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FEATURES OF THE ROMANIAN BLACK SEA COAST ZOOPLANKTON DYNAMICS

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A b s t r a c t

The paper shows the major features of zooplankton in varoius sectors of the Romanian coast of the Black Sea, studied over the 1960-1966 period. The results of researches led to the determination of seasonal and pluri-annual dynamics for the major zooplankton species, depending upon changes in environment (winds, marine currents salinity level, water temperature and phytoplankton). A specific zooplankton biocenosis was determined - the zone comprised between 5 to 30 marine miles far from shore, with a depth between 20 and 50 m.

Our researches on zooplankton were conducted in the 1960-1966 period in the Black Sea sector washing the Romanian continental platform, while the bulk of the samples were collected from 30 sea mile-long, zone stretching all along the coast of the Black Sea. The depth of the investigated zone varied between 20 and 50 m, while the total water volume was of 360 km^3.

Most of the experimental material was collected by us during

some complex expeditions, when observations were made concerning wind direction and strength, sea condition, depth, transparence degree and colour, water temperature and currents. Water samples were collected for chemical (salinity, nitrate, phosphate and silicate content), and biological analyses (phytoplankton, zooplankton and ichtyoplankton).

Some 967 samples from 403 stations were examined. The samples were collected with a 36 cm diameter block net for the 0–10 m, 10–25 and 25–50 m standard horizons, while at lower depth stations the collection proceeded at every 25 m. The biomass was estimated on basis of the average organisms weight, per sexes and development stages, for Copepods, or only per species and size for the rest of the organisms.

Environment factors for zooplankton

The zooplankton, made up of short-lived organisms, is strongly influenced by the alteration in environment factors, a fact wich explains its wide variability both to qualitative and quantitative composition. Hence, depending upon the development stage of the organisms one or several factors can have a stimulating or inhibiting role, inducting in some species or groups, either higest development, or hindering their development, or even causing their disappearance.

The environment factors studied were those affecting in an obvious manner zooplankton, namely the winds, marine currents, water salinity level, temperature and phytoplankton. These factors act in close relation, conditioning each other, having different effects, in connexion with season and development stage of zooplankton.

The winds. As northern winds are predominant they bring to the sea shore water sheets with a rich nutrient content, having indirectly a favourable effect on the subsequent development of zooplancton, creating excellent conditions of life. This fact is mirrored in the high value of zooplankton mass (as in the 1960 summer). The long-lasting tempests create precarious living conditions for fish and zooplankton (as in the winters of 1963–1966), while the big number of calm days, over longer priods

promonte zooplankton growth (as in the summers of 1965-1966). Sea currents are inconstant, close to the Romanian coast ; the researches could not detect, over longer period, a predominance from one of the sectors, nor the same direction along a profile, or, at the same station, from the surface down to the bottom. Due to the changeableness of the currents, the large water mass was moving permanently in various directions, generating the insular dissemination of zooplankton under the form of patches of various concentrations, while its qualitative and quantitative composition differed both from one station to another, and in cross-section, at the same station. The low depth cold counter-currents can bring in summer a large mass of water from the lower horizons, with entire fauna: so, in midsummer we could find the Pseudocalanus elongatus (Boeck) Copepod in the 0-10 m horizon (July 1960 and 1962), or big amounts of spratt (in the summer of 1965).

Water temperature, at the surface, registred high differences, assuming an annual curva with the lowest point in January-March, and a peak in July-August; in the deep layers, the seasonal differences were very small. Homothermy of a large mass of water recorded generally in the autumn, was delayed in some years as far as December (1960). Water temperature is the main factor conditioning the occurrence, development or disapperance of zooplankton, each species having favourable and lethal thermic limits. Pseudocalnus elongatus is abundant in the upper layers, at temperatures varying between 8^0 and 12^o C. Higer temperatures constrain them to move down to the deeper layers where temperature is also lower. Penilia avirostris (Dana) develops more abundantly when water temperature is over 21^oC (July-August). In the years when a favourable thermic regime existed, with mild winter and warm spring, a satisfactory zooplankton development was achieved all the year round (1961, 1962). In the years with very low temperatures, especially during the first half, zooplankton development was hampered. This resumed its normal course when water temperature ceised up to the level currently recorded in the respective season (1966).

Salinity level registered also big annual shifts, particularly in

the 0-10 m layer. This affected also stenohaline organisms. The high salinity level in the summer of 1960 favoured mass development of Penilia avirostries Cladocera, unlike the unfavourable effect on this species observed in 1964, when salinity assumed an unstable character and in 1965, when salinity level was very low.

As a food basis, phytoplankton precedes zooplankton growth and, thanks to its qualitative and quantitative influence, it can have a positive or negative effect. The thrivingness of small-size edible species Exuviaella cordata (Ostfenfeld), Cyclotella caspia (Grunow), etc. had a positive effect on zooplankton ; thus, in 1962, when the edible species were more numerous in spring, their positive influence was mirrored in the subsequent development of zooplankton; the 1963 spring, when a qualitatively and quantitatively poor phytoplankton was recorded, had a negative influence on zooplankton development (VINTILA, V., 1962).

Ecological grouping of zooplankton

The multitude of minute organisme making up zooplankton were classifield in various ways, after the following cryteria : size, perference for a certain environment factor, feeding, posibility to be consumed by other organisms, etc.

We consider significant the following classification : zooplankton proper - holoplankton - and larval plankton - meroplankton. Holoplankton was more abundant in the investigated zone, while meroplankton was predominant only as a biomass.

By grouping zooplankton organisms after water temperature at points where the respective species development had reached a peak, we could differentiate three categories: relative cryophilic, thermophile and indifferent.

