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Response of rocky shore communities to anthropogenic pressures in Albania (Mediterranean Sea): Ecological status assessment through the CARLIT method

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ABSTRACT

The lower mid-littoral and shallow subtidal communities were studied in the district of Vlora (Albania), three years after the establishment of a Marine Protected Area, with particular attention to the long-lived species. The bioconstructions built in the mid-littoral zone by the calcified rhodobiont *Lithophyllum byssoides* were in poor condition and sometimes even dead. In contrast, the brown alga *Cystoseira amentacea* constituted lush stands. For assessing the ecological status of the studied area, the CARLIT method, based upon macroalgal communities, was applied. The observed range of ecological status was wide ('high' through 'bad') and was overall among the lowest assessed to date in the Mediterranean Sea. The occurrence of extensive sea-urchin barrens, though not taken into consideration by the CARLIT index, confirmed the poor condition of large sectors of the study area. Overall, the CARLIT index is well correlated with anthropogenic pressures, as assessed by the LUSI index.

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1. Introduction

The Mediterranean Sea is a hotspot of marine biodiversity that is under siege due to high demographic pressure, a high percentage of worldwide shipping and tourism and the highest worldwide rate of biological invasions (Bianchi and Morri, 2000; Galil, 2000; Boudouresque and Verlaque, 2002; Boudouresque, 2004; Lotze et al., 2006; Coll et al., 2010, 2012; Lejeune et al., 2010; Zenetos et al., 2010; UNEP/MAP, 2012; Bianchi et al., 2014; Giakoumi et al., 2015). Different pressures act over time and in unison, with possible synergy effects, to affect the species, the ecosystems and their ability to deliver ecosystem services (e.g. Worm et al., 2006; Halpern et al., 2008; Waycott et al., 2009).

Within the framework of the Water Framework Directive (WFD, 2000/60/EC) (E.C., 2000) of the European Union (EU), several indices based upon marine indicator species have been proposed to assess the ecological status of coastal water bodies, e.g. the CCO index (Cover, Characteristic species, Opportunistic species), based upon intertidal seaweeds along the European Atlantic coasts (Ar et al., 2016) and the EEI (Ecological Evaluation Index, based upon macroalgae), PREI (*Posidonia oceanica* Rapid Easy Index, based upon the *P. oceanica* seagrass), R-MaQUI (based upon lagoon macrophytes), MAES (for mesophotic

assemblages between 50 and 150 m depth, based upon ROV-imagery) and CARLIT (Cartography Littoral), based upon mid-littoral and shallow water species for the Mediterranean coasts (Orfanidis et al., 2003; Ballesteros et al., 2007; Sfriso et al., 2007; Gobert et al., 2009; Nikolić et al., 2013; Cánovas et al., 2016). The indicator species of good ecological status used for the CARLIT index (Ballesteros et al., 2007) are the long-lived species, i.e. seagrasses, *Lithophyllum byssoides* (Lamarck) Foslie (Rhodobionta, Archaeplastida) and *Cystoseira* spp. (Phaeophyceae, Stramenopiles), which are usually regarded as sensitive to pollution and coastal development. For this reason, they were included within the Berne Convention on the conservation of European wildlife and natural habitats (Appendix I: strictly protected flora species) (Council of Europe, 1979) and the Barcelona Convention for the protection of the marine environment and the coastal regions of the Mediterranean (Annex II: 'Endangered or threatened species that the Parties shall manage with the aim of maintaining them in a favourable state of conservation') (Barcelona Convention, 1976, 1996).

Lithophyllum byssoides (synonym *Lithophyllum lichenoides*) is a calcified red alga that thrives exclusively within a narrow vertical range a few centimetres above the mean sea-level (lower mid-littoral zone sensu Pérès, 1982). It is the ecosystem engineer of the *Lithophylletum lichenoidis* Giaccone 1993 association (Giaccone et al., 1993), shall harbours both marine and terrestrial taxa (Molinier, 1958, 1960). Its mid-littoral location exposes it to sea-surface pollution. Under suitable

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environmental conditions (unpolluted, dim light and high hydrodynamics), it can constitute large bioconstructions referred to as *Lithophyllum byssoides* rims (Picard, 1954; Blanc and Molinier, 1955; Ballesteros, 1984; Laborel et al., 1994a). Due to the very narrow vertical distribution range (± 10 cm) of *L. byssoides* and to its slow growth rate (Favre et al., 2013; Thibaut et al., 2013), such bioconstructions require a long period of relative stabilisation of the sea-level to settle. Consequently, *L. byssoides* rims are valuable indicators of near-stable or slowly rising sea-level and high sea-water quality over long periods (Laborel et al., 1983, 1993, 1994b; Morhange et al., 1992; Morhange, 1994; Laborel and Laborel-Deguen, 1996; Bressan et al., 2001; Favre et al., 2013).

Species of the genus *Cystoseira* C. Agardh (Phaeophyceae, Stramenopiles) are canopy forming brown algae dominating several assemblages from the subtidal fringe (<1 m below the mean sea level) down to the lower limit of the euphotic zone (infralittoral and circalittoral zone *sensu* Pérès, 1982) (Feldmann, 1937; Molinier, 1960; Pignatti, 1962; Verlaque, 1987; Ballesteros, 1988, 1990a, 1990b; Giaccone et al., 1994). The zonation and the extension of these assemblages are under the control of a range of environmental conditions (light, temperature, hydrodynamics, water quality and grazing) (Sauvageau, 1912; Ollivier, 1929; Vergés et al., 2009). Among the *Cystoseira* species, *Cystoseira amentacea* [previously referred to as *Cystoseira stricta* (Montagne) Sauvageau and *Cystoseira spicata* Ercegović] is a species widely distributed in the Mediterranean Sea. It belongs, like *Cystoseira mediterranea* Sauvageau and *Cystoseira tamariscifolia* (Hudson) Papenfuss, to a morphological group restricted to the subtidal fringe, (Sauvageau, 1912; Feldmann, 1937; Ribera et al., 1992). *Cystoseira amentacea* is the ecosystem engineer of the *Cystoseiretum stricta* Molinier, 1958 association, which harbours hundreds of species and can occupy extensive zones of wave-exposed shallow hard substrates (Molinier, 1960; Bellan-Santini, 1968; Boudouresque, 1971a, 1971b).

