

An Attempt Using Hydro-Acoustic Approach For Rapid Coral Reef Mapping in Malaysia

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Abstract

An attempt in using the hydro-acoustic approach was applied to map out the reef substrates around some of the islands located in the Marine Parks of Malaysia. The acoustic ground discrimination system (AGDS) was able to translate the echo signals into hardness and roughness indices which explains unique characteristic for each bottom type recorded. The real time track data was interpreted using Surfer7 for plotting thematic maps showing depth contours, 3D depth profiles and bottom surface areas. The overall results obtained were highly satisfactory and very reliable compared with other known techniques. From the surveys carried out, the hydro-acoustic method had demonstrated itself to be a better alternative compared to the conventional transect line observations and satellite imageries, with respect to the time and costs spent on the respective surveys and in the production of high quality data, especially in large scale surveys.

Introduction

Coral reefs are amongst the most biologically diverse and productive ecosystems in our planet. Its existence is of ecological and economic importance and the coral reefs are however, vulnerable and sensitive to changes in its environment. Coral reefs are currently facing direct threats not only from human induced or anthropogenic activities, e.g. coral mining, coastal reclamation, fish blasting etc., but also through global climatic changes, i.e. greenhouse effects. On a global scale, rising sea temperatures poses as the single largest threat to coral reefs, as massive bleaching will follow as a consequence to the increased in surrounding water temperatures. Hence, immediate measures around the world via numerous initiatives are being taken to ensure the well-being and longevity of the coral reefs. To start with, baseline studies, i.e. live coral coverage, distribution, condition, biodiversity, etc., must be well documented before a strategic management plan with sustainable objectives can then be drafted out based on the specific needs of the area concerned, and taking into account also on the socio-economic component and their requirements.

In Malaysia, the Federal Government has taken the initiative in conserving corals by declaring the majority of these habitat areas as Marine Parks. Coral reef management comes under the purview of the Marine Park Section, Department of Fisheries Malaysia (DOFM) courtesy of the Marine Parks of Malaysia Order 1994, as conferred by the Fisheries Act 1985. In

the year 1994, 38 islands off the east coast of Peninsular Malaysia and in the Federal Territory of Labuan were legally declared as Marine Parks and by the year 1998, the total added up to 40.

The objectives for the establishment of the marine parks are:

- i. To conserve and protect the marine ecosystem especially coral reef areas in order to ensure the sustainable utilization of the marine resources in the marine park waters.
- ii. To conserve, protect and manage the marine eco-system for the sustainable exploitation of the fisheries resources in the coastal waters.
- iii. To conserve and manage the marine parks for research on biodiversity, for education and for eco-tourism.

In order to investigate the establishment and distribution of the coral reefs within these Marine Parks, we have been working closely with the relevant authorities in Malaysia in collecting the baseline data of the coral reef.

Materials and Methods

Over the years, coral survey techniques have depended heavily on direct measurement and censoring with SCUBA diving apparatus. SCUBA diving remains still the most reliable survey technique to date as it allows first hand data collection, provided that the personnel are skilled and knowledgeable in this field.

However, it is almost impossible to produce a broad scale map with SCUBA diving methods, taking into account of the high risks associated to diving for the operator/diver, as well as the time consuming processes and the costly implementations. This method is also restricted by the water depths, tidal currents, bad weather and poor visibility.

In the early 90's, the remote sensing techniques were introduced as a new survey tool. Using GIS interpretation on various types of satellite images, thematic maps on physical characteristic of the water body can be obtained. Over time, the resolution of satellite images had thus increased significantly, hence enabling more information to be obtained, including the mapping of coral reefs. However, remote sensing on coral reef to date is confined to identification of general reef features in shallow water. The report on "Marine Park Island Management Conceptual Plan for Peninsular Malaysia, 1994" clearly outlined the shortcomings of using satellite images. At the current stage, more ground truthing work is needed to complement the remote sensing results from satellite images.

