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COMARGE Workshop: Habitat Classification and Mapping on Deep Continental Margins, 4-6 June 2007

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ABSTRACT

Under the auspices of the Census of Marine Life (CoML) field programme Continental Margin Ecosystems on a Worldwide Scale (COMARGE), a workshop was held in Southampton, U.K., on 4-6 June, 2007, to examine habitat mapping on continental margins. This was attended by 22 scientists, including geophysicists, geologists and biologists. Oral presentations were given on data sets from a range of areas: the Gulf of Mexico, Brazil, West Africa, NW Europe, the Arabian Sea, Japan and Mexico. A number of more theoretical talks were also presented, and a habitat mapping exercise was carried out. On the final day, a "brainstorming" session was carried out to produce a list of what the participants considered to be "Habitats" on continental margins, together with a list of factors which influence these features to create habitats.

KEYWORDS

CoML, COMARGE, continental margins, deep sea, habitat mapping

ISSUING ORGANISATION

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1 Introduction and Aims of the Workshop

In July 2006, the Census of Marine Life (CoML; http://www.coml.org/) field programme "Continental Margin Ecosystems on a Worldwide Scale" (COMARGE; http://www.ifremer.fr/comarge/en/index.html) held a meeting at the Institute Océanographique in Paris, France. COMARGE is an international network of scientists which aims to describe and understand biodiversity patterns on continental margins (*c*. 200 to 4000 m water depth). At this meeting, a working group was formed to examine landscape patterns and processes on continental margins. This group had two overall aims:

1) To quantify and compare habitat heterogeneity on continental margins.
2) To develop a common framework for habitat description.

A workshop was held by the working group in Southampton, U.K., on 4-6 June 2007 to address these issues. This brought together a group of 22 scientists, including geophysicists, geologists and biologists, to compare the approaches adopted in mapping habitats in different geographic regions. This report outlines the proceedings of the meeting.

2 Participants

Participant	Organisation
David Connor	Joint Nature Conservation Committee, UK.
Mark Costello	University of Auckland, NZ.
Marina da Cunha	University of Aveiro, Portugal.
Campbell Davies	CSIRO Marine and Atmospheric Research, Australia.
Elva Escobar	Universidad Nacional Autonoma de Mexico.
Kerry Howell*	University of Plymouth, UK.
Veit Huehnerbach	NOCS, UK.
Alan Hughes	NOCS, UK.
Hiroshi Kitazato	Japan Agency for Marine-Earth Science and Technology.
Janne Kaariainen	NOCS, UK.
Neil Kenyon	NOCS, UK.
Renato Kowsmann	Petrobras, Brazil.
Tim Le Bas	NOCS, UK.
Lisa Levin	Scripps Institute of Oceanography, USA.
Lenaick Menot	Institut Océanographique, Paris.
Carlos Mortera	Instituto de Geofisica, Mexico
Bhavani Narayanaswamy	Scottish Association for Marine Science, UK.
Karine Olu	IFREMER, France.
Ana Paula	Petrobras, Brazil.
Luis Pinheiro	Universidade de Aveiro, Portugal.
Gilbert Rowe	Texas A&M University, USA.
Myriam Sibuet	Institut Océanographique, Paris.

*Dr. Kerry Howell was unable to attend in person, but participated remotely in selected discussions.

3 Programme

Overview

The first day was dedicated to fourteen oral presentations of data sets from variety of continental margins, covering issues to do with habitat mapping from a range of areas: the Gulf of Mexico, Brazil, West Africa, NW Europe, the Arabian Sea, and Japan.

On the second day, the presentations examined the theoretical basis of existing classification schemes, and a habitat classification exercise was also carried out. This focused participants attention on different issues, such as the importance of scale, and stimulated much discussion.

The final day consisted of only two presentations, which directly addressed the topic of habitat classification schemes in the deep sea. The remainder of this day was taken up with discussions of how best to approach the development of a habitat classification scheme which would be relevant to the COMARGE community. Wednesday also included two “brainstorming sessions”, where participants listed as many types of “habitat” that they consider to occur on continental slopes, then produced a list of the factors they consider that influence the assemblages associated with these. Different “habitat groups” were allocated to particular participants who agreed to synthesise these after the meeting.