Albania has about 427 km of coastline facing the Adriatic and Ionian seas, within the Mediterranean Sea. The marine environment of the Albania coast varies widely from north to south. The Adriatic northern part is dominated by shallow waters, sandy beaches, sandspits, wetlands and lagoons, whereas the Ionian southern part is a rugged rocky coast with high reliefs and caves (Tilot and Jeudy de Grissac, 1994). Located in the middle part of Albania, the city of Vlorë is the second largest port (for trade and fisheries) in the country and one of the most attractive tourism resorts in the eastern part of the Mediterranean Sea (Fraschetti et al., 2011). The resident population is about 150,000 inhabitants and about 2 million tourists were accommodated in 2008 (INSTAT, 2008). The north and south coasts of the Bay of Vlorë are occupied by extensive beaches. Facing Vlorë, Sazani Island and the Karaburun Peninsula are composed mainly of Cretaceous limestone rocks. In contrast with Vlorë, the rural population of Sazani Island and the Karaburun Peninsula is low, with 5–20 inhabitants km⁻². Sazani Island is military territory and Karaburun Peninsula was declared a natural reserve in 1966. In April 2010, the coastal and marine area of Sazani Island and the Karaburun Peninsula were raised to the status of Marine Protected Area (MPA), which is the first and the only existing MPA in Albania (Kashta et al., 2011).

Only a very few data sets regarding the presence, abundance and patterns of distribution of marine species and communities were available in this area, these being 3 seaweed checklists (Kashta, 1986; Kupe and Miho, 2006; Antolić et al., 2010), an in-depth study of the genus *Cystoseira* (Ercegović, 1952) and a general assessment of biodiversity and communities (Fraschetti et al., 2011).

The aim of the present study was to assess (i) the distribution and state of conservation of the *Lithophyllum byssoides* rims, the *Cystoseira amentacea* stands and shallow subtidal communities (ii) the ecological status of coastal waters of the region by means of the CARLIT method, especially along the coastline of Sazani Island and Karaburun Peninsula, after the establishment of the MPA, (iii) the comparison between two methods of calculation of the CARLIT index (Ballesteros et al., 2007;

Nikolić et al., 2013), and (iv) the congruence of the CARLIT index versus two proxies of anthropogenic pressure (Lopez y Royo et al., 2009; Flo et al., 2011).

2. Materials and methods

2.1. Sampling sites

The study was conducted in May 2013 in the district of Vlorë (Albania, Mediterranean Sea). Most of the study area was located within the MPA of Sazani Island and the Karaburun Peninsula (Fig. 1). The shore south to Orso Bay, though belonging to the MPA, was not explored. Although *L. byssoides* and *C. amentacea* are perennial and long-lived species that can be observed year round, late spring is the most suitable period for such field work, as erect branches of *C. amentacea* are then fully developed.

2.2. Identifying ecological regions in the studied area

No coastal water bodies have been previously delineated in Albania, a country which does not belong to the EU, and is not bound to apply the European WFD requirements. We therefore undertook the following delineation by coastal water bodies according to the ridgelines watershed: the western and northern shores of Karaburun Peninsula, the eastern shore of Karaburun Peninsula and the southern and eastern shores of the Bay of Vlorë, the western and the eastern shores of Sazani Island (Fig. 1).

2.3. Mapping of lower mid-littoral and shallow subtidal communities

The geomorphological characteristics of the shoreline were drawn on black and white A3 format aerial photographs from Google Earth®. The scale was 1:2500. Three observers worked on board a small boat (length 5 m) moving at low speed (3 to 6 km h⁻¹) a few metres from the shore. The species and communities were entirely mapped. Observations were entered within a Geographical Information System (GIS) database (ArcGis10®), allowing the extraction of latitude and longitude of each location, using the coordinate system WGS-1984-UTM-zone-34N.

The *Lithophyllum byssoides* rims of measurable size (i.e. at least 0.2-m width and 1-m long) and with a distinct overhang were exhaustively mapped and their vitality was visually assessed (alive rims vs dead).

Among the shallow subtidal communities, down to 2-m depth, we mapped *Cystoseira amentacea*, *Cystoseira compressa*, *Corallina caespitosa*, *Mytilus galloprovincialis*, the mosaic of stands of other erect macroalgae and the barren grounds of encrusting corallines with the sea urchins *Paracentrotus lividus* (Lamarck, 1816) and *Arbacia lixula* (Linnaeus, 1758). For taxonomic and nomenclatural purposes, the worldwide electronic database *algabase.org* (Guiry and Guiry, 2015) was followed.

2.4. Ecological status assessment

The ecological status of coastal water bodies of the study area was assessed by means of the CARLIT method (Ballesteros et al. (2007)). The CARLIT method is based upon the mapping of geomorphological characteristics obtained in the field (slope, morphology and natural/artificial substrate) and some mid-littoral and shallow subtidal species and communities of the rocky shoreline.

Six relevant geomorphological situations identified by Ballesteros et al. (2007), according to the coastline morphology and natural/artificial substrates (Table S1), were mapped.

The species and communities taken into account, according to a decreasing level of sensitivity (SL, from 20, very sensitive, to 1, not sensitive to disturbance, are listed in Table S2).

