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Macroalgae, a suitable indicator of the ecological status of coastal rocky communities in the NE Atlantic

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ABSTRACT

Despite the great importance of shallow rocky communities (<30 m deep) due to their contribution to the biodiversity of coastal waters, most efforts in ecological status assessment of marine waters have been carried out in the implementation of soft bottom biotic indices. Therefore, in this paper, a methodology for the environmental evaluation of coastal rocky communities for the Bay of Biscay (NE Atlantic), the CFR index (Quality of Rocky Bottoms), is presented. This index is based on the analysis of seaweed communities throughout the depth gradient, from the intertidal to the shallow subtidal, through the combination of a multimetric approach, which combines the richness of characteristic macroalgae populations, their total cover, the presence of opportunistic species and the physiological condition of the whole macroalgae community. Quality thresholds for these indicators are based on both ecological data and expert judgment. Finally, a preliminary application of this metric to sites with theoretically good and bad environmental conditions is used to analyze the suitability of the index. As a result, the four selected indicators responded in a significant way to the pressure gradient tested, proving to be appropriate for the type of pressure analysed and obtaining coherent results in the final quality assessment with the CFR index. In conclusion, the CFR index has proved to be an effective tool for the assessment of the ecological quality of coastal rocky communities, based on the analysis of macroalgae assemblages.

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1. Introduction

As registered in other regional seas within the Northeast Atlantic biogeographic region (NEA), rocky substrates are very abundant on many coastal areas all along the North coast of Spain (Bay of Biscay), making possible the development of a great variety of benthic communities that are dominated, in most cases, by different species of macroalgae (Van den Hoek, 1975; Borja et al., 2004). From the intertidal to the shallow subtidal (<30 m), a continuous and heterogeneous mosaic of environments (platforms, blocks, pools, ridges, crevices, overhangs) are colonized by the most competitive assemblages of species of flora and fauna in response to a combination of physical (tide, wave exposure, light, substrate), chemical (salinity, nutrients) and biological factors (competence). Moreover, the contribution of the rocky benthic communities (''coastal reefs'') to the specific richness and, consequently, to the structural and functional biodiversity of the marine environment seem to be very significant (McRoy and Lloyd, 1981), as recognized by their proposal as natural habitats of communitary interest, whose conservation requires the designation of Zones of Special Conservation at European level (92/43/CE Habitat Directive, habitat code 1170: reefs). In the same way, benthic habitats remain as an

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important part of the "coastal water bodies" established for the implementation of the Water Framework Directive (WFD 2000/60/CE).

Based on the extensive field work carried out during the last century, general patterns of distribution and specific composition of intertidal communities have been documented worldwide (cf. Raffaelli and Hawkins, 1996) and have usually been applied as reference conditions for comparisons in ecological and biogeographic studies at regional scales (e.g. Fischer-Piette, 1955; Anadón and Niell, 1981; Borja et al., 2004). Nevertheless, the information concerning subtidal communities on hard substrates is more recent, scarce and often limited to specific at-risk sites due to anthropogenic activities (habitat modification, pollution, overexploitation of living resources) (Borja, 1994; Juanes and Canteras, 1995; Gorostiaga and Díez, 1996), or provided through the global assessment of commercial stocks of seaweeds (cf. Juanes and Sosa, 1998).

Broad-scale mapping studies of reef communities, together with information on the biological and environmental tolerances of different species and assemblages, constitute an important management tool needed for the ecological assessment of sustainability of these habitats (cf. Díaz et al., 2004). Responses of seaweed communities to common anthropogenic disturbances in coastal areas have been summarized by Orfanidis et al. (2001). However, it is not known which species are most sensitive in any particular situation and these will not be constantly present even under good water quality conditions (Wells, 2006).

Moreover, Ecological State Groups of marine benthic macrophytes (ESG) based on their functional characteristics and growth strategies (Littler and Littler, 1980) have been included in different indices for the assessment of the ecological status of this biological element (e.g. Orfanidis et al., 2003; Wells, 2004). Nevertheless, we still fail to precisely establish the limits for the natural variability in the benthic communities and, consequently, we are unable to discriminate many of the ecological responses registered because of natural or anthropogenic disturbances (e.g. Echavarri et al., 2007). Establishing causal relationships between stressors and effects at the individual, species or community level on marine systems is a difficult task that requires the use of multiple lines of evidence (Adams, 2005). Thus, there is an urgent need for tools that contribute to the management of human activities in the marine environment, by providing indicators that measure the extent of impact of an activity on part of the ecosystem (Rogers and Greenaway, 2005).

