missing in the first place. Therefore, we assume that it would be of use to give the results of our investigations. Even though they were carried out at only one station in the coastal area of the central Adriatic, these investigations cover rather long period.

STUDY AREA, MATERIAL AND METHODS

The investigations were carried out at a station in the Kaštela Bay where depth reaches 42 m. The Kaštela Bay is a rather closed coastal region influenced strongly by the nearby land (Fig. 1). The annual ranges of temperature and salinity variations exceed to a considerable extent those in the channel area and open waters of the central Adriatic (Buljan and Zore-Armanda, 1979). The salinity values are considerably lower in the Kaštela Bay than in the areas which are under the influence of the open sea. This is mainly due to the fresh water inflows from the Jadro River and to the submarine springs (Alfirević, 1966).

The material was collected once a month by double vertical hauls of a plankton net of »Helgoland« type in the period January 1970 — December 1977. The area of mouth aperture of this net is 1.6 square metres and mesh size 0.516 mm. The net was towed from 35 m detph to surface at a speed of

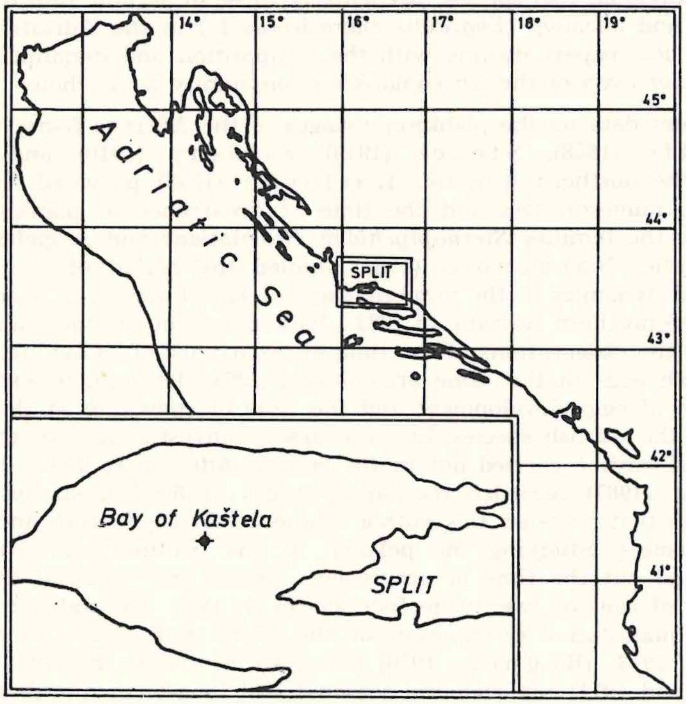

Fig. 1. Study Area

0.5 m/sec. The data on temperature and salinity were contemporeaneously collected from standard oceanographic levels.

Before beind sorted, the material was sedimented for 24 hours in beakers of one litre to obtain the data on the quantity of zooplankton expressed in cm^3/m^2. Larval stages were afterwards extracted, identified and counted. Larvae and postlarvae were, as a rule, determined up to the species level. In cases when this was not possible they were determined up to the level of genus.

The numerousnes of the larval fish stiges was given as a number of individuals under a square metre. It should be mentioned here that numerical data give only relative and not the absulte relations since the larval stages of different fish species were taken into consideration. However, these different fish species have different starting lengths and different growth rates and therefore the number of individuals of one species was not absolutely comparable to that of the others.

RESULTS AND DISCUSSION

A total of 41 species of the larval fish stages were found in the period of eight years of investigations together with 11 genera in cases when the identification could be done only up to the level of genus (Table 1). The time of their occurrence in the plankton is also given in the Table. To a certain extent, this time is also an indicator of the approximate time of spawning of the adult fish.

