Edited by

Peter T. Harris and Elaine Baker

SEAFLOOR GEOMORPHOLOGY AS BENTHIC HABITAT

GeoHab Atlas of Seafloor Geomorphic Features and Benthic Habitats

Second Edition

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SECOND EDITION

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Peter T. Harris

UNEP/GRID-Arendal, Arendal, Norway

Elaine Baker

UNEP/GRID-Arendal, School of Geoscience, University of Sydney, Sydney, NSW, Australia

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Fine-scale seabed habitats off Capri Island, southern Italy

C. Violante, M. De Lauro and E. Esposito

Insitute of Marine Science (ISMAR), National Research Council (CNR), Naples, Italy

Abstract

Capri Island is located in the southern sector of the Bay of Naples at the eastern margin of the Tyrrhenian basin off Campania, southern Italy. A seabed area of the northern submerged flank of the island covering $\sim 13\ km^2$ was mapped and sampled to characterize geomorphic features and benthic habitats at high resolution (1:5.000 scale). The investigated seabed includes the submerged areas near the island's coastal cliffs and the offshore zone, up to a depth of 150 m. Morphology and substrate composition of the seabed were characterized using swath bathymetry and sidescan sonar imagery integrated with grab sampling, SCUBA diving, and towed video inspections. The seabed in the study area was characterized by suboutcropping rocky (limestone) areas with thin (<2 m) sediment cover. Geomorphic features included ledge, slope, terrace, and plain. Benthic environments were dominated by coarse biogenic sediments and carbonate buildups made by encrusting organisms (coralligenous bioconstructions), with soft sediments (sandy mud) occurring in water depths of more than 100 m. Seafloor vegetation (*Posidonia oceanica*) was locally identified alongshore at depth ranging from 5 to 30 m.

Keywords: Insular shelf; coralligenous bioconstructions; biogenic sediments; multibeam sonar; sidescan sonar; *Posidonia oceanica*; Capri Island; Bay of Naples

Introduction

The study area is located on the northern, submerged flank of Capri Island in the Bay of Naples, southern Italy (Fig. 24.1). The island is almost completely bordered by high and steep rocky cliffs of structural control, with marine areas characterized by suboutcropping rocky substrate. The total surface of the survey area is $\sim 13\ km^2$, extending up to a distance of 2 km from the coastline. Seabed sediments are mainly coarse and biogenic in origin, with biogenic carbonate buildup (coralligenous bioconstructions) occurring widely (D'Argenio et al., 2004; De Lauro and Violante, 2015).

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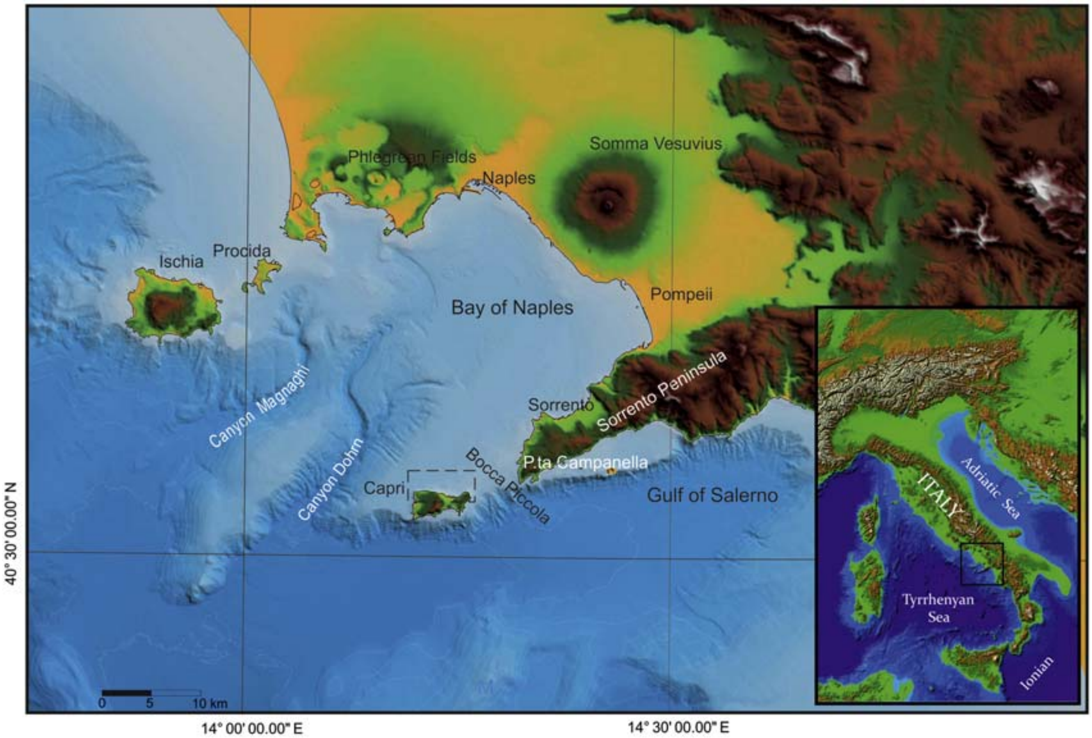

