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ZOOPLANKTON PRODUCTION IN THE MEDITERRANEAN SEA

PRODUCTION ZOOPLANCTONIQUE EN MEDITERRANEE

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Few investigations have been carried but in the Mediterranean Sea basin as yet where direct analysis included production and specific production in populations of certain planktonic organisms. Among these are the works by Razouls (1972, 1973, 1975), Gaudy (on copepods, 1976), Franqueville (1974), Fenaux (1976) in which production was estimated by the growth rate. These and some other observations made in the Mediterranean though being significant are still insufficient to be the basis for comprehensive estimates of zooplankton production in the basin. Therefore an attempt was made to calculate the production and specific production (denoted by C, i.e. production per unit mass) of major zooplankton groups using the physiological method proposed by Winberg (1966).

This attempt had the following prerequisites : first, the Institute of Biology of South Seas has organized a number of expeditions (R/V "Akademik A. Kovalevsky", "Professor Vodyanistky" and others) in different regions of the Mediterranean and collected vast material on zooplankton sampled by a single method, by standard layers, counting- weighting determination with taxonomic and size differentiation. The present report is based on the material concerning production obtained from 50 stations during 4 cruises to the Aegean and Adriatic Seas, Tunisian Strait and Algerian-Provençal Basin (Fig.1, Table 1).

Second, Ivleva (1973, 1981) and other researches from the Institute of Biology of South Seas were studying in the 70s the metabolic rates of large number of coelenterates, crustaceans, chaetognaths at different temperature in the Mediterranean and Atlantic. The studies provides equation parameters of relationship between metabolism and body mass of animals.

Third, relatively reliable data are gained on the food utilization coefficient per growth - K_2 , in the Mediterranean Sea basin in particular (Razouls and Apostolopoulou, 1977 ; Grézé, 1983).

It resulted in carrying out the computer calculations of basic zooplankton components' production according to the algorithm made by Zharov. The algorithm included :

(1) abundance and biomass of various size categories of certain taxonomic groups ;

(2) relation between metabolism R at given temperature and organism mass w $R = Aw^b$;

