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Some observations on eutrophication associated changes in phototrophic and heterotrophic pico- and nanoplankton assemblages in the Northern Adriatic Sea

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SUMMARY

The size class structure of the smaller than 20 µm plankton community was downshifted along a trophic gradient across the Adriatic Sea. Both phototrophic and heterotrophic picoplankton heavily dominated during the summer stratified period compared with the winter mixed period. Cyanobacteria dominated the phototrophs, especially in the eutrophic Po delta region.

The shallow northern Adriatic is under the eutrophicating influence of the Po and other northern Italian rivers, and strong evidence exists that anthropogenically increased nutrient input is increasing primary production causing eutrophication. Previous studies indicated that the eutrophication was reflected in increased plankton biomass, and downshifts in micro- and nanoplankton size class structure (the only size classes then analyzed). To extend our data set the nano- and picoplankton (both phototrophs and heterotrophs) were sampled along a trophic gradient created by Po River discharge, to determine if the eutrophication induced biomass increases and size class changes we previously observed in the microplankton would be reflected in the smaller nano- and picoplankton.

Samplings were conducted along an east-west trans-Adriatic trophic gradient between the Po River delta, Italy and the Istrian Penisula, Yugoslavia, and along a north-south trophic gradient toward the central Adriatic during stratified and mixed water column periods. Samples were collected throughout the water column to establish the physical/chemical characteristics, and to enumerate the smaller plankton elements. Plankton samples were preserved with both glutaraldehyde and Lugol iodine solution, and examined by autofluorescence, or after subsequent decoloring and staining with DAPI or FITC were enumerated using epifluorescence techniques. Organisms were classified as phototrophic and heterotrophic nanoplankton (2-20 µm), and phototrophic and heterotrophic picoplankton (0.2 - 2 µm).

Our previous analyses indicated that changes in the phototrophic community structure from a microplankton dominated community to a community with more nanoplankton occurred with the transition from a mixed to stratified water column, and that some microplankton heterotrophs showed a similar downshift in size class structure. The study reported herewith indicates a further downshift in size classes of both smaller phototrophs and heterotrophs and a relative increase in the biomass of the phototrophic and heterotrophic picoplankton at the western stations under stratified conditions.

The mean water column phototrophic picoplankton densities increased 2-4 fold at eastern and 10-20 fold at the western transect stations compared with winter lows. The average water column densities ranged from 25,000 to 10^6 ml^{-1}. The cell density increase of this component was particularly pronounced at the surface where the water column maximum usually occurred, in contrast to the eastern stations, where the maximum concentrations of this component occurred in the 20-25 m layer.

The phototrophic nanoplankton component increased about an order of magnitude from winter lows with average water column concentrations of 300 to 4,600 ml^{-1} at the eastern stations and 700 to 7,000 ml^{-1} at the western stations.

It is clear that Po river induced eutrophication increased the volume biomass in all phototrophic and heterotrophic pico- and nanoplankton components at western stations near the Po delta during both oceanographic periods. While the ca. 2-fold volume biomass increases in the nanoplankton components (both phototrophs and heterotrophs) along the transect are of similar magnitude, the picoplankton components (both phototrophs and heterotrophs) exhibited a marked 11-fold and 7-fold increases along the east to west gradient. Since the highest biomass was concentrated at the surface at western stations, the surface gradient was even more pronounced, 41-fold and 18-fold respectively. In that context, the south to north gradient becomes even more pronounced, with an average water column increase for each component of 2-3 times that observed on the east to west transect.

High concentrations of cyanobacteria occurred in the surface layers especially at the nutrient richer western stations, indicating that they can thrive in high light intensities given adequate nutrient supply. Their tendency to exhibit a deeper maximum at more oligotrophic stations, may reflect their ability to adapt to lower light intensity close to the depth of the nutricline, since the surface layers at those stations are usually nutrient depleted. The pronounced heterotrophic picoplankton (bacteria) increases at the more eutrophic sites under stratified conditions may reflect high water column temperatures, which increase growth rates, especially assuming an increased availability of dissolved organic matter in this high biomass region.

The observed densities of heterotrophic picoplankton were not sufficient to support observed ciliated protozoan populations, but it is hypothesized that the combined availability of heterotrophic picoplankton (10^5 to 10^7 ml^{-1}) and phototrophic picoplankton (10^4 to 10^6 ml^{-1}) represented a pool of particles dense enough to serve as the food source for the ciliated protozoans as well as the heterotrophic nanoplankton.

