Advisory Committee on the Marine Environment **ICES CM 2001/ACME:02**
Ref.E

REPORT OF THE

Workshop on Deep-Seabed Survey Technologies

Bergen, Norway

31 January–2 February 2001

International Council for the Exploration of the Sea

Conseil International pour l'Exploration de la Mer

Palægade 2–4 DK–1261 Copenhagen K Denmark

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1 OPENING OF THE MEETING AND INTRODUCTION

The workshop was supported by the ICES Advisory Committee for the Marine Environment and the ICES Study Group on Marine Habitat Mapping. The workshop was hosted by the Institute of Marine Research in Bergen, Norway and chaired by Thomas T. Noji. Arne Hassel was appointed rapporteur.

The workshop was previously entitled "Deep-Water Survey Technologies and the Development of Standards for Marine Habitat Mapping".

2 TERMS OF REFERENCE

2.1 Background for the workshop

Recent developments in integrated habitat mapping techniques offer powerful tools for deep-water sustainable resource management. There is a growing interest in maritime countries to conduct marine habitat mapping surveys. This is due to the growing dependency upon marine habitats for meeting current social and economic needs, and due to advances in acoustic as well as database technology (GIS) enabling the rapid collection, archiving and presentation of survey and other data. Acknowledging the growing importance of marine habitat mapping for marine science and environmental management, the ICES Marine Habitat Committee decided to establish a Study Group on Marine Habitat Mapping (SGMHM) (C.Res.2:39; 1998), which provides advice in relation to the development of a classification system for marine habitats, development of a tool to measure marine habitat quality, knowledge on effects of human-induced habitat change, and knowledge on the effects of anthropogenic pollutants/contaminants on habitats and living resources.

At the first SGMHM meeting held in conjunction with the OSPAR/ICES/EEA habitat classification workshop in Oban, Scotland from 6–10 September 1999, the SGMHM agreed with the usefulness of marine habitat maps and supported three joint OSPAR/ICES proposals designed to advance developments in the production of high-quality habitat maps:

1) To carry out a joint cooperative comparison of deep-sea survey technologies and to explore the possible development of standards in this field;
2) To produce a detailed habitat map of the North Sea using existing data, to test data access and cooperation between Contracting Parties;
3) To carry out a pilot project for habitat mapping to EUNIS level 3 in the entire OSPAR area, which would test the EUNIS classification.

2.2 Scope of the workshop

Because of the need to initiate collaboration between institutes conducting or planning marine habitat investigations and in response to the proposals made by ICES and OSPAR, the Institute of Marine Research agreed to host a Marine Habitat Mapping workshop to discuss survey technologies and strategies, data formats and mapping products for deep-water habitats. The intention is to cover a range of environments from shelf depths to the deep sea. The workshop would also provide the opportunity for participants to present brief talks and posters on current and planned marine habitat mapping activities and to discuss international cooperation as well as joint projects.

2.3 Objectives of the Workshop

The workshop is intended to be a forum for geologists, benthic ecologists, GIS database experts and others to develop an integrated approach to deep-water habitat mapping to ensure that techniques/standards for data storage, interpretation and presentation are compatible. Primary objectives of the workshop are:

1) Compile and review information on deep-sea survey technology to map the seabed and benthic habitats;
2) Identify and compile information on existing data sets from mapping of the sea bed and benthic habitats;
3) Consider harmonization or standardization of survey technology, data processing, interpretation and map products (GIS) for future applications;
4) Consider collaboration and possible joint projects between ICES countries on marine habitat mapping field activities.

3 MINUTES OF THE MEETING

3.1 Day 1

O. Misund started the meeting talking about (the wonderful weather and) the aims of the project. He also presented a draft description of the new research vessel "G. O. Sars".

T. Noji continued describing the WKDSS: Workshop on Deep Seabed Survey Technology.

Background: ICES SGMHM later becoming a working group. Earlier workshop in Oban, September 99.

Objectives: Compile information on deep-sea technology; Identify and compile information; Standardization of survey technology; -GIS-Collaboration; Asking for proposals for the project.

3.1.1 Lectures

3.1.2 Jens Hovem

"ISACS: Integrated System for Analysis and Characterization of the Seafloor"

The presentation addressed interpretation of the backscatter data from the Oslo Fjord, TOPAS-sonar, low frequency, narrow beam, multibeam sonar, use of models, backscattering as a function of frequency, angle, roughness of seafloor, density, sound velocity, models of roughness, e.g., BORIS.

3.1.3 Andrew Kenny

"A trial of three sonar systems for monitoring seabed habitats"

The presentation addressed: systems to discriminate between sublittoral habitats, assessment of the repeatability of different acoustic mapping techniques, cost/benefit of techniques, sidescan sonar, interferometric bathymetry, RoxAnn.

3.1.4 Anthony Grehan

"Galway at the gateway to Atlantic"

Site: West of Ireland. The presentation addressed: EU Fifth Framework Margin Project, Ecomound and Aces, habitat mapping in Galway, use of ROV (ARAMIS), carbonate mounds and cold coral exploration, advanced mapping with video and sonar, medium-scale mapping using sediment profile imagery (SPI), Euromarge-NB High resolution pictures.

3.1.5 Adolfo Uriate

"Sedimentological and biological mapping of the Basque continental shelf"

The presentation addressed: the production of charts characterizing the morphology of the continental shelf, different seabed types, cruises to collect bathymetric data, sidescan, RoxAnn, calibration of RoxAnn with Van Veen grabs, data analysis and filtering, correlation between seabed and fish, GIS.

3.1.6 Pål Buhl-Mortensen

"Videorecordings as a tool for mapping habitats"

The presentation addressed: areas investigated with ROV and video, pipelines and nearby areas, coral reefs on Haltenpipe (Sula reef), Nord Leksa, Storegga, Norne-Åsgard and Tautra ridge, the relationships between number of species and analysed video sequences from inspection of pipelines, "HABIMAP" as a tool to calculate the number and density of species.

3.1.7 Brian Todd

"Habitat mapping of the Gulf of Maine"

The presentation addressed: Georges Bank, Canadian mapping activities, multibeam investigations from1996–present in the area, mapping procedure, relevance for fisheries, multibeam mapping (bathymetry, backscatter), groundtruth (geophysics, geology), benthic habitat map.

3.1.8 Dick Pickrill

"Sea Map: Canada's national proposed offshore mapping program"

The presentation addressed: different multibeam systems, the Seamap-concept and relevance for fisheries, petroleum industry, health and safety, economic zones, offshore, infrastructure.

3.1.9 Page Valentine

"Geologic mapping of fishery habitats off New England using multibeam and seabed sampling techniques"

The presentation addressed: fisheries MPAs, pollution, waste disposal, lack of regional surveys, multibeam mapping, groundtruth methods (navigation, video/photo, video-assisted grab), and applications of research results to fishery management strategies.

3.1.10 Mick Geoghegan

"Irish National Seabed Survey"

The presentation addressed: multibeam Simrad EM 130, seabed mapping project, different chart types, SVP (Sound velocity profiles).

3.1.11 Craig Brown

"High resolution mapping of seabed biotopes in UK waters"

The presentation addressed: 3-year project 1998–2001, Ministry of Agriculture, sidescan, AGDS, Hammon grab, 2 m beam trawl, video, QTC-data overlain on sidescan with bathymetry.

