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Study of water turbidity in the Port of Pollença (Balearic Islands)

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The Bay of Pollença is in the north of Majorca, between the capes of Formentor and Pinar. The Port of Pollença is located to the north-west of the bay. It is 610 m long and 2700 m wide, with a maximundepth of 7 m.

The Port has in the last years suffered a problem of turbidity during the summer months. This was particulary serious and longlasting in 1987, and prompted an investigation into its causes which was initiated at the end of that year.

The present contribution shows the results from one year's (1988) monitoring of the following parameters: temperature, total suspended matter, dissolved oxygen, nitrates, nitrites, phosphates, silicates, pigments and phytoplankton according the most common methods (APHA, 1981; Strickland & Parsons, 1972). Water was sampled monthly, and weekly in the summer, at surface from six stations: five near the shore and one in the centre of the Port.

Minimum (Min.), maximum (Max.) and average (Med.) values for the three stations along the shore, with a maximum depth of 2 m (A), and for the other three stations, with a maximum depth between 2 and 7 m (B) are presented in table 1.

TABLE 1. Results of water analysis

	A			B		
	Min.	**Max.**	**Med.**	**Min.**	**Max.**	**Med.**
Susp. Matter (mg/l)	5.20	29.70	12.60	5.20	31.51	9.80
Temperature (°C)	12.50	28.30	21.80	12.30	27.30	21.25
Oxygen (mg/l)	3.86	8.85	5.96	3.75	8.72	5.81
Phosphates (µg at P/l)	0.10	3.04	0.45	0.14	2.91	0.43
Nitrates (µg at N/l)	0.09	8.36	1.86	0.06	4.85	1.59
Nitrites (µg at N/l)	0.03	1.74	0.29	0.03	0.60	0.22
Silicates (µg at Si/l)	0.80	14.70	2.56	0.70	5.00	1.59
Chlo. a (mg/m^3)	0.03	3.81	0.79	0.00	1.54	0.28

On one occasion, at the end of summer, sediments were sampled with a dredge sampler from 13 stations and analyzed for: Loss-on-ignition (LI), organic carbon (OC), total nitrogen (TN) and particle size: percentage of sand (Sa), silt (Si) and clay (Cl), according to the standarized methods (M.A.P.A., 1986).

Throughout the year, low dissolved oxygen content and very substancial nutrient and total suspended matter contents were the most significant features of the study area, and not very different from other western mediterranean areas (Rodriguez & Vives, 1984; Establier *et. al.*, 1987).

Nutrient release into the water column from sediments is probably very important. Fine sediments with high organic matter levels are accumulated in the centre of the Port (Table 2: St. 1, 2, 3, 10, 11). Organic matter can have a autochthon origin or it may be allochthonous near the mouth of seasonal streams Table 2: St. 6, 13).

TABLE 2. Results of sediment analysis

		%LI	%OC	%TN	%Cl	%Si	%Sa
Station	**1**	15.8	6.0	0.2	18.0	21.0	50.2
	2	16.4	6.5	0.3	17.5	21.0	52.2
	3	16.6	4.9	0.3	15.0	22.0	57.0
	4	7.6	2.0	0.1	8.0	5.5	79.0
	5	5.4	1.7	0.1	5.0	2.0	91.2
	6	11.0	3.3	0.1	7.5	10.0	76.2
	7	5.6	1.4	0.2	2.7	5.3	86.2
	8	4.2	1.3	0.1	4.1	5.5	80.5
	9	6.8	2.0	0.1	4.5	6.5	70.2
	10	20.1	5.8	0.4	27.5	24.5	38.7
	12	7.5	2.0	0.2	6.5	9.5	74.0
	13	15.6	4.5	0.3	14.0	4.0	69.7

The nutrient content in the water column together with high summer temperatures and a low level of marine dynamics creates ideal conditions for a phytoplankton bloom. In August the most confined area of the Port (Table 1: A) showed maximum chlorophyll *a* values. Thus the phytoplankton density, normally between 2 and 6. 10^3 cells /ml, reached values between 43 and 47.10^3 cells/ml as a result of a massive development of nanoplankton and small dinoflagellates and diatoms.

The phytoplankton bloom is an important component of the total suspended matter and also of water turbidity in the summer. There is also an inorganic compoment, source of which is the sand derived from an artificial beach in the bay. The continuous input of allogenous matter prevents a correct sedimentation and turbulence favours a resuspension of sediments which contribute to the turbidity of water.

In the Port of Pollença, an enclosed coastal area exploited for various touristic uses (artificial beach, leisure harbour,...), seawater undergoes an increasing process of eutrophication, which prevails in the summer months, and is reflected by a high level of turbidity.

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Monitoring of the Blooms along the Bulgarian Black Sea Coast

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Abstract : Blooms are seasonal phenomena . They are coastal(local and offshore (regional) in the western part of the Black Sea. They reflect adequately the eutrophication and show cycling controlled by solar activity - a basis for bioprognosis.

Introduction. With progressive eutrophication and increasing sea pollution the blooms become very actual. The aim of the monitoring was to make ecological evaluations and prognosticate a protection of the sea from pollution by means of controlling the blooms.

