

## Proposal for a Critical Bathymetric Studies Working Group

### Executive Summary

A SCOR working group should be formed to evaluate and recommend bathymetric studies in critical regions of the world's oceans that are currently under-surveyed. These critical regions are those in which bathymetric surveys would provide highly valuable data. These data would apply to studies of currents, ocean mixing, tsunami propagation, and safe navigation as well as enhancing the accuracy of estimations of seafloor topography based on satellite altimetry. The working group would be charged with performing an independent, multi-dimensional analysis of the costs and benefits of these bathymetric studies and to identify regions where such studies would reap maximal societal and scientific return. This group would aim to offset the current trend of narrowly focused, proposal-driven, bathymetric studies that are funded solely for scientific purposes. While the SCOR working group would have no funding authority, the impetus generated by widely broadcasting their recommendations would bolster the chances of success of proposals to survey and study those regions identified by the working group. Their recommendations would include the collection of ancillary data (such as side-scan sonar images) to fulfill the promise of multi-disciplinary benefit to society and science.

### Background

Currently, the coverage of the world's oceans by bathymetric mapping is highly heterogeneous, with very dense coverage in some areas, such as near busy coastal ports, and very sparse coverage in other areas, such as the South Pacific Ocean. This is clearly true for public domain data, but is likely to be true as well for the secret or proprietary data held by national military organizations and private industrial firms, respectively. To some degree, the oceans suffer the "Tragedy of the Commons" (Hardin, 1968), where the ocean is exploited by all, but under the stewardship of none. This is as true for exploration as much as it is for fisheries. Only areas of specific interest are mapped in detail, while vast areas are left unexplored.

While the accurate mapping of seafloor topography is in great demand, it remains woefully incomplete. The need for accurate bathymetry is demonstrated by its use in satellite altimetry estimations of seafloor topography, tsunami modeling, global circulation studies, oceanic mixing models, and even safety to navigation, as was demonstrated by the grounding of the US Navy nuclear submarine *San Francisco* in January 2005. From deep ocean circulation (Mercier and Speer, 1998) to ocean mixing (Polzin, *et al.*, 1997; Ledwell, *et al.*, 2000), bathymetry plays a significant role as a boundary or triggering condition. The contention has been made that we know the surface of the moon better than we know the solid surface of the Earth. Yet, the resource requirement for complete mapping of the seafloor is huge. An evaluation of the Global Ocean Mapping Project (GOMaP) estimated that 1,000 ship-years would be required for complete survey coverage, not considering transits and redundant coverage (Carron *et al.*, 2001). At current ship costs, this approximates US\$10 Billion (\$10<sup>10</sup>), and hence has a very low probability of becoming a reality.

The new working group will complement, and naturally follow on from, the activities of SCOR WG 107 which last met in 1997 (Summerhayes *et al.*, 2001). WG 107 was charged with establishing the scientific needs for improved knowledge of ocean depths, with specifying the accuracy and resolution requirements and with recommending actions and priorities. The WG came up with six priority actions the fourth of which was to fill substantial gaps in the more remote or less often explored oceanic areas. Whereas many of the technical recommendations of WG 107 are now being addressed there has been a noticeable lack of advance in filling gaps in ocean bathymetry. The new working group is planned to build on WG 107 by providing strong arguments rooted in a broad spectrum of oceanographic research to convince scientists, hydrographers and, above all, funding agencies of the need for a new approach. The proposed membership of the new working group has very little overlap with that of WG 107.

## **Rationale**

While complete mapping is unrealistic, carefully focused studies of limited extent (i.e. in critical regions selected to have the greatest impact on science and society) are a real possibility. These studies would maximize the advancement of knowledge across the full range of bathymetric applications, from enhancing satellite altimeter-based estimations of seafloor topography to safe navigation. These focused studies would differ from currently funded studies in that they would be optimized for the full spectrum of applications as opposed to evaluations based on a single discipline or geographic region, i.e. the data will be collected with more than one intended use. This will require a multi-disciplinary analysis of needs and sensitivity by an objective group of scientists, something that has not been done in the past. A SCOR working group is an ideal vehicle for such analysis.

The proposed working group would provide guidance and suggest priorities for bathymetric surveys that would complement the current bathymetric coverage, filling in blank or sparse regions in the context of multiple applications of bathymetry. The use of satellite altimetry to calculate free-air gravity anomalies, which are then correlated with bathymetric relief for estimating seafloor topography in regions otherwise unsurveyed, provides an important means of obtaining leverage from the limited, acoustic survey resources available. Thus, one of the evaluations would be of the impact of an acoustic bathymetric survey on the quality of the altimetric estimations within the region. Likewise, modeling of tsunami propagation is highly dependent on accurate bathymetry as tsunamis "feel" the influence of seafloor topography at all depths; their speed is depth-dependent and they are focused or scattered by depth variations in their path such as occur at seamounts. The tragedy of the Indian Ocean tsunami of December 2004 has made the public highly aware of the need for effective propagation modeling, threat analysis, and appropriate warning infrastructure. Bathymetry provides the critical foundation for the first two components.