For each geomorphological situation, the length of the coast occupied by each community type was measured and the ecological quality

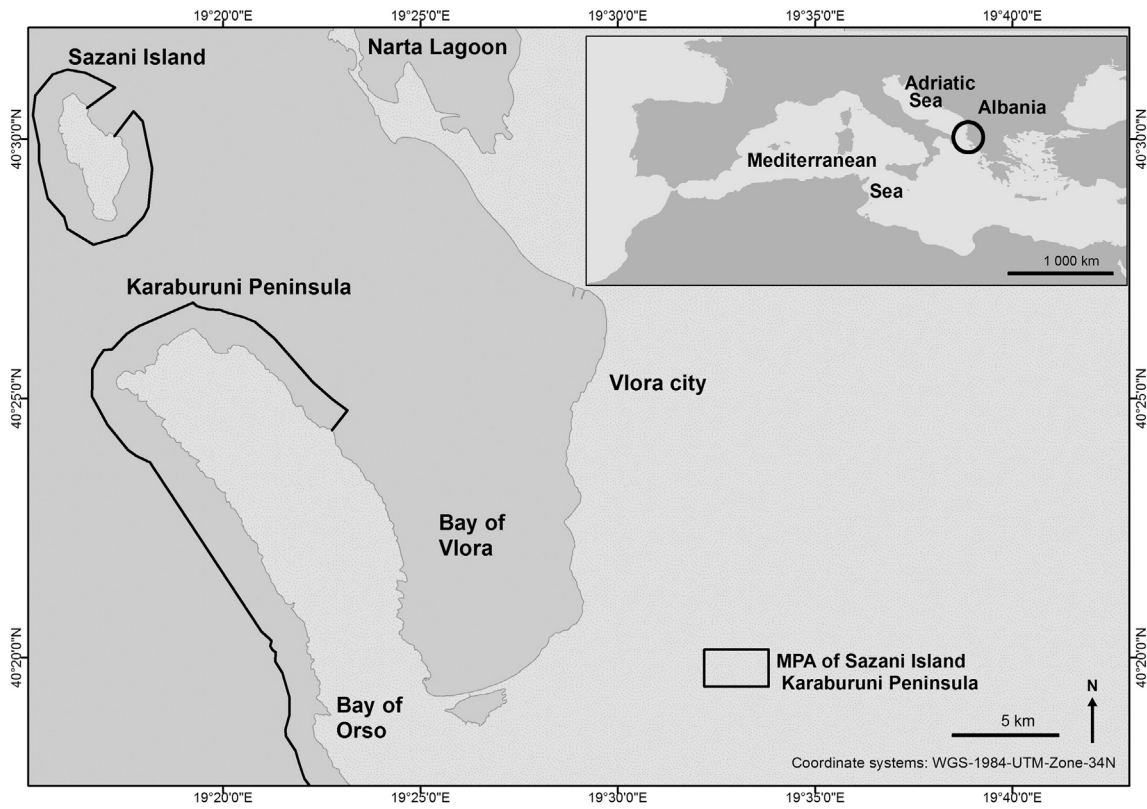


Fig. 1. The study site (district of Vlora) with the location of the Sazani Island and Karaburuni Peninsula MPA. Albania in the Mediterranean basin (above right).

value (EQ) was calculated using the formula:

$$EQ_{ssi} = \frac{\sum (I_j * SL_j)}{\sum I_j}$$

where *i* is the geomorphological situation; EQ_{ssi} is the ecological quality value of the geomorphological situation *i*; I_j is the length of the coastline with the species/community *j*, SL_j is the sensitivity level of the species/community *j* (Table S2) and $\sum I_j$ is the total length of the coastline occupied by the geomorphological situation *i*.

According to the WFD, the ecological status of a coastal water body has to be expressed in terms of ecological quality ratios (EQR). This ratio indicates the relationship between the value of the biological parameters (here species and communities) recorded for a given coastal water body and the value for these parameters in the reference conditions applicable to this body.

The EQR (Ecological Quality Ratio) of the geomorphological situation of a coast is calculated as the ratio between the EQ obtained (EQ_{ssi}) and the EQ obtained in the reference sites corresponding to the same 'geomorphological situation' (EQ_{tsi}) (Table S1). Therefore, the EQR of a coast corresponding to a coastal water body is calculated according to the following formula:

$$EQR = \left(\frac{\sum [(EQ_{ssi}/EQ_{tsi}) * 1_i]}{\sum I_i} \right)$$

where *i* is the geomorphological situation; EQ_{ssi} is the EQ at the study site for the geomorphological situation *i*; EQ_{tsi} is the EQ at the reference sites for the geomorphological situation *i*; I_i is the coastal length occupied by the geomorphological situation *i* ($I_i = \sum I_j$) and $\sum I_i$ is the total length of the coastline of the coastal water body ($\sum I_i = \sum \sum I_j$).

The EQR is expressed as a numerical value between 0 and 1. The ecological status of a coastal water body is defined as follows:

EQR	Ecological status
1 to >0.75	High
0.75 to >0.60	Good
0.60 to >0.40	Moderate
0.40 to >0.25	Poor
0.25 to 0.0	Bad

Nikolić et al. (2013) developed a slightly modified CARLIT index for the eastern Adriatic Sea. The equations and the rationale are the same as described by Ballesteros et al. (2007). The differences lie in the geomorphologically relevant situations (Table S3) and in some species and communities, in their sensitivity levels (Table S4). The two methods of calculation of the CARLIT Index have been applied to the same database and water bodies.

2.5. Assessment of anthropogenic pressures

A water quality assessment of coastal water bodies must be done in relation to anthropogenic pressures. The assessment of known pressures that could affect the water quality within the study area was performed using the land use pressures according to CORINE Land Cover information system 2000–2006 (Büttner et al., 2004; CORINE land cover, 2006). We considered maps of the coast spanning a 1 km wide strip along each coastal water body: the western and northern shores of Karaburuni Peninsula, the eastern shore of Karaburuni Peninsula, the southern and eastern shores of the Bay of Vlora, and the western and the eastern shores of Sazani Island.

Land uses simplified index (LUSI) was calculated according to Flo et al. (2011). Assessment of anthropogenic pressures on the coastal zone by calculating the LUSI index using the publicly available data is described in UNEP/MAP (2011). In the present study, we used the adaptation of LUSI index proposed by Nikolić et al. (2013) (Table S5).

