

THE CHANGING BIOGEOGRAPHY OF THE MEDITERRANEAN SEA: FROM THE OLD FRONTIERS TO THE NEW GRADIENTS

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While the Mediterranean Sea as a whole is considered as a single distinctive province of the Atlantic-Mediterranean warm-temperate region, its high compartmentalization into fairly isolated sub-basins implies the existence of a number of distinct biogeographic sectors within the Mediterranean Sea (Lejeune et al., 2010). A major inner frontier is said to be the Straits of Sicily, which was acting as a filter bridge between the western and eastern basins during the immigration waves from the Atlantic since the Pliocene (Bianchi et al., 2012).

However, ongoing rapid environmental change, driven by both climate and human influx, is apparently challenging this long established view (Coll et al., 2010). Present seawater warming is favouring the spread of tropical species entering through the man-made Suez Canal and the natural portal of the Straits of Gibraltar, or introduced intentionally or accidentally by human activities. To date,

marine alien species established in the Mediterranean Sea approach 1000, i.e. nearly one tenth of the native biota (Zenetos et al., 2012).

Northward moving of surface isotherms, due to climate warming and to the associate change in water circulation, is allowing warm-water species, either exotic or native, to cross the Straits of Sicily and to penetrate in sub-basins where they were formerly absent (Francour et al., 2010). Thus, the wall between West and East has apparently been torn off: species coming from the tropical Atlantic through Gibraltar have reached the Levant Sea while Red Sea species have reached the Western Mediterranean (Gambi et al., 2008).

The spread of tropical organisms together with sea water warming are leading to what has been called the ‘tropicalization’ of the Mediterranean Sea (Bianchi, 2007). Tropicalization has been said to affect especially the southern sectors of the Mediterranean, which result more and more occupied by tropical exotic species. Contemporaneously, the northward spread of southerners, i.e., Mediterranean indigenous species with (sub)tropical affinities which were confined in the southern parts of the basin until recently, should cause the ‘meridionalization’ of the northern sectors, where the temperature conditions are not yet favourable for the tropical invaders.

The Ligurian Sea, located in the NW of the basin, is one of the coldest sectors of the Mediterranean. There, sea water warming has been causing mortality of native species with cold-temperate (boreal) affinity and establishment of warm-water newcomers, either southerners or aliens.

Based on the analysis of historical data series, temperature rise and warm-water species richness showed correlated between 1950 and 2010. However, notwithstanding a general positive trend, the number of southerner species did not increase consistently – rather, it apparently oscillated over decadal time-scales. On the contrary, the number of tropical aliens has been growing continuously with time; they are showing eurythermal enough to settle and survive in the Ligurian Sea,

flanking or even replacing the natives (Fig. 1).

These results contradict the above-mentioned scheme that opposes a ‘tropicalized’ southern Mediterranean to a ‘meridionalized’ northern Mediterranean. The northern Mediterranean is getting more and more tropical too, although pace and intensity of ‘tropicalization’ are lower than in the southern Mediterranean.

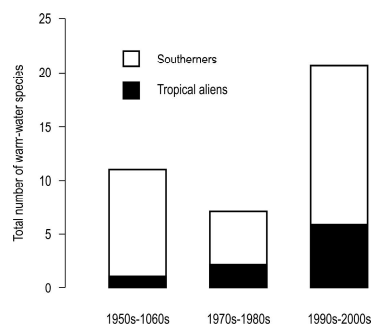


Figure 1. Historical trend of occurrence of tropical alien (black) and native southerner (light grey) warm-water species in the Ligurian Sea. Data come from surveys on the sessile epibenthos of subtidal rocky reefs.

Should the present sea-water warming continue in the future, the Mediterranean would undergo a generalised process of biotic homogenisation, and the well established differentiation among its distinctive sub-basins would probably fade away. The traditional idea of a major biogeographic frontier between western and eastern Mediterranean at the Straits of Sicily should be abandoned in favour of a series of smooth gradients in a south-north direction, with alien species assuming an even greater role in the future biogeography and ecology of the Mediterranean Sea.

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