

THE PHYTOPLANKTONIC ASSIMILATORY PIGMENTS ALONG THE ROMANIAN COAST OF THE BLACK SEA DURING 1976

Bologa Alexandru

Romanian Marine Research Institute Constanța

ABSTRACT:

The amounts of phytoplanktonic assimilatory pigments in the Danubian predeltaic area and the area less influenced by the Danube off the Romanian coast of the Black Sea were quarterly (monthly) recorded; the measurements were done in order to follow the quantitative dynamics of phytoplankton for a more detailed analysis of the blooms in these areas.

As related to the numerous research works on the Black Sea phytoplankton, fewer quantitative data were reported so far on the phytoplanktonic assimilatory pigments from the different areas of this basin (5; 6; 17). The proportions of chlorophyllic and carotenoid pigments vary within a wide range even with one and the same species and under similar ecologic conditions. Thus, though the quantitative values of these pigments do not represent a direct measure of the biomass or the planktonic primary production (7), the settlement of some concordances has been achieved between the quantity of assimilatory pigments and the qualitative and quantitative configuration of the natural phytoplanktonic population (8;

9; 10).

Among the spectrophotometric dosings of assimilatory pigments, the value of chlorophyll a is particularly interesting, as well as the values of the ratios of chlorophyll a/c, a/a+b and the ratio of D_{430}/D_{665} (D = optical density at the given wave length) (9); as D_{430} represents the optical density value of all carotenoid pigments - vegetal and animal - for better accuracy in determination, we substituted the ratio D_{480}/D_{665} for D_{430}/D_{665} (D_{480} exclusively representing extinction of carotenoid pigments of vegetal origin).

The chlorophyll a value is the main indication of the assimilatory ability and that of the achievement of the primary production implicitly. The chlorophyll a/c ratio permits estimates on the senility degree of the population. The chlorophyll b/a+b ratio indicates a considerable fraction of dead phytoplankton. The D_{430}/D_{665} ratio (D_{480}/D_{665} respectively) represents the diversity degree of the populations, as reflected in high numerical values of this ratio. It is considered that the poor pigmentary diversity (11) is due to marked quantitative prevalence of chlorophyll a over the other assimilatory pigments. The vertical distribution of D_{430}/D_{665} ratio implicitly conveys the vertical distribution of specific diversity, increasing, as a rule, proportionally with depth; the increase was in part attributed to the persistence of carotenoid pigments and phaeophytin in the decomposing plankton and excrements (11). The ratio of D_{430}/D_{665} is considered as dependent on the total pigmentary content of the phytoplanktonic cells, it being greater in populations with poor chlorophyll content per dry substance unit and smaller in presence of richer chlorophyll content.

MATERIAL AND METHOD

In order to complete the knowledge of quantitative phytoplankton dynamics along the Romanian coast, the study on the assimilatory pigments was resumed in the predeltaic area and the zone less influenced by the Danube. During 1976, trimestrial samplings were carried out in the predeltaic area, in section eastward from Portița - in April, June, August and October - and in the zone less influenced by the Danube in section eastward from

Constanța - in February, May and October - as well as decadal samplings performed at Agigea from January to December. The investigation network included 5 stations (16 horizons) in section Portița, 5 stations (16 horizons) in section Constanța and 3 stations (6 horizons) at Agigea (near shore); in all, 251 samples were processed.

The study of phytoplanktonic assimilatory pigments was carried out following the usual technique based on the method of RICHARDS & THOMPSON (15) improved by STRICKLAND & PARSONS (19) and others (1; 13; 14; 20). The 0.5 to 3.0 liter sea water samples were filtered in vacuum through Millipore HAWP 04700 membrane filters (ϕ 0.45 μ). The measurements were carried out with a Beckman M 25 spectrophotometer. The determination of concentration of chlorophyllic pigments a, b and c was performed by standardized readings of the optical density D at 750 (turbidity correction), 665, 645 and 630 nm; nonstandardized determinations for estimating the astacin (C_A) and nonastacin (C_N) carotenoid pigment concentration were performed at 510 and 480 nm.