In the relative cryophilic groupe, we included some Tintinnids Tintinnopsis beroidea (Stein) , Pleurobrachia pileurs (Müller), the Rotifera, Calanus helgolandicus (Claus), Pseudocalanus elongatus and Olthona

similis (Claus). The occurence of the relative cryophilic organisme in high number was correlated with low water temperature. These organisms were found in high numbers in winter and spring, from top to bottom layers. As water temperature increases towards the top, these organisme move downwards, to the deeper sheets, where temperature is favourable to their life; some of them, such as the relative cryophilic Tintinnids and most of the Rotifera, disappear from the plankton during the warm season. Mention should be made on the fact that the relative cryophilic Copepod can be found sometimes in top layers, being carried up by cold bottom currents or for feeding purposes, during the dark period of the day; this phenomenon was recorded also in other sectors of the Black Sea (KOVALI, 1963).

The thermophile organisme are reprezented by Noctiluca millaris by every Cadocerans species, the Centropages ponticus (Giesbrecht) and Paracalanus parvus (Claus) Copepods. The peak growth in the investigated area was recorded in the warm season and only in the top waters layers. Penilia avirostris was the most typical Cladocer representative, appearing suddenly in July, in a very great number, persisting, isolatedly late in the autumn in years when temperature never went below 11°C. In a zone closed to the shore, the Cladicerans appeared a few months earlier (BACESCU and colab., 1962; PETRAN A., 1966).

The other organisms observed were less affected by temperature, reaching their annuall peak within the same water layer, both in the cold season and in warm season. This eurythermy shiuld not be considered as the organisms had not an optimum development temperature; on the contrary, both for them and for the other groups, an optimum temperature existed, varying between wider ranges than for first two groups.

As concerning salinity, it was observed that the major part of zooplankton organisms were euryhaline, their anundance in the same profile being equally high, both in water layers with a low salinity, and in those with a high salinity level, a fact that was confirmed also in the north-western area of the Black Sea (KOVALI, 1961). Referring to the 0-10 m layer, that is the layer with widest salinity differences, we observed that marked sea water softening assumed a temporary character

being more extended only over restricted areas ; that is why it did not affect zooplankton to a large degree, as the latter could avoid soft water film, moving down to the deeper layers where they could find á favourable salinity, It was noted that the major part of relative cryophilic organisms were also stenohaline; besides of these, a preference for water with a higher salinity level was observed at Paracalanus parvus, Oikopleura dioica (Hol) and Sagitta, too.

A significant classification of zooplankton per group is that which considers its possibility to be consumed by planktonofagous fish and young fish. Thus, these organisms were classified into liable to be consumed or nourishing and non-edible or non-nourishing groups. The researches conducted in the Black Sea by every riveran state, showed that most of the zooplankton organisms were consumed both by fish and young fish, varying with the development stage and season. The balance between the nourishing and non-nourishing zooplankton was always in favour of the latter. Year by year, begining in winter and up to end of summer, the non-nourishing zooplankton group was predominant ; in the autumn, the nourishing zooplankton surpassed frequently the non-nourishing groups as concerning biomass value. Mention should be made of the fact that most of the nourishing zooplankton was consumed intensely by planktonofagous fish and young fish in the warm season, and that the amount recorded by the author was in many instances made up only of remanent zooplankton; this fact was taken into consideration when interpreting our data. The best development results of non-nourishing zooplankton were registered in 1961, when high values were registered also for the nourishing group. A similar phenomenen was observed also in the 1965. summer, fact that prompted us to reach the conclusion that the generally favourable conditions could induce a satisfactory development in the two groups, in parallel; nevertheless, only one of them is predominant.

Zooplankton dynamics

Sïhnificant results were recorded both to zooplankton distribution in time and space and along the coast and in the open sea. Within the same

profile, and during the same expedition , the numerical and biomass values were clearly distinct. These differences varied between tens of mg/cu.m., ip to thousanda of mg/cu.m as concerns biomass, and of tens of thousands exem./cu.m. as concerns the organisms number; similar differences were observed also within the same month, and from one year to another.

Zooplankton concentration at a certain point, near the shores or in the opee sea, or an increase or decrease in the population depending upon the distance to the shore was not constant in any month, both near the shore and in the open sea. Thus, we reached the conclusion that zooplankton from the area of our investigations assumed an insular dissemination, under the form of patches with various concentration, widely differing levels, depending of space and time, a fact recorded also in other zones of the Black Sea (KOVALI L., 1961, 1963; MARGINEANU C., PETRAN A. 1961, 1964).

The cross-section distribution of zooplankton varied against the horizontal one, taking place according to well-established laws. Almost permanently the upper layers were populated more abundantly both with phytoplankton, the existence of which depended of sun-light, and also with most of the zooplankton organisms feeding at this horizon. Noctiluca miliatis, Tintinnids, Rotifera, meroplankton, Cladocerans, thermophile and eurythermal Copepods, Sagitta and Oikopleura dioica prefered, in every season, the 0-10 m. water sheet, where they could be found in the highest numbers. Copepods and Pleurobrachia pileus (Müller) which are sensitive to tigh temperature differences, reached in the lower layers peaks surpassing those near the top, paticularly in the warm season. The instances when the general rule of organism and biomass number decrease from top this rule under particular environment conditions were notes for the Noctiluca miliaris, Pleurobrachia pileus, some Tintinnidae and Rottifera, Bivalvia larval, Calanus helgolandicus Pseudocalanus elongatus.

Wide numerical differences were noted in each individual species, both in time and space, due, on the one hand, to the abiotic conditions, and, on the other, to the biotic conditions (food and consumer animals).

