A C T A A D R I A T I C A
INSTITUT ZA OCEANOGRAFIJU I RIBARSTVO - SPLIT
SFR JUGOSLAVIJA

Vol. XV, No. 5

THE OSCILLATIONS OF THE QUANTITY OF THE ANCHOVY'S PLANKTONIC PHASE IN THE CENTRAL ADRIATIC FROM 1968 TO 1971

OSCILACIJE KOLIČINE PLANKTONSKE FAZE BRGLJUNA U SREDNJEM JADRANU U PERIODU OD 1968. DO 1971.

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INTRODUCTION

In the research of fish population dynamics a great attention is payed to the planktonic phase of their life. It is known that survival of the eggs, larvae and postlarvae has a great influence on recruitment and, in this way, on oscillations of adult stock (Hempel, 1963; Nikolski, 1969). On the other hand, connoisseurship of the oscillations of the stocks, as the factors which have influence on them, is important for successful forecasting of the catch.

There were many attempts to bring the oscillations of the economically important fish stocs to the connection, among other things, with periodical changes of climatic and hydrographic factors, and organic production in separate regions.

For the Adriatic, Buljan (1953) was first who showed periodical changes of the environment. He found that increased ammounts of the water of higher salinity are coming periodically from the Eastern Mediterranean to the Adriatic. According to this author (Buljan, 1968), this water masses bring the increased quantity of nutritient salts which should reflex on the organic production. Then, it has been found that inflows of the Mediterranean water affect the long terme fluctuations of fitoplankton (Pucher-Petković, 1966 and 1968) and zooplankton (Vučetić, 1965 and 1970). It has been noticed that inflow of the Mediterranean water has the influence on the primary production increase (Pucher-Petković and Vučetić, 1969). Buljan (1968) has found that the inflow of the Mediterranean water influences the annual fish catches. For explanation the causes of sardine catch fluctuations in the Adriatic, work of Županović (1968) is rather important. According to him, the correlation between fluctuations of the climatic and hydrographic factors and long term oscillations of sardine catches along the eastern Adriatic coast exists. Furthermore, investigations of Zore-Armanda *et al.* (1971) has showed that factors which affect the more intensive exchange of water masses between the Eastern Mediterranean and the Adriatic, and these are gradients of the air pressure and penetration of the cold continental air, directly reflex on the primary production, and on the quantity of blue fish in the Adriatic about three years later.

Karlovac J. (1970), studying the oscillations of the quantity of planktonic sardine stages in the Central Adriatic during the spawning seasons from 1965/66 to 1969/70, found that sardine's eggs were appearing in the greatest number during the spawning season 1968/69. Vučetić (1971) on the same area, for 10 years period (from 1959 to 1969), found out that quantity of sardine and anchovy eggs, as the larvae of all fishes, showed tendency of further icrease from 1965 on, which she brings to the connection with improved

feeding conditions, because of intensified dynamic of the water masses.

The aim of this work was to try to find some eventual causes of the variations of the anchovy, *Engraulis encrasicolus* (L i n n a e u s, 1758), planktonic phase quantity in the Central Adriatic, where the above mentioned autors have been conducted their researches.

METHOD AND MATERIAL

The investigations have been conducted in the Central Adriatic at the stations Stončica (high sea), Pelegrin (channel region) and Kaštelanski zaljev

