



FIFTEEN YEARS OF MONITORING MACROALGAE ASSEMBLAGES ALONG THE ROCKY COASTS OF TUSCANY

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Introduction

The Water Framework Directive (WFD 2000/60/EU) and the Marine Strategy Framework Directive (MSD 2008/56/EU) require the assessment of the ecological quality of the main coastal marine habitats. In the Mediterranean Sea, the CARLIT method (CARTography of LITtoral and upper-sublittoral benthic communities, Ballesteros et al., 2007) has been proposed as a tool for defining the ecological quality of rocky coastal environment. This is a cartographic method that determines the linear development of macroalgal assemblages, allowing these data to be entered into a Geographic Information System (GIS).

The present contribution reports data obtained through CARLIT method along the Tuscany coasts across 13 years.

Material and Methods

Ten sites were considered: five distributed along the Tuscany coasts and five on Tuscan Archipelago islands (Fig. 1). In each site, three stretches of coastline were sampled by visual census from a small boat at a distance of 3-4 metres (Fig. 2). Data were collected in late Spring/early Summer. The presence of the main assemblages was noted together with the geomorphological characteristics of the coastline. A sensitivity value was assigned to each sampling unit in relation to the dominant assemblage (Table 1). The ecological quality ratios (EQR) represent the relationship between the values of the biological parameters observed and the values for these parameters in the reference conditions

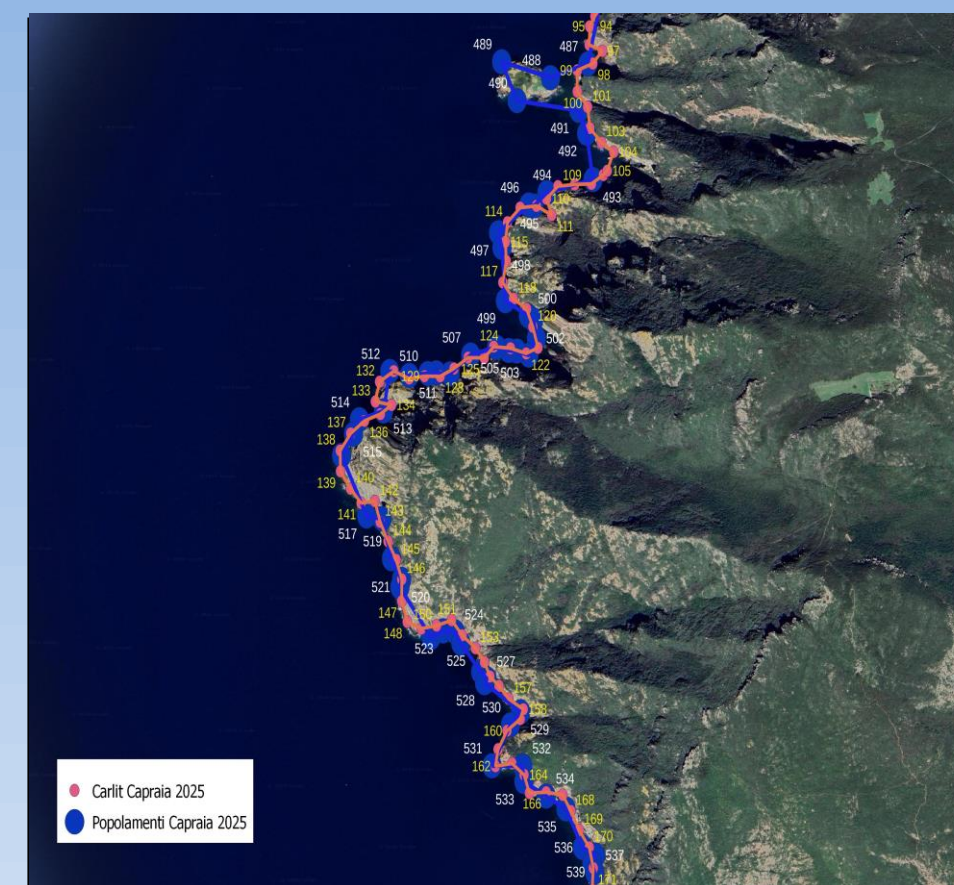


Fig 1. Map of the study site of Capraia



Fig 2. visual sampling

Table 1. Values of CARLIT index and ecological quality obtained in ten sites of Tuscany across fifteen years of monitoring. Yellow= moderate, green = good, blue = high.