Table 1. The species of the larval fish stages found in the Kaštela Bay, the time of their occurrence in the plankton and global numerical frequency (in percentages)

	Months												Frequency
Species (Genus)	1	2	3	4	5	6	7	8	9	10	11	12	%
1	2	3	4	5	6	7	8	9	10	11	12	13	14
Sardina pilchardus (Walb. 1792)	×	×	×	×	×					×	×	×	13,38
Sardinella aurita Valenciennes, 1847						×		×	×				0,33
Engraulis encrasicolus (Linnaeus, 1758)				×	×	×	×	×	×	×			25,16
Merluccius merluccius (Linnaeus, 1758)		×											0,07
Gadiculus argenteus Guichenot, 1850	×	×		×									0,38
Merlangius merlangus merlangus Linnaeus, 1758			×	×									0,33
Micromesistius poutassou (Risso, 1826)				×									0,03
Trisopterus minutus capelanus (Lacepède, 1800)		×											0,08
Phycis blennoides (Brünnich, 1768)			×	×									0,08
Gaidropsarus mediterraneus (Linnaeus, 1758)										×			0,04

1	2	3	4	5	6	7	8	9	10	11	12	13	14
Serranus cabrilla (Linnaeus, 1758)						×							0,66
Serranus hepatus (Linnaeus, 1758)				×	×	×	×	×	×				5,47
Serranus scriba (Linnaeus, 1758)					×	×	×			×			0,19
Dicentrarchus labrax (Linnaeus, 1758)										×			0,04
Cepola macrophthalma (Linnaeus, 1758)					×	×	×	×	×	×			2,26
Trachurus trachurus (Linnaeus, 1758)	×		×						×				0,24
Mullus surmuletus (Linnaeus, 1758)					×	×							0,07
Mullus sp.					×	×		×					0,19
Sparus pagrus (Linnaeus, 1758)							×		×				0,07
Boops boops (Linnaeus, 1758)				×	×	×							0,42
Diplodus annularis (Linnaeus, 1758)					×	×	×	×					2,68
Diplodus sargus (Linnaeus, 1758)					×	×				×			0,94
Pagellus sp.	×			×									0,08
Spicara maena maena (Linnaeus, 1758)				×	×	×							1,97
Spicara smaris (Linnaeus, 1758)					×								0,14
Spicara sp.							×						0,52
Chromis chromis (Linnaeus, 1758)						×	×	×	×				0,61
Coris julis (Linnaeus, 1758)					×	×	×	×	×	×			3,25
Symphodus (Crenilabrus) doderleini Jordan, 1891								×					0,04
Symphodus sp.								×					0,04
Trachinus sp.							×						0,08
Uranoscopus scaber (Linnaeus, 1758						×							0,04
Scomber (Pneumatophorus) japonicus Houttuyn, 1782									×				0,04
Gobius sp.	×	×	×	×	×	×	×	×	×	×	×	×	14,70
Callionymus maculatus Rafines.ue, 1810		×	×	×	×					×	×	×	1,32
Callionymus phaeton Günther, 1861						×	×	×	×				0,67
Callionymus pusillus Delaroche, 1809				×	×	×	×	×	×	×			6,08
Blennius sp.					×		×	×					0,71
Sphyraena sphyraena (Linnaeus, 1758)					×								0,04
Mugil cephalus cephalus (Linnaeus, 1758							×	×					0,08
Mugil sp.		×											0,07
Scorpaena notata Rafinesque, 1810								×					0,11
Scorpaena sp.							×		×				0,10
Lepidotrigla cavillone (Lacepède)						×	×		×				0,07
Arnoglossus kessleri Schmidt, 1915				×	×	×	×	×					0,72
Arnoglossus laterna (Walbaum, 1792)							×	×					0,11
Arnoglossus sp.		×											0,07
Platichthys flesus italicus (Günther, 1862)			×										0,11
Solea impar Bennett, 1831				×	×			×	×				0,19
Solea lascaris (Risso, 1810)					×								0,04
Solea sp.							×		×		×		0,10
Lepadogaster lepadogaster lepadogaster (Bonaterre, 1788)		×											0,04
Unidentified													14,70

The larval stages of anchovy *(Engraulis encrasicolus L.)* were found to be numerically dominant in the area of the Kaštela Bay. As to the proportion of presence they are followed by the larval stages of the family *Gobiidae,* and species *Sardina pilchardus, Callionymus pusillus, Serranus hepatus, Coris julis, Diplodus annularis, Cepola macrophthalma, Spicara maena maena* and *Callionymus maculatus* (Table 1). The larval stages of these nine fish species and one family (genus) make up 76.8% of the total number of larval fish stages recorded from the Kaštela Bay.