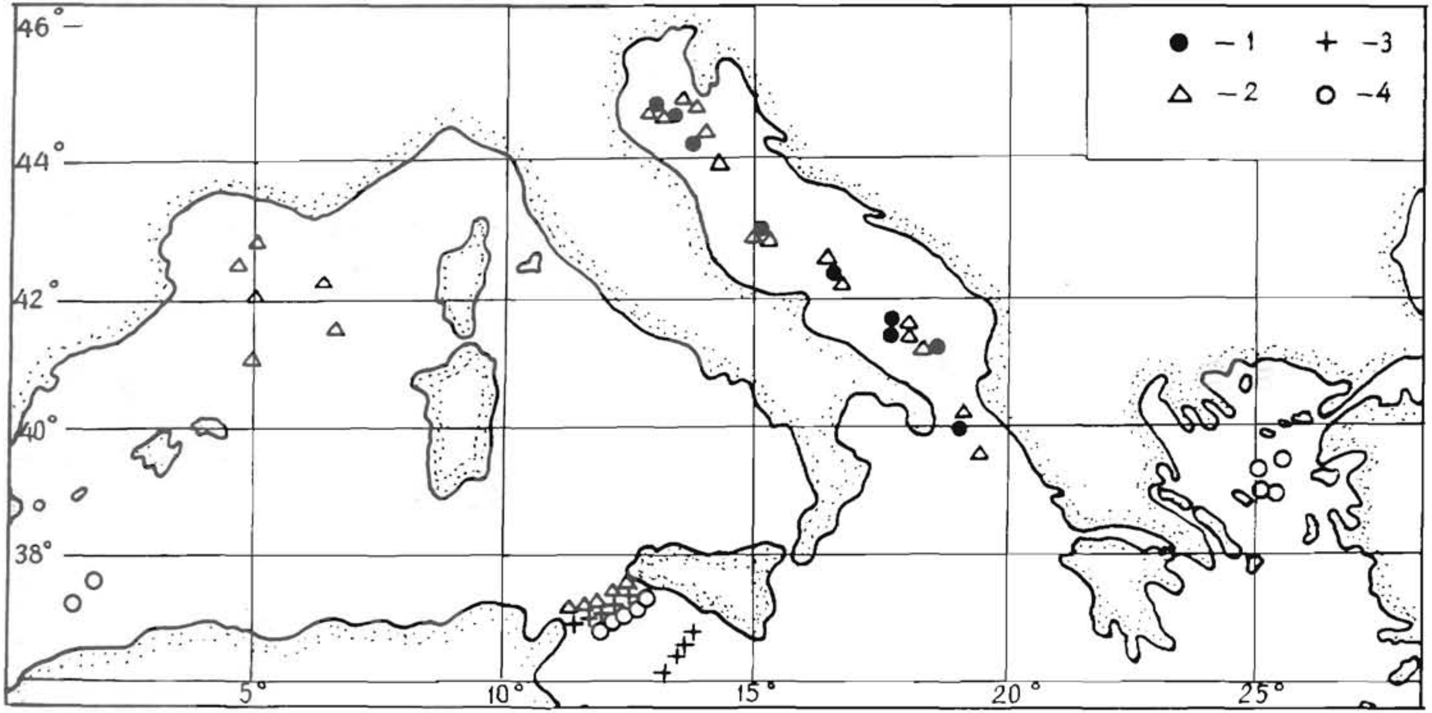

Figure 1 - The map of sampling stations :

1) the 3^{d} cruise of the R/V "Akademik A. Kovalevsky"
2) the 12^{th} cruise of the R/V "Professor Vodyanitsky"
3) the 71^{st} cruise of the R/V "Akademik A. Kovalevsky"
4) the 90^{th} cruise of the R/V "Akademik A. Kovalevsky"

(3) dependence of production P upon metabolism and food utilization coefficient per growth K_2

$$P = R \frac{K_2}{1 - K_2}$$

Production of copepods was estimated according to size groups. It appeared that despite the high abundance of the microplanktonic group < 0.5 mm (nauplii and first copepodites of small-size species) their share in the total production is not great and within the 0-50 m layer it makes about 7 % (Fig.2). Such insignificant value of this category agrees well with the general law of copepod growth expressed by an S-shaped curve and with low biomass of the size group. The major production share falls within the 0-50 m layer containing copepods of the 0.5-I mm size ; however with increasing depth the tendency is observed of further size groups domination, mainly of 1-2 mm.

The results of the studies fulfilled in summer, autumn and winter-spring period in the region from the Agean Sea to Algerian- provençal basin showed that copepod production within the 0-50 m layer varied between 1.63 and 8.82 mg.m-3 with average value of 4.25 $mg.m^{-3}$ or 212.5 $mg.m^{-2}$ (Table 2). Within the 50-100 m layer this value amounted to 1.68 $mg.m^{-3}$, at 100-200 m it was 0.95 $mg.m^{-3}$. On the whole, copepod production within the upper 200 m made 391.5 $mg.m^{-2}$ of wet biomass. The error of this value is limited by 20-25 %.

The values of the specific production C are determined according to the biomass and production values. In copepods they varied within 4-18 % daily, depending on depth, temperature, size and age composition of the population. Figure 3 shows the decrease of value C which is more distinct in the transition from the 50-100 m layer to that of 100-200 m. This is determined on the whole by the drop in temperature. Besides, the figure demonstrates the values of the average biomass and production of copepods varied with depth.

The aboved-mentionned works by French colleagues concerning study of production in copepod populations showed specific production value being very close to the author's data. Razouls (1975) considers this value approaches 13-15 %, Gaudy (1976) defines it in May-June as 12 % on the average for 6 copepod species. Thus, other materials on the Mediterranean along with the published data on other aquatoria with similar ecological conditions (Grézé, 1978 ; Zaika, 1983) are approximating the author's results according to which the average annual specific copepod production within the 0-100 m layer makes about 10 % daily.