Figure 24.1
Location map of study area (dashed area) in the Bay of Naples, eastern Tyrrhenian margin, southern Italy.

Capri Island is set in front of the Punta Campanella promontory (Sorrento peninsula), separated by the Bocca Piccola passage, a narrow strait of water ~5 km wide and averaging 70 m in water depth. Through this passage the interior waters of the Bay of Naples are in direct communication with the neighboring basin of the Gulf of Salerno (Fig. 24.1). The island is composed mainly of Mesozoic limestone, tectonically uplifted since the lower Pleistocene (Brancaccio et al., 1991; Barattolo et al., 1992). A steep fault scarp (the Capri scarp) bounds Capri, Bocca Piccola, and Punta Campanella to the south, resulting in a very narrow continental shelf with erosional shelf break, while the northern Capri offshore slopes gently toward the Bay of Naples. Canyon catchment areas develop off Faraglioni and Punta Carena, located in the SE and SW corners of the island, respectively, directly connecting the coastal cliffs with the continental slope (Fig. 24.1) (D'Argenio et al., 2004).

Capri Island as well as the Bocca Piccola passage and the Punta Campanella promontory are characterized by highly dynamic marine environments. The surface circulation of this area is dominated by currents of the Tyrrhenian Sea with a marked barotropic component, which can drive the motion of the water masses inside the Bay of Naples along a prevailingly NW–SE direction (De Maio et al., 1985; Pierini and Simioli, 1998; Gravili et al., 2001). In addition, the presence of a strong current at the outer boundary of the bay may generate Tyrrhenian water masses that canalize through the Bocca Piccola passage forming a jet current oriented from SE to NW (Cianelli et al., 2013). The deeper circulation, instead, is directly influenced by the sudden decrease of water depth when approaching the study area due to the presence of the Capri scarp to the south and the Canyon Dohrn to the north (Fig. 24.1). As in the whole Mediterranean basin, tidal oscillations are typically quite small with amplitudes of the order of a few tens of centimeters. The tides in the Bay of Naples are mainly semidiurnal. The vertical excursions reach maximum values of ~40 cm during spring tide, while during neap tide oscillations are weaker.

The Capri Island benthic environment is exposed to high anthropogenic pressure due to maritime trafficking, fishing, laying of telecommunications cables, and recreational boat activities. In particular, human predation on date mussel *Lithophaga lithophaga* living in calcareous rocks significantly affected rock habitats off Capri and Sorrento peninsula. This mussel is actively collected by SCUBA divers who break the rocks with rock hammers and sledgehammers to expose the mollusks, causing the disappearance of the whole benthic community (Russo and Cicogna, 1992; Fanelli et al. 1994). Despite different pressures and impacts of anthropic stressors, the Capri Island coralligenous environments are considered to be in good condition (Ferrigno et al., 2017).

In February 2000 the insular shelf around Capri was mapped and sampled by IAMC-CNR Naples using the CNR research vessel Tethys (De Lauro et al., 2000). Swath bathymetry and backscatter data were collected using a 240 kHz Reson SeaBat multibeam and 100 kHz Klein sonar systems. Bathymetric data were gridded to a spatial resolution of 5 m (Fig. 24.2), while processing and mosaicking of the sidescan sonar records resulted in backscatter maps with submeter resolution (see Fig. 24.4). Surface sediment samples were collected by grab at 13 representative stations across the survey area (Fig. 24.3). Additional investigations including towed video inspections by Remote Operated Vehicle (ROV), sidescan sonar surveys, and scuba diving were carried out in 2014 from aboard the CNR research vessel Urania (Violante and De Lauro, 2014).

In this work part of the data set acquired around Capri has been used to characterize at high resolution (1:5.000 scale) the geomorphic features and benthic habitats of a selected seabed area of the northern submerged flank of the island. No statistical analyses have been carried out to analyze relationships between abiotic surrogates and benthos.

