

Effects of Unplanned Development on Marine Biodiversity: A Lesson from Albania (Central Mediterranean Sea)

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ABSTRACT

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Human activities determine dramatic changes in natural systems, especially in marine coastal areas. This is especially true when economic development is fast and scarcely regulated, representing a serious threat to biodiversity. Besides the obvious prediction of impairment of natural systems, forecasting the effects of human activities can be particularly challenging since they affect species and assemblages, the patterns of distribution and extent of which are often totally unknown. In Vlora Bay, we show through an interdisciplinary project that 15 y of coastal development can result in a loss of over 50% of seagrass cover and a decline in macroalgae cover such as *Cystoseira* spp., which are structurally and functionally crucial habitats that provide essential goods and services for local human communities and recreation. Furthermore, illegal fishery practices (date mussel fishery, trawling, and use of explosives) contribute to depict a scenario of fragmentation and loss of shallow species-rich assemblages. Large-scale changes in sedimentation patterns have been recognised as one of the main drivers of those changes. This model of development, associated with nearly irreversible environmental consequences, as observed in Albania, can serve as an example for many other Mediterranean areas, showing a combination of high biodiversity and low protection regime. We discuss the urgent need for ecosystem-based management to ensure sustainable development while conserving and managing natural biodiversity and resources.

ADDITIONAL INDEX WORDS: *Biodiversity, habitat mapping, habitat fragmentation, human impacts, rocky assemblages, Cystoseira, Posidonia oceanica, Albania.*

INTRODUCTION

Coastal communities are under increasing pressure from multiple stressors determining habitat loss and risks of ecosystem change (Halpern *et al.*, 2008; Hoegh-Guldberg *et al.*, 2007; Lotze *et al.*, 2006), the magnitude of which is difficult to predict (de Young *et al.*, 2008). The implications of these processes, however, are obvious: human impacts lead to decreasing diversity and complexity of biogenic habitat structure, as well as decreases in the size of organisms (Airoldi, Balata, and Beck, 2008; Beck *et al.*, 2009). The causes of these changes are often only partly known, making policies of environmental restoration difficult (Hooper *et al.*, 2005).

Marine and coastal ecosystems provide crucial goods and services that support communities and economies, including food security, recreational opportunities, and other benefits (Boero and Bonsdorff, 2007; Sala *et al.*, 2008). Effective

environmental management and protection help maintain high productivity and high diversity in marine systems, safeguarding social and economic development. Management tools, such as ecosystem-based management, fishery reserves, and Marine Protected Areas (MPAs), are cornerstones of marine conservation (Christie, White, and Deguit, 2002; Cicin-Sain and Belfiore, 2005).

The Mediterranean Sea is considered a hotspot of biodiversity (Bianchi and Morri, 2000; Maiorano, Falcucci, and Boitani, 2006; Shi *et al.*, 2005), but it is also dramatically threatened by human disturbances (Boero, 2003; Frascchetti *et al.*, 2009; Myers *et al.*, 2000). Aquaculture, fish-trawling, chemical pollution, and sewage discharges are the most common sources of human impacts that affect biodiversity and the good and services it provides at regional scales. Uncoordinated development together with poor management of the effects of modification and destruction of marine and coastal habitats are major issues, resulting in overexploitation and habitat degradation (EEA, 2006).

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Within the Mediterranean area, especially in the eastern basin, some regions are less affected by human activities, even though, in most cases, the lack of quantitative information on spatial and temporal variations of their biodiversity and of floro-faunistic inventories might raise expectations about the presence of pristine environments that might not be present anymore. Poor historical baseline data prevent impact assessment and restoration practices (Bulleri, Underwood, and Benedetti-Cecchi, 2007).

Albania, in the western part of the Balkan Peninsula, has about 427 km of coastline facing the Adriatic and Ionian Seas. There are approximately 3.5 million inhabitants, 46% of whom live in urban areas. The coastal area of Albania is one of the hottest spots of biodiversity in the Mediterranean Sea (NEA, 1999). The coastal landscape is highly heterogeneous, including lagoons, wetlands, sand dunes, river deltas, and hydrophilous and hygrophilous forests.

In the last 10 to 15 y, Albania has undergone profound changes, almost without peer among other transition economies. The effects of such transformation have become very visible in terms of spatial distribution of human activities, and in the living condition of the people in urban areas, especially for those areas growing rapidly (World Bank, 2007). In 2001, about 55% of the Albanian population lived in the lowlands near the coast; this number reached 60% in 2008 (Table 1a, Figure 1A). This trend created favourable conditions for high land speculation due to a general lack of appropriate planning instruments and development control measures. Since 1991, many efforts have been devoted to face environmental problems, with the constitution of the Committee of Environmental Protection (KMM), transformed as the National Environmental Agency (NEA/AKM) in 1998, and finally as the Ministry of Environment in 2001 (*e.g.*, The National Action Plan on Environment, approved in 1993; The Law on Environment Protection, approved in 1993 and amended in 1998; The National Strategy and Action Plan of Biodiversity, approved in 2000). Unfortunately, the enforcement of existing legislation is often lacking because of inexperience, low awareness, or inadequate staff of governmental bodies (Cullaj *et al.*, 2005). Furthermore, as opposed to many Mediterranean regions that are increasingly investing in Marine Protected Areas as efficient conservation tools within a framework of an ecosystem-based management, Albania still lacks a management plan for the protection of its coast (Abdulla *et al.*, 2008).