Material and methods. The blooms in the Black Sea were studied annually (1954-1990) according to a standard expedition scheme of profiles and stations up to 55-90 km off the coastal line. Every season the monitoring included an area from 9-15 thousand square kilometers down to the sulphydric hydrogen layer. The volume of investigation amounted to more than 10 000 half a litre quantitative samples; the Utermöl method was used for cells counting ($10^6/m3$) by species level.

Results and discussion. The spatial structure of the phytoplankton along the Bulgarian coast has a seasonal nature. Several zones became prominent towards the shore : 3 miles-broad coastal zone under intensive anthropogenic and recreative influence with chronic blooms; a 10 to 20 miles-broad one under the influence of the Danube and the cyclonic sea currents directed southwards, with regional blooms; a 30 to 40 miles-broad open sea one, with 1-2 degrees lesser in quality and with an uniform content. The vertical structure has seasonal nature as well : at spring and summer temperature stratification, the blooms are at the surface, (above the 25 m) and during winter homothermy, they are distributed to the bottom. The combined influences of factors such as temperature, salinity and content of nutriments on the spring blooms are strongly showed (R= 0.9); simple correlative function between salinity and spring blooms is negative (r= -76)as they begin at low salinity and rapid increasing of water temperature.

By means of statistical and spectral analysis, the influence of the solar activity was proved upon the dynamics (1954-1987) of Black Sea plankton diatoms in Bulgarian open sea (PETROVA-KARADJOVA, APOSTOLOV, 1988). Dual maximum development in the three 11-year cycles of sun-spots (19-21 cycle by the Zürich numeration) was found out : the first maximum occurs 1 or 2 years after the maximum of the sun-spots cycle and the second one coincides with its minimum. Diatom cycles showed a period of approximately 5.5 years, which proved valid for other plankton species as well. The maxima and minima of the solar cycles were followed by or coincided with mass blooms of species belonging to different taxa, as follows :

Nitzschia seriata Cl. The bloom was discovered in February-March 1959 (on an average of 2367 x 10^6/ m3) from the Danube's mouth to the Bosphorus (PETROVA, SKOLKA, 1964) two years after the maximum of the 19th sun cycle (1957).

Cerataulina Bergonii Perag. A dominant diatom species in the 1964 spring bloom (on an average of 48 x 10^6/m3) which coincides with the minimum of the sun cycle (1964).

Prymnesium parvum Carter. The blooms of this toxical species of Chrysophyta appeared in coincidence with those of the diatoms : in September 1959 (maximum 150 x 10^9/ m3) with mass mortality for the fauna (PETROVA, 1962)and in March 1964 (on an average of 520 x 10^9m3) in the Bourgas Lake, but as water temperature reached 10.4°C, no fish mortality occured (PETROVA, 1966; KOLAROV, 1965).

Detonula confervacea (Cl.) Gran. In 1969 the winter bloom of this diatom species at 20 miles off Varna (on an average of 2973 x 10^6/m3) was registered a year after the maximum of the 20th sun cycle (1968).

Sceletonema costatum (Grev.) Cl. the spring bloom at 30 miles off Varna (on an average of 6183 x 10^6/m3) perfectly coincided with the minimum of the 20th sun cycle in 1976. It was constant throughout the winter-spring months with very frequent local blooms in relation to human pollution along the shore.

Until 1970 the Diatoms predominated in the Black Sea. The progressive organic pollution and the increase of seasonal water temperatures during the period 1971-1980 changed the flora with a predominance of Dinoflagellates in the western half of the sea. The maximum of the 21st sun cycle was registered in 1979 and its minimum in 1986 and in the spring of these two years appeared regional, about one month long, blooms of the dinoflagellate Exuviaella cordata Ost. (PETROVA-KARADJOVA, 1979; SUKHANOVA et al., 1988), lately identified as Prorocentrum minimum (Pav.)Schil. (MARASOVICH, 1986). The concentrations of this species varied, but were the highest in bays (e.g. in the Varna Bay maximum 280 x 10^9 in 1979 and 220 x 10^9/m3 in 1986).

Phaeocystis pouchetii (Hariot) Lagerheim is a Haptophyceae we discovered for the first time along the Bulgarian Black Sea coast in August-September 1989 (only in the form of disintegrated jelly-like colonies) above the 25 m layer and up to 30 miles in the open sea between the Cape of Caliacra and the Cape of Emine at water temperature of 20-24°C. The species is known to be present in the North Sea (ZENKEVICH, 1956). Now it has appeared in front of Denmark and Ireland with unpleasant smell and foam on the beaches; fish migrate from blooms areas. The small colonies of Phaeocystis get swallowed by Noctiluca, which follows its blooms (KAT, 1982; REPORT ICES, 1989/:18). In the Bulgarian areas the species appears as whitish stripes and spots on the surface of the sea. The observations are continuing.

The monitoring proved the cycling of the regional blooms and the possibility for their prognosticati approximately every 5.5 years in dependence on the prognoses of the sun cycles with the annual, continual and gradual seasonal local blooms as a back ground.

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