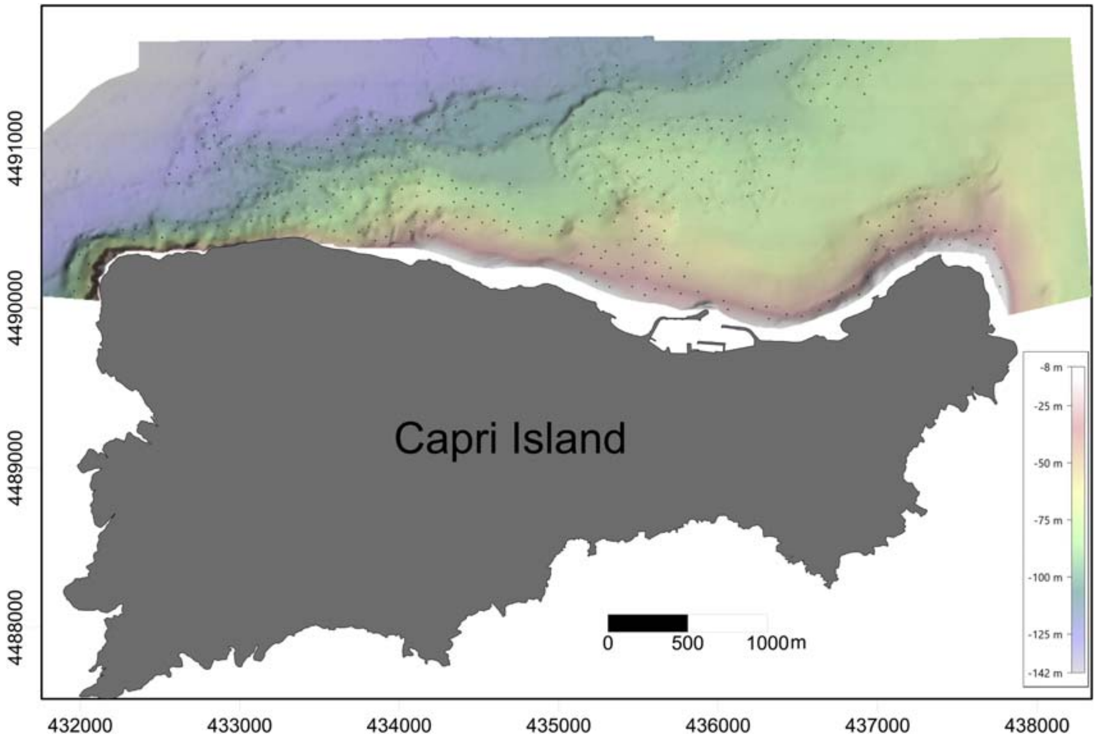

Figure 24.2
Multibeam sonar bathymetric map of northern Capri offshore based on a 5 m grid with indication of suboutcropping rocky areas (dotted areas).

Geomorphic features and habitats

Geomorphic features off Capri are strongly conditioned by suboutcropping rocky areas (Fig. 24.2). Within the study area, the topographic relief associated with suboutcropping calcareous rocks is on the scale of several meters with the main geomorphic features broadly oriented parallel to the coastline (E–W). The slope gradient is 3.5 degrees on average, locally approaching to subvertical along the coastline. Based on observed differences in seafloor morphology (e.g., slope, structure, complexity) geomorphic features were identified and classified (Fig. 24.3).

Grain size properties of the 13 sediment samples were determined by sieve separation of the gravel, sand, and mud fractions and by laser granulometry on the combined mud and sand fractions, using a Sympatec analyzer. Sandy biogenic sediments constitute the dominant sediment fraction in the survey area (72.61%), composed mostly of skeletal grains and bioclastic material (80%). Six of the collected samples were classified as coarse sand with gravels, three as coarse sand, two as muddy sand, one as fine sand, and two as sandy