Analogical calculations were made on euphausiids, amphipods, chaetognaths, as well as medusae, siphonophores, salps and doliolids.

Production of euphausiids ans amphipods made in average for all regions 0.077 $mg.m^{-3}$ within the 0-50 m layer, 0.026 $mg.m^{-3}$ within the 50-100 m layer and 0.013 $mg.m^{-3}$ within the 100-200 m layer or 6.5 $mg.m^{-2}$ in the entire 0-200 m layer. It corresponded to 2 % of the copepod production. In chaetognaths the average total production in the 0-200 layer amounted to about 53 $mg.m^{-2}$ while coelenterates and tunicates, somewhat artificially combined in estimations according to the common high water contents in the body, yielded still higher production, i.e. about 133 $mg.m^{-2}$.

The size composition of taxons under consideration is, in contrast to copepods, from 2-3 to 10 mm and more. Here in euphausiids and amphipods as well as in coelenterates and tunicates the main share of production falls within size categories of 2-3 and 3-6 mm and in chaetognaths - even larger size categories (Table 3). Just as in copepods, the share of production of large size groups shows the increase in the lower layer.

Specific production indices in different taxonomic groups vary according to the habitat layer depth and population composition ; particularly, in euphausiids ans amphipods C ranges from 0.01 to 0.12, thus averaging almost 0,05. In chaetognaths C varies from 0.02 to 0.24 and mean weight value for the 0-200 m layer is 0.07.

The group of coelenterates and tunicates exhibited the maximum specific production of 0.05-0.26 averaging about 0.12 within the 0-200 m layer. It is possible that these values are closer to the minimum ones since data are available on a higher specific production in salps. Fenaux (1976) reported of specific production value 0.27 in appendicularians during winter-spring period. Thus, it may be assumed that tunicates demonstrate relatively higher production rate comparing with other plankton groups.

The production values in different taxonomic groups should not be summed while analysing the trophic structure of planktonic communities, since one group may contain organisms of various trophic levels. Consequently, bearing in mind the future target we tried to divide the production of all major planktonic taxonomic groups into shares formed by phytophags, euryphags and predators.

In this case production or appendicularians, salps ans diliolids, half of the euphausiid and amphipod production and main part of that of copepods were ascribed to production of phytophags. Second half of euphausiid and amphipod production together with the production of some part of copepods and certain groups of animals attributed to the "others" were attached to the trophic level of euryphags consuming animal and plant food and detritus. The category of predators included chaetognaths, siphonophores, medusae, certain amount of the "others" and copepods.

It is known that many copepods, one way or another, are characterized by euryphagy, therefore their grouping into three above-mentioned throphic categories on the basis of the available published data should not be considered as an exact alimentary characteristic of a given family, but rather as their mean statistical distribution over trophic levels. However, even such shematization allows to obtain relatively adequate notions of the production of certain ecological categories in plankton and, consequently, of the functioning of the entire pelagic system.

As long as the obtained biomass and production values are expressed in wet weight of organisms having different contents of water, ash and ash-free organic matter, the comparisons impede understanding of their real ecological significance within a given ecosystem. That is why their production afterwards was converted in terms of dry ash-free matter according to numerous published data on the subject, particularly on the Mediterranean Sea (Mazza, 1964 ; Pavlova, Vityuk, 1967 ; Ivleva, 1981 ; etc.).

The ash-free matter content was admitted as follows : appendicularians, 0.10 ; copepods, 0.14 ; amphipods and euphausiids, 0.19 ; chaetognaths, 0.05 ; salps, doliolids, 0.02 ; coelenterates, 0.015.

Results of estimations, generalizing production materials of the total zooplankton in terms of dry organic matter with differentiation at trophic levels, show (Tableau 4) that within the upper 100 m layer the phytophags form over 50 % of total production, euryphags - more than 20 % and predators - about 25 %.

With increasing depth the share of predators is growing from 23.9 % (0-50 m) to 30.5 % (100-200 m). Accordingly, the significance of phytophags drops from 54 % in the upper layer to 36 % in the lower one.