SITE	2011	2012	2013	2014	2017	2018	2019	2020	2021	2022	2023	2024	2025
Livorno	0.73		0.68			0.71			0.71			0.74	
Piombino	0.64		0.68			0.69						0.71	
Cala di Forno			0.96			0.82			0.91			0.81	
Argentario	1.03	1.05	0.96						0.81			1.01	
Ansedonia			0.58			0.68			0.66			0.89	
Capraia		0.95			1.05		1.01						0.83
Elba nord	0.62			0.75	0.75			0.71				0.74	
Elba sud		0.69		0.66	0.73			0.68				0.63	
Montecristo	1.22	1.04		1.00	1.17		1.14						
Giglio		0.86	0.83	0.83	0.87		0.89	0.71					0.93

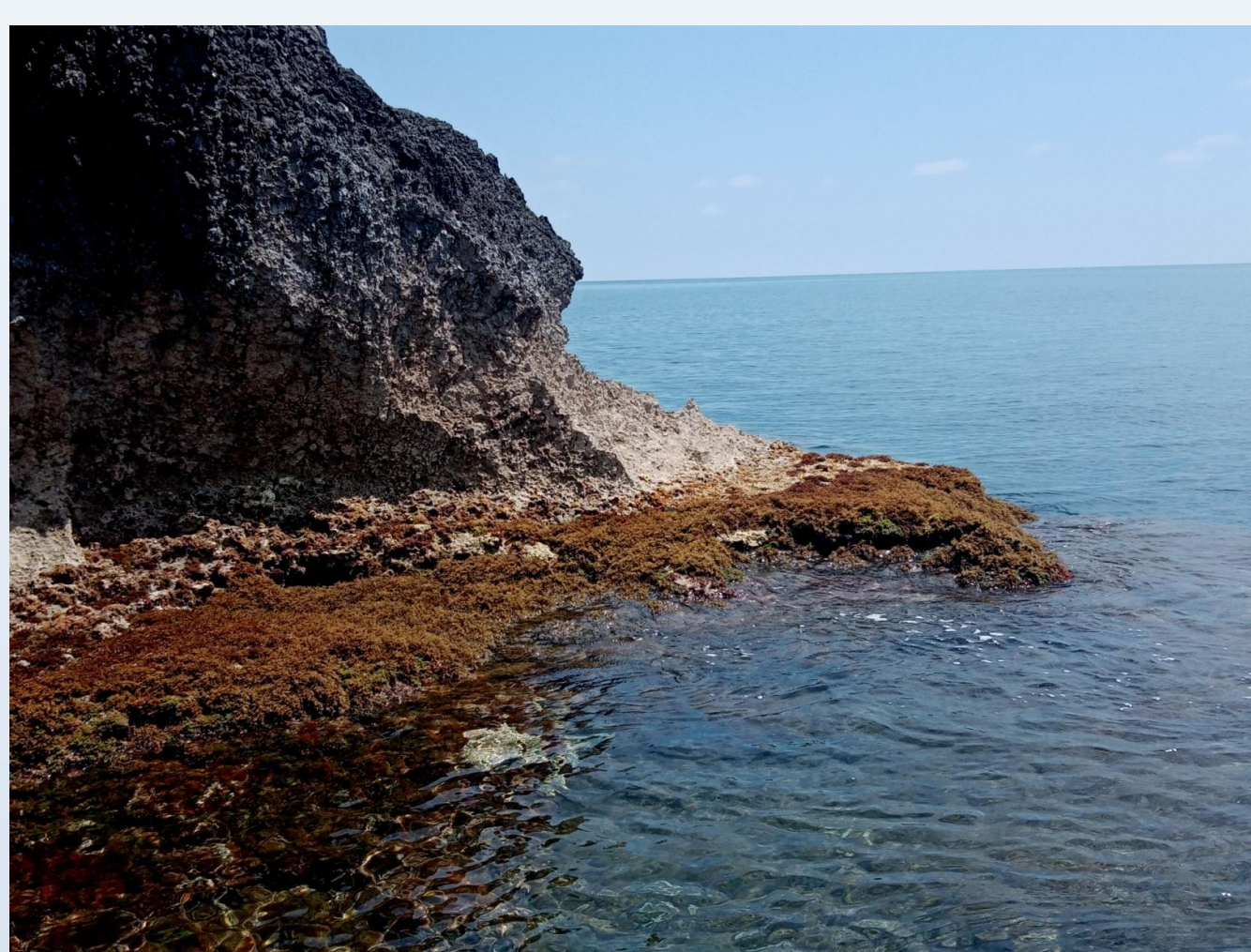


Fig 3. *Lithophyllum byssoides* (above) and *Ericaria amentacea* (below)

