Adaptive Bathymetric System

The Adaptive Bathymetric System (ABS) is designed easily, rapidly and at low cost to create a three-dimensional model of a coral reef. It is adaptive because the space between the lines of the survey grid varies based on a series of factors ranging from predicted shape of the reef to the equipment used to record its depth. This causes the survey grid to differ in appearance for each survey, in contrast to traditional survey grids that consist of equally spaced lines. ABS grids are also shorter than traditional grids and therefore cost less to navigate.

A detailed knowledge of seafloor topography is fundamental to understanding the biological systems associated with coral reefs. While surveying coral reefs has played a vital role in navigational safety for centuries, traditional hydrographic surveys are usually coarse, missing smaller yet significant features, and are limited to navigational depths. Recent work on fish spawning aggregation around coral reefs raises the importance of understanding the topography of certain coral reefs at depths of up to 1,000 metres. Bathymetric maps are derived using expensive, complicated equipment and technology using a survey vessel. The survey typically consists of taking seafloor morphologic readings by following an equidistant grid pattern. The cost and complexity of these methods are beyond the reach of most marine-resource managers and do not allow for work at large scales because of the time it takes for a ship to navigate a traditional survey grid.

Coral reefs have high biological diversity and are essential to the reproductive cycle of many fish species. They are also visually spectacular and sustain local, national and international economies through tourism and fisheries. Physical topography such as depth, slope, aspect and curvature can be derived from detailed bathymetric surveys, which are, unfortunately, expensive to conduct since they require specialised vessels and equipment. This places bathymetry data out of the reach of most marine scientists and managers, thus limiting the information needed to understand and manage reef communities. Fish Spawning Aggregation (FSA) sites occur largely at reef promontories, and/or the seaward extension of reefs near deep water. Marine scientists need a simple, affordable and accurate method to provide detailed geographical references and topographical description of the FSA locations at depth of up to 1,000 metres.

ABS

The initial goal of ABS is to create a coral-reef mapping protocol that is accurate, simple to implement and inexpensive. ABS consists of repeating a three-step process that adapts a variable survey grid to a variety of conditions, collects depth data with in expensive off-the-shelf sonar and GPS equipment and processes the data in a standard GIS system for three-dimensional visualisation. The variable survey grid is adapted to the desired seafloor detail, equipment used, terrain, areas of interest and resources available. In contrast, standard hydrographic survey grids are uniform because they typically consider only the desired seafloor detail (grid spacing) and areas of interest (grid location). This causes the survey grid to look different for each survey, in contrast to traditional survey grids that consist of equally spaced lines. However, the process ensures that the information about the area of interest is as relevant as that of a traditional survey.

Methodology

A step-by-step walk-through of the application of ABS using an echo sounder with integrated (D)GPS and data logger. The preparation of the adaptive survey grid consists of drawing the Site Model, learning the limits of the depth-sounding equipment and adapting the survey grid to these conditions.

A. Drawing the Site Model

The goal of the Site Model is to predict the depth and shape of the reef and to identify areas of interest. This consists of referencing the site with latitude and longitude, drawing the site shape, predicted depth curves and identifying areas of interest. This phase consists of four steps:

1. Locating the site: setting the latitude and longitude of the site is best accomplished using a satellite image or a nautical chart.
2. Drawing the site shape: drawing an approximation of the reef ridge over the satellite image using available knowledge.
3. Drawing predicted depth curves: depth curves are typically derived from depth data collected during past visits to the site or other existing data.

4. Drawing the area of interest: the original purpose of ABS is to gain a deeper understanding of the reef morphology where Fish Spawning Aggregation (FSA) has been observed. FSA visual survey methodology already requires a detailed description of spawning locations.

B. Learning Equipment Limits

Learning about equipment limits is essential to adapting the survey grid. Choice of echo-sounder transducer is critical: the narrower the cone angle, the more precise the echo sounder. This is illustrated in Figure 4a. The Lowrance Electronics model LCX-15 MT is an effective tool for mapping reefs. It includes integrated GPS tracking system (accurate to 10m or 3m if using Differential) and has high power output (1-kW RMS) to reach deep water. It also records the information on a digital chip that can be used by GIS software. The unit comes with a dual-frequency transducer that allows for increased detail at shallow depth with a narrow 200kHz cone, and deep water (approx. 915m) penetration at 50kHz. The device is designed to find fish and can provide acceptable maps of low-relief seabed at depths of up to 300m, depending on conditions. If conditions exceed these alternative transducers arrays can be selected in the fish-finding or bathymetric-survey range of equipment.

C. Drawing the Adaptive Grid

Drawing the adaptive grid is based on setting the grid spacing to half the size of the minimum seabed feature that needs to be recorded, the equipment used, the terrain, the areas of interest and the availability of resources.

5. Setting the minimum grid size: if the need is to sample seabed slope variations that occur over at least 100 meters the initial grid must be set at 50 meters.

6. Adapting the grid to the equipment

The grid needs to be adjusted for the transducer: for example, using a 50KHz/19-degr transducer at 600 metres resolution will be a 100 metre radius. It would be a waste of time and fuel to sample these areas every 50m because this large footprint means not much would be gained for our purposes: grid lines are thus set to 100m in the 600m zone.

7. Adapting the grid to the terrain and area of interest: the top of the coral reef is expected to be flat with little morphological variations so this area is sampled every 200m without creating substantial distortions for our purpose. FSA is the focus of this survey thus the grid is kept at its minimum of 50m in this.

8. Adapting the grid to the resources available: most of the survey cost is tied up in fuel costs and field time. A low budget drives the decision to keep the 100m resolution only in the FSA area and around the tip of the reef. During this last stage all grid cells are closed so that each grid cell has 4 sides.

9. Final grid: the figure shows the difference between a standard 50m grid and the ABS grid. The traditional evenly spaced grid surveys the reef uniformly. The ABS has coarse information about the overall reef shape but more details where it matters

Concluding Remarks

The Adaptive Bathymetric Systems reduces the cost and time required to produce a three-dimensional model of a reef, as compared to traditional survey methods, because it produces survey grids that are shorter and uses low-cost, off-the-shelf tools and equipment. The simplicity of the method will allow marine-conservation practitioners to map reefs by themselves, and it offers the potential of deployment at a variety of scales.

Editorial note: A much more lengthy and detailed version of this article may be obtained from author Jean-Lois B. Ecochard.

https://www.hydro-international.com/content/article/adaptive-bathymetric-system