At the same time, this region received scarce attention from the scientific community, with an ensuing lack of quantitative information about patterns of distribution of key species and habitat types before urbanization, industry, water pollution, soil erosion, fishing, and tourism significantly affected the condition of the Albanian coast. The consequence is that a structured framework of scientific literature on patterns of distribution and change of marine biodiversity in this area of the Mediterranean is lacking, or very limited to locally available grey literature. A literature search of the keyword: "Albania" in combination with "marine," "diversity," "benthic," and "habitat" on the Web of Science database provided only a few papers, mostly related

Table 1a. List of social indicators, population and density (in brackets; persons/km²), representing the potential human pressure on coastal marine habitats. Bold highlights data discussed in the text.

Municipality	2001	2008
Berat	193,020 [107]	172,694 [96]
Diber	189,854 [73]	143,341 [55]
Durres	245,179 [474]	314,862 [456]
Elbasan	362,736 [35]	349,530 [32]
Fier	382,544 [140]	379,221 [138]
Gjirokastrer	112,831 [39]	102,990 [26]
Korce	265,182 [43]	260,890 [43]
Kukes	111,393 [103]	75,746 [133]
Lezhe	159,182 [236]	160,752 [234]
Shkoder	256,473 [72]	249,982 [70]
Tirane	597,899 [71]	811,388 [491]
Vlora	192,982 [71]	148,651 [55]
Total	3,069,275 [107]	3,170,048 [110]
Total population living in coastal areas (%)	55	60

Table 1b. List of economic indicators, (I) harbours and vessels[†] and (II) fish production[‡], representing the potential human pressure on coastal marine habitats. Bold highlights data discussed in the text.

(I) Harbour	Vessels by Type of Fishing			
	Inshore	Purse Seiners	Trawl	Total (%)
Durres	13	1	84	98 (46)
Sarande	20	0	4	24 (11)
Shengjin	8	1	19	28 (13)
Vlora	24	4	33	61 (29)
Total	65	6	140	
Total % by type of fishing	31	3	66	
Parameters				
(II) Fish Production	2001	2007	Temporal Variation (%)	
Fishing activities (catch, tons)				
Marine	1466	1974	35	
Coastline	116	473	308	
Total marine catch	1582	2447	55	
Coastal lagoon	240	295	23	
Inland waters	1588	2145	35	
Total catch	1828	2440	33	
Aquaculture (production, tons)				
Aquaculture	35	1430	3986	
<i>Mitylus galloprovincialis</i>	150	1041	594	
Total production	185	2471	1236	
Sea cage aquaculture (surface used, m ²)				
Vlora Bay	2500[§]	6506^{**}	160	
Total surface	8000 [§]	12,023 ^{**}	50	

[†] Source: INSTAT (2006, 2008) database (www.instat.gov.al).

[‡] Source: MEFWA (2004).

[§] Source: MEFWA (2004).(www.instat.gov.al).

[§] Source: FAO (2005).

^{**} Estimates by mean of Google Earth maps prospection.

to phytoplankton (Saracino and Rubino, 2006; Vadrucci *et al.*, 2008).

This study represents a first attempt to summarise the potential causes of impacts on the coastal Albanian coast and