The above-mentioned conditions were interpenetrated, but the conclusion was reached that in some periods, one of the factors was preponderant over the other.

The numerical dynamics of zooplankton organisms showed for the zone and period of our investigations, some significant conclusions to which we shall refer briefly.

Noctiluca miliaris, an epiplanktonic species is a much more numerous reprezentative of non-nourishing zooplankton and can be found, at some stations, in impressive agglomerations (98,000 exempl/cu. m./. These organisms prefer high water temperatures and reach maximum density in June-July. In the years with warm springs (1961-1962), the peak was registered in June, while in the other years, in July. Within the same year, the numerical differences in the 0-10 m. layer registered 1 to 2 peaks, preceded and followed by small amounts. The cases when the number of individuals at the top surpassed that recorded in the deeper layers, were infrequent, and only in Aufust-October, when this species registered a poor development.

Although found in small numbers. Pleurobrachia pileus is frequent, populating the deeper layers, particularly in the warm period of the year. The annual average values showed that in 1961, this species recorded the best development level, when such big amounts were registered every month.

Meroplankton is well represented by the Bivalvia and Cirripedia larval. Its main development feature is the fact that it is more abundamt in the 0-10 m. layers. The annual average curve registered 2 peaks, one early in the year (April-May), the other, which was also the highest, late in the year (September-December).

Copepods are an important component of the nourishing zooplankton groups on the Romanian Black Sea littoral, both as concerns its permanent presense, all year round, at every depth, as well as its appreciable numerical value, particularly as concerns some species. They form large agglomerations depending upon the predominant species and season, either in top layers, or in deeper horizons.

Calanus helgolandicus, an open sea cryophilic species, was observed in every stage, but in smaller amounts as compared with the other Copepods. The best represented was the nauplius stage, which amounted to some 94 per cent, near the top, in earm season; the adult species never exceeded 1%. In cold season, and at lower depths, the number of adults increased, reaching 10 per cent. The curve of annual average values varied, depending upon the depth, recording usually 1-2 high monthly averages. In cold season, the biggest amounts were found near the top, while in warm season, in bottom layers. The 1960-1962 period was very favourable to the development of this species; it is during this period that the peaks for the three water horizons were recorded. Starting with 1963, the amount dropped significantly, becoming unsignificant at the end of the period under investigation. The dynamics of this species was highly affected by its consumption by spratt, as Calanus helgolandicus is its favourite food. The 1964-1965 period registered the record of spratt fishing, and lowest numerical values of this Copepod.

Pseudocalanus elongatus is a numerous species that can be found in the entire water column and in every season. It was well represented by the nauplius stage, in differing amounts, depending upon season and horizon (between 51 and 91 per cent) - only exceptionally, in the 1960 summer, it surprassed numerically the Copepodit stage. Being a relative cryophilic species, its highest density was found in the cold water layers; that is why during the warm season it moved down to the deeper layers, where it could varied depending upon the water sheet where it lived. Near the top, we found 1 to 2 peaks, early and late in the year, with marked peaks in summer; in deeper layers, usually during the warm season (July-August), we always recorded lower peaks than those near the top. The 1964-1965 period when small amounts of Pseudocalanus elongatus were found coincided with an abundant spratt fishing.

Paracalanus parvus was the most numerous specie of Calanida, confining itself to top layers, where it was found in large numbers, irrespective of the season. Just as the other Copepods, the nauplius stage was predominant representing 90 per cent ot the population, late in the year.

In the 0-10 m. layer, the annual average curve registered usually a single peak, in September-December. The best development rates were recorded in the 1961-1963 and years. At every development level, Paracalanus parvus was the food both for anchovy and mackerel, larval, and young fish; it was observed that the massive presence of tese fish species resulted in the decrease of the number of this Copepodae, a fact that was more marked in September and October 1965.

Acartia clausi can be found permanently in plankton, making up large agglomerations in top layers. The curve of the annual average value for the 0-10 m. layer usually registered a single peak, located differently, depending upon the specific conditions in the respective year. Thus, in 1961, the peak was recorded in March, while in 1966 in August. In deeper layers, the curve with a single peak was more frequent, particularly in summer, when the bottom water layer became warmer, the species moved down to deper layers. In 1966, when Acartia clausi was very abundant in August, reaching its growth peak, fishing was very poor, while in the years when fishing was very intense (1961-1962), the peaks for this Copepod were registered at the begining of the fishing season; in the other years, with abundant fishing, the number of this species individuals was quite low.

Centropages ponticus was found in front of the Romanian shore only in a restricted period and in limited amounts. The biggest quantities were found permanently in the 0-10 m. layer, and the annual average curve reached a single peak, in August, standing out from the rest of the average values; this fact demonstrated that the species found favourable growth conditions only in a restricted period of the year, In the years with very high temperatures for this month (1960, 1963 and 1966) the number of individuals of this species reached a peak, while in the other years when water temperature in August did not surpass the average of 22^{o}C, the number of these organisms was much lower.

Oithona similis was better developed in the deeper layers examined while the average exceeded frequently that at the top. The peaks for this species were recorded in cold season, and the indiyiduals thrived only

in some years (1960-1961). In the years when this species recorded a satisfactory development in the water layers where it was found in larger amounts, water temperature never went above 12°C, while salinity level was high. Olthona similis finds infrequently optimum development conditions on the Romanian littoral.