Hydroacoustic techniques have been used over the past six decades, mainly for undersea warfare. The acoustic technology harnesses a powerful underwater sonic searchlight to detect, observe and enumerate physical and biological parameters of interest. Based on the hydro-acoustic theory, this technique is now being adopted to conduct reef survey. It is a faster means of ground truthing compared to SCUBA diving. The other significant advantage of machinery survey is it minimizes the possibility of human error due to subjective individual interpretation and observation during the survey.

Our studies were conducted using the *RoxAnn*TM, a system which processes hydro-acoustic signals from a United Kingdom manufacturer, Sonavision Ltd.. This equipment was used in conjunction with the Fugro SeaStar 3100LRS DGPS system for differential positioning (latitude/longitude) with an accuracy of less than ± 1 m range. A *Furono* 200kHz (150 Watt) single beam echosounder was used to relay depth and other relevant signals to the *RoxAnn*TM.

*RoxAnn*TM also widely known as Acoustic Ground Discriminating System (AGDS) is a

state-of-the-art hydro-acoustic remote sensing tool. When connected to any single/dual/multi beam echo-sounders, it listens to and processes the signals returns from the transducer. These returned signals are simplified to the first echo (E1), second echo (E2) and depth. The first echo, E1 received is the measure of the acoustic backscatter of the substrate; which is referred to as roughness. Rougher materials scatters more acoustic energy back towards to the transducer, whereas smooth substrates will act like a mirror and most of the acoustic energy will be reflected away from the transducer. The second echo return is the measure of the acoustic impedance of the substrate. The softer the substrate is, the greater is the acoustic impedance. Hence, E2 is often described as representing the hardness. The timing diagram for E1 and E2 is shown below.

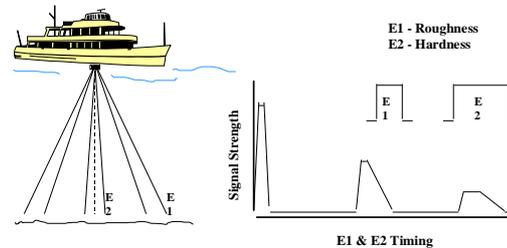


Figure 1a: Echo signals return of the E1 and E2.

A complete AGDS incorporates the input of real time, geo-referenced survey data i.e. the longitude and latitude as shown in Figure 1b. For each valid E1 and E2 signals collected, AGDS sends a RS232 string containing depth, E1 and E2 information to the PC/laptop for processing using the *RoxMap* Scientific software. With the information gathered from E1 and E2, a *RoxSquare* is configured (Figure 1c). It is a Cartesian graph, where E1 (index of roughness) is plotted along the Y-axis and E2 (index of hardness) is plotted along the X-axis. Since every substrate will have a different range of E1 and E2 values, these areas can be classified with an assigned colour. With the addition of longitude and latitude information, track lines are coloured according to the substrate type and are generated on built-in electronic charts.

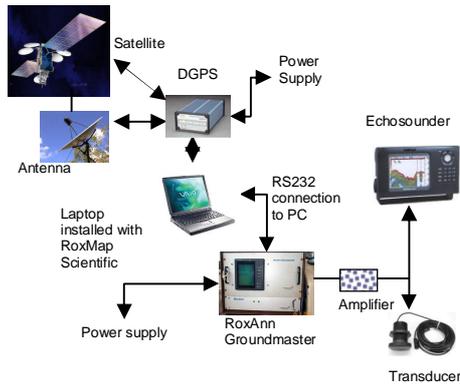


Figure 1b: The diagram above is showing the setup of the AGDS.

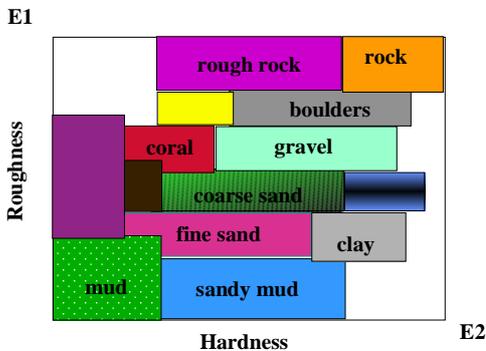


Figure 1c: RoxSquare showing different ranges for the E1 and E2 echoes.