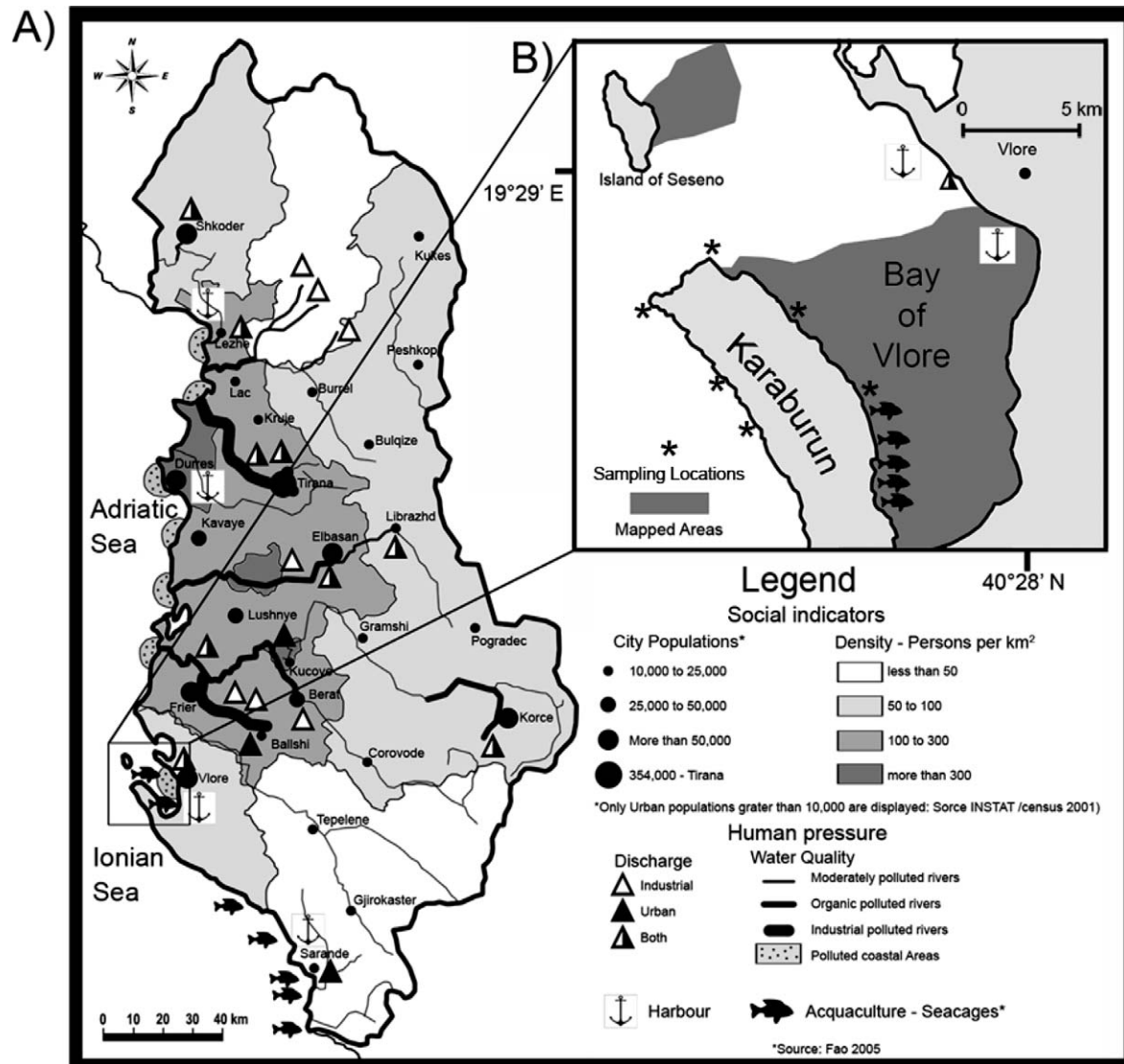


Figure 1. (A) Map of the principal social and economic indicators of Albania, indicating the main polluted sites, principal demographic pattern (INSTAT), and the distribution of the main infrastructures potentially affecting marine habitats, drawn modified from UNEP (2000) and Cullaj *et al.* (2005). (B) Close-up of the study area (mapped area and sampling locations) with the distribution of the main sources of human disturbance potentially affecting coastal assemblages.

to provide quantitative information on the distribution of coastal benthic habitats and assemblages in Vlora Bay (Albania), where a very fast but also totally unregulated economic development represents a potential threat to marine biodiversity. Reefs, *Posidonia* meadows, and *Cystoseira* canopy-forming species on coastal rocky shores invariably appear in lists of priority habitats (EU Habitat Directive), but, in spite of this high consideration, they are at risk on a global scale (Beck *et al.*, 2009; Gorman, Russell, and Connell, 2009; Waycott *et al.*, 2009). Here, we specifically focus on rocky coastal assemblages and seagrass meadows, which are considered among the most diverse and productive systems in the marine environment (Ballesteros, 2006; Witman, and Dayton, 2001). In this study, we used a combination

of different approaches: habitat mapping to describe the presence and extension of priority habitats and assemblages inside the bay between 0 and 30 m depth, and a quantitative analysis of the spatial distribution of benthos at 5 m depth in six locations inside and outside the bay.

MATERIALS AND METHODS

Study Area: Vlora Bay

The town of Vlora (40°28' N, 19°28' E) is one of the most ancient cities in Albania. It is the second largest port (for commercial and fishery) of the country and one of the most attractive tourist centres in the eastern part of the Mediter-

raean Sea (see Table 1, Figure 1B). Resident population is about 150,000 people (INSTAT, 2008), and, presently, the most important economic activities are based on tourism (about 2 million people in 2008).

