Note

Capacity Building in Ocean Bathymetry

The Nippon Foundation GEBCO Training Programme at the University of New Hampshire

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Abstract

A successful Capacity Building project in hydrography is underway at the University of New Hampshire. Organised by the General Bathymetric Chart of the Oceans and sponsored by the Nippon Foundation, the programme trains hydrographers and other marine scientists in bathymetric mapping. Participants are formally prepared to produce bathymetric maps when they return to their home countries through a combination of graduate level courses and workshops, practical field training, participation in deep ocean research cruises, working visits to other laboratories and institutions, focused lectures from visiting experts, and the preparation of a bathymetry map of their area from public domain data. Intangible but necessary preparation includes the networking with professionals in bathymetry and related fields within Ocean Mapping, and the building of a cadre of graduates who will form the basis of international bathymetric mapping in the future.

Introduction

Through the International Hydrographic Organisation (IHO), hydrographers cooperate in many ways, including contributing to the production of bathymetric maps of the deep ocean through the General Bathymetric Chart of the Oceans (GEBCO). GEBCO predates the IHO, and since 1974 has been allied with both IHO and the Intergovernmental Oceanographic Commission (IOC) of UNESCO. GEBCO produces world bathymetry maps, in paper and digital form, a digital grid of depths, and a Gazetteer of undersea names. In order to help build increased capacity in bathymetric mapping, GEBCO has established an international training programme in ocean bathymetry. In partnership with the Nippon Foundation of Japan, GEBCO has contracted with the Center for Coastal and Ocean Mapping/NOAA-UNH Joint Hydrographic Center of the University of New Hampshire, to develop and offer a graduate certificate in Ocean Mapping. This paper reports on the first year of this programme.

The Need for Capacity to Produce Ocean Bathymetry

Although bathymetry is a fundamental science having a wide range of applications, availability of accurate bathymetry is in general taken for granted. However, the seafloor is largely unexplored: an overwhelming proportion of it has never been measured directly but only

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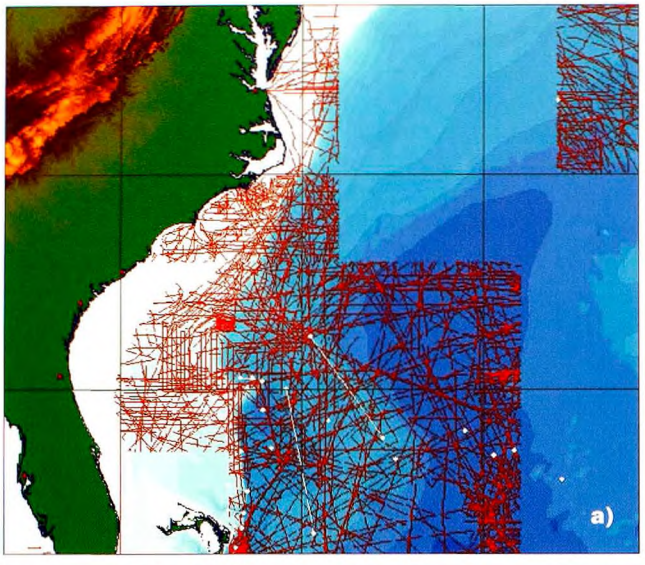
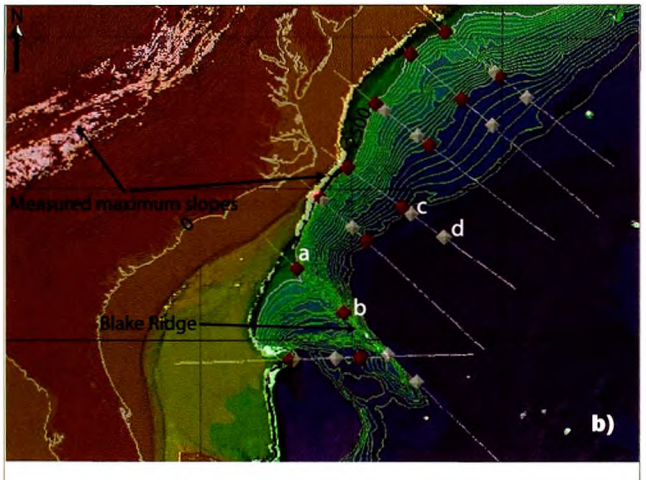
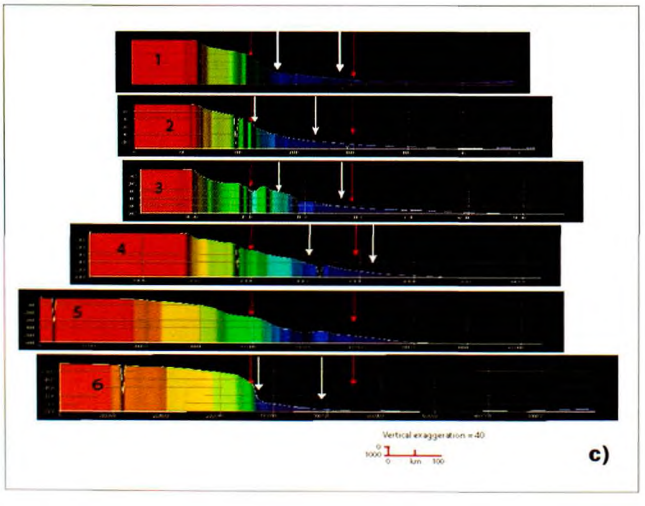