The larval stages of the family *Gobiidae* excluded, which embrace relatively a large number of species, it appears that the anchovy (*Engraulis encrasicolus* L.) and sardine *(Sardina pilchardus* Walb). are absolutely predominant in the ichthyoplankton of the Kaštela Bay. Therefore the seasonal succession of the occurrence of species in the plankton may be devided into two fundamental aspects i. e. the sardine aspect in the colder part of the year (November-Aprail) and the anchovy aspect in the warmer part of the year (May-October). It was also found that the larval stages of sardine accounted for 47.06% in the total number of species in the November-April period while anchovy accounted for 33.54%. This shows that the occurrence of the sardine larval stages is accompanied by the considerably lower number of other species, what is also well evident from Table 1.

To examine to what extent the number of specimens of individual species in the plankton reflects the relative abundance of the adult part of their populations, our results were compared with the data on the numerical composition of trawl catches realized from the Kaštela Bay from September 1963 to August 1964 (J u k i ć, 1975). According to J u k i ć, a total of 44 species and two genera of fish, where the determination was not made up to the level of species (these data refer only to Osteichthyes) were recorded from these catches. Of these species, 31 (70.5%) were recorded from the plankton during our investigations, as well. The comparison of the number of species typical for trawal catches with the annual means of numerousness of their larval stages in the plankton showed a positive correlation (Fig. 2). The coeffi-

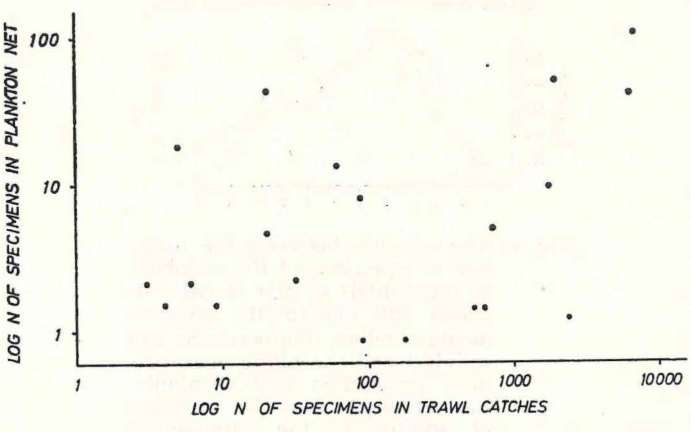

Fig. 2. The relation between the larval stages of the demersal fish species and the number of their adult individuals in the trawl catches from the Kaštela Bay

cient of correlation obtained there was relatively high ($r = 0.4864$; $P < 0.01$). This indicates that the species the number of the stages of which are prevalent in the Kaštela Bay are prevalent as well in their larval stages. On this basis it may be concluded that relative numerical proportion of individual species in the plankton of the study area may be a rather good indicator of the quantitative relations of the adult stages of the populations.

Further, it was of interest to study the distribution of the number of species and individuals of the larval fish stages during the year as well as their relation to some biotic and abiotic environmental factors. Therefore, the distribution of monthly means of the number of species and individuals covering the period of eight years was compared with monthly means of temperature and salinity for the column of water from 20 m depth to surface, as well as with the monthly means of the primary production of phytoplankton and the zooplankton volume for the same period (Fig. 3).