The oceans, particularly currents and mixing, play a significant role in shaping and moderating our global climate. Recent research suggests that small variations in bathymetry and seafloor roughness can have major effects on current steering and deepwater mixing. For the global climate scientific community to gain an operative understanding of these processes, a knowledge of accurate seafloor topography and roughness are a required input to modeling efforts.

The proposed working group will be charged with evaluating the sensitivity of all of these efforts to improved bathymetry in critical areas. The working group will also evaluate the multi-dimensional benefits of improved bathymetry to the entire spectrum of scientific research and understanding, as well as the benefits to society in terms of hazard response and mitigation. SCOR is a logical source for a broad spectrum, scientifically supportive, neutral party to evaluate the optimal use of resources to the benefit of all ocean sciences. They are best able to break the competitive, narrow interest log jam in specific, research-focused surveys and to identify critical areas of bathymetric research that will optimize the benefit to, and impact on, science and society.

Finally, the working group would issue guidelines and recommendations for the collection of ancillary geophysical data, in addition to bathymetry, that would enhance the utility and impact of the bathymetric data in other multi-disciplinary studies. It will also seek to ensure standards of stewardship, archiving, and distribution necessary to make the collected data available to the multiple studies to which they might apply and to ensure the long-term preservation of the data to their continued, effective, and wise use.

The SCOR Working Group on Critical Bathymetric Studies has the potential to significantly extend, and obtain leverage from, the investment of limited resources for describing the ocean's floor.

## Terms of Reference

1. Identify and evaluate the most critical regions needing new bathymetry. Using multi-dimensional analysis and evaluation, rank the regions according to their impact on both science and society.
2. Provide both:
  - a) independent evaluations of the global advantage of studying the bathymetry of certain regions and
  - b) compelling arguments and recommendations for those studies.

## Meetings

If the working group is approved, work would begin at an opportunistic meeting at the Fall 2005 American Geophysical Union (AGU) meetings in San Francisco, December 2005. (No funds would be requested from SCOR for this meeting). Interactions amongst the working group Members and the General Bathymetric Chart of the Oceans (GEBCO), the International Hydrographic Organization (IHO), the Intergovernmental Oceanographic Commission (IOC), the IOC's Consultative Group on Ocean Mapping (CGOM), the U.S. National Geophysical Data Center (NGDC) (as the World Data Centre for Marine Geology & Geophysics and the IHO's Data Centre for Digital Bathymetry) will determine whether to add Associate Members, as well as establishing communications infrastructure and protocols for the working group. The primary agenda for the first full working group meeting, in early 2006, would be to establish a work schedule, an electronic forum for meeting, interaction, and consultation, and a schedule of subsequent physical meetings.

A working period of four years is proposed for the working group to:

- i. assemble,
- ii. define the evaluation process,
- iii. acquire and define the requirements of science and society for bathymetry,
- iv. review extant data in the context of multi-disciplinary requirements for data,
- v. evaluate the relative value of bathymetric studies in various geographic regions, and
- vi. generate a working group report on the results of that final evaluation and publish summaries in peer-reviewed journals and elsewhere.

The final physical meeting would probably be at either GEBCO 2009 or Fall AGU 2009, and would highlight the public release of the working group report. A summary of the working rationale and results of the working group would be published in one or more peer-reviewed journals.

## Working Group Members

1. Chairman, someone with broad experience in bathymetry and its diverse applications
  - a. *Suggestion: Dr. Walter H.F. Smith, Laboratory for Satellite Altimetry, NOAA, Silver Spring Maryland, USA. Chair, GEBCO Sub-Committee for Digital Bathymetry with research interests focused on reconnaissance of global deep-water bathymetry from space. Member SCOR WG107.*
2. Bathymetric data resource expert
  - a. *Suggestion: Dr. George F. Sharman, Director WDC Marine Geology and Geophysics, Boulder, USA*
  - b. *Suggestion: Dr. Christopher G. Fox, Director IHO Data Center for Digital Bathymetry, Boulder, USA*
3. Tsunami modeling expert
  - a. *Suggestion: Dr. Kenji Satake, Active Fault Research Center, National Institute of Advanced Industrial Science and Technology, Japan. Internationally recognized modeler.*
  - b. *Suggestion: Dr. Vasily Titov, Research Scientist, Tsunami Program, Ocean Environment Research Division, Pacific Marine Environmental Laboratory, USA*