3.1.12 Douglas Masson

"Atlantic Margin Environment Survey"

The presentation addressed: AFEN—Atlantic Frontier Environment Network, characterization of seabed sediments, sedimentary processes, biology, geochemistry, sidescan sonar, sediment coring, seabed photography. CD on AFEN can be ordered via WWW.GEOTEK.CO.UK (AFEN).

3.1.13 Brian Bett

Same area/project as above (Faroe - Shetland Islands)

The presentation addressed: large-scale regional description of the current state of seabed, joint sidescan sonar and photographic classification.

3.2 Day 2

3.2.1 Lectures

3.2.2 Antonio Pascoal

"Marine robots. Advanced tools for marine habitat mapping"

The presentation addressed: applications of marine robots for habitat mapping tasks, "MARIUS", development of an autonomous underwater vehicle, "DESIBEL", development and testing of the navigation and control systems for SIRENE, marine robots designed to study shallow-water hydrothermalism in the Azores (project "ASIMOV").

3.2.3 Alan Butler

"Optional Seabed Habitat Mapping"

The presentation addressed: regional marine planning (Australia's Oceans Policy), large marine ecosystems, habitat classification, definitions of habitats (physical, biological, chemical variables), video systems, rock dredge, epi-benthic sledge, acoustics.

3.2.4 Jan Helge Fosså

"Coral-related investigations in Norway"

The presentation addressed: *Lophelia pertusa* corals in Norwegian region, methods for surveying corals.

3.2.5 Terje Thorsnes

"Mareano - marine areal database for Norwegian waters"

The presentation addressed: "MAREANO", multidisiplinary approach, multibeam, environmental monitoring, shaded relief maps, seabed sediment maps, habitat maps.

3.2.6 Randy Cutter

"Habitat mapping and classification of juvenile fish and benthic infauna using acoustic and optical imaging"

The presentation addressed: sea-floor data collection, integration, visualization, exploration, and modelling, sidescan sonar, single and multiple beam, 3D maps showing video-animation, underwater video, video sled, bottom video mosaic image, integrating acoustic and optical data with biological data.

3.2.7 Gary Green

"Habitat mapping along the eastern Pacific, habitat characteristic scheme"

The presentation addressed: classification scheme for marine benthic habitats, biotic and abiotic factors, using classes, subclasses, etc.

3.2.8 Ricardo Serrão Santos

"Marine conservation in the Azores: From inventory and classification towards mapping of habitats and biodiversity"

The presentation addressed: Azores, climatic and biochemical processes, overexplotation of limpets and lobsters, demersal fisheries, hydrothermal ecosystems, "ASIMOV" (Advanced System Integration for Managing the coordinated operation of robotic Ocean Vehicles).

3.2.9 Lene Buhl-Mortensen

"Registration of benthic habitats and macrofauna in Danish waters"

The presentation addressed: uses of the Danish marine database, identification of habitats and species in need of protection, acoustics (large scale), ROV, trawl, sledge, box core (small scale).

3.2.10 Bill Meadows

"Use of GIS and acoustic survey techniques to assist in habitat mapping"

The presentation addressed: sidescan mapping in the English Channel: Dredge tracks, sand wave fields, QTC classification (coarse gravel, mixed sand, mobile sand).

3.2.11 Sigmar Arnar Steingrímsson

"Review of existing databases (biological data) in Iceland: Possible interaction with physical data"

The presentation addressed: bathymetry of Nordic Seas, hydrographical stations around Iceland, BIOICE-Benthic invertebrates of Icelandic water, stations, Icelandic groundfish survey.

3.2.12 Michael Schlueter

"GIS technique and *in situ* oxygen profiles for spatial calculations of geochemical budgets"

The presentation addressed: Norwegian Sea-Greenland Sea, primary production and sea-floor bathymetry, flux and remineralization of organic matter, O_2 profiles, correlation between primary production, water depth and organic carbon flux to the sea floor.

4 GROUP TASKS, REPORTING AND RECOMMENDATIONS

Day 1— tasks

(a) Assess and recommend, if possible, strategies for collecting field data for marine habitat mapping; (b) compare and recommend, if possible, technologies used for marine habitat mapping

Day 2— tasks:

(a) Assess and recommend, if possible, formats for marine data; (b) assess database types and requirements with respect to ease of data exchange as well as research and management applications

Day 3— tasks:

(a) Identify large-scale marine habitat mapping needs; (b) discuss proposals for cooperation and joint projects

The participants worked in the following groups during Days 1 and 2 to address specific points on the agenda. Day 3 tasks were addressed in a plenary session.

4.1 Group Participants

4.1.1 Group A

Bett, Brian J.
Buhl-Mortensen, Pål
Cardigos, Frederico
Greene, H. Gary
Limpenny, David

Masson, Douglas G.
Santos, Ricardo Serrão
Steingrímsson, Sigmar Arnar
Todd, Brian
Pascoal, Antonio

4.2 Group B

Davies, Jon
Buhl-Mortensen, Lene
Cogan, Christopher
Grehan, Anthony J.
Longva, Oddvar
Meadows, Bill
Schäfer, Angela
Tempera, Fernando
Uriarte, Adolfo
Kenny, Andrew
Pickrill, Dick

4.3 Group C

Brown, Craig
Butler, Alan
Cutter, Randy
Geoghegan, Michael
Hovem, Jens
Misund, Ole Arve
Schlueter, Michael
Thorsnes, Terje
Valentine, Page

4.3.1 Day 1 Group A

Brian Todd, Chair

Working Definition of Habitat: "Set of physical and chemical conditions on the sea floor and in the water column in which flora and fauna exist"

The definition of habitat is affected by oceanographic conditions:

- geological
- physical
- chemical

For example, seabed morphology, sediment texture, water mass dynamics, nutrient supply, etc.

Note that habitat encompasses both spatial and temporal variables.

1) Strategies:

- Crucial to "mine" existing scientific data before designing and executing new field surveys.
- Need to identify the scale of habitat interest, i.e., small region (tens of metres) up to large regions (e.g., continental shelf).
- Even if the area of interest is relatively small, it is important to appreciate the regional setting.

2) Technologies:

- Collect and retain (archive) data, i.e., do not discard any data which are not used at present.
- Application of technology is dependent on the objective, i.e., the area and objects to be mapped; for example, a small inlet vs. an entire continental shelf!
- Acoustic technologies such as multibeam, sidescan sonar, seismic are suitable for relatively large areas.
- Photographic technology (still camera/video) is useful for small areas.
- Limitations include turbidity. In this case "acoustic" photography and laser line scanning/laser stripping are alternatives.
- Future technologies (now becoming operational) include autonomous underwater vehicles (AUVs) hosting various acoustic tools.
- Introduction of AI (artificial intelligence) techniques for AUVs applications. AI for correlation of bathymetry with groundtruth data?

3) Integration:

- Monitoring of strategic sites should be included in habitat mapping programmes.

4.3.2 Day 1 Group B

Bill Meadows and Anthony Grehan, Co-Chairs

Can universal backscatter models be applied to many diverse geographic needs? If so, then calibration techniques could allow localized survey data sets to be compared with other areas.

Natural environmental changes (e.g., temperature, current) are additional controlling factors in defining habitats (GIS can help visualize multivariate systems). Dynamics of sediment affect biology.

Classification methods are driven by legislation but might not reflect the types of data now available.

