GENERAL BATHYMETRY OF THE PACIFIC OCEAN

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Because of the increasing pressure on sedentary marine species — both in coastal areas and offshore seamounts — there is an increasing need for mapping the potential habitat of these resources so that fisheries managers and decision makers can make informed decisions about coastal resources.

Contrary to land resources, which can be mapped using satellite products, the marine environment is more difficult to map because water absorbs visible light and radar frequencies very quickly, and the ocean is basically opaque from the sky for depths beyond 50 m, even using airborne Lidar (laser bathymetry).

TRADITIONAL OCEANOGRAPHIC SURVEYS

High-resolution mapping of the ocean floor requires expensive equipment (multi-beam and side-scan sonars), operated from oceanographic ships with high operational costs. For these reasons, direct ocean floor mapping is very limited, and traditional marine charts can miss important relief features outside the areas surveyed by hydrographic ships.

Figure 1 depicts the sounding lines used to produce the marine chart NZ14606. It shows that some areas have been intensively surveyed, such as the Tonga Trench or Savannah seamount chain (French Polynesia), whereas there is much less information for the Cook Islands or Line Islands (Kiribati). This is not necessarily a problem when the area is a large abyssal plain, but it does not allow the systematic inventory of underwater features such as seamounts and ridges.

On a global scale, the International Hydrographic Organization (IHO) and the Intergovernmental Oceanic Commission (IOC) of UNESCO digitised available marine charts (contour and track lines based on soundings, coastlines) to produce a global 1-minute bathymetric grid known as the General Bathymetric Chart of the Oceans (GEBCO). Because it was produced from marine charts, this grid will not provide more information than paper charts, but it is a convenient global digital grid of ocean bathymetry.

PREDICTED BATHYMETRY

Because mapping the ocean floor is difficult and onerous, oceanographic surveys target areas of interest such as trenches, ridges and seamounts. But it means the existence of these features must be known prior to the survey planning and it requires baseline information on the probable location of unsurveyed underwater features.

In June 1995, the US Navy declassified Geosat altimeter data (height of the sea surface) which, combined with ERS-1 radar data, allowed Smith and Sandwell (1994) to derive a map of marine gravity anomalies used later to predict the seafloor depth between the surveyed bathymetry tracks. In 1997, the authors produced a two-minute global map of predicted seafloor topography for latitudes between 72°S and 72°N (Sandwell and Smith 1997).

This initial work was later refined and several derived products are now available to the general public, combining the predicted bathymetry with other sources of information

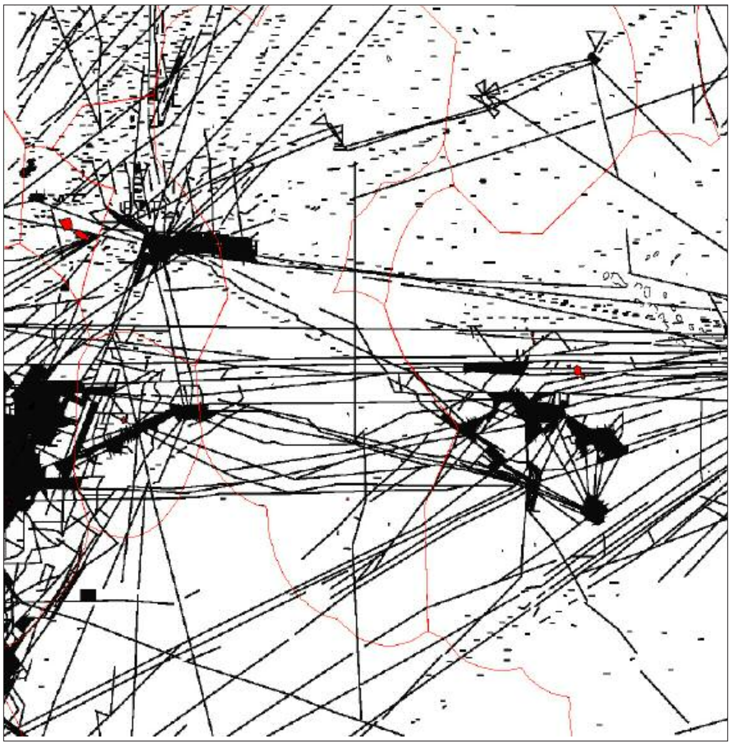

Figure 1: Diagram of sounding line density of chart NZ14606 and Pacific Island EEZs

such as GEBCO or Shuttle Radar Topography Mission (SRTM) elevation data, and with various grid sampling (from 30 seconds to 5 minutes).

