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A new methodology based on littoral community cartography dominated by macroalgae for the implementation of the European Water Framework Directive

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Abstract

Macroalgae is a biological key element for the assessment of the ecological status in coastal waters in the frame of the European Water Framework Directive (WFD, 2000/60/EC). Here we propose a methodology for monitoring water quality based on the cartography of littoral and upper-sublittoral rocky-shore communities (CARLIT, in short). With the use of spatial databases, GIS, and available information about the value of rocky-shore communities as indicators of water quality, it is possible to obtain an environmental quality index representative of the ecological status of rocky coasts. This index, which completely fulfils the requirements of the WFD, is expressed as a ratio between the observed values in the sector of shore that is being assessed and the expected value in a reference condition zone with the same substrate and coastal morphology (Ecological Quality Ratio, EQR). The application of this index to the coast of Catalonia (North-Western Mediterranean) is presented.

Keywords: Littoral communities; European Water Framework Directive; Bioindicators; Cartography; Macroalgae

1. Introduction

The application of the European Water Framework Directive (WFD, 2000/60/EC) requires the assessment of the ecological status of coastal waters in order to implement management plans that prevent their further deterioration. The ecological status of a water body has to be evaluated based upon the status of different biological indicators (e.g. phytoplankton, macroalgae, seagrasses, benthic invertebrates) and supported by hydromorphological and physico-chemical quality elements. Also, and according to the WFD, the resulting ecological status has to be expressed as a ratio between the values of the biological elements observed by a given body of surface water and the values for these elements in a site with no, or very minor, disturbance from human activities (reference conditions).

Several marine benthic groups have been successfully used as indicators of stress and pollution. Macroinvertebrates living in soft-bottom benthic communities are the most frequently used group in impact and monitoring studies (e.g. Pearson and Rosenberg, 1978; Rygg, 1985; Ros and Cardell, 1991; Dauer, 1993) and several biotic indices using soft-bottom benthos have been proposed (e.g. Majeed, 1987; Grall and Glémarec, 1997) and used or adapted to comply with the requirements of the WFD (Borja et al., 2000; Simboura and Zenetos, 2002; Rosenberg et al., 2004).

Benthic macrophytes are also good indicators of water quality (e.g. Borowitzka, 1972; Munda, 1974; Littler and Murray, 1975; Belsher, 1977; Levine, 1984; Gorostiaga and Díez, 1996; Díez et al., 1999). Attached algae, because of their sedentary condition, integrate the effects of

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long-term exposure to nutrients or other pollutants resulting in a decrease or even disappearance of the most sensitive species and its replacement by highly resistant, thionitrophilic or opportunistic species (Murray and Littler, 1978). Therefore, the study of macroalgal communities has been considered useful in order to analyze changes in water quality (Fairweather, 1990) and "macroalgae" is, in fact, one of the key biological elements to be considered in the determination of the ecological quality status of any given coastal water body in the framework of the WFD. However, despite the relatively ancient existing knowledge on the impact of pollution in the structure of algal-dominated communities, there has been little tradition among phycologists to propose biotic indices based on macroalgae. One exception is the rhodophyta/phaeophyta mean Ratio Index that displays strong changes in relation to water quality (Cormaci et al., 1985; Giaccone, 1991; Cormaci and Furnari, 1991; Giaccone and Catra, 2004; Tunesi, 2004). Another exception is the ecological evaluation index (EEI), recently proposed by Orfanidis et al. (2001), which was designed to estimate the ecological status of transitional and coastal waters under the requirements of the WFD.

Algal-dominated littoral and upper-sublittoral communities developing in rocky shores are severely affected by urban and industrial effluents (Bellan and Bellan-Santini, 1972; Belsher and Boudouresque, 1976). Evidences on the effects of industrial and waste water discharges have been reported for the Fucophyceae (Bellan-Santini, 1968; Arnoux and Bellan-Santini, 1972; Chryssovergis and Panayotidis, 1995; Soltan et al., 2001) and other algae (Belsher, 1977; Terlizzi et al., 2002) highlighting different sensitivity levels for different macroalgal groups.