Habitat Mapping

Benthic habitats were investigated in May 2007, as part of the CISM project (Centro Internazionale di Scienze del Mare, Interreg II, Italia-Albania; CoNISM, 2008). Overall, more than 1160 data points were registered along 28 continuous line transects (approximately 2 per km of coastline) to assess the presence of different habitats and assemblages from the surface to 30 m depth (Figure 1B). For each data point, depths were recorded by continuous data registration with a digital echo sounder and a differential global positioning system (GPS) identified geographic coordinates. Free divers (often using underwater scooters) performed the data acquisition at each point. For a better characterisation of the distribution of benthic habitats and assemblages and a more precise definition of the map, the number of transects was occasionally increased in case of sharp discontinuities (in terms of substrate morphology). Identification of habitats was based on the features that create structural complexity, such as plants (*e.g.*, seagrass meadows), animals (bioconstructors), or geological features (rocky reefs, sandy substrate) (Fraschetti, Terlizzi, and Boero, 2008). Habitats were defined following the indications by the Regional Activities Center for Specially Protected Areas (RAC/SPA, 2006) and the classification of Mediterranean benthic marine habitat types, as recently revised by Fraschetti, Terlizzi, and Boero (2008). ArcGis 8.1 was used for distribution maps of benthic habitats. The georeferencing was provided according to the UTM-WGS 84 (Italian national grid) coordinate system. The area of each habitat was calculated using ArcGis 8.1, combining data from bathymetry and habitat mapping. Data were also taken to evaluate the presence of impacts, (*e.g.*, alteration of sedimentary regime, destructive fishery, human pressures, coastal development) on rocky bottom benthic assemblages. The result is a map of benthic marine habitats of this area from 0 to 30 m depth.

Spatial Patterns of Benthic Assemblages

In addition to habitat mapping, photographic samples were collected in order to quantify spatial patterns and diversity of assemblages in exposure *vs.* open coasts of Karaburun Peninsula (Figure 1B). For each of the two levels of exposure, samples were undertaken in three locations, and three sites (separated by 50–100 m) were selected randomly within each location. The sampled locations were randomly selected from a set of possible locations separated by at least 3 km and characterised by similar environmental features (in terms of slope, type of substrate, and wave exposure). The experimental design consisted therefore of three factors: exposure (Ex, 2 levels, fixed), location (Lo, 3 levels, random), and site (Si, 3 levels, random and nested in location and exposure), with $n = 10$ replicates yielding a total of 180 photographic samples.

The assemblages were sampled photographically at 5 m depth. Photographs were taken with a Nikonos V underwater camera, 28 mm focal length, close-up macro system and two SB 105-Nikon strobes. In order to prevent potential problems due to loss of observation units, 13 randomly located surfaces of 16×23 cm were photographed in each site, and a random subset of 10 of these was used in the analyses. Sampling was undertaken in May 2007. The slides were analyzed under a binocular microscope by superimposing a transparent subdividing grid of 24 equally sized squares. For each slide, percent cover values of algae and sessile animals were estimated by assigning a score to each taxon ranging from 0 to 4 within each square and summing these 24 values. Organisms filling less than a quarter of the square were given an arbitrary value of 0.5 (Dethier *et al.*, 1993). Final values were expressed as percentages. No attempt was made to count motile and/or fast-moving animals such as gastropods, ophiuroids, and amphipods. Destructive samples were also collected to aid the identification of taxa in the laboratory, and specialists assisted in the taxonomic identification of organisms. Multivariate analyses were based on a total of 128 taxa. Of these, 69 were identified as species. Due to problems of taxonomic identification from slides, the remaining ones were included in the analyses at coarser levels of taxonomic resolution.

A distance-based permutational multivariate analysis of variance (PERMANOVA; Anderson, 2001a) was performed to analyse spatial patterns of the multivariate assemblages. The analysis was based on Bray-Curtis dissimilarities on square-root-transformed data to smooth out the contribution of conspicuous taxa to the multivariate patterns. Each term in the analysis was tested by 4999 random permutations of appropriate units (Anderson, 2001b; Anderson and Ter Braak, 2003).

Multivariate patterns of variation of assemblages at the scale of sites and locations across the two levels of coastal exposures were visualised by nonmetric multidimensional scaling (nMDS) of sites' centroids. Centroids were obtained using averages from principal coordinates of the $n = 10$ observations (McArdle and Anderson, 2001; Terlizzi *et al.*, 2007). The Similarity Percentage (SIMPER) procedure (Clarke, 1993) was employed to analyze the percentage contribution of each variable to the Bray-Curtis dissimilarities among levels of the factor exposure, allowing the identification of taxa most characterising the differences in sheltered *vs.* exposed rocky assemblages. A cutoff criterion was applied to allow identification of a subset of species for which the cumulative percentage contribution to the observed value of dissimilarity reached 75%.

All multivariate analyses were performed using the computer program PRIMER v. 6 (Clarke and Gorley, 2006), including the add-on package PERMANOVA+ (Anderson, Gorley, and Clarke, 2008).

Analysis of variance (ANOVA) was used to test, for the number of taxa, the same hypotheses described above for the whole assemblage. Prior to analyses, the assumption of homogeneity of variances was checked using Cochran's *C*-test. ANOVA was performed using GMAV version 5 software (University of Sydney, Australia).

Table 2. List of habitats and relative surfaces identified on hard and soft substrates. The total percentage cover is related to the total area; the relative percentage cover represents the proportion covered from each habitat according to the substratum category.