Monday 4th June

9:00-9:30	Welcome and background to meeting.	Alan Hughes, Lenaick Menot and Myriam Sibuet
9:30-10:30	Gulf of Mexico	Elva Escobar, Carlos Mortera and Gilbert Rowe
10:30-10:50	Tea Break	
10:50-11:30	Brazilian margin	Renato Kowsmann and Ana Paula
11:30-12:10	Gulf of Guinea/Angolan Margin	Karine Olu and Alan Hughes
12:10-12:30	Discussion	
12:30-13:30	Lunch at NOCS	
13:30-14:30	Gulf of Cadiz	Neil Kenyon, Marina da Cunha, and Luis Pinheiro
14:30-14:50	Rockall Bank	Kerry Howell and Bhavani Narayanaswamy
14:50-15:10	NW Scotland	Veit Hühnerbach
15:10-15:30	Discussion	
15:30-15:50	Tea Break	
15:30-15:50	West of Shetland	Alan Hughes and Bhavani Narayanaswamy
15:50-16:10	Norway	Pål Buhl-Mortensen
16:10-16:30	Sea of Japan	Hiroshi Kitazato
16:30-18:00	Discussion	
18:00	End	

Tuesday 5th June

Topic 1: Habitat mapping and issues of scale (Chair: Lenaick Menot)

09:00-09:30 Western Australia Campbell Davies

09:30-10:00 "Comparison of multibeam backscatter data and side-scan sonar data for habitat mapping" - Tim Le Bas.

10:00-10:30 "Habitat Classification in Europe: MESH and WGMHM" - David Connor

10:30-10:50 Tea Break

10:50-12:00 Habitat mapping exercise – Tim Le Bas (assisted by Alan Hughes and Veit Hühnerbach)

12:00-12:30 Discussion

12:30-13:30 Lunch

13:30-14:15 "Concepts for the classification of marine habitats and ecosystems" - Mark Costello.

14:15-15:00 "Macrofauna and megafauna species distributions in relation to habitats" - Gilbert Rowe

15:00-15:30 Discussion

15:30-15:50 Tea Break

15:50-16:35 "Environmental influences on regional deep-sea species diversity?" - Lisa Levin

16:35-17:30 Discussion

Wednesday 6th June

Topic 2: A classification scheme for COMARGE (Chair: Alan Hughes)

09:00-09:45 "Overview of existing classification schemes for marginal ecosystems" – Lenaick Menot.

09:45-10:30 "Scientific Experts' Workshop on Biogeographic Classification Systems in Open Ocean and Deep Seabed Areas Beyond National Jurisdiction" – Elva Escobar.

10:30-10:50	Tea Break
10:50-12:30	Discussion
12:30-13:30	Lunch at NOCS
13:30-17:00	Discussion: Future directions for habitat mapping on continental margins. Recommendations for future work?
17:00	End of Workshop

4 Summary of Talks

Monday

After the initial welcome by Alan Hughes and Lenaick Menot, Myriam Sibuet outlined the overall aims of COMARGE: (1) Large scale biodiversity patterns and processes, (2) Landscape scale classification (including habitat mapping), (3) Habitat heterogeneity in relation to regional diversity, and (4) Anthropogenic inputs on margins. This workshop concerned the third of these aims.

The first of the scientific presentations was given by Carlos Mortera who presented information on the bathymetry and physiographic provinces in the Gulf of Mexico. A lot of this work has been carried out in this area as a result of exploration by the oil and gas industry. Elva Escobar then proceeded to discuss her approach of using β-diversity to define habitats in the southern gulf. Not all habitats in the area could be defined using sidescan sonar. Gil Rowe went on to examine whether the fauna "recognize" the geological heterogeneity in the northern gulf, i.e., should we define the habitats, or let the fauna define it? He identified four distinct, depth-related assemblages, and noted that the underling driver on distribution appeared to be food limitation.