The distribution of both the number of species and the number of individuals shows an increase in the period from April to October. However, the

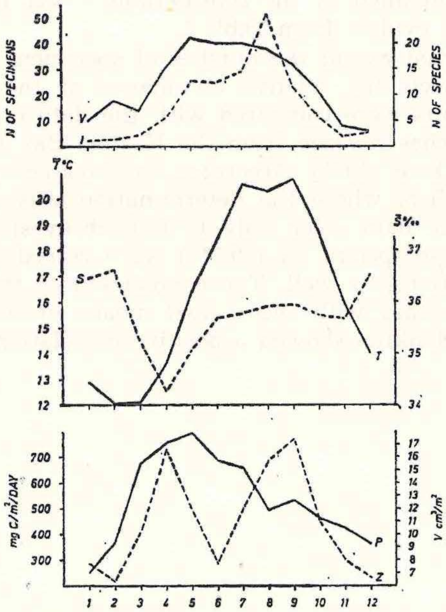

Fig. 3. The relation between the numbers of species and the numbers of individuals of the larval fish stages and the abiotic environmental factors (temperature and salinity) and the biotic ones (primary production and zooplankton volume) (v = the number of species, i = the number of individuals, t = temperature, s = salinity, p = primary production, z = zooplankton volume)

maximum number of species was found to occur in May and the maximum number of individuals in August (Fig. 3). The analysis of their relations to the environmental factors is given in Table 2.

Table 2. The relation of the numbers of species and the numbers of individuals of the larval fish stages to the annual variations in the abiotic (T and S) factors and the biotic ones (primary production and zooplankton volume)

	Number of Species		Number od Individuals	
	r	P<	r	P<
Temperature	0.668	0.02	0.792	0.01
Salinity	—0.414	—	—0.140	—
Primary Production	0.706	0.02	0.383	—
Zooplankton Volume	0.583	0.05	0.594	0,05

As it is obvious the largest number of species of the larval fish stages may be found in the plankton of the Kaštela Bay during the warmer part of the year (Fig. 3, Table 2). This finding agrees well with the data of Karlovac (1967) for the Kaštela Bay. The positive and statistically significant correlation coefficient between the distribution of the number of species during the year and temperature was to be expected since it is known that the number of species of fish of Mediterranean-Atlantic and circumtropical zoogeographical origin exceeds to a considerable extent the number of Mediterranean-borreal and Arctic-borreal species in the Adriatic. Further, the good agreement between the numbers of species and the annual variations in primary production and zooplankton (Fig. 3, Table 2) may be accounted for by the adaptability of the time of spawning of of fish to the trophical environmental conditions. It is known, namely, that the time and place of spawning of the major part of fishes comes as a result of adaptation which should provide the optimum trophical conditions for parents prior to the very spawning on one side, and the favourable conditions for the development of eggs and the nutrition of postlarvae, on the other (Nikolski, 1963).

The distribution of the numbers of individuals as well as the distribution of the numbers of species showed positive relation to temperature, primary production and zooplankton quantity (Fig. 3). However, the coefficient of correlation was found not to be statistically significant with primary production. (Table 2). High coefficient of correlation with temperature shoved that the numbers of larval stages is objectively high at higher temperatures. Namely, since the development and growth of the larval stages of fish as well as those of all the polkilotherms, are higher at higher temperature, their probability of occurence at higher temperatures is lower than when their development lasts longer. Therefore their increased numerousness at higher temperatures in the Kaštela Bay may be held to be a real consequence of the higher production of eggs and probably lower mortality rates.

Relatively high and statistically significant coefficient of correlation between the number of larval stages of fish and the volume of zooplankton shows that their numerousness and survival are probably affected by the quantity of available food. Thus, it may be assumed that the correlation found is not the direct one, but the one realized through the development stages of zooplankters mainly belonging to microzooplankton. This was concluded on the basis of earlier investigations of the nutrition of postlarvae of sardine (Karlovac, 1967), anchovy (Duka, 1963; Regner, 1971), and of the species *Serranus hepatus* and *Cepola macrphthalma* (Regner, 1977), i. e. of the species dominant in the Kaštela Bay as to their numerousness. These studies showed that the microzooplankton prevails in their food composition, particularly the development stages of copepods.

With respect to the insignificant correlation coefficients, salinity seems not to have any considerable influence to the quantitative-qualitative distribution of the larval stages of fish during the year.