Evidence on the suitability of benthic macrophytes as indicators of effects against different pollution gradients is undoubted (e.g. Chryssovergis and Panayotidis, 1995; Schiel et al., 2006). Likewise, the inclusion of macroalgae in the list of biological quality elements to be used for the assessment of the ecological status of coastal waters in the context of the European Water Framework Directive has supported such a capacity. Hence, important advances in the development of specific indices for evaluation of this element using different approaches have been carried out in recent years (e.g. Orfanidis et al., 2003; Panayotidis et al., 2004; Wells, 2004; Ballesteros et al., 2007). Adjustment and intercalibration exercises between metrics proposed in the different biogeographic regions (i.e. Mediterranean, NE Atlantic) are under development and will allow more comprehensive improvement in the assessment of this element. Moreover, as argued by Ballesteros et al. (2007), further applications of those methods to other water types will require, in most cases, several transformations of the biological assemblages, reference conditions or the sampling design.

Despite the current differences among indices, an important question arises on the actual extension of the management units to be evaluated. At present, most of the proposed metrics have been developed for the assessment of a very small part of the already defined water bodies (sensu WFD), the intertidal zone. Nevertheless, according to the Habitats Directive (92/43), coastal reefs, including both the intertidal and the subtidal environments, constitute an ecological unit, whose conservation management must be focused from an integrated point of view. Reasons for the exclusive use of intertidal communities as the assessed element were provided by Ballesteros et al. (2007) regarding the likely effects of pollutants and desalinated water plumes, on a coastal zone without significant tidal currents. However, urban and industrial discharges through deepwater submarine outfalls are widespread on all coasts, with a more significant impact on subtidal communities. Besides, ecological status is concerned with other kinds of anthropogenic pressures, as important as discharges, that should also be taken into account and that may affect the subtidal communities to a greater extent (e.g. Bolam et al., 2006).

In consequence, in this paper we present a multimetric methodology for the integral environmental evaluation of the Quality of Rocky Bottoms (in short CFR), in agreement with the principles of the WFD and based on the analysis of intertidal and subtidal seaweed communities.

2. General description of the CFR index

The CFR index (GESHA, 2005) provides a quantitative approach for reflecting, in a homogeneous way, the ecological condition of hard substrate habitats throughout the extent of the water bodies in the North coast of Spain (Water Type CW NEA1), based on independent assessment of the quality status at different bathymetric levels (intertidal/subtidal). This metric integrates those features suggested by the European Water Framework Directive (WFD) for the assessment of seaweed communities, including the composition (Richness, R; presence of Opportunistic species, O) and the abundance (Cover, C), complemented with a measure of their conservation status (physiological Status, S). Furthermore, these indicators will comply with the requirements for the evaluation of those "coastal reef habitats" that, regarding the European conservation objectives (Habitats Directive 92/43), are important in each water body.

The quality of the rocky benthos assemblages for a single station is calculated as the arithmetic sum of the specific scores for each indicator at this site ("transect × depth") (Eq. (1)):

$$\mathrm{CFR} = R + C + O + S \tag{1}$$

The Richness value (*R*) evaluates the number of different "characteristic macroalgae" populations that are present along the transect with a significant coverage (ca. > 1%), according to a previously established list for each biogeographic region. Moreover, the Cover score (C) assesses the relative extent of the whole sampling unit that is occupied by those assemblages, considered all together. In this case, different quality thresholds must be considered for diverse degrees of exposure of intertidal sites and depth ranges of subtidal stations, as well as the morphological characteristic of substrates. The third indicator quantifies the abundance of Opportunistic species (O) in relation to the total vegetated surface, as one of the first symptoms of several anthropogenic disturbances, mainly related to nutrient enrichment. In addition, the assessment of the physiological Status of macroalgae (S) takes into account an expert estimation about the ''health'' of the whole macroalgae community through the combined analysis of different environmental features (reduced development of fronds, low densities, depigmentation, physical damage, level of epiphytism), which might not be related to natural causes.