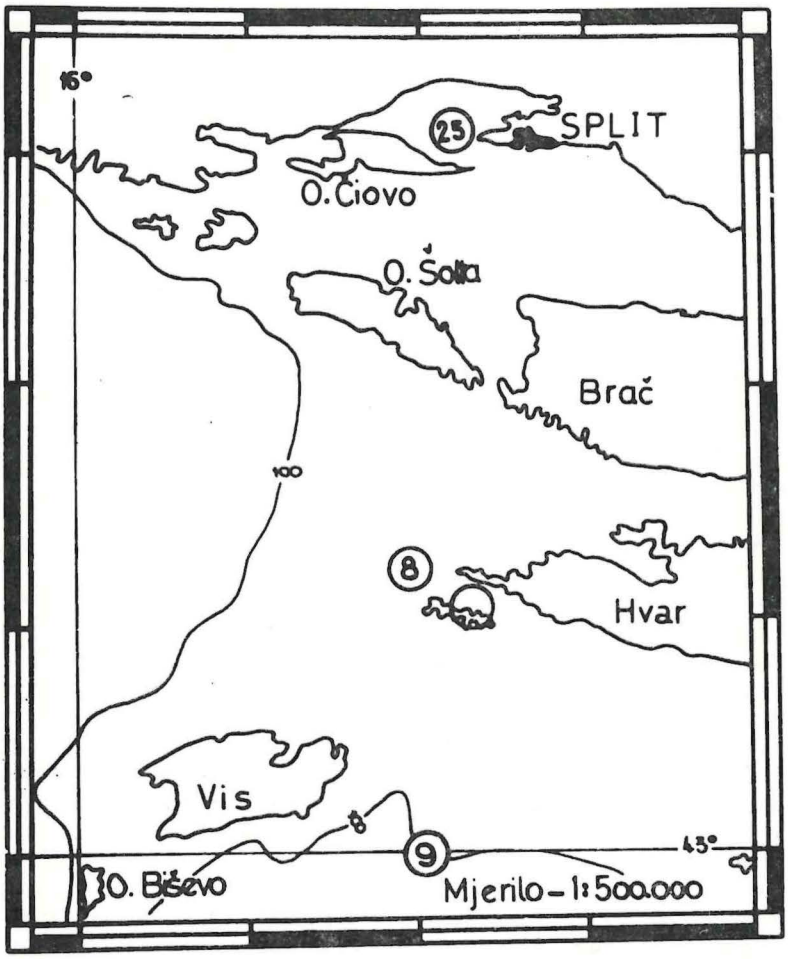

Fig. 1 Area of investigation
Stations:
No. 9 — Stončica
No. 8 — Pelegrin
No. 25 — Kaštelanski zaljev

(closed area in the vicinity of the shore) which are situated on the transversal profile in a level of Split (Fig. 1). On the mentioned stations the Institute of Oceanography and Fisheries has been conducting the complex research work.

For this work the material was collected by vertical hauls with the »Helgoland« type net (K ü n n e, 1933) once a month from the beginning of 1968 to the end of 1971. The part of that material, namely, the one from 1968 and 1969 was alreday used for the study of the ecology of the anchovy planktonic phase during the seasons of their appearance on the investigated area (R e g n e r, 1972).

Anchovy eggs, larvae and postlarvae were separated from the plankton samples and counted. The length of the larger and smaller egg's diameter and length of larvae and postlarvae was mesured. The larvae and postlarvae have been classified according to length into the 2, 4, 6 and 8 mm groups, indicated with the lower class limits. In the length group of 2 mm there are larvae and postlarvae which have passed over to active feeding recently, and in the others are postlarvae of different ages.

During the four years of the investigation it was cought totally 1710 eggs, 708 larvae and 470 anchovy postlarvae.

RESULTS

The analysis of the material showed that all planktonic stages of the anchovy were appearing on the investigated area from April to October, except in 1969 when they were found in plankton from March to November.

Although the horizontal distribution analysis of the anchovy planktonic stages pointed out some differences in their quantity at individual stations, in this work we were regarding the investigated profile as a whole.

The greatest number of anchovy eggs was found in 1969, and certain increase was noted in 1971. To make distinction from the eggs, larvae were the most numerous in 1968. The number of postlarvae from length group of 2 mm has been increased from 1968 to 1971, and number of 4 mm group postlarvae decreased. The greatest number of 6 and 8 mm groups postlarvae, thus the oldest ones, was found in 1969. (Tab. 1).

Table 1. Distribution of the anchovy planktonic phase on the investigated profile during the period 1968—1971

		larvae	postlarvae			
year	eggs	2 mm	2 mm	4 mm	6 mm	8 mm
1968	373	235	55	45	12	2
1969	501	151	75	36	13	5
1970	400	149	76	32	6	2
1971	436	173	78	26	7	0

Larvae and postlarvae length groups as a percents of a total eggs number are given in Fig. 2. Although they are calculated for a whole spawning season,

they could be used for a rough estimation of the survival rates. From the mentioned figure it could be seen that in 1969 survival rates were relatively constant, and that a percent of postlarvae who reached the 3 mm length group was the highest (1%). By basing it on this, and on maximal appearance of the eggs in the plankton for all the period of investigations, it could be concluded that 1969 was the most favourable for the anchovy's spawning.