4. Physical Oceanographer specializing in ocean circulation and climate.
  - a. *Suggestion: Dr. Sarah T. Gille, Assistant Professor, Scripps Institution of Oceanography and Department of Mechanical and Aerospace Engineering, University of California San Diego, USA. Research interests include Southern Ocean climate and dynamics, wind-forcing of the Southern Ocean and heat transport via the Antarctic Circumpolar Current, subgrid-scale parameterization for climate models, satellite oceanography from altimeter and scatterometer data, interpretation of ocean general circulation model output.*
5. Physical Oceanographer specializing in ocean tides and tsunamis.
  - a. *Suggestion: Dr. David J. Webb, National Oceanography Centre, Southampton, U.K. Research interests include large scale ocean circulation (both wind driven and thermohaline, ocean tides and tsunamis. Formerly Head of Ocean Circulation and Climate Advanced Modelling Project (OCCAM). Associate Member WG 107.*
6. Biological Oceanographer
  - a. *Suggestion: Dr. Alan Butler, Torres Strait and Northern Fisheries and Ecosystems, CSIRO Marine Research, Cleveland, Queensland, Australia. Research interest in the strategic development of 'optimal' techniques for the assessment of habitats and diversity, and characterization of ecosystems, using surrogate-based methods (e.g. classification of backscatter from acoustics) to predict underwater habitats SE of Australia and on the NW Shelf.*
7. Bathymetrist with expertise in multi-dimensional analysis
  - a. *Suggestion: Dr. Martin Jakobsson, Department of Geology and Geochemistry, Stockholm University, Sweden. Research interests in Paleoceanography and seafloor processes of the Arctic Ocean, development of robust techniques for combining historical and contemporary bathymetric data sets, and the use of GIS and 3D-visualization for handling and analyzing marine geological and geophysical data.*
8. General Bathymetric Chart of the Oceans (GEBCO) specialist
  - a. *Suggestion: Dr. Hans Werner Schenke, Alfred Wegener Institut, Bremerhaven, Germany. Chair, GEBCO Sub-Committee on Undersea Feature Names (SCUFN), GEBCO specialist in ocean bathymetry. Research interests in bathymetry of the Southern Ocean, especially the Weddell Sea. Member SCOR WG107*
  - b. *Suggestion: Dr. Jose Frias Salazar, INEGI, Aguascalientes, Mexico. GEBCO specialist in ocean bathymetry. Vice-President of the International Bathymetric Chart of the Caribbean Sea and the Gulf of Mexico (IBCCA).*
9. General Bathymetric Chart of the Oceans (GEBCO) specialist
  - a. *Suggestion: Dr. Robin Falconer, Institute of Geological and Nuclear Sciences Ltd., New Zealand. Manager of the Natural Hazards Group of IGNS. Interest in strategic management, geological hazards, marine science, geographic information systems.*
  - b. *Suggestion: Dr. Vaughan Stagpoole, Institute of Geological and Nuclear Sciences Ltd., New Zealand.. Recently completed a new bathymetry compilation of the Ross Sea Sector South of 60°S. Senior person in all the UNCLOS work in New Zealand. Marine geophysicist with research interests in the crustal dynamics and thermal evolution of sedimentary basins.*
10. Bathymetrist and marine geophysicist
  - a. *Suggestion: Dr. Srinivas Karlapati, National Institute of Oceanography, Goa, India. Research interests in understanding the evolution of Arabian Sea. Graduate of the first Nippon Foundation/GEBCO training course in ocean bathymetry.*
  - b. *Mr. Cristian Rodrigo, Navy Hydrographic and Oceanographic Service (SHOA), Valparaiso, Chile. Works in National Oceanographic Data Centre (CENDOC). Experience of bathymetric mapping and setting up database systems. Practical marine geophysics experience on the Chilean hydrates program.*

## References

- Carron M J, P R Vogt and W-Y Jung, 2001, A proposed international long-term project to systematically map the world's ocean floors from beach to trench: GOMaP (Global Ocean Mapping Program), *International Hydrographic Review*, 2(3), 49-55.
- Hardin, G., The Tragedy of the Commons, *Science* 162 (1968) 1243-1248.
- Ledwell, J.R. *et al.*, Evidence of enhanced mixing over rough topography in the abyssal ocean, *Nature* 403 (2000) 179-182.
- Mercier, H and Speer, K.G. Transport of bottom water in the Romanche Fracture Zone and the Chain Fracture Zone, *J. Phys. Oceanogr.* 28 (1998) 779-790.
- Polzin, K.L., *et al.*, Spatial variability of turbulent mixing in the abyssal sea, *Science* 276 (1997) 93-96.
- Summerhayes, C.P. *et al.*, *Improved Global Bathymetry*, Scientific Committee on Oceanic Research, Report of Working Group 107, (2001).