Resolution depends upon water depth.

Spatial resolution increases with the number of classes.

Good knowledge of regional geology is needed to extrapolate existing data.

Bathy data sets can be seamless in coverage but backscatter data sets are less easy to overlay seamlessly.

Recommendation:

*Tools exist for 100 % coverage. There is a strong recommendation for 100 % coverage in multibeam and swathe backscatter to be applied.

Sediment type defines the best type of acoustic and physical techniques to be used. It is always best to use a blend of tools.

Recommendation:

*Define the highest resolution appropriate to top layer definition, size of area and depth.

Empirical data on substrate types and survey sites can be used to define best mapping techniques.

Functional groups of species would better define biology-sediment relationships.

There is a need to define the attributes that can be mapped by each technique.

Recommendation:

*Groundtruthing of multibeam with high-resolution acoustics sidescan-seismics and on a smaller scale with physical sampling is acceptable as a nested technique to optimize sampling effort.

There are two types of groundtruthing requirements, sedimentological and biological, which require differing techniques.

Recommendation:

*Groundtruthing should always be bottom geo-referenced.

Recommendation:

*For geological purposes groundtruthing should include the top few centimetres of substrate. Wentworth still valid for definitions in particle size.

BIOLOGICAL (mainly benthic) requirements in groundtruthing:

Recommendation:

*Visual techniques are great aid (consider precise geolocation, non-invasive sampling, videomosaic–stills).

Recommendation:

*Is biological homogeneity related to acoustic homogeneity?

It is most efficient to use preliminary geological data to direct the effort of biological sampling.

Temporal (time series) tracking is an important dimension.

Consider what information biology (e.g., indicator species) can give in mapping the physical environment.

Classification using traditional biological methods may not be suitable for use in geological frameworks.

Standardized collection techniques (or documentation of methods) are essential.

4.3.3 Day 1 Group C

Page Valentine, Chair

Strategies for collecting field data:

1) The following should be considered:

    a) Purpose of survey for present and future uses;
    b) Scale of the survey;
    c) Water depth;
    d) Cost vs. funding availability.

2) Multibeam echosounding and backscatter data from ME would be the first choice for all except small-scale surveys. The latter may best be conducted with high-resolution sidescan sonar. e.g., areal vs. site-specific surveys.

3) Ensure that raw data are stored!

4) Groundtruthing:

   a) Various methods can be used depending upon the objective:

      - sidescan sonar;
      - video/photo;
      - sub-bottom profiling;
      - coring;
      - grabs;
      - other method

5) Exploit new proven technology.

Note: Navigation is extremely important! E.g. towed vs. hull-mounted systems.

Day 1 Plenary Comments and Recommendations

Working Definition of Habitat: "Set of physical, chemical and biological conditions on the sea floor and in the water column in which flora and fauna exist".

A particular habitat is affected by oceanographic conditions:

- geological
- physical
- chemical
- biological

For example, seabed morphology, sediment texture, water mass dynamics, nutrient supply, fauna, etc.

Note that habitat encompasses both spatial and temporal variables.

It was noted that this working definition is in accordance with terms used in the report on Habitat Classification by the European Topic Centre on Nature Conservation (ETC/NC) nature information system (EUNIS).

Recommendations:

4.3.4 Strategies

a) It is crucial to "mine" existing scientific data before designing and executing new field surveys.

b) Purposes of the survey for present and future uses should be considered when planning and conducting field surveys.

c) Water depth and substrate should be considered with regard to the technologies suitable for the survey.

d) Cost vs. funding availability should be considered with regard to the selection of technologies used for the survey.

e) There is a need to identify the scale of the habitat of interest, i.e., small region (tens of metres) up to large regions (e.g., continental shelf).

f) Even if the area of interest is relatively small, it is essential to assess this within the larger regional setting.

4.3.5 Technologies

a) Collect and archive data, i.e., do not discard any data which are not immediately used, as they may be instrumental for future purposes.

b) There is a need to define the attributes that can be mapped by each technique.

c) Choose the highest resolution appropriate to the definition of the surficial sea floor substrates, size of area and depth.

d) Multibeam echosounding (ME) and ME backscatter data should usually be the first choice as a tool for describing the sea floor for all except small-scale surveys. Small-scale surveys are best conducted with high-resolution tools.

e) Various methods can be used for groundtruthing and depend upon the objective.

f) Groundtruthing of any remote sensing data must be conducted.

g) Groundtruthing with photographic technology (still camera/video) is useful for medium-scale transects and fine-scale discrete sites. Note that limitations to the application of photographic techniques include turbidity. In this case "acoustic" photography and laser line scanning and laser stripping are alternatives.

h) Groundtruthing with cores and grabs is useful for discrete sites.

i) Groundtruthing and calibration of backscatter data should be conducted at strategic sites.

By calibration, we refer to:

- understanding the acoustic parameters of the survey system;
- frequency, gain level, etc., of transmitted/received signal;
- acoustic footprint, beam angle, water column structure.

By groundtruthing, we refer to:

- interpreting backscatter using sample, video, and other types of data (physical properties of samples);
- high frequency systems;
- backscatter dominated by surface texture and roughness of sea floor;
- photographic data good for groundtruth;
- low frequency systems—penetration sub-seafloor, backscatter will have component of subsurface input; substrate sampling will give better groundtruth.

j) The Wentworth scale is still valid for definitions of particle size.

k) Visual techniques are a great aid in describing habitats. These techniques should ensure precise geolocation and minimum disturbance of the seabed. Video footage is useful for habitat characterization.

l) Groundtruthing should always be bottom geo-referenced.

m) Accuracy of navigation is extremely important.

n) The potential influence of seabed fauna and flora on acoustic measurements should be considered.

o) The development of new technologies and their application should be encouraged if the technologies are proven to be robust. Future technologies (now in a testing phase) include new sensors and platforms, autonomous underwater vehicles (AUVs) hosting various acoustic tools, artificial intelligence (AI) techniques for AUVs, etc.

p) Non-destructive methods (e.g., photography) should be used if possible, particularly where long-term monitoring is intended.

4.3.6 Integration

a) Monitoring of strategic sites should be included in habitat mapping programmes.

b) Consider what information biology, e.g., indicator species, community characteristics, can provide for mapping the physical environment.

c) It is always best to use a suite of proven techniques for assessing and monitoring habitats.

4.3.7 Day 2 Group A

Brian Bett, Chair

1) Aerial remote sensing, e.g., satellite and aircraft: often done as international collaboration to established data types and standards. Non-problematic.

2) Routine hydrographic operations, e.g., CTD and towed undulator casts. Standards exist (e.g., WOCE). Non-problematic.

3) Large-scale remote sensing of the seabed, e.g., seismic, sidescan and multibeam): Bathymetric data in x-y-z format should pose no problems, and international bodies exist to “aid” compilation of data (GEBCO). Other “interpreted” data, e.g., backscatter, will in most cases be transferred in an image format (e.g., GEOTIFF), though there is obvious need for attention to geodetic requirements (projection, datum, etc.).

4) Small-scale remote sensing of the seabed, e.g., photo and video surveys: No standards exist for either methodology or data reporting. It is thought highly unlikely that any such standards could be usefully derived. There is, however, a need for appropriate supporting data, e.g., navigation and image scaling.