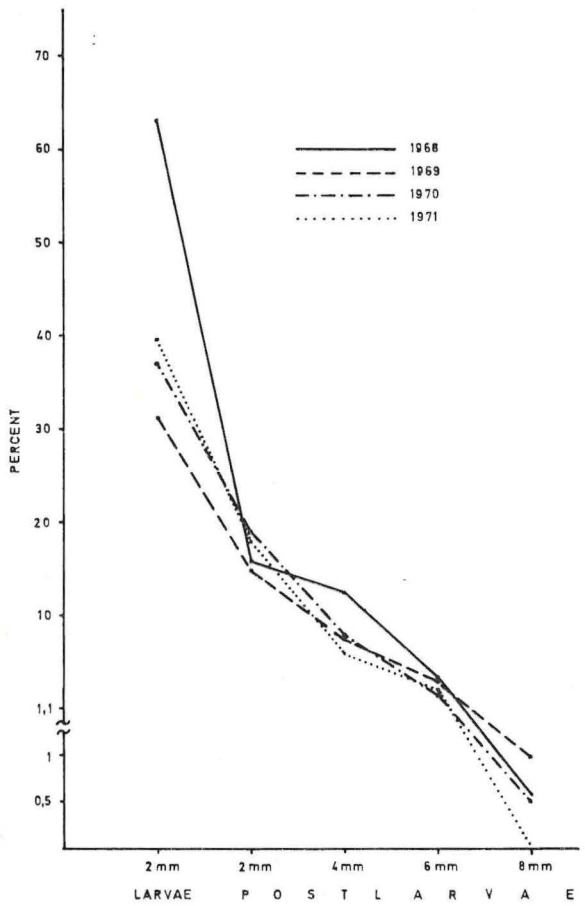

Fig. 2 Survival of anchovy larvae and postlarvae during 1968—1971 period. (Length groups are given in a percents of a total eggs number).

Analysis which have been conducted regarding the egg size, has shown that the both diameters have been reduced from the beginning to the end of the spawning season. Certain differences have been found in the mean year values of the both diameters, i. e. both of them are increasing from 1968 to 1971. (Tab. 2).

Table 2. Mean values of larger and smaller diameter of the anchovy eggs

	larger diameter months				smaller diameter months			
year	IV	V	VIII	m	IV	V	VII	m
1968	1,57	1,46	1,26	1,43	0,59	0,59	0,53	0,57
1969	1,56	1,53	1,32	1,47	0,60	0,58	0,55	0,57
1970	1,57	1,55	1,31	1,47	0,60	0,60	0,56	0,58
1971	1,58	1,55	1,33	1,48	0,63	0,61	0,56	0,60

DISCUSSION

The results of distribution analysis of the total annual number of anchovy eggs, larvae and postlarvae, showed that the greatest number of the eggs and the oldest postlarvae was found on the investigated profile in 1969. This could indicate that conditions for anchovy spawning, as for the survival of the postalarvae were the most favourable that year, which could be connected with the increase of primary production in the Adriatic (Z o r e - A r m a n d a *et al.*, 1971). Furthermore, it was found that the oscillations of the total annual quantity of the anchovy eggs and postlarvae from 6 and 8 mm length groups on the investigated profile are similar to those of the primary production annual means for the same area (Fig. 3).* According to this, it can be con-

