

The use of geographic information systems in sea and freshwater ecosystems

Carla Giansante & Sandro Pelini

Summary

In the Abruzzo region of Italy, the fishing and sale of the bivalve molluscs are a considerable economic resource requiring over 100 boats. Local production is increased also by farmed mussels. Freshwater fishing is practised extensively in Abruzzo rivers, frequently affected by the presence of dams, and great quantities of fish are periodically reintroduced. It is therefore necessary to monitor activities to determine the quality of Abruzzo freshwater. The Abruzzo region has assigned the *Istituto Zooprofilattico Sperimentale dell'Abruzzo e del Molise 'G. Caporale'* (IZS A&M) the task of monitoring, classifying quality of freshwater and sea water within its territory and controlling bivalve molluscs, in accordance with Italian law. Since 1996, the IZS A&M has conducted the several programmes to monitor programmes, define mollusc quality and to classify the quality water in accordance with European and national law. A geographic information system has been developed to provide decision-making support for the improvement of the quality of human welfare and the environment.

Keywords

Abruzzo, Geographic information system, Italy, Map, Sea, Water.

L'utilizzo del sistema informativo geografico nello studio degli ecosistemi marini e d'acqua dolce

Riassunto

Nella regione Abruzzo, in Italia, la pesca e la vendita dei molluschi bivalvi sono un'importante risorsa economica che coinvolge più di 100 imbarcazioni. La produzione locale è incrementata anche dagli allevamenti di mitili. Anche la pesca sportiva nelle acque dolci è molto praticata sui fiumi d'Abruzzo, frequentemente interessati dalla presenza di dighe e da immissioni periodiche di grandi quantità di pesce. Di conseguenza, è necessario monitorare e determinare la qualità delle acque per lo svolgimento di queste attività. Dal 1996 la Regione Abruzzo ha affidato all'Istituto Zooprofilattico Sperimentale dell'Abruzzo e del Molise "G. Caporale" (IZS A&M) l'incarico dei monitoraggi e delle classificazioni delle acque dolci e marine del proprio territorio e del controllo sanitario dei molluschi bivalvi, in adempimento alle norme europee e nazionali. A tale riguardo, è stato implementato un sistema informativo geografico (GIS) per fornire ulteriore supporto alle decisioni da assumere finalizzate al miglioramento della salute umana e della qualità dell'ambiente.

Parole chiave

Abruzzo, Acqua, Italia, Mappe, Mare, Sistema informativo geografico.

Introduction

In coastal areas, the presence of bacteria, viruses, chemical contaminants and toxic phytoplankton organisms constitutes a significant hazard to human health. Some of these organisms produce very powerful toxins that can reach high concentrations, especially during the blooming period. Among the approximately 5 000 marine algal species, some 75 produce algal toxins. These latter mainly belong to the taxa first of Dinoflagellates and then Diatoms. Human intoxications recorded to date have been associated with filtering bivalve mollusc consumption. Based on the symptoms observed the principal poisoning syndromes have been described as paralytic, diarrhetic, neurotoxic, amnesic and termed paralytic shellfish poisoning (PSP), diarrhetic shellfish poisoning (DSP), neurotoxic shellfish poisoning (NSP), amnesic shellfish poisoning (ASP), respectively (1). Moreover, marine water is always contaminated near the mouth of rivers by civil and industrial wastewater that can contain pathogenic micro-organisms and toxic heavy metals that, also in this case, are accumulated in molluscs, thus becoming potential sources of contamination. The European Union has promulgated Regulation 2004/854/EC (4) that establishes the criteria for the bivalve mollusc sampling and monitoring plans; it also sets the parameters for safe consumption. The parameters to be analysed are as follows:

- *Escherichia coli* (molluscs)
- *Salmonella* spp. (molluscs)
- mercury (molluscs)
- cadmium (molluscs)
- algal biotoxin PSP (molluscs)
- algal biotoxin DSP (molluscs)
- algal biotoxin ASP (molluscs)
- organochlorine (molluscs)
- organophosphorous pesticides (molluscs)
- phytoplankton analysis (water).

