Trophic characteristics of the Sibenik Bay (Middle Adriatic)

T. PUCHER-PETKOVIC and I. MARASOVIC

Institute of Oceanography and Fisheries, SPLIT **(Croatia)**

The Institute of Oceanography and Fisheries has performed the monitoring of physical, chemical and biological properties of the sea water at five stations in front of major Dalmatian towns (Zadar, Sibenik, Split, Ploce and Dubrovnik) ever since 1976.

The present paper presents the results of 14-year research of plankton parameters (phytoplankton density and biomass, zooplankton biomass, and diatom/dinoflagellate ratio), and the most important factors affecting this community (N-salts, P-PO_4, O_2 saturation, transparency). Data used were from Institute's internal publication (Studies and Reviews, 1977-1991).

Sibenik Bay was chosen (station S1) as an area of the highest, IV trophic level of Dalmatian area (VILICIC, 1989). Progressive eutrophication has caused very prominent changes in the plankton community which should be emphasized.

Plankton parameters are an order of magnitude higher here than at other stations. Sibenik Area Station S1 Position : 43°44'0"N; 15°53'5"E; Depth : 32 m Krka River discharges and town effluents are principal sources of eutrophication.

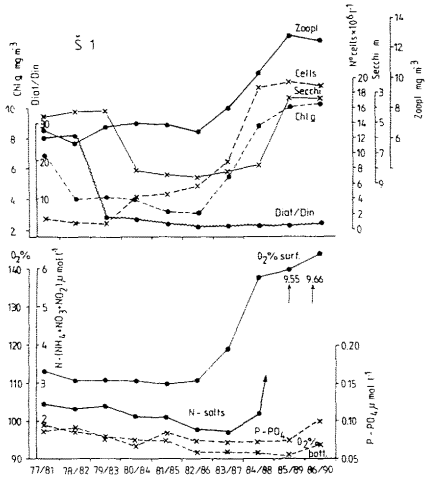

Fig.1 : Annual trend in biological and chemical parameter in the Sibenik area, expressed as 5-year running averages.

Surface layer, where photosynthetic activity is most intensive, was taken into account, except for O_2%. Observations are for summer only. This layer is most strongly affected by land runoff in summer due to intensifica-tion of municipal effluent discharge and the presence of a pycnocline. Fig. 1 shows the variations of studied parameters. As of 1980/84, biological parameters have constantly increased, reaching the highest values for the most recent annual series. Surface chlorophyll *a*, observed over 5-year periods, ranged from 2.84 to 11.65 mg m^{-3}, phytoplankton density from 1,800 to 19. 400 x 10^6 cells l^{-1}, whereas zooplankton biomass varied from 5.7 to 12.8 mg m^{-3} (vertical hauls), REGNER (1991) recorded progressive changes in zooplankton copepod community between 1985 and 1988, ascribing them to coastal water eutrophication.

Progressively higher oxygen saturation points are ascribed to increased photosynthetic activity in the surface layer. Although O_2 saturation had never been below 100%, it has recently reached values as high as 140%. However, bottom oxygen saturation tends to decrease as expected, even though the station is rather shallow.

Higher plankton quantities induced a reduction in the sea water transparency. Phytoplankton composition has also changed, so that the diatom to dinoflagellate ratio has been considerably altered in favour of dinoflagellates. *Prorocentrum minimum*, one of the species taking part in summer phytoplankton blooms in this area, has developed ever more intensive summer blooms (MARASOVIC, 1990). A greater proportion of dinoflagellates in the phytoplankton community, as a consequence of environmental enrichment, is well known in other coastal areas of the eastern Adriatic, as well (MARASOVIC and PUCHER-PETKOVIC, in press).

Whereas phosphates remained at the same level throughout the period of our research, the most recent annual series show an enormous increase of N-salts, particularly nitrates.

To conclude, described changes have in fact taken place in a relatively short time. The continuity of these processes are of serious concern, since they are indicative of the fact that natural fluctuations have been overwhelmed by land effects.

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The effect of eutrophication on the Copepods of the Adriatic Sea

Dubravka REGNER

Institute of Oceanography and Fisheries, SPLIT **(Croatia)**

The aim of this paper is to determine the consequences of progressive eutrophication effects caused by human activity on the composition and density of copepods.