5) Physical samples of the seabed and associated fauna. There are some useful standard classification schemes available for sediment data (Wentworth and Folk) that might form the basis of standard reporting. It is also thought useful to archive geological core samples in appropriate repositories. Similarly, there are general standards that are applicable to biological material, e.g., nomenclature should follow international standards. It is particularly important that biological reference collections are maintained. Such collections should ultimately be sent for curation in national museums to acknowledge the dynamic nature of taxonomy and to ensure the long-term value of the original data.

The group did not discuss metadata in detail, but thought that a minimum standard of data banking with central agencies should be recommended. The group noted the existence of a number of standard formats (e.g., ROSCOP/EDMED) and EU-funded initiatives on oceanographic metadata collection and central storage.

4.3.8 Day 2 Group B

Christopher B. Cogan, Chair; Jon Davies, Rapporteur

General Issues:

It is important to clarify the type of data under discussion, because there are several types:

- Spatial data – data that can be georeferenced such as point, line, or area records.
- Non-spatial data – i.e., laboratory studies.
- Derived data products – the result of calibration or interpretation. Value added.

Data Formatting:

Raw data (or nearly raw) are important to maintain in their native format. These data may be more useful for archive purposes rather than actual use or distribution. This also ensures the original resolution is maintained.

Additional formats will also be important to maintain. This will often require the raw data to be reformatted into an international standard. Some of the current formats may be acceptable under ISO (International Organization for Standardization), i.e., ASCII, CSB, DXF, VPF (vector product format), and GEOTIFF (for raster data). It is unclear which of these formats are simply popular at the moment and which are supported under ISO standards. For data distribution, data may need to be in a database format (i.e., Oracle, Sybase) to allow sub-sets of the data to be extracted when the entire data set is not needed. This is particularly important for the transfer of data in GIS format.

It is important to identify the native data structure (i.e., raster, vector, point) as these are often converted back and forth. This should always be documented in the accompanying metadata in the section for Spatial Data Organization Information.

Spatial data are often collected with local geodetic parameters, depending on the characteristics of the paper base maps used in the country or region. It is reasonable to keep the data in this format as long as all the parameters are documented in the metadata to allow reprojection to other systems. This includes, for example, a complete description of the map datum and offsets used.

If the data have well-documented metadata, and the metadata are kept as part of the data to avoid loss, there should not be any great problems with formats for data exchange. The data set value will be highly dependent on metadata.

Metadata Standards:

The data are only as valuable as the metadata allow. Metadata must be compliant with established standards. The most accepted standard is published by the U.S. Federal Geographic Data Committee (FGDC-STD-001-1998) and is in the process of "Harmonization" with ISO standards in progress. Of particular importance to marine data are the FGDC "profiles" for Biological Data, Shoreline Data, and Remote Sensing Data. Metadata authoring tools are available and should be used rather than free-form written documentation. Below are two examples to be aware of:

GCMD Metadata authoring tool: http://gcmd.gsfc.nasa.gov (link to authoring tool)

Metamaker tool: http://www.nbii.gov.datainfo/metadata/tools/metamaker.html

Metadata Servers:

There are many sources of metadata to assist in data mining. One large international source is the Global Change Master Directory (GCMD) for earth science and global change metadata: http://gcmd.gsfc.nasa.gov

There are also more specialized metadata servers for particular regions, such as the European Oceanographic and Marine metadata server: http://www.sea-search.net

Data Distribution:

The International Council of Scientific Unions (ICSU) World Data Center System (WDC) is a good start for international data distribution: http://www.ngdc.noaa.gov.wdc.wdcmain.html

Many other data servers exist, however, data format standards, completeness, and longevity are less certain when dealing with local institutions and budgets.

Miscellaneous Issues:

The data-dictionary within the metadata is critical to maintain documentation of the codes used for data attributes. This information is referred to in the metadata as "Entity/Attribute Information".

Metadata need to be recorded as the data are gathered, not afterwards.

Issues with interpreted data – when data have value added beyond the original raw data, we must decide exactly what the additional data or decisions are based upon. If, for example, the data have be combined and aggregated into a classification, the description of the classification system must be well documented. The group did not enter into a discussion on the use of marine habitat classification systems.

Data analysis and interpretation must have a well-documented "audit-trail" including key decisions to ensure future understanding and allow for re-interpretation.

4.3.9 Day 2 Group C

Page Valentine, Chair

Formats:

Standards? No! Impossible. But database structure and format must be documented. This permits the use of software to find and "translate" data.

Need for an "audit trail" on gear used, mode of deployment, etc.

Metadata:

Yes, but standards exist. Compare existing standards and use the common features.

GIS:

No favourites.

Note on storage:

Raw data - Despite desire to archive all data, it may be beyond capacity (e.g., acoustic data). Consider storing interpreted output in GIS, but it is essential to consider what the GIS is intended to be used for, e.g., researchers, liaison with public, regulatory agencies.

Visualization:

Yes, but again we have no technical prescriptions. Scales and capacity to zoom are important. Printouts are often important. "Pop-up" approaches in GIS have great utility and merit and are simple. Use of true database queries in pop-up mode is being explored. In addition to queries, it is important to display best interpretation, e.g., findings from a multivariate analysis, on a map. Moral: GIS does not substitute for the scientist's duty to interpret critically, etc.

Check with terrestrial experts. They are handling larger sets of data than those often considered from marine investigations. Has the wheel already been invented?

Day 2 Plenary Comments and Recommendations

4.3.10 Data formats

a) It is important to establish the type of data:

- Spatial data, e.g., point, line, area;
- Non-spatial data, e.g., rates, derived data products, etc.;
- Raster or vector types.

b) Raw data should always be stored in their native format.

c) Raw data should always be stored in the original resolution.

With regard to specific types of data, some recommendations were made and are listed below. It is noted that this list is <u>not</u> exhaustive.

d) With reference to data formats for aerial remote sensing, refer to established international standards and data formats.

e) With reference to data formats for routine oceanographic (e.g., salinity, temperature, conductivity), refer to established international standards and data formats (e.g., WOCE).

f) With reference to data formats for large-scale remote sensing of the seabed (e.g., seismic, sidescan, multibeam), it was noted that IHO standards are being developed for multibeam bathymetric data. Multibeam data quality control procedures should be employed and documented. Every endeavour should be made to collect high-quality data. Bathymetric data may be in x, y, z format. Backscatter data, and other derived mapping parameters, may be transferred and stored in image format (e.g., GEOTIFF). See also relevant recommendations on "metadata" below!

g) With reference to data formats for small-scale remote sensing (e.g., photography, video records), no standards exist to our knowledge. A proper record of supporting data (e.g., georeferencing, image scaling) should be ensured. Still photos can be made more accessible if they are available on commonly used data storage media, e.g., CD-ROM.

h) With reference to data formats for physical samples of the seabed and associated fauna, refer to established international standards (e.g., Wentworth scale for sediment grain size, standard international nomenclature for taxonomic descriptions).

i) When raw data must be reformatted, if possible, it should be done according to international standards. Some current formats may be acceptable under ISO (International Organization for Standardization). Commonly used formats include ASCII, CSV, DXF, VPF (vector product format) and GEOTIFF (for images).

j) Data formats should be in accordance with end-user needs.

k) It is vital that corresponding metadata are accessible.

l) If possible, geological core samples as well as seabed fauna should be archived in repositories.

m) Data originating from publicly funded research should be made publicly available.