If our data on monthly distribution of the number of fish larvae and postlarvae are compared with the data from earlier periods, some changes are found to have took place. Namely, after Vučetić (1970) in the 1956—1967 period the larval stages of fish reached maximum numbers in May an June, while our findings show that in the 1970—1977 period they reached maximum numbers in August (Fig. 3). This may be indicative of the fact that some changes have took place for the some few last years and that these changes probably have exerted some influence on the distribution of the number of larval stages in the study area. After Pucher-Petković (1975) in the 1968—1972 period the phytoplankton bloom occurred in the Kaštela Bay in winter (February—March), in autumn (November—December) and in August, while in earlier periods (1962—1967 and 1934) the phytoplankton bloom occurred only in spring and winter while in the summer it showed stagnation. On this basis Pucher-Petković concludes that the changes in the annual dynamics of phytoplankton occurring in the most recent years in the Kaštela Bay are probably due to the intensified organic pollution as a consequence of the effluents of the town of Split. Therefore it may be assumed that this eutrophication affects both the time of spawning and the survival of the planktonic stages of fish, which are indirectly connected with phytoplankton through zooplankton.

And finally, the analysis of the long-term fluctuations of the larval fish stages in the Kaštela Bay was also carried out. The data on the total number of species and individuals of the larval fish stages found in the study area during each individual year were used for these data were compared with the annual means of temperature and salinity for the entire water column from bottom to surface, as well as with the annual values of the gross primary production (g C/m^2/year) and the mean annual values of the zooplankton volume expressed in cm^3/m^2.

The distribution of all the parameters analysed during the 1970—1977 period is given in Fig. 4.

During the period of investigations both the quantity of species and the quantity of individuals showed two maxima both in the same years. However, while the quantity of species showed the absolute maximum in 1975 and that of individuals in 1971. From those years on a continuous decrease was practically recorded till the end of the period of investigations (Fig. 4). The comparison of these two parameters gave the negative correlation coefficient ($r = -0.208$) not statistically significant. Further, it may be seen from the Fig. 4 that there is not any significant correlation between the fluctuations of the number of species and the number of individuals and the fluctuations of abiotic and biotic environmental factores except between the number of larval stages and zooplankton quantity. This is even better shown by the calculated coefficients of correlation given in Table 3.

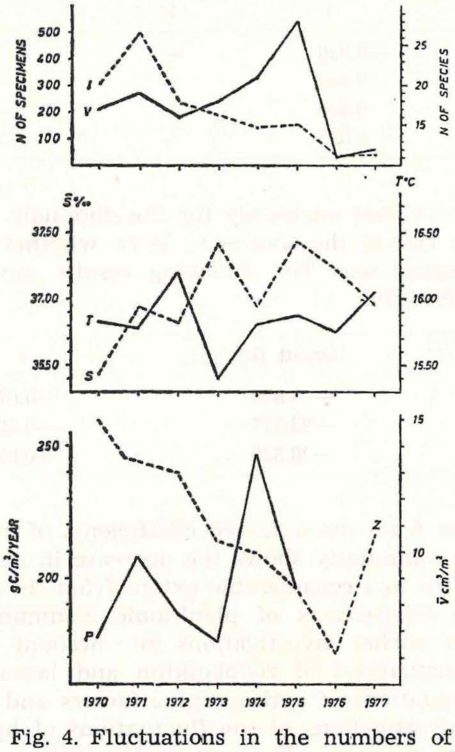

Fig. 4. Fluctuations in the numbers of species and in the numbers of individuals of the larval fish stages as related to the fluctuations of the abiotic environmental factors (temperature and salinity) and the biotic ones (primary production and zooplankton volume). (v = the number of species, i = the number of individuals, t = temperature, s = salinity, p = primary production, z = zooplankton volume).

