The Status of Coastal Benthic Ecosystems in the Mediterranean Sea: Evidence from Ecological Indicators

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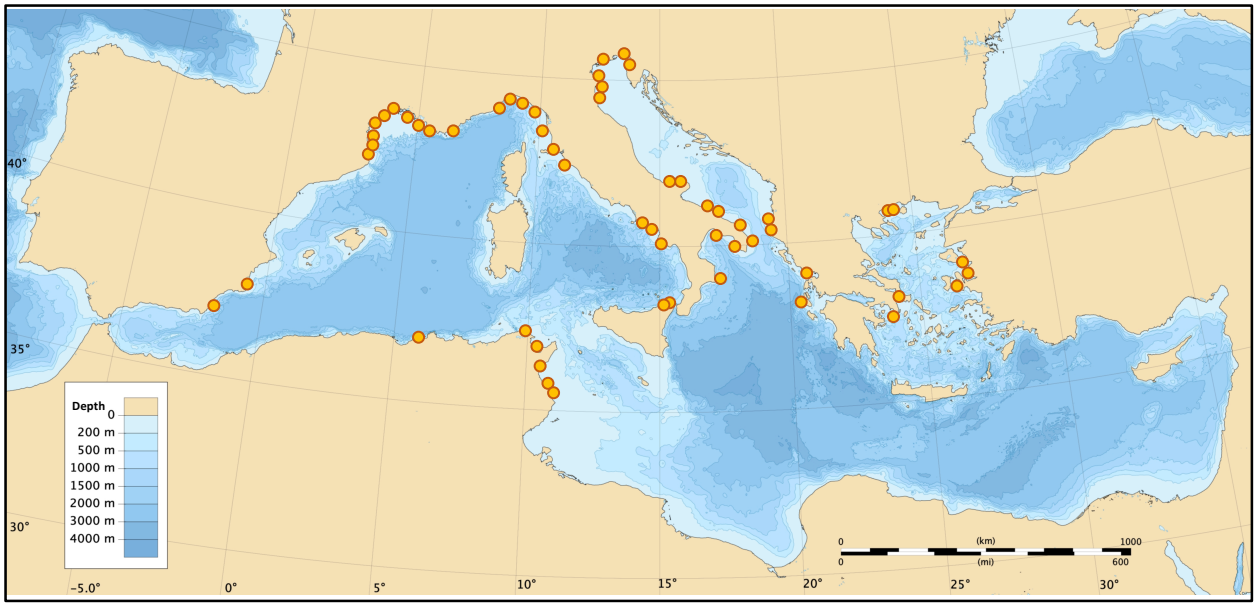
Supplementary material