4.3.11 Metadata

a) Metadata must comply to international standards. Some current standards are published by the U.S. Federal Geographic Data Committee (FGDC; FGDC-STD-001-1998), and these are in the process of "harmonization" with ISO standards.

b) When possible, use of metadata authoring tools should be used rather than "free form" written documentation.

c) Metadata should be recorded as data are recorded and not afterward.

d) The data dictionary within the metadata must be available, since it is critical for the documentation of codes used for data attributes.

e) There must be a clear audit trail (gear, procedures, etc.) for all analysis and interpretation of data, e.g., to permit future re-interpretation of the data. There is often a need for clarification of interpreted data due to "value" added beyond the original raw data.

f) "Common denominators" from established metadatabases should be identified and should eventually be part of a recommendation by ICES for ICES standards. A number of organizations (ROSCOP/EDMED, EU initiatives, U.S.G.S.) have defined standards. The GCMD for earth sciences is a large international library for metadatabases (Global Change Master Directory at http://gcmd.gsfc.nasa.gov/).

g) Geodetic information should be fully documented to permit, e.g., reprojection to other systems. The documentation should include complete description of the datum and offsets applied.

4.3.12 Databases

Several types of databases exist and no one type can be recommended for all purposes. It was noted that appropriate database formats will vary depending on end-user needs. Different user requirements exist for data in development compared to data in distribution or data archives. In general, it was agreed that the database should be digital and accessible via the Internet.

4.4 Day 3 Plenary report: Large-scale habitat mapping needs and future collaboration

It was noted that under the European Union Research Framework Programme 5, it is possible to conduct a so-called Concerted Action, which is aimed at supporting the exchange of data, interpretation of data, collaboration between partners, etc. Next deadline is 4 May, 2001 (not confirmed).

Funding from such a concerted action is available for:

a) project manager;

b) data management;

c) meetings, travel, etc.

Possible themes for concerted-action projects:

a) production of new thematic maps;

b) identify metadata sources relevant for habitat mapping;

c) habitat mapping in relation to fisheries-related issues such as "essential fish habitats";

d) habitat mapping in relation to biodiversity issues and marine protected areas;

e) habitat mapping in relation to other relevant issues;

f) long-term monitoring programmes for marine habitats;

g) technological development of marine habitat mapping tools.

Possible joint field surveys:

Oceanographic sites of interest, which could be a focal point for **field surveys** related to habitat mapping were considered. Two regions were presented by researchers, who seek collaboration. These were:

1) Mapping of the deep-sea benthos in the Azores—Seamount biology, marine resources, hydrothermal vents; contact person Ricardo Santos;

2) Mapping at mid-Atlantic Ridge as part of Census of Life investigations—contact person Jan Helge Fosså or Odd Aksel Bergstad (odd.aksel.bergstad@iMrno) also at IMR

It was noted that there may be a need for a reference site for the above two sites, as the sites under (a) and (b) are characterized by rapid changes and extremes in bathymetry.

4.5 Day 3 Plenary Recommendations

4.5.1 Concerted Action or Demonstration project

The general consensus was to develop a Concerted Action or Demonstration project with the following goals:

a) To "mine" existing data for a variety of bio-physiographic settings and produce new thematic maps for mega-, meso-, macro- and microhabitats using GIS;

b) To identify gaps in geological and biological data needed for production of various types of habitat maps;

c) To assess and interpret the data from different software platforms and to test the exchange of data between the partners;

d) To test various existing standards for data formats and metadatabases;

e) To provide a link to pelagic habitat mapping.

A more detailed report (Annex 4) on recommendations for such a concerted action was made during the first steering committee meeting on 2 February in Bergen.

Potential participants:

- All WKDSST participants;
- International research projects, e.g., EU initiatives, GLOBEC, WGMHM, BIOMARE;
- Research organizations, e.g., SOC, IFREMER, SAMS.

Potential coordinators:

Keith Hiscock (MARLIN)
Eric Jagtmann (WGMHM chair)
Orla Gallagher (Irish Marine Data Center)

Tentative steering committee:

H. Gary Greene
Brian Todd
Dick Pickrill
Terje Thorsnes
Page Valentine
Randy Cutter
Alan Butler
Jon Davies
Pål Mortensen
Ricardo Santos
Thomas Noji
Christopher Cogan
Lene Buhl-Mortensen

Action: It was agreed that Anthony Grehan and Jon Davies would contact the potential coordinators for a concerted action and report to the tentative steering committee.

Possible meetings of the steering committee at upcoming conferences include:

a) St Johns, Newfoundland meeting on the Geology of Marine Habitats in May.

b) WGMHM meeting in Galway, Ireland in April.

5 POSTERS

Several posters were presented at the workshop. Abstracts for some of these are presented below.

PERSPECTIVES ON MARINE HABITAT CLASSIFICATION AND MAPPING

Christopher B. Cogan

Alfred-Wegener Institute for Polar and Marine Research, Bremerhaven, Germany

Our understanding of marine habitat function is limited by our current approach to evaluating marine systems. In previous decades, we were mainly data limited. In recent decades, we have been limited by our ability to analyse and model multiple marine environments as integrated systems. Currently, we are most limited by our ability to formulate questions and synthesize the data and models to conduct our investigations. Habitat classification is of fundamental importance to a suite of marine issues including the assessments of the widely differing types of management areas, environmental quality reports, environmental degradation analysis, toxic spill response planning, fisheries management, and long-term ecosystem health. If our conceptual model of these habitats is in error, or if it varies implicitly with respect to multidisciplinary research, the products of our research are likely to be flawed, or at best inadequate. Marine habitat mapping requires that we can clearly define marine habitats. Definitions of habitat types must be robust enough to be stable for extended periods of time, and be useful to a variety of disciplines, which may have different perspectives and use different terminology. Habitats are complexes of interacting processes usually considered to have some degree of spatial autocorrelation. Some of these processes are directly measurable (i.e., via remote sensing), and our measurement results can be used as a best estimate classifier to assign particular areas a habitat designation. This approach is entirely valid, but we must keep in mind that this "sensor driven" technique will continuously change as technological improvements change our sensor data. The other major approach to habitat classification is to piece together all we know about the function and structure of a habitat, and use that knowledge to describe a region even if some of the critical characteristics are difficult or impossible to quantify.

USING GIS FOR INVESTIGATIONS OF BENTHIC-PELAGIC COUPLING WITHIN THE MARINE ORGANIC CARBON CYCLE IN BIOGEOGRAPHICAL REGIONS

Angela Schaefer and Michael Schlueter

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The marine organic carbon cycle was calculated for different regions in the northern North Atlantic. Supported by a Geographic Information System (GIS) a new method of spatial modelling was established to derive spatial distribution of marine organic carbon fluxes and to establish basin-wide budgets. Local variability and regional aspects within the marine carbon cycle were taken into account to characterize biogeographical regions of different marine regimes: the Greenland Basin, the Norwegian Sea, the Greenland and Norwegian continental margins, the Voering and Island Plateaus and the Faroe-Shetland Trough. The flux of organic carbon from the photic zone to the deep sea and its degradation at the sea floor was modelled. Organic carbon fluxes at the sea floor were determined by *in situ* oxygen demand measurements in surface sediments. In contrast to these locally limited one-dimensional data, primary production at the sea surface derived from satellite imagery and water depth were chosen as two-dimensional highly resolved spatial data sets. The derived relationship and cell-by-cell-calculations enabled the extrapolation of the spatial distribution of organic carbon flux to the sea floor.

