

# **The GIS approach to detect the influence of the fresh water inflows on the marine-coastal waters: the case of the Apulia Region (Italy) through standard monitoring data**

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## **Abstract:**

The water quality in the marine coastal areas is affected by “natural” features (geomorphology, hydrology) as well as by the “human” use of land. Understanding the linkage between water quality and river catchments is fundamental for the evaluation of different options in the coastal zone management. Monthly monitoring surveys were performed by ARPA Puglia during the January 2008-December 2009 period, both in the Adriatic and Ionian Seas. Spatial and temporal patterns of water chemical-physical parameters and the trophic index (TRIX) were investigated using the GIS approach for the evaluation of the influence of freshwaters inflows on the coastal area. The results indicate the effectiveness of standard monitoring activities in the water quality control and the usefulness of the GIS tool in order to detect the influence of the river’s runoff.

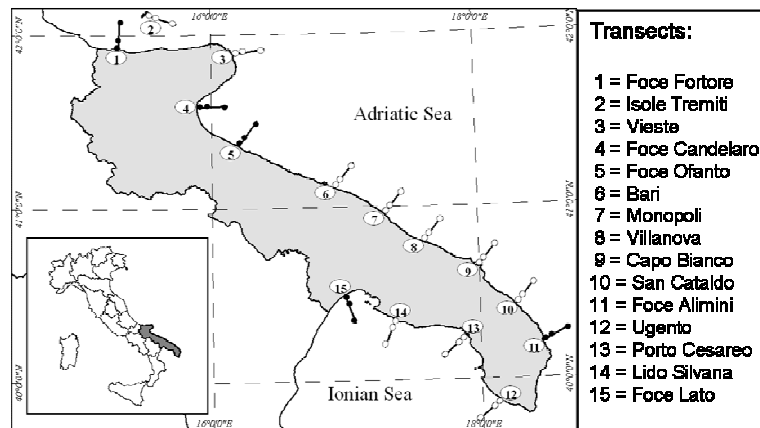
**Keywords:** GIS, mixed effect modeling, TRIX, coastal water, river runoff

## **1. Introduction**

The coastal zones are areas where natural processes (change in precipitation inputs, erosion, weathering of terrain materials) as well as anthropogenic influences (urban, industrial and agricultural activities) are concentrated (Focardi et al, 2009). Among the anthropogenic activities, are worth of notice the over-utilization of groundwater resources, the pollution and discharge of wastewaters into the sea. Particularly, the rising water demand from agriculture in Southern Italy, an area with a natural water resource scarcity, leads to the accumulation of nutrients in river basins. An overall quantitative estimate of nutrients loadings runoff to the Mediterranean sea is reported by Strobl et al. (2009). Mixing between inland and coastal waters represents a key process for biological productivity, with strong implications for the whole coastal system functioning and ultimately on the fishery. For this reason, the understanding of linkage between river catchment and water quality in the associated coastal zone is fundamental for evaluation of different options in the integrated coastal zone management. The purpose of this study is to investigate the influence of the freshwater inflows on the marine-coastal waters of the Apulia Region by mean of GIS approach. Standard water monitoring surveys were performed by ARPA Puglia during January 2008-December 2009 period along Apulian coasts. Spatial and temporal surface distribution of TRIX index (Vollenweider et al., 1998) was examined to evaluate the trophic status and surface quality of the coastal water and was studied in relation to the physical (salinity) and biological (Chlorophyll a) parameters.

