COASTAL AND MARINE KEY HABITATS IN THE MEDITERRANEAN SEA

KLJUČNI OBREŽNI IN MORSKI HABITATI V SREDOZEMLJU

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Key words: Mediterranean Sea, Northern Adriatic, biodiversity, habitats, seagrass meadow, coralligenous assemblages
Ključne besede: Sredozemsko morje, severni Jadran, biodiverziteta, habitati, travniki morske trave, koraligenske združbe

ABSTRACT

The Mediterranean Sea is known as a biodiversity hot spot in terms of species, as well as at the ecosystem level with varied and rich benthic habitats. If this high biological diversity can be mainly explained by environmental conditions (interface between tropical an temperate regions, hydrology, climate, habitat heterogeneity), the historical factors also played a major role (remnant of the Tethys Ocean, Messinian crisis, Atlantic Ocean connection, opening of the Suez Canal).
The diversity of Mediterranean benthic habitats is the basis of biological diversity. Among these habitats, seagrass meadows and coralligenous assemblages appear as key habitats, and have been taken into account in two action plans of the Regional Activity Centre for Specially Protected Area and Biodiversity (UNEP, MAP, RAC/SPA). If the extension of seagrass meadows in the Mediterranean basin has been estimated at 30,000 to 40,000 km^2, with considerable amounts of data concerning the location of main meadows, there are important gaps in knowledge concerning the composition and distribution of coralligenous assemblages and maërl beds. Data concerning coralligenous assemblages are sparse and most of the information is based on data obtained in the northwestern Mediterranean, with some data additionally available in southern Italy and the Alboran Sea.
The northern Adriatic constitutes a particular biogeographical sector due to its northern location, superficial depth, and important nutrient discharges from rivers. Extensive seagrass meadows, composed of four of the five species present in the Mediterranean basin, have been observed in this region; the lack of rocky substrate and the high sedimentation, however, seem to be unable to support extensive coralligenous assemblages.

IZVLEČEK

Sredozemsko morje je znano kot vroča točka biotske raznovrstnosti, tako zaradi vrst, ki živijo v njem, kot zaradi njegovih ekosistemov z zelo različnimi in bogatimi bentoškimi habitati. Če lahko to visoko biodiverziteto pojasnimo predvsem z okoljskimi razmerami (hidrologijo, klimo, raznovrstnostjo habitatov) v tej mešanici med tropskim in zmernim območjem, pa so eno glavnih vlog pri tem odigrali tudi zgodovinski dejavniki (ostanek oceana Tetida, mesinska kriza, povezava z Atlantskim oceanom, odprtje Sueškega kanala).
Raznolikost bentoških habitatov je temelj biodiverzitete Sredozemskega morja. Med temi habitati se travniki morske trave in koraligenske združbe zdijo kot ključni habitati, kar je tudi razlog, da so bili upoštevani v dveh akcijskih načrtih Regionalnega centra za posebna območja varstva in biodiverziteto

(UNEP, MAP, RAC/SPA). Medtem ko je bilo ocenjeno, da travniki morske trave v Sredozemskem bazenu pokrivajo med 30.000 in 40.000 km^2, pri čemer velika količina podatkov zadeva lokacije glavnih travnikov, pa obstajajo kar velike vrzeli v znanju o sestavi in razširjenosti koraligenskih združb in zaplat morskega dna, prekritih s kalcificiranimi algami (maerl). Podatki o koraligenskih združbah so redki, sicer pa največ informacij izhaja iz podatkov, pridobljenih v severozahodnem Sredozemlju, nekaj dodatnih podatkov pa tudi iz južne Italije in Alboranskega morja.
Severni Jadran oblikuje tako posebno biogeografsko območje zaradi svoje severne lege, majhne globine in pomembnih količin hranil, ki v morje pritekajo z rekami. V tem območju so bili locirani obsežni travniki morske trave, ki jih zastopajo kar štiri vrste, ki sicer uspevajo v Sredozemskem bazenu. Vendar vse kaže, da zaradi pomanjkanja skalnih matičnih podlag in visoke sedimentacije obstoj večjih koraligenskih združb ni mogoč.

