Trophic conditions of waters in the Gulf of La Spezia (Ligurian Sea)

E. CATTINI, R. NAIR, C. PERONI and G. ROSSI

ENEA-CRAM, LA SPEZIA (Italy)

Introduction

The Gulf of La Spezia (Ligurian Sea) is divided by a breakerwater into an inner zone (harbour) and an external zone. The harbour is subjected to pollution from various sources, the most important of which are of civil origin. In order to estimate the trophic conditions of waters in the Gulf, surface and bottom water samples were collected monthly in the period December 1989 - June 1991 to analyse chlorophyll a and nutrient concentrations. The following nutrients were determined: N-NH3, N-N02, N-N03, P-P04, total P, organic P and Si; just before sampling, the main physico-chemical parameters (pH, temperature, salinity and dissolved oxygen) were recorded.

Methods

Sample collection was carried out in three stations (Fig. 1): station 1, near a sewage pollution source (Lagora channel outfall); station 2, within the harbour, but far from pollution sources; station 3, outside the harbour.

Nutrients were determined by an AutoAnalyze Technicon II utilizing standard methodologies (Methods of Seawater Analysis, 1983). Chlorophyll a was measured by the method SCOR-UNESCO (1964). Physico-chemical parameters were recorded *in situ* by an Idronaut Ocean Seven Probe (Milan).

Results and discussion

As expected, the three stations show different situations (Tab. 1). Trophic parameters exhibit higher values at the station 1, which is located near the pollution sources, and reveal a relationship with rain events. This can explain why chlorophyll peaks related to atmospheric events occur in addition to expected peaks in spring and autumn. In fact salinity is inversely correlated to ammonia ($p<0.05$) nitrates ($p<0.02$) and silicates ($p<0.01$) and to chlorophyll too ($p<0.01$), which is, in turn, positively correlated to the same nutrients ($p<0.02$ for ammonia, $p<0.01$ for nitrates and $p<0.001$ for silicates). This means that primary production is stimulated by the inputs of nutrients from Lagora channel which are enhanced by run-off after rain events. The lack of correlation between chlorophyll and phosphate might mean that phosphate is the limiting nutrient; this can also be supported by the fact that sometimes chlorophyll and phosphate maxima are out of phase. The strong correlation between ammonia, nitrates, phosphate and silicates indicates the same source.

Station 3, outside the harbour, shows peaks of nutrients lower than station 1, and in this case silicates and nitrates are negatively and strongly ($p<0.001$) correlated to salinity. A similar, but weak relationship ($p<0.05$) can be observed between salinity and phosphate, whereas there is no correlation with ammonia. These data can be explained by the influence of river Magra waters which directly affect station 3 outside the breakerwater. In fact, silicates and nitrates are typical of riverine waters, while ammonia is typical of sewerage. Chlorophyll shows a lower number of peaks which are, in addition, less intense than in station 1 and is very weakly related ($p<0.1$) only to nitrates.

Station 2, inside the harbour and far from pollution sources, is only partly affected by continental inputs (negative correlation of salinity versus silicates and nitrates with $p<0.01$), in particular by Lagora channel, as it can be inferred by a strong correlation between ammonia, silicates, nitrates and phosphate.

As a preliminary conclusion, it can be said that the harbour environmental conditions do not appear severely impaired from a trophic point of view. This can be supported by the moderate difference in nutrient concentrations between stations 1 and 3 and by comparison with other similar environments (FRILIGOS, 1976; FABIANO *et al.*, 1978; SEIKI *et al.*, 1991). The relatively good trophic conditions of waters in the La Spezia harbour can be attributed to local hydrodynamism. BORELLA *et al.* (1992) have demonstrated an exchange between water inside and outside the harbour driven by a combined pumping effect of tide and a seiche.

Bottom water samples show the same trend, but less variability in comparison to surface samples. The effect of regeneration by sediments have to be analyzed.

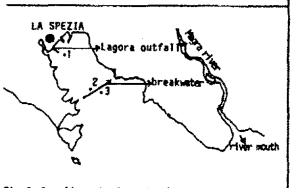

Fig. 1. Sampling stations in the Gulf of La Spezia

Tab. 1. Some results of measurements in waters of the La Spezia Gulf (nutrients as µg-at/l, chlorophyll a as µg/l)

station	1	2	3
P-P04	0.26 (0.03- 1.14)	0.09 (0.01- 0.39)	0.07 (0.01- 0.15)
" b	0.11 (0.03- 0.34)	0.10 (0.02- 0.42)	0.07 (nd - 0.24)
N-NH3	3.32 (nd -13.98)	1.07 (nd - 3.43)	0.69 (nd - 2.69)
" b	1.23 (nd - 3.54)	0.96 (nd - 3.01)	0.62 (nd - 1.76)
N-N03	3.18 (0.10-17.17)	1.88 (0.06- 7.95)	1.86 (0.11- 6.80)
" b	1.29 (0.12- 4.01)	1.11 (0.04- 3.38)	0.87 (0.04- 3.36)
Si	5.10 (1.13-15.64)	2.80 (0.63- 8.77)	2.91 (0.50-12.37)
" b	3.06 (0.67- 5.88)	3.43 (0.45- 7.51)	2.03 (0.63- 4.64)
Chl. a	5.85 (0.65-15.36)	2.96 (0.10-12.67)	1.56 (0.08- 4.11)
" b	3.19 (0.27- 7.06)	2.05 (0.25- 7.88)	1.24 (0.05- 4.05)
Sal. ‰	35.86 (30.91-37.95)	36.70 (33.53-37.82)	36.69 (31.62-37.99)
" b	37.58 (36.70-37.99)	37.68 (36.91-38.06)	37.70 (37.04-38.12)

b = bottom water sample nd = not detected

REFERENCES

BORELLA A., CAMBIAGHI M., MARRI P., MELONI R., MISEROCCHI M., NAIR R. & TOMASINO M., (in press).- Gulf of La Spezia : an analysis of the mechanisms of water exchange between the inner Gulf and the open sea.

FABIANO M., CONTARDI V. & ZUNINI-SERTORIO T., 1978.- Ecologia e biologia dei porti del Mar Ligure e alto Tirreno. I. Osservazioni sulle concentrazioni di PO4---, NO2-, NO3- e SiO3 --. *In atti 2 Congresso A.I.O.L.* : pp. 175-180.

FRILIGOS N., 1976.- On eutrophication in the Western Basin of the Saronikos Gulf, January 1973. *Thalassia Jugoslavica*, 12 (2) : pp. 455-462.

GRASSHOFF K., EHRHARDT M. & KREMLING K., 1983.- Methods of seawater analysis. *2nd Edition, Verlag Chemie*, Weinheim, 419 p.

SCOR-UNESCO, Working Group, 1964.- Determination of photosynthetic pigments. *In : Determination of photosynthetic pigments in sea-water.* UNESCO, Paris : pp. 9-18.

SEIKI T., DATE E. & IZAWA H., 1991.- Eutrophication in Hiroshima Bay. *Marine Pollution Bulletin*, 23 : pp. 95-99.