New tools and techniques in ocean mapping
Synopsis of Panel 3 discussions:

SUMMARY

Executive Summary: Even if GEBCO manages to coordinate a huge amount of surveys and get high quality multibeam survey data from a large part of the world, there will be a call for alternative techniques to fill gaps for a foreseeable future. A synopsis from the Future of the Ocean Forum panel 3 discussion is presented below.

Moderators:
Dawn Wright, ESRI, USA
Martin Jakobsson, Department of Geological Sciences, Stockholm University, Sweden

Panel members
Jamie Adams, Google, USA
Duncan Mallace, QPS, UK
Paul Cooper, CARIS BV, USA
Bjorn Jalving, Kongsberg Subsea Division, Norway
Hans Öiås, Swedish Maritime Administration, Sweden

Do we have the tools and techniques to map the world ocean?

It is not only the available technology to directly measure seafloor depths that matters for GEBCO since the task to map the ocean floor also involves bringing all available depth measurements together into a database for the compilation a coherent bathymetric portrayal of the world ocean floor. Therefore, bathymetric post-processing and analyses software, database technology, computing infrastructure and gridding techniques must be brought into the discussion regarding available tools and techniques in ocean mapping along with the latest development of seafloor mapping methods. This is reflected by the four main topics that were in specific focus for the discussion in Panel 3:

1. Mapping technologies
    a. *Sonars and mapping platforms*
    b. *Crowd source technologies*
    c. *Satellite-derived bathymetry*
2. Cloud computing and database infrastructures
3. The gridding concept and formats
4. Auxiliary parameters to bathymetry

Mapping technologies

Sonars and mapping platforms

The technological development constantly improve the accuracy, resolution and seafloor coverage for echo-sounding methods. The modern most widely used acoustic mapping technology is based on the multibeam echo sounder with the capability of mapping a swath underneath the vessel. The width of a mapped swath of the seafloor is for a modern multibeam around five times the water depth and sometimes better. Interferometric sonars exist and are being developed with much wider swath widths, specifically suited for shallow water mapping or installation in AUVs due to their smaller size. However, the quality of depth measurements of interferometric sonars are not yet at the level of conventional multibeam echo sounders, although the side-scan information they collect are of superb quality. Next in line we might see sonars based on a mix between the interferometric and more conventional multibeam technology.

While the echo sounding technique is constantly being improved, both with respect to performance and availability, the mapping of the world's ocean floor is increasing only slowly. This is particularly true for the sea-ice covered and iceberg infested portions of the oceans and the most remote areas with sparse ship traffic such as the south Pacific. The panel discussion therefore converged to discuss the development of unmanned vehicles of various sorts. The discussion is here summarized with the following conclusions:

- Available commercial and custom developed AUVs are optimal for high-resolution mapping of smaller areas, but limited with respect to range preventing longer (weeks) missions.
- Gliders equipped with multibeam sonars would extend the range substantially compared to traditional AUVs, but available multibeam sonars are not small enough to be installed on gliders.
- Fleets of low maintenance autonomous surface or underwater vehicles may provide a solution of mapping remote areas.
- An unmanned mapping barge, steered by satellite communication and equipped with an ultra-narrow beam deep-water multibeam would permit systematic high-resolution mapping of the deep world ocean. This is one idea raised to reach the goal of map the entire world ocean floor at resolution substantially better than 100 x 100 m.

The Shell ocean discovery XPRIZE is currently challenging teams to develop new deep-sea technologies for autonomous, fast and high-resolution ocean mapping. The price of $7 million is designed to bring the target of a fully mapped world ocean seabed closer, fully in line with GEBCO goals.

Crowd source technologies

Using crowd sourced bathymetry is not new to GEBCO. Bathymetry provided by the Norwegian company Olex comprised a significant source for the compilation of the International Bathymetric Chart of the Arctic Ocean (IBCAO) Version 3.0 grid released 2012. The Olex depth measurements originate from their automatic charting system installed primarily on fishing vessels. The Olex database is growing fast because the fishing vessels share their logged depths in order to collectively build better seafloor maps. Bathymetric data from Olex also played a major role in the GEBCO 2014 grid. Several additional companies based on the crowd source philosophy exist on the market. Small and easy to install NMEA-loggers storing depths from any ship echo sounder already exist and are being further developed. IHO has a crowd source working group with substantial GEBCO engagement. This working groups is tasked to draft recommendations for the minimum metadata to be provided along with depth measurements and discuss available technologies, and online upload technologies and storage. Panel 3 discussed the crowd source technology which is spreading beyond installing loggers on conventional echo sounders. One such example is SmartFin, a collaboration between researchers at the Scripps Institution of Oceanography that has developed surfboard fins that record ocean temperature, pH, salinity, location, and wave characteristics. The fin broadcasts data straight to phones using the Bluetooth wireless technology. Even if the SmartFin not is logging depths, it highlights innovative thinking out of the box. A major conclusion from the discussion on crowd source technology was:

- Crowd sourcing is a powerful concept in ocean mapping that has a huge potential to substantially boost the targeted mapping, specifically in shallow water.

