Distribrution of crustacean micronekton across a Mediterranean front

J.-C. MIQUEL[1] and J.-Ph. LABAT[2]

[1]Groupe de Recherches Marines, UNSA, NICE **(France)**
[2]Observatoire Océanologique, UPMC, VILLEFRANCHE SUR MER **(France)**

Fronts are regions of larger-than-average horizontal gradients of water properties such as temperature, salinity and density, and are places of particular biological significance (LE FEVRE, 1986). In the northeastern part of the western Mediterranean, the Ligurian Sea, the water circulation is characterized by a permanent cyclonic flow running southwest along the French Riviera. This cyclonic circulation is marked by a steep salinity and density gradient (frontal zone) separating the inshore current (coastal and peripheral zone) from the offshore water mass of high surface density (central zone) (PRIEUR, 1981). This geostrophic front is a permanent feature of the Ligurean Sea and its position fluctuates only by a few miles (NM).

The present note reports data on the distribution of crustacean macroplankton and micronekton across the front in late summer (September) 1984. Sampling took place along a 123° transect from Cap Ferrat at 11 stations distant of 3 NM each. The hauls were carried out with an Omori net of 2 m^2 surface opening and 590 µm mesh size. They were double oblique from the surface down to 200 m depth, and were performed at night to minimize the effect of diurnal migration. The location of the frontal area at the time of sampling was obtained from hydrological data collected concomitantly and was situated at 7-15 NM from the shore (PRIEUR, personal communication).

Twelve species of euphausiids and shrimps were fished. The species names and their total captures are reported in table 1. *Meganyctiphanes norvegica* was the most common species and was clearly concentrated in the central waters, well off the frontal area. *Nematoscelis megalops* was the second most common species and presented peaks of abundance in the frontal zone as well as in offshore waters, but was scarce in coastal waters. The other two species well represented had nonrandom distributions: *Stylocheiron longicorne* was concentrated mainly in frontal waters and *Euphausia krohni* was the only species with a clear preference for inshore waters. The respective abundance of *M. norvegica* and *E. krohni* in the Ligurian offshore/inshore gradient is in opposition to previously reported distributions in NW European waters (MAUCHLINE, 1984). Shrimps were caught only in small numbers and the data gave little information on their distribution.

Table 1.- Species of crustacean macroplankton and micronekton fished in September 1984 and number of specimens caught.

Euphausiids	number	Shrimps	number
Euphausia hemiggiba	2	*Gennadas elegans*	5
Euphausia krohni	206	*Pasiphaea multidentata*	6
Meganyctiphanes norvegica	1409	*Pasiphaea sivado*	21
Nematoscelis megalops	913	*Sergestes arcticus*	2
Stylocheiron longicorne	137	*Sergestes robustus*	1
Thysanopoda aequalis	4	*Sergestes sargassi*	1

The influence of the front on the distribution of the species was studied by correspondence analysis (CA). The aim of the CA is to describe parsimoniously the total inertia of a multidimensional data set in a sample of few dimensions (or axes). Among the inertia methods, CA is concerned with contingency tables and use a Chi-square metric. Only the 7 most abundant species at the 11 stations were retained for the CA. Figure 1 gives the station coordinates on the two main CA axes against their distance from the coast; these two axes accounted for 62.7 % and 32.3 % of the inertia respectively (interpreted as part of information). Axis 1 reflects the opposition between *E. krohni* (coastal species) and *M. norvegica* (mainly offshore species). As shown in figure 1, this effect is related to the distance of the stations to the coast and is most important at the frontal zone. Axis 2 describes the species spatial distribution after removal of the coast-offshore effect. This axis is linked to an opposition between *M. norvegica* and *N. megalops* / *Stylocheiron longicorne*. The three frontal stations are clearly set apart from the others by their low coordinates on the second axis, which is due to a neat dominance of *N. megalops* and *Stylocheiron longicorne* in these stations (Fig. 1).