The calculation of chlorophyllic pigment concentration followed the trichromatic equations recommended by UNESCO (20); concentration of chlorophylls is expressed in $\mu\text{g l}^{-1}$ ($=\text{mg m}^{-3}$). The calculation of relative concentration of carotenoid pigments was done according to the formulae of RICHARDS & THOMPSON (15); the specific coefficients of absorption for these pigments being not entirely known, their relative concentrations are usually given in (MSPU)SPU l^{-1} instead of (mg)g m^{-3} . The average of the pigimentary values over stations and sections was calculated on the basis of the scheme assumed by MOROSOVA-VODIANITSKAIA (12) for the quantitative study of phytoplankton; the average vertically (through horizons) was performed as an arithmetical mean. Pigimentary ratios were calculated from the seasonal (monthly) average values for all sectors.

RESULTS AND DISCUSSIONS

The results of the determination of concentration and distribution of assimilatory pigments and phytoplankton along the Romanian coast during 1976 are synthesized in the form of seasonal (monthly) average values for the sectors of Portița, Con-

stanța and Agıgea.

The pigment dosings show, for the predeltaic area - section Portița - a maximum value of chlorophyll a of 3.57 mg m^{-3} in April, which is a distinctly higher value as compared with 0.17 mg m^{-3} in June, 1.02 mg m^{-3} in August and 2.20 mg m^{-3} in October (Fig.1). This maximum value confirms the abundant growth of the phytoplanktonic populations responsible for the spring bloom - a well known phenomenon from the previous years (2; 3; 4; 16; 18) - which burst out in 1976, too. The values of chlorophyll b are generally lower and those of chlorophyll c higher than those of the principal assimilatory pigment - particularly in April.

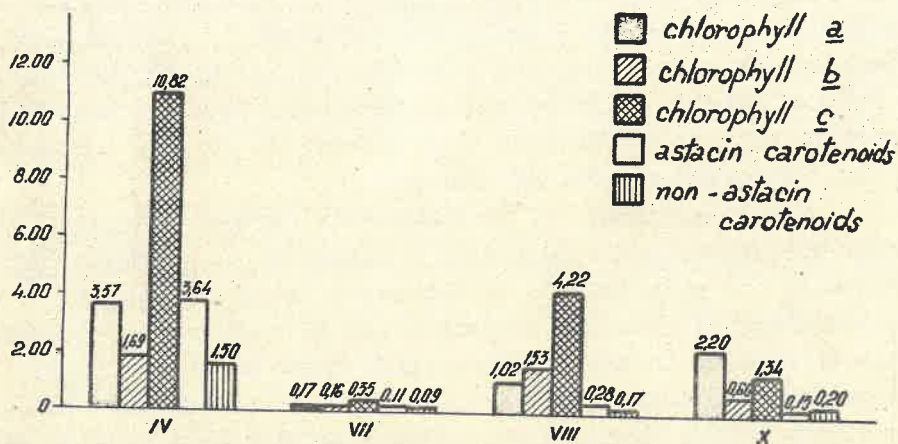


Fig.1 - Histogram of monthly average values of chlorophylls (mg m^{-3}) and carotenoids (MSPU l^{-1}) in sector Portița in 1976

The chlorophyll a/c ratio shows rather similar values during spring and summer (within $0.24 - 0.48$) and is much higher (1.64) in autumn time; this latter ratio indicates the presence of young phytoplanktonic populations, which means pronounced physiological vigour (assimilatory ability) of the cells in October. The chlorophyll b/a+b ratio, representing a fraction of the dead

phytoplankton, also takes values between narrow limits (0.21-0.60), with the greatest value (0.60) in August. The ratio of D_{480}/D_{665} as an expression of the diversity degree of the populations, takes the minimum value (0.09) in October. The values of the assimilatory pigments in the predeltaic area are higher in 1976 in comparison with earlier data of 1963 (17), which show lower values for chlorophyll a: 1.79 mg m^{-3} in February, 0.85 mg m^{-3} in August and 0.15 mg m^{-3} in September.