The preliminary proposal of the index (GESHA, 2005) considered a range of the CFR values from 0 to 100, with balanced contributions of the four indicators (0–25 points). Differential weights for the selected indicators were later adjusted through the assignment of dissimilar specific ranges of scores for each single indicator (cover: 0–40 points; opportunistic species: 0–30 points; richness and physiological status: 0–15 points), established after the application of a ''Delphi consultation'' between experts from the different Spanish Northeast Atlantic regions (Juanes et al., 2006).

Furthermore, a prior definition of (a) ''characteristic species'' of macroalgae that constitute well-defined, conspicuous populations, (b) ''opportunistic species'' related to anthropogenic disturbances and (c) ''invasive species'' was carried out (Table 1) according to the specific works for this coastal area (Anadón and Niell, 1981; Juanes and Gutiérrez, 1991; Juanes et al., 2005). The former group of species is the basis for the estimation of cover, richness and physiological status.

Regarding the application procedure, the basic ''sampling unit'' for the assessment of the four indicators was established as one random surface of standardized length and width (''transect''), according to the specific characteristics of each station (intertidal/subtidal). In the intertidal zone, transects include the fringe usually colonized by macroalgae, from the mid-littoral to the infralittoral, covering a 5 m coastline length stretch. Conversely, in the subtidal zone, random transects of 25 m of length and 5 m of width were proposed for different ranges of depth, considering direct surveys by scuba divers. A minimum number of three replicates per station was suggested as optimum, which means values will be representative of the CFR score for that site. Only sufficiently large, stable substrata suitable for colonization by macroalgae are used for the CFR assessment. In addition, a correction factor of this indicator should be introduced for those sites with significant natural sedimentary zones or where the abundance of unstable substrates may suppose a clear difficulty for the colonization by macroalgae.

Alternatively, in order to facilitate the extensive application of this index in subtidal areas, the index is being validated for the use of new technologies, such as Remotely Operated Vehicles (ROV), as a useful tool to carry out different kinds of subaquatic works (Guinda et al., 2006).

Taking into account the seasonal variability of macroalgae communities, the suitable period for application of the CFR index is from late spring (June) to late summer (September), the period of maximum development for most seaweed

Table 1 – Lists of ''characteristic'' ''opportunistic'' and ''invasive'' species of macroalgae'' for the intertidal and the subtidal environments of Cantabria (N Spain, Bay of Biscay)

Characteristic species		Opportunistic species	Invasive species
Intertidal	Subtidal		
Bifurcaria bifurcata	*Calliblepharis ciliata*	*Blidingia* spp.	*Sargassum muticum*
Caulacanthus ustulatus	*Cladostephus spongiosus*	*Bryopsis* spp.	
Cladostephus spongiosus	*Codium tomentosum*	*Chaetomorpha* spp.	
Codium tomentosum	*Corallina* spp.	*Cladophora* spp.	
Corallina spp.	*Cystoseira baccata*	Ectocarpales	
Cystoseira baccata	*Cystoseira tamariscifolia*	*Enteromorpha* spp.	
Fucus spp.	*Desmarestia ligulata*	*Ulva* spp.	
Gelidium latifolium	*Dictyopteris membranacea*	*Ceramium* spp.	
Gelidium sesquipedale	*Dictyota dichotoma*		
Gigartina spp.	*Gelidium sesquipedale*		
Laminaria ochroleuca	*Halidrys siliquosa*		
Laurencia spp.	*Halopithys incurvus*		
Leathesia difformis	*Halopteris filicina*		
Litophyllum tortuosum	*Halurus equisetifolius*		
Nemalion helminthoides	*Heterosiphonia plumosa*		
Pelvetia canaliculata	*Laminaria ochroleuca*		
	Peyssonnelia sp.		
Saccorhizza polyschides	*Saccorhizza polyschides*		
Styphocaulon scoparia	*Spatoglossum solieri*		
	Sphaerococcus coronopifolius		
	Styphocaulon scoparia		
	Taonia atomaria		

Table 2 – Numerical scoring system for the assignment of the ecological status of each sampling station

CFR values	EQR	Status
83–100	0.83–1	High
62–82	0.62–0.82	Good
41–61	0.41–0.61	Moderate
20–40	0.2–0.4	Poor
0–19	0–0.19	Bad

populations in temperate seas. This will avoid the seasonal episodic explosion of ephemeral species occurring in April–May (“naturally opportunistic species”).