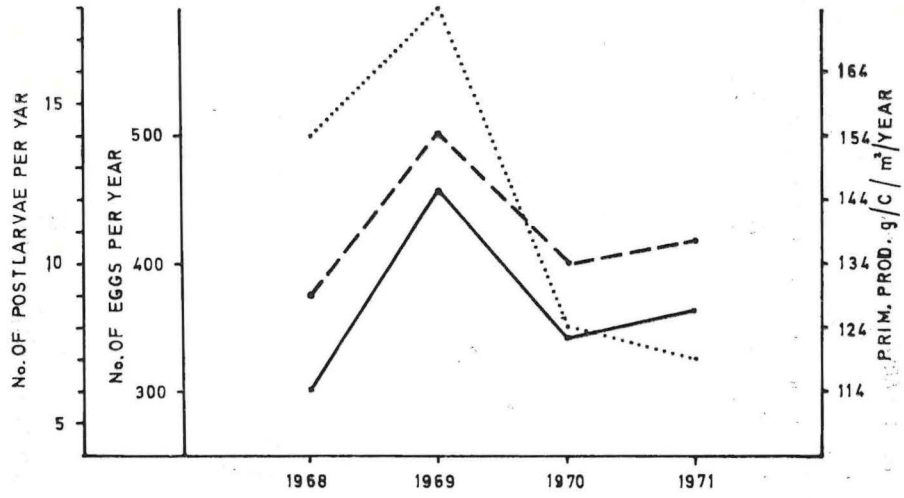

Fig. 3 The relation between primary production and number of anchovy eggs and postlarvae from length groups of 6 and 8 mm; ———— primary production; — — — — — eggs; . . . . . 6 and 8 mm postlarvae.

* The primary production is expressed as a mean annual value for the stations Kaštelanski zaljev and Stončica together. Data for the first three years are taken from Z o r e - A r m a n d a et al. (1971), and for 1971 are used unpublished data of T. P u c h e r - P e t k o v i ć.

cluded, although only a short period was investigated, that the quantity of available food could be one of the main factors affecting eggs quantity and survival of the postlarvae. Our results are similar to those of P a v l o v s k a j a (1958, 1961 and 1964) who found that increased ammounts of available food result with increased quantity of ovocits in the gonads of the Black Sea anchovy, and that a quantity of postlarvae increases with a quantity of zooplankton.

It has to be told that neither adult anchovy nor its postlarvae are fitofagous, because the adult anchovy feds mostly on copepods, mysids and the embryos of coastal crustacean species (D e m i r, 1965), while postlarvae feed on copepod eggs, nauplii and copepodits. Fitoplankton was found in stomach contents of anchovy postlarvae only in small quantities (P a v l o v s k a j a, 1958; D u k a, 1963; R e g n e r, 1971). This results show that the primary production would not affect the eggs quantity and survival of the oldest postlarvae directly, but probably by increased zooplankton production.

Larvae and postlarvae from length groups of 2 mm do not show dependence of primary production (Fig. 4). The greatest number of larvae was found in 1968. In 1969 and 1970 their number declines in order to increase again in 1971. What was the cause of their decrease in 1969, when the eggs were found in the greatest number, it could not be explained for the present.

Percentage increase of postlarvae from length groups of 2 mm in 1970 and 1971, and rise of their number from 1968 towards 1971 corresponds to

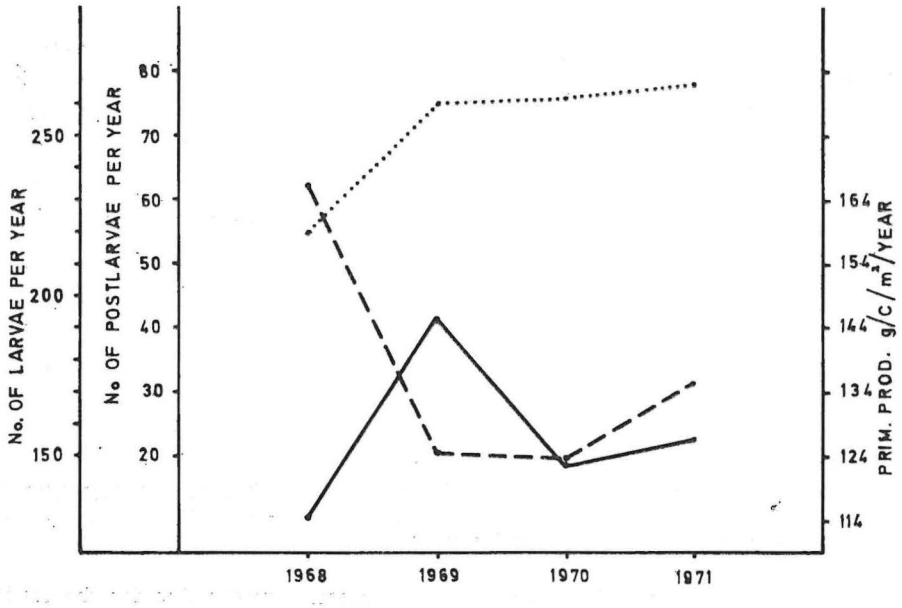

Fig. 4 The number of anchovy larvae and postlarvae from 2 mm length group compared with primary production; ———— primary production; — — — — — larvae; . . . . . 2 mm postlarvae.