Ana Falcao and Renato Knowsmann presented data on Campos Basin mega provinces, which has 81% of Brazil's oil reserves. They noted that down the Campos slope there was varying slope steepness, with slopes of up to 51° in escarpment. Ana outlined the work carried out during the OCEANPROF programme, which is being carried out in partnership with the Brazilian oil industry (PETROBRAS). The continental slope was classified into a variety of categories: Mature and immature canyons, turbidite fans, salt ridges, salt withdrawal basins, carbonate pinnacles, seeps, corals convex slopes, slope/debris apron. These features were used as targets for biological sampling. They also noted that there were authigenic carbonate seep chimneys present on the slope. However, the variability in the assemblages appeared to be primarily associated with water masses and primary productivity.

The focus of the presentations then moved to the eastern Atlantic, with Karine Olu presenting information on the REGAB site in the Gulf of Guinea/Angolan margin, examined during the BioZaire programme. This work used a ROV to generate microbathymetry. Large bivalve molluscs (Mytilids) were associated with highest methane concentrations, although the methane concentrations were spatially variable. Alan Hughes then described commercial surveys that had been involved in off the coast of Angola, which aim at providing baseline information on benthic environment to be included in environmental impact assessments. Significant bathymetric trends were noted which are apparently related to variations in organic carbon inputs.

Further to the north, Luis Pinheiro described the geology of the Gulf of Cadiz, particularly in relation to the large number of mud volcanoes observed there. In this area, fluids, which come from deep within sediments at the intersection of faults, may control faunal distributions. The location of the fluid seepage was ephemeral, moving annually, so that the distribution of the associated organisms also moves. Mud volcanoes and carbonates were aligned along the faults.

Neil Kenyon then explained how the Mediterranean undercurrent forms channels in the Gulf of Cadiz, plunges downslope and builds sand bodies. Sand accumulates, then fails and flows downhill and pods, creating fields of sand waves 20 metres thick. This undercurrent extends from 800 m to 1200 m.

Marina da Cunha then presented data from Portuguese mud volcanoes. It is clear that there is a lot of variability between these volcanoes, resulting in a high faunal diversity, as each has a different community associated with it. The shallower mud volcanoes contained more background fauna, while the deeper ones had more distinct faunas with high endemicity. Some of the differences between the mud volcanoes may have been due to variations in their age. Marina then described the different assemblages associated with three different mud volcanoes: the Mercator Volcano, the Darwin volcano and the Carlos Ribeiro Volcano.

Bhavani Narayanaswamy presented data from Rockall Bank, where there were a number of habitats: reefs. Sidescan sonar identified ice flow plough marks which had the cold-water stoney coral *Lophelia pertusa* growing on it. The aim of this work was to identify reef habitats for conservation and oil activity avoidance of annex 1.

Veit Huhnerbach presented a computer-assisted interpretation method for long-term habitat mapping and monitoring, which has been used successfully to identify *Lophelia pertusa* reefs off the coast of Norway and in the Minch (NW Scotland). To guarantee consistent, highly detailed interpretation of different acoustic facies/habitats throughout the entire reef structure, texture analysis methods were used, using the University of Bath package *TexAn.* Extensive ground-truthing is a pre-requisite for this sort of study. Different seabed facies (live coral, dead coral framework and sediment covered rubble, as well as, background sediment), could be successfully distinguished using this method. This is important and potentially useful for long-term monitoring and management of cold-water reefs against economic (e.g. fishing) and environmental (e.g. pollution) impacts.

Alan Hughes then presented data from the West of Shetland, from studies carried out under the auspices of the Atlantic Frontier Environmental Network, a consortium of government, oil industry and academia. This formed part of the UK government Strategic Environmental Assessment (SEA) 4. This is an area very rich in seabed habitats, and drivers of faunal distribution include the underlying geology, bottom waters, currents, sediments, org. fluxes. The SERPENT project are also using industrial ROVs for small scale habitat mapping, in the vicinity of oil and gas industry structures.

The presentations then moved to the Pacific, with Hiroshi Kitazato presenting information from Sagami Bay, Japan, where there is extensive cold seep and vent activity.