While Etopo2 is certainly the best known global seafloor predicted bathymetry product, the original Smith and Sandwell (S&S) data were slightly mis-registered in latitude and longitude when the grid was produced (Marks and Smith 2004), and this shift is apparent when comparing the predicted bathymetry with sonar data (see Figs 3 and 4 on p. 52), or when displaying atoll coastlines produced from Landsat 7 ETM+ (visible and infrared) or SRTM elevation data on top of shaded bathymetric data. Note that predicted bathymetry matches here the sonar data because the very same sonar data were used to produce the grid (and interpolated using gravity anomaly data).

The newer S2004 bathymetric grid produced by Walter Smith from the S&S data and blended with the GEBCO data is properly registered. It uses GEBCO data for depths shallower than 200 m, and a blend of the two datasets between 200 and 1000 m. That mitigates the fact that predicted bathymetry is less reliable for shallow water and the resultant grid is the best global bathymetric grid available at the moment (see Table 1).

The shaded bathymetry produced from S2004 for each country can be found on the SPC PROCFish Portal in the GIS repository[1].

INVENTORY OF SEAMOUNTS

The availability of global bathymetric grids made it possible to conduct a systematic inventory of potential seamounts using a filter that detects peaks and searches for local rises of 1000 m or more from the seabed. Kitchingman and Lai (2004) used the Global Digital Elevation Model (Etopo2) grid and identified between 14,000 and 32,000 potential locations of seamounts, Wessel (2001) used the S&S grid to extract around 15,000 seamounts locations for the whole world.

The methodology (filter and thresholds) and source data grid used for the inventory of these potential seamounts have a significant impact on the results and their usability. Because the Etopo2 grid is mis-registered, so are potential seamounts (the distance between Wessel and Kitchingman seamounts can be up to 10 km).

Moreover, predicted bathymetry is less reliable in areas shallower than 200 m, around land masses, and is averaged because of the initial S&S two-minute resolution. As a consequence, atolls are often falsely detected as one or more seamounts, as depicted in Figure 5 on p. 52. Screening and cleaning of this data are currently undertaken by the Pacific Islands Oceanic Fisheries Management project (SPC Oceanic Fisheries Programme/ GEF).

HIGH-RESOLUTION MAPPING OF SEAMOUNTS

Once seamounts and other underwater features are identified, either from previous hydrographic surveys or using

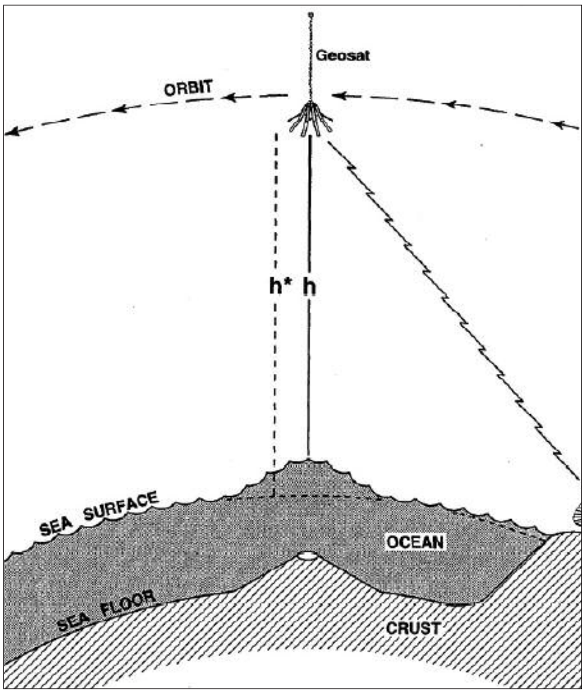

Figure 2: Satellite altimetry used produce gravity anomaly grid (reproduced from Sandwell and Smith 1997)

Table 1 Bathymetric grids and source data

Grid	Resolution	Source	Comments
Etopo2	2 minutes	S&S, IBCAO, DBDBV, GLOBE	Mis-registration in latitude and longitude
GINA	30 seconds	S&S, IBCAO, GTOPO30	Correctly registered but smoothing effect observed (Marks and Smith 2004)
GEBCO	1 minute	Charts contour lines	Chart accuracy, smoothing effect
S2004	1 minute	S&S, GEBCO	Correctly registered

IBCAO: International Bathymetric Chart of the Arctic Ocean
DBDBV: Digital Bathymetric Data Base - Variable Resolution
GTOPO30: Global 30 Arc-Second Elevation Data Set
Globe: Global Land One-kilometer Base Elevation

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[1] http://www.spc.int/coastfish/sections/reef/PROCFish_Web

predicted bathymetry, they can be fully mapped by oceanographic vessels using multibeam and side-scan sonars. Figure 6 (p. 52) shows the Capricorn Seamount as displayed with a one-minute resolution (S2004 grid) and with a 200 m resolution (multibeam data).