Most studies dealing with biological indicators in aquatic ecosystems need the collection of small samples that are supposed to represent more or less wide areas or long stretches of shore. Sorting, identifying and quantifying these samples are very time-consuming tasks and need a lot of people and good taxonomical skills. Representativeness and time-consumption are central issues in monitoring designs and they are hardly overcome when working in communities thriving in soft-bottoms or in the water column. However, most macroalgal communities are easily identifiable in the field with easy-to-acquire expertise and, therefore, allow the monitoring of wide areas with relatively low effort. Moreover, the incorporation of Geographical Information Systems (GIS) methodology in habitat and community cartography provides a powerful tool to analyse and represent the data obtained with great accuracy. In fact, cartography of littoral and upper-sublittoral species or communities has been already used in Mediterranean Marine Protected Areas (MPAs) to represent the distribution/abundance of several communities/species as a start for monitoring long-term changes related to anthropogenic disturbances (Bianconi et al., 1987; Meinesz et al., 1999, 2001; Soltan, 2001; Mangialajo et al., 2003; Cottalorda et al., 2004; Mangialajo, 2005).

Here, we describe a methodology aimed at using the cartography of littoral and upper-sublittoral benthic communities as an approach to the use of macroalgae as a key biological quality element for the assessment of the ecological status in coastal waters in the frame of the European Water Framework Directive. This methodology (CARLIT, in short) combines community cartography and available information about the value of the communities as indicators of water quality, using GIS technology, to provide an index that fulfils the requirements of the abovementioned Directive: it takes into account sites in reference conditions and it is expressed as a numerical value ranging between zero and one. We report the application of this methodology to the coast of Catalonia (North-Western Mediterranean), which is presented as a case study.

2. Method description

The sampling survey consists in a run of the entire coast to be assessed with a small boat kept as close as possible to the shoreline. Littoral and upper-sublittoral communities (or combination of communities) are identified and directly annotated in a graphic display (aerial photographs, nautical carts or orto-photographs). This graphic support has to be of an appropriate scale (in our case the scale was of 1:10,000 or 1:5,000, smaller enough to differentiate the shorter sector length to be cartographied) and suitable to be used in the field. The final result is a partition of the rocky shoreline in several sectors, each one characterized by a community category (corresponding to a single community or combination of communities) (Table 1). Sedimentary shores are usually not considered – with the exception of extremely sheltered environments and coastal lagoons where both seagrasses and certain species of seaweeds can be abundant – because they are most of the times devoid of any apparent animal or vegetal coverage. Highly human-modified water bodies such as the inner part of harbours and marinas are not sampled, as they do not reflect the environmental quality of the adjacent coast.

We have chosen the Catalan coast (North-Western Mediterranean) as a case study. Catalonia displays a high morphological coastal heterogeneity as well as a high diversity of land and coastal uses (Agència Catalana de l'Aigua, 2005), thus being an excellent region to validate the performance of new environmental monitoring methodologies. The Catalan coast is divided into several water bodies according to their typologies (Vincent et al., 2002) and their anthropogenic pressures and resulting environmental impacts (Agència Catalana de l'Aigua, 2005) (Fig. 1).

Sampling was performed along the totality of the rocky shores present in the Catalan coast, which represents about 43% of the entire coast (402 km at a scale of 1:5,000). The length of each measured sector was at least of 50 m smoothed to the path of the small boat used at a distance of about 3 m of the shoreline. Sampling was performed in the shortest possible period of time in order to reduce the effect of the great seasonal variability associated to

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Table 1
Summarized description and sensitivity levels of the main community categories distinguished in the monitored coasts