1. BACKGROUND

As a semi-closed sea, located at the conjunction between the Black Sea, the Red Sea and the Atlantic Ocean, the Mediterranean is characterized by a limited surface and volume (0.8% and 0.3% of the oceans respectively). Located at the interface between a temperate and sub-tropical climate, the Mediterranean appears today as an extremely complex environment whose history has largely created its biological richness.

A remnant of the once extensive Tethys Ocean, the Mediterranean Sea was connected to the Indopacific Ocean until 10 Ma; the closure of the Atlantic connection (6 Ma) induced an important desiccation (Messinian crisis) until the re-opening of the Strait of Gibraltar (5 Ma); thereafter, the alternation of ice ages with warm interglacials and at last the opening of the Bosporus strait (7.500 B.P.) played a major role in this region (see synthesis in Bianchi et Morri 2000). The opening of the Suez Canal in 1869 restored the connection between the Mediterranean and the Indopacific Ocean via the Red Sea.

All these events were of great influence on the repartition and composition of Mediterranean species and habitats. Species and habitats are of three main origins: (i) endemic elements (paleoendemic and neoendemic species), (ii) Atlantic element (boreal, temperate and subtropical), (iii) Indo-Pacific element (panoceanic relic species and Red Sea migrants). These elements are distributed more or less abundantly in different parts of the Mediterranean and ten biogeographical sectors are usually distinguished (Figure 1, Bianchi et Morri 2000), although a new approach proposes fewer sectors (UNEP-MAP-RAC/SPA 2008).

Another factor to be taken into account is the diversity of available habitats; the Mediterranean Sea exhibits a large continental shelf as well as important depths (up to 5,124 m), with complex geological structures (two main basin separated by a shallow strait, several underwater dorsals, numerous islands, coastal lagoons, varied substrate and slopes). Temperature, light, water movement, nutrient availability and salinity act as forcing factors in species repartition. Finally, interaction between indigenous but also introduced species must be considered, as well as increasing levels of human activities (coastal management, discharges, pollution, exploitation of living resources, climate change...).