6 SUMMARY COMMENTS FROM THE CHAIR

With over 37 participants from 11 countries, the workshop served as a forum for useful discussion on deep-seabed technologies and habitat-mapping methodologies, data formats, metadatabases and future collaboration on relevant issues. The recommendations from the plenum will be presented to the ICES Working Group on Marine Habitat Mapping (WGMHM) at the WGMHM meeting in Galway, Ireland in April 2001. Furthermore, the workshop served to disseminate information on current and planned marine habitat mapping projects and to build global links among the research organizations.

There is no doubt that with the recent developments in deep-seabed survey technologies and database systems, high-resolution large-scale marine habitat mapping of the sea floor has become a reality. The integration in GIS databases of geological, chemical and biological data facilitates access to and visualization of information about marine habitats. Supplemented with information on human activities, integrated multi-layered products are particularly important as tools for environmental managers and other end-users. The production of detailed maps and the implementation of long-term monitoring of marine habitats are and will become increasingly important for the management and protection of marine resources including biodiversity.

ANNEX 1: AGENDA

Workshop on Deep-Seabed Survey Technologies (WKDSST)

The workshop shall begin at 9.00 h on Wednesday, 31 January, and close at 15.00 h on Friday, 2 February.

Day 1 (Wednesday, 9.00 – 17.30 h): Marine habitat mapping activities

- Strategies for collecting field data for marine habitat mapping
- Technologies used for marine habitat mapping with a focus on acoustic mapping technologies, groundtruthing and biological sampling
- Integration of broad-scale physical data with fine-scale biological data

Tasks: (a) Assess and recommend, if possible, strategies for collecting field data for marine habitat mapping; (b) compare and recommend, if possible, technologies used for marine habitat mapping

09:00	Tom Noji & Ole Arve Misund	Welcome. Background. Goals. Other.
	Hovem, Jens	ISACS Integrated system for the analysis and characterization of the seafloor, EU-MAST3 project 1996-1999
	Kenny, Andrew	The repeatability of side-scan sonar, multibeam bathymetry (based upon interferometric techniques) and AGDS in discriminating habitats
	Grehan, Anthony J.	Some deep-water, small to medium scale, optical benthic mapping techniques
	Uriarte, Adolfo	First steps in the sedimentological and biological mapping of the Basque Continental Shelf
10:30		COFFEE
	Buhl-Mortensen, Pål	Video-recordings as a tool for mapping and monitoring of benthic megafauna
	Todd, Brian	Gulf of Maine marine habitat mapping.
	Pickrill, Dick	SeaMap: Canadas national proposed offshore mapping program.
	Valentine, Page	Geologic mapping of fishery habitats off New England using multibeam and seabed sampling techniques
	Geoghegan, Mick	Progress to date in the Irish National Seabed Survey
	Brown, Craig	High-resolution mapping of seabed biotopes in UK coastal waters using a combination of side-scan sonar, AGDS and biological sampling
12:00		LUNCH
	Masson, Douglas G.	Large-scale deepwater habitat mapping west of the UK - the AFEN experience, (1) seafloor characterisation

	Bett, Brian J.	Large-scale deepwater habitat mapping west of the UK: the AFEN experience, (2) benthic ecology”
13:05		Group discussions
15:30		COFFEE
16:00		Group summaries
17:30		Close for the day

Day 2 (Thursday, 9.00 – 17.30 h): Storage, exchange and presentation of marine habitat mapping data

- Formats for marine data to facilitate data exchange
- Metadatabase and metadata standards to facilitate dissemination, e.g., by Internet.
- Usefulness of different GIS and other database systems for marine habitat mapping

Tasks: (a) Assess and recommend, if possible, formats for marine data; (b) assess database types and requirements with respect to ease of data exchange as well as research and management applications

09:00		Continued from day 1
	Pascoal, Antonio	Marine Robots: Advanced Tools for Marine Habitat Mapping.
	Butler, Alan	Application of advanced technologies to characterise seabed and water column biotic assemblages; Optimal seabed mapping
	Fosså, Jan Helge	Coral-related investigations off Norway
	Thorsnes, Terje	MAREANO – Marine Areal Database for Norwegian waters.
	Cutter, Randy	Habitat mapping and classification of juvenile fish and benthic infauna using acoustic and optical imaging and direct sampling
	Greene, H. Gary	Habitat mapping along the eastern Pacific; Habitat characterization scheme
10:30		COFFEE
	Santos, Ricardo Serrão	Data collection and biological interpretation in ASIMOV project. Mapping and classification of Azorean SACs
	Meadows, Bill	Use of GIS and acoustic survey techiques to assist in habitat mapping
	Buhl-Mortensen, Lene	Registration of benthic habitats and macrofauna; long time series

	Steingrímsson, Sigmar Arnar	Review of existing databases (biological data) in Iceland: possible integration with physical data?
	Schlueter, Michael	GIS technique and in situ O_2-profiles for spatial calculations
12:00		LUNCH
12:45		Film on Norwegian Coral Investigations, Group discussions, Subgroup to discuss groundtruthing of backscatter data
15:30		COFFEE
16:00		Group summaries
17:30		Close for the day

Day 3 (Friday, 9.00 – 17.30 h): Coordinated international habitat mapping

- Summary of ongoing and planned marine habitat mapping activities
- Discuss collaboration and possible joint projects between ICES (and other) countries on marine habitat mapping activities

Tasks: (a) Identify large-scale marine habitat mapping needs; (b) discuss proposals for cooperation and joint projects

	Continued from day 2.
09:00	Plenary discussions
09:30	COFFEE
10:30	Plenary discussions
10:50	LUNCH
12:00	Plenary discussions, Workshop summaries & recommendations for future actions
12:45	Subgroup discussion on collaboration on the production of thematic maps for marine habitats
13:00	Tour of the Division of Environment at IMR
14:00	Close of the workshop
15:00	