Category	Description	Sensitivity level
Cystoseira mediterranea 5	Continuous belt of *C. mediterranea*/*stricta*	20
Cystoseira crinita	Populations of *C. crinita*	20
Cystoseira balearica	Populations of *C. balearica*	20
Cystoseira sheltered	Populations of *Cystoseira foeniculacea*/*barbata*/*spinosa* v. *tenuior*/*compressa*v.*pustulata*	20
Posidonia reef	Barrier and fringing reefs of *Posidonia oceanica*	20
Cymodocea nodosa	*Cymodocea nodosa* meadows	20
Zostera noltii	*Zostera noltii* meadows	20
Trottoir	Build-ups of *Lithophyllum byssoides*	20
Cystoseira mediterranea 4	Almost continuous belt of *C. mediterranea*/*stricta*	19
Cystoseira mediterranea 3	Abundant patches of dense stands of *C. mediterranea*/*stricta*	15
Cystoseira mediterranea 2	Abundant scattered plants of *C. mediterranea*/*stricta*	12
Cystoseira compressa	Populations of *C. compressa* v. *compressa*	12
Cystoseira mediterranea 1	Rare scattered plants of *C. mediterranea*/*stricta*	10
Corallina	Belt of *Corallina elongata* without *Cystoseira*	8
Haliptilon	Belt of *Haliptilon virgatum*, without *Cystoseira*	8
Mytilus	Mussel (*Mytilus galloprovincialis*) beds, without *Cystoseira*	6
Encrusting corallines	Belt of *Lithophyllum incrustans*, *Neogoniolithon brassica-florida* and other encrusting corallines	6
Green algae	Upper sublittoral belts of *Ulva* and *Cladophora*	3
Blue greens	Communities dominated by Cyanobacteria and *Derbesia tenuissima*	1

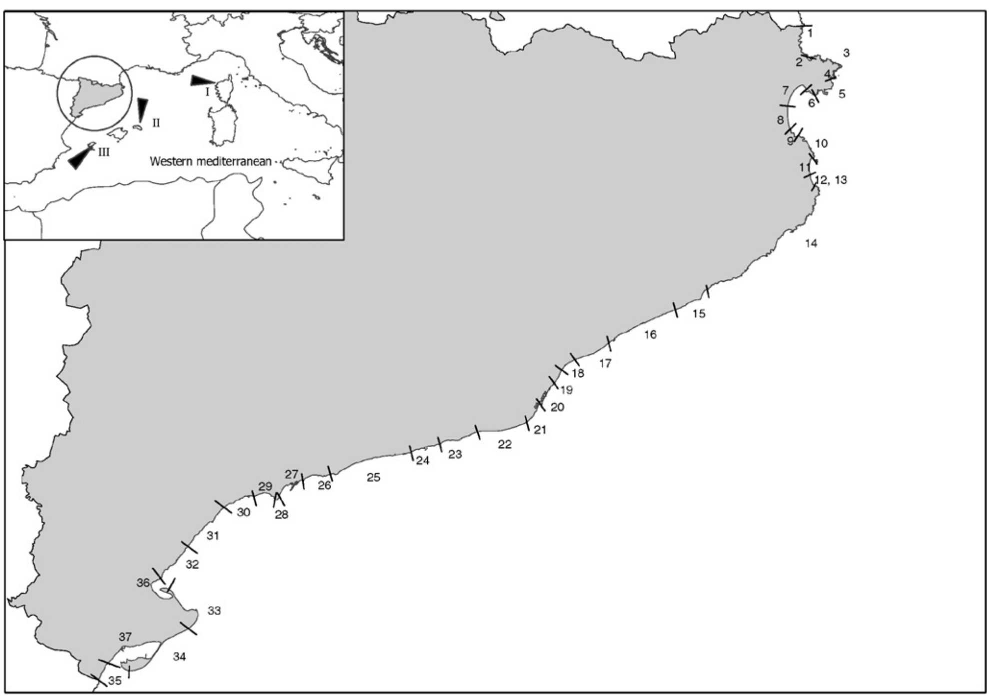

Fig. 1. Geographical situation of Catalonia in the Western Mediterranean and the reference zones (arrows): Corsica (I), Menorca (II) and Eivissa-Formentera (III). The coast of Catalonia is divided into 37 water bodies delimited according to their typology and anthropogenic pressures and impacts.

the littoral communities used as indicators (Ballesteros, 1989, 1991). The best period to carry on this kind of study in the North-western Mediterranean is spring (from April to June), but this may vary when considering other geographical areas.

The presence and the abundance of several littoral and sublittoral communities respond to the natural geomorphological variability of the coastal environment (Ballesteros, 1992) and it is not only determined by water quality or anthropogenic disturbances. Thus, geomorphological factors mostly influencing the establishment and the development of the littoral and upper-sublittoral communities were defined in each resulting sector of coastline. Each geomorphological factor considered is partitioned into several categories, i.e. geomorphological categories (Table 2).