The final product of monitoring activities is the elaboration of yearly sea water maps that display areas suitable for *Chamelea gallina*, *Mytilus* spp., *Ensis* spp. and *Solen* spp. Fishing, depending on the test results. The

classification is then used to regulate the sale of molluscs (immediate sale for molluscs from Area A; short purification period before sale for molluscs from Area B while a longer purification period is required for molluscs from Area C).

In Directive 79/923/EEC (3), the European Union also requests that waters where mollusc beds are found must be classified, based on chemical and physical parameters, in order to improve water quality and to guarantee the quality of fished products. The following parameters must be analysed:

- temperature (water)
- dissolved oxygen (water)
- salinity (water)
- pH (water)
- colour (water)
- total suspended solids (water)
- mercury (water)
- cadmium (water)
- organochlorine and organophosphorous pesticides (water)
- *E. coli* (molluscs).

Annual sea water maps developed from monitoring activities where molluscs are fished display areas where water quality needs to be improved or where it should be protected. In regard to rivers, Directive 78/659/EEC of the European Union requires that monitoring programmes are implemented for freshwater designation and classification to protect freshwater fish (2). In this case the monitoring of chemical and physico-chemical parameters (air and water temperature, dissolved oxygen, pH, total suspended solids, biochemical oxygen demand, total phosphorus, nitrites, phenolic compounds, petroleum hydrocarbons, non-ionised ammonia, total ammonium, total residual chlorine, total zinc, dissolved copper, cadmium, lead, mercury, nickel, chromium, arsenic) is needed to classify the rivers as waters for Salmonidae, suitable for the fish such as trout, or water for Ciprinidae, suitable for more rustic fish, such as carp or barble.

The European Union indications for sustainable development establish that the evolution of territory and the planning of infrastructure must be based on scientific data.

For this reason, the Abruzzo region has assigned the *Istituto Zooprofilattico Sperimentale dell'Abruzzo e del Molise 'G. Caporale'* (IZS A&M) the task of researching and analysing all activities connected to the local fishing industry to evaluate the need to reduce fishing activities and to regulate the building of new harbours and the granting of marine concessions.

To monitor and display results of the different programmes and tasks, a geographic information system (GIS) was developed and the classification of water was performed by creating thematic maps for each parameter and defining final maps. This allows the user to have immediate access to all information available for decision-making support to improve environmental and human welfare strategies.

Materials and methods

The GIS produced a final map for each monitoring programme and, as an intermediate step, thematic maps for each parameter analysed, as described below.

Sea water maps for bivalve molluscs

The coastal waters of the Abruzzo region have been divided into a grid, with polygons parallel to the coastline, each represented by a perpendicular line to the coast (transept). In general, the transepts were positioned in front of river mouths or wastewater pipes going into the sea. Eight monitoring points were positioned along each transept, starting at 500 m and ending at 2 250 m from the coastline, and each monitoring point was set inside a polygon. All data collected during the monitoring and the sampling plans were related to these polygons. The grid was drawn using ArcGIS™ 9.0. (Environmental Systems Research Institute, Inc., Redlands, California). For each parameter a thematic map was created to observe the trend of its concentration during the monitoring period and to draw a final classification map of areas for mollusc breeding.

Sea water quality of the Abruzzo region for mollusc breeding

To classify waters into the two categories (quality of water to be improved and high quality water that must be protected from pollution), the coastal waters of the Abruzzo region were divided into a grid, with polygons parallel to the coast line starting at 500 m and ending at 3 000 m from the coastline (transept). The transepts set for the monitoring plan were the same used in the programme for sea water maps for bivalve molluscs. All waters 3 000 m from the coast fall into the category termed 'to be protected'. All data were analysed in ArcGIS™ 9.0. and maps were created for each parameter, which meant that the trend of its concentration during the monitoring period could be visualised and a final map of water classification drawn for mollusc breeding.

Monitoring programme for freshwater designation and classification for fish

All Abruzzo rivers, especially those flowing through national and regional parks or other protected areas, were monitored to control water quality and to identify measures to be taken in case standards fixed by the European Union were not met. Each river was divided into segments and data on environmental parameters surveyed according to the specific programme. With the GIS that was developed, rivers can be visualised on specific maps, showing the results of the monitoring programme. The map displays whether water is fit for *Salmonidae* or for *Ciprinidae* or whether it is not acceptable for aquatic animal populations, depending on chemical and physical-chemical parameters.