Finally, assignment of quality status for each station was established according to the five classes proposed by the Water Framework Directive, following the boundaries indicated in Table 2. This scale is based on the same ranges proposed by the REFCOND (2003) for the boundaries of the ecological quality ratios (EQR), so, dividing each value by 100 the corresponding EQR value is obtained.

3. Location of assessment sites

Selection of sampling stations within a specific water body should take into account the total extent of the hard substrates and the depth gradient. Distribution of seaweed populations along that gradient responds to the combination of different physical, chemical and biological factors, making up specific zonation patterns. Such models for the vertical distribution of intertidal macroalgae along the north coast of Spain (Bay of Biscay) were outlined by Anadón (1983), showing differences in the characteristic intertidal belts due to biogeographic features (longitudinal variation) and to the exposure conditions.

In the same coastal area, significant differences in the quantitative composition of subtidal benthic communities (fauna and flora) were observed along several depth ranges (Juanes and Canteras, 1995; Juanes et al., in preparation), but without a clear knowledge of the actual diversity and heterogeneity of those subtidal reef habitats.

The CFR index was developed to be applied in a homogeneous way in both the intertidal and the subtidal communities within a “water body” (*sensu* WFD), but taking into account the singularities of the two environments. Accordingly, two types of coastal sites were distinguished in the intertidal zone: broad semi-exposed rocky platforms, with slope lower than 45°, and exposed cliffs, with slope higher than 45° and mainly vertical substrates.

Concerning subtidal habitats, description of characteristic macroalgae populations and recognition of their general patterns of distribution were carried out based on the use of raw data provided by Juanes et al. (2005). In this work, whose main objective was the mapping of subtidal reef habitats along the 150 km shoreline of Cantabria (N Spain), the seaweed populations were inventoried and quantified in 31 transects, from the lower intertidal to a maximum depth of 25 m.

Along each diving transect, the specific cover of the most conspicuous macroalgae was recorded in homogeneous segments (cf. Juanes et al., 2005). The matrix of “segments” × “cover of characteristic populations of macroalgae” was the basis for performing a Multidimensional Scaling ordination analysis (MDS) in order to find out similarities between species abundances at different ranges of depth. Square-root transformed data were used to calculate the Bray-Curtis similarity measure.

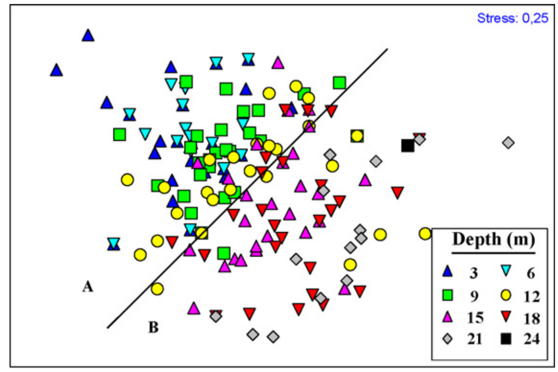

Fig. 1 – MDS analysis distribution of the different subtidal segments according to their relative coverages (% of total segment) of characteristic populations of macroalgae. Symbols for different 3 m deep-class segments are indicated in the legend.

Results of the MDS analysis are shown in Fig. 1. Though overlapping of some class segments demonstrated that the structure of rocky reef assemblages is invariably patchy in space and time (Creese and Kingsford, 1998), a clear depth gradient was noted throughout the vertical profile, with more significant differences between two groups represented by segments from 0 to 12 m depth and from 13 to 24 m depth, respectively.

As a result of the MDS analysis, two subtidal fringes were proposed for standardization of the application of the CFR index. Those were characterized by two depth ranges, one from 5 to 15 m and another from 15 to 25 m.

4. Adjustment of “quality thresholds”

The establishment of the evaluation system for each single indicator has been carried out by the combination of the statistical analyses of ecological data and expert judgment, based on the scientific literature and the knowledge of this ecosystem.