Thus, at a depths, certain rearrangement of zooplankton functional organization occurs, predators using the production of lower trophic levels more effectively in depth. In the upper layer the ratio of their production to total production of phyto- and euryphags makes 0.30, growing to 0.40 in the lower layer.

In both cases these indices are very high and, on the one hand, undoubtely reflect great balance of trophic relations in plankton of the Mediterranean Sea ; on the other hand, they may indicate insufficiently adequate sorting of zooplankton according to trophic categories on the basis of the presently available alimentary characteristics of various species.

Therefore, a more detailed study of trophic relations, food composition and ration of basic zooplankton components seems to be one of the major tasks of further investigations of the Mediterranean pelagic ecosystem, processes of production, transformation and destruction of organic matter in this system.

Fenaux R. - Cycle vital, croissance et production chez Fritillaria pellucida (Appendicularia), dans la baie de Villefranche-sur-Mer, France. *Mar. Biol*, 34 (2), 1976 ; 229-238.

Franqueville C. - Essai d'estimation de biomasses et de production secondaire de quelques espèces du micronecton de Mediterranée nord- occidentale. *Tethys*, 6 (4), 1974 ; 741-750.

Gaudy R. - Feeding four species of pelagic copepods under experimental conditions. *Mar. Biol.*, 25 (2), 1974 ; 125-141.

Gaudy R. - Etude du plancton de la zone nord de la rade de Villefranche-sur-Mer a la fin du printemps (17 mai 1971 au 16 juin 1971). III. Production secondaire des copépodes pelagiques. *Vie et Milieu*, 26, f.I, ser. B, 1976 ; 77-106.

Grézé V.N. - Production in animal populations. In O. Kinne (ed.) Marine Ecology, V (4), 1978 ; 89-114.

Grézé V.N. - Food utilization efficiency and production in populations of marine copepods. Biology of Sea, 1983, 2, Vladivostok ; 20-25.

Homen B., Regner D. - Some preliminary data on the nutrition of dominant copepods in the Kastela Bay. Rapp. et proc.-verb. *Comm. Int. Exp. Sci. Mediterr.*, 24, 10, 1977 ; 163-164.

Ivleva I.V. - Quantitative correlation of temperature and respiratory rate in poikilothermic animals. *Pol. Arch. Hydrob.*, 20 (2), 1973 ; 283-300.

Ivleva I.V. - The environmental temperature and rate of energetic metabolism in aquatic animals. Kiev, Naukova dumka, 1981 ; p. 232.

Mazza J. - Premières observations sur les valeurs de poids sec chez quelques copépodes de Méditerranée. *Rev. Trav. Inst. Pêch. Marit.*, 28 (3), 1964 ; 292-301.
Mironov G.N. - About the maximum length and the P/B coefficient in Sagitta setosa in the Black Sea. Biology of Sea, 1973, 28, Kiev, Naukova dumka ; 23-26.
Pavlova E.V. - Vityuk D.N., About some chemical components content in the body of copepods of the Adriatic Sea. *In* : Biology and distribution of plankton of the South Seas. Moscow, Nauka, 1967 ; 99- 104.
Razouls C. - Estimation de la production secondaire (copépodes pélagiques) dans une province néritique méditerranéenne. Thèse de doctorat. Paris, 1972 ; 1-301.
Razouls C. - Variations annuelles quantitatives de deux espèces dominantes de copépodes planctoniques : *Centropages typicus* et *Temora stylifera* de la région de Banyuls : cycle biologique et estimation de la production. *Cah. Biol. Mar.*, 14 (3), 1973 ; 361-390.
Razouls C. - Estimation de la production globale des copépodes planctoniques dans la province néritique du golfe du Lion (Banyuls-sur-Mer). II. Variations annuelles de la biomasse et calcul de la production. *Vie et Milieu*, 25, f. I-B, 1975 ; 99-122.
Razouls C. - Apostolopoulou M., Bilan énergétique de deux populations de copépodes pélagiques *Temora stylifera* et *Centropages typicus*, en relation avec la présence d'une thermocline. *Vie et Milieu,* 27 (1, ser. B), 1977 ; 13-25.
Reeve M.R. - Baker L.D., Production of two planktonic carnivores (chaetognath and ctenophore) in South Florida inshore waters. *Fish Bull* 73, (4), 1975 ; 238-248.
Winberg G.G. - The growth rate and metabolic intensity in animals. *Modern Biology Achievements*, 61 (2), 1966 ; 274-293.
Winberg G.G. (ed.) - The methods for the estimation of production of aquatic animals. Higher School Publisher, Minsk, 1968 ; p. 246.
Zaika V.E. - About the appendiculariae and sagittae production in the neritic zone of the Black Sea. Biology of Sea, 1969, 17; Kiev Naukova dumka ; 65-78.
Zaika V.E. - Comparative productivity of hydrobionts. Kiev, Naukova dumka, 1983 ; p. 206.
Zaika V.E. - Pavlova E.V., Kovalev A.V. The planktonic crustaceans diet. *In* : The expeditionary researches in the Mediterranean Sea in May- June 1968. Kiev, Naukova dumka, 1970 ; 78-85.