The distribution of the numbers of species, temperature, salinity and primary production (Fig. 4) shows the normal fluctuations with the basic period of about three years. This period was established for these parametaers, with the exception of the number of species of fish larvae and postlarvae from this area, during some earlier investigations in which the method of spectral analysis was used (R e g n e r, 1979). However, the distribution of the larval fish stages and the volume of zooplankton show, as mentioned above, the tendency of decrease from the begining to the end of the period of investigations. Since the total numbers refers to a larger number of different fish species, the de-

Table 3. The relation between the long-term fluctuations of the number of species and the number of individuals of the larval fish stages and the fluctuations of temperature, salinity, primary production and zooplankton volume

	Number of Species		Number of Individuals	
	r	P <	r	P <
Tempearture	—0.336	—	—2.242	—
Salinity	0.301	—	—0.387	—
Primary Production	0.306	—	—0.127	—
Zooplankton Volume	0.024	—	0.752	0.05

crease trends were calculated separately for the dominant species (sardine and anchovy) and for the rest of the species to learn whether the phenomenon of this decrease is a general one. The following results covering the period of investigations, were obtained:

	Trend (b)	r	P <
Sardine	— 3.850	—0.679	0.1
Anchovy	—23.317	—0.797	0.02
Other Species	—26.620	—0.835	0.01

As it may be seen from the obtained coefficients of regression, the aggregate ichthyoplankton community shows the decrease in number.

These finding differ to a considerable extent from the results of the earlier investigations of the fluctuations of planktonic communities in the central Adriatic. Taking these earlier investigations into account it should have been expected that the fluctuations of zooplankton and larval fish stages would coincide with the fluctuations of hydrographic factors and primary production. Namely, the earlier investigations of the fluctuations of hydrographic parameters showed that the stronger inflows of water masses of the intermediate layer of the eastern Mediterranean in the Adriatic took place from time to time (they are called ingressions) which cause the increase of salinity and winter temperatures of the southern and central Adriatic (Buljan, 1953) These waters carry the higher quantities of nutrient salts whick positively affect the primary production (Buljan, 1968). The investigations of the primary production and the density of phytoplankton shoved that the fluctuations of phytoplankton responded very regularly to the ingressions of the Mediterranean waters in the areas influenced by the open sea. Their influence is also felt in the area of the Kaštela Bay where, in addition, the influence of local factors is even stronger (Pucher-Petković, 1970). Further, it was shown that the increase in primary production results in an increase in the quantity of zooplankton, what is later positively reflected in the catch of the pelagic fish in the central Adriatic (Vučetić and Pucher-Petković, 1969; Pucher-Petković, Zore-Armanda and Kačić, 1971). Fluctuations of salinity, temperature, primary production and quantity of zooplankton were found to affect the production of anchovy eggs, as well as the number and mortality rate of their postlarvae, even in the very coastal area of the Kaštela Bay (Regner, 1979).

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It is apparent, however, that neither the zooplankton quantity nor the number of larval fish stages in the Kaštela Bay have recently coincided with the fluctuations of hidrographic parameters and phytoplankton. This irregularity was already found in the postlarvae of anchovy in the 1971—1976 period (Regner, 1979). It should be mentioned here that the total number of larvae of fish in the Kaštela Bay showed very regular fluctuations in the 1959—1969 period (Vučetić, 1971). However, in 1961—1966 period the changes in the quantity of zoophankton coincided with the phytoplankton fluctuations (Vučetić, and Pucher-Petković, 1969).

Thus, it may be assumed that both the zooplankton and the larval fish stages in the Kaštela Bay have recently been under the adverse affect of some factors which is evident from the decrease in their numbers. The pollution growing recently in this area may be assumed to be one of these influencing factors.

For example, the investigations of the concentrations of heavy metals (Zn, Cd, Pb and Cu) in the sea water carried out along the profile the Kaštela Bay — Monte Gargano in the central Adriatic showed that the concentrations of these metals were highest just in the Kaštela Bay. It was also observed that the mean annual concentrations of the rest of these metals, with the exception of copper, showed the tendency of increase in the Kaštela Bay in the 1975—1978 period (Vukadin, personal communication). The observed decrease in the quantity of zooplankton and the larval fish stages in the Kaštela Bay is likely to be due to this phenomenon.