Variability in richness and global cover of the characteristic assemblages of macroalgae in the two selected subtidal fringes (5–15 m and 15–25 m) were analysed independently, based on the raw data on non-standardized segments provided by Juanes et al. (2005), for the previously mentioned transects. The resultant probability distribution functions for each indicator are represented in Fig. 2 (richness values) and 3 (cover percentages).

The richness distribution functions showed a similar increasing pattern at both depth ranges, with the 50% probability value corresponding to about five macroalgae populations (Fig. 2). However, slightly higher richness values were observed in the case of the deeper area, where there was

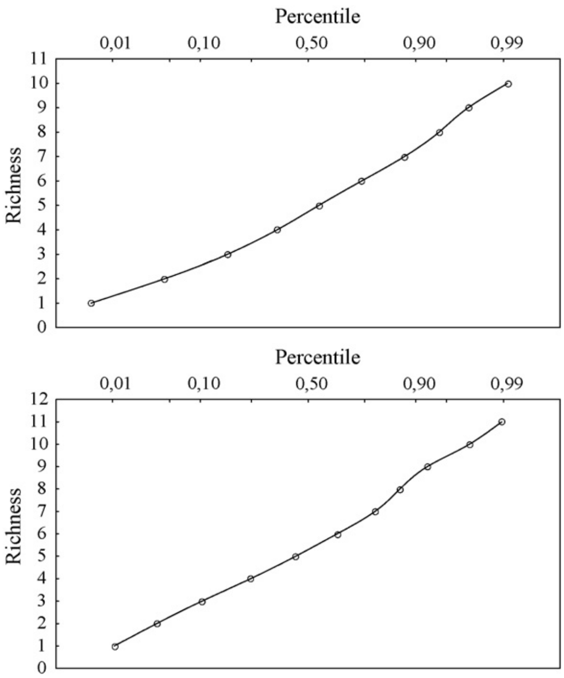

Fig. 2 – **Richness probability distribution functions for data (number of characteristic macroalgae populations) of subtidal segments in the shallower (top graph, 5–15 m) and the deeper (bottom graph, 15–25 m) Cantabrian water bodies (Bay of Biscay).**

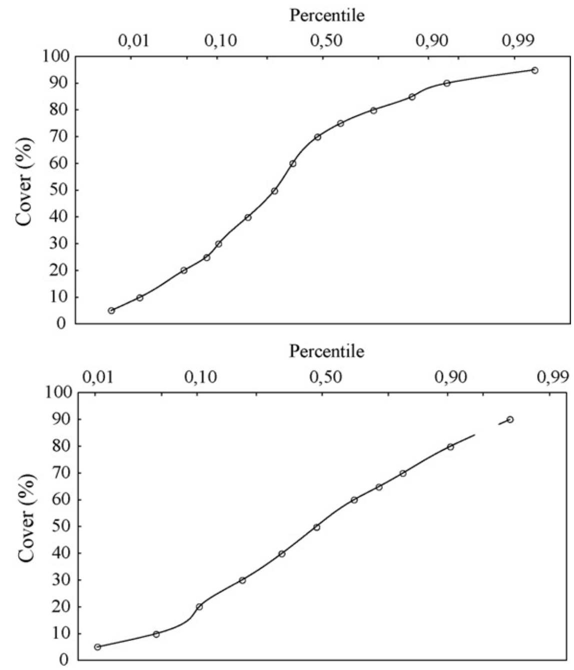

Fig. 3 – **Macroalgae coverage probability distribution functions for data (number of characteristic macroalgae populations) of subtidal segments in the shallower (top graph, 5–15 m) and the deeper (bottom graph, 15–25 m) Cantabrian water bodies (Bay of Biscay).**

a 75% of probability of finding richness values above 4, in contrast to the 65% probability registered in the shallower area. Thus, it is somewhat more probable to find more conspicuous populations of macroalgae in the 15–25 m fringe. Even though, the observed differences were not sufficient to justify the establishment of different scales of evaluation of this indicator at the two levels of the subtidal zone (Table 3).