For each coastal water body all scores for pressure were summed. Afterwards, a correction was applied to this sum in order to take into account the degree of confinement that could emphasize or diminish the effect of these pressures on the water body. Depending on the concave, convex or straight shape of the coastal line, the sum was multiplied by the correction factor 1.25, 0.75 or 1.00 (Table S5).

$$\text{LUSI Index} = (A + B + C + D) * E.$$

In addition to the LUSI index, which provides a quantitative value assessing the anthropogenic pressures, we also tested the qualitative index proposed by Lopez y Royo et al. (2009) based on the surface area occupied by urban, agricultural and industrial activities using the Google-Earth images (for further details see Lopez y Royo et al., 2009).

3. Results

3.1. Distribution and state of conservation of *Lithophyllum byssoides* rims

In the lower mid-littoral zone, *L. byssoides* was widespread. In 96 localities, it has built bioconstructions larger than 0.2-m wide and 1-m long for a cumulative length of ~2.5 km for a total coastline length of ~68 km, which represents 3.6% of the rocky coastline (Fig. 2, Table S6). Most of the *L. byssoides* rims were facing W and NW (Fig. 2). Although large *L. byssoides* rims, up to ~1-m wide, were previously reported in the study area (Tilot and Jeudy de Grissac, 1994), most *L. byssoides* rims were relatively narrow with a width of <0.5 m.

At Sazani Island, especially in its southern part, a number of *L. byssoides* rims were in very poor condition (Fig. 2: arrows). They were located at a relatively low tide level, resulting in an unusually frequent covering by the sea water, even under calm conditions. They were deeply bored by holes and a network of blow-holes, making some of them a veritable lacework of calcareous bioconstruction. Lastly, their upper side

was densely coated with perennial macroalgae, especially *Corallina caespitosa*, a species previously misidentified as *C. mediterranea* or *C. elongata*, and commonly used as a proxy of the upper limit of the subtidal zone. The vitality of these *L. byssoides* rims was considered as nil and their status as dead (fossil *L. byssoides* rims). In contrast, at Karaburuni Peninsula and in the north of Sazani, the upper side of the rim showed a more or less continuous cover of living *L. byssoides*, and the rims were considered as alive (Fig. 2: solid circles). However, with regard to the fossil *L. byssoides* rims, they were often perforated by a network of holes, so their health status was considered as intermediate.

3.2. Distribution of *Cystoseira amentacea* stands and shallow subtidal communities

Cystoseira amentacea is well-distributed on the western and northern sides of the Karaburuni Peninsula and the western part of Sazani Island. On the eastern side of the Karaburuni Peninsula, *C. amentacea* populations are less continuous and are replaced southwards by *C. compressa* (Fig. 3).

Beyond the *L. byssoides* rims and the *C. amentacea* stands, either barren-grounds or stands of erect macroalgae were present, except in front of the totally artificialized north-eastern part of Sazani Island that is occupied by the concrete bunkers and reclamations of a military base, with no macroscopic marine stands. Barren-grounds were characterized by encrusting corallines and sea urchins, *Paracentrotus lividus* and *Arbacia lixula*. These barren-grounds thrived from ~30 cm below the subtidal fringe down to at least 2 m depth. They occurred on the eastern side of the Karaburuni Peninsula and the western side of Sazani Island (Fig. 3). Along the rocky shores of the southernmost part of the Bay of Vlorë, the barren-grounds extended up to the sea surface. Stands of erect macroalgae consisted in a patchwork of species, mainly *Corallina caespitosa*, *Halopteris scoparia* (Linnaeus) Sauvageau, *Padina* sp., *Dictyota* spp. and four species of the genus *Cystoseira*: *C. barbata*