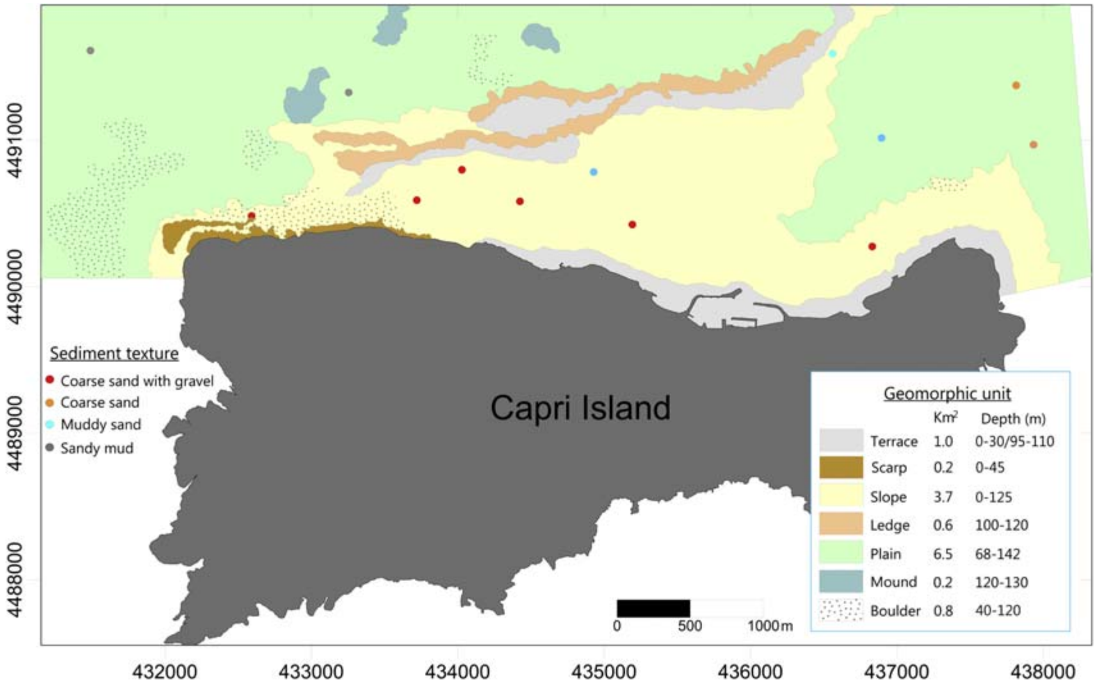

Figure 24.3
Geomorphic features of the study area, with surface areas and water depth ranges indicated. Texture of surface sediments at sample stations is also shown.

mud. The overall mud fraction is 12.3%. Gravel-dominated sediment occurs mostly along the coast at the base of calcareous cliffs. However, very coarse sand and gravel are very common up to a depth 100 m.

Seabed textures were assessed based on backscatter data supported by grab samples. Ten acoustic facies have been recognized and classified in the survey area (Fig. 24.4). Five acoustic facies are associated with sediment grain size, one corresponds to hard substrata, two relate to biological features (carbonate buildups and seafloor vegetation), and one is associated with landslide blocks. Substrate features aided by benthic community data from video and scuba inspections were combined with geomorphic features by Geographic Information System (GIS) overlay analysis to discriminate benthic habitats of the study area that are described below (Fig. 24.5 and Table 24.1).

Plains: These cover 6.5 km^2 in water depth ranging from 60 to 150 m with average gradients nearly reaching 1 degree. The northwest sector of the survey area (4.2 km^2) is occupied by a plain composed of sandy mud in water depths of more than 100 m (Fig. 24.4A). The northeast sector is also occupied by plains that are characterized by suboutcropping rocky areas mantled both by thin (<2 m) veneers of coarse biogenic sand (1.3 km^2) and muddy biogenic sand [1.0 km^2 (Fig. 24.4B)].