the found increase of mean values of both diameters of anchovy eggs (Fig. 2, Tab. 2). According to Blaxter and Hempel (1963), the egg size, i. e. yolk reserve affects the survival of postlarvae just passed over to active feeding. The found correlation between the egg size and quantity of youngest postlarvae (Fig. 5) could be explained in this way.

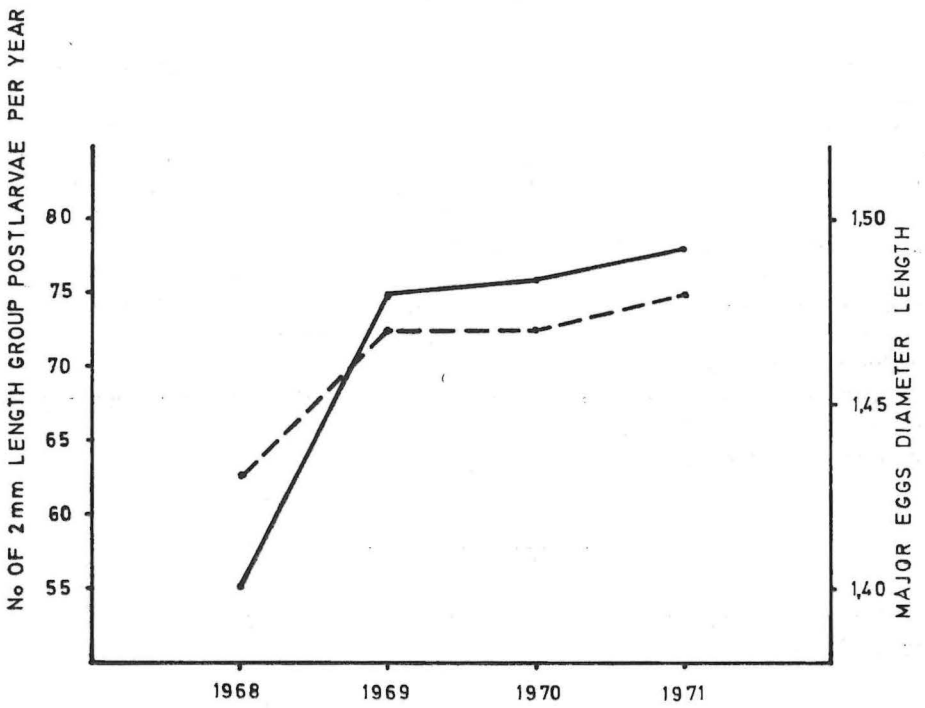

Fig. 5 The number of anchovy postlarvae from 2 mm length group and annual means of egg's larger diameter lengths; ———— 2 mm postlarvae; — — — — — larger egg's diameter.

The increase of primary production on the profile Kaštelanski zaljev — Stončica is followed by increase of annual means of both egg diameters in 1969, but from 1969 primary production has been declining and the egg size furthermore slowly rises (Fig. 3 and 5). Increase of the egg size in 1969 could be explained by the improved feeding conditions, but not the increase in years when the primary production declines. We could conclude that this problem is complex, because the egg size can be affected by the other factors. According to Hempel (1963 and 1971) and Nikolski (1969), the growth structure of the adult stock can influence on the egg size. De Ciechomski (1966) showed, for the argentine anchovy, that larger and older femals produce the larger eggs. With the anchovy from our area of investi-

gation could be the same. Investigation of the relation between mean seasonal temperature values and the egg size of the anchovy shoved in the Central Adriatic at the stations Stončica and Pelegrin in 1968 and 1969 that the temperature might also affect the egg size in the reverse sense (Regner, 1972, Fig. 6).