Olthona nana was the most numerous Copepod, its average values being often of the order of tens of thounsands exempl/cu.m. It was more abundant in the topmost layers, where its development reached also the peak. The annual average curve growe continuously beginning with the first months of the year, reaching a marked peak late in the year, in Octomber-December, when large-size Copepodae were found in small number. In 1966, when fishing was poor, we found the highest monthyaly averages in August and September, while in 1965, when noumerously young mackerel were caught, the monthly average of Olthona nana was very low.

Cladocerans are organisms with a seasonal occurrence in plankton populating topmost layers where they crowd in big numers. They are the predominant element in summer uooplankton, their occurrence depending on water temperature, too. In the years when high temperature were recorded in spring (1961, 1962), Cladocerans occurred in April, while in the years with low temperatures (1960, 1966), they were recorded only starting with June.

Podon polyphemoides was the first Cladocera to appear in plankton and could be found usually in reasonable amounts of hundreds exempl/cu.m.; infrequently it consisted of theusands exempl/cu.m. The annual average curve had a single peak, differently located from one year to another. Thus, in 1961-1962, this peak was recorded in April, while in 1966- in October.

The Evadne genus was represented in the plankton by the Evadne spinifera (Müller) and Evadne tergestina (Claus) species, the latter being more numerous. The annual average curve had a single peak, in the June-August interval. The asual cross-bedding was registered also for the species belonging to this genus, with the highest valuea near the top. The individual e belonging to it prefered higher temperatures, above 22°6 C, and

the peak values coincided also with high salinity levels. The best development conditions were found in 1966, when the number of consumer organisms was small, while in the 1961-1962 period the condition was rezerve. The fact that in the summer of the three years temperature and salinity were equally favourable, hence they could not affect the development of these species, was also taken into consideration.

Penilia avirostris was found in the plankton in July and in some years it developed quite well, becoming the predominating form of summer plankton. Although short-lived, it could find favourable life conditions near our coast, almost every year. The annual curve registered a single peak, in July-August. Maximum development was recorded in 1960, when both temperature and salinity reached a high level in August. Like for the other Cladocerans, a correlations between the amount found in the sea water and the number of consuming organisme was established.

Tintinnids are usually found in the topmost layer, and the biggest amounts are recorded early and late in the year, that is in the cold season. The months with a peak were different from one year to another, and were comprised in January-May and September-December intervals. These organisms are important as possible competitors for food, namely of nourishing zooplankton, and their high numerical growth affected the other organisms, a fact observed in the months with a single peak.

Rotifera are organisms that announce the coming of spring, a season when they assume maximum growth. The biggest crowds were found in the topmost layers, where they could reach a density of thousands exempl/cu.m. In warm season, in some months they disappeared from the entire water column, from top to bottom.

Oikopleura dioica was a relatively numerous species, living in top layers where it could be found in the biggest agglomerations. Its occurrence in plankton was only temporary, although no indices could be detected that the species were demending as to temperature and salinity.

Sagita live in small numers, infraquently in reasonable amounts. In the 0-10 m layer, the average values were somewhat higher. In the first half of the year, they could be found in small amounts. with peaks in

August and October. Fish eggs and larvae were found in plankton, most numerous being those of anchovy. The biggest agglomerations were formed in the 0–10 m. layer. In 1960, a record year for anchovy eggs and larvaes number, a corresponding amount of zooplankton was also registered, a fact that points to the conclusion that reproduction took place under high sea trophicity condition, that affected positively the survival rates of this species caught in the next two years in big amounts.

In the zooplankzon there were some leading organisms whose annual variation reached a significant weight. These were Noctiluca miliaris, the Copepods and the Cladocerans.

During year, zooplankton registered wide differences from one month to another, depending of the abiotic environment factors, food dynamics and number of consumers; these variations were represented by a curve starting from low level in winter and up to high levels in summer. Depending of the waters layer they could be found, the curve assumed a steeper or less steep slope. Topmost, the differences between the lowest and the highest values were ot the order of hundreds of grams. In cross section, a stratification was found generally, namely the highest values near the top and the lowest ones, at the bottom. In deeper layers, the peaks were registered at least one month later than in the next upper layers.

The seasonal distribution was achieved for the Black Sea in several ways, some workers introducing, basides the four seasons, also intermediate periods. Taking into account waters temperature, some predominant forme and the fact that every month most of the samples were collected in the second half, we grouped the months for each season as follows: winter (December to February), spring (March to May), summer (June to August), and autumn (September to November). This mathematical division of the seasons did not take into account to the same degree the specific conditions existing in each year. Nevertheless, it was convenient as we had the same measurement unit for evaluating zooplankton seasonal dynamics and for reading pisciculturaI informations.

Winter zooplankton included Copepods as a predominant element

in the nourishing group, as they represented, every year 98 per cent of the wihole biomass. The predominant species were : Pseudocalanus elongatus, Calanus helgolandicus, and in some years also Olthona nana. The trophic value of winter zooplankton from the investigated zone had a low significance as food for fish ; this was confirmed by the small spratt egg and larval; numbers to which environment instability was added.

Spring zooplankton was characterized by the occurence of Rotifera, of the first Podon polyphemoides and Evadna spinifera Cladocerans and of the benthic larval. In spite of the fact that the nourishing biomass registered quite high values in some years, it was exceeded in a significant way by the non-nourishing biomass, in the entire mass of water (diagram 1). The 0-10 m. layer was permanently the best populated one, with a high biomass content; the Copepods were predominant in the nourishing group. The first signs of spring are recorded at the level of 0-10 m. depth, where water becomes warmer, while the temperature favourable to zooplankton development can reach 20°C ; in some years it never went beyond 10°C. In the 1961-1962 spring, a high thermic regime and a small number of stormy days were recorded; under these conditions the trophic basis was high and thanks to its quality and quantity early in the year, it attracted to the coast a large number of fish. Thus, big amounts of fish were caught in this season. As in the other years of the experiment a low trophic basis was registreed in spring, the amount of fish caught was very small (Diagram 3).