Information obtained both about community categories distribution and geomorphological variables is transcribed into a geo-referenced graphical support (e.g. orto-photographs), on a Geographical Information System (GIS). The coastline generated over this graphical support can

Table 2
Geomorphological variables and categories distinguished for every sector of coast

Geomorphological factors	Levels
Coastline morphology	High continuous coast Low continuous coast Metric blocks Decimetric blocks
Substrate constitution	Calcareous Metamorphic rock Granite Sandstone Conglomerate
Coastline slope	Horizontal Sub-vertical Vertical Overhanging
Coastline orientation	North Northeast East Southeast South Southwest West Northwest
Natural or artificial	
Degree of wave exposure (perpendicular distance to the nearest coast)	0–500 m 500–1000 m >1000 m Island

show strong changes from one year to another (due to the building of new harbours or jetties, dredging, beach regeneration), and, thus, has to be regularly updated. The coastline is divided into the sectors defined during the sampling survey. Every single sector of the coast is characterized by the community category and the different geomorphological features.

Sensitivity levels regarding the vulnerability and the resistance of communities to environmental stress related to water quality are assigned to each community category based on previous knowledge. Information about the sensitivity levels of Mediterranean littoral and upper-sublittoral communities has been obtained from expert judgement and from the numerous available publications and reports on this subject (e.g. Bellan-Santini, 1968; Golubic, 1970; Belsher, 1977; Ballesteros et al., 1984; Boudouresque, 1985; Rodríguez-Prieto and Polo, 1996; Rodríguez-Prieto et al., 1997; Panayotidis et al., 1999; Soltan et al., 2001; Pinedo et al., in press). A scale from 1 to 20, with values increasing from low to high sensitivity levels, is established in our case study (Table 1), but it is possible to use any other scale.

A first environmental quality assessment of any stretch of coastline (i.e. corresponding to a water body or whatever) can be calculated as

$$\mathrm{EQ} = \frac{\sum (l_i * \mathrm{SL}_i)}{\sum l_i}$$

where

EQ environmental quality of a particular stretch of coastline,

l_i length of the coastline occupied by the community category i,

SL_i sensitivity level of the community category i.

The Water Framework Directive states that the results of the classification systems shall be expressed as ecological quality ratios (EQR) for the purposes of classification of ecological status. These ratios represent the relationship between the values of the biological parameters observed for a given water body and the values for these parameters in the reference conditions applicable to that body. The ratio is therefore expressed as a numerical value between zero and one, with high ecological status represented by values close to one and bad ecological status by values close to zero:

$$\mathrm{EQR} = \frac{\text{Observed values of biological parameters}}{\text{Reference values of the biological parameters}}$$

In our approach three undisturbed (or with only very minor disturbances) sites were selected for deriving reference conditions and they were chosen in order to represent the whole Western Mediterranean coasts, Alboran Sea excluded. One site is located in Corsica (coastal front of the Regional Natural Park of Corsica) and two in the Balearic Islands (MPA of North Minorca and MPA of Eivissa and Formentera) (Fig. 1). These sites cover a wide range of coastal geomorphologies, from different geological origins (volcanic, granite, calcareous, metamorphic) to different wave exposures and coastal morphologies. The reference sites were surveyed and cartographied following the methodology described above.

Combining the six geomorphological variables used (see Table 2) for the three reference sites we obtained 174 different real situations, corresponding to sites characterized by one unique combination of geomorphological categories (e.g. high continuous coast, calcareous, vertical, north, natural, island). A non-metric multidimensional scaling (MDS) analysis (Clarke and Warwick, 1994) was performed regarding all these 174 different situations and the percentage of coast occupied by each community category for each situation, in order to assess which are the most relevant geomorphological situations to be taken into account.