CONCLUSIONS

1. A total of 41 species of larvae and postlarvae of fish were identified from the plankton of the Kaštela Bay. There were found also 11 genera in cases when the determination was possible only up to the level of genus.

2. Annual succession may be divided into two aspects — the aspect of sardine in the colder period and the aspect of anchovy in the warmer period of the year. These two species are at the same time numerically most abundant.

3. The comparsion between the numbers of individual species of adult fish from the trawl catches and the number of their larval stages in the plankton showed positive correlation. Thus it may be concluded that the stocks of the adult part of populations are in some connection with their larval stages.

4. The largest number of species was recorded in May and largest number of individuals in August. Annual distribution of the numbers of species and individuals shows good correlation with the annual variations in temperature, primary production, and zooplankton quantity.

5. The lag of the maximum number of the larval fish stages in relation to the earlier reported ones was observed. This lag may be accounted for by the changes in the annual dynamics of phytoplankton due to the growing organic pollution.

6. The long-term distribution of the numbers of species of fish larvae, temperature, salinity and primary production vas found to show normal fluctuations with the basic periods established earlier in the area of the Kaštela Bay. On the contrary, the quantities of zooplankton and larval fish stages

show gradual decrease. Thus, it may be concluded that they are adversely affected by some factors the influence of which have been felt for the ten last uear only. The decreases in the number of zooplankton and the larval fish stages are likely to be partly the result of the increased concentration of heavy metals in the Kaštela Bay. These concentrations seem to have recently shown the tendency of increase.

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REFERENCES

Alfirević, S. 1966. Les sources sous-marines de la baie de Kaštela. Acta Adriat., 10 (12): 39p.

Buljan, M. 1953. Fluctuations of salinity in the Adriatic. Izvješća — Reports, 2 (2): 64p.

Buljan, M. 1968. Fluktuacija oceanografskih svojstava srednjeg Jadrana u razdoblju od 1962—1967. g. Pomorski zbornik, 6: 845—965.

Buljan, M. and M. Zore-Armanda. 1979. Hydrographic properties of the Adriatic sea in the period from 1965 through 1970. Acta Adriat., 20 (20): 368p.

Duka, L. A. 1963. Pitanie ličinok hamsi (*Engraulis encrasicolus* L.) v Adriatičeskom more. Tr. Sev. Biol. St., 16, 299—305.

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 (3): 445—470.

Jukić, S. 1975. Kočarska područja u srednjem Jadranu. Acta Adriat., 17 (1): 86p.

Karlovac, J. 1953. Sternoptychidae, Stomiatidae and Scopelidae in the Adriatic sea. Izvješća-Reports, 5 (2B): 44p.

Karlovac, J. 1967. Etude de l'écologie de la sardine, *Sardina pilchardus* Walb., dans la phase planctonique de sa vie en Adriatique moyenne. Acta Adriat., 13 (2): 112p.

Nikolski, G. V. 1963. The ecology of fishes. Acad. Press. London & New York, 352p.

Pucher-Petković, T. 1970. Sezonske i višegodišnje fluktuacije primarne produkcije u srednjem Jadranu. Pomorski zbornik, 8: 847—856.

Pucher-Petković, T. 1975. Fitoplankton Kaštelanskog zaljeva u odnosu na organsku poluciju. Pomorski zbornik, 13: 491—500.

Pucher-Petković, T., M. Zore-Armanda and I. Kačić. Primary and secondary production of the Middle Adriatic in relation to climatic factors. Thalassia Jugoslavica, 7 (1): 301—311.

Regner, S. 1971. Prilog poznavanju ishrane postlarava brgljuna, *Engraulis encrasicolus* (Linnaeus, 1758), u srednjem Jadranu. Ekologija, 6 (1): 157—164.

Regner, S. 1976. On the early stages of Fishes in the Cenral Adriatic in 1973. Rapp. Comm. int. Mer Médit., 23 (8): 63—65.