ANNEX 2: LIST OF PARTICIPANTS

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ANNEX 3: WKDSST PARTICIPANTS' EXPERTISE AND INTERESTS

Name	Mapping Technology Methods	Data storage and visualization	International cooperation
Bett, Brian J.	Lead biologist on AFEN – Atlantic Frontier Environmental Network; sidescan sonar, seabed photography and sampling	Practical experience of the needs and problems of such data management	Survey of deep-water habitats around the Faroes; European collaboration
Brattegard, Torleiv	Mapping benthos. Faroe Islands, Iceland, Svalbard, Jan Mayen		
Brown, Craig	Benthic ecology, UK habitat mapping project; side-scan sonar and AGDS systems for mapping biological assemblages	Storage and presentation of marine habitat mapping data	ICES Study Group on Marine Habitat Mapping
Buhl-Mortensen, Pål	Benthos and habitat survey.	Video-recording analyses, faunal analyses of complex habitats	Collaboration with deep-water coral researchers from Great Britain, and Germany
Buhl-Mortensen, Lene	Macro-benthos survey	Application of the Danish database, MADS, to study fauna distribution in relation to habitats	BIOICE and BIOFAR mapping of fauna on the Icelandic and Faroe continental shelves; Nordic cooperation
Butler, Alan	Acoustics, single and multi-beam, towed video, sampling by corers, sleds, trawls, etc. Habitat classification scheme for Australia.	Predictive habitat maps that couple many variables.	Discussing international cooperative surveys on seamounts and ridges, SW Pacific
Cardigos, Frederico	"MAROV - Mapping of Marine Habitats of the Azores using Robotic Ocean Vehicles"; automatic interpretation of collected data	Commonly accepted standards in biological communities mapping using remote tools as data collectors; sampling scales	ASIMOV - Advanced System Integration for Managing the coordinated operation of robotic Ocean Vehicles.
Cogan, Christopher	Multi-spatial and multi-thematic scale data for marine habitat mapping; terrestrial habitat analysis and classification; quantitative biodiversity	GIS, remote sensing / digital image processing; GIS for large volume database management; metadata standards, database access	EC and broader international co-operative research
Cutter, Randy	Benthic biological habitat classification; prediction and remote determination of habitat characteristics.	Interactive CD-ROM GIS databases; 3-D visualization GIS tools (Fledermaus).	
Davies, Jon	Acoustic remote sensing, groundtruthing, GIS, habitat classification	GIS for analysis, interpretation and presentation of marine benthic data. Standards in the collection, interpretation and storage of marine data	EC projects on seabed mapping. EC Habitats Directive. Requirements for monitoring re Habitats Directive and the Water Framework Directive.
Fosså, Jan Helge	Mapping benthic fauna, deep-water corals, kelp-forest ecology,	Use of GIS for visualization	ICES and OSPAR committees; cooperation on cold-water coral research
Geoghegan, Michael	Mapping of the seabed using MBES and shallow seismic techniques		
Greene, H. Gary	Geology; geophysical techniques in characterizing habitats, habitat characterization and classification	GIS use for habitat mapping (ArcInfo, ArcView)	Establishing a standard habitat classification scheme
Grehan, Anthony J.	Benthic ecologist, faunal assemblage delineation, photo, video and sediment profile imagery	Development of standard protocols	EU proposal for habitat prediction models from available acoustic data and limited groundtruthing

Hovem, Jens	Acoustic remote sensing		
Name	**Mapping Technology Methods**	**Data storage and visualization**	**International cooperation**
Humborstad, Odd-Børre	"Ecosystem effect of trawl and Danish seine fishing"		
Kenny, Andrew	Reviewing acoustic mapping technologies for application in monitoring marine SACs in the UK	Image analysis of side scan data for classification of seabed features; bathymetric and side scan data	Standardize acoustic data acquisition; habitat classification; terrestrial and intertidal methods
Limpenny, David	Combining sidescan mapping and physical and biological sampling to produce habitat maps	Acoustic/physical/biological/ photographic data into GIS	
Løkkeborg, Svein	Technologies for seabed mapping and biological sampling. In charge of the project "Ecosystem effect of trawl and Danish seine fishing"		
Longva, Oddvar	Geological interpretation of the sea bottom bathymetry, seismics, sidescan sonar, cores, surface samples		
Masson, Douglas G.	Seafloor characterisation, sedimentology, sediment transport processes, sidescan sonar	Sidescan sonar data processing and presentation	
Meadows, Bill	Acoustic techniques; texture mapping using sidescan mosaic imagery; multibeam backscatter data for seabed classification	GIS display and creation of vectorized maps; Methods of summarizing and reducing data	Habitat Mapping by remote acoustic methods
Misund, Ole Arve	Large-scale mapping of Norwegian Shelf;		EU projects; ICES and OSPAR; EcoQO development
Noji, Thomas	Large-scale mapping of Norwegian Shelf; contaminant transport; biogeochemical cycles	GIS; standardized formats for data	EU projects; ICES and OSPAR; EcoQO development
Nøttestad, Leif	"Ecosystem effect of trawl and Danish seine fishing"		
Ona, Egil	Multi- and single-beam backscatter data interpretation		
Pascoal, Antonio	Development and operation of ocean platforms (including autonomous surface and underwater vehicles)	GIS and other database systems for marine habitat mapping	Autonomous Surface Craft and Underwater Vehicles with European and American teams
Pickrill, Dick	Mapping of benthic habitats on continental shelf and upper slope		
Santos, Ricardo Serrão	Mapping and classification of marine habitats of the Azores using robotic ocean vehicles and standard SCUBA diving techniques. Automatic interpretation of collected data	Video and photographic recording of marine species. Bionomic maps.	MARÉ - Integrated Management of Coastal & Marine Areas (Azores); BIOMARE; OSPAR/EEA.
Schäfer, Angela	Integration of biological (e.g., benthos biology) and geochemical information	GIS	EU initiatives
Schlueter, Michael	Integration of biological (e.g., benthos biology) and geochemical information	GIS	Several EU initiatives

Stein-grímsson, Sigmar Arnar	Integration of broad-scale physical data with fine-scale biological data: using existing databases on biological data with new physical data (multibeam).	Usefulness of different GIS and other database systems for marine habitat mapping: presentation of information to stakeholders.	Planned marine habitat mapping activities and possible collaboration in terms of expertise and equipments
Tempera, Fernando	"MAROV - Mapping of Marine Habitats of the Azores using Robotic Ocean Vehicles"; automatic interpretation of collected data.	Standards in biological communities mapping using remote tools as data collectors; sampling scales	MAROV - Mapping Marine Habitats (Azores) using ROVs; MARÉ - Integrated Management of Coastal & Marine Areas (Azores)
Thorsnes, Terje	Leader of marine group for Geological Survey Norway	GIS	EU projects
Todd, Brian	Geophysical and geological tools for habitat mapping from near shore to continental slope on the Scotian Shelf	MB bathymetric and backscatter data; GIS for multibeam, geoscientific and bioscientific data	Canada/USA marine habitat mapping in the Gulf of Maine
Uriarte, Adolfo	Sea-floor mapping with acoustic techniques; sidescan sonar, RoxAnn	GIS and programs dealing with presentation of data (e.g., Surfer)	
Valentine, Page	Interpretation of multibeam and sidescan sonar imagery using video/photo and geological and biological characteristics of the seabed.		Interested in comparing approaches to habitat mapping, interpretation, and application of results in other countries.

ANNEX 4: EU CONCERTED ACTION (SUPPORT FOR NETWORKING)

Development of new thematic maps linking acoustic mapping to biology in a GIS environment to underpin sustainable management.

or

Application of acoustic mapping as a tool for ocean management

Steering Committee

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Objectives

A) New thematic maps useful for management in:

- fisheries
- biodiversity

B) Standardization through creation of a glossary of terms

C) Provide management performance measures for MPAs etc.

D) Technological development, standards, quality control, etc.

E) Identify existing meta data sources relevant to habitat mapping

Apply thematic maps to different physiographic zones

Refer to COSTA strategy identifying phyiographic zones.

Depth

- Fjord
- Coast
- Shelf
- Slope

- Deep-Sea

Latitudinal

1) High
2) Temporal
3) Tropical
4) Mediterranean

Types of Maps

Basic Thematic Map Types

1. Bathymetry

    - Sedimentary environments
    - Predictive benthic habitat/biology

Important Biology Control Parameters

1) Hydrographic – temperature, current (energy)
2) Depth
3) Substrate
4) Organic material flux/particle transport (nutrients)

Static/dynamic raw data and interpretative data levels

a) Static Raw Data Levels

1) Bathymetry

Recent advances in remote sensing technologies facilitate the production of high-resolution bathymetric maps.