Considering its biomass value, summer plankton was dominated by non-nourishing organisms; of these, Noctiluca miliaris reached, in some years, the density of several thousand/cu, m. (diagrams 1, 3). In summer, plankton was made up of the major species, confined to various water layers, depending upon their preference for a certain temperature. The most representative nourishing organisms wers the Penilia avirostris Cladocerans and Centropages ponticus Copepods. The summer of 1960 was characterized by high biomass value, in the entire water mass, while Noctiluca miliaris and Penilia avirostris reached peak values. The biggest fish eggs and larvae amount were also recorded in this period, reaching

DIAGRAM 1

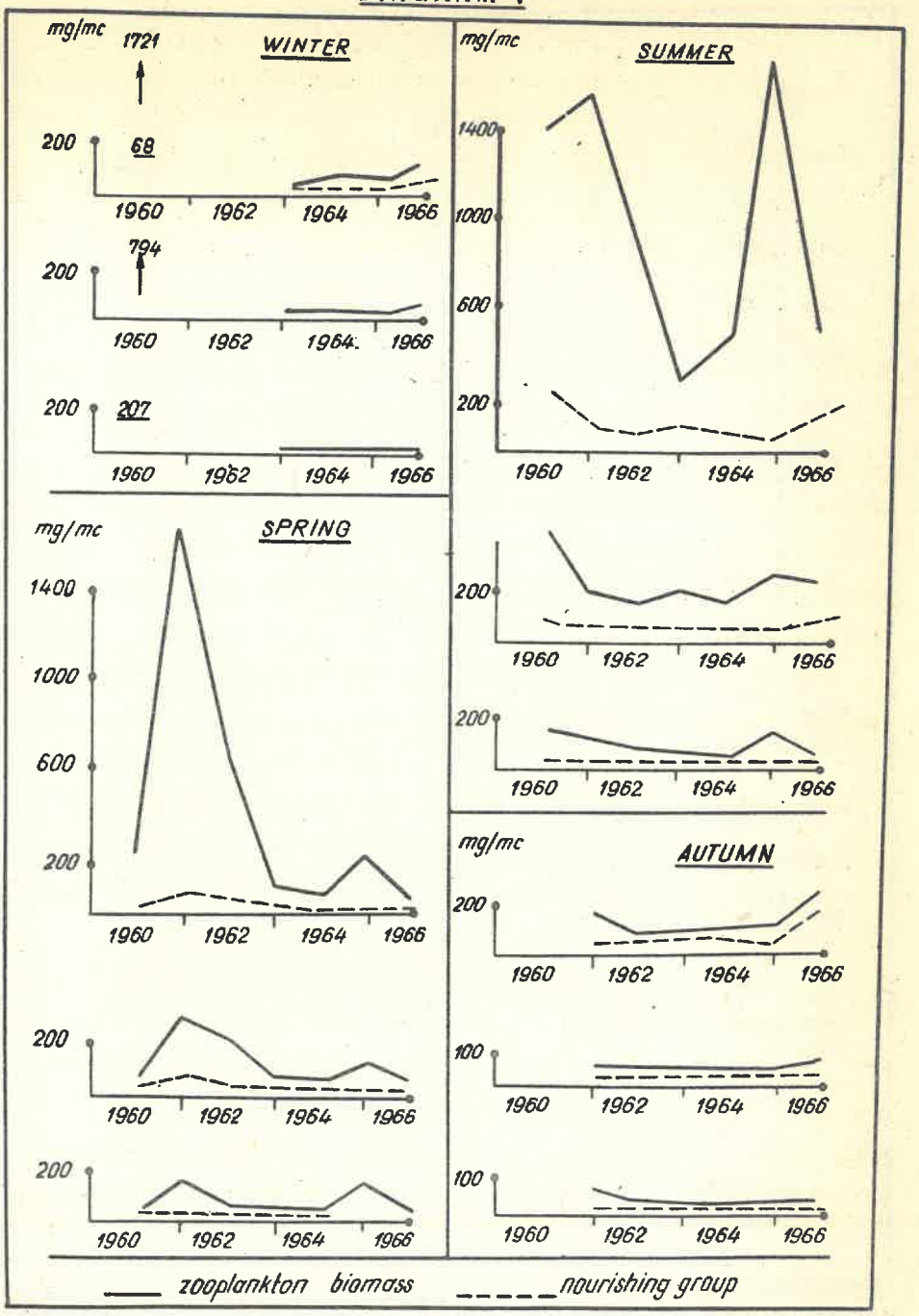

Diagram 1 – The whole zooplankzon biomass and that of the nourishing group, per season, over the 1960–1966 period