In contrast, the global cover distribution functions showed clear differences between the two subtidal levels (Fig. 3). In this way, values were notably higher in shallower areas, where 50% probability corresponded to values above 70% of coverage versus values over 50% registered in the distribution function of deeper zones. Moreover, different coverage values correspond to probabilities of 20% (40% coverage at 5–15 m and 30% coverage at 15–25 m) and 5% (20% coverage at 5–15 m and 10% coverage at 15–25 m). Such a different pattern justified the proposal of deep-specific quality thresholds for this indicator in the subtidal zone, corresponding to the given values (Table 4).

Regarding the intertidal zone, the higher visibility and accessibility of the benthic communities of this level provide a better starting point for estimates of macroalgae richness and global cover. According to Wells (2006), shore exposure effects on macroalgae communities produce a significant reduction in abundance of the dominant species and slightly lower average species richness.

Longitudinal and altitudinal variations in this coastal fringe were studied in different regional coasts (cf. Juanes and Sosa, 1998), showing a few types of homogeneous zonation patterns along the N coast according to the richness and coverage of the macroalgae populations

Table 3 – Quality thresholds for richness (number) of the characteristic macroalgae populations in different intertidal types (semiexposed/exposed) and depth ranges

Richness (number of characteristic macroalgae populations)

Score	Semiexp. int.	Exposed int.	5–15 m	15–25 m
15	>5	>3	>5	>5
11	4–5	3	4–5	4–5
7	2–3	2	2–3	2–3
3	1	1	1	1
0	0	0	0	0

Table 4 – Quality thresholds for coverage (%) of the characteristic macroalgae populations in different intertidal types (semiexposed/exposed) and depth ranges

Coverage (%)

Score	Semiexp. int.	Exposed int.	5–15 m	15–25 m
40	>70	>50	>70	>50
30	40–69	30–49	40–69	30–49
20	20–39	10–29	20–39	10–29
10	10–19	5–9	10–19	5–9
0	<10	<5	<10	<5
+10	For substrates that make difficult the settlement of macroalgae			

Table 5 – Quality thresholds for quantification of relative coverage of opportunistic species (% of the surfaces colonized by characteristic populations) in intertidal and subtidal areas

Opportunistic species (% of vegetated surfaces)		
Score	Intertidal	Subtidal
30	<10	<5
20	10–19	5–9
15	20–29	10–19
5	30–69	20–49
0	>70	>50
−10	If invasive species are observed	

present. That made possible the expert proposal of ranges of these indicators for the two levels of shoreline exposure (Tables 3 and 4).

Occurrence of massive proliferations of opportunistic species related to anthropogenic disturbances (mainly green macroalgae due to N-rich discharges) used to be a likely indicator in many impact assessment studies regarding eutrophicated coastal areas. However, quantification of precise coverage thresholds for this species related to different quality status has not yet been suggested. Therefore, expert judgment was the main basis for adoption of two specific scales for assessment of the proportion of opportunistic species on the intertidal and subtidal stations (Table 5). This differential evaluation assumed a more likely occurrence of this type of species in the intertidal conditions, allowing less strict quality limits for these stations.

Furthermore, proposals for establishment of quality thresholds for the physiological condition of benthic communities constitute a subjective task which, although controversial, is necessary. Moreover, the expert diagnosis of global health status of benthic communities may contribute to predict ecological impairments. This was the approach used for the development of the UK assessment methodology for the angiosperms of coastal and marine waters, based on the epiphyte coverage references of seagrasses quoted by Burdick and Kendrick (2001).

In the case of the CFR index, similar quality thresholds were applied to the global evaluation of different features (reduced development of fronds, low densities, depigmentation, physical damage, level of epiphytism) in the whole macroalgae community (Table 6).

Table 6 – Quality thresholds for estimation of the proportion (%) of the macroalgae assemblages showing unhealthy conditions

Physiological status (%)	
Score	Intertidal/subtidal
15	<10
11	10–29
7	30–49
3	50–79
0	>80

5. Application

In accordance with the preceding suggestions and proposals for the application of the CFR index, a preliminary trial of this metric was done in two coastal zones characteristic of a priori good and bad ecological conditions. The former site, named La Arnía, was located within an already designated coastal Special Area for Conservation (SAC, 92/43 Habitats Directive) and, consequently, was selected as representative of a pristine area without anthropogenic pressures. In contrast, the site named Ontón was considered a significantly impacted coastal area (GESHA, 2005), due to the direct discharge to the coastline of effluents from a Fluorine factory (Fig. 4).