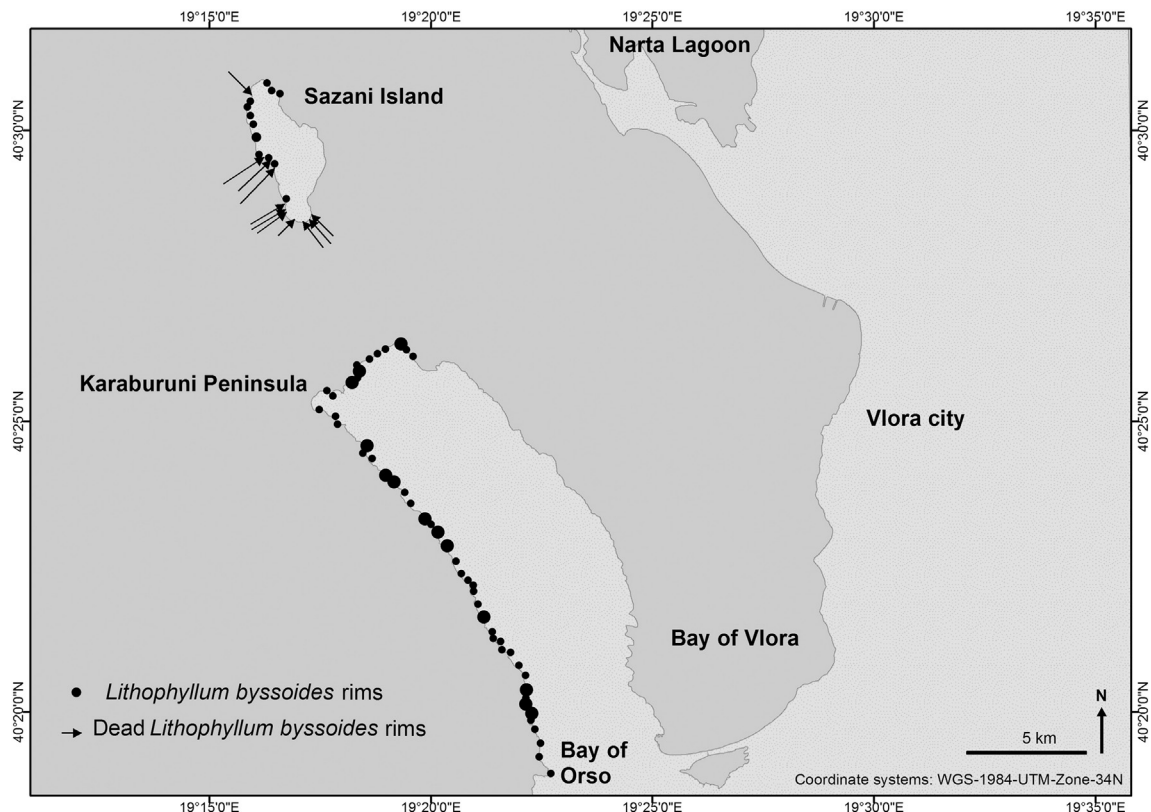


Fig. 2. Distribution and vitality of *Lithophyllum byssoides* rims in the study area (for exact location, see appendix S6). When two or more *L. byssoides* rims are too close to be separately represented, they are depicted by a larger solid circle.

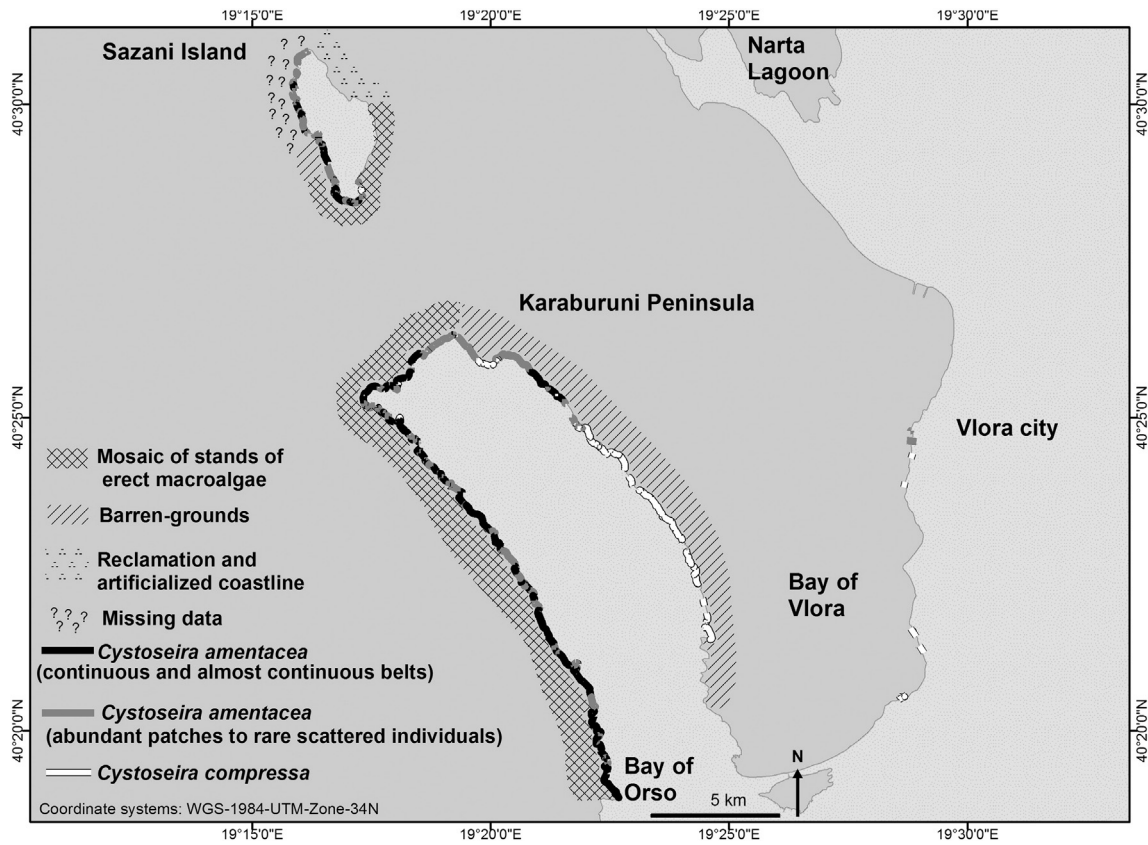


Fig. 3. Distribution of *Cystoseira amentacea*, *C. compressa*, mosaic stands of erect macroalgae, barren-grounds and reclamation and artificialized coastline in the study area.

