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Coastal waters classification based on physical attributes along the NE Atlantic region. An approach for rocky macroalgae potential distribution

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ABSTRACT

According to requirements for intercalibration of assessment methods of vegetation quality elements along the North East Atlantic region, within the scope of the European Water Framework Directive (WFD), a better classification system of coastal regions is needed. To accomplish that goal, a quantitative classification approach was launched in order to establish common typologies for assessment of this biological quality element. This was preliminarily based on a physical classification of the coastal waters that included two consecutive steps, a first one devoted to the establishment of "biotypes" (large areas), and a latter one dealing with recognition of the variability within biotypes ("subtypological variants"). The NEA region coastline was subdivided into 550 consecutive stretches (40 km long). Then, physical variables (sea surface temperature, photosynthetically active radiation, wave exposure, tidal range and salinity) were calculated in reference points of each stretch, 5 km from the coast. This information was based mostly on satellite acquired data, using specific procedures proposed in this work. Physical typologies of NEA coastal waters were obtained by statistical analyses. Five different biotypes were selected (i.e. coastal sectors of the European coast) by national experts as baseline information to be used on intercalibration of assessment methods for vegetation within the WFD. Variability of environmental conditions on those biotypes was also analyzed and compared with previous classifications carried out at the national scale. Results from this study showed the feasibility of this methodological approach as a useful tool for assessment of the actual homogeneity of coastal environments.

1. Introduction

The European Water Framework Directive (WFD; 2000/60/EC) establishes the aim of achieving by 2015 a "good ecological status" for all bodies of surface water, including transitional and coastal ones. For this purpose, Member States (MS) have to assess the Ecological Status (ES) of water bodies, assigned through the evaluation of biological, physico-chemical and hydromorphological

Abbreviations: BQE, biological quality elements; ES, ecological status; GFO, geosat follow-on; GIG, geographical intercalibration group; IC, intercalibration; LME, large marine ecosystem; MS, member state; MSFD, marine strategy framework directive; NEA, North East Atlantic; NOAA, national oceanic and atmospheric administration; NODC, national oceanographic data center; PAR, photosinthetically active radiation; SST, sea surface temperature; WFD, water framework directive.

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quality elements. One of the biological quality elements (BQE) in coastal and transitional waters is the vegetation (macroalgae and angiosperms), for which MS have proposed different methodologies for the assessment of ES. In order to enable the consistency of the national assessment systems with the normative definitions (WFD) and the comparison of those between MS, it is then necessary to perform an intercalibration (IC) exercise. Hence the essence of the intercalibration is to ensure that good ecological status represents the same level of ecological quality everywhere in Europe (Annex V WFD). To reduce dissimilarities due to spatial gradients, the intercalibration exercise is performed in a first step inside each Geographical Intercalibration Groups (GIGs) (European Commission, 2009a).

The North East Atlantic (NEA) GIG is a very heterogeneous region, with coastal waters which present diverse vegetation composition, including zones as diverse as the Canary Islands and Norway. In fact, the final results of the first phase of the IC exercise (2005–2008) showed the great difference within the NEA GIG and the difficulty of the establishment of common standardized assessment methods and reference conditions for the vegetation quality elements within the NEA intercalibration area (European Commission, 2009a). At present, common intercalibration types inside the NEA GIG are agreed for both coastal and transitional water bodies. For coastal waters these have been based on the obligatory factors (salinity and tidal range) plus optional factors (depth, current velocity, exposure, mixing and residence time). This resulted on the adoption of six coastal water body types (CW–NEA): 1/26, 3/4, 7, 8, 9 and 10 (European Commission, 2009b). These general types try to integrate the heterogeneity of coastal environments recognized at a lower scale within the coastal classifications developed by MS (Moy et al., 2003; Roger et al., 2003; Bettencourt et al., 2004; Spanish Environmental Ministry, 2008; Leonardsson et al., 2009; Ministry of Housing, 2009; Ministère, 2010; NLWKN, 2010).

A general problem in the implementation process of the WFD is the need to find a balance between typologies being too specific (too many types) and being too general (types do not sufficiently reflect natural variability) (Hering et al., 2010). In the case of the NEA GIG, because of the broad nature of some typologies (CW-NEA1/26), further subdivisions seemed to be necessary in order to produce results. The recognition of suitable "common types" is an urgent need and a preliminary task before intercalibration of classification methods can be finalized (European Commission, 2009c). Therefore, in the second phase of the IC exercise (2008–2011) further work in this field was proposed by experts in order to review the common intercalibration types defined in the first IC phase.