CONCLUSIONS

1. It has been found that oscillations of the total annual quantities of the anchovy eggs and the postlarvae from 6 and 8 mm length groups were, during the investigated period, similar to those of annual means of primary production. It can be supposed that more abundant appearance of eggs and postlarvae from quoted active feeding groups in 1969 could be caused by more intensive inflow of Mediterranean water masses into the Adriatic, which caused the increase of organic production in that year.

2. The mean annual anchovy egg size increases from 1969 to 1971. This increase could be only partially explained with improved feeding conditions for adult fish, because the egg size grows even in the years when primary production declines.

3. It has been found that the quantity of postlarvae from length group of 2 mm, just passed over to active feeding, seems to be dependent upon the egg size, i. e. yolk reserve.

ACKNOWLEDGEMENTS

I use this opportunity to express my thanks to dr Jožica Karlovac for useful suggestions during accomplishment of this work, and to dr Tereza Pucher-Petković who put at my disposal her unpublished data about the primary production for 1971. I also express my thanks to ing. Josip Dujmov and technician Antica Petrić for technical assistance.

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Received for publication November 24, 1972

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KRATAK SADRŽAJ

Materijal je sakupljan jedan put mjesečno od početka 1968. do kraja 1971. godine planktonskom mrežom tipa »Helgoland« na postajama Stončica, Pelegrin i Kaštelanski zaljev, raspoređenim na transverzalnom profilu u nivou Splita. Nađena jaja, larve i postlarve brgljuna su izbrojeni i izmjereni. Izmjerene larve i postlarve su svrstane u dužinske skupine od 2, 4, 6 i 8 mm. U skupini od 2 mm nalaze se larve i postlarve koje su tek prešle na aktivnu ishranu, a u ostalima postlarve koje se isključivo aktivno hrane.

Jaja brgljuna i postlarve iz dužinskih skupina od 6 i 8 mm nađeni su u najvećem broju u 1969. godini. Porast njihovog broja može se tumačiti poboljšanjem uvjeta ishrane adultnog brgljuna i postlarava iz navedenih dužinskih skupina, jer je 1969. godine došlo do pojačanog priliva mediteranske vode u Jadran, što je uvjetovalo porast primarne produkcije. Uspoređujući oscilacije brojnosti jaja i postlarava brgljuna iz skupina od 6 i 8 mm s godišnjim srednjacima primarne produkcije, nađeno je da se te vrijednosti tokom istraživanog perioda podudaraju, na osnovu čega bi se moglo zaključiti da primarna produkcija ima utjecaja na spomenute planktonske stadije. Utjecaj primarne produkcije na jaja i postlarve brgljuna vjerojatno nije direktan, već bi se mogao ostvarivati preko povećane produkcije zooplanktona kojim se, prema dosadašnjim podacima, adultni brgljun i njegove postlarve hrane.

Larve brgljuna i postlarve iz dužinske skupine od 2 mm, koje su tek prešle na aktivnu ishranu, ne pokazuju poklapanje s primarnom produkcijom. Smanjenje količine larava zabilježeno je u 1969. godini, kada je primarna produkcija bila najveća. Što je utjecalo na pad njihove brojnosti, za sada nije bilo moguće objasniti.

Kretanje brojnosti postlarava iz skupine od 2 mm poklapa se s promjenama srednjih godišnjih vrijednosti veličine jaja, na osnovu čega se može zaključiti da bi njihova brojnost mogla ovisiti o veličini jaja, odnosno o rezervi žumanca koja im stoje na raspolaganju.

Značajniji porast veličine jaja brgljuna uočen je u 1969. godini, što bi se moglo tumačiti boljom ishranjenošću adultne ribe zbog povećane primarne produkcije. Međutim, veličina jaja raste i u 1970. i 1971. godini, kada primarna produkcija opada. To bi moglo ukazivati da bi na promjene veličine jaja brgljuna na istraživanom području, uz eventualnu ishranjenost adultne ribe, mogao imati znatnijeg utjecaja i niz drugih faktora, koje bi trebalo istražiti.