For the area less influenced by the Danube, the pigmentary average values in the sectors of Constanța and Agigea are presented. In section Constanța the maximum chlorophyll a value of 1.41 mg m^{-3} was recorded in February, confronted by 0.47 mg m^{-3} in May and 0.95 mg m^{-3} in October (Fig.2). In this sector, too, the maximum value of chlorophyll a indicates the beginning of the same blooming phenomenon of March-April which has been mentioned for the predeltaic area. In the sector of Constanța, chlorophyll a is associated with chlorophyll c in high amount, which diminishes the chlorophyll a/c ratio in February as compared with

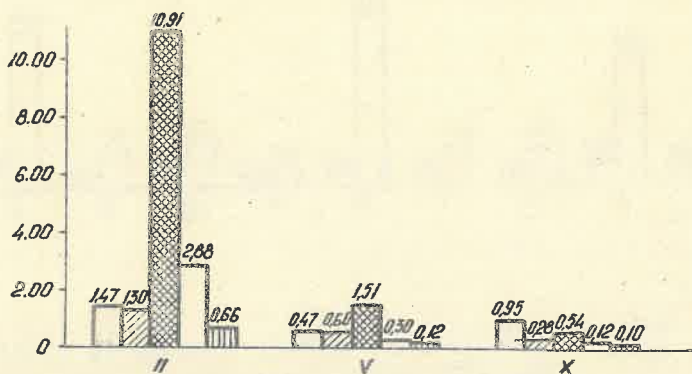


Fig.2 - Histogram of monthly average values of chlorophylls (mg m^{-3}) and carotenoids (MSPU l^{-1}) in sector Constanța in 1976 (key, idem Fig.1)

the other seasons. The higher value of chlorophyll a as related to chlorophyll c, that is the increased chlorophyll a/c ratio (1.75) and the decreased chlorophyll b/a+b and D_{480}/D_{665} ratios (0.22 and 0.10 respectively) are characteristic of this sector, too, in October. By comparison, in 1963 (17), the values of chlorophyll a were greater in May (0.76 mg m^{-3}) and smaller in October (0.80 mg m^{-3}).

At Agigea, the monthly average values of chlorophyll a, of the same size order as in the other two sectors, denote the occurrence of the bloom in March (2.24 mg m^{-3}) and June (3.12 mg m^{-3}) (Fig.3). Attention is seized by the high value of chlorophyll a in October (2.74 mg m^{-3}) and the minimum ratio of chlorophyll b/a+b (0.11) in October and December; the ratio of D_{480}/D_{665} is also minimum in October.

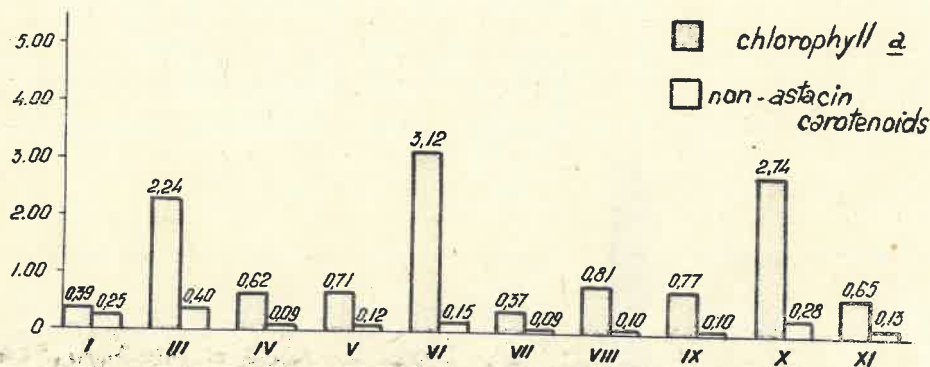


Fig.3 - Histogram of monthly average of chlorophyll a (mg m^{-3}) and non-astacin carotenoids (MSPU l^{-1}) in sector Agigea in 1976

The decadal data on assimilatory pigments permit detailed analysis of the blooming phenomenon at Agigea during June, 1976 (tab.1). The most telling pigmentary values are these of

chlorophyll a: 1.29 mg m⁻³ for the first decade, 0.50 mg m⁻³ for the second one and 7.59 mg m⁻³ for the third one (Fig.4). In the third decade, with yearly maximum values of chlorophyll a, the decrease of the average of this pigment offshore is evident as follows: station 1 - 10.16 mg m⁻³, station 2 - 8.03 mg m⁻³ and station 3 - 3.06 mg m⁻³. Because of the clear predominance of chlorophyll a over the other chlorophylls, the chlorophyll a/c ratio is a maximum in this decade (5.19). Consequently, the diversity index - represented in the method of assimilatory pigments by the ratio of D₄₈₀/D₆₆₅ - is a minimum at this moment (0.03). The analysis of the evolution of the assimilatory pigments and their quantitative ratios at Agigea during June points out the bloom and its occurrence by the end of the month.