DIAGRAM 2

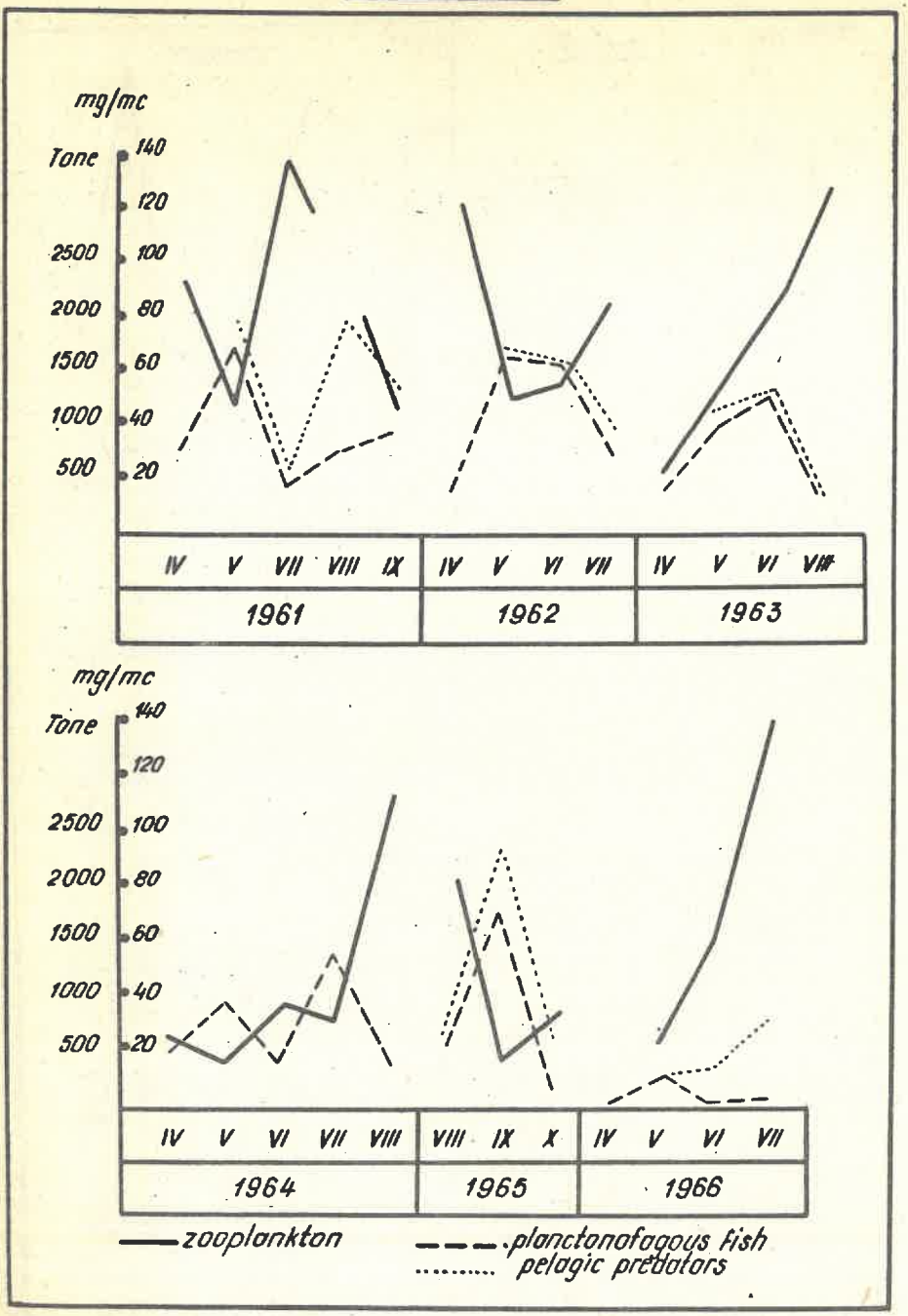

Diagram 2 – The nourishing zooplankton biomass and the amount of planktonofagous fish together with the pelagig praying organisms caught in some caracteristic months

