SEASONAL DYNAMICS OF DINOPHYSIS SPP. WHICH CAUSED A DSP OUTBREAK DURING THERMAL STRATIFICATION IN THE GULF OF TRIESTE

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Many recent reports of algal blooms recorded in several inshore waters, including harmful effects provoked by toxic species, suggest that such toxic blooms are becoming more frequent and more wide spread (SMAYDA, 1990).

The outbreak of diarrhetic shellfish poisoning (DSP) in the Gulf of Trieste (Adriatic Sea) was recorded for the first time in September 1989 (SEDMAK & FANUKO, 1991) and was associated with an increased cell density of eight *Dinophysis* species. The highest abundance of *Dinophysis* spp. in September 1989 coincided with the toxicity peak in mussels from two shellfish farms in inshore waters along the Slovenian coast. DSP toxins were again detected in mussels during routine monitoring (mouse assay, YASUMOTO, 1981). High temperatures, a stratified water column and the relative absence of turbulence are conditions known to be favourable for growth and persistence of relative high abundances of dinoflagellates from late spring to early autumn (PAERL, 1988; DELMAS *et al.*, 1992).

In view of these findings and our own data from 1986-1992 revealing the presence of *Dinophysis* spp. from May to October, we followed *Dinophysis* spp. abundance as well as environmental conditions (temperature, salinity, water column stratification), including nutrients during 1993. Sampling was carried out at five depths (subsurface, 5, 10, 15 m and above bottom) in an offshore station in the southern part of the Gulf of Trieste (depth of 20 m) in the vicinity of two shellfish *Mytilus galloprovincialis* farms from May to October 1993, monthly, and approximately biweekly from mid-June to mid-September 1993. From fixed sea water samples (1 l) for phytoplankton counts, subsamples of 100 ml were concentrated in the sedimentation chambers and the entire chamber bottom was examined at 100 x magnification according to UTERMÖHL (1958). Water samples for nutrients (PO_4^{3-}, NO_3^-, NO_2^-, NH_4^+, Si) were analysed using standard colorimetric procedures (GRASSHOFF, 1976). Hydrographic profiles were recorded using a CTD probe. During the investigated period the temperature ranged from 12.6°C (May) to 26°C (end of August). The most pronounced thermal stratification of the water column was observed at the beginning of June (ΔT = 7.85°C; ΔT = temperature between the base of the upper mixed layer and the bottom), while the whole summer period (July and August) was characterised by a thick (10 to 16 m) homogeneous upper layer and a slight decrease of surface temperature (from 26 to 23.2°C). The water column was well mixed in September and October. The pool of inorganic nitrogen ($NO_3^- + NO_2^- + NH_4^+$) was never completely exhausted and the concentrations were always above 1 µmol/l. During the period of thermal stratification the concentrations of phosphate above the thermocline remained low, while below the thermocline they increased. Silicate varied from very low values in July (0.63 µmol/l) to extremely high (11.95 µmol/l) in August after a thunderstorm.

Five *Dinophysis* species were found from May to October : *D. acuminata, D. caudata, D. fortii, D. rotundata* and *D. sacculus. D. caudata* and *D. fortii* were registered over the entire investigated period and *D. rotundata* occurred sporadically almost on every sampling. On the contrary, *D. sacculus* and *D. acuminata* were present in July and from August to September, respectively. Surprisingly, over the period of the most pronounced stratification the cell density of *Dinophysis* spp. was low (up to 40 cells/l below the thermocline). Only at the end of August, when the water column became homogenised, *Dinophysis* spp. cell numbers increased to reach the maximal density of 4460 cells/l, followed by a slight decrease to 1260 cells/l in September and 770 cells/l in October. Only a few specimens of *Dinophysis* spp. were present in water samples in November. In the period of the maximal density the highest concentrations occurred between 10 and 15 m, while above the bottom cell numbers were much lower. The only exception was the sampling on 26 August, when bottom density exceeded 4400 cells/l, and was approximately 50 times higher than densities from the upper water layers. In October *Dinophysis* spp. cells were equally distributed through the water column. No significant correlation was found between cell numbers and nutrient concentrations.

Mouse bioassays on mussels growing in two shellfish farms near the sampling station were carried out from the beginning of July to mid-November. The first positive result for the presence of DSP toxins was recorded at the end of August and lasted till the end of October. In November the mouse test was negative.

These results coincided well with the increased cell density of *Dinophysis* spp. at the end of the summer and the scarcity of toxic species in water samples in November. A distinctive feature was the long persistence of DSP found in wild growing shellfish (mainly *Arca noe*) from different locations in the vicinity of the sampling station. Toxicity was detectable until January 1994, although no *Dinophysis* species were found from December on. One reason is probably the low winter sea temperatures which reduce the metabolic activity of shellfish and thus slow down the detoxification processes (SECHET *et al.*, 1990), but we also have to consider the ecophysiological characteristics that differentiate *Arca noe* from the blue mussel.