2500 m+100 nm
FOS + 60 nm
1,2,3 .... 7 : Location of profiles



mapped through extrapolation from sparse, widely spaced data. Estimates are that, at most, a mere 5 to 10% of the ocean floor has been explored ((Holcombe and Moore 2000); (Committee on National Needs for Coastal Mapping and Charting Ocean Studies Board Mapping Science Committee 2004); (Harper and Sharman 2003). Almost every scientific and hydrographic cruise is a voyage of exploration, one that will result in areas of the seafloor being directly mapped for the very first time. As witness, the last twenty years of ocean exploration have seen the discovery of gas hydrates in sea floor sediments, of pharmaceuticals from the sea, of 'black smokers', of cobalt crusts, and of chemosynthetic life on ocean ridges. These are regarded by many ocean scientists as but a few of the myriad discoveries that remain to be found.

Despite its wide-ranging uses, bathymetry has often been dismissed in the minds of many marine scientists as merely measuring depth to the seafloor. These scientists used bathymetry as the spatial structure for their own investigations, and consider it to be complete. Unfortunately, 'Bathy-

Figure 1: Area -Northwestern margin of Atlantic Ocean.

a) shows the Cruise track coverage in the foreground and depth contours in the background. Land the Coast line is encircled by blue colour.

b) shows maximum calculated slopes. Light green colour contours in the background are depth contours (0, 2,500 and deeper). White solid lines are profiles (numbered 1 to 7). Grey solid blocks (denoted as 'c & d') are the locations of FOS and FOS+60nm. Red solid blocks (denoted as 'a & b) are the locations of 2,500m and 2,500m+100nm.

c) showing the profile stack from north to south. White solid arrows are the locations of FOS & FOS+60 nm (points 'c & d' as in 1b). Red solid arrows are the locations of 2,500m and 2,500m+100nm (points 'a & b' as in 1b).

Table 1 GEBCO Core Subjects

Depth measurements
- Multibeam echo-sounder (MBES), single-beam echo-sounder, multichannel seismics
- Remote sensing - lidar
- Instrumentation packages
- Sidescan
- AUVs

Oceanography
- Acoustics; backscatter, physics of sound in the sea, chemistry of ocean water, propagation of sound
- Associated science: fisheries, turbulence, tsunami modelling
- Oceanography: tides
- Environmental aspects: coastal oceanography, slope and shelf processes
- Marine biota and mammals

Sea Floor
- Plate tectonics, sea floor morphology, ocean basins, sedimentary processes, hydrothermal-thermal processes
- Gravity-magnetic relationships to seafloor fabrics

Positioning
- Geodesy
- Satellites
- Navigation and positioning on and in sea

Maps and Charts
- IHO standards
- Map/chart production
- GIS
- Nomenclature of features

Data processing
- Digitising, sampling
- Data bases
- Gridding
- Contouring
- Spatial statistics: Kriging, fractals
- Post processing of MBES data

IT subjects
- Web site creation and authoring
- Programming/coding: applications of, use of,

GEBCO as an entity
- History of GEBCO and Ocean Mapping
- Needs and requirements: use of GEBCO by cable layers, oil companies, defence, and v.v.
- Copyright, who owns soundings, contours, charts
- Outreach, community relationships
- UNCLOS - Maritime Law

Personal Skills
- Writing, oral presentation, communication

Table 1: Topics to be included in the training of bathymetrists, after GEBCO.

metric maps tend to be taken as gospel with inadequate appreciation of the sketchy database on which they may be built, or the inadequate quality of (some) of the original data' (SCOR Working Group 107 2002) reflects the reality that deep bathymetry is far from complete and needs improving.