Zooplankton material for this study was collected from bottom to surface at five stations in the eastern Adriatic with HENSEN plankton net (73/100, silk N° 3). One of them was in the coastal waters in front of Dubrovnik (Gruz) harbour, two in the Vela Luka Bay (channel region of the middle Adriatic) and the last two in the open middle Adriatic) and the last two in the open middle Adriatic (Fig. 1).

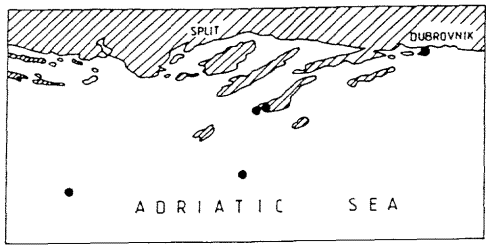

Fig.1 The study area

Fifteen years of investigations (1977-1991) on copepods in front of Dubrovnik harbour have shown that about 30 species are present in summer (REGNER, 1986, 1987, 1989, 1991). Although some predominantly pelagic copepods such as : *Neocalanus gracilis, Calocalanus plumulosus, Clausocalanus parapergens, Pleuromamma gracilis, Heterorhabdus papilliger, Corycaeus flaccus* and some others appear from time to time, neritic species usually occur with higher densities. *Acartia clausi* is always dominant in summer, with an extraordinary high percentage of up to 80 %. In 1991, the percentage of *Acartia clausi* was 93% of all other copepods. In addition recent results (July 1991) indicate that the density of copepods show an increasing trend of about 1300 copepods/m^3 . The increasing trend of the percentage of *Acartia clausi* and the increasing copepod density we can connect with the progressive eutrophication of eastern Adriatic coastal waters and the increasing phytoplankton density in fifteen years period.

In Vela Luka Bay, about 35 species of copepods were found in 1990. The maximum number of species was found at the entrance to the bay, exposed to the strongest impact of open sea waters. Nevertheless, the species composition is diverse in the inner part of the bay, with some pelagic species in addition to those of neritic origin. So, the presence of the copepods: *Lucicutia flavicornis, Mecynocera clausi, Euchaeta hebes, Heterorhabdus pappiliger* and some others, predominantly pelagic species, indicate a mixing of coastal and pelagic influences throughout the study area. Dominant copepods were: *Acartia clausi* constituting as much as 93% in July, *Centropages kroyeri* (up to 50% in autumn), *Temora stylifera, Labidocera wollastoni* etc. Apart from the high percentage of *Acartia clausi* in summer, the eutrophication effects of human activities can be seen in the inner part due to an unexpected high biomass for such a shallow station. This phenomenon was observed especially in summer.

At stations close to the Jabuka Pit and Palagruza (open waters of the middle Adriatic), about 50 species of copepods were found. Although this number is smaller then expected, we can explain it by seasonal samplings of zooplankton in 1986 and 1987. *Ctenocalanus vanus*, the most wide-spread Adriatic species was dominant of the present copepods with about 11%. Furthermore *Acartia clausi* was present by 6%, *Clausocalanus jobei* by 4,6%, *Centropages typicus* by 4.4% etc. From time to time, with just a few specimens : *Clausocalanus mastigophorus, Calocalanus plumulosus, Clausocalanus parapergens, Haloptilus longicornis, Lucicutia flavicornis, Macrosetella gracilis, Scolecithricella dentata, Corycaeus flaccus* and some other predominantly pelagic species appeared, as a consequence of dynamics of water masses and mixing of coastal and open-sea waters at the studied stations. The number of copepods per m^3 is low-about 112/m^3 which is usual for open waters of the middle Adriatic.

Conclusions

From the results mentioned above we conclude:

1. The recent results in front of Dubrovnik (coastal sea) have shown progressive changes under the influence of eutrophication, such as the increasing trend of the percentages of *Acartia clausi* and the increasing copepod density.
2. In the Vela Luka Bay (channel region) the eutrophication effects of human activities can be seen in the upper part of the bay through unexpectedly high biomass and high percentage of *Acartia clausi*, too.
3. No changes have been recorded yet from the open middle Adriatic.

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