Code	Habitat	Total Habitat Surface (ha)	Total Coverage (%)	Relative Coverage (%)
I	Seagrass meadows	1512.79	12.36	
I.1	<i>P. oceanica</i> meadows	409.40	3.35	27.06
I.2	Dead mattes of <i>P. oceanica</i>	862.54	7.05	57.02
I.3	Matte with <i>Cymodocea nodosa</i> and <i>Caulerpa racemosa</i>	87.60	0.72	5.79
I.4	Mosaic of <i>P. oceanica</i> and matte	91.95	0.75	6.08
I.5	Mosaic of <i>P. oceanica</i> and matte with <i>C. nodosa</i>	61.30	0.50	4.05
II	Muds	10,347.83	84.56	
II.1	Coastal terrigenous muds	7396.80	60.44	71.48
II.2	Coastal terrigenous muds with <i>Turritella communis</i>	2951.03	24.11	28.52
III	Sands	331.10	2.71	
III.1	Coastal detritic bottom	203.93	1.67	61.59
III.2	Well-sorted fine sands (SFBC)	1.25	0.01	0.38
III.3	SFBC with <i>C. nodosa</i>	125.92	1.03	38.03
IV	Rocks	46.14	0.38	
IV.1	Infralittoral algae	1.36	0.01	2.95
IV.2	Barrens			
IV.3	Coralligenous formations (CFs)	0.92	0.01	1.99
	Total	12,237.86		

RESULTS

Habitat Mapping

Overall, the bay is characterised by a gently sloping substrate extending from the surface to about 30 m depth. Thirteen habitat types (Table 2) were identified inside Vlorë Bay, on a surface of 12,238 ha. The brown algae *Cystoseira* spp. such as *Cystoseira barbata* formed very small patches in the shallow infralittoral habitat, and their area cover was thus difficult to estimate. Below the *Cystoseira* fringe, from the surface to about 5 m depth, approximately the 95% of rocky substrata were characterized by barrens, showing the impact of the illegal date mussel fishery (as recorded by Fanelli *et al.* [1994] and Frascchetti *et al.* [2001] for the facing Apulian coast, Italy). Occasionally, a patchy algal-dominated assemblage characterised by a mosaic of turf and erect algae such as *Halimeda tuna* and *Halophytis incurvans* was found.

The seagrass meadows accounted for about 12% of the total area (Table 2, Figure 2A) and were characterized by the presence of *Posidonia oceanica*. Seagrass meadows were present under five conditions, distinguished on the basis of their fragmentation state (Table 2, Figure 2B.) *Posidonia oceanica* (accounting for a relative coverage of 27% of the total) was found at about 5 m depth in the area close to the island of Seseno. About 10% of the seagrass was interspersed among dead matte, *i.e.*, what is left of dead rhizomes and roots, including interstitial sediment. The meadow density decreased progressively at higher depth and shoots completely disappeared at a depth lower than 10 m, where living *P. oceanica* is substantially replaced by dead matte, one of the most abundant habitat types inside the bay (accounting for the 7% of the total area and 57% of the habitat). Small patches of the seagrass *Cymodocea nodosa* were also recorded on sandy patches and in association with dead matte (accounting for about 2% of the total area).

Below 10–15 m depth, sandy substrata and rocky reef (including coralligenous formations) covered a small percentage (2.71% and 0.38%, respectively) of the total investigated area (Table 2, Figure 2A). The term “coralligenous formations” (CFs) broadly defines the secondary hard substrates formed by bioconstructors (*e.g.*, calcareous encrusting algae, bryozoans, serpulids, *etc.*) and the biota inhabiting them (Ballesteros, 2006; Sarà, 1969; Virgilio, Airolidi, and Abbiati, 2006). They accounted for about 2% of the total area (Figure 2B), and they principally characterised the subtidal cliffs between 20 and 30 m depth along the coast of Karaburun Peninsula on the western side of Vlorë Gulf. Muddy substrata accounted for about 84% of the total area investigated (Table 2, Figure 2A), especially in the central part of Vlorë Bay and along the coastal area of Seseno’s Island.

Spatial Patterns of Benthic Assemblages

ANOVA on the mean number of taxa showed a significant among-site variability (ANOVA_{12,162}, $F = 4.21$, $P < 0.0001$) and a significantly lower number of taxa inside than outside the bay (ANOVA_{1,4}, $F = 8.96$, $P < 0.04$). PERMANOVA detected significant variation of assemblage at the scale of locations and sites and an overall pattern of significant differences in sheltered *vs.* exposed assemblages (Table 3). Such multivariate patterns of assemblages were well-represented by the nMDS ordination of sites’ centroids, which showed clear-cut differences in sheltered *vs.* exposed assemblages, despite the spatial variation among and within locations (Figure 3).