Hydrographers fully understand the use of shallow water bathymetry in preparing nautical charts for the safety of life and navigation at sea, and support it at many organisational levels, deep water bathymetry has not benefited from the same level of support. Having such a fundamental importance in marine sciences, to the point where the accuracy of other branches of marine sciences depends on the accuracy of bathymetry, has not secured it a significant level of institutional support. Fortunately, the Nippon Foundation GEBCO reported here represents a major step towards rectifying this deficiency.

Need for the Training Programme

Very generally, the rate at which mapping of the sea floor progresses is a function of:
- the size of the surface to be mapped
- the efficiency of the mapping tools that can be applied
- the speed of the platforms that carry those tools, their amount of use and the areas that they are deployed in
- the organisational structures in place to assimilate the raw data and transform it into maps
- the number of skilled people who work at the task

(Carron et al. 2001) address items a), b) and c) and conclude that if the world ocean could be surveyed by modern multibeam methods, to survey only the areas deeper than 500m would require something like 800 ship years. Clearly the world

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Canadian Hydrographic Service, Ottawa, Canada
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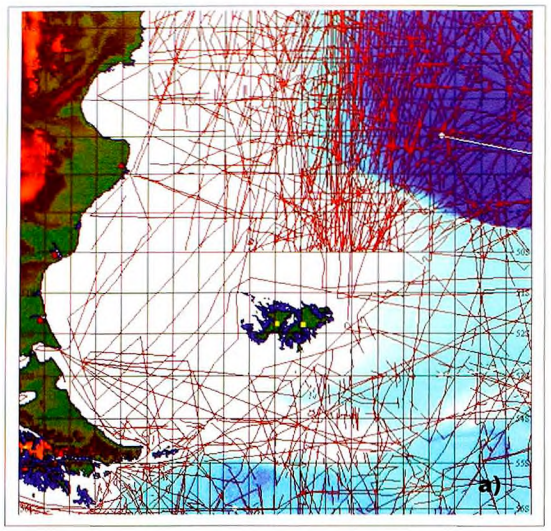
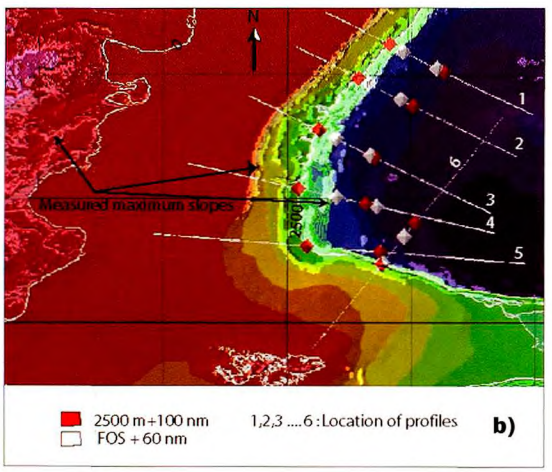
National Geophysical Data Center, Boulder, USA
National Oceanography Centre, Southampton, United Kingdom
University of Stockholm, Stockholm, Sweden

Table 2: Institutions hosting GEBCO Nippon Foundation scholars on training assignments, 2005.





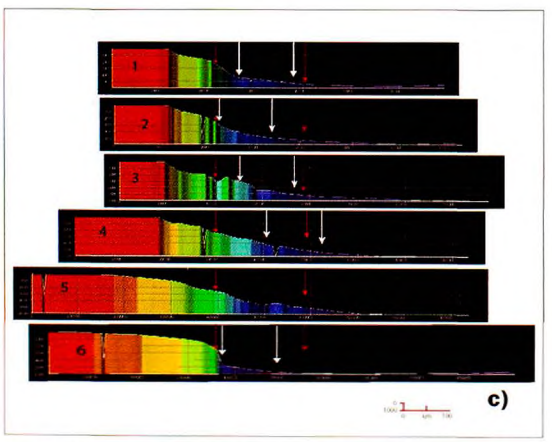


Figure 2: Area - Southwestern margin of Atlantic Ocean.
a) the details are as in Figure 1a.
b) the details are as in Figure 1b.
c) the details are as in Figure 1c.

ocean must be mapped by the Coastal States of the world working in concert. The organisational structure they do so through is the GEBCO organisation, an international organisation which produces charts and digital grids of the world ocean by collating, interpreting and contouring, with the aid of directional fabrics revealed by satellite gravity, soundings and multibeam bathymetry collected by surface ships. GEBCO also evaluates and authorises undersea feature names for use on its products which are published in a Gazetteer. GEBCO has formal links to the scientific and hydrographic communities through the Intergovernmental Oceanographic Commission (IOC of UNESCO) and the International Hydrographic Organization (IHO).