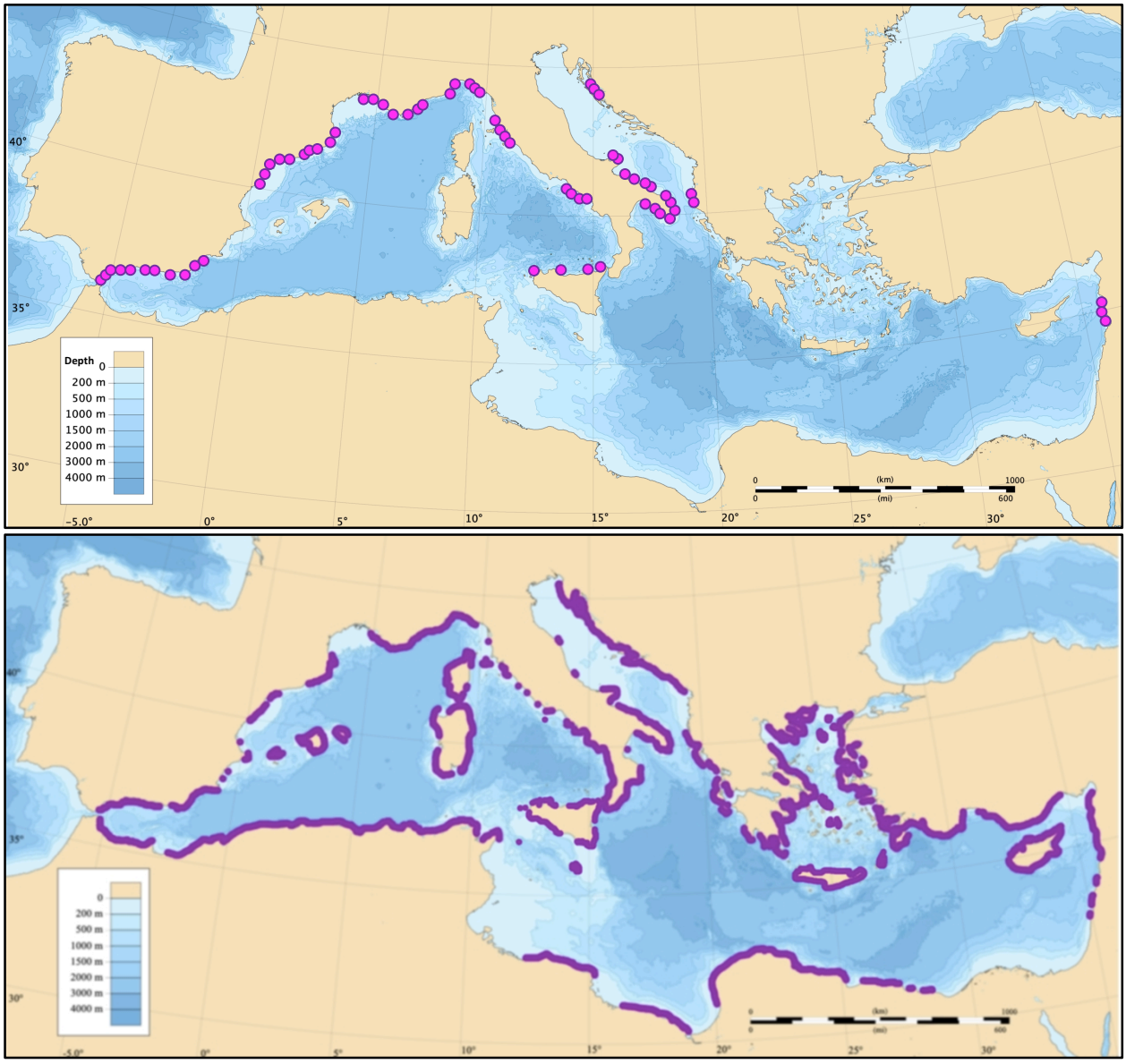
Appendix S1. Spatial distribution of sites.
Appendix S2. Details on calculation of ecological indicators and Ecological Quality Ratio (EQR).
Appendix S3. EQR data for the four investigated ecosystems (provided as a separated .xls file).

Appendix S1. Spatial distribution of sites.