Results of this MDS analysis shows that "Coastline morphology" (Fig. 2) and "natural/artificial" (fig. 3) are the most important variables determining the community categories found in the reference sites. The combination of these variables permits to define six different "geomorphological relevant situations" (GRS) (Table 3). The values of EQ are calculated for each one of these GRS situations taking into account all the sectors of coast belonging to each GRS present in the three reference sites. The

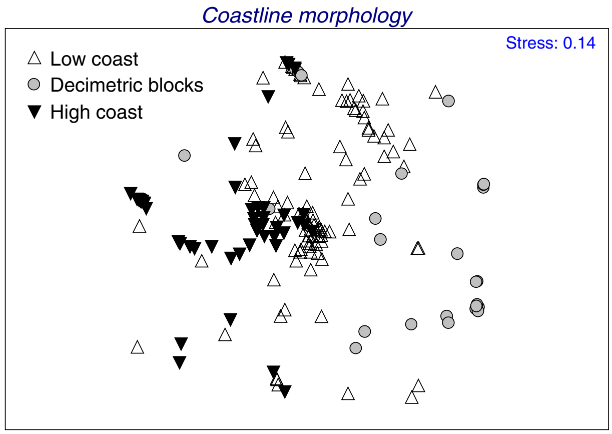

Fig. 2. MDS analysis: distribution of the 174 different situations resulting from all the available combinations of the geomorphological variables considered in reference sites according to the percentage of coast occupied by each community category for each situation. High coast, low coast + metric blocks and decimetric blocks are indicated with different symbols.

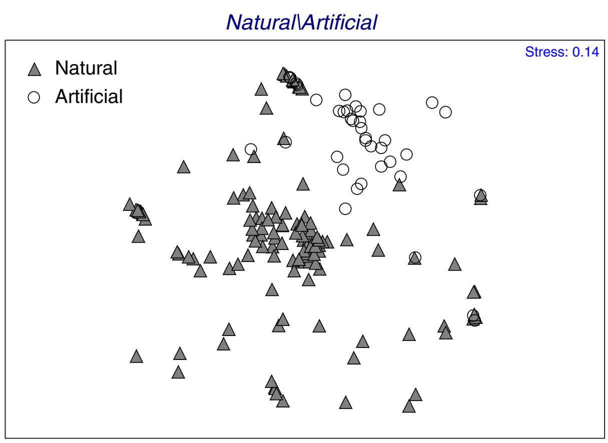

Fig. 3. MDS analysis: distribution of the 174 different situations resulting from all the available combinations of the geomorphological categories considered in reference sites according to the percentage of coast occupied by each community category for each situation. Natural and artificial substrates are indicated with different symbols.

Table 3
Ecological quality values (EQ_i) calculated for the six geomorphological relevant situations in reference conditions

Geomorphological relevant situation (i)	Coastal morphology	N/A	EQ_i
1	Decimetric blocks	Artificial	12.1
2	Low coast	Artificial	11.9
3	High coast	Artificial	8.0
4	Decimetric blocks	Natural	12.2
5	Low coast	Natural	16.6
6	High coast	Natural	15.3

obtained values of EQ are, thus, considered to be the highest possible for each GRS.

Table 4
Correspondence between ecological quality ratios (EQR) intervals and ecological status (ES) classes according to expert judgement of our data and the normative definitions of the classes in the WFD

EQR	Ecological status (ES)
>0.75–1	High
>0.60–0.75	Good
>0.40–0.60	Moderate
>0.25–0.40	Poor
0–0.25	Bad

The EQR of every sector of coast is thus calculated as the quotient between the EQ obtained at the study site and the EQ obtained in the reference sites corresponding to the same "geomorphological relevant situation".

Therefore, the EQR of a coast is calculated according to the following formula:

$$\mathrm{EQR} = \frac{\sum \frac{\mathrm{EQ}_{\mathrm{ssi}} * l_i}{\mathrm{EQ}_{\mathrm{rsi}}}}{\sum l_i}$$

where

i situation,
$\mathrm{EQ}_{\mathrm{ssi}}$ EQ in the study site for the situation i,
$\mathrm{EQ}_{\mathrm{rsi}}$ EQ in the reference sites for the situation i,
l_i Coastal length in the study coast for the situation i.