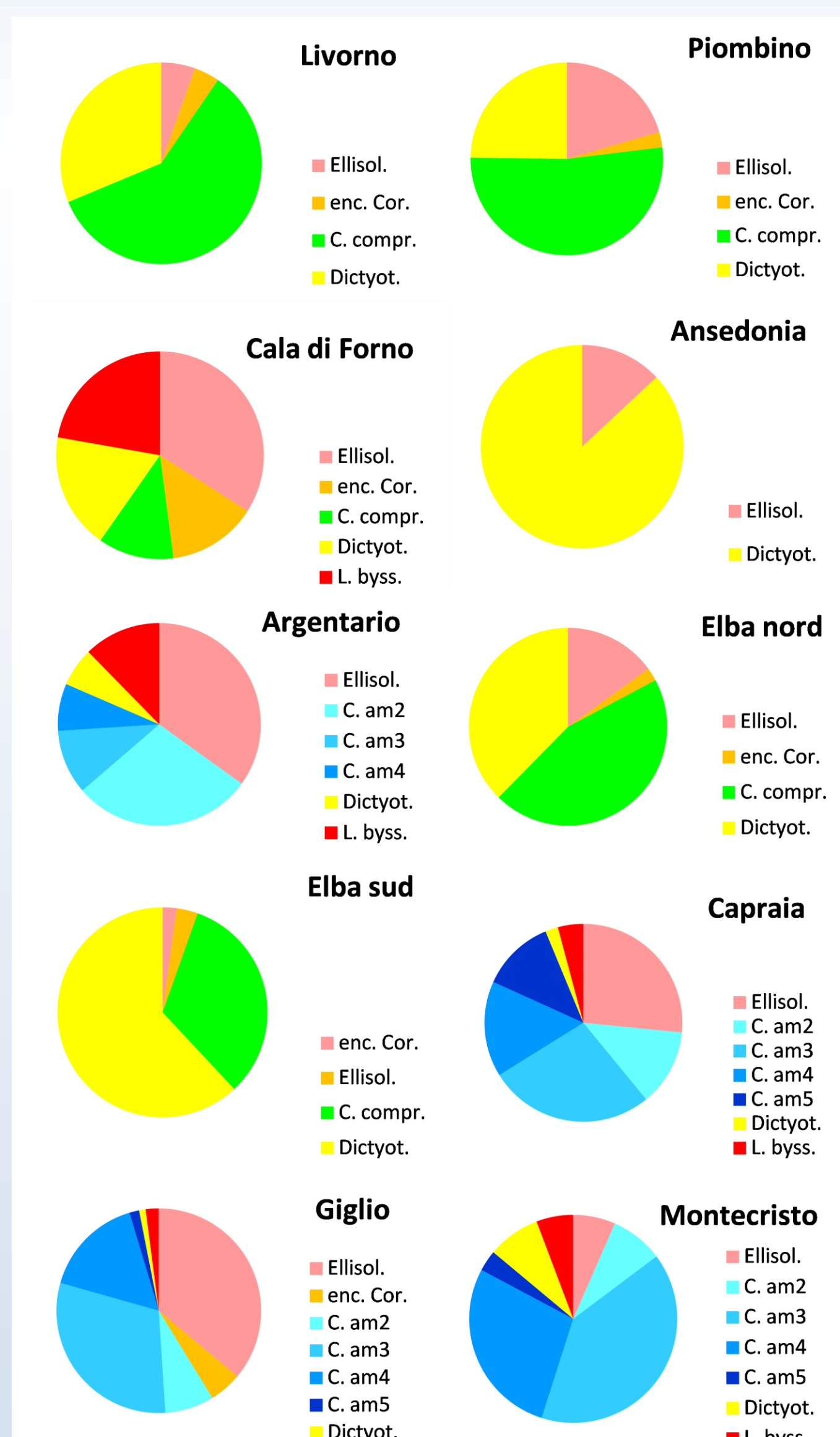


Fig 4. Map of the study sites.