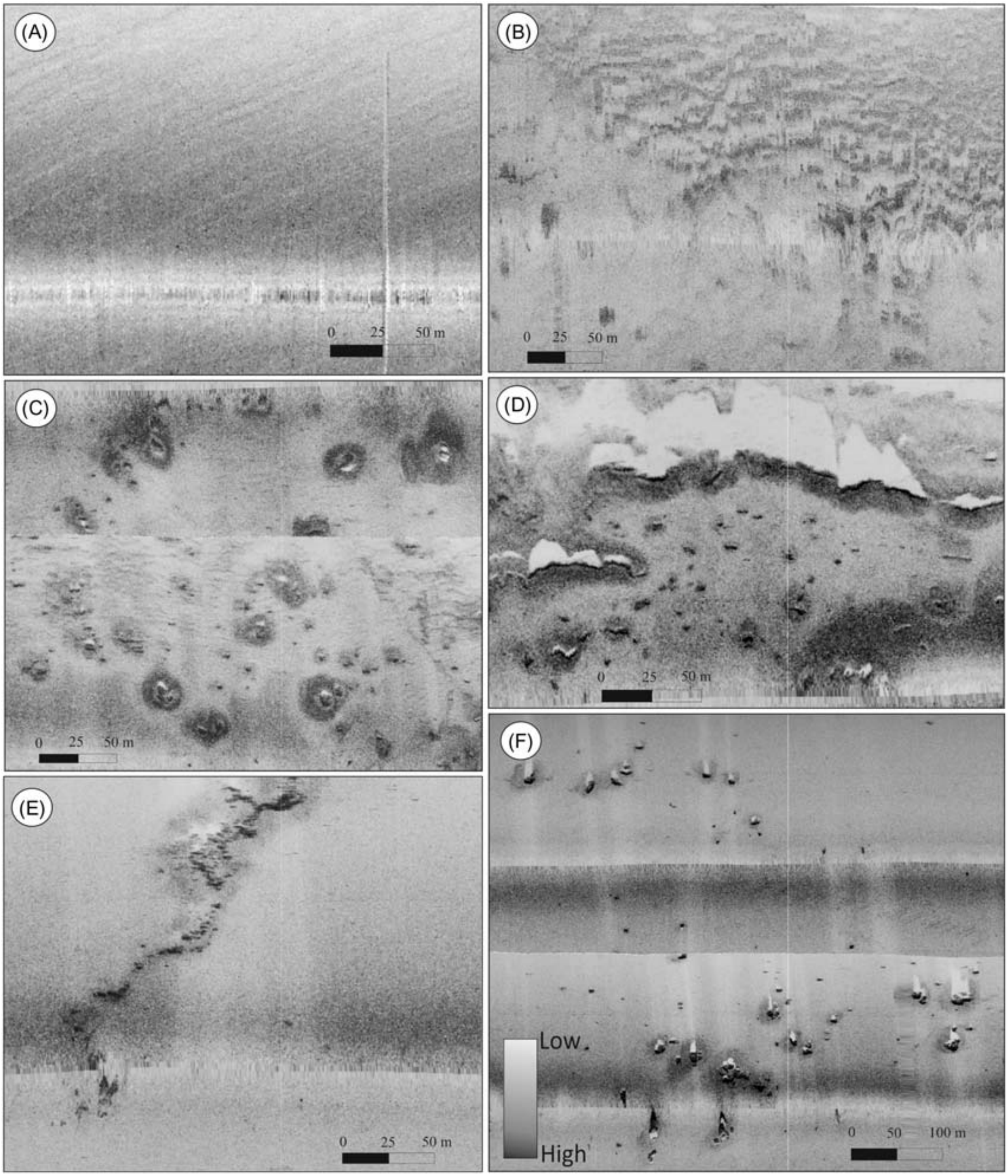

Figure 24.4

Main acoustic facies identified off Capri Island. (A) Sandy mud with current lineations. (B) Biogenic coarse sand (high and irregular backscatter; top right) gradually passing into muddy detritic sediments. (C) Subcircular biogenic buildups (acoustic shadows) surrounded by coarse organogenic sediments (high backscatter values). (D) Narrow elongated areas with coralligenous bioconstructions (high backscatter values and acoustic shadows) on muddy detritic substrate. (E) Elongated areas with high backscatter values (biogenic buildups) on muddy substrate (low and homogeneous backscatter area). (F) Sparse boulders (acoustic shadows) colonized by coralligenous on muddy substrate (low and homogeneous backscatter area).