The EQR value ranges from 0 to 1. According to the WFD, water bodies have to be classified into five ecological status (ES) classes as defined in Annex V of the WFD, ranging from high ecological status to bad ecological status. The settings of the boundaries in the EQR values corresponding to different ecological status classes must align with the normative definitions of the classes in the Directive and shall be established through the intercalibration exercise (Vincent et al., 2002). In a first approach, and according to our data, we propose the correspondence between EQR and Ecological Status Classes as reported in Table 4.

3. Case study

This methodology has been applied to the Catalan coast every year since 1999. The geomorphological variables of the different sectors of the Catalan coast were evaluated in 2001, together with the geomorphological and community cartography of the reference sites. Here we present the results corresponding to the monitoring of May 2005.

The Catalan coast is divided into 37 water bodies (WB) defined according to their typology and their anthropogenic pressures and impacts (Fig. 1; Agència Catalana de l'Aigua, 2005), as proposes the WFD (for details see Vincent et al., 2002; Borja et al., 2004). Two water bodies do not correspond to coastal but transitional waters (WB 36 and 37). Furthermore, only two of the remaining water bodies (WB 33 and 34) are completely devoid of rocky shores and, therefore, most areas of the Catalan coast can be evaluated by the CARLIT methodology. According to the results presented in Table 5 and Fig. 4, the Catalan coast can be divided into four different zones. The northern coast (WB 1 to 14) has mostly a good to high ecological status, with the exception of two bays affected by the runoff of four river mouths. Most of the central coast (WB 15 to 25) has a poor to moderate ecological status (with one water body, situated very close to the city of Barcelona, with a good status). The southern coast (WB 26 to 31) mainly has a good ecological status. The southern-most coast (WB 32 to 37) is highly influenced by the Ebro river and it is, therefore, mainly sandy; however the reduced rocky areas are mostly classified as having a good to moderate ecological status.

Table 5
Ecological quality ratio (EQR) and ecological status (ES) corresponding to every water body from Catalonia for the year 2005

Water body code	Water body name	EQR	ES
1	Portbou-Llançà	0.85	High
2	Badia de Port de la Selva	0.71	Good
3	Cap de Creus	0.68	Good
4	Badia de Cadaqués	0.43	Moderate
5	Cap Nofeu	0.88	High
6	Canyelles	0.90	High
7	Roses-Castelló d'Empúries	0.55	Moderate
8	Sant Pere Pescador-Fluvià	0.59	Moderate
9	L'Escala	0.65	Good
10	Montgrí	0.86	High
11	Torroella de Montgrí-el Ter	0.51	Moderate
12	Pals-Sa Riera	0.27	Poor
13	Sa Riera	0.27	Poor
14	Begur-Blanes	0.98	High
15	Blanes-Pineda de mar	0.66	Good
16	Pineda de Mar-Mataró	0.59	Moderate
17	Mataró-Montgat	0.54	Moderate
18	Montgat-Badalona	0.48	Moderate
19	Sant Adrià del Besós	0.46	Moderate
20	Barcelona	0.57	Moderate
21	Llobregat	0.39	Poor
22	El Prat de Llobregat-Castelldefels	0.25	Poor
23	Sitges	0.53	Moderate
24	Vilanova i la Geltrú	0.49	Moderate
25	Cubelles-Altafulla	0.57	Moderate
26	Tarragona Nord	0.72	Good
27	Tarragona-Vila-seca	0.46	Moderate
28	Cap de Salou	0.62	Good
29	Salou-Cambrils	0.49	Moderate
30	Cambrils-Mont-roig del Camp	0.66	Good
31	Vandellós i l'Hospitalet de l'Infant	0.74	Good
32	L'Ametlla de Mar	0.63	Good
33	Delta Nord	–	Not evaluated
34	Delta Sud	–	Not evaluated
35	Alcanar	0.56	Moderate
36	Badia del Fangar	–	Transitional waters
37	Badia dels Alfacs	–	Transitional waters

When considering the Catalan coast as a whole and evaluating coastal sectors that correspond to the different municipalities we obtain that 41.8% of the coast is in High condition, 32.7% is in Good condition, 23.5% is in moderate condition and 1.9% is in Poor condition. Only 0.04% of the rocky coast is qualified as being in Bad condition. It is necessary to remain here that the inner parts of harbours and marinas have not been considered as they are included in the category of highly modified water bodies and they do not represent the ecological quality of the open waters. However, some of the communities developing in such areas are dominated by blue green algae and, therefore, they could be assessed as being in Bad ecological quality.