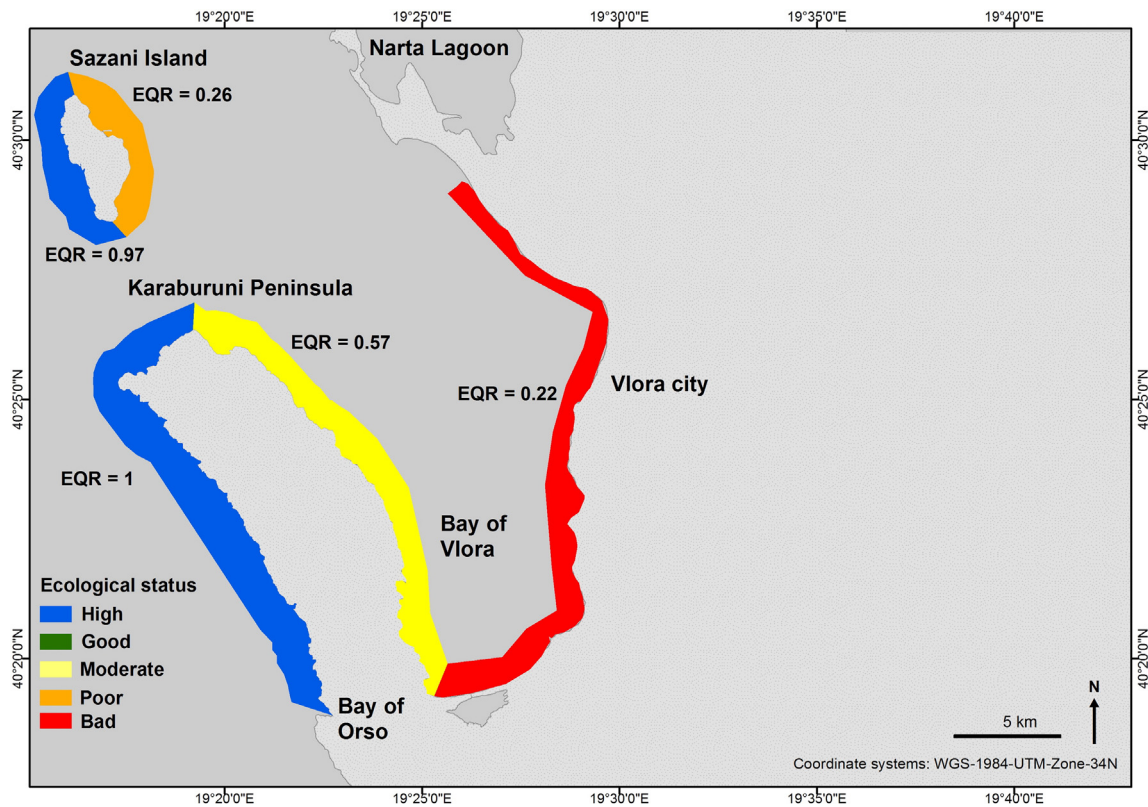


Fig. 4. Ecological Quality Ratio (EQR) and ecological status of the different coastal water bodies of the study area in 2013, according to the Ballesteros et al. (2007) CARLIT method.

(Stackhouse) C. Agardh, *C. crinita*, *Cystoseira crinitophylla* Ercegović, *C. corniculata* (Turner) Zanardini. Large populations of *Cystoseira foeniculacea* (Linnaeus) Greville f. *foeniculacea* and *C. barbata* were found in rock pools close to Narta Lagoon, at the northern mouth of the Bay of Vlora. Lastly, a drift specimen of *C. foeniculacea* f. *latiramosa* (Ercegović) A. Gómez Garreta, M.C. Barceló, M.A. Ribera & J.R. Lluch was found in a fish net, at Vlora harbour, which indicates its occurrence in the study area. No individual of *Fucus virsoides* was found during our field surveys.

3.3. Ecological status and anthropogenic pressures

The ecological status of the northern and western shores of the Karaburun Peninsula and of the western shore of Sazani Island was high. In contrast, the three other coastal water bodies fell within the bad to moderate ecological status range (Fig. 4, Table 1). Except for one coastal water body (eastern shore of Karaburun Peninsula), the ecological status was identical whatever the CARLIT index calculation used (Ballesteros et al., 2007 versus Nikolić et al., 2013); however, the Nikolić et al. (2013) EQR was often higher (Table 1).

In order to validate the use of the CARLIT index, the EQR values (calculated for both CARLIT methods) were compared with values of LUSI (Land Uses Simplified Index) and Lopez y Royo et al. (2009) pressure index obtained for each coastal water body (Table 1). The calculated EQR values were significantly correlated with the LUSI index ($r = 0.85$, with Ballesteros et al., 2007 method; $r = 0.87$, with Nikolić et al., 2013 method; both being significant, $p > 0.001$) confirming a good response of the CARLIT method to the different levels of disturbance.

It is worth noting that, in contrast, the Lopez y Royo et al. (2009) pressure index was more roughly linked to the calculated EQR values than the LUSI index (for the both CARLIT methods) (Table 1), indicating the poorer efficiency of the former.

4. Discussion

The lower mid-littoral and shallow subtidal communities (0–2 m depth) were studied in the district of Vlora (Albania), three years after the establishment of a Marine Protected Area.

In the lower mid-littoral zone, *L. byssoides* rims represented 3.6% of the coastline, a significant value although lower than some percentages previously measured in the western Mediterranean (Table 2). Most of the *L. byssoides* rims were facing W and NW, which is consistent with the wave exposure and the dim light conditions required by the species and the distribution described in other Mediterranean regions (Molinier, 1960; Sicsic, 1967; Bianconi et al., 1987). They were narrow (<0.5 m wide) while much wider *L. byssoides* rims have been described in the Mediterranean Sea (Bianconi et al., 1987; Laborel, 1987; Monbailliu and Torre, 1990; Laborel et al., 1994a; Harmelin et al., 1996; Boudouresque, 2003; Faivre et al., 2013). Many *L. byssoides* rims were dead or in very bad state with frequently a network of holes. Several possible causes of regression of *L. byssoides* rims have been reported in the literature, namely trampling, sea surface pollution and the worldwide rise in sea-level (Verlaque, 2010; Faivre et al., 2013; Thibaut et al., 2013). In the study area, the absence of wide *L. byssoides* rims, the steep

shore profile and the difficulties of berthing or reaching these bioconstructions from the land, mean that trampling can be ruled out as a possible cause of degradation. Pollution which enhances the development of bioeroder organisms and the formation of holes (Laborel, 1987; Morhange et al., 1992; Laborel et al., 1994a, 1994b; Riggio et al., 1994; Boudouresque, 2003), is a better candidate because the waters of the Bay of Vlora are impacted by inputs of numerous pollutants from unmanaged expanding urbanization, the navy base at Karaburun, maritime traffic, environmentally uncontrolled touristic pressure and sewage from a hydrochloric acid factory (Tilot and Jeudy de Grissac, 1994; Fraschetti et al., 2011). Finally, all Mediterranean *L. byssoides* rims were formed during the stabilisation or the slow rising of the sea-level throughout the Little Ice Age (LIA) (late 13th through early 19th centuries). The current acceleration of the worldwide rise in sea-level (3.3 mm a^{-1} between 1993 and 2009; Nicholls and Cazenave, 2010) would appear to be too rapid for the growth capacities of *L. byssoides* rims (Verlaque, 2010; Faivre et al., 2013; Thibaut et al., 2013). In the study region, the occurrence of subtidal species on the upper side of the lowest *L. byssoides* rims agrees well with this hypothesis. Similar submersion of *L. byssoides* rims has already been reported in the central Adriatic Sea (Faivre et al., 2013) and in the northwestern Mediterranean basin (Thibaut et al., 2013). The co-occurrence, in the same area, of *L. byssoides* rims in good and bad conditions could be due to different wave exposure; under highly exposed conditions, the rims are located higher, and are therefore less vulnerable to the sea level rise, than under less exposed conditions.