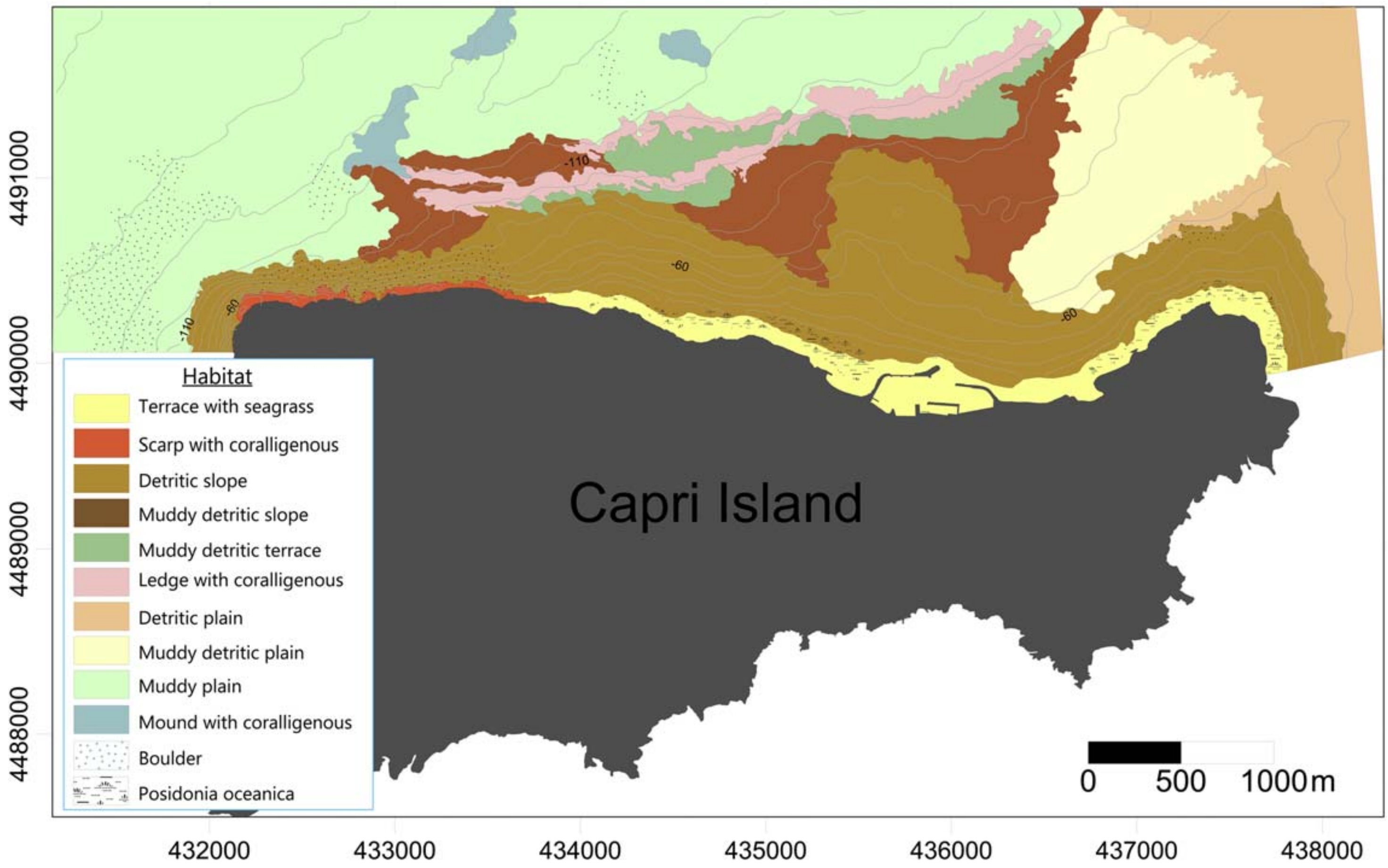

Figure 24.5
Map of the benthic habitats of northern submerged flank of the Capri Island.

Table 24.1: Benthic habitats identified off Capri Island.

Geomorphic unit	Substrate	Dominant biota	Habitat
Terrace	Rock with thin sandy gravel	Posidonia oceanica	Terrace with seagrass
Scarp	Rock	Coralligenous	Scarp with coralligenous
Dipping slope	Detritic (coarse biogenic)	Coralligenous	Detritic slope
Gentle slope	Muddy detritic	Coralligenous	Muddy detritic slope
Terrace	Muddy detritic	Soft corals and Coralligenous	Muddy detritic Terrace
Ledge	Rocky bedding planes with thin muddy detritic	Coralligenous	Ledge with coralligenous
Plain	Detritic (coarse biogenic)	Rhodoliths	Detritic plain
Plain	Muddy detritic	Fossorious organisms	Muddy detritic plain
Plain	Sandy mud	Fossorious organisms	Muddy plain
Mound	Mud	Coralligenous and fossorious organisms	Mound with coralligenous
Boulder field	Rock	Coralligenous	Boulder

Slopes: Slopes cover 3.7 km^2 of the survey area, from the base of the Capri coastal cliffs up to a depth of ~100 m. In this area, gradients range from 30 degrees near the coastal cliffs to 3.5 degrees in the distal areas. Seabed composition is characterized by coarse biogenic sand with a fine gravel fraction locally reaching 20%, with a higher mud fraction in water depths of more than 80 m. In its middle and lower parts, the slope is characterized by numerous subcircular mounds ranging from a few to 25 m in diameter corresponding to coralligenous bioconstructions (Fig. 24.4C).