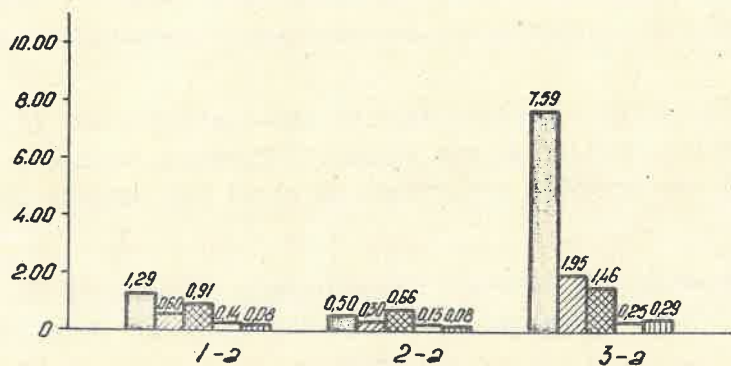


Fig.4 - Histogram of monthly average values of chlorophyll a (mg m⁻³) and nonastacin carotenoids (MSPU · l⁻¹) in sector Agigea in 1976 (key, idem Fig.3)

Table 1

Average values of chlorophyllic (mg m^{-3}) and carotenoid (MSPU l^{-1}) pigments in sector Agigea during the decades of June, 1976

Decade	Stations	chl.a	chl.b	chl.c	C _A	C _N	chl. a/c	chl. b/a+b	C _N /chl.a (D ₄₈₀ /D ₆₆₅)
1 st (10.VI)	1	1.44	0.44	0.64	0.10	0.04	2.25	0.23	0.02
	2	0.55	0.53	0.42	0.09	0.08	1.05	0.37	0.14
	3	1.19	0.56	0.24	0.13	0.06	1.14	0.32	0.05
	average	<u>1.29</u>	<u>0.60</u>	<u>0.91</u>	<u>0.14</u>	<u>0.08</u>	<u>1.14</u>	<u>0.31</u>	<u>0.06</u>
2 nd (19.VI)	1	0.46	0.12	1.00	0.18	0.11	0.46	0.20	0.23
	2	0.34	0.23	0.33	0.08	0.05	1.03	0.40	0.14
	3	0.40	0.30	0.52	0.10	0.06	0.76	0.42	0.15
	average	<u>0.50</u>	<u>0.20</u>	<u>0.66</u>	<u>0.13</u>	<u>0.08</u>	<u>0.75</u>	<u>0.60</u>	<u>0.16</u>
3 rd (29.VI)	1	10.16	2.15	1.32	0.29	0.37	7.69	0.17	0.03
	2	8.03	2.24	1.14	0.20	0.30	7.04	0.21	0.03
	3	3.06	0.77	1.05	0.16	0.14	2.91	0.20	0.04
	average	<u>7.59</u>	<u>1.95</u>	<u>1.46</u>	<u>0.25</u>	<u>0.29</u>	<u>5.19</u>	<u>0.20</u>	<u>0.03</u>

The vertical distribution of the assimilatory pigments indicates maximum values in the sector of Portița, both for chlorophylls and carotenoids, at surface (0 m) in all seasons (Tab.2).