The data reported indicates that in the Ligurian Sea the distribution of euphausiids is marked by (1) a gradient between offshore and coastal waters; (2) a concentration of some species in the frontal zone. Species associated with the front are predominantly carnivores (*N. megalops* and *Stylocheiron longicorne*) whereas those involved only in the offshore/inshore gradient most probably feed on smaller particles (*M. norvegica, E. krohni*).

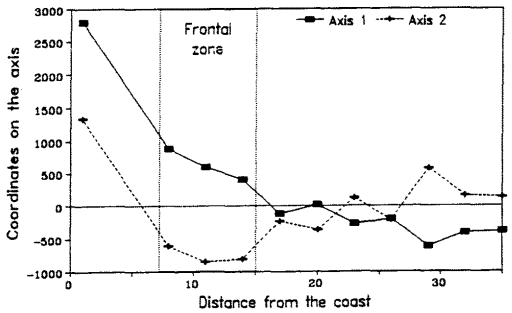

Figure 1. Station coordinates on the two main correspondence analysis axes against their distance from the coast.

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(1)Present address: IAEA - Marine Environment Laboratory, B.P. 800, MC98012 Monaco Cedex

Cysts of blooming dinoflagellates from Black Sea

Snejana MONCHEVA

Department of Marine Biology and Ecology
Institute of Oceanology - BAS - VARNA **(Bulgaria)**

The fact that blooms in Black Sea are spreading both in space and time is related to recurently increased anthropogenic impact on the basin (BODEANU 1984, ZAITZEV 1986, NESTEROVA 1987). While there is much information on species involved and environmental factors contributing to these events almost no attention has been paid to dinoflagellates life cycle and its relation to the blooms in Black sea ecosystem. The present paper is aimed at investigation the different stages in life history of the most frequent blooming dinoflagellates along the Bulgarian Black Sea coast.

Both phytoplankton sampling and laboratory culture experiments have been undertaken. Phytoplankton was monitored on monthly and weekly rates in Varna Bay (Bulgarian Black Sea coast) for species composition, abundance outbursts and blooming species populations morphological heterogenity during the period 1984-1991. The details on monoculture procedures and phytoplankton succession are given elswhere Moncheva 1991 a,b). All species counts are made following the inverted microscope technique.

For most of the dinoflagellates blooming along the Bulgarian Black Sea coast, sexual reproduction has already been reported in the literature (Tabl.1)

Heterocapsa triquetra: Vegetative cells are present in the plankton during winter, spring and autumn and entirely absent in summer months with almost regular blooms in April - May. Oval, thick walled structures with d=28-31µ have been registered in May 1988 at a population density of 3.1x10^5 cells/l amounting to 1.9x10^5 cells/l (e.g.64%) at the surface and varying with depth (down to 15 m) from 36 to 72% (fig. 1a). At t° above 20°C no vegetative cells are present in the plankton. Perhaps encystment may be related to t° factor which is quite in agreement with Susumu (1986).

Table 1: Dinoflagellate species blooms along the bulgarian sea coast (1984-1991)

year / species	1984 a	1984 b	1985 a	1985 b	1986 a	1986 b	1987 a	1987 b	1988 a	1988 b	1989 a	1989 b	1990 a	1990 b	1991 a	1991 b	Sexual * cycle known
Prorocentrum minimum	7 11	8.6 60.1	6 7	0.7 0.4	6	480	7	30.5	7	3.2	6	250	6	1.6	7	41.5	ND
Heterocapsa triquetra	5	39.5	4	3.8	5	13.6			5	47.3	6	5					+
Prorocentrum micans	11	2.9					10	1					7	1.2	7	1.2	ND
Goniaulax polyedra	11	1.4					10	2.2	7	1.3							+
Scrippsiella trochoidea											7	16	7	0.2	8	1.9	+
Polykrikos schwartzii											6	0.08			7 8.9	0.02 0.05	+
Gymnodinium catenatum															7 8.9	0.9 2.7	+

a - month; b - abundance (1x10^6 cells/l); ND - no data; * - after MATSUOKA *et al.* (1989)

Prorocentrum minimum: vegetative cells present in the plankton throughout the whole year with local and regional blooms (1979, 1986) both in late spring - summer and autumn months. In June 1988 at t° above 20°C and cell density 9.2x10^5 - 1.5x10^5 (19.4%.) cells/l are dark brown spheres of d=12µ without flagella (fig.1b), the same structures being registered in old lab cultures.