In our survey, once the depth profiles and seabed classification information are successfully recorded, the 2D and 3D thematic maps can be plotted in *Surfer7*. All maps were plotted in *Universal Transverse Mercator* projection, WGS-84 datum.

Results and Discussion

We have conducted numerous coral mapping surveys using the hydro-acoustic approach since 1996 within Malaysia's marine park waters. Satisfactory results were obtained throughout all the classification surveys. We have continued to develop and better our approach in coral mapping surveys and at this current stage, we can comfortably classify seabed types down to certain genus levels such as *Montipora* and *Acropora*. Our results have been proven to be reliable and consistent with other comparison studies using methods such as the underwater video recordings, hyperspectral and multi-spectral satellite images.

Taking Pulau Tioman (Teluk Berus) as our most recent concluded coral mapping survey, we have determined that the most commonly classified seabed type was sedimented sand with a percentage of 79.1% area coverage. On the other hand, live corals were the least common seabed type found and showing only 0.04% area coverage. Other seabed types found were foliose (1%), encrusting corals on boulders (9.6%), corals mixture (3.5%), sand (6.3%), mixture of live and dead corals (0.1%), branching corals (0.3%) and rubbles (0.06%). Figure 2a and 2b shows the 2D and 3D track line results respectively. The results obtained correlate well with ground truthing exercises conducted within a fixed 50x100m quadrat area for consistency testing and along with random spot diving observations.

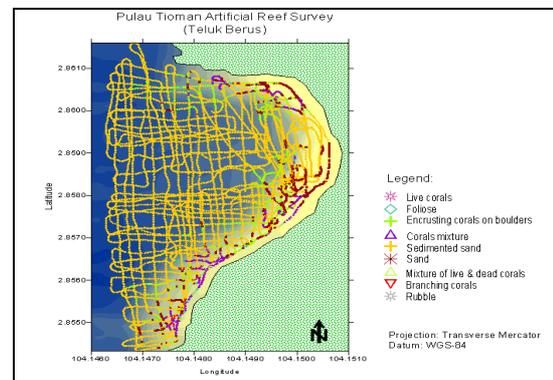


Figure 2a: 2D track line showing seabed classification at Teluk Berus, Pulau Tioman.

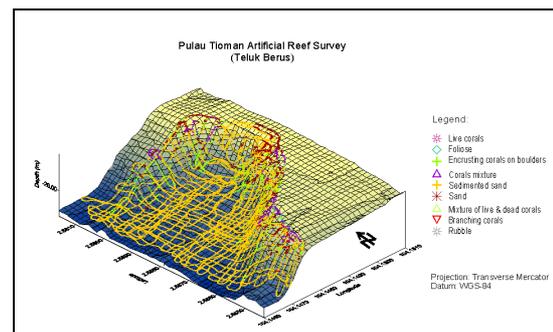


Figure 2b: 3D track line and depth contour at Teluk Berus, Pulau Tioman.

Another example of the reliability of the hydro-acoustic approach in coral mapping was demonstrated during the coral mapping survey exercise executed in Pulau Perhentian in the year 2001. The exercise covers Pulau Perhentian Besar, Perhentian Kecil and Susu Dara, which falls under Pulau Perhentian group of islands.

The percentage of the seabed type classified at Pulau Susu Dara is displayed in the Table 3a. Ratio of dead corals to live and dead coral was found to be 0.21 which indicate that the reef was in very healthy condition. Figure 3a shows the 3D track line result at Pulau Susu Dara.

Coral growth form	Percentage, %
Massive	5.50
Dead coral	8.70
Encrusting	3.10
Bedrock	4.00
Massive, branching	3.60
Table, encrusting	3.40
Branching	9.00
Branching on sand	6.30
Table	2.00
Sand, rubble	40.30
Sand	14.10
Total	100.00
Total live coral	32.90
Total dead coral	8.70
Ratio of <u>Dead coral</u> Live+dead coral	0.21

Table 3a: Table above is showing the distribution of the seabed classification in percentage at Pulau Susu Dara.