Table 2

Average values of vertical distribution of chlorophylls (mg m^{-3}) and carotenoids (MSPU l^{-1}) in sector Portița in 1976

Month	Horizon (m)	chl.a	chl.b	chl.c	C _A	C _N
IV	0	8.28	2.63	18.46	6.32	2.84
	10	3.36	1.77	10.63	3.57	1.24
	15-20	1.77	1.12	11.67	3.30	0.75
	25	1.66	0.96	6.31	2.19	0.80

(Table 2)

Month	Horizon (m)	chl. a	chl. b	chl. c	C _A	C _N
IV	35-50	1.17	0.53	3.57	1.51	0.53
	0	0.24	0.23	0.46	0.13	0.09
	10	0.16	0.15	0.40	0.12	0.11
VI	15-20	0.17	0.11	0.12	0.12	0.10
	25	0.14	0.15	0.30	0.10	0.09
	35-50	0.18	0.19	0.40	0.12	0.09
VIII	0	1.32	1.71	4.38	0.23	0.17
	10	1.07	1.49	4.16	0.30	0.23
	15-20	1.05	1.57	5.01	0.29	0.18
	25	0.71	1.30	3.36	0.27	0.14
	35-50	0.74	1.22	3.28	0.26	0.09
X	0	3.61	1.10	2.30	0.21	0.29
	10	2.42	0.60	1.28	0.12	0.23
	15-20	3.12	0.22	0.98	0.11	0.34
	25	0.51	0.41	0.96	0.18	0.04
	35-50	2.41	1.05	1.50	0.32	0.07

The same is characteristic of the sector of Constanța, except in May, when a quantitative increase of all categories of pigments with depth is recorded (horizons 35-50 m) (Tab. 3). At Agigea, not far from the shore (down to the depth of 10 m), the vertical distribution of the assimilatory pigments does not reflect the evenness which is evident in the other sectors, showing only an increasing tendency of their concentration with depth in January and a decreasing one in April, June-July and September-December. The reference data of 1963 (17), not localized and corresponding to a smaller maximum depth (to the horizon of 25 m), suggest quantitative accumulation of assimilatory pigments with depth; the change could be explained by the growing turbidity on account of the suspended matter and as a consequence of the concentration of the phytoplanktonic populations in the upper layer. The analysis

Table 3

Average values of vertical distribution of chlorophylls
(mg m^{-3}) and carotenoids (MSPU l^{-1}) in sector
Constanța in 1976

Month	Horizon (m)	chl. <u>a</u>	chl. <u>b</u>	chl. <u>c</u>	C _A	C _N
II	0	1.42	1.26	12.07	2.83	0.85
	10	1.00	1.17	8.63	1.96	0.59
	25	1.26	1.05	9.05	2.57	0.59
	35-50	1.20	1.04	8.77	2.67	0.45
V	0	0.45	0.46	1.11	0.20	0.08
	10	0.38	0.59	1.26	0.23	0.08
	25	0.45	0.53	1.49	0.46	0.12
	35-50	0.51	0.54	1.36	0.20	0.12
X	0	1.30	0.52	0.70	0.11	0.09
	10	1.29	0.25	0.52	0.11	0.15
	25	0.40	0.22	0.49	0.11	0.05
	35-50	0.24	0.15	0.21	0.21	0.09

of the vertical distribution of the assimilatory pigments indicates the predominance of chlorophyll a over chlorophyll c at all horizons in the sector of Portița in October, in the sector of Constanța in October, and at Agigea in April, June and September-December.

CONCLUSIONS

1. Maximum values of chlorophyll a concentration were recorded in the predeltaic area in February (3.57 mg m^{-3}) and October (2.20 mg m^{-3}), in the sector of Constanța in February (1.41 mg m^{-3}) and at Agigea in March (2.24 mg m^{-3}), June (3.12 mg m^{-3}) and October (2.74 mg m^{-3}).

2. High values of chlorophyll a concentration, on account of considerable biomass of planktonic microflora, indicate the occurrence of spring blooming phenomena - in sections Porti-

ța, Constanța and Agigea - and summer bloom - at Agigea - as well as the occurrence of large quantities of phytoplankton at fall, in sections Portița and Agigea.

3. In sections Portița and Constanța, the chlorophyllic and carotenoid pigments take higher values near the water surface in all seasons.

4. The analysis of the pigmentary ratios permit close correlation of the blooming phenomena at Agigea with high values of chlorophyll a/c ratio and low values of the D_{480}/D_{665} ratio.

5. The higher values of the phytoplankton assimilatory pigments, as compared to 1963, attest the increase of the quantity of phytoplankton as a result of the increasing eutrophication of the Romanian coastal waters, which is manifest within the last ten years.