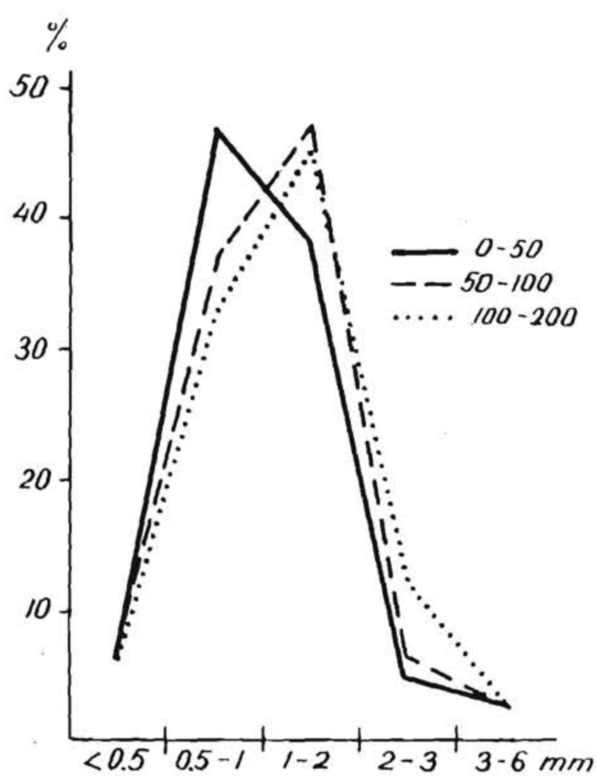

Figure 2 - Distribution of the copepod production by their size groups

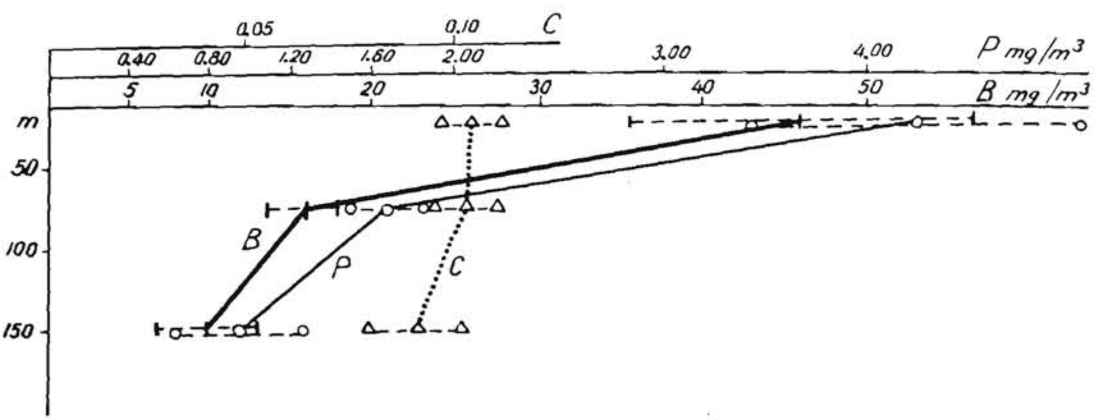

Figure 3 - Biomass (B), production (P) and specific production (C) of copepods in different layers of the Mediterranean Sea.