Tuesday

The second days presentations started with Campbell Davies**,** who outlined habitat classification in the seas around Australia, where this issue has been extensively examined. This presented a four level classification scheme. Within this scheme, the first level refers to *Provinces*, which are regional (sub continental) and include areas such as offshore islands, the northwest shelf, South Australian gulfs, South Tasman Rise and the Lord Howe Rise. Demersal fishes were then used to identify provincial scale variation. *Biomes* sit within provinces. These reflect paleo changes and environmental gradients with depth zones and may be linked to water masses. For the fish assemblages, they are ssociated with different. A third level of classification was then described which includes bio-geomorphic units, and are subregional. Examples included gulfs, ridges, canyons, faults, seamounts, slope etc. An example of a process that may influence Level 3 processes would be productivity. A further layer of classification then describes "Primary biotopes", which generally include what are generally recognized as habitats. These are local scale features, observed on a kilometer scales, and are identified by swath mapping and trawls.

David Connor then discussed habitat mapping from a European perspective. Habitat mapping in Europe has been carried out under the auspices of the 'Development of a framework for Mapping European Seabed Habitats (MESH)" programme, as well as the ICES "Working Group on Marine Habitat Mapping (WGMHM)". These employ habitats nested in landscape classification systems. David outlined a number of challenges to classification, such as how to mesh influencing factors, the issues surrounding continua (as there are few hard boundaries between habitats), complexity and biogeography, which all lead to spatial variability. The fact that these are dynamic environments, and biological communities change naturally also leads to temporal variability.

The EUNIS classification system was used in MESH. This has been applied to the Atlantic Ocean and Baltic Sea, and mixes habitats with classification types. While this contains some deep water habitats, at present this is limited; there is clearly potential to expand this to include more deep water habitats.

Mark Costello, one of the project leaders in the Ocean Biogeographic Information System (OBIS), a COML field project, outlined problems associated with classifications, i.e., that habitats and ecosystems are concepts that are context dependant, with no evolutionary hierarchy or universal metrics. He then discussed different definitions of habitats (e.g., biotopes, facies, ecotypes, seascapes, geosystems, landscapes), which reflect different workers perspectives, and sampling methods. Three groupings were outlined: Regions (defined by opinion), Seascapes (defined by physiographic features), and Biotopes (defined by biology of species). OBIS is suitable for a range of uses, such as analyzing the distribution of taxa with depth, calculating the species ranges of individual species, or to carry out research on biogeography.

Lisa Levin gave a presentation on the regional environmental influences on deep-sea diversity. This focused on the role of factors such as depth, latitude, dissolved oxygen, flow, catastrophic disturbance, and climate change.

Gil Rowe discussed how classification was carried out before computers were routinely available and habitat boundaries were set where species ranges start and stop. He then demonstrated how PRIMER Version 6 can be used to create a classification system, using data from the Gulf of Mexico. The question was raised concerning whether we should refer to the main groupings as habitats based solely on faunal communities? Gil recommended that a combination of physical and chemical data is used to define habitat, and then the fauna is used to monitor changes in alpha diversity. Some discussion followed on the use of indicator species and dispersal patterns of organisms. It was suggested that biodiversity conservation requires a focus on individual species.

Tim Le Bas then presented an overview of geophysical methodologies, focusing on the differences between sidescan sonar and multibeam backscatter techniques. With sidescan sonar the width of the information can be up to 15 times that of the water depth, whereas with multibeam backscatter, the width of the information is a maximum of 5 times the water depth. The scattering strength from different substrates changes with the angle and differs between multibeam and sidescan sonar. The resolution of backscatter is lower, it is time consuming to calibrate, and is affected by weather. Side scan sonars require a lot of interpretation, and do not produce bathymetry, and it is impossible to stop a ship "mid-survey" to take a ground-truthing sample. In theory, it is possible to mount high resolution multibeam and sonars on ROVs or AUVs.

Wednesday

The following questions were outlined as topics for discussion:

- What is the purpose of a COMARGE classification scheme?
    1. An ecological tool.
    2. A framework to organize hypotheses on factors driving distribution and diversity patterns.
- What are factors unique to continental margins?
- Where are the main studies along continental margins?
- Is it possible to compare geomorphologically similar areas, and to then ask questions about their biology?
- To what extent can we consider ecological functions in defining ecosystems?
- What is the role of species as indicators and ecosystem engineers?