BIBLIOGRAPHY:

1. BALLESTER A., 1960 - Critica de los métodos espectrofotométrico y cromatográfico en el estudio de los pigmentos del plancton. Inv. Pesq., 3p: 613-630.
2. BODEANU N., 1966 - Caracteristicile și dinamica fitoplanctonului din zona de mică adâncime de la țărmul românesc al Mării Negre. Stud. și cerc. biol., Ser. bot., 18, 3: 249-262.
3. BODEANU N., 1968 - Quelques caractéristiques du phytoplancton de la zone de faible profondeur du littoral roumain de la mer Noire. Rapp. Comm. int. mer. Médit., 19, 3: 561-563.
4. BODEANU N., 1969 - Cercetări asupra fitoplanctonului din zona de mică adâncime la litoralul românesc al Mării Negre. In Ecologie marină, 3, Ed. Acad., București: 65-147.
5. FINENKO Z.Z., 1964 - Soderjanie hlorofila v planktone Cernogo i Azovskogo morei. Okeanologhia, 4, 3: 462-468.
6. FINENKO Z.Z., 1970 - Rascet produkții fitoplanktona v Cernom more po soderjaniu hlorofila. Biol.moria, 19: 74-82.
7. MARGALEF R., 1954 - Consideraciones sobre la determinación cuantitativa del fitoplancton por la valoración de pig-

mentos solubles y los factores que afectan a la relación entre cantidad de pigmento y peso seco. P.Inst.biol.apl., 16: 71-84.

8. MARGALEF R., 1958 - Temporal sucesion and spatial heterogeneity. In: Perspectives in Marine Biology (ed. A.A.Buzatti-Traverso) Univ.Calif.Press, Berkeley - Los Angeles: 323-349.
9. MARGALEF R., 1960 - Valeur indicatrice de la composition des pigments du phytoplancton sur la productivité, composition taxonomique et propriétés dynamiques des populations. Rapp.Comm.int. mer.Médit., 15, 2: 277-281.
10. MARGALEF R., 1963 - Modelos simplificados del ambiente marino para estudio de la sucesion y distribucion del fitoplancton y del valor indicator de sus pigmentos. Inv. Pesq., 23: 11-52.
11. MARGALEF R., 1967 - Some concepts relative to the organization of plankton. Oceanogr. Mar. Biol. Ann. Rev., 5: 257-289.
12. MOROSOVA-VODIANITSKAIA N.V., 1954 - Fitoplankton Tchernogomoria, II. Tr.Sevast.biol.st., 8: 11-99.
13. PARSONS T.R., 1966 - The determination of photosynthetic pigments in sea water. A survey of methods. In Determination of photosynthetic pigments in sea water (Monogr. on oceanogr.,meth., 1); UNESCO, Montreux: 19-36.
14. PARSONS T.R., STRICKLAND J.D.H., 1963 - Discussion of spectrophotometric determination of marine plant pigments, with revised equations for ascertaining chlorophylls and carotenoids. J.Mar.Res., 21, 3: 155-163.
15. RICHARDS F.A., THOMPSON T.G., 1952 - The estimation and characterization of plankton populations by pigment analysis. II. A spectrophotometric method for the estimation of plankton pigments. J.Mar.Res., 11: 156-172.
16. SKOLKA V.H., 1967 - Considerații asupra variațiilor calitative și cantitative ale fitoplanctonului litoralului românesc al Mării Negre. In Ecologie marină, 2, Ed.Acad.,

București: 193-293.

17. SKOLKA V.H., 1968 - Les pigments assimilateurs du phytoplancton du littoral roumain de la mer Noire. Rapp.Comm.int. mer.Médit., 19, 3: 567-570.
18. SKOLKA V.H., 1969 - Dinamica fitoplanctonului din zona de larg a platformei continentale românești a Mării Negre în anii 1964-1967. In Ecologie marină, 3, Ed.Acad., București: 149-226.
19. STRICKLAND J.D.H., PARSONS T.R., 1965 - Particulate organic matter. Determination of phytoplankton pigments. In A Manual of Sea Water Analysis, Fish.Res.Bd.Canada, 125: 107-112.
20. UNESCO, 1966 - Determination of photosynthetic pigments. In Determination of photosynthetic pigments in sea water (Monogr. on oceanogr. meth., 1), Montreux: 9-18.