Satellite-derived bathymetry

The gap between the coastline and where depth measurements exist on the continental shelf is large in several vast remote areas on Earth. Surveying of the areas using conventional methods from ships, and even with AUVs, may be enormously challenging and expensive. Furthermore, LIDAR is expensive and limited to clear water. In such remote areas, where other means of seafloor mapping not is easily feasible, bathymetry derived from satellite imagery may provide a specifically promising method. Freely available imagery, such as Landsat 8, as well as commercial higher-resolution satellite images comprise vast data sources with global coverage. The development of satellite derived bathy methods that are not based on only the optical spectrum may overcome the non-clear water issue. The discussion in Panel 3 on the use of satellite-derived bathymetry is summarized in the following conclusions of importance for the GEBCO task of mapping the world ocean from the coast to the deepest parts of the oceans:

- Shallow water bathymetry derived from satellite imagery constitute a promising technique that may be particularly useful in remote areas where other available mapping methods not are feasible. Derived depths from satellite imagery are not as high quality and accurate as from other conventions mapping methods, but it is a source better than nothing with huge spatial coverage.

A pilot project between GEBCO and Google will be initiated to further investigate the application of satellite derived bathymetry on global scale. Ongoing projects aiming towards the development of the satellite image derived bathymetry mapping method exist within the GEBCO that involves the University of Minnesota Polar Geospatial Center.

Cloud computing and database infrastructures

The present GEBCO central bathymetric database as well as databases of regional mapping projects under GEBCO resides on servers at the host organizations. While the underlying bathymetric source data from mapping campaigns amounts to vast amounts of terabytes, the amount of data cleaned and ready to go into a regional bathymetric database, or directly to GEBCOs central repository, is more on the order of gigabytes. The sizes of these databases will naturally increase once GEBCO targets a higher resolution global coverage, but will remain far from the amount of raw ship soundings collected at sea. This together with that GEBCO moves towards establishing more regional projects at host organization around the world, points towards several potential benefits of using a cloud based infrastructure for the regional mapping projects under GEBCO and for its central repository as well as for gridding and processing routines. Several potential hinders and questions were identified during the Panel 3 discussion:

- Will it be possible to efficiently handle different access levels to such a cloud based database and computing infrastructure?
- The productions of a coherent bathymetric gridded compilation from a broad range of data sources involves an iterative process where depth data cleaning is alternated with gridding and analyses. Will a cloud based database permit efficient work on data with a suite of software?
- Will the network speed restrict the use of such cloud based database structure to only the most technologically developed countries?

In order the address these questions a pilot project was initiated between Esri and the GEBCO regional mapping project IBCAO.

The gridding concept and formats

The GEBCO 2014 grid, as well as the grids produced by linked regional mapping projects (e.g. IBCAO, IBCSO), are based on vastly heterogeneous source data implying that some areas are well mapped while others are extremely poorly mapped. In some areas of the world ocean much higher resolution final grids would be possible to produce than the GEBCO 2014 (0.5 x 0.5 min), IBCAO (500 x 500 m) and IBCSO (500 x 500 m) grid. But since no there is no widely spread grid-format for variable sized grids that common software read, GEBCO as well as regional mapping projects have stuck to produce grids with one set cell-size resolution, even if the applied gridding approaches lend themselves well to produce variable sized grids with resolution steered by the density of the source data. The BAG (Bathymetry Attributed Grid) is however a grid format that Esri, Caris, QPS and several other software producers have begun to implement, which may be suitable to store variable sized grid. In Panel 3 there was a technical discussion on variable sized grids and the general conclusions were:

- Variable grids will be more in demand as the end-user community begin to realize that this is an option to get bathymetric overviews of large areas and details of smaller areas in one convenient database.
- GEBCO could drive the community of software vendors toward a solution, but it must be kept in mind that software vendors often do not make open standards, the Open GIS Consortium (OGC) does and then software vendors adopt/promote those.

Auxiliary parameters to bathymetry

Along with bathymetry information about the seafloor composition is widely asked for by the end user community. Panel 3 discussed other efforts such as GEOHABs (Marine Geological and Biological Habitat Mapping).

Raw comments from notes below, not yet worked on:

Backscatter Working Group capacity and affordability to access are important but regarding the data acquired by these different platforms, a focus on **backscatter** information is needed; Backscatter to identify the bottom, and what kind of resources can be exploited or protected

- Variable resolution issues here too
- Dawn shares GEOHABs Backscatter Working Group efforts and working document; shares that special issue of Marine Geophysical Researches
- For the GEBCO road map they might want to coordinate with GEOHAB working group; shake hands between communities; draping
- Is it GEBCO's role to push into this arena? Sometimes it is too hard to reconcile; can we get Backscatter for the entire world even? it might be too early at the present to talk about Backscatter within GEOHAB but a possibility for the future road map; Backscatter on top of GEBCO grid is one specific use case