Changes in the phytoplankton community structure from microplankton domination to an increased abundance of smaller sized classes (nanoplankton) were previously observed to be associated with the transition from the mixed to a stratified water column seasons, which also downshifted the microzooplankton biomass structure toward the smaller size classes. These additional data clearly indicate that eutrophication associated increases in biomass, and downshifts in size class structure extend to the picoplankton, and further increase the biomass represented by the smaller size class components at the western stations.

CONCLUSIONS

- eutrophication causes a downshift in the size class structure of food webs along a trophic gradient across the Adriatic Sea
- the size class downshift was most pronounced in eutrophic regions off the Po delta, markedly increasing the cell densities and volume biomass of both phototrophic and heterotrophic picoplankton
- the size class downshift occurred primarily during the summer months when the water column was stratified
- the size class downshift mirrored a previously reported downshift in larger ciliated protozoans along the same trophic gradient.

REFERENCES

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P-I2

The phytoplankton successions in the Gulf of Triest

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The week-to-week samplings of phytoplankton throughout one year demonstrated that the phytoplankton assemblages of the Gulf of Triest, Northern Adriatic, changed in time very abruptly within a week or two. The populations of one or two dominant species declined precipitously and became rapidly insignificant or even vanished from the samples.

In the studied year (March 1983 till April 1984) the diatom Chaetoceros affinis became dominant in mid-March, concomitantly with the vernal warming of the seawater. In April the bloom of Prymnesium parvum was observed, successively followed by flowering of diatoms: Ch. simplex , Nitzschia delicatissima complex, and Skeletonema costatum. In May the diacmic small-sized dinoflagellates occured, having the second annual pulse in winter. Gymnodinium simplex and G. paulseni co-dominated with Prorocentrum micans. Beside them the tiny cells, arbitrarily named microflagellates flourished in May. In terms of number microflagellates constituted 64% of the total year cell density .

Fairly stable and sharp thermocline in June probably induced phytoplankton to become stratified. In the upper layers microflagellates co-occured with Meringosphaera triseta, whereas the layers below 10 m depth were populated by the large-sized armoured dinoflagellates: Peridinium spp., Ceratium spp., Dinophysis caudata, D. sacculus, Goniaulax polyedra, that occured in deeper layers until October.

July is the month of diatom proliferation in the Gulf. In the year 1983 the populations of Rhizosolenia alata f. gracillima, Cerataulina pelagica, N. delicatissima complex, N. seriata complex and N. closterium developed in July and were replaced in August by the assemblage of Bacteriastrum delicatulum, Rhizosolenia fragilissima, Guinardia flaccida and again R. alata f. gracillima.

In August in the 20 m deep layer only an unusual bloom of the silicoflagellate Distephanus speculum was observed. The bloom lasted for two weeks.

The September peak was characterized by R. fragilissima, C. pelagica, N. closterium and Thalassiothrix mediterranea. Towards the end of the month the chlorophyte Chlamydomonas sp. could be distinguished among numerous microflagellates.

The second Chaetoceros spp. bloom occured in October. This time the dominant among ten chaetoceros species was Ch. compressus. At the end of October the fraction of large-sized dinoflagellates declined, but the unusual green dinoflagellate appeared in all the layers (Gyrodinium pavillardi) concomitantly with the increase of nutrients especially nitrates.

The cooling of the water and decrease of light intensity in November still did not inhibit the phytoplankton growth. Leptocylindrus danicus co-dominated with the microflagellates, and the modest pulses of the centric and pennate diatoms were observed at the end of the month. Among them the most abundant were: Rhizosolenia stolterfothii, R. styliformis, Ch. compressus, Hemiaulus hauckii, G. flaccida, Thalassiosira decipiens, N. closterium, N. delicatissima complex, T. mediterranea, Cocconeis scutellum and Navicula sp.

Finally in December the skimpy winter flora completed the year successions. Till March the coccolithophorids Pontosphaera huxleyi and Acanthoica aculeata co-dominated with small-sized dinoflagellates G. simplex and G. paulseni and with few tiny tychopelagic diatoms: N. closterium, N. tenuirostris and Amphora marina.

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