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MARINE HABITAT CLASSIFICATION AND MAPPING WITHIN ICES: WHERE TO GO FROM HERE?

Eric Jagtman
National Institute for Coastal and Marine Management/RIKZ,
P.O. Box 20907, 2500 EX The Hague, The Netherlands
[tel: +31 70 3114217, fax: +31 70 3114200, e-mail:e.jagtman@rikz.rws.minvenw.nl]

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Introduction

Increasing human impacts such as fishing, shipping, land reclamation and oil drilling have resulted in environmental pressure on marine areas. The international community has reacted by committing itself to a number of international agreements (e.g., OSPAR Convention of 1992, Annex V) specifying that a precautionary approach should be adopted to prevent areas from suffering irreversible ecological damage. To implement such an approach we need to define the intrinsic value of habitats and its management requirements. Moreover, since human-induced changes of the marine environment are known to have potentially large-scale impacts, we should assess the quality and functioning of habitats on a truely international scale (ICES, 2000). It is against this background that ICES, as part of its adopted scientific objectives [Strategic Plan, Objective 1e], aims to develop a classification system and to map coastal marine habitats, continental shelves and slopes, and the open ocean.
In this paper developments in marine habitat classification and mapping are discussed in relation to the objective chosen. The paper first discusses habitat classification and mapping from a geophysical and a biological perspective. It is emphasised that a combined effort from both disciplines is needed to advance the development of a common marine habitat classification system. To conclude, a stepwise approach for the development of a marine habitat classification for ICES is presented, identifying priorities for future work.

Seabed imaging

Modern technology makes it possible to effectively map the geophysical characteristics of the seabed.
The ICES Working Group on the Effects of Extraction of Marine Sediments on the Marine Ecosystem (WGEXT) has reviewed a variety of sonar devices in relation to survey objectives (Kenny et al., 2000).
In this review side scan sonar (swath) systems were indicated as generally being most suited for detailed biotope mapping and professional geophysical surveys. These systems enable the production of high resolution seabed maps and provide information on structure and dynamics of the seabed. Modern sonar systems can operate in

water of a few meters depth to full ocean depths. This virtually opens the opportunity to map the continental shelf and beyond, provided that ample funds are available. Seabed imaging will geophysically characterise marine habitats. Adding biological information to this establishes a firm basis for large-scale marine habitat classification and mapping.

Biological classification

In marine habitat classification rapid developments are taking place. Actual progress in this field is described by a number of speakers at the ICES 2000 Annual Science Conference (see e.g. Davies and Moss, 2000; Allee, 2000). Major initiatives are the development of a Pan-European marine habitat classification system called EUNIS (Davies and Moss, 1999; Connor et al., 1997), and likewise, the development of a prototype for a national marine and estuarine ecosystem classification system in the USA (the ARC classification; Allee, 2000). Both EUNIS and the ARC classification make use of the same type of information to produce a habitat classification. EUNIS follows a hierarchical approach. On the upper hierarchical levels (levels 1-3) simple habitats are distinguished, characterised by physical characteristics like depth and bottom substrate. The lower end of the scale (levels 6-7) defines, on top of the physical characterisation, precisely described habitats at the species or community level. The ARC classification actually makes use of the same modifiers as in EUNIS, but adopts a more practically oriented approach to the classification of habitats. The ARC system takes into account that the amount of information available on many ecosystems is limited. The classification system is structured to allow aggregation at different levels, depending on the amount of data available on an ecosystem. Aggregating at higher levels will thus result in more general information, whereas more specific information becomes available, more specific categorization can occur (Allee, 2000).

In view of the aim to develop a habitat classifation system for the ICES area a justifiable question is
'which parts of ARC or EUNIS are useful to further the development of an ICES classification?'
From discussions in the ICES Study Group on Marine Habitat Mapping (SGMHM, 2000) and at the joint OSPAR/ICES/EEA workshop on marine habitat classification in Oban (OSPAR/ICES/EEA, 1999) it can be concluded that the classification systems mentioned provide a solid basis for the development of a habitat classification for the ICES area. On the other hand points of particular interest for future work can be identified:

- The EUNIS level 3 classification is suitable for use as a template for classification in the ICES area, but further development of the habitat classification at the levels 4 and 5 is advised. At this level of detail regional difficulties in habitat classification may be properly addressed. This is a prerequisite to make the use of habitat maps worthwhile to ICES.

- Since EUNIS is primarily a European-based classification system, testing and mapping of the proposed habitats in a variety of regions within the ICES area is needed. This will evaluate to what extent the current classification is suitable for use in other areas, e.g. deep sea water.

- The present classification of pelagic habitats is underdeveloped and needs further work

With these points in mind a step by step approach is discussed here that is believed to support the development of a habitat classification system that is applicable for large-scale areas. This approach mainly makes a connection to the EUNIS classification for the practical reason that the ARC classification still is in the prototype-stage. Future developments in the ARC classification (or any marine habitat classification) may help to further fine-tune the proposed approach to the needs of ICES.