DIAGRAM 3

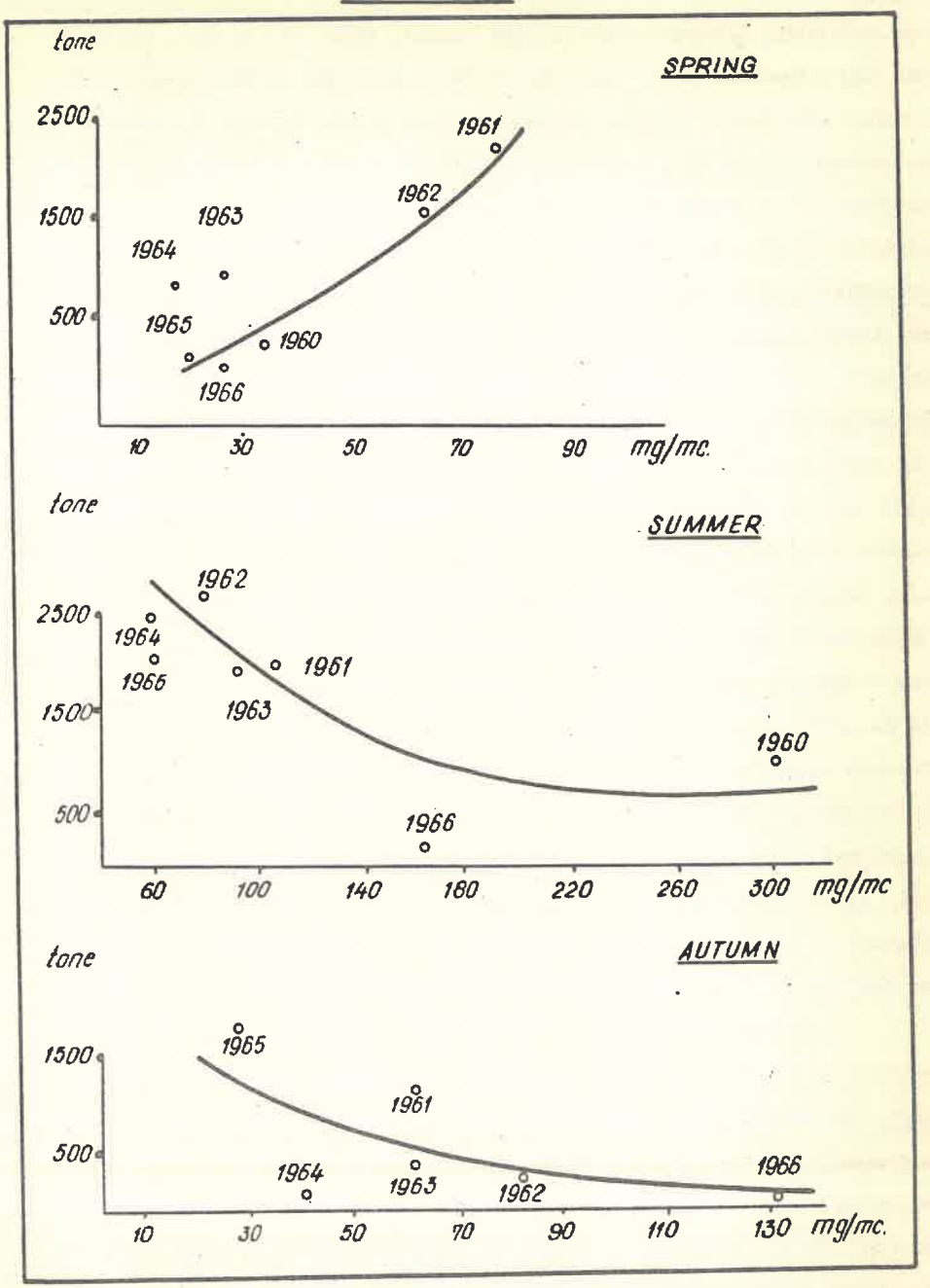

Diagram 3 – Correlation between nourishing zooplankton biomass and amount of planktonofagous fish caught

a density of 54 exempl/cu.m on the average. All these entitle us to considerer this summer as to upper limit of trophicity. In the 1961 summer, non nourishing biomass reached high values, while that of the nourishing one was somewhat lower than the previous year due to the presence of smaller amounts of Penilia avirostris. Taking into account the number of consummer organisms, we can say that the summer of 1971 favorred the development of young fish and of adult planktonofagous fish. This favourable situation of the nourishing basis was maintained also in 1962, when Centropages ponticus reached a peak development. The 1963 summer recorded the lowest non-nourishing biomass value, due to the presance of Noctiluca miliaris in July and August, in very low numers. Taking into account the presence of consumer species, we can say that trophicity was lower than the average level. Low biomass values were recorded in the summer of 1964, due to the factt that the species characteristic to this season were poorly developed. A uncommon phenomenon to wich we shall refer is the high number of Copepodae in the nourishing group, wich was the hlighest in the entire period. Taking into account also the small number of consumer specis, we can place this summer at the lower limit of trophicity, in the 1963 summer, the non-nourishing organisms found exceptional development conditions and their biomass recorded the highest values of the entire period; but, considering its trophicity, we can place it below the average level, thanks to the presence in small number of consomer specis. As the summer registred reasonable biomass values, with a small number of consumer specis, it can be situated in the group of years with an average productivity.

Autumn zooplankton was characterized by the presence of a hig number of minute Copepods, formed of Paracalanus parvus and Olthona nana, as well as of a small amount of zooplankton. The marked decrease, sometimes down to the disappearnce of larg size Copepods, could be also observed. The nourishing biomass values were closed to those recorded in spring. Although homothermy was recorded in autumn, we could observe the usual stratification with the highest values topmost, and lowest at the bottom; by its feeding habit, zooplankton is linked with the top layer. The

highest trophic biomass in 1961, 1966 years, attracted fish to the shore, fact confirmed by fishing. In 1965, unusual amounts of young mackrel were caught and, following its wide consumption, biomass was very much reduced, particularly when compared with that in summer.

The monthly analysis of the amount of fish caught and of the existing trophic biomass, showed that prior to the fishing peaks, high values or peaks of the nourishing biomass had been recorded; in our opinion, this attracted fish to the coast. Fish inflence on zooplankton was obvious, as in the months when peak amounts of fish were caught the nourishing biomass registred low values (Diagram 2).

Some relations betwen zooplankton amount and that of planktonofagous fish caught could be estalished for each seasqn. A direct relation was established in spring between the amount of nourishing zooplankton and that of planktonofagous fish: when a rich food existed, the amount of fish caught in spring was the highest, while in the years with a poor trophic basis, the amount of fish caught was small (Diagram 3). In summer, the relation between fish and food was reversed: while the amount of fish caught was small, the zooplankton number was high. The drop in the amount of fish was due to the anchovys and mackrel withdrawal to the open sea, for reproduction purposes, while the increase in the zooplankton curve to the significant increase in the thermophilic organisms. The amount of nourishing zooplankton in this season was important also for the further fish generations : the 1960 summer favoured the new anchovys generations thanke to the exceptional amount of zooplankton and this fact mirrored also in the next two year fishings. A reverse. A reverse relation was observed during the next autumn : thus for small nourishing biomass during this season was interesting as food for fish in view of wintering. Due to the specific hydrometeorological conditions of the Romanian Black Sea coast, the relationship existing between fish and food was less evident during this season.

Discussions

The research work so far have show that zooplankton development on the Romanian coast of the black Sea had a specific character, both

as compared with other sectors and the less deep zones close to the shore, the stone facies and the sand facies with Aloidis.