The importance of geological controls were discussed, i.e., the nature of the rock (carbonate or volcanic), the type of sediments, nature of fracturing, fluids and fluxes (where present), and active versus passive margins. There are also clearly bathymetric changes, which may be related to geological changes, as well as hydrographic controls (e.g., the influence of upwelling, flow, oxygen minima, and water masses), as well as trophic controls on systems. "Hotspots" of biological activity, such as submarine canyons, seamounts, carbonate mounds, channels, cold seeps, and oxygen minimum zones, also need to be considered.

The discussion proceeded to address two main questions: (1) Whether a classification should be a top-down or a bottom-up process, and (2) whether we should adopt a hierarchical classification and on which basis?

1) Top-down vs bottom-up classifications

Top-down classifications follow a physiognomic approach. Physical, chemical, geological or biological criteria, which are known or suspected to structure biological communities in particular ways, are used to define habitats *a priori*, to create what one may call seascapes. This is the case for most deep-sea classification scheme. Bottom-up classifications follow a taxonomic approach, with biological communities being grouped according to their faunal affinities in order to define discrete entities, habitats or biotopes. EUNIS was created using this approach.

The advantage of the top-down classification is that data are already available at a global scale, although at low resolution, to define and map habitats (e.g. data on bathymetry, primary productivity, and water masses). Lower scale/higher resolution data are in most cases easier or faster to obtain than biological data. For similar ship-time, multibeam or side-scan sonar cover larger areas than faunal sampling, and data processing is less labour intensive than for a biological samples. The main limitation of this approach to classification, however, is that habitats are defined *a priori*. What we perceive as a habitat is not necessarily what the fauna perceive as a habitat.

The bottom-up approach is not exempt of bias either. There are few clear boundaries between biological communities, so when trying to develop a classification scheme according to faunal affinities we create discrete entities where there is in fact a continuum. These may also vary according to which element of the fauna is considered (e.g. meio-, macro-, or megafauna). The main limitation of this taxonomic approach, especially in the deep-sea, is the paucity of data available. Few areas have been adequately sampled and most species are undescribed. It was noted however that for large scale patterns a lower taxonomic resolution (e.g. family) could be sufficient. Focusing on dominant species might also be a valid approach although, depending on the purpose of the classification, the use of “diagnostic species” may be inconsistent with the goal of defining representative areas (e.g. for marine protected areas).

Finally, it was decided to adopt a top-down approach and list:

a) What could be considered as a habitat on continental margins, mainly based on topography, sedimentology or bioherms; the hardware in a sense.

b) Which factors could influence benthic communities, mainly physico-chemical factors; the software in a sense.

The next step was to identify which combinations of the “hard-“ and “software” lists would have a biological meaning according to the literature, i.e. which combinations could we validly consider as a habitat.

2) A hierarchical classification or not?

Many classification schemes are hierarchical, although opinions differed on the usefulness of a hierarchy. The advantage of this type of classification scheme is that it utilises the hierarchy in the factors which structure benthic communities and it is straightforward to use. The disadvantage of hierarchial classification systems is that no hierarchy would be universal and perfectly fit all ecosystems. A hierarchy was adopted in the list of physico-chemical factor that could affect the distribution of species (see “outputs” below). This hierarchy is based on spatial scales although the boundaries are vague.

5 Outputs from meeting:

A “brainstorming” session was carried out on Wednesday to produce: (1) a list of what the participants considered to be “Habitats”, and (2) a list of factors which influence these features to create habitats. The second of these was divided according to scale.

List of Habitats

Muddy slope
Canyons
Mud volcano
Carbonate mound with *Lophelia* Reef
High energy > 30 cm/sec
Bivalve beds
Cinder cones
Pock marks/sink holes
Active faults
Sandy barchans
Steep escarpments
Diapirs
Banks and Rises
Deep-sea Fans
Seamounts
Oxygen minimum zones
Dropstones
Cemented stones
Furrows
Seep sediments
Mass transport deposits (muddy)
Turbidites
Iceberg ploughmarks
Depocenters
Whale falls
Hypersaline lakes – brine pools
Innactive Carbonates
Bacterial mats
Sand waves
Contourite drifts
Seamounts
Diapiric ridges
Sponge beds
Xenophyophore beds
Coral gardens