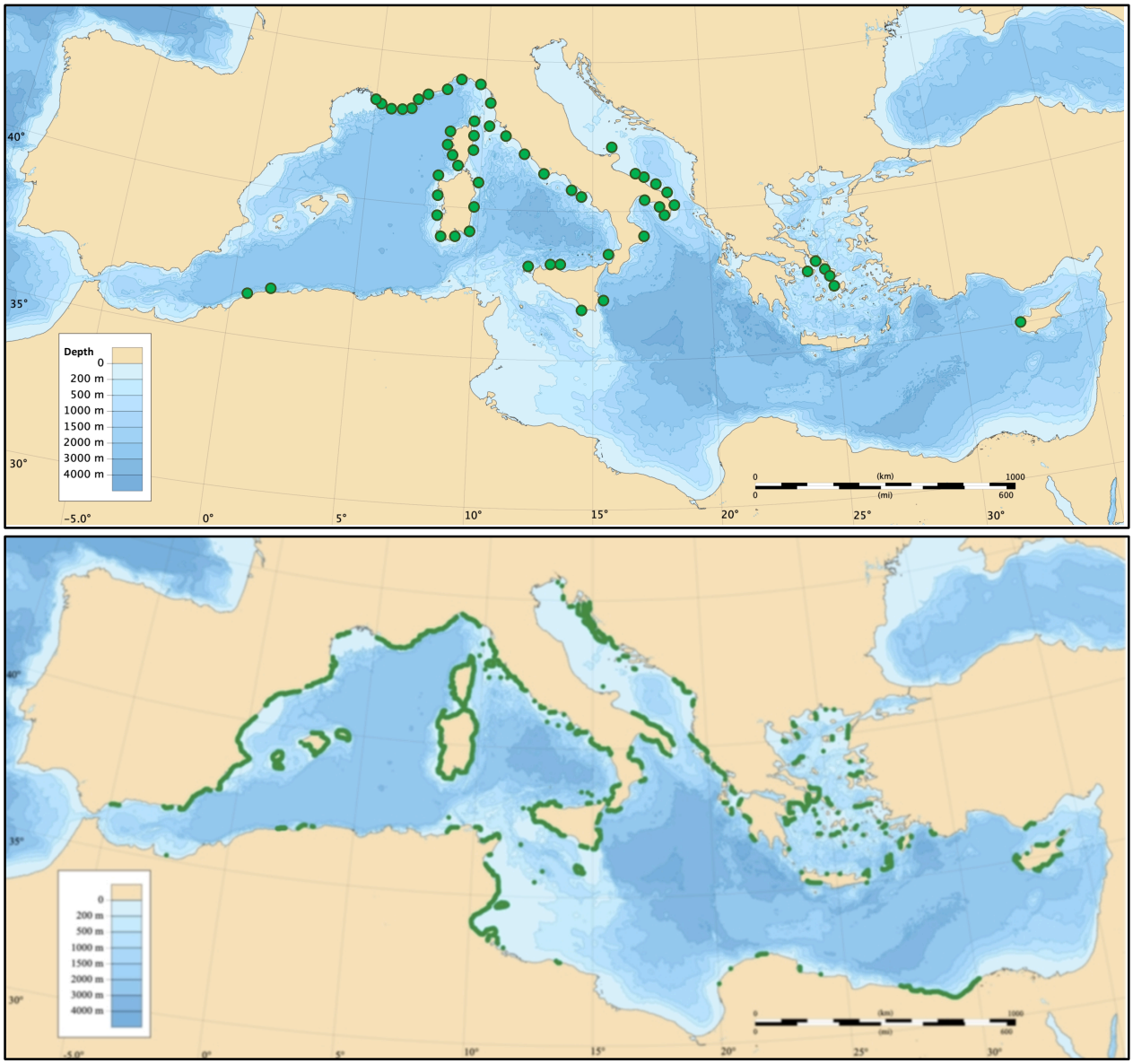
Note that each point on the map could comprise more than one site. Geographic coordinates of all sites were reported in Appendix S2. When not directly available in documents, latitude and longitude were derived approximately based on maps, location names and other geographic details found in the papers. For each habitat, the approximate distribution along the Mediterranean coasts is provided, except for coastal soft bottoms, since they are present in the infralittoral and/or circalittoral zones along almost the entire Mediterranean coast. Information contained here has been derived from data that is made available under the European Marine Observation Data Network (EMODnet) Seabed Habitats initiative (www.emodnet-seabedhabitats.eu), financed by the European Union under Regulation (EU) No 508/2014 of the European Parliament and of the Council of 15 May 2014 on the European Maritime and Fisheries Fund.



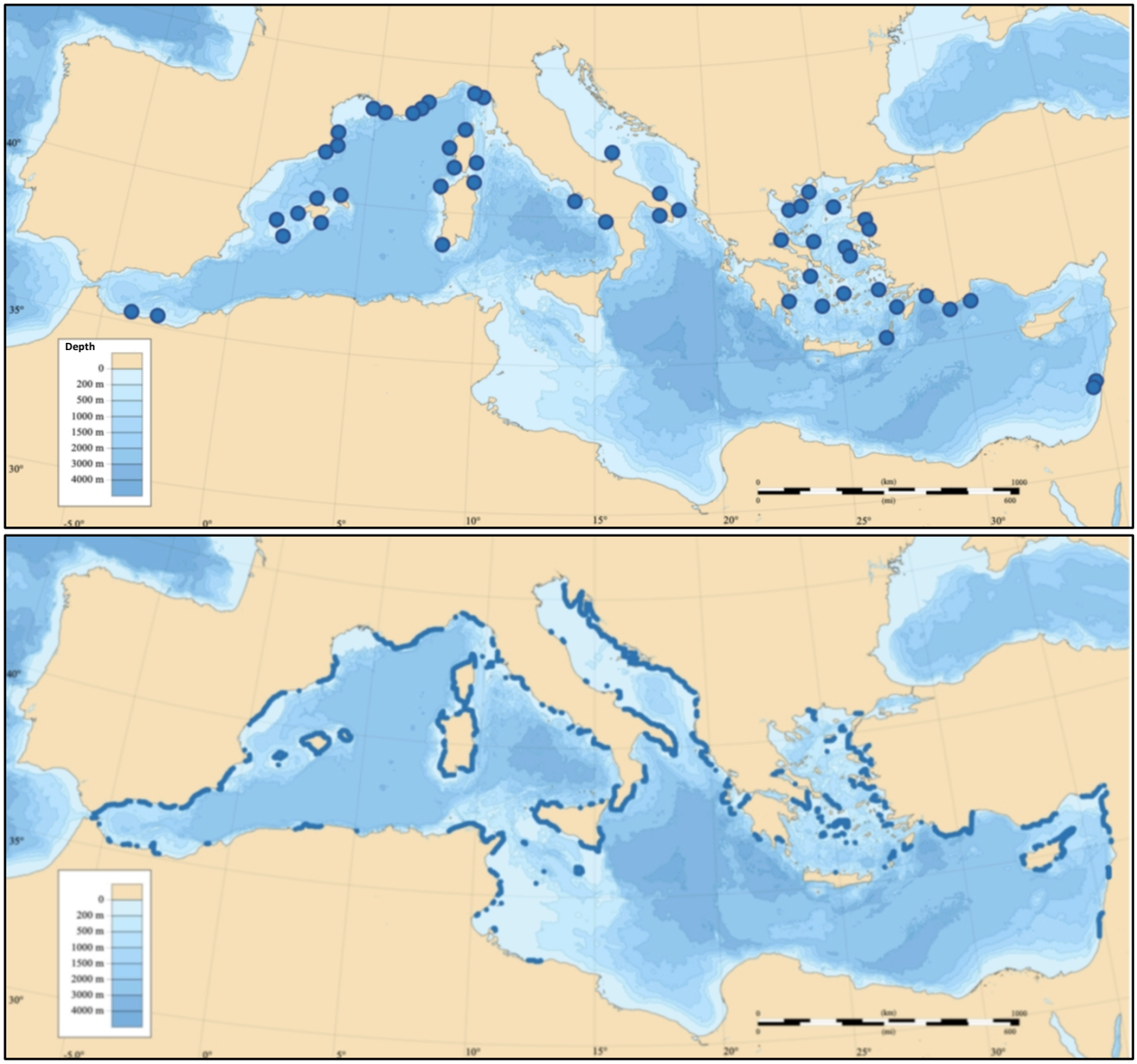
Map of sites with EQR for coastal soft bottoms quantified using M-AMBI.