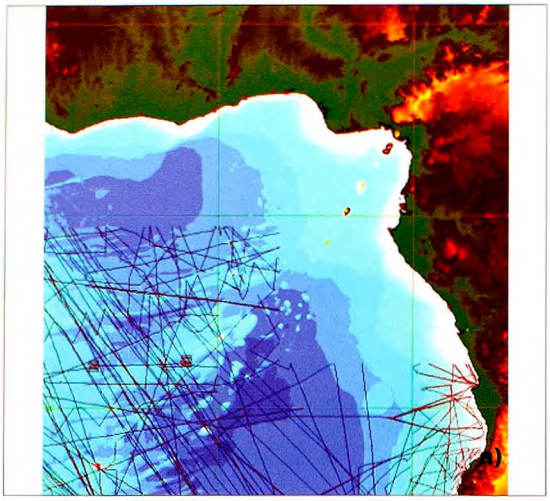
This leaves item e) the number of skilled people who work at the task to be addressed. Since the number of skilled bathymetrists has been diminishing, the Nippon Foundation GEBCO project was designed to train new workers so that the 'area of ocean to active bathymetrist' ratio is improved.

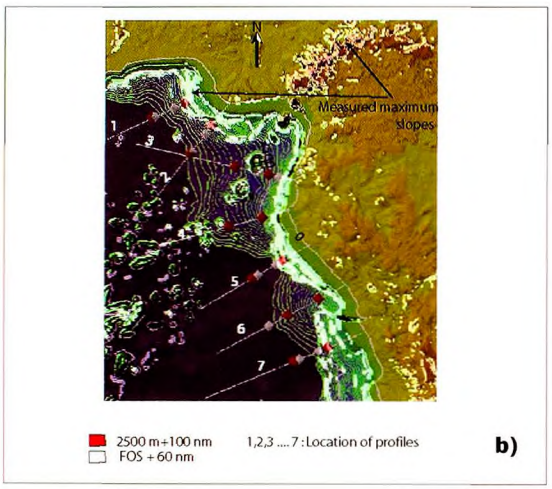
Establishing the Programme

The Nippon Foundation

In 2003, GEBCO proposed, and the Nippon Foundation accepted, establishment of a programme to train a new generation of scientists and hydrographers, mostly from less developed countries. GEBCO developed the learning objectives for a training course and established performance criteria against which potential teaching organisations could be evaluated. Based on these two documents, a search for a suitable teaching organisation which could run the course in ocean bathymetry was undertaken. This process led to the submission of proposals from six universities in five countries. To make the final choice between these well-qualified teaching organisations, GEBCO set up a neutral Evaluation Group which ranked the six organisations and announced their unanimous decision that the best candidate was the Center for Coastal and Ocean Mapping/Joint Hydrographic Center at the University of New Hampshire (UNH).

Advertising for potential students resulted in 57 applications from people in 32 countries. GEBCO and the Nippon Foundation jointly selected students on the basis of previous education, language competency, likelihood of successful completion,





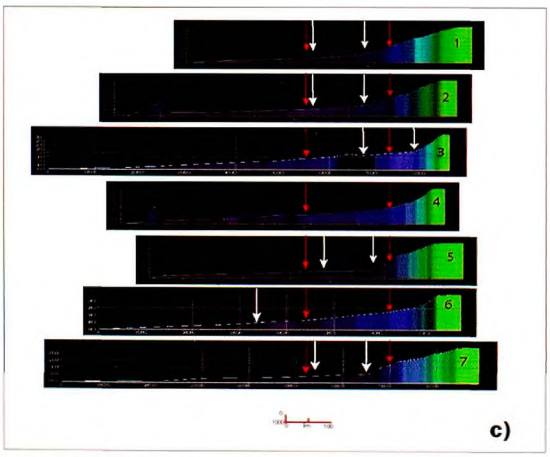


Figure 3: Gulf of Guinea – Central and west African margin.