While the multibeam sonar captures bathymetry, a side-scan sonar captures texture and morphology. The side-scan sonar reflects the type of substrate and habitability of the area for deep bottom fish species and, when available, can be mapped on top of the bathymetry on a three-dimensional model.

High-resolution data for seamounts that have already been mapped is generally available from the Internet, in particularly from the Seamount Catalog of the Seamount Biogeosciences Network (http://earthref.org), from where it is possible to download multibeam data, mixed with predicted bathymetry. On the PROCFish portal, there is a MapInfo file with the location of seamounts referenced in the catalog with direct links to the seamount pages.

The linkage between the deep bottom fish resources and seamounts is currently a research topic and is one of the topics of the Marine Geological Habitat Mapping (GeoHab)2007 conference that will be held in New Caledonia in 2007.

CONCLUSION

While only a small part of the Pacific Ocean has been thoroughly mapped by oceanographic vessels, predicted bathymetry is available globally and allows the localisation of underwater features such as seamounts, which can be surveyed in detail at a later time using multibeam and side-scan sonars. Yet some caution is necessary when using S&S-derived products because of the mis-registration observed in some products and because of the limited resolution of these grids.

Figure 7 summarises the various bathymetric grids and datasets cited in this article and indicates how they are related.

A future article will examine methods that can be used to produce shallow water bathymetry maps (between 0 and 50 m).

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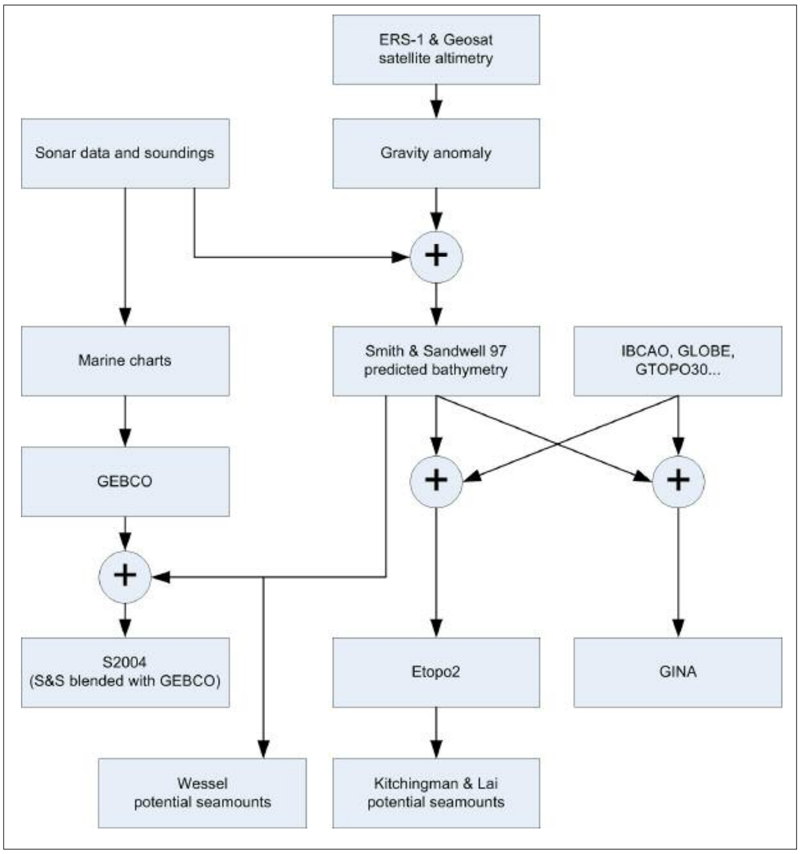

Figure 7: Datasets and their relationships

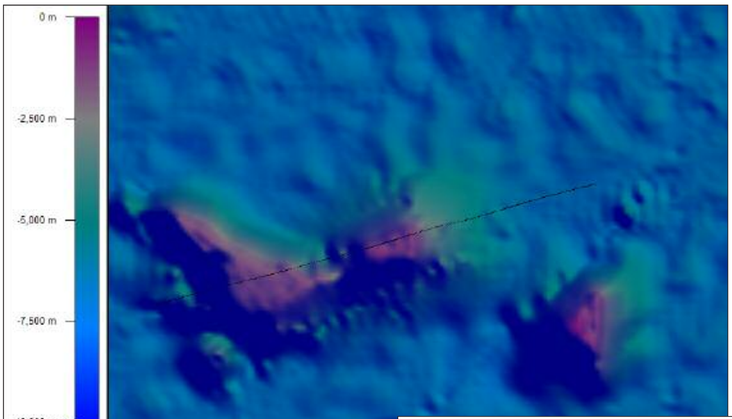

Figure 3: S2004 shaded relief and sonar sounding points from NOAA's National Geophysical Data Center