In both sites, the CFR index was applied at three stations located within the intertidal zone, at 10 and at 20 m depth subtidal areas, respectively, by means of non-destructive, direct observation methods. Partial scores for each single indicator (*R*, *C*, *O*, *S*) and final CFR values for these stations are summarized in Table 7.

It was observed that single and global scores from La Arnía were in agreement with the expected values for an unaltered site (possible reference conditions), obtaining the maximum values in almost all cases. Consequently, the final state for the three stations was qualified as ‘‘high’’. Likewise, different levels of impairment might be estimated at Ontón after the application of the index. Predicted effects of the industrial discharge were apparently reflected by the different quality scores, with higher intensity in the intertidal level where the algal cover had nearly disappeared. At the subtidal level, the theoretical disturbance seemed to promote the abundance of opportunistic species, mainly in the shallower station, and the general deterioration of the physiological status of the whole community. Therefore, in accordance with what was previously suspected, the final scores for these stations corresponded to a ‘‘bad’’ state, in the case of the intertidal and ‘‘moderate’’ state, for the two subtidal stations.

6. Discussion

According to the preliminary results of the studied sites, the CFR index showed a clear capacity to detect differences in the ecological status of two opposite environmental situations. In addition, the industrial discharge in the coastline of Ontón generated a gradient of disturbance from the intertidal (near-field) to the subtidal (far-field) that was also reproduced in the final scores of this index and so in the ecological status of the three sampling stations of this site. Therefore, it is clear that, from a single evaluation of the intertidal level, the global status of this coastal zone would have been misjudged. Thus, it would have been assumed that these effects would have been attained by all the subtidal communities and that it would remain in a bad state. Otherwise, if only a local effect (near field) had been considered, the quality of the subtidal stations would have been overestimated, giving a good score instead of the moderate level actually assigned. Both types of errors may be reduced by the complementary analysis of the different coastal environments.

In consequence, it seems that differential but homogeneous assessments of the identified depth fringes (intertidal,

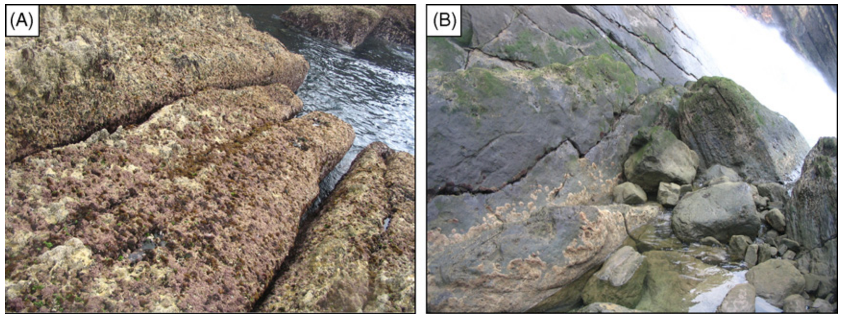

Fig. 4 – General view of the intertidal fringes of the two selected sites for preliminary application of the CFR index. (A) La Arnía: a priori good ecological condition; (B) Ontón, a priori bad ecological condition.

Table 7 – Summary of results of application of the CFR index (single quality scores for each indicator and global value for the index), in three levels along the altitudinal gradient of two coastal sites in theoretical good (La Arnía) and bad ecological conditions (Ontón)

Site	Level	Richness	Coverage	Opport./invasiv.	Physiol. status	CFR	EQR	Ecol. status
La Arnía	Intertidal	15	40	30	15	100	1	High
	5–15 m	15	40	20	15	90	0.9	High
	15–25 m	15	40	30	15	100	1	High
Ontón	Intertidal	3	10	0	0	13	0.13	Bad
	5–15 m	11	30	5	3	49	0.49	Moderate
	15–25 m	11	20	20	3	54	0.54	Moderate

5–15 m, 15–25 m) appear to be one of the strengths of the proposed metric. However, when using subsamples for the characterization or the evaluation of an environmental variable, we always assume a certain degree of uncertainty due to the representativity of those ''land segments'', whose magnitude depends on the variability of the process we analyze (pollution, hydromorphological changes, etc.). In this way, the importance of the precise identification and characterization of the anthropogenic pressures (magnitude, timing, etc.), as well as the evaluation of the natural ranges of variation for the correct sampling design within each water body, should be highlighted (GESHA, 2005). In this sense, the implementation of procedures for the assessment of different biological quality elements (macroalgae, macroinvertebrates, phytoplankton) at water body level is a future task to be solved at the European Intercalibration Groups.