Cystoseira amentacea stands were well distributed in the study area, especially on the western and northern shores of the Karaburun Peninsula and the western part of Sazani Island. The species has long been considered as highly sensitive to anthropogenic pressures, e.g. pollution, resulting in dramatic regression events (Bellan-Santini, 1966; Janssens et al., 1993; Soltan et al., 2001; Boudouresque, 2003). In the southern Adriatic Sea, Falace et al. (2010) mention local regressions near Torre Guaceto but also extensive populations forming a continuous belt along the Apulian coast. In fact, an extensive mapping of northwestern Mediterranean populations (Southern France and Corsica) revealed that *C. amentacea* still formed an almost continuous belt in most suitable habitats, despite pollution and coastal development (Thibaut et al., 2007, 2014, 2015). The disappearances of *C. amentacea* stands were only restricted to coastal artificialized areas (harbours, reclamations) and waters severely polluted by urban and industrial sewage. Accordingly, continuous or almost continuous stands of *C. amentacea* observed in some parts of the study area, although indicating that the water body was not degraded, could not be considered per se as a proxy of pristine waters.

In 1992, some specimens of the mid-littoral furoid *Fucus virsoides* J. Agardh, an Adriatic endemic species common in the northern part of the Sea (Munda, 1972), were reported in the Bay of Vlora (Kashta, 1986, 1992). This record constituted the southern limit of distribution of the species. No individual of *F. virsoides* was found during our field survey, as already reported by Kashta (1995–1996), which confirms the general decline of the species in the mid-Adriatic Sea (Mačić, 2006; Falace et al., 2010).

Table 1
Comparison of EQR and ecological status of coastal water bodies according to the two CARLIT methods (Ballesteros et al., 2007 and Nikolić et al., 2013) and two indices of anthropogenic pressure: LUSI (calculation method from Nikolić et al., 2013) and the Lopez y Royo et al. (2009) pressure index.

	Ballesteros et al., 2007		Nikolić et al., 2013		LUSI index	Lopez y Royo et al. (2009) pressure index
	EQR	Ecological status	EQR	Ecological status		
Western shore of Sazani Island	0.97	High	1.00	High	0	No pressure
Eastern shore of Sazani Island	0.26	Poor	0.29	Poor	4	Moderate pressure
Western and northern shores of Karaburun Peninsula	1.00	High	1.00	High	0	No pressure
Eastern shore of Karaburun Peninsula	0.57	Moderate	0.62	Good	2	High pressure
Southern and eastern shores of the Bay of Vlora	0.22	Bad	0.22	Bad	10	High pressure

Table 2

Cumulative length of *Lithophyllum byssoides* rims in some Mediterranean areas and percentage of the length of rocky coastline. The scale of the map used for measuring the lengths is specified.

Area	Region or country	Cumulative length of rims	Length of the rocky coastline (scale of the map)	Percentage of rims	Reference
Sazani Island and Karaburun Peninsula MPA	Albania	~2500 m	68,376 (1:2500)	3.6%	This study
San Fiorenzo Gulf	Northern Corsica	0 m	17,804 m (1:2500)	0.0%	Thibaut and Blanfuné, 2014
Scândula MPA (Punta Nera to Punta Scândula)	Western Corsica	~7980 m ^a	~28,500 m (1:5000)	28%	Bianconi et al., 1987
Monte Carlo to Cap d'Ail	French Riviera	14 m	3500 m (1:2500)	0.4%	Thibaut and Blanfuné, 2014
Saint-Raphaël to West Sainte-Maxime	Eastern Provence	15 m	7500 m (1:2500)	0.2%	Thibaut and Blanfuné, 2014
Cap-Croisette to Endoume and Frioul Islands (Marseille)	Western Provence	6618 m	47,271 m (1:2500)	14.0%	Thibaut and Blanfuné, 2014
Racou to Cerbère	French Catalonia	1512 m	50,400 m (1:2500)	3.0%	Thibaut and Blanfuné, 2014

^a In fact, not the cumulative length of rims, but that of 50-m segments encompassing a *L. byssoides* rim.

With regard to the large areas covered with barren-grounds, the total lack of environmental management is clearly to be blamed. The regime shift from marine forests to barren-grounds devoid of erect macroalgae is generally linked to the overexploitation of predatory fish, which gives rise to the rapid expansion of herbivorous sea urchin populations (Sala et al., 1998, 2012; Steneck, 1998; Boudouresque and Verlaque, 2013; Ling et al., 2015). Overfishing, not only using fishing nets and trawling but also by means of the illegal use of explosives, and the illegal breaking of shallow water rocks for date mussel *Lithophaga lithophaga* (Linnaeus, 1758) extraction, have already been denounced by Tilot and Jeudy de Grissac (1994) and Frascchetti et al. (2011). These illegal harvesting methods are still widely spread, according to fishers themselves and to a student involved in the establishment of the MPA (Simon Moncelon, pers. comm.). Such destructive practices are known to have a dramatic impact on marine Mediterranean communities (Fanelli et al., 1994; Frascchetti et al., 2001; Guidetti and Boero, 2004; Devescovi et al., 2005). In addition, the sedimentary inputs from the Vjosa River, which runs north to Vlorë (although the cyclonic general surface circulation flows northwards; Orlić et al., 1992), the pollution from the urban sewer of the Vlorë city (Maiorano et al., 2011) and the current increase in tourism pressure might be related with the worsening of coastal water quality in the Bay of Vlorë.

