The importance of habitat features in low-relief continental shelf environments

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Abstract – Benthic habitats can be loosely divided into low and high relief based upon gross bottom topography. While fish community studies in high relief environments such as coral reefs have been extensively studied using in situ visual analysis, most studies of low relief environments have utilized trawl-based methodologies. Such studies while valuable, are unable to detect small-scale variations in habitat availability and faunal responses to that variation. This paper presents the availability of other techniques, ranging from visual surveys to sonar and bathymetric analysis, which allow researchers to address questions of habitat utilization in low relief environments. © 1999 Ifremer / CNRS / IRD / Éditions scientifiques et médicales Elsevier SAS

habitat / fish community / topography

Résumé – Importance des caractéristiques de l'habitat dans les environnements à faibles reliefs du plateau continental. À partir de la topographie des fonds marins, les habitats benthiques peuvent être grossièrement divisés entre des environnements à faibles reliefs ou à reliefs élevés. Alors que des analyses visuelles in situ ont été largement utilisées dans l'étude de communautés de poissons composant les environnements à reliefs élevés tels que les récifs coralliens, la plupart des études dans des environnements à faibles reliefs ont été réalisées par des méthodologies fondées sur le chalutage. Malgré leur intérêt, ces techniques ne détectent pas la variabilité à petite échelle de l'habitat et les réponses de la faune. Le présent travail présente d'autres méthodes, allant du relevé visuel à la détection par sonar et à l'analyse bathymétrique, qui permettent d'étudier l'utilisation de l'habitat dans les environnements à faibles reliefs. © 1999 Ifremer / CNRS / IRD / Éditions scientifiques et médicales Elsevier SAS

habitat / communauté de poissons / topographie

The first impression of a benthic habitat often comes from a look at a bathymetric chart. At one extreme, areas with widely spaced isobaths (lines of equal depth) which lack other bathymetric traits are often termed 'featureless' or 'low relief'. At the other extreme, areas of closely spaced or wildly fluctuating isobaths indicate dramatic subsurface features of high relief such as continental shelf submarine canyons or volcanic seamounts. Habitats with such complex topography often contain associated, conspicuous faunal compositions. Examples include geological features such as rock outcrops [20], the steep walls of submarine canyons [7] and well known biotic habitat examples such as coral reef [14] and kelp bed habitats [8]. In these high relief environments, visual habitat assessment is often a critical tool for fisheries management.

The broad continental shelf along the east coast of the United States is an excellent example of a low relief habitat. The fish communities of this region have been studied for years with fisheries managers long relying on

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fish landings and trawl surveys to assess fish stocks in this area. Habitat studies, at least at the spatial scale of those cited above, are relatively rare. Why is this? The implicit assumption has been that because it is apparently absent, topographical complexity must not be important in low relief habitats.

A very practical way to view the division between low and high relief environments can be based on fishing techniques themselves. In this case, the major technique for the east coast groundfish fishery is the otter trawl. Any sort of bottom which allows a trawl to pass over can be functionally defined as low relief, otherwise the net is ripped or snagged and the bottom should be deemed high relief and avoided. Using this sort of informal assessment, most of the northeast coast continental shelf would be considered 'low relief', and happens to be heavily fished. This idea is further reinforced by a variety of studies, many of which actually incorporate trawl data. These studies demonstrate a variety of large-scale physical and biological factors structuring mesoscale (1–1000 km) faunal distributions on low relief continental shelf habitats. Factors which have been shown to be important include depth, bottom water temperature, and broad geographical region [6, 12, 13], seasonal associations [17], as well as sediment type [16, 20]. Using these studies, benthic habitat can be viewed as a relatively large-scale phenomena in which fish distributions are determined by latitude, whether the bottom is muddy or sandy, or by narrow versus wide fluctuations in temperature. Other large scale processes such as gradual bathymetric changes, large geologic features (e.g. banks and basins), and changes in sedimentary regime are likewise important [18, 20].

Variations at the mesoscale are also an important factor. The use of trawl-based studies is an efficient way to demonstrate relative changes in fish density and distribution in relation to such variation. These studies do however have an inherent spatial bias. Any data taken from a trawl are value-averaged over the trawl distance (e.g. density for a given species is the number of individuals of that species caught in the trawl, per the area trawled). This necessarily ignores any phenomena on a scale smaller than that of the trawl length. In addition, trawl-based studies cannot address questions of small-scale topographic structure in low relief environments because the trawl sampling cannot 'recognize' such features.