Data Generation

a) Data mining
b) Shallow-water remote sensing techniques
c) Deeper-water acoustic remote sensing techniques

Development of map interpretation standards - educational need

2) Remote Sensing using Acoustic Backscatter

Remote sensing techniques used for bathymetric mapping also generate additional useful information (e.g., multibeam backscatter)

3) Ground truthing

Required for both sediment and biology

b) Interpreted Data Levels

- Morphological map
- 3-D backscatter representation
- Substrate map

    i) Combine Map 2 with other geological/geophysical survey techniques

- Major geological features
- Mesoscale Biology

    i) Gross biological characterization at level of visible megafauna

c) Dynamic Levels

1) Hydrography
2) Sediment transport
3) Nutrient flux

Types of Products

1) Hazard maps
2) Essential fish habitat maps
3) MPA designation

Note: Predator-prey relationships can be mapped out.

Physiographic zones present in partner countries

	High Latitudes	**Temperate Mediterranean**	**Tropical**
Inshore, Fjord	Juan de Fuca including fish; Norway		
Coast	Norway Canada (laser)	USA – east coast	
Shelf	USA – west coast (Alaska) Norway Canada	USA east coast USA west coast Spain Greece Ireland Norway France	France
Slope	Norway Canada - canyons	Ireland Spain Greece France	
Deep-sea	Norway - NPD	Ireland Spain Greece	
Seamounts/ carbonate mounds		Azores Ireland	Hawaii

Pilot Study

- Look at the range of SEAMAP applications as a way to choose project pilot studies.
- Size of study depends on basic question addressed and existing data
- Look at industry, particularly software development in GIS

ANNEX 5: THEMATIC MAPS OF GEOLOGIC SUBSTRATES AND BIOLOGICAL HABITATS IN THE GULF OF MAINE REGION

Page Valentine, U.S. Geological Survey

A major outcome of discussions at the Bergen workshop[1] was the realization that an important goal of seabed mapping should be the production of thematic maps that show a variety of attributes. Each attribute can be envisioned as a layer in a Geographic Information System (GIS). Some layers are static (e.g., substrate type, sun-illuminated topography, seabed backscatter), some are dynamic (e.g., seawater temperature, productivity, sediment transport), and some are both static and dynamic (e.g., floral and faunal assemblages).

Thematic maps provide the framework for conducting research on biodiversity, on the identification of "essential fish habitat", on the disturbance of the seabed by fishing gear, on improving strategies for bottom-fishing, and for identifying and understanding the natural and human processes that affect the seabed such as sediment transport, the concentration of contaminants, and environmental change.

The U.S. and Canada have completed mapping surveys in a variety of seabed environments in the northwestern Atlantic Ocean. Extensive multibeam data and associated observational data of the seabed exist in the Gulf of Maine region, including Stellwagen Bank and the Great South Channel off New England, and Georges Bank, Browns Bank, and the Scotian Shelf off Canada. Many of the environments in the mapped regions are common to both the U.S. and Canada.

In parallel with a demonstration project proposed by European colleagues to produce thematic maps using existing European data, the U.S. (U.S. Geological Survey and National Marine Fisheries Service) and Canada (Geological Survey of Canada and Department of Fisheries and Oceans) are proposing to work together to develop methods and maps that will standardize the portrayal of seabed attributes common to the Gulf of Maine region shared by both countries.

We propose to hold in 2001 a joint workshop on thematic mapping for the purpose of developing strategies for choosing appropriate map themes, metadata guidelines, scales and projections, and publication methods (paper, CD-ROM, GIS layers). Participants will include geologists, biologists, and fishery managers. A variety of seabed type areas will be selected for the production of thematic maps using existing data. Upon completion of the maps in 2002, a workshop will be held in conjunction with a meeting of the ICES Working Group on Marine Habitat Mapping, the ICES Advisory Committee on the Marine Environment, or other appropriate groups where the results can be shared with European colleagues, both scientists and managers.

[1] Workshop on Deep-Seabed Survey Technologies (WKDSST), Bergen, Norway, January 31 to February 2, 2001. Supported by the International Council for the Exploration of the Sea (ICES), namely the ICES Advisory Committee for the Marine Environment and the ICES Working Group on Marine Habitat Mapping. Host institution: Norwegian Institute of Marine Research. Chair: Thomas T. Noji.

ANNEX 6: INVESTIGATIONS OF SEA SCALLOP DISTRIBUTION AND HABITAT REQUIREMENTS IN THE GULF OF MAINE REGION

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As a result of discussions at the Bergen workshop[2], U.S. and Canadian scientists decided to explore the possibility of conducting a joint research project directed at assessing the distribution and habitat preferences of sea scallops (*Placopecten magellanicus*) in the Gulf of Maine region. Scallop larvae drift for many weeks in and out of U.S. and Canadian waters. In effect, both countries manage a single scallop stock that is distributed in similar sedimentary environments on both sides of the international border. At present, the two countries are conducting seabed habitat mapping surveys in the Gulf of Maine region using very similar geological and biological approaches.

Recent research by geologists and biologists in the Georges Bank-Browns Bank region of the Gulf of Maine has shown that scallops are able to flourish in these food-rich waters, but they are geographically limited to bare gravel habitats and to sand habitats where sand movement is minimal. Sea scallops apparently cannot survive in moving sand or on gravel that is overgrown by attached fauna. In addition, there is evidence that scallop populations depleted by overfishing on Georges Bank can increase markedly in areas that have been closed to fishing for 4–5 years.

The Canadian fishing industry is now using this knowledge and multibeam sonar maps of the seabed to adopt more efficient strategies for harvesting scallops, which include directed fishing on particular habitat types and the use of less intrusive fishing gear. The New England Fishery Management Council is now evaluating the implementation of a rotational area management strategy for the U.S. scallop industry. This scheme would open and close designated areas for the purpose of both enhancing the overall scallop harvest and reducing gear impact on seabed habitats.

The U.S. (U.S. Geological Survey and National Marine Fisheries Service) and Canada (Geological Survey of Canada and Department of Fisheries and Oceans) are proposing to conduct joint studies of sea scallop distribution and habitat requirements in the Georges Bank-Browns Bank region. A collaborative research effort is the most productive way in which to address issues such as defining and mapping scallop essential fish habitat (EFH), evaluating the impact of scallop gear on habitats, and determining the most effective strategies for both managing and harvesting the valuable scallop resource.

Research will begin in 2001 and continue through 2002 and concentrate on a determination of the extent of scallop habitat types, the availability of food, the regional and temporal distribution of scallop larvae, an analysis of the concentration of effort by the scallop fleet, and an evaluation of the fishing efficiency and seabed impact of scallop gear types. Research strategies will be developed jointly with scientists and fishery managers. A workshop will be held in 2003 to evaluate research results and their value to management of the resource and of seabed habitats. The workshop also will be an opportunity to share information with European colleagues and possibly to stimulate similar collaborative research throughout the North Atlantic basin.

[2] Workshop on Deep-Seabed Survey Technologies (WKDSST), Bergen, Norway, January 31 to February 2, 2001. Supported by the International Council for the Exploration of the Sea (ICES), namely the ICES Advisory Committee for the Marine Environment and the ICES Working Group on Marine Habitat Mapping. Host institution: Norwegian Institute of Marine Research. Chair: Thomas T. Noji.