Maps for sea water concessions

A map displaying all the concessions locations was created using, nautical digital charts (Nos 33 and 34) of the Italian Hydrographic Institute (Fig. 1). All concession areas (mollusc breeding farms, gas platforms, marine reserves, anchorage points, dumping sites for harbour sediments) on these charts, were geo-referenced and a specific GIS was developed.

Results

Figures 2, 3 and 4 provide examples of final maps showing the three monitoring programmes. In Figure 2 waters are classified

into areas A, B, C according to the results of activities. In Figure 3, water is classified into areas that need to be protected or improved. Figure 4 provides an example of *Ciprinidae* classification of rivers.

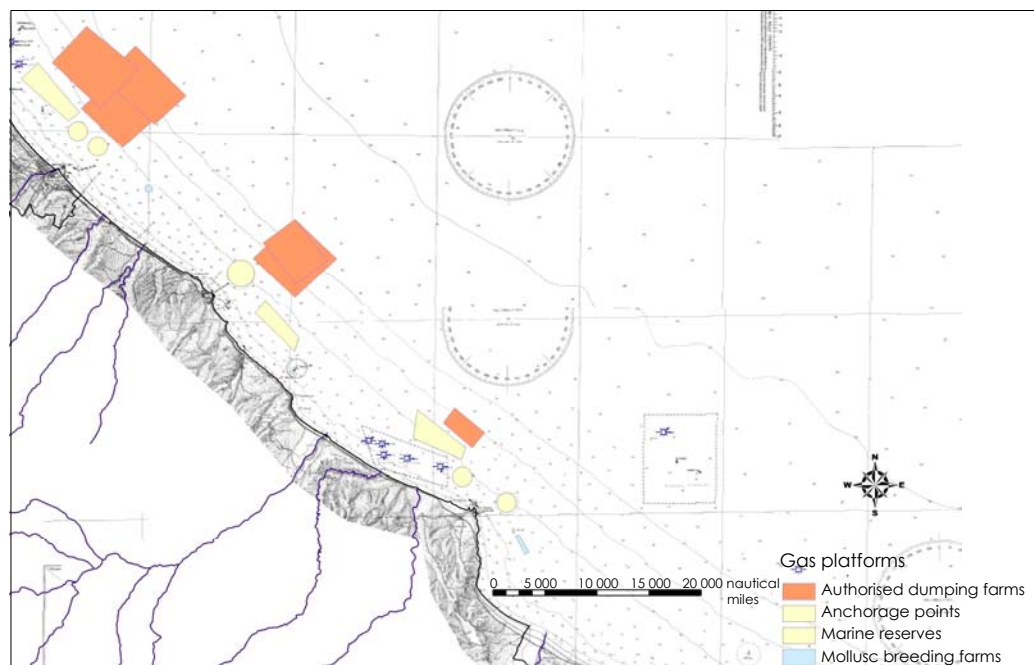


Figure 1
Localisation of the concessions in nautical chart no. 33