The intercalibration exercise is carried out within "common intercalibration types", but compositional differences in biological communities still remain within a common type. Therefore, an adjustment is needed to remove the effects of such biogeographical discrepancies that can make comparability difficult (Guinda et al., 2008). Partly, the biogeographical variation is due to the climatic gradient across countries, being temperature one of the most important parameters (van den Hoek, 1982a,b; Breeman, 1988). The important role of the temperature is therefore recognized as one of the most important environmental factors directly responsible for differences in the geographical distributions of marine organisms resulting in the delimitation of large biogeographical regions. But other variables determining the geographical seaweed distribution may be found, such as salinity, water movement and light (Lüning, 1990; Rinne et al., 2011; Spatharis et al., 2011). There is considerable literature showing that populations and communities are strongly correlated with those abiotic characteristics (Roff and Taylor, 2000). Furthermore, it could be advantageous to use these physical factors in large scale classifications, due to the possibility of a continuous data acquisition against the lack of homogeneous reliable biological information all around a large area. Based on such assumptions it is possible to consider that physical characteristics might be used as surrogate indicators of ecological processes. The development of classification systems based on those proxies would allow for the establishment of different geographical zones for IC macroalgae purposes in NEA region.

Globally there have been fewer such attempts, mainly due to difficulties in acquiring data on that scale. Of the existing biogeographic classifications, the Large Marine Ecosystems (LMEs) are perhaps the most widely used for management purposes. These "large regions" are characterized by distinct bathymetry, hydrography, productivity and trophically dependent populations, and they were devised through expert consultation. On the other hand, the European Community and International Conventions have elaborated different classifications along the European coast, as the WFD ecoregions for transitional and coastal waters, the Marine Strategy Framework Directive subregions (MSFD; 2008/56/EC), the OSPAR regions and the EUNIS system (Davies et al., 2004). Apart from that, several approaches have been developed to classify national coastal waters, being the most commonly used variables: exposure to wave action, temperature, current velocity, tidal range, depth, substrate type, topography, salinity and solar radiation (e.g. Dethier, 1990; Roff and Taylor, 2000; Connor et al., 2004; Lombard et al., 2004; Snelder et al., 2006; Mount et al., 2007; Madden et al., 2009; Verfaillie et al., 2009). However, main results of these classifications are represented as habitat patches instead of continuous coastal areas, as necessary for the IC exercise.

For river vegetation elements, an interesting approach that considers "subtypological variants", characterized by distinct physical features and biological communities, has been developed (European Commission, 2009a). The proposal tries to deal with diverse patterns of species dispersal, climatological gradients or regional specificities within a common intercalibration type.

Bearing this in mind, as the main goal of the work, it was tried to provide suitable information to justify the establishment of physically homogeneous coastal zones for potential distribution of macroalgae under the NEA GIG coastal area. The physico-chemical characteristics were used to establish such a quantitative classification, the "biotypes", which, after a more detailed analysis reflecting the variability at this lower scale (biotypes), should be able to identify likely "subtypological variants" for these coastal areas.

The integration of current technical advances from this research field, and following a four-steps procedure (Fig. 1), constituted the starting point for the establishment of suitable biotypes along the NEA intercalibration region.

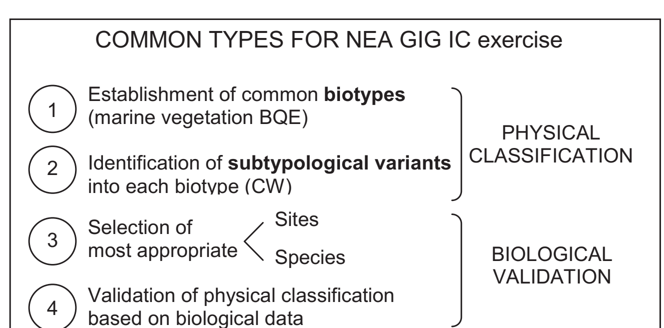

Fig. 1. Summary of the main steps proposed for the establishment of common IC types.