A stepwise approach to the development of a classification system for the ICES area

Assess geophysical characteristics and link data to an existing marine habitat classification

The structure of the seabed and its dynamics are important factors in determining the species composition of benthic communities. Knowing this, it makes sense, as a first step, to start to characterise and map ecosystems on basis of geophysical characteristics. As was discussed by Kenny et al. (2000) sonar systems are excellent tools for this task. By linking geophysical data to existing marine habitat classification systems we can translate data in defined habitat types. Diagram 1 shows how this procedure can be put into practice, based on defined habitat levels in the EUNIS classification.

Diagram 1: stepwise characterisation of habitats

In EUNIS at level 1 *marine habitats* are distinguished from terrestrial habitats

Step 2: Assess physical habitat characteristics, and link them to an existing classification. Major distinguishing criteria used in EUNIS are at this level: seabed or watercolumn, littoral or sublittoral, and hard or soft substrate. This results in seven types of level 2 habitats: e.g.: *littoral rock and other hard substrata (type A1)*

Step 3: Further assessment of physical habitat characteristics to define level 3 habitats. Major distinguishing criteria used in EUNIS are dynamics (exposure to wind and wave action) and further details on substrate. An example of a level 3 habitat type is e.g.: *littoral rock moderately exposed to wave action (type A1.2)*

Step 4: Assess biological characteristics, and link them to the classification. Major distinguishing criterion in EUNIS at the 4th level is the biology: communities and associations
Result: level 4 habitat: e.g *fucoids and barnacles on moderately exposed littoral rock (type A1.2/B-MLR.BF)*

Step 5: More detailed assessment of biology, to be linked at the 5th level of the habitat classification. Major distinguishing criterion in EUNIS: more detailed data on species or community composition
Result: level 5 habitat: e.g.: *Fucus vesiculosus and barnacle mosaics on moderately exposed mid eulitoral rock (Type A1.2/B-MLR.BF.FvesB)*

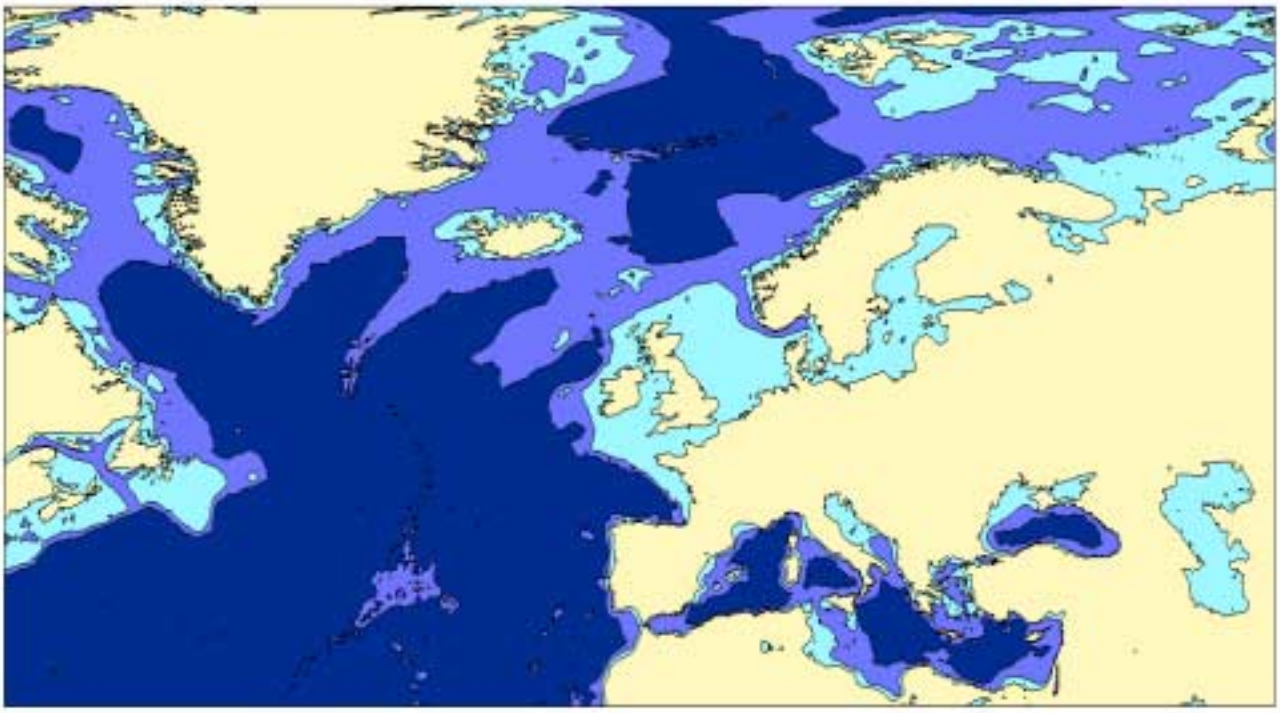
Examples of habitat types described were taken from the EUNIS-report (Davies & Moss, 1999)

The examples in the diagram show that the mere use of data on substrate and tidal regime allow us to define level 2 habitat types. By adding information on dynamics, level 3 habitat types are defined whereas level 4 and 5 habitat types include biological information[1].