Expedition	Time	Region	Number of stations	Number of samples	Water layer, m
"Akademik A. Kovalevsky", the 3^{d} cruise	VII.I960	Adriatic Sea	8	40	0-200
"Professor Vodyanitsky", the I2th cruise	III-IV.I982	- " -	I3	79	0-200
- " -	IV.I982	North Algerian-Provencal Basin	6	30	0-200
- " -	III.I982	Tunisian Strait	5	I4	0-200
"Akademik A. Kovalevsky", the 7Ist cruise	IX.I972	- " -	9	72	0-500
"Akademik A. Kovalevsky", the 90th cruise	IX.I980	- " -	5	9	0- 80
- " -	IX.I980	Aegean Sea	4	42	0- 25
		In all:	50	286	

TABLE I - MATERIAL USED FOR CALCULATION OF ZOOPLANKTON PRODUCTION

Region	Time	0-50 m			50-100 m			100-200 m		
		B	P.	C	B	P	C	B	P	C
North Algerian-Provencal Basin	IV.1982	56.7	8.82	0.155	10.3	1.47	0.140	8.6	0.68	0.080
South Adriatic	III.1982	54.3	4.08	0.075	14.8	1.12	0.075	9.8	0.89	0.091
	IV.1982	26.2	1.92	0.073	10.2	0.88	0.086	7.5	0.71	0.094
	VII.1960	15.7	2.40	0.153	10.3	1.61	0.156	6.9	1.04	0.149
North Adriatic	III.1982	102.0	6.40	0.062	23.0	1.62	0.070			
	IV.1982	74.1	6.30	0.085	21.2	1.77	0.083			
	VII.1960	22.0	3.48	0.157	25.5	4.39	0.172	27.6	2.83	0.103
Tunisian Strait	III.1982	39.3	3.28	0.084	22.7	1.81	0.080	5.1	0.42	0.083
	IX.1972	17.2	1.63	0.095	8.1	0.53	0.065	3.0	0.12	0.040
	*) IX.1980	76.5	13.65	0.178						
Aegean Sea	*) IX.1980	29.3	5.24	0.178						
Mean		45.2	4.25	0.104	16.2	1.68	0.103	9.8	0.95	0.091
Abs. mean error		±9.76	±0.81	±0.013	±2.27	±0.36	±0.013	±3.09	-0.33	0.012
%		21	19	12	14	21	13	31	35	13

*) Indices for the 0-25 m Layer were not included in calculation of the mean

TABLE II - BIOMASS (B), PRODUCTION (P) IN mg.m^{-3}, SPECIFIC DAILY PRODUCTION (C) OF COPEPODS IN DIFFERENT REGIONS OF THE MEDITERRANEAN SEA BY WATER LAYERS

Region	Time	0-50 m					50-I00 m					I00-200 m				
		<0.5	0.5-I	I-2	2-3	>3	<0.5	0.5-I	I-2	2-3	>3	<0.5	0.5-I	I-2	2-3	>3
North Algerian-Provencal Basin	IV.I982	2.I	62.2	I8.7	I0.3	6.7	I.7	45.2	36.2	I2.6	4.3	0.9	40.9	29.5	20.4	8.3
South Adriatic	III.I982	I.6	46.7	40.9	4.4	6.4	9.3	32.9	46.6	8.9	2.3	5.9	29.0	60.3	4.4	0.4
	IV.I982	4.0	5I.5	37.4	7.I	-	3.8	32.4	53.0	8.4	2.4	3.3	32.6	53.2	8.5	2.4
	VII.I960	8.6	3I.8	52.5	4.9	2.2	7.I	I9.8	57.7	I0.9	4.5	8.4	26.2	56.6	8.8	-
North Adriatic	III.I982	I4.9	4I.7	38.5	3.2	I.7	4.I	27.7	64.2	4.0	-					
	IV.I982	5.9	30.4	6I.7	I.4	0.6	5.2	28.2	65.0	I.6	-					
	VII.I960	I7.7	37.4	39.I	4.I	I.7	8.8	20.4	62.0	5.2	3.6	9.5	23.4	54.2	9.8	3.I
Tunisian Strait	III.I982	2.I	62.6	27.7	5.0	2.6	4.2	56.5	29.3	5.8	4.2	2.4	37.7	46.8	8.9	4.5
	IX.I972	I0.0	60.2	26.9	2.I	0.8	II.7	72.8	I3.5	I.8	0.2	I0.7	40.8	22.I	26.4	-
Mean %		7.4	47.I	38.0	4.7	2.8	6.2	37.2	47.3	6.5	2.8	5.8	32.9	46.0	I2.4	2.9
$mg \cdot m^{-3}$		0.3I	2.00	I.62	0.20	0.I2	0.I0	0.62	0.80	0.II	0.05	0.05	0.3I	0.44	0.I2	0.03