SIMPER (Table 4) highlighted that the taxa characterising most of the assemblages in the sheltered coasts were represented by boring sponges of the family of Clionidae, encrusting forms of sponges (*Crambe crambe*, *Spirastrella cunctatrix*), and encrusting (ECR) and turf-forming algae

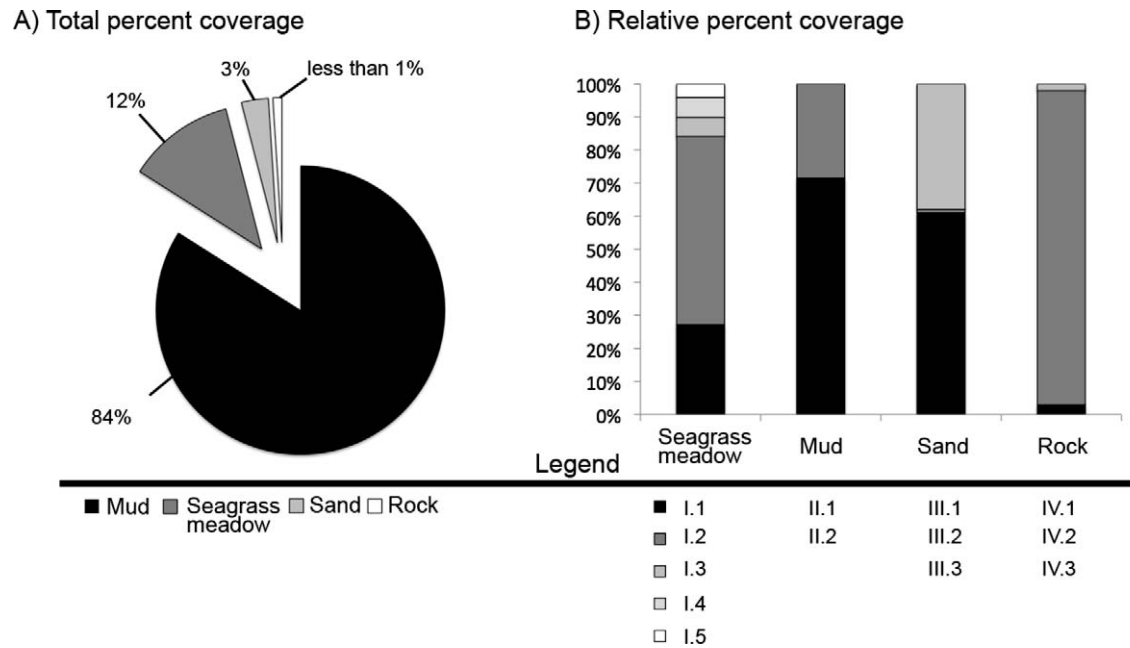


Figure 2. (A) Total percentage cover of muds, *Posidonia*, sands, and rocky reefs. (B) Extent of the four main categories identified, expressed as percentage. The extension of each habitat is indicated according to the code assigned in Table 2.

(Turf). The lower abundance of these taxa on the exposed coasts, along with the almost exclusive presence of some species of algae (e.g., *Sargassum* spp., *Dictyopteris polypoides*, *Flabellia petiolata*, *Padina pavonica*, *Dictyota dichotoma*, *Cystoseira spinosa*), Hydrozoans (e.g., *Aglaophenia* spp.), and Bryozoans (e.g., *Hornera frondiculata*), was most responsible in determining the differences in assemblages between sheltered and exposed assemblages.

DISCUSSION

In Albania, mitigation of the effects of human activities is particularly challenging since a complex suite of stressors is presently operating in the sea and along the coast. However, our study can be paradigmatic, and the results may be extended to many other regions of the Mediterranean Sea. Habitats and assemblages within Vlora Bay are largely

impacted by human activities. A massive presence of dead matte suggests that a larger extension of seagrass meadows was present in the bay. Unfortunately, no published information is available to assess these changes on the basis of a direct comparison of quantitative data. Also, inside the bay, the shallow infralittoral zone is mostly represented by barrens, and the former habitat of *Cystoseira* is present in form of small patches. Waycott *et al.* (2009) individuated two major causes for seagrass loss: (1) direct impacts from coastal development and dredging activities and (2) indirect impacts from declining water quality. The same reasons could be

Table 3. Permutational MANOVA on the basis of the Bray-Curtis dissimilarities on square-root-transformed data from 128 variables (taxa).

Source	df	MS	Pseudo-F	P (perm)	Comp. Var.
Ex	1	64,529	2.91	0.0236*	22.10
Lo(Ex)	4	22,183	2.77	0.0002	22.09
Si(Lo[Ex])	12	8020.9	5.58	0.0002	26.03
Res	157	1437.9			37.92
Total	174				

Each test was based on 4999 permutations of appropriate units. Ex = exposure, Lo = location, MS = mean squares, P (perm) = P value under permutation, Pseudo-F = Test di Fisher, Si = site. Comp. Var. = components of variation.

* P-value obtained using a Monte Carlo drawn from the asymptotic permutation distribution (for details, see Terlizzi *et al.*, 2007).