The CARLIT index is used in most of the EU Mediterranean countries: Spain, France, Italy, Malta and Croatia (Ballesteros et al., 2007; Buia et al., 2007; Mangialajo et al., 2007; Omrane et al., 2010; Blanfuné et al., 2011; Sfriso and Facca, 2011; Bermejo et al., 2012, 2013; Nikolić et al., 2013; Ferrigno et al., 2014; Thibaut and Blanfuné, 2014). It is here applied for the first time in Albania, a non-EU country. The broad acceptance of this methodology for the assessment of the ecological status of coastal water bodies is due to the fact that (i) it is not destructive (no collection of species required); (ii) the mapping only concerns intertidal and very shallow marine habitats (no SCUBA diving required); (iii) large coastal

stretches can be exhaustively explored; (iv) the considered taxa are relatively easy to identify by well-trained observers; (v) the CARLIT index is robust, with the ecological status of a given coastline congruent at a long time scale (Cavallo et al., 2016; Torras et al., 2016).

The ecological status assessed by the CARLIT method was high for the northern and western shores of the Karaburun Peninsula and the western shore of Sazani Island. In contrast, the three other coastal water bodies fell within the bad to moderate ecological status range. Nikolić et al. (2013) proposed some improvements to the CARLIT method, e.g. a change in the species taken into account and a local adaptation of Ecological Quality values of the relevant geomorphological situation. Measuring the substrate slope for each habitat and community type, as suggested by the authors, was time-consuming and adopting their improvements only had a slight effect on the final assessment.

Overall, the ecological status of the study area was among the worst recorded in the areas already studied in the western Mediterranean basin and the Adriatic Sea (Table 3). Overall, despite the establishment of a MPA in 2010, the ecological status of a large part of the area was still poor or bad in 2013. No improvement was apparent when compared with the 2007 situation (Frascchetti et al., 2011), rather to some degree a decline in status. The same conclusion has been drawn for this area through an assessment of macrobenthos and fish, carried out in June 2015 (Samjir Bekiraj and Lefter Kashta, unpublished data).

The ecological status of the study area exhibited a good correlation with the LUSI index as a proxy of anthropogenic pressures, as previously evidenced by Bermejo et al. (2013) and Nikolić et al. (2013). In contrast, the Lopez y Royo et al. (2009) pressure index appeared not to be suitable at coastal water body scale.

In the light of the experience gleaned on the occasion of the present study, certain improvements to the method might also be suggested. Firstly, the delineation of 5 categories of abundance of *C. amentacea* could be usefully simplified into only 2 or 3 categories, as already suggested by Nikolić et al. (2013). Secondly, it might seem logical to lessen

Table 3

Comparison of the ecological status of coastal water bodies in different Mediterranean regions, based upon the CARLIT methodology. Number of coastal water bodies falling within each category (high through bad).

Study area	High	Good	Moderate	Poor	Bad	Total	Reference
District of Vlorë (Albania)	2	0	1	1	1	5	This study
Alboran Sea (Andalusia, Spain)	11	6	2	1	0	20	Bermejo et al., 2013
Catalonia (Spain)	5	9	15	4	0	33	Ballesteros et al., 2007
France, including Corsica	19	9	7	2	0	37	Blanfuné et al., 2011
Genova-Portofino area (Liguria, Italy)	1	1	1	0	0	3	Mangialajo et al., 2007
Capo Carbonara MPA (Sardinia)	2	0	0	0	0	2	Ferrigno et al., 2014
Malta	7	1	1	0	0	9	Blanfuné et al., 2011
Eastern Adriatic Sea (Croatia) ^a	4	0	0	1	1	6	Nikolić et al., 2013

^a According to the Ballesteros et al. (2007) method, slightly modified.

the weight of *C. amentacea* within the index calculation, in light of the fact that the species is less sensitive to water pollution than previously assumed (Thibaut et al., 2014; but see comments below). Thirdly, the presence of *L. byssoides* rims seems to be overweighted, and their death by submersion could be wrongly attributed to a decline in ecological quality, while actually due to the rise in sea level (Favre et al., 2013; Thibaut et al., 2013). These suggestions, at a broader geographic range (the Adriatic and the Western Mediterranean Basin), will be the subject of further studies.

As regards the weight, possibly too high, of *C. amentacea* within the CARLIT index calculation, it should be considered that the WFD uses the assemblage/habitats/species as indicators of water quality. The WFD says that water quality has to be high enough to not modify the species diversity, functionality and the habitats in the water body. If these three parameters are indistinguishable between a given place and a reference site (i.e. a place where human disturbances are nil or kept at a minimum), and the bioindicators used (in this case macroalgae of the habitats constituted by them) show no differences, it means that the water quality is not affecting the assemblages/habitats, and thus, this is consistent with the aims of the WFD. In this case, there would be no need to downweight the value of *C. amentacea* as the habitat remains unmodified in relation to a pristine place (Enric Ballesteros, pers. comm.). Furthermore, the article that claims that *C. amentacea* is less sensitive to pollution than previously expected (Thibaut et al., 2014) does not provide nutrient or pollution data. Finally, several papers unequivocally relate the effects of increased pollution values with the decline of *C. mediterranea* (the vicariant species of *C. amentacea* in some areas of the Mediterranean Sea) (Arévalo et al., 2007; Pinedo et al., 2007, 2015).

At present, the Sazani Island-Karaburun Peninsula MPA, established in 2010, is not yet managed as an MPA. The management plan and its implementation are just at their very inception, so that the present study may represent a useful tool to support the implementation of the management plan and as a baseline for future comparisons.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <http://dx.doi.org/10.1016/j.marpolbul.2016.05.041>.

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