TABLE III – THE PERCENTAGE OF DISTRIBUTION OF COPEPOD PRODUCTION BY SIZE GROUPS (mm) IN DIFFERENT WATER LAYERS

Region, time	0–50 m			50–100 m			100–200 m		
	Ph	Pe	Pc	Ph	Pc	Pc	Ph	Pe	Pc
1	2	3	4	5	6	7	8	9	10
North Algerian-Provencal Basin IV.1982	259.1 / 36.0	92.5 / 12.9	114.5 / 14.2	35.2 / 4.8	29.9 / 4.1	25.1 / 2.7	9.9 / 1.4	23.1 / 3.2	3.1 / 0.4
South Adriatic III.1982	172.9 / 23.6	34.5 / 4.8	17.5 / 2.1	36.6 / 5.1	9.1 / 1.3	12.1 / 1.7	37.3 / 4.8	40.4 / 5.6	13.7 / 1.9
IV.1982	142.1 / 12.1	12.2 / 1.6	41.7 / 2.3	17.0 / 2.4	15.9 / 2.2	22.9 / 2.0	23.8 / 3.3	29.3 / 4.1	18.3 / 2.6
VII.1960	147.5 / 18.5	46.8 / 6.1	129.1 / 9.7	61.3 / 8.0	13.8 / 1.9	57.4 / 3.7	45.0 / 6.2	29.5 / 3.9	57.8 / 6.5
North Adriatic III.1982	28.6 / 3.7	70.2 / 13.1	75.4 / 7.7						
IV.1982	206.9 / 28.8	97.9 / 13.1	51.2 / 5.0	60.9 / 8.5	13.6 / 1.9	17.6 / 2.3			
VII.1960	291.4 / 17.5	188.7 / 20.7	317.3 / 24.9	149.3 / 18.5	53.9 / 6.9	190.5 / 13.5	146.4 / 19.1	112.9 / 14.1	229.8 / 18.0
Tunisian Strait III.1982	211.4 / 22.2	57.1 / 7.3	114.8 / 6.5	71.4 / 9.3	36.5 / 4.6	34.3 / 2.4	16.2 / 2.3	19.0 / 2.6	15.4 / 1.7
Mean $mg \cdot m^{-2}$	182.4 / 20.3	73.4 / 8.3	107.6 / 9.0	61.6 / 8.0	20.4 / 3.2	51.4 / 4.0	46.4 / 6.1	42.3 / 5.5	56.3 / 5.1
%	50.3 / 54.0	20.2 / 22.1	29.5 / 23.9	46.2 / 52.7	15.3 / 21.0	38.5 / 26.3	32.0 / 36.6	29.0 / 32.9	39.0 / 30.5

TABLE IV - PRODUCTION (IN $mg.m^{-2}$) OF PLANKTONIC PHYTOPHAGS (Ph), EURYPHAGS (Pe) AND PREDATORS (Pc) BY WATER LAYERS. NUMERATOR - WET, DENOMINATOR - DRY ASHLESS MATTER.