[1] The current EUNIS classification in fact makes use of biological information at level 3, but the way modifiers are described (angiosperms present? foliose algae present? vegetation cover?) seem to indicate that they describe ecosystem-structure or dynamics rather than community- or species characteristics.

At the higher levels of the classification it is quite easy to map habitats. A typical level 2 habitat map could look like the map presented in diagram 2. This map simply distinguishes between depth zones, thus marking out the main EUNIS habitat types abyssal zone (>2000 m depth, habitat type A6), bathyal zone (depth between 200 and 2000m depth, habitat type A5) and shelf-habitats (depth <200m, littoral and sublittoral, habitat types A1-A4).

Diagram 2: simple physical habitat map



Legend: black-grey: depth >2,000 m, dark grey depth 200-2,000m, light grey depth <200m

The map shows that even very simple characteristics can form the basis for a -admittedly rather coarse- map of the system that in principle can cover a large area. It shows that modern technology combined with geophysic science enables us to effectively produce basic habitat maps for large marine ecosystems like for instance the North Sea or the Baltic, or indeed the whole ICES area. In order to be able to produce maps for these (international) systems data-storage in a central database and agreements on data-formats are required. The ICES work-structure (science committees, working groups) gives ample opportunity to make further arrangements for this.

Aim for common biological standards (level 4)

It goes without saying that when using habitat maps in assessing the effects of human-induced environmental impacts, biological data must be included in the map. This paper is written from the perspective of the development of a generally accepted ICES classification system. Seen from this perspective, it is at the intermediate levels 4 and 5 of the (EUNIS) classification that we need to extend physical habitat descriptions with additional biological data (on communities or species). After all, at this level of the classification habitats still are rather abstractly defined. This enhances the chance that systems will, over larger areas, have a lot of

biological characteristics in common. Moreover, this will produce habitats of a practical size that may best fit in with management objectives like nature conservation or the designation of marine protected areas. To ICES it is important to define binding habitat descriptions for at least 'EUNIS level 4' type of habitats. This will create a common ground to communicate about marine habitats. At the deeper levels of the EUNIS classification (levels 6 and 7) local structuring conditions and detailed biological descriptions become dominant. At these levels there is room to include habitat types that give a close description of the (biogeographic) variance in marine ecosystems. In developing a habitat classification that covers the whole ICES area this is not a research priority.
I suggest to leave the development of these rather 'specialist' levels (6 and 7) in the classification to national research institutes, provided that there is always a key that allows data to be translated back to the commonly defined and accepted level 4.

Focus on the shelf

Data-collecting activities should focus on the continental shelf. This is the part of the marine ecosystem most seriously affected from human-induced environmental impacts. Moreover, the vast majority of biological sampling programs in operation is confined to the shelf. In order to define where additional biological information is required physical habitat maps, in demonstrating (in)homogeneities in the seabed structure, are useful tools for the strategic design of benthic sampling programs

Keep developing the classification for deep waters

In the deep oceanic waters there are large gaps in biological data that need filling in. Consequently, the habitat descriptions for the bathyal, abyssal and pelagic zone are still poorly developed and need further work. This will start shortly, as this issue is put on the agenda of the OSPAR/ICES/EEA workshop on marine habitat classification that will be held in Southampton (UK) in September 2000.

Acknowledge biogeographical variation

Because of the vast size of the ICES area there is a need to give room to include descriptions of biogeographic variance in a classification. In parts of the EUNIS classification this is already included. Habitat type 7 (pelagic habitats) for instance distinguishes between high Arctic, boreal temperate subarctic and meditteranean subtropcial offshore waters. On top of that, a classification that covers the entire ICES area should reflect habitat diversity on the east-west line as well. It will be a big challenge to develop a classification system that is flexible enough to cover all these variations.

Conclusions

To summarise in conclusion, the following steps are advised to advance the development of a classification system that is applicable throughout the ICES area:

- Start to develop a classification by assessing hydrographic and geophysical features of areas. Link these data to the higher levels of an existing marine habitat classification. This will provide a solid basis for habitat classification throughout the ICES area.

- Biological data should then be added, overlaying the physical habitats at a practical level. To create a common ground to communicate about marine habitats it is important to ICES to define binding habitat descriptions for at least 'EUNIS level 4' type of habitats.

- In collecting additional biological data first concentrate on the shelf, this being the part of the marine ecosystem most seriously affected from human-induced environmental impacts. This will produce fast results, knowing that the vast majority of biological sampling programs in operation is confined to the shelf.
- Advance the development of a classification for deep waters
- Allow room for biogeographical variation to be included in the classification

It is felt that by approaching the classification-issue in this way, working step by step from coarse to fine, we can further the development of a classification system that will be of good use to ICES.

Acknowledgement

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