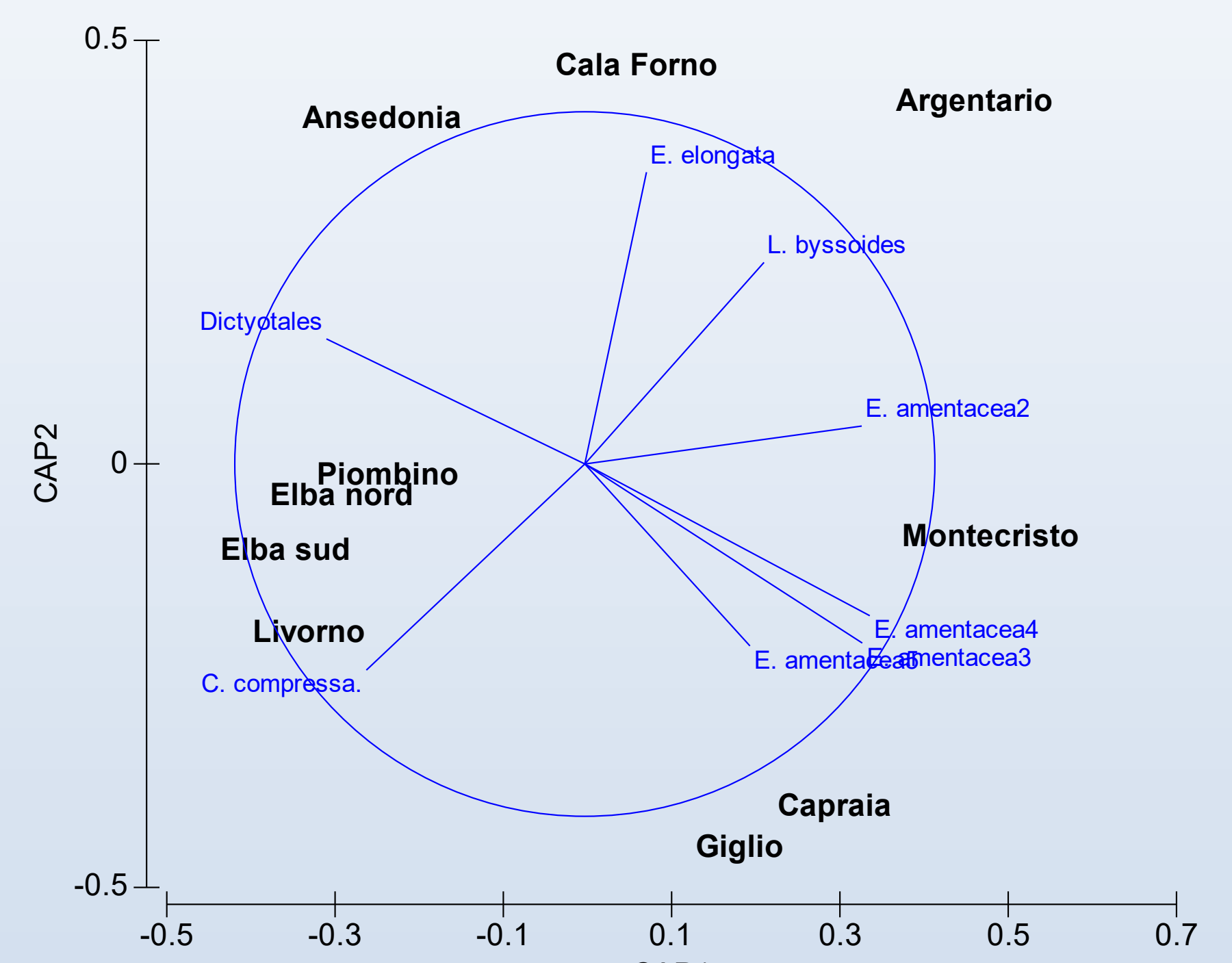


Fig 5. CAP analysis.

Results and Conclusions

Results showed that, across 13 years of monitoring, the ecological status was stable in most sites (Table 2). Four sites resulted in good status (Livorno, Piombino, Elba nord, Elba sud) and five sites in high status (Cala di Forno, Argentario, Capraia, Montecristo, Giglio). Ansedonia was the only site where the ecological quality improved from 2013 to 2024.

The ecological quality mirrors the level of anthropogenic pressure of the sites, as a high quality characterizes the little islands (Capraia, Montecristo, Giglio) and the continental coasts with low urbanization, such as Cala di Forno and Argentario.

The high ecological quality is mainly associated with well-developed populations of the brown alga *Ericaria amentacea*, but biogenic structures of the calcareous red alga *Lithophyllum byssoides* are also present. Both macroalgae are sensitive to most anthropogenic pressures and climate change and are declining in large areas of the Mediterranean Sea (Thibaut et al. 2005, 2013). The presence and stability of these macroalgae populations over the last fifteen years confirm the high ecological value of many areas of Tuscany, increasing the importance of monitoring, which is necessary to highlight any changes in a timely manner, and of adequate conservation plans.

The combined action of sea water warming and increased human pressure is leading to phase shifts in most Mediterranean Sea habitats, with abrupt changes in species composition and community structure. In this context, the availability of a series of historical data, such as those obtained from monitoring coastal assemblages in Tuscany, can help describe possible trajectories of change (Bianchi et al. 2019), guiding environmental management and eventual mitigation plans.

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