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SERGESTES ARCTICUS KRÖYER 1855: SIZE GRADIENTS IN THE LIGURO-PROVENÇAL BASIN

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The study of samples of pelagic Eucarid crustaceans obtained from a large area in the Liguro-Provençal basin gives evidence to density and size gradients which are probably influenced by the surface circulation. A relationship between life cycles and drift in the water masses is suggested. Over a period of two weeks (August 17-29, 1991) using the R/V Minerva (CNR), an area of 8600 sq. naut. mi. was covered, and 20 sampling stations were located along four transects : A, Genoa-Calvi; B, Monaco-Calvi; C, Marseilles-Gulf of Porto; and D, perpendicular to B, from 43.13.89N 07.35.66E to 43. 32.63N 08.15.49E (Fig.1). The standard haul for macroplankton consisted in an oblique tow of a 15 feet open I.K.M.T. (2x2 mm mesh in the cod end) from 750 m to the surface in steps. The haul lasted two hours at a ship speed of about 3 knots. The net opening was 17.55 m^2; the amount of filtered water per hour was 97571 m^3. After the sorting, crustacean decapods were identified as to species and measured as to carapace length in mm under the dissecting microscope. This paper concerns *Sergestes arcticus*, the second most abundant species among crustacean decapods, for which the vertical space covered by the sampling includes the largest part of the population (FRANQUEVILLE 1971, SARDOU and ETIENNE 1988). In this species ontogenetic migrations have been described. At night young specimens crowds surface waters (HARGREAVES 1984). Maturity in males is at about 28 mm tl (HANSEN 1922) which corresponds to 8 mm carapace l. Females reach larger sizes. A total of 1156 specimens was collected with numbers ranging from 8 to 189 per haul. The carapace length-frequency distributions can be assigned to three groups :

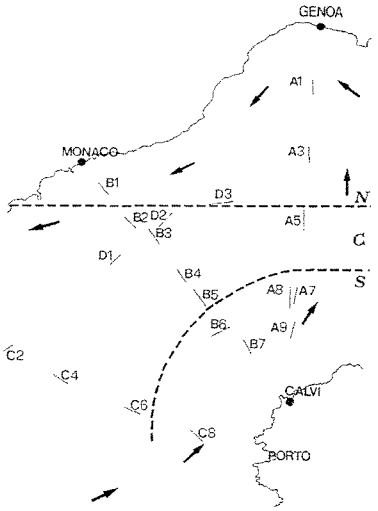

Fig.1. Sampling stations (capital letters and numbers) and surface currents (arrows) are indicated. On the basis of sizes of *Sergestes articus*, three sectors (N. northern, C. central, S. southern) have been distinguished.

- a) Northern sector of the Basin, i.e. Stations A1, A3, B1, D3; *S. arcticus* is present with low densities (average 41.76 per haul) and large sizes (Fig. 2a).
- b) Southern sector, on the Corsican side (St. A7, A8, A9, B6, B7, C8): the average number of shrimps is 54.34; a significant part of the length-frequency distribution is formed by small individuals (Fig. 2c).
- c) Central sector encircled by the Liguro-Provençal front (St. A5, B2, B3,B4, B5, D1, D2, C2, C4, C6) : samples are generally richer in number (N=66.3) and composed of both young (in lesser quantity) and adults (Fig. 2b).

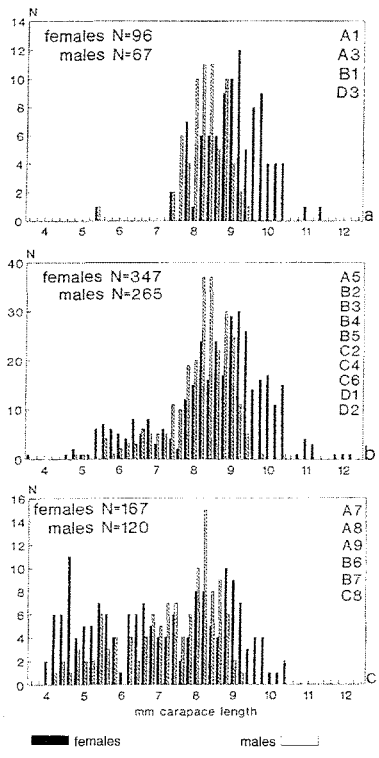

Fig. 2 a, b, c. Length/frequency distributions of *S. arcticus* recorded in the northern, central and southern sectors of the sampled area.

In our opinion the concentration of young individuals in the Corsican sector is of particular interest, indicating a nursery area which is probably fed from the South-West. In fact, it could be related to a drift along the Atlantic surface waters, a branch of which enters the Gulf of Genoa from the South along the West coast of Corsica. On the other hand, large individuals can move by means of the Liguro-Provençal coastal current towards the West, gaining a position from which eggs and larvae can return to the Corsican area. The overall drift of the shrimps is probably slower than the current gyre, given that *S. arcticus* moves daily up and down in the water column, touching water layers which have different speeds (the deepest layers are also the slowest). Young individuals could be transported more quickly because they inhabit higher waters than adults. We have recorded this general pattern of distribution of young and adults in other eurybathic crustacean decapods and euphausiids of the same area. Horizontal migrations necessary to complete the life cycle have been described in several species of Acetes (XIAO and GREENWOOD, 1993).

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