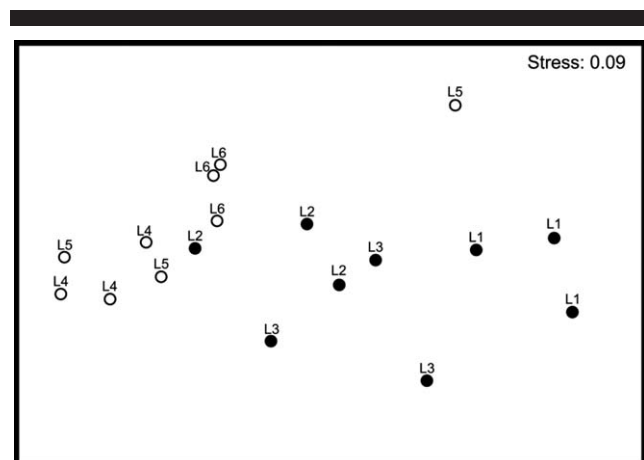


Figure 3. Nonmetric multidimensional scaling (nMDS) on the basis of the Bray-Curtis dissimilarity measure of sites' centroids for each location (L1 to L6). Black circles = exposed sites; white circles = sheltered sites.

Table 4. SIMPER analyses: taxa most contributing to percentage dissimilarities between sheltered vs. exposed rocky assemblages.

Taxa	Exposed Average Abundance	Sheltered Average Abundance	Relative Contribution %	Cumulative %
<i>Cliona viridis</i>	1.89	3.54	9.11	9.11
<i>Peyssonnelia</i> spp.	2.14	0.68	6.23	15.34
Turf	2.17	0.99	5.98	21.32
<i>Crambe crambe</i> / <i>Spirastrella cunctatrix</i>	1.33	1.84	5.96	27.28
Clionidae	0.91	1.68	5.24	32.52
ECR	1.49	1.45	5.06	37.58
Dark filamentous algae	1.20	1.08	4.55	42.13
<i>Sargassum</i> spp.	1.47	0.02	4.25	46.38
Enc. bryozoans (EB)	1.18	1.14	4.01	50.39
<i>Aglaophenia</i> sp.	1.39	0.19	4.00	54.39
<i>Jania rubens</i>	1.22	0.00	3.43	57.82
<i>Dictyota dichotoma</i>	1.05	0.04	2.90	60.72
<i>Dictyopteris polypoides</i>	0.93	0.00	2.77	63.49
<i>Hornera frondiculata</i>	0.97	0.00	2.70	66.19
<i>Padina pavonica</i>	0.67	0.50	2.70	68.89
<i>Flabellia petiolata</i>	0.86	0.16	2.53	71.42
<i>Padina pavonica</i>	0.67	0.50	2.70	68.89
<i>Cystoseira</i> spp.	0.86	0.00	2.49	73.91

linked to the high fragmentation observed for the genus *Cystoseira* spp.

In Albania, most urban and industrial wastes are unloaded directly (*i.e.*, without treatment) into the rivers, causing high levels of pollution (see Bienen, 2004; Cullaj *et al.*, 2005; UNEP, 2000) (Figure 1A). The town of Vlora does not have a sanitary wastewater treatment system, wastewaters being discharged directly into the sea, without any treatment (Figure 1A). Many infrastructures, such as harbours and dams, or interventions of coastal land reclamation, coupled with a general and uncontrolled informal building along the shore, modify sediment regimes and alter coastal dynamics (*e.g.*, increase sedimentation, coastal erosion). In particular, Vjosa River is the main source of sediment for Vlora Bay (with 8 million tons of sediment transported per year) (CISM; CoNISM, 2008). Coastal dynamics from the Vjosa outfall to the entire Vlora Bay have been heavily affected by drastic modification of the river outfall position from 1870 to 1990 (Boçi, 1994), recent dams construction, and extraction of building trade material (*e.g.*, sand and gravel) (CISM; CoNISM, 2008), and, finally, the development of harbours (both touristic and industrial), functioning as barriers to sediment dispersion. These two aspects represent a serious threat to local biodiversity and are possibly the cause of the observed deterioration within the bay. The relevant and increasing sedimentation processes will likely exacerbate the patterns observed here. According to the Specially Protected Areas of Mediterranean Importance (SPAMI) conservational value, the presence of wide extension of key habitats inside the bay is still noticeable. The limited residual area of seagrass meadows compared with the wide surface of dead matte (57% of the total *Posidonia*) is already documented in the present study, and other regression processes are expected in the future. Canopy-forming macroalgae like *Cystoseira brachicarpa* and *Cystoseira amentacea* are recognised as key structural and functional elements of marine ecosystems at a wide range of locations (Benedetti-Cecchi *et al.*, 2001; Eriksson, Rubach, and Hillebrand, 2006, 2007;

Jenkins, Hawkins, and Norton, 1999), which serve a function that is difficult for other species to fulfil. Irrespective of their recognised role, canopy algae are thought to be in worldwide decline, and many local extinctions have been documented, particularly in Europe (Airoldi and Beck, 2007; Benedetti-Cecchi *et al.*, 2001; Gorman and Connell, 2009).