Scarps: These are subvertical hard bottoms that cover 0.2 km^2 at the base of the coastal cliffs in water depth ranging from 0 to ~100 m (see Fig. 24.6A).

Ledges: These form narrow, E–W elongated features that cover 0.6 km^2 in water depth ranging from 100 to 120 m. Ledges correspond either to suboutcropping bedding planes or to the lower curved margin of ancient landslide deposits colonized by coralligenous bioconstructions (Fig. 24.4D). They vary from ~ 6 m to more than 20 m in height with gradients of 4–20 degrees.

Terraces: In the nearshore area wave-cut terraces with slightly convex slopes of <5 degrees are present at the base of coastal cliffs up to a depth of ~30 m. These are narrow structures that cover 0.5 km^2 characterized by a thin (<2 m) sediment cover of gravel and very coarse sand with patches of *Posidonia oceanica* (Fig. 24.6G). Nearly flat, slightly

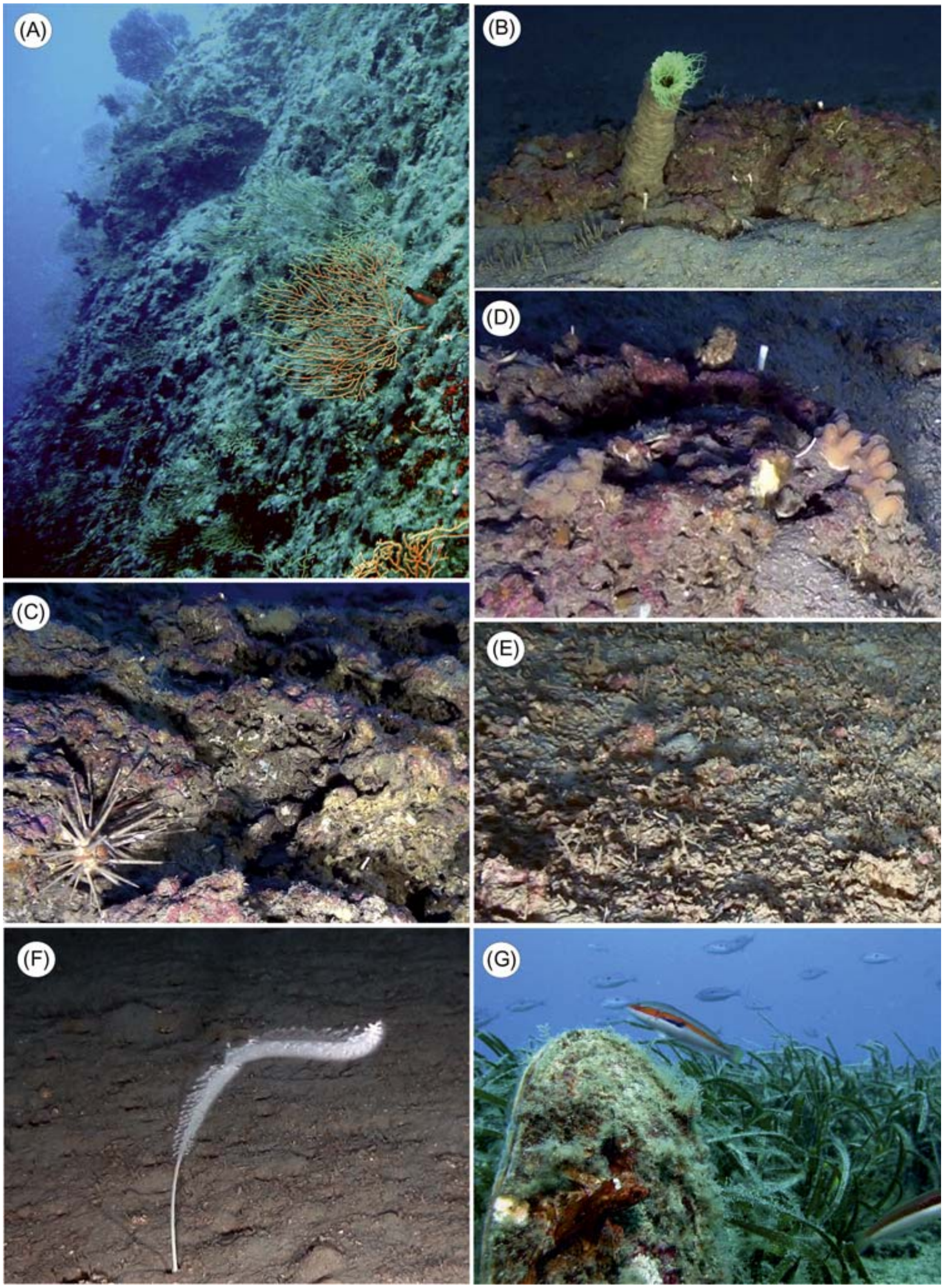

Figure 24.6

Some benthic assemblages inhabiting the Capri nearshore and offshore areas. (A) Coralligenous incrustation on subvertical scarp dominated by fan corals (gorgonians from the genus *Eunicella*). (B) Coralligenous bioconstruction inhabited by big suspension feeders (serpulids), pencil urchins (C), and corals (D). (E) Detritic bottom dominated by Rhodoliths. (F) Muddy bottom with bioturbation marks inhabited by pivotant soft corals (*Pennatulacea*). (G) *Posidonia oceanica* meadows colonized by fan mussels of the species *Pinna nobilis*.

concave, terraces also occupy 0.5 km^2 behind ledges in 95–110 m water depth. Here the seabed is composed of muddy detritic sediments with sparse mound-shaped bioconstructions reaching 10 m in diameter (Fig. 24.4D).

Mounds: Low relief elongated mounds resulting from suboutcropping calcareous rocks cover 0.2 km^2 at a depth of 120/130 m. In these areas seabed composition is characterized by sandy mud with elongated coralligenous bioconstructions (Fig. 24.4E).

Boulder fields: Metric and plurimetric rocky boulders resulting from cliff recession are scattered on the seabed up to distances of several hundred meters from the coast (Fig. 24.4F). They cover 0.8 km^2 in water depth ranging from 40 to 120 m and are mostly colonized by coralligenous bioconstructions.

Biological communities

The geologic configuration of the study area gave rise to benthic environments that are characterized by a very high biological productivity. Seabed assemblages are dominated by carbonate biogenic buildups (coralligenous bioconstructions) and coarse biogenic sediments (coastal detritic; Pérès and Picard, 1964) with crustose coralline algae and suspension feeder species including fan corals, bryozoans, and serpulids being the dominant biota (Fig. 24.6).