4. Discussion

As a monitoring tool, the CARLIT methodology shows many advantages over methodologies involving sample collection. Above all it is a non-destructive methodology, which is important if we take into account that most *Cystoseira* species (and other seaweeds of the order Fucales which dominate the intertidal zone in most temperate to subtropical areas) are very sensitive and vulnerable to natural or anthropogenic disturbances and have very slow recovery rates (Thibaut et al., 2005; Arévalo et al., in press).

The absence of samples implies lack of laboratory work, which allows a quick processing of the data and reduces the total cost of monitoring. However, the development of the GIS with the introduction of the whole set of geomorphological data is a very slow process, but once the GIS is created it can be used from year to year with small modifications. Thus, EQR values and the final assessment of the ecological status, are quickly and easily achieved once the GIS is developed and the field monitoring performed.

The littoral environment displays a high physical and biological heterogeneity. The selection of one to few specific stations (with one or a few samples each) to assess the ecological quality of a water body that can spread over several tens of km of rocky shore has a substantial risk of not being representative. The CARLIT methodology lessens or completely obviates this risk because all (or a great section) of the shore is monitored and the variability of the macroalgal populations associated to physical or other environmental variables is integrated for each water body. Furthermore, the continuous monitoring of the coastline allows the location of small sewage outfalls and other environmental problems at a reduced scale, which is extremely important in the establishment of accurate management plans.

The CARLIT methodology major limitation is that it cannot assess shorelines which are completely sandy, even if there are rocky bottoms in the lower sublittoral or offshore that are suitable for macroalgal growth. Furthermore, the assessment of coastlines with low percentages