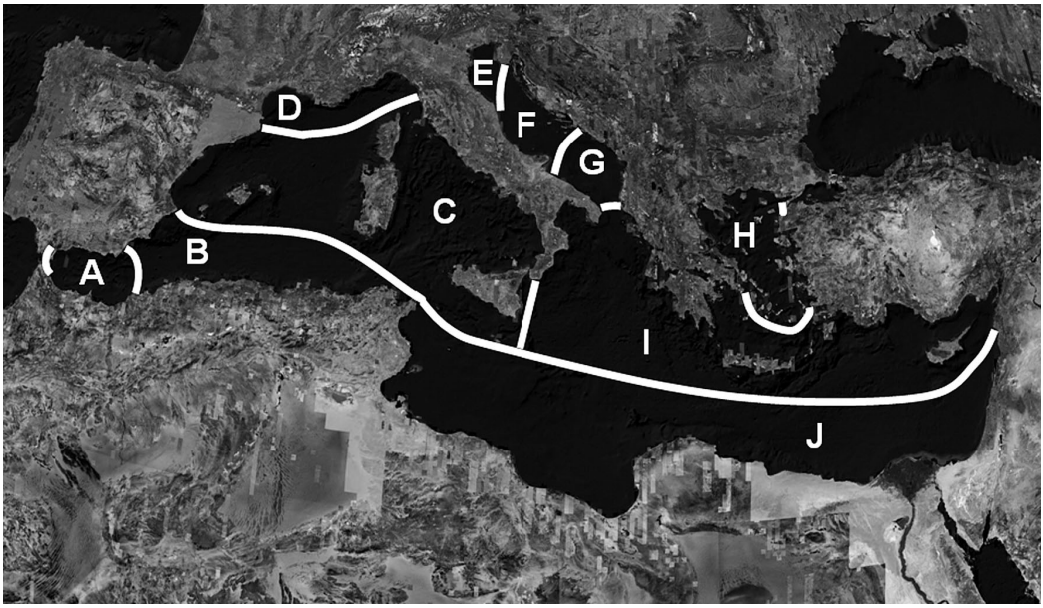

Figure 1: Biogeographical sectors of the Mediterranean Sea (according to Bianchi et Morri 2000). (A) Alboran Sea; (B) Algeria and southern Spain; (C) Balearic Sea to Tyrrhenian Sea; (D) Gulf of Lyon and Ligurian Sea; (E) North Adriatic; (F) Central Adriatic; (G) South Adriatic; (H) North Aegean; (I) Ionian Sea and South Aegean; (J) Gulf of Gabes to the Levant Sea.

Slika 1: Biogeografska območja Sredozemskega morja (po Bianchi in Morri 2000). (A) Alboransko morje; (B) Alžirija in južna Španija; (C) Balearsko območje in Tirensko morje; (D) Lyonski zaliv in Ligursko morje; (E) severni Jadran; (F) srednji Jadran; (G) južni Jadran; (H) severno Egejsko morje; (I) Jonsko in južno Egejsko morje; (J) Gabeški zaliv in Levantinsko območje.

2. MEDITERRANEAN HABITATS

The great number of habitats constitutes the basis of biological richness and the baseline of the benthic bionomics concept in the Mediterranean Sea (Peres et Picard 1964, Bellan-Santini et al. 1994, Relini 2000). These habitats are regularly used to evaluate sites of interest for conservation within the European framework (NATURA 2000), as well as for the Barcelona convention (UNEP-MAP-RAC/SPA 2002).

The Protocol concerning specially protected areas and biodiversity in the Mediterranean, adopted by the Contracting Parties of the Barcelona Convention in 1995, contains indications to prepare inventories at the national and regional levels (UNEP-MAP-RAC/SPA 1995). The Regional Activity Centre for Specially Protected Areas (RAC/SPA), in collaboration with Mediterranean experts, elaborated a reference list of species and habitat types, to select the sites to be included in national inventories, and a Standard Data Form (SDF) (UNEP-MAP-RAC/SPA 2002). From the technical point of view, the SDF is an adaptation of tools developed in the context of the European Union's NATURA 2000 and EMERAUDE networks of sites, to the specific Mediterranean features. With the objective of helping countries to identify and

assess these marine habitats, the RAC/SPA initiated the production of a handbook to interpret marine habitats (Bellan-Santini et al. 2002). Finally, 18 biocenosis and 55 facies (associations or ecomorphoses) were included on the reference list (Table 1).

Table 1: Reference list of biocenosis to select sites to be included in the national inventories
Tabela 1: Referenčni seznam biocenoz za izbiro lokalitet, primernih za vključitev v nacionalne inventarje

SUPRALITTORAL	Biocenosis of supralittoral sands
MEDIOLITTORAL	Biocenosis of muddy sands and muds
	Biocenosis of mediolittoral coarse detritic bottoms
	Biocenosis of the upper mediolittoral rock
	Biocenosis of the lower mediolittoral rock
INFRALITTORAL	Euryhaline and eurythermal biocenosis
	Biocenosis of well sorted fine sands
	Biocenosis of superficial muddy sands in sheltered waters
	Biocenosis of coarse sands and fine gravels mixed by the waves
	Biocenosis of coarse sands and fine gravels under the influence of bottom currents
	Posidonia oceanica meadows
	Biocenosis of infralittoral algae
CIRCALITTORAL	Biocenosis of muddy detritic bottom
	Coralligenous biocenosis
	Semi-dark caves
BATHYAL	Biocenosis of bathyal muds
	Biocenosis of deep sea corals
	Caves and ducts in total darkness

Moreover, among the eight action plans adopted by the Contracting Parties of the Barcelona Convention, two are devoted to key habitats: the "Action plan for the conservation of marine vegetation in the Mediterranean sea" and the "Action plan for the conservation of the coralligenous and other calcareous bio-concretions in the Mediterranean sea" (UNEP-MAP-RAC/SPA 2005, 2008).