Map of sites with EQR for intertidal rocky fringe quantified using CARLIT (upper panel) and approximate distribution of this habitat (lower panel) along the Mediterranean coast (modified from https://www.emodnet-seabedhabitats.eu).



Map of sites with EQR for *P. oceanica* beds quantified using PREI (upper panel) and approximate distribution of this habitat (lower panel) along the Mediterranean coast (from Telesca et al. 2015)



Map of sites with EQR for shallow rocky reefs quantified using reef-EBQI (upper panel) and approximate distribution of this habitat (lower panel) along the Mediterranean coast (modified from https://www.emodnet-seabedhabitats.eu).

Appendix S2. Details on calculation of ecological indicators and Ecological Quality Ratio (EQR).

M-AMBI

The Multivariate AMBI (M-AMBI) is an indicator used to define the ecological quality status of marine benthic communities, and specifically those inhabiting soft bottoms, including estuarine, coastal and lagoon soft substrates. It is based on integrating the response of three indices and, namely the AZTI's marine biotic index (AMBI, Borja and Muxika, 2005), species richness, and the Shannon-Wiener index. AMBI assigns a value to the status of benthic communities based on the species found and the proportion of species belonging to different groups according to their sensitivity-tolerance to degraded conditions. The values of the three indices are condensed and weighted depending on the type of the environment (from typically estuarine to coastal marine) (Muxica et al., 2007). Also, reference values for calculation of the EQR are set depending on the specific habitat type.

A total of 16 papers and 7 governmental reports were selected from the screening of the scientific literature and online governmental databases (see Appendix S2), searched from 2007 until 2019. Documents were selected if reporting data on actual assessments of the status of coastal soft bottoms communities using M-AMBI (Muxica et al., 2007) based on data collected after 2000. M-AMBI values provided in scientific publications and reports were directly inserted into the dataset. Documents providing values of AMBI, species richness, and *H'* were also considered and used to calculate M-AMBI values. Data on macrobenthic communities from Terlizzi et al. (2008) were also used to integrate the dataset. In such cases, values of M-AMBI were calculated using the AMBI V.5 software (www.ambi.azti.es). For calculation of the index, [AMBI = 1, *H'* = 4; SR = 40] and [AMBI = 6, *H'* = 0; SR = 0] were used as reference values for high and low limits respectively (Muxica et al., 2007; Ruellet and Dauvin, 2007).

Values for sites located < 1 km apart were averaged. Values from the same site obtained in different seasons were also averaged. When more than one year of assessment was available for the same site, the most recent evaluation was considered.