a) the details are as in Figure 1a.

b) the details are as in Figure 1b.

c) the details are as in Figure 1c.

support/endorsement of home organisation, likelihood of working in ocean mapping upon completion, and geographic distribution of home state to offer maximum cross-fertilisation among the class. Students for this pioneer class came from Argentina, Fiji, India, Japan, Kenya, Nigeria and Peru, with backgrounds in hydrography, geology, geophysics and oceanography. At the university, housing in the Graduate Students residence was reserved, and a special laboratory in CCOM/JHC was furnished with a new computer installed and networked for each student. The students began their work in the Fall Semester of 2004 and they quickly learned to work together, forging friendships and a network that will last them for the duration of their careers (Angwenyi et al. 2005).

Components of the Training Programme

University courses

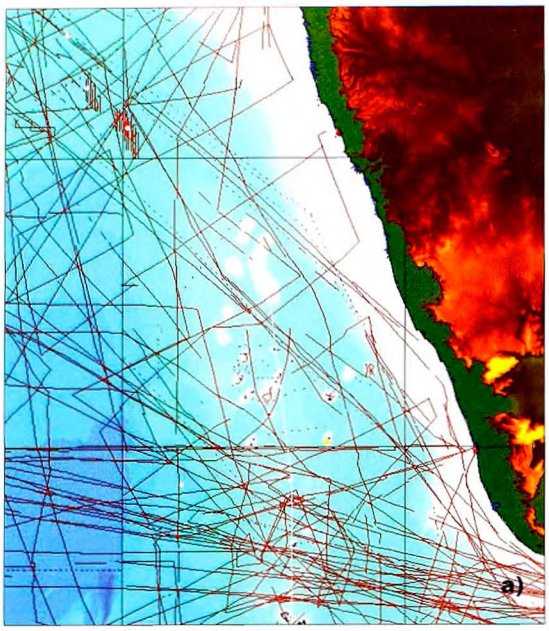
A GEBCO working group established the topics in which a modern bathymetrist should be skilled: these are listed in Table 1. A selection of Graduate courses at UNH, consisting of lectures, practical laboratory-based projects and day boat exercises, covers the required topics. Teaching staff consists of UNH faculty and research scientists as well as other experts brought in from elsewhere for limited periods to give specialist lectures. Other graduate students not sponsored by Nippon Foundation also take the same courses, allowing further co-operation and network building.

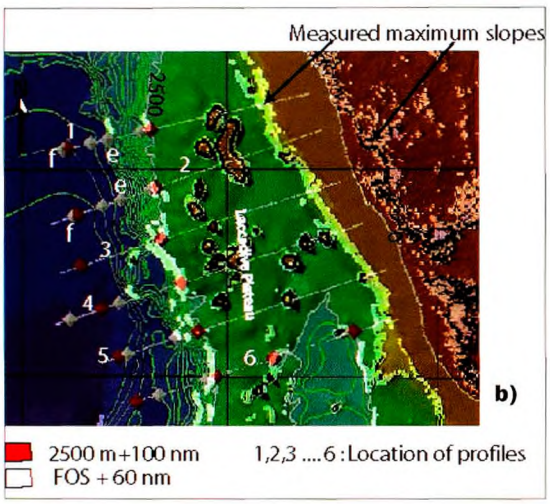
Ship cruises

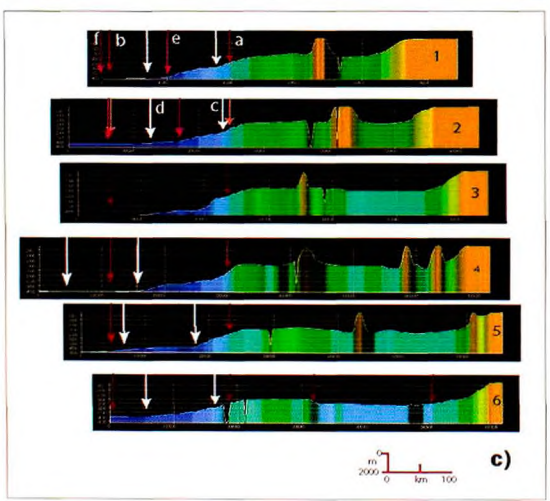
Prior to entering the programme, the students had all worked at sea, but not necessarily on a deep ocean cruise. As part of their training, they participate as working members on a cruise, with watch keeping and data processing duties.