Such bias is an important consideration, because low relief does not necessarily equal no relief. Low relief continental shelf habitats contain numerous features which provide distinct topographic relief and potential habitat variability (and value) at much smaller scales. At the smallest scales, these features include but are not limited to shell, biogenic feeding depressions, storm-generated sand waves and various sessile biological structure such as amphipod tubes and sponges [2, 4]. When discrete structures such as these serve as habitats to benthic and demersal organisms they are termed 'microhabitats' (sensu [1]). Within the context of a trawl-based study, we can at best make some guesses about the presence of microhabitat features (such as the presence of shells or sponges) by looking in the trawl bycatch, while completely missing others (such as amphipod tubes or storm-generated sand waves) which pass through or are passed over by the trawl.

Previous studies have shown these small-scale microhabitat features to have significant effects on benthic faunal distributions [2, 4]. Most often in these studies, the presence of a given microhabitat feature serves to enhance faunal densities relative to adjacent areas which lack those features. This is especially true for smaller fauna and juveniles of larger species which utilize the benthos for feeding and cover.

Microhabitat features vary in their spatial extent. The studies cited above noted positive faunal responses to habitat features ranging from single bivalve shells in featureless sand to expanses of storm-induced sand waves extending over hundreds of meters. Examples of topographic change and habitat structural elements can be found at any spatial scale ranging from meters to hundreds of kilometers [9].

As we expand our scale from the single individual organism interacting with a specific habitat feature to populations responding to suites of habitat features over large scales, the techniques we employ must change (*table I*). Techniques which are effective at examining small-scale processes (e.g. direct observation using ROVs and submersibles) are difficult or impossible to use at larger scales. Identification of larger scale habitat variation requires remote sensing techniques such as sector or side scan sonar. At the largest scales, variations in bathymetry may be important to fauna not only in the absolute changes in depth, but also for more subtle aspects of bathymetric variability. For these sorts of estimates, techniques which measure fractal dimension and rugosity may be required [5, 10]. At the largest end of this spectrum we are considering the same spatial scales covered by the trawl-based studies discussed above.

Making the link between these various spatial scales and between the vastly different methodologies outlined in *table I* is difficult. While large scale, remote techniques such as side scan sonar can detect variations in geological structures (thus identifying different potential habitats), whether these variations are structuring animal distributions requires visual groundtruthing (i.e. small scale visual techniques) to determine if fauna are responding to these variations. In addition each technique has physical limitations and biases. For example, side scan sonar techniques are able to see some important features (e.g. rocky outcrops) much more easily than other more subtle features (e.g. storm generated sand waves) [20].

There are temporal considerations which should be made as well. Habitat features, especially the small-scale features discussed here, are not static through time. Biologically features such as sponges, amphipod tubes and feeding pits will appear and disappear with respect to the factors influencing individual species' population dynamics. Storms create and destroy sand waves while burying or exposing rock outcrops and shell cover. Additionally, human-caused factors, most notably trawling activities, are a potentially large factor affecting habitat characteristics in these low-relief environments. Trawling over time has been shown to strongly effect community composition in a variety of continental shelf ecosystems [19]. The physical action of trawling, dredging and other bottom fishing activity can disperse and destroy many small scale habitat features. Benthic environments undisturbed by trawling activity have been shown to have greater concentrations of epibenthic fauna and potential small-scale habitats [3]. What is not known is how long it takes for bottom to 'recover', [15] that is to proceed from recently trawled to a state where small-scale habitat types have returned to unimpacted densities.

These observations and questions have potentially important management implications. We can make the case that the continental shelf, while low relief, is not a homogenous environment but instead contains a variety of habitat types that exist at different spatial scales. Furthermore, at least some fauna respond to the presence of habitat variation. The next step is to evaluate the importance of these observations. Are fauna using benthic habitat continuously, or only during a portion of their life history? Is habitat use seasonal? Are these habitats 'essential' (sensu [11]), that is does a shortage of such habitat represent a bottleneck to the population dynamics in species of interest? Managers making decisions, particularly those that involve closing areas to trawling and other activities that impact the bottom, need the answers to these questions in order to understand the importance of low relief benthic habitat to the species they manage.

Table I. Assessment techniques which take into account habitat features at a variety of spatial scales within low relief continental shelf environments.

Technology	Type of Data	Analysis Methodology	Spatial Scale	Management Implications
Video/Still Imagery	Simultaneous habitat type (biotic and abiotic) and faunal distributions	Categorical habitat distributions, faunal associations and density	1–100 m	Correlation of fauna with microhabitat features and fine scale density structure
Sector Scanning Sonar	Grey scale reflectance (fine scale survey)	Qualitative interpretation of small scale features	10–100 m	Time series analysis of changes in habitat features (coincident with video survey)
Sidescan Sonar	Grey scale reflectance - wide area survey	Comparison of mean gray scale values	10–1000 m	Correlation of fauna with sediment type and texture
Bathymetry (Leadline, Single Transducer Sonar, Multibeam)	Bathymetric contours	Fractal geometry, rugosity, slope	100–1000 m	Correlation of faunal distributions based on bank features and depth

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