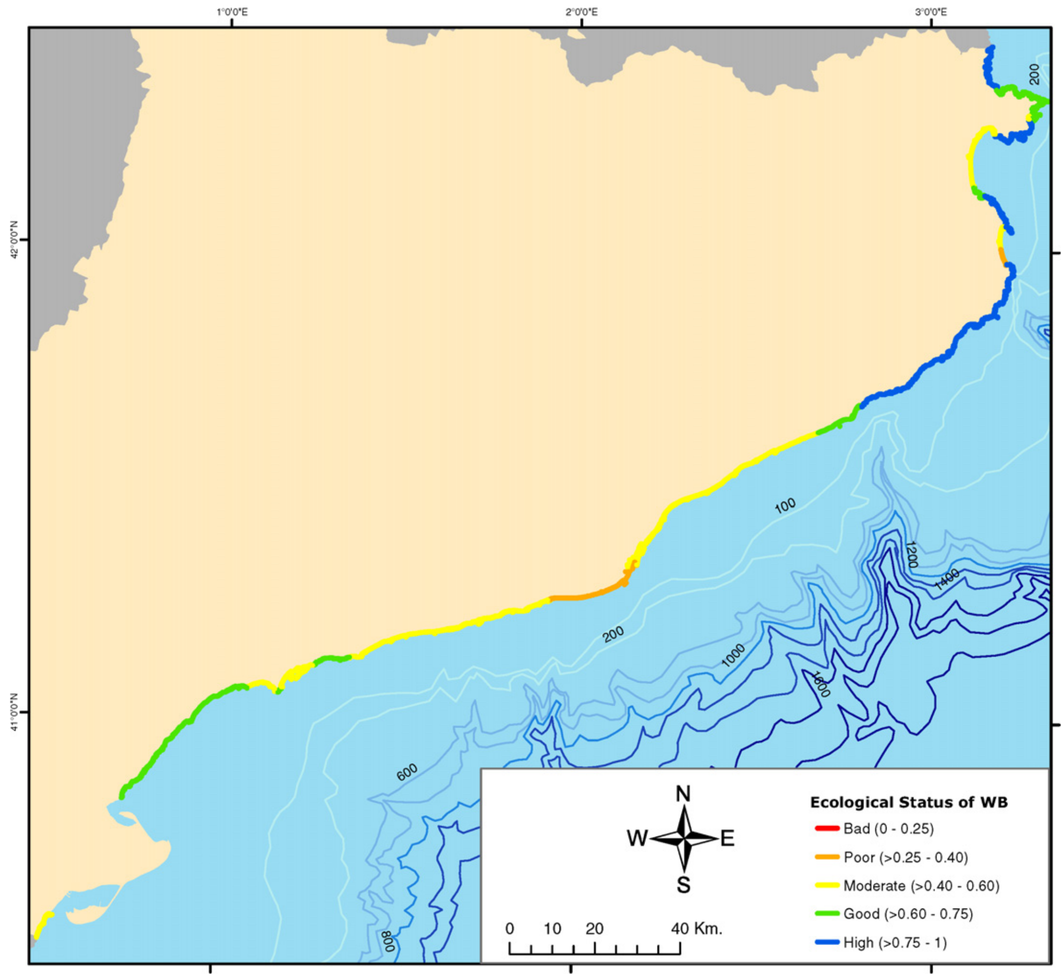

Fig. 4. Cartographical representation of the Ecological Status of the different water bodies present in the Catalan coast in 2005.

of rocky shores may be undervalued due to the lower structural complexity of their upper-sublittoral macroalgal stands, which often lack of extensive *Cystoseira* assemblages (authors, pers. obs.).

Another possible objection is that the CARLIT methodology only takes into account the algal assemblages present in a narrow belt in the limit between the littoral and sublittoral zone, ignoring the much more extensive sublittoral assemblages. However, in some aspects this drawback can be considered as an advantage because littoral communities are more prone to be affected by several pollutants that, together with the desalinated water plume, flow near the sea suface (Soltan et al., 2001). Moreover, sublittoral stands are strongly affected by anthropogenic factors other than water pollution, such as over-fishing and its cascading effects (Sala et al., 1998) or, even, global hydrological changes (Alongi et al., 2004; Serio et al., 2006) that can mask or interfere with the effects of pollution.

The choice of reference sites and sensitivity levels for each community category can be changed according to the Mediterranean region that is being assessed, always taking into consideration the available information on species and communities and expert judgement for each region. It is also important to stress that, especially in regions with very long coastlines, it is not necessary to monitor the entire coastline but randomly chosen representative subsectors of the coast for each water body.

Several studies have reported outstanding vegetation changes in the intertidal zone along environmental pollution gradients (e.g. Littler and Murray, 1975; Murray and Littler, 1978; Fairweather, 1990; López Gappa et al., 1993; Díez et al., 1999) and we are confident that CARLIT methodology can be applied to other seas. However, its application will require several transformations, such as the sampling method (terrestrial or aerial), or the communities to be evaluated and their sensitivity levels.

The assessment of the ecological status of the water bodies from the Catalan coast with the CARLIT methodology closely agrees with the results obtained in the same coast by Pinedo et al., in press using samples collected in the upper-sublittoral zone, multivariate analytical methods to detect environmental quality gradients, and expert judgement to establish the ecological status classification. The northern coast, with mostly a good to high ecological status, has tourism as the main economical sector, with low industrial development, agriculture based on irrigated

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crops, and a high percentage of land covered by Mediterranean forests (Agència Catalana de l'Aigua, 2005). The central coast, with poor to moderate ecological status, is mainly composed by urban and industrial land, with vineyards as the main crop in some areas (Pinedo et al., in press). The southern coast, with a good ecological status, is mainly occupied by Mediterranean crops not requiring irrigation, tourism being an emergent economical sector (Agència Catalana de l'Aigua, 2005). Finally, the southern-most coast, with a moderate ecological status, is mainly affected by the runoff of the Ebro river, whose waters drain most of the northeastern Iberian Peninsula from the forested mountains of the Central Pyrenees to irrigated crops from the lower Ebro basin; it also has moderate industrial development in its lower part (Agència Catalana de l'Aigua, 2005). Therefore, results obtained by the application of the CARLIT methodology in Catalonia are in agreement with results obtained by usual rocky shore sampling methodologies and the anthropogenic impacts and pressures of each sector of coast evaluated. Application of the CARLIT methodology to other Mediterranean areas is highly recommended in the frame of the European WFD in order to properly evaluate its helpfulness and shortages.

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