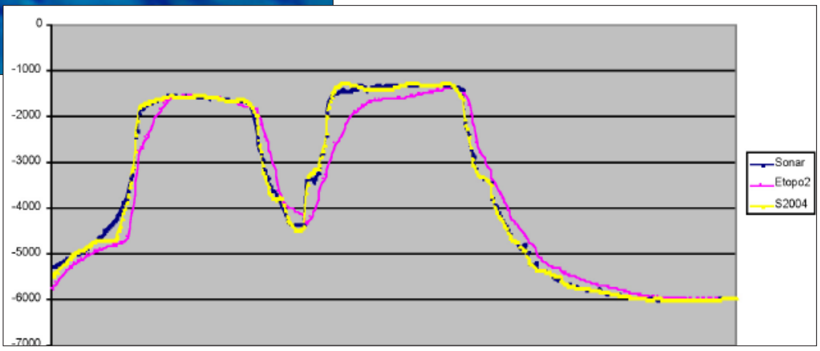

Figure 4: Extraction of Etopo2 and S2004 values with corresponding sonar data along the transect shown in Figure 3

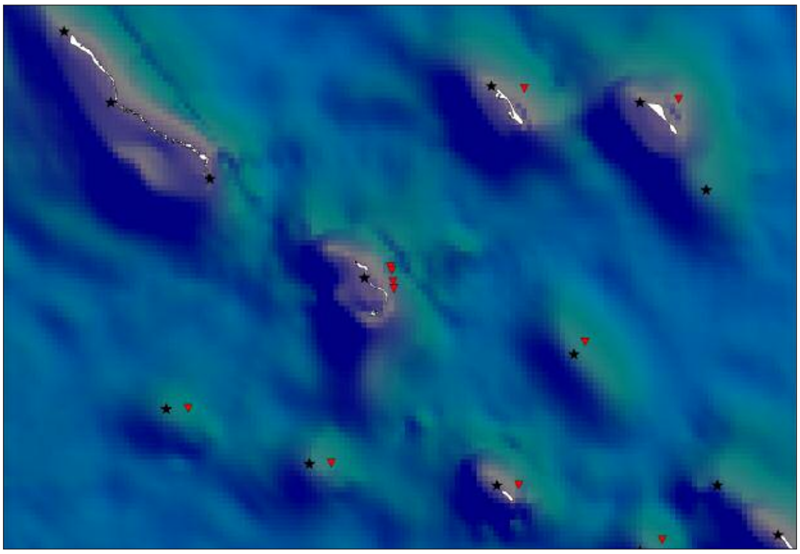

Figure 5: Kitchingman (triangles) and Wessel (stars) potential seamount locations

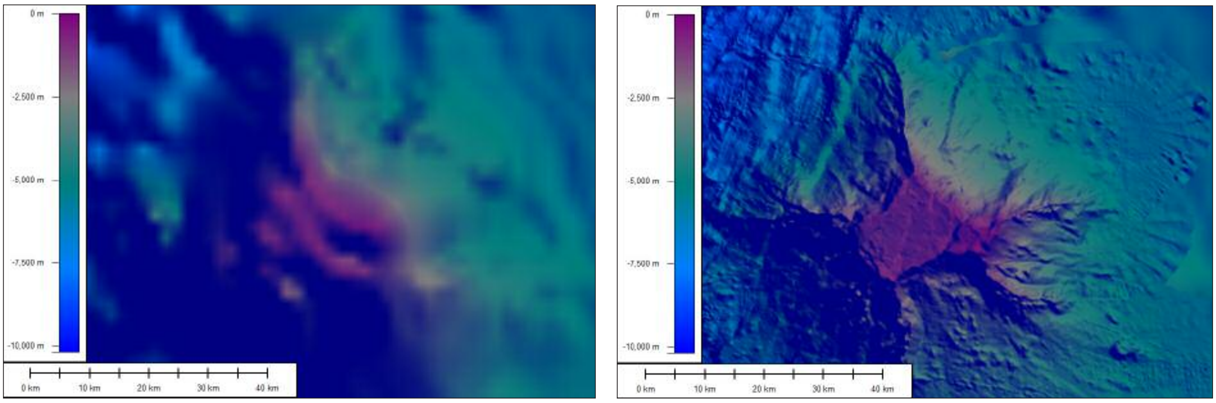

Figure 6 Shaded relief of Capricorn Seamount near Tonga trench at one-minute (S2004) and 200 m (sonar) resolution