## 2. Materials and Methods

The standard water monitoring surveys were carried out at 15 transects along the Apulian coast (Fig.1). For each transect three sampling points, at distances ranging from 100 m to 3000 m, were chosen. Five transects were located in front of rivers mouth. Monthly water sampling of salinity, chlorophyll *a*, dissolved oxygen, dissolved inorganic nitrogen (DIN) and total phosphorus (TP) was performed from January 2008 to December 2009. In order to describe the spatial and temporal trend of TRIX, salinity and chlorophyll *a* in Apulian region coastal waters, we computed two types of maps for these parameters through interpolation via kriging using a linear variogram with slope=1 and anisotropy=1 (Golden Software, 2002). Namely, Surface Water Maps (hereafter SWM; Fig. 2) are calculated by space (transects) and time (months) interpolation of data collected at surface water, while Depth Water Maps (DWM; Fig. 3) are calculated by space (sampling points) and time (months) interpolation of data collected along the water column. The distribution of TRIX values among coast type and season have been analyzed through a mixed effect models, taking account the spatial autocorrelation of data (transect as random factor) and different variance-covariance structure (transect x station x season). The fixed factors were: season (four levels: winter, spring, summer, autumn); coast type (two levels: river mouth, coast); station (three levels: ST1\_500 m, ST2\_1000 m; ST3\_3000 m). The initial full model was:  $Y = \text{season} \times \text{coast type} \times \text{station}$ . The model was refined, in order to define the fixed part, by manual backward stepwise selection using maximum likelihood to remove not significant terms. The resulting model was validated to verify the normality of residual.