Fish farming is another threat potentially driving the observed changes. Albanian aquaculture is well developed in inland waters, whereas mariculture, by means of floating cages positioned on open sea, is relatively recent. The first aquaculture farms were established along the coast from Vlora Bay to the south border of Greece. At present, there are about 12,000 m² of marine area (estimates through Google Earth satellite images) (Table 1) dedicated to European seabass (*Dicentrarchus labrax*) and gilthead seabream (*Sparus aurata*). In Vlora Bay, many structures (54% of the national surface dedicated at this activity, Table 1) are concentrated along 3 km of shore (Figure 1B) on the east coast of Karaburun Peninsula. The potential impacts of fish aquaculture are significant, ranging from aesthetic aspects to direct pollution like dispersion of organic matter (waste feed and faeces), nutrients, and pharmaceutical agents into the water column and in sediments. The most common effects of fish-cage cultivation are mainly of local concern, resulting in eutrophication problems. The lack of monitoring and adequate control measures of this growing industry could potentially contribute to the degradation of marine habitats (Mantzavrakosa *et al.*, 2007; Terlizzi *et al.*, 2010).

At assemblage level, patterns of distribution of shallow rocky assemblages significantly differed inside and outside the bay, and significantly varied among and within locations. Also, significantly higher numbers of taxa were found in the exposed locations. Of course, exposed and sheltered assemblages are subjected to substantial natural environmental differences. However, other stressors and disturbances are driving relevant changes in the assemblages in the location inside Vlora Bay, which are more exposed to anthropogenic disturbances, leading to a general biodiversity homogenisa-

tion. Canopy-forming algae such *Sargassum* sp., *Dictyotales*, *Dictyota dichotoma*, and *Cystoseira* spp. are still abundant outside the bay and drive the observed differences between exposed and sheltered locations, with percentage cover reaching values over 80% of photographic samples. Inside the bay, barren rocks were the dominant habitat featured by the presence of encrusting forms of sponges, and encrusting and turf-forming algae. Here, shallow rocky subtidal habitats are largely represented by barrens heavily threatened by the destructive illegal fishery of the European date mussel *Lithophaga lithophaga* (L.) (Bevilacqua *et al.*, 2006; Fanelli *et al.*, 1994). This activity is less pronounced outside the bay, which is less accessible to this detrimental source of disturbance and is characterised by a significantly richer assemblage dominated by a complex mosaic of habitat-forming algae and invertebrates. The importance of this phenomenon was remarked by Naylor (1995), while Dayton *et al.* (1995) and Hall (1999) cited it as a prime example of fishery disturbance on subtidal hard substrates. The clearing action of this fishery is responsible of a regime shift from multilayered macrobenthic assemblages to coralline barrens in large areas of subtidal reefs in many areas of the Mediterranean Sea (Fanelli *et al.*, 1994; Frascchetti *et al.*, 2001). Date mussel fishery already has led to the desertification of hundreds of kilometres of the calcareous rocky coast in Apulia also causing the substantial exploitation of this species. This illegal fishery can have profound ecological consequences, and regional and national bodies should stop this form of exploitation. This suggests that, inside the bay, habitat fragmentation and degradation are possibly caused by the immediate impacts of coastal development. Signs of impacts are still limited in space, but the failure of subtidal assemblages to recover from natural and human disturbance and their ultimate replacement by degraded habitats are concrete risks recognised globally (Gorman and Connell, 2009). Under this perspective, appropriate management and conservation measures able to reverse the observed trends are urgently needed.

Fisheries, although this sector accounts for a small portion of Gross Domestic Product (GDP; 2% in 2003) of the country's economy (MEFWA, 2004), represent another activity leading to overexploitation of marine resources coupled with a general degradation of habitats. Recently, the amount of vessels registered in Albanian ports was 211, with 75% of vessels registered in Durres and Vlora ports (Table 1). In particular, 67% of Albanian fleet is devoted to trawling, one of the most impacting fishery activities both directly on soft bottoms and indirectly on community structure. Unfortunately, the official data do not completely reflect the real dimension of fishing pressure on the Albanian coast, since there are several small vessels that do not have fishing licences. In the 1990s, the institutional framework collapsed, and the management of fisheries resources and ports virtually ceased, and various illegal fishing activities grew along the coastline. The lack of enforcement of regulations encourages the unlicensed fishing and illegal trawling, which are destroying some of the nursery areas for demersal species (MEFWA, 2004).

From these considerations, it is evident that in Albania multiple sources of disturbance are causing profound changes

to coastal systems. The challenge should be to remove or at least to reduce the effects of human activities, through a combination of conservation and management efforts acting at regional scale and including land-based and marine-based sources of impacts. The scientific community should be actively involved in building a framework of monitoring and mitigation strategies to overcome the widespread tendency to consider the effects of individual threats in isolation. At present, the model of development accompanied by nearly irreversible environmental consequences observed in Albania has been surely imported from other Mediterranean areas, experiencing a combination of high biodiversity and low protection regime, such as wide portions of the facing Apulian coast. The urgent need of an integrated coastal management strategy, ensuring sustainable development while conserving and managing natural biodiversity and resources, is a prerequisite to reducing the cumulative effect of stressors and accommodating the broad range of impacts on coastal habitats, so as to protect them from further losses.

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