For the intertidal communities, the technical alternative to overcome this problem comes through the application of a methodology that considers the monitoring of all of the shore (or a great stretch), as proposed by Ballesteros et al. (2007). However, this possibility is not suitable for most rocky shores in the NE Atlantic region. Moreover, extensive assessment systems for characterization of macroalgae assemblages in the subtidal zone have not yet been developed; though hydroacustic and ROV technologies have been used in experimental tests in different coastal zones (Parry et al., 2003; Tkachenko, 2005; Guinda et al., 2006).

Anyway, the use of non-destructive, semi quantitative indicators facilitates the application of the CFR index. Thus, the only limitations for extensive application of this index are due to the physical environment (shoreline geomorphology, meteorological and hydrographic conditions for diving) and the total extension of habitats that must be assessed. That sampling option has been also proposed in similar works (Orfanidis et al., 2003; Wells, 2004; Ballesteros et al., 2007) in order to reduce the total cost of monitoring (Panayotidis et al., 2004; Ballesteros et al., 2007) or to avoid the current lack of standardization in detailed taxonomic analyses (Dauvin, 2005) and knowledge of sensitivity of species to different types of disturbance (Wells, 2004).

On the other hand, the four indicators selected have proved to be appropriate for the type of pressure we have analyzed. Thus, richness, cover and opportunistic species varied in a significant way along the pressure gradient, modifying the final score of the index. Close to the discharge point, the practical elimination of the vegetated cover resulted in the worst ecological condition registered in this study. In the shallower subtidal station (5–15 m) the partial recovery of richness values was relatively more significant than that observed for the cover of macroalgae, highlighting the insufficiency of those indices based on the exclusive presence of certain characteristic species (e.g. Wells, 2004) without an additional abundance estimate. In addition, opportunistic species seemed to respond significantly to environmental conditions, despite the industrial character of the discharge. Finally, the physiological status is the only indicator that did not show any significant improvement even at the deepest station, justifying the search for the causes of these apparent effects from other ''lines of evidence'', in the sense of Adams (2005).

At this point, the importance of indices as tools for synthesizing the environmental data in order to advise managers on the decision-making process should be remembered. Traditional ecological studies based on the quantification of the composition and structure of impaired versus control benthic communities (e.g. Gorostiaga and Díez, 1996; Ballesteros et al., 2007; Echavarri et al., 2007) may constitute a perfect and complementary line of evidence to confirm results of synthetic indices. For that purpose, validation of the CFR index is currently being carried out (Guinda et al., 2006).

Fortunately, for the rocky communities in the N coast of Spain (Bay of Biscay-NE Atlantic), the effects of the most significant pressures identified on the coastal zone are restricted to a relatively reduced area. Therefore, it will not be very difficult to find well conserved coastal zones to be used as reference conditions. This may be the case of the site of La Arnía, which ecological conditions were in a high state throughout the depth profile. However, the apparent increase of opportunistic species in the shallower subtidal station highlighted the need for carrying out an extensive application of the CFR index in order to adjust the thresholds for the different indicators.

In conclusion, the multimetric approach applied for the assessment of the ecological quality of coastal rocky communities, the CFR index, has demonstrated that macroalgae may be a good indicator to detect likely effects of anthropogenic pressures (e.g. urban and industrial discharges). However, further applications, intercalibration and validation of this index against traditional ecological analysis are needed in order to better adjust the quality scores and properly evaluate the strengths and weaknesses. In this way, future applications of remotely operated vehicle technologies (ROVs) might improve the effectiveness (time, extent of the total area surveyed) of this methodological approach for its extensive use in the assessment of reef habitats, in an attempt to comply with both the normative and the scientific objectives.

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