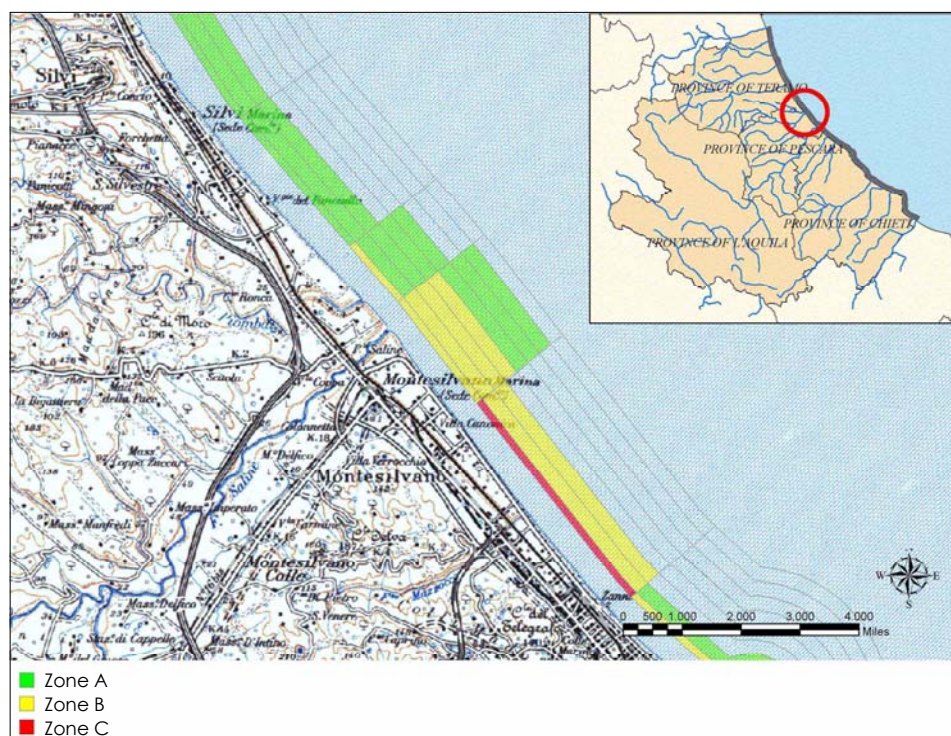


Figure 2
Sea water maps for *Chamelea gallina*

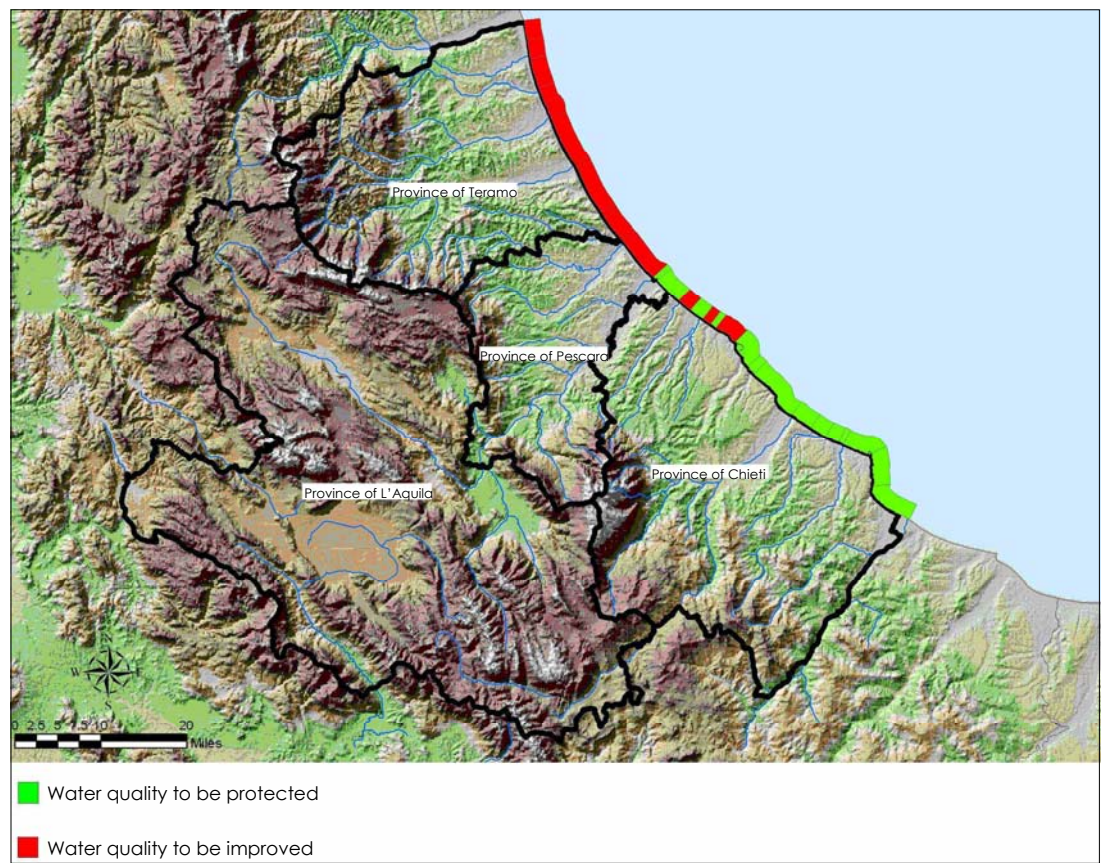


Figure 3
Sea water maps for mollusc breeding

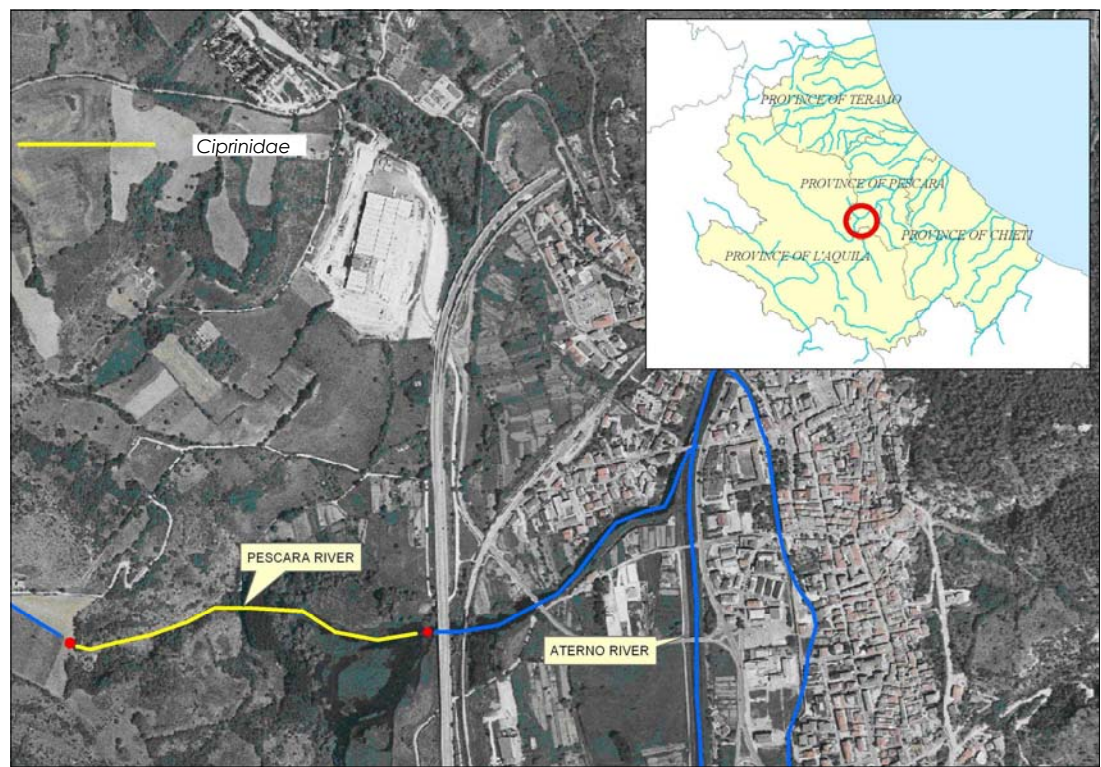


Figure 4
Freshwater maps

Discussion

These monitoring programmes are conducted by the IZS A&M and the GIS is updated every year. Sea water quality maps enable the authorities to immediately decide and communicate the following to fishermen:

- areas with high-quality waters, where fishing does not require further controls before marketing
- waters where molluscs have to be depurated before despatch to the markets
- areas where fishing is not allowed.

This information is also useful to identify the causes of pollution and to identify the appropriate measures to be applied to improve water quality. The study of each contaminant trend could assist in directing the efforts of competent authorities towards specific

protection programmes. The sea water map of human activities is necessary to decide on the future use of the Adriatic Sea to avoid the risk of incompatible activities. For example, it would be necessary to forbid fishing in the areas designed for damping of harbour sediments, to ensure food safety and prevent toxic molecules from entering the food chain. The use of GIS, therefore, contributes to avoid social conflicts and helps in the programming of activities that aim to achieve sustainable development. Furthermore, GIS contribute to the decision-making process by facilitating the immediate visualisation of water quality in a given area.

References

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