Wood falls
Glacial fans
Shipwrecks
Boulders, rocks
Mobile/gravel sands
Manganese nodules and crusts
Phosphorite sands and crusts
Channels
Sand, gravel, pebbles, muddy sand,
Trench
Basin
Terrace
Shelf edge
Pinnacles
Mounds, hills
Blowout holes
Ripple marks
Foram sands
Flanks
Gas Hydrates
Immature/Mature Canyons
Sediment Drifts

The question was raised concerning whether or not habitats could be considered in the same way for different size classes of animals (i.e., meio, macro and megabenthos), as these would be influenced by factors operating at different spatial scales.

Factors influencing features to form habitats

Large Scale
Water Masses
Productivity
Water Depth
Oxygen
Current velocity
Temperature
El Nino
Source of OM
Quality of OM
Stratification
Hurricanes
Latitude
Slope (angle of the seafloor)

Internal waves
Larval supply
Seasonality
Ice cover
benthic storms

Medium
Grain Size (all scales)
Internal Waves

Small
Oxygen
Fluid flow (reduced compounds)
Current velocity
Anthropogenic impacts…
Biology/bioturbation
Slope stability
Cementation
pH/CCD
Orientation
Sorting coefficient

Definition of scale: < 1 km is small/ large scale – larger than the habitat…

6 Conclusions

A wide variety of factors were identified as leading to habitat heterogeneity on continental margins. One of the principle questions at the start of the workshop was whether or not it was possible to produce a standardized classifications for margin habitats. Given the wide range of ideas and approaches to habitat mapping, this is certainly not a trivial proposition, and where this has been carried out effectively (e.g., with MESH and around Australia) it is only after a long process of development. While it would clearly have been unrealistic to expect this from one short workshop, the participants acquired a wider understanding of the issues involved, as well as a clearer picture of the magnitude of the work ahead of them if a unified classification scheme is to be developed for continental margins.

7 ACKNOWLEDGEMENTS

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Alan Hughes was also funded through DCUK2, funded by the Esmée Fairbairn Foundation.

Appendix A: Discussion document prepared by Alan Hughes and Lenaick Menot prior to the workshop.

Approaches to habitat classification on continental margins.

Introduction

COMARGE is an international network of scientists which aims at addressing key ecological issues concerning continental margin ecosystems (*c*. 200 to 4000 m water depth). In July 2006, at a COMARGE meeting at the Institute Océanographique in Paris, a working group was formed to examine landscape patterns and processes on continental margins. This group had two overall aims:

a) Quantify and compare habitat heterogeneity on continental margins.
b) Refer to a common framework for habitat description.

It was decided that a workshop to address these issues would be held in Southampton on 4-6 June, 2007. This workshop will bring together geophysicists and biologists to compare the different approaches adopted by both groups in mapping habitats in different geographic regions.

Background

Bathyal continental margins (200 to 3000 m water depth) occupy 17.8% of the World Ocean area (Zezina, 1997), and offer a wide variety of environmental conditions due to differences in water depth, surface primary productivity, current activity, the topography of the sea-floor, sediment characteristics, underlying geology, lateral and downslope sediment transport processes and the physical and chemical nature of the overlying water masses. To map the distribution of benthic species within large areas such as this, geophysical classifications of habitat types, as surrogates for marine community types, are the only practical approach. In shallow waters, the relationship between major habitats and physical factors are relatively clear. However, in deeper waters, species diversity often increases and relationships between major habitat types and community types can become less distinct (Roff et al., 2003). Where there is little variation in several geophysical factors, we may need to place greater reliance on direct mapping of the biological communities themselves; this may be the case in the deep sea, where large areas may be covered in seemingly homogeneous muds and silts.