Visits to associated laboratories

To round out their training, to help them build networks and feel that they are part of the GEBCO organisation, to apply some of their newly-acquired theoretical knowledge and hopefully to improve the bathymetry map they are producing, a visit to another laboratory can be enormously useful. This includes familiarisation with the programmes the visited organisation is engaged in, as well as some directed work under supervision. Participating laboratories in 2005 are listed in Table 2.







Mapping projects

In addition, during the entire year, students produce a map of an area of ocean adjacent to their home country. In addition to being incorporated into the next edition of GEBCO Digital Atlas, these maps are a vehicle for Capacity Building in the region they encompass. Extending the area included in the map, which the students will do on returning to their home institution, will frequently require working with neighbouring countries to demonstrate techniques learned during the teaching programme and to obtain existing, and possibly new, data in adjacent areas. The newly trained Nippon Foundation graduates will be able to extend and apply their knowledge through teaching, demonstrating and explaining the importance of bathymetric mapping, not only within their own countries but also with neighbouring countries and engage them in the production of a map at larger scales.

Benefits

The Nippon Foundation project is not designed to advance the instruments used in mapping the oceans. Rather it is focused on the human component of mapping. As pointed out above, vast areas of the seafloor are not measured but must be interpreted. The number of scientists trained in interpretation will be vastly increased through the Graduate Diploma component of the project.

It is very likely that the Nippon Foundation project will significantly impact the choice of areas of the ocean to which Ocean Mapping tools are deployed. The Graduate Diploma component will provide trained bathymetrists to areas of the world where such talent is presently in short supply or totally lacking. Their new technical skills, reinforced by the network of other ocean scientists they will have developed during the training programme, will be

Figure 4: The Southeast Arabian Sea.

a) the details are as in Figure 1a.

b) the details are as in Figure 1b. The locations of alternative FOS and FOS+60nm are shown as points 'e & f' respectively.

c) the details are as in Figure 1c. The locations of alternative FOS and FOS+60nm are shown as points 'e & f' respectively.

applied to mapping areas of the ocean that has not benefited from much attention in the past.

Conclusion

The personnel trained and developed by the above means will extend the existing network of the GEBCO community into developing countries which, prior to this programme, would not have been capable of producing bathymetric maps. The work carried out by the graduates will enable the rescue of a large volume of old data, produce a new world map in paper form, enable detailed regional map production, and increase the capabilities of scientists in developing countries through networking and reinforced training. Thus, at the end of the project, GEBCO will be ideally poised to meet the challenges ahead, supported by a network of active, younger, well-trained GEBCO scientists and hydrographers from developing countries. It is expected that many of these people will participate in GEBCO's Working Groups and Committees, where they will contribute to their on-going work and continue to develop their personal capacities through such active involvement.

References

- Angwenyi, C., Karlapati, S., Montoro, H., Morishita, T., Mustapha, A.A., Monahan, D., Peralta, W.R., and Sharma, S. (2005). Multi-dimensional, multi-national, multi-faceted hydrographic training; the Nippon Foundation GEBCO training programme at the University of New Hampshire. In United States Hydrographic Conference. San Diego, California. THSOA
- Carron, M.J., Vogt, P.R., and Jung, W.-Y. (2001). A Proposed International Long-Term Project to Systematically Map the World's Ocean Floors From Beach to Trench: GOMaP (Global Ocean Mapping Programme). International Hydrographic Rev, 2(3 (New Series)): 49-55
- Committee on National Needs for Coastal Mapping and Charting Ocean Studies Board Mapping Science Committee (2004). A Geospatial framework for the Coastal Zone. National Needs for Coastal Mapping and Charting, The National Academies Press, Washington, D.C.
- Harper, B., and Sharman, G. (2003). Leadline to multibeam, sextant to GPS & crow quill to computer: Bathymetric data collection, compilation, archiving, and distribution in the past century. In Charting the secret world of the ocean floor: the GEBCO project 1903-2003. Monaco. IHO and IOC., p. CD
- Holcombe, T.L., and Moore, C. (2000). Data Sources, Management and Presentation. In Sovereign Limits beneath the Oceans: The scientific and technological aspects of the definition of the continental shelf. Oxford University Press. pp. 230-249
- SCOR Working Group 107 (2002). Improved Global Bathymetry, Report IOC Tech Series No 63, IOC, UNESCO

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