The first action plan focuses on *Posidonia oceanica*, one of the five seagrasses present in the Mediterranean Sea. The meadows composed of this species are considered the basis of the Mediterranean coastal waters' richness due to the surface area they occupy (20-30% of the sea-floor between 0 and 50m depth) and owing to the essential part they play at the biological level in maintaining the coastal equilibrium and their concomitant economic activities (Boudouresque et al. 2006a). The role of *Posidonia oceanica* meadows in marine coastal environments is often correctly compared to that of a forest (Boudouresque et al. 2006b). Considerable data concerning the location of the main Posidonia meadows in the 18 countries is available, and an important number of natural monuments (barrier-reef, atolls) have been identified (Boudouresque et al. 1990). The actual challenge is (i) to ensure the conservation of this species (management, legal protection), (ii) to avoid loss and degradation of these meadows, and (iii) to ensure the conservation of marine vegetal assemblages that could be considered as natural monuments.

In the second action plan, coralligenous concretions are considered a typical Mediterranean underwater seascape comprising coralline algal frameworks that grow in dim light conditions and in relatively calm waters (Ballesteros 2006). Mediterranean maërl beds should be considered as sedimentary bottoms covered by a carpet of free-living calcareous algae (Corallinaceae or Peyssonneliaceae), which also develop in dim light conditions. Although there is an overall knowledge on the composition and distribution of coralligenous assemblages and maërl beds, there are also certain gaps in the existing knowledge. Concerning distribution, little data is available at small scale, data which would be important for an appropriate management of these structures. Regarding the composition of coralligenous and maërl assemblages, most of the information is based on data obtained in the northwestern Mediterranean, with some additional data collected in southern Italy and in the Alboran Sea, while other regions are poorly known. In order to improve this situation, the following actions are proposed: (i) to compile all existing information at all levels and scales on the distribution of coralligenous assemblages and maërl beds, and (ii) to conduct punctual field missions in potential places hosting extensive and mostly unknown coralligenous assemblages and maërl beds.

3. NORTHERN ADRIATIC HABITATS

The Adriatic Sea constitutes a particular biogeographical sector. It presents several specific characteristics: geographical situation (northernmost part of the Mediterranean Sea), coastal morphology (rocky in its eastern part with numerous islands, sandy with lagoons and estuaries in its western part) and bathymetry (low depth especially in the northern part). The Northern Adriatic also presents a relatively high tidal range (up to 1m), high temperature and salinity variations, wind-driven water circulation, important stratification of its water column, important nutrient discharges by rivers and high productivity (Stravisi 1983, Stachowitsch 1991). The human impact appears important in this region, given the intensive urbanization of the coastline.

These specific abiotic conditions, associated with high biological production, allow differentiation of a great number of key habitats (seagrass meadows, Cystoseira assemblage, coralligenous biocenosis), specific associations (*Fucus virsoides*), and a high biodiversity (nearly 2,000 animal species) (Lipej et al. 2006).

Seagrass meadows, located in lagoons (e.g. Venice lagoon) as well as in open sea, present a particular extension, where four of the five species present in the Mediterranean basin are identified. The presence of a relic of a Posidonia meadow (0.5 – 4.0 m depth) along the Slovenian coast indicates the presence of a much larger meadow in the past (identification of dead mattes at more than 10 m depth in the Gulf of Trieste). This northern Posidonia meadow, discovered recently, covers a surface of only 0.63 ha and appears to be threatened; its conservation represents a challenge for the future (Vukovič et Turk 1995, Makovec et Turk 2006).

Conversely, coralligenous biocoenosis, biogenous formations based on calcified algae (Peyssonelliaceae and Corallinaceae), appear less present due to the limited rocky substrate and the high sedimentation rate, at least in the northwestern part. As a rule, it is a precoralligenous

stage (Bellan-Santini et al., 2002) that is reported. These precoralligenous formations occur under the biocenosis of infralittoral algae (8 to 10 m depth), in areas where more or less large boulders prevail (Gamulin-Brida 1967). The facies with *Cladocora caespitosa*, a typical Mediterranean anthozoan, has also been observed in these areas.

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