Prorocentrum micans: As vegetative cells also found throughout the year with irregular outbursts (tabl. 1). Naked dark brown spheres of d=30µ found for the first time in 1984 are identical to the structures reported by BRAARUD, ROSSAWICK (1951) as cysts (fig. lc.). In 1987 at t° 18°C and 1.1x10^6 cells/l they amount to 9.4x10^3 cells/l. In the same sample in von Stosch medium at 22°C in lab the number of vegetative cells increase to 4.5x10^6 cells/l and that of the spheres to 169x10^3 cells/l. In old culture (11.3x10^6 cells/l) they amount to 270.5x10^3 cells/l.

Goniaulax polyedra: Vegetative cells present mainly in spring-summer and autumn months. Cysts are registered for the first time in Nov. 1984. In Oct. 1987 at t° 18°C and concentration of cells 2.2x10^6 the cysts number is 67.6x10^3. In lab at 22°C after 2 days incubation in von Stosch medium the ratio is inverse - 788.9x10^3 vegetative cells and 1.2x10^6 cells/l cysts.

Scrippsiella trochoidea: For the first time the species is found in the plankton in 1989. Cysts (oval cells, d=25-30µ, with very short and tiny spines) identified at t° above 20°C at cell density 1.9x10^6 cells/l in conc. 11.6x10^3 (16.8%) in August 1991. Absent in the plankton in winter - late autumn months.

Polykrikos schwartzii: Absent in the plankton in winter - late autumn months. Cysts identified in July 1989 at the water - bottom interface at a density of 4x10^5 cells/l while the number of vegetative cells in the plankton is 2.5x10^5 cells/l.

Gymnodinium catenatum: A new species in Black sea phytoplankton found for the first time in 1991. No cysts detected yet.

For the species *P. micans* and *P. minimum* whether the cysts are planozygotes or temporary cysts needs further investigation. The role suggested for the cysts includes short and longterm survival in adversory conditions, bloom initiation, species dispersion, genetic restoration but the importance of these roles remains largely hypothetical (PFIESTER and ANDERSON, 1987, BINDER and ANDERSON, 1990). As most of the species reported are present throughout the whole year as vegetative cells, it is rather speculative to consider cysts only a way of survival under unfavourable conditions. As we consider eutrophication an ecological background of high density population maintenance, we are likely to consider sexual reproduction induced by eutrophication, responsible for nuclear reorganization and population genetic restoration (MADHU, 1980).

The documentation of cysts reported makes it possible to revise the concept about phytoplankton assemblages formation along the Bulgarian Black Sea coast (PETROVA - KARADJOVA, 1973) and proves its relative autonomy of development addressing especially the local blooms.

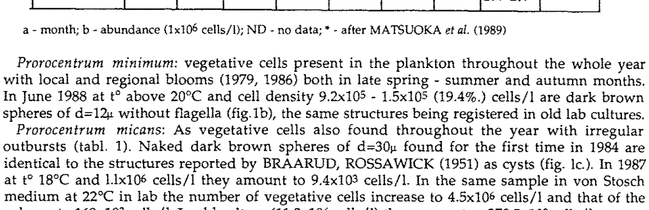

Fig.1: Cysts of *Heterocapsa triquetra* - a; *Prorocentrum minimum* - b; *Prorocentrum micans* c; *Goniaulax polyedra* - d(x750).

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