The work by A. PETRAN (1966) regarding zooplankton characteristics and dynamic within the Mamaia profile, refers to the same period of time as our researches, and shows that the adundance of meroplankton in Mamaia zone is a characteristic feature, with Balanus naupiii reaching highest numbers in May-June and October, while the annual peaks are of the order of several hundred of mg/cu, m., representing 50 to 93 per cent of the trophic biomass of the respective months. In the area under investigation by us, meroplankton had second-hand signifieance in the nourishing biomass : 13 per cent at the utmost, while the Balanus naupiii biomass never surpassed a density of several tens of mg/cu. m in months with peak development. Calanus helgolandicus was very infrequently found in the Mamaia zone, while in the area of our investigations this Copepod was present at every development srage, showing this species preference for lower depth in winter, too, whwn water temperature was maintained within favourable rangs in these layers. In winter, the trophic biomass in the Mamaia area was very much reduced, as compared with that found by us when biomass values were higer. In spring, no wide biomass values were recorded. but the predominance of this species varied because of the particular significance of meroplankton and Rotifera in the Mamaia areas. The highest values for the nourishing biomass were recorded in summer in both zones, and the quantitative differences were similar. Some years, the biomass in the Mamaia area surpassed 1-3 time the values found by us ; dominant were the Balanus naupiii and the Centropages ponticus Copepod. The zone investigated by the author was dominated in summer by Cladocerars species, where Penilia avirostris was predominant, accounting for 80 per cent of the nourishing biomass. Autumn zooplankton, in both zones, was qualitatively and quatitatively poor; some years, meroplankton was the dominant group of the nourishing biomass of Mamaia, while in the zone investigated by us, Copepods were predominant.

Quantitative and qualitative differences were observed also as compared to the stone studied by PORUMB (1966) and the dand facies with Aloidis, studied by BACESCU and col. (1961), The differences ranged

within the limits shown for the Mamaia zone, as the depth of the former zone was of 25 m. at the utmost. The researches conducted by the author during the 1958–1959 period, in 30 m depth zone, comprised between Constantza an Portitza, just like the work by BACESCU and. col., pointed to the particular significance of Balanus nauplii and Rotifera, as part of the nourishing biomass (MARGINEANU and PETRAN, 1959).

The north-western Black Sea zone studied in detail by KOVALI (1961, 1963) is closed to that studied by us to the physical-chemical features. The results obtained following investigations over a number of years, hawe allowed the establishment of some development laws for the zooplankton, as a whole, these corespond to our findings. There are. neverthless, many differences as to the qualitative and quantitative composition of zooplankton, due to the fact that the researches were conducted in another period (1951–1960). In both areas, the quantitative and qualitative significance of spring zooplankton near large schools of pelagic fish and the permanent motion of plankton agglomeration depending upon hydrologic conditions was confirmed. The links we have established between ocean planktonofagous fish an nourishing biomass corresponded mainly with the data obtained by DIMOV (1965) for the Bulgarian VODIANITZKI (1954) aprecia-ted the average value of the Black Sea zooplankton biomass between 120 and 300 mg/cu. m for the nourishing biomass. In the investigated zone, we foun· such values only in summer, fact wich led us to the conclusion that the productivity of the Roumanian Black Sea littoral was below the average level.

Summary

The paper shows the features of the zooplankton, studied over the 1960–1966 period, in the zone comprised between 5 and 30 marine miles far from the shore, with depths reaching 50 m in open sea. It also determines some relations between planktonofagous fish and their food basis.

The effect of the main environmet factors on the qualitative and quantitative zooplankton composition is analysed and the contribution of the

marine currents to the uneven distribution of zooplankton is shown, together with the significant role of temperature in the occurrence, development an disappearance of zooplankton organisms.

The significance of the numerical zonal and pluriannual dynamics, depending upon the environment is analysed for the major species dynamics. The annual average curve and the marked annual peaks for each species, depending upon the layer it lives in, are shown.

As a biomass, zooplankton is dominated by the Copepods and Cladocerans, and by Noctiluca miliaris. In a single year the zooplankton biomass registred wide differences from one to the other, represented, geberally by a curve with the lowest peack in winter, and the highest one in summer, and, depending upon the water layer the respective species lives in, the slope of the curve was steep or less steep. The cross section distribution shoved the hishest values near the top, and the lowest one in the deeper layers.

Depending upon the season, the qualitative and quantitative zooplankton composition registred big alterations, mirroring the variations in the physical-chemical and biological factors. The dominant element in winter zooplankton of the npurishing group were the Copepods, making up nearly 98 per cent of biomass, and in some years Noctiluca miliaris population was better developed. Spring zooplankton was characterized by the occurence of the first Podon polyphemoides and Evadne spinifera Cladocerans, while the summer zooplankton, by the predominance of the Penilia avirostris and Evande tergestina Cladocerans, and of the Centropages ponticus Copepod. The widest variations in the population, including almost every representative of marine zooplankton species, confined to various water layers, depending upon temperature found in summer. Autumn zooplankton was poor both quantitatively and qualitatively being dominated by minute representatives of the Copepods, (Paracalanus parvus and Olthona nana).

Relations were established between fish and its food very year, depending upon the season. Thus, in spring there was a direct relation between planktonofagous fish and nourishing zooplankton; when food was

abundant in spring, record amounts of fish were cough. In summer and in autumn, the relations were reversed.

It was observed that monthly, prior to fihing, record amounts of fish, biomass peaks had been registered, which had attracted fish towards the shore, and in the period when record fishing was obtained ; the nourishing biomass registered always small or minimum values.

Although zooplankton behaviour in the investigated area agreed with the development laws, determined for the Black Sea, some specific features, with a local character, were observed making it differ both from the zooplankton at low depth of the sand and stone facies facing the Romanian shore, and from that in other sectors of the Black Sea.

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