Coralligenous bioconstructions are important refugia and biodiversity hotspots for many organisms, attracting several invertebrate and fish species (Cerrano et al., 2010; Braga and Aguirre, 2004). They are made of encrusting calcified rhodophyta (see Fig. 24.6C and D) under conditions of uniform salinity, clean water, and high hydrodynamics (Ballesteros, 2006; Bo et al., 2015). In the study area three different types of coralligenous bioconstructions are found: (1) protuberances and concretions along subvertical rocky cliffs, dominated by fan corals (gorgonians from the genus *Eunicella*) and encrusting sponges (Fig. 24.6A); (2) mound-shaped buildups growing on both boulders and outcropping/ suboutcropping rocky areas along slopes, which are dominated by suspension feeders (predominantly bryozoans, polychaetes and serpulids (Fig. 24.6B); and (3) biogenic banks on ledges and mounds, inhabited by pencil urchins, corals, and sponges (Fig. 24.6C and D). All these structures are surrounded by very coarse biogenic sediments derived from their dismantling (see Fig. 24.4C and D).

Plains and slopes in water depths of <80 m are characterized by detritic bottoms made of calcareous skeletons of benthic organisms such as mollusks, bryozoans, cnidarians, echinoderms, and macroalgae that comprise up to 85% of the sediment grains. Here free-living colonies of crustose coralline algae from the genus *Lithophyllum* (rhodoliths) are the dominant biota (Fig. 24.6E). Muddy sediment fractions significantly increase on the lower sectors of the slope (water depths of more than 80–90 m) and in less exposed plain sectors (muddy detritic bottoms). These areas are dominated by filter-feeding organisms such as pivotant soft corals (*Pennatulacea*; Fig. 24.6F) and serpulids. Muddy plains that are in water depth of more than 100 m are characterized by bioturbation marks (mostly burrows and mounds) produced by fossorious organisms including echinoderms, worms, mollusks, and crustaceans. In the nearshore area, terraces covered (or draped) with sandy gravel sediment are habitats for discontinuous patches of the marine phanerogam *P. oceanica* locally colonized by the fan mussel *Pinna nobilis* (Fig. 24.6G), down to a depth of more than 30 m.

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