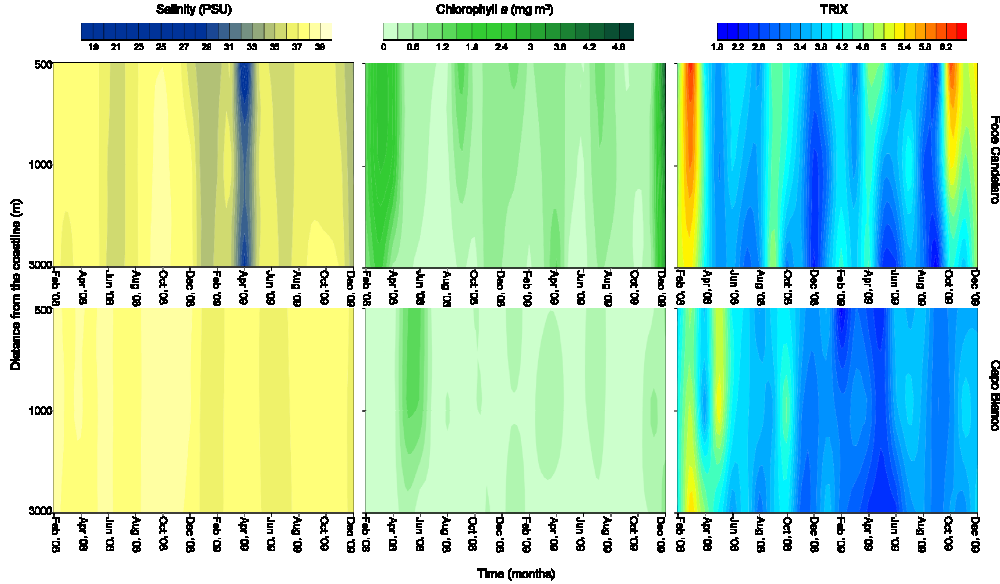


**Figure 1:** Study area and transects: river mouth stations (filled circles) and coastal stations (empty circles).

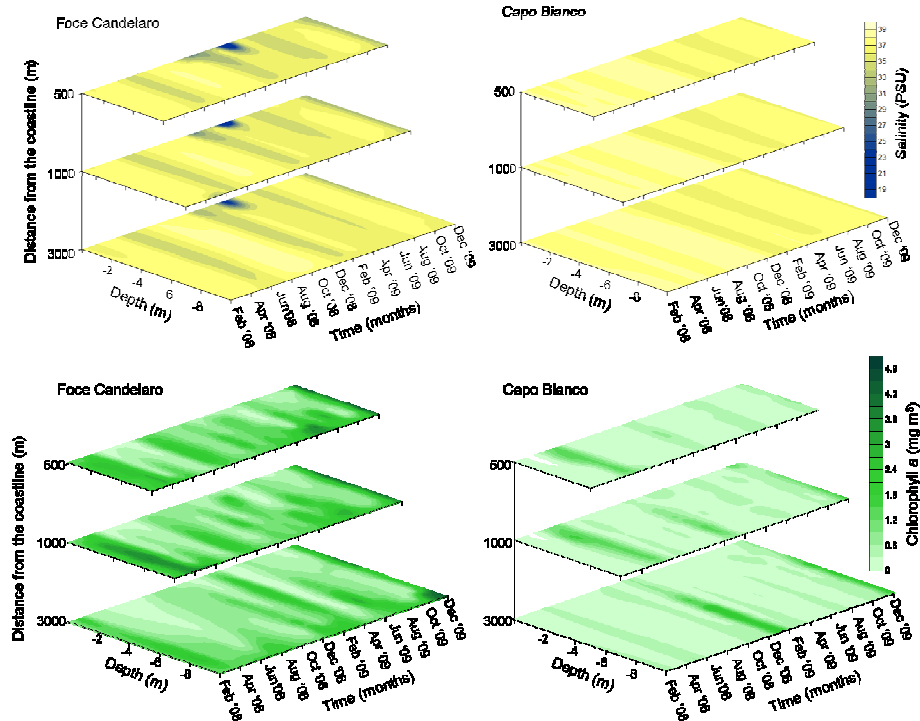
## 3. Results

SWM of salinity, chlorophyll *a* and TRIX value related to all transects were studied. An example is reported in Fig. 2. The river mouth transects showed different characteristics with respect to the coastal ones. In fact, mouth river transect was characterized by the presence of low salinity waters throughout the two years and high chlorophyll *a* and TRIX value (February-April 2008 and October-December 2009) with respect to the coastal ones. In order to investigate whether and how the river waters and coastal discharge affected the water column, the DWM of salinity and chlorophyll *a* were

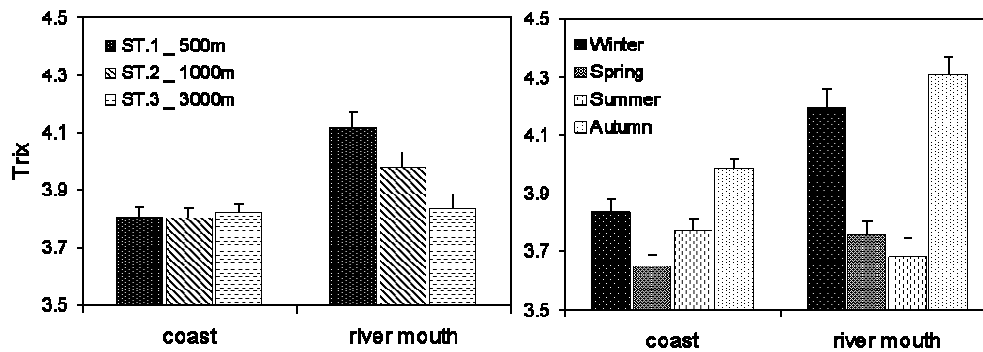
studied along all transects. The layer of fresher waters and chlorophyll *a* were detected along the water column for the transects reported above (Fig.3). The selected statistical model indicates that TRIX index is affected by the interaction between coast type and 1) distance from the coastline 2) season (Fig. 4).



**Figure 2:** SWM of salinity, chlorophyll *a* and TRIX value in the river mouth (Foce Candelaro) and coastal transect (Capo Bianco) by kriging using a linear variogram with slope=1 and anisotropy=1. Note the not proportional distance among the stations.



**Figure 3:** DWM of salinity and chlorophyll *a* in the river mouth (Foce Candelaro) and coastal transect (Capo Bianco) by kriging method using a linear variogram with slope=1 and anisotropy=1.



**Figure 4:** Mean values ( $\pm 1$  e.s.) of TRIX index among coast type and i) distance from the coastline (left) ii) season (right) following the result of the final mixed linear model.

#### 4. Concluding remarks

The investigation of the influence of freshwater on the marine-coastal waters was carried out at different sites of Apulia region, using the distribution of the TRIX index. With regard to the Northern Adriatic Sea, previous studies are available on the influence of salinity on the distribution of TRIX index on the coastal environment (Cocchi and Scagliarini, 2005). This work represented the first study regarding the role of land-derived water discharge in the coastal area in Apulia region, where most of the rivers are torrent-like characterized by temporary regime (Anonymous, 2005). The main results highlight the influence of the river runoff on the coastal water quality. A clear-cut distinction between rivers' mouth and coastal sites is revealed by means of statistical analysis. The highlighted differences are related to: low and homogenous TRIX values along coastal transects, while higher values and a gradient from inshore to offshore have been detected according to rivers' mouth sites.

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