OPPORTUNITIES FOR OCEAN MAPPING AT THE ENDS OF THE EARTH

The International Polar Year

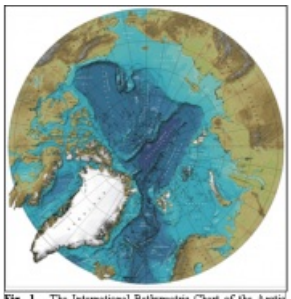

Fig. 1. The International Bathymetric Chart of the Arctic Ocean (IBCAO), downloadable as a digital grid from http://www.ngdc.noaa.gov/mgg/bathymetry/arctic/arctic.html

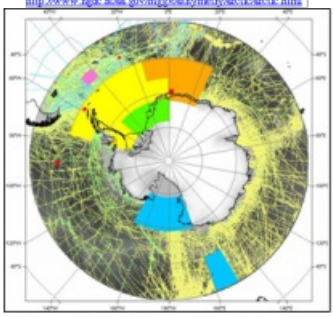

Fig. 3. Distribution of data points in the IBCSO data base.

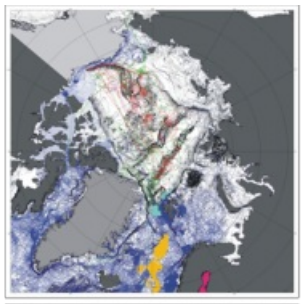

Fig. 2. Distribution of data points used in the construction of IBCAO.

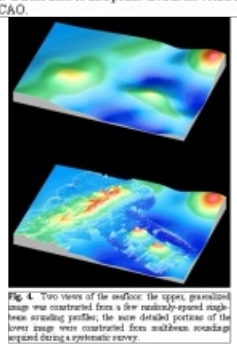

Fig. 4. Two views of the seafloor: the upper, generalized image was constructed from a few randomly-spaced single-beam sounding profiles; the more detailed portions of the lower image were constructed from multibeam soundings acquired during a systematic survey.

Bathymetric mapping remains incomplete in the Arctic and Southern Oceans. Some proposed International Polar Year activities could help improve the situation by collecting new soundings during vessel transits to and from their operating areas, and by making their observations available for inclusion in existing international databases

Introduction

The Arctic and Southern Oceans present significant challenges to marine scientists whose investigations require detailed maps of the seabed.

For example, physical oceanographers need fine-scale portrayals of seafloor roughness and topography, to understand and predict the transport of water through deep, intermediate and shallow regions. Benthic ecologists need to know the detailed morphology and character of the seabed, to help explain the occurrence and distribution of specific bottom-dwelling and bottom-feeding species.

Earth scientists seeking to understand ancient and recent geological history look for clues in the patterns left on the seabed by sediment erosion and deposition, and in the finer structures of rock outcrops. Similarly, students of paleoglaciology and paleoclimate search for indicators of past conditions, which help establish a context for understanding climate change and rising sea levels.

Unfortunately, studies such as those listed above cannot proceed satisfactorily in the polar areas: their bathymetry is poorly known, given the remoteness of these regions and their unfriendly operating environments. To be sure, there have been some advances, but much remains to be done in order to develop research-grade portrayals of seafloor morphology that are coherent and reliable.

Current International Polar Year (IPY) proposals identify a number of marine scientific missions to the polar regions. At relatively minor expense, these expeditions could easily collect bathymetric observations if their operational plans included transits or activities in areas where the quantity and quality of depth observations remain inadequate for scientific purposes. When assimilated into existing databases, these new soundings would no doubt enhance our understanding of regional bathymetry.

Current Initiatives

At present, two international initiatives are maintaining bathymetric databases for use in the construction of detailed portrayals of the seafloor in the polar regions: the International Bathymetric Chart of the Arctic Ocean (IBCAO), and the International Bathymetric Chart of the Southern Ocean (IBCSO). Both initiatives are led by researchers operating in academic and research environments.

The IBCAO and IBCSO have been endorsed by the International Arctic Science Committee (IASC) and the Scientific

Committee on Antarctic Research (SCAR), respectively. These affiliations reflect high levels of acceptance by the Arctic and Antarctic research communities. Moreover, the technical integrity of the projects is assured through close liaison with the Intergovernmental Oceanographic Commission (IOC) and the International Hydrographic Organization (IHO).