Regner, S. 1977. On the feeding of *Serranus hepatus* (L.) and *Cepola macrophthalma* (L.) postlarvae in the Central Adriatic. Rapp. Comm. int. Mer Médit., 24 (5): 87—89.

Regner, S. 1979. Ekologija planktonskih stadija brgljuna, *Engraulis encrasicolus* (Linnaeus, 1758), u srednjem Jadranu. Ph. D. Thessis, Beograd, 186p.

Steuer, A. 1910. Planktonkunde. Leipzig, 723p.

Stiasny, G. 1910. Beobachtungen über die marine Faune des Triester Golfes in Jahre 1909. Zoool. Anz., 35: 583—587.

Štirn, J. 1969. Pelagijal severnega Jadrana. Njegove oceanološke razmere, sestav in raspodelitev biomase tekom leta 1965. Razprave-Dissertationes, 12 (2): 92p.

Varagnolo, S. 1964. Calendario di comparse di uova pelagiche di Teleostei marini nel plancton di Chioggia. Arch. Oceanogr. Limnol., 13 (2): 240—279.

Varagnolo, S. 1964a. Variazioni diurne della presenca degli stadi di sviluppo di alcuni Teleostei marini nel plancton di Chioggia. Bol. Zool., 31 (2): 1037—1047.

Vatova, A. 1928. Compendio della Flora e Fauna del mare Adriatico presso Rovigno. Mem. R. Com. Talassogr., 143.

Vučetić, T. 1965. Long-term observations of zooplankton fluctuations in the Bay of Kaštela. Proc. gen. Fish. Coun. Medit., 8: 261—265.

Vučetić, T. 1970. Fluktuacija zooplanktona u srednjem Jadranu. Pomorski zbornik, 8: 867—881.

Vučetić, T. 1971. Fluctuations à long terme du macrozooplankton dans l'Adriatique centrale: oeufs de *Sardina pilchardus* Walb., *d'Engraulis encrasicholus* L. et larves de differentes poissons. Arch. Oceanogr. Limnol., 17 (2): 141—156.

Vučetić, T. and T. Pucher-Petković. 1969. Long term observation of plankton fluctuation in the Central Adriatic. Stud. Rev. gen. Fish. Médit., 41: 13—23.

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LARVALNI STADIJI RIBA NA PODRUČJU KAŠTELANSKOG ZALJEVA

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KRATKI SADRŽAJ

Tokom osmogodišnjeg perioda istraživanja (1970—1977) nađena je na području Kaštelanskog zaljeva 41 vrsta larvalnih stadija riba u planktonu, kao i 11 rodova u slučajevima kada je identifikacija vršena samo do roda. Ustanovljeno je da su na ovom području brojčano dominantni larvalni stadiji brgljuna i srdele, te da devet vrsta i jedan rod čine 76,8% ukupnog broja larvalnih stadija riba nađenih na istraživanom području (Tab. 1).

Izvršena je komparacija brojčane zastupljenosti pojedinih vrsta riba u kočarskim hovinama na području Kaštelanskog zaljeva i brojnosti njihovih larvalnih stadija u planktonu. Nađena je pozitivna i statistički signifikantna korelacija (Sl. 2).

Ispitivanja raspodjele broja vrsta i primjeraka larvalnih stadija riba pokazala su pozitivnu korelaciju sa godišnjom raspodjelom temperature, primarne produkcije i količine zooplanktona na području Kaštelanskog zaljeva (Sl. 3; Tab. 2), dok sa salinitetom nije nađena značajnija povezanost.

Analiza dugoročnih fluktuacija je pokazala da na području Kaštelanskog zaljeva brojnost larvalnih stadija riba, temperatura, salinitet i primarna produkcija pokazuju normalne fluktuacije sa osnovnim periodom od oko tri godine, dok količine larvalnih stadija riba i zooplanktona pokazuju trend opadanja (Sl. 4). Iznesena je predpostavka da bi jedan od uzroka ovoj pojavi mogao biti porast koncentracije nekih teških metala koji je zadnjih godina zapažen na području Kaštelanskog zaljeva.