While the development of marine biotope mapping historically begun from a biological perspective, nowadays more emphasis is usually given to geophysical classification and mapping of habitats. This trend has been fostered by the development of new technologies, mainly sonar and echo sounders, to accurately map the bathymetry, topography, roughness and nature of the seafloor. These new technologies offer an easier and faster way to map habitats than is possible to map biological communities directly. Remote habitat mapping may guide biological sampling and identify the probable location of boundaries or gradients between community types. "Seascapes", as identified by geophysical surveying, may not correspond to biotopes, however, but may correspond to sets of community types that require further subdivision according to more detailed physical factors. For example, on continental slopes benthic communities may change with bathymetric depth, although there is not a notable change in the sediment type indicated from the geophysics of the region. On continental margins the factors that may influence the distribution of the fauna, may not be immediately obvious from remote sensing (e.g., the quantity, quality and periodicity of organic carbon inputs may be important drivers behind species distributions).

The development of habitat classification in shallow seas has been motivated by conservation issues. The same issues are now leading to the expansion of habitat mapping into deeper waters. Hierarchical classifications have been developed for the deep-sea, which basically follow a top-down process from larger to smaller-scale habitats, while the biological approach would adopt a bottom-up classification, from individual stations to increasingly large clusters of stations. Though data on benthic communities are scarce in the deep sea, some regions have received greater attention and the assemblages present are better known.

In shallow waters habitat mapping often utilizes photography to examine the biological aspect of biotopes. While this approach is also useful in the deep sea, this approach has limitations. Specifically, the majority of species in the deep sea are small, infaunal invertebrates which do not appear in photographs. These organisms generally dominate the abundance, biomass and diversity of deep sea assemblages.

Anthropogenic Impacts:

In monitoring anthropogenic inputs, we may use various criteria to assess the "health" of a marine community, e.g.: species number, species diversity, and various biotic indices. The broad type of community expected in a region can be judged from the mapped habitat type and/or from composition indicator species. Habitat mapping also aids in defining suitable "reference" and background communities (Roff et al., 2003). In addition, what were once thought of rare and unique deep-sea communities, such as deep-sea coral and chemosynthetic communities, are now proving to be more widely distributed that we originally thought as we learn more about the specifics of their habitat characteristics.

The increasing use of the deep sea for mining, disposal activities and fishing makes the need for accurate habitat mapping that much more relevant and imperative. For example, accurate information on locations and sizes of *Lophelia* reefs, as well as data on the associated fauna, are necessary to better manage these areas. The use of Geographic Information Systems (GIS) provides the best platform to integrate large data sets into geographically meaningful, immediately useful products.

Aims of the workshop

- Identify areas of continental margins that have been studied in sufficient detail, both from a geophysical and biological point of view, to examine the following questions:

  1. Are what geologists/biologists define as habitats what faunal assemblages see as habitats?
  2. Is there a relationship between habitat heterogeneity and faunal diversity at regional scale?
  3. Can we identify representative habitats and assemblages?

- Compare the different classification schemes used, examine how they differ, and whether it is practical to merge them to allow direct comparisons between studies.

- The issue of scale is likely to be central to discussions at the workshop. Can we identify what scales are most relevant/important to both biologists and geophysicists?

- Assess whether the classification systems previously suggested (e.g., Greene et al, 1999) are too general for classifying continental slopes.

- Can we use habitat mapping to identify trends in diversity? How does this relate to the overall aims of COML?

<u>Glossary:</u>

The terms habitat and biotope have either been defined as the physico-chemical environment characteristic of the place where a community of organisms is living or the sum of the environment and its associated community. Nowadays, the more widely accepted terminology is to give habitat the former definition, that is to say to limit habitats to the abiotic factors, while giving the biotope the second acceptation following the formula:

Biotope = Habitat + Community (or Biocenose)

[However] Biotope (Oxford English Dictionary): The smallest subdivision of a habitat, characterized by a high degree of uniformity in its environmental conditions and in its plant and animal life.

Biocoenosis (OED): An association of organisms forming a biotic community; the relationship that exists between such organisms.

Habitat (OED): The locality in which a plant or animal naturally grows or lives; habitation. Sometimes applied to the geographical area over which it extends, or the special locality to which it is confined; sometimes restricted to the particular station or spot in which a specimen is found; but chiefly used to indicate the kind of locality, as the sea-shore, rocky cliffs, chalk hills, or the like.

Habitat: A spatially recognisable area where the physical, chemical and biological environment is distinctly different from surrounding environments. (Valentine et al., 2005).

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