Ranges of EQR for M-AMBI (Borja et al., 2007):

<0.20 = bad
0.20-0.40 = poor
0.41-0.61 = moderate
0.62-0.82 = good
0.82-1.00 = high

CARLIT

The CARLIT index defines the status of the intertidal-upper subtidal fringe, and it is used especially for rocky shores (Ballesteros et al., 2007). It is based on the extension of different types of macroalgal communities along the coast, each of them weighted by a sensitivity score, which is maximum for canopy-forming algae (e.g., brown algae of the genus *Cystoseira*) and minimum for tolerant-opportunistic algae (e.g., green algae). The sum of weighted coast length for each community gives the index value, which is then standardized for reference conditions specific for a given region.

A total of 9 papers and 6 governmental reports were selected from the screening of the scientific literature and online governmental databases (see Appendix S2), searched from 2007 until 2019. Documents were selected if reporting data on actual assessments of the status of the rocky intertidal fringe using CARLIT (Ballesteros et al., 2007) based on data collected after 2000. CARLIT values provided in scientific publications and reports were directly inserted into the dataset. Data on some site in the south Tyrrhenian Sea (North Sicily) were added (Sarà, unpublished data).

Ranges of EQR for CARLIT (Ballesteros et al., 2007):

<0.25 = bad

>0.25-0.40 = poor
>0.40-0.60 = moderate
>0.60-0.75 = good
>0.75-1.00 = high

PREI

The *Posidonia oceanica* Rapid Easy Index (PREI; Gobert et al., 2009) considers five descriptors of the status of *P. ocenanica* meadows: (1) shoot density, (2) shoot surface, (3) E/L (ratio between epiphyte biomass and leaf biomass) measured on shoots sampled at the same depth; (4) depth of the lower limit and (5) type of this limit (regressive, progressive or stable). The index integrates the sampled value for each descriptor with reference values (min and max). Then, EQR is calculated standardizing the obtained integrated value with the maxim value of the index calibrated specifically for the geographic area of interest.

A total of 5 papers and 5 governmental reports were selected from the screening of the scientific literature and online governmental databases (see Appendix S2), searched from 2007 until 2019. Documents were selected if reporting data on actual assessments of the status of coastal soft bottoms communities using the PREI index (Gobert et al., 2007) based on data collected after 2000. PREI values provided in scientific publications and reports were directly inserted into the dataset.

Ranges of EQR for PREI (Gobert et al., 2009):
<0.100 = bad
0.100-0.324 = poor
0.325-0.549 = moderate
0.550-0.774 = good
0.775-1.000 = high

reef-EBQI

The Ecosystem Based Quality Index for rocky reefs (reef-EBQI; Thibaut et al., 2017) integrates 11 descriptors based on the abundance of 11 corresponding functional groups of organisms to assess the status of rocky reef ecosystems: (1) Primary producers (algae), (2) detritus feeders, (3) filter and suspension feeders, (4) sea urchins, (5) invertivorous invertebrates (e.g., *Octopus vulgaris*), (6) herbivorous fish, (7) omnivorous fish, (8) invertivorous fish, (9) piscivorous fish, (10) planktivorous fish, and (11) sea birds. Abundance of each groups (in term of cover, number, or biomass, depending on the group) is ranked in five categories, from 0 to 4, which correspond to bad to high conditions. Ranks are then summed and the values standardized for the maximum possible value to calculate the EQR.

A total of 2 papers were selected from the screening of the scientific literature (see Appendix S2), searched from 2007 until 2019. Documents were selected if reporting data on actual assessments of the status of subtidal rocky reefs communities using reef-EBQI (Thibaut et al., 2017) based on data collected after 2000. Reef-EBQI values provided in scientific publications were directly inserted into the dataset. Raw data on macrobenthic and fish communities of shallow subtidal rocky reefs from Bevilacqua et al. (2006), Fraschetti et al. (2012, 2013), Sala et al. (2012), Guarnieri et al. (2016), Rilov et al. (2018), Sini et al. (2019) and Katsanevakis S. et al. (unpublished data) were also used to calculate the index in additional sites. Lack of information on some ecosystem components was integrated by expert judgement, following Thibaut et al. (2017). The confidence index (CI), expressing the reliability of the reef-EBQI value, was in most cases >>0.70 (indicating a high reliability of evaluations).

Ranges of EQR for reef-EBQI (Thibaut et al., 2017):
<0.35 = bad
>0.35-0.45 = poor
>0.45-0.60 = moderate
>0.60-0.75 = good

>0.75-1.000 = high

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Appendix S3. EQR data for the four investigated ecosystems (provided as a separated .xls file).