IBCAO

Launched in 1997, the IBCAO produced a preliminary description of the Arctic seafloor in grid and map form by 2000 (Figure 1). At first glance, the IBCAO map appears to provide a complete morphological description of the Arctic Ocean basin and the surrounding land masses. However, in the oceanic zone it is necessary to keep in mind that the grid and map are derived from a compiled database that is incomplete, and that features a highly uneven distribution of disparate depth points (Figure 2). Many of the data points shown in Figure 2 do not correspond to actual sounding locations, having been extracted from isobaths on hand-drawn contour maps. Moreover, many of the points that do correspond to real measurements are characterised by observational and navigational uncertainties, along with inconsistencies in the procedures that have been applied in their reduction and processing. In the construction of the IBCAO, significant time and effort were expended in harmonising these points so they would constitute a coherent body of information.
An examination of Figure 2 reveals numerous regions (particularly in the central ocean basin) where depth values were obtained from isobaths supplemented by widely and randomly spaced sounding tracks. These areas would benefit significantly from any new soundings, but the same could be said for nearly all other parts of the map, including those where controlled surveys have been carried out.

IBCSO

The IBCSO was first proposed in 2002 as an activity within the framework of the German Polar Ocean Bathymetry Coordination Effort (POBACE). The project's primary focus to date has concentrated on the identification of suitable datasets south of 50°S (Figure 3) and on the development of procedures for assembling and merging these datasets.
Figure 3 portrays the distribution of depth information in two forms: grids (solid coloured areas) developed from compilations of all available data, and track lines (yellow and blue lines) that correspond to an accumulation of numerous sounding profiles. In essence, the grids occupy two main sectors: one ranges from 75°W to 25°E and from the coastline of Antarctica to 60°S; the other occupies the Ross Sea. The track lines are highly variable in their density distribution, with a noticeable scarcity of observations in the Pacific sector. New soundings would improve the situation anywhere within the IBCSO extent.
So far there has been no attempt to combine the data for the purpose of developing a regular grid throughout the compilation area. New bathymetric data would be easy to assimilate at this stage of the project; however, additions will be accepted at any future date for absorption into the database and grid.

Ocean Depths

At present, the acoustic echo sounder represents the only effective technology for mapping ocean depths with the accuracy and resolution necessary for many types of scientific investigations.
Certain types of acoustic measurements are better than others; for optimum results, sounding equipment and operating characteristics must be specified with care. For instance, a multi-beam sounding system is preferable to single-beam: the former will map a swath of underlying seabed in the same amount of time as the latter will measure depth along a single profile, and the end result will be far more informative (Figure 4).
Multi-beam equipment tends to be more expensive than a single-beam sounder, and more demanding in its operation. Not many polar-capable vessels are fitted with multi-beam sounders, while most if not all carry single-beam sounders that are at least capable of operating in shallow (<200m) waters. Of the icebreakers that can operate in thick Arctic or Antarctic ice, few are equipped with multi-beam sounders.
It is acknowledged that satellite altimetry has been used to good effect to develop maps of global bathymetry that offer generalised portrayals of major seafloor features]. However, it must be appreciated that the methodology suffers from depth inaccuracies that exceed 100m in areas with complicated seafloor sediment accumulations or crustal density variations, and that it is limited to coarse resolutions in the 5–10km range. Moreover, the inclined planes of most polar-orbiting satellites militate against their use for measuring Arctic depths because they do not overfly the central basin.

IPY Cruises

Unfortunately, the polar regions do not lend themselves well to sounding operations on conventional vessels. To improve prospects for collecting useful observations, echo sounders must usually be operated from nuclear submarines operating beneath the ice or from large, ice-strengthened vessels that can cope with unfavourable sea and climate conditions during extended cruises to distant places. Such vessels are expensive to operate and their services are in heavy demand. On polar scientific deployments, their missions tend to assume a multidisciplinary character; circumstances permitting, research organisers and managers are encouraged to add bathymetric mapping to the mix of cruise activities.
It is recognised that observations collected under such circumstances may not meet all of the rigorous standards that qualify the readings gathered during conventional hydrographic surveys. However, in regions where little is known about the seabed, all new soundings must be perceived as prospective improvements to existing databases, particularly when accompanied by appropriate metadata such as navigation and sounding specifications, accuracy estimates, sound velocities and corrections for sound velocity variations.

Depth Observations

IPY marine investigators who will be traversing or operating in regions that remain poorly mapped and who will have echo-

sounding equipment at their disposal are encouraged to contact the project leaders of the IBCAO or IBCSO: as appropriate, with outlines of cruise deployment plans and descriptions of anticipated sounding opportunities.

In return, project leaders will provide information concerning areas where new soundings could enhance existing databases. They will also recommend track locations and orientations that would maximise prospective benefits. All data contributions will be fully acknowledged.
The IBCAO and IBCSO project leaders are Martin Jakobsson of Stockholm University and Norbert Ott of the Alfred Wegener Institute, respectively.

Acknowledgement

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Note by the editor

This article on submission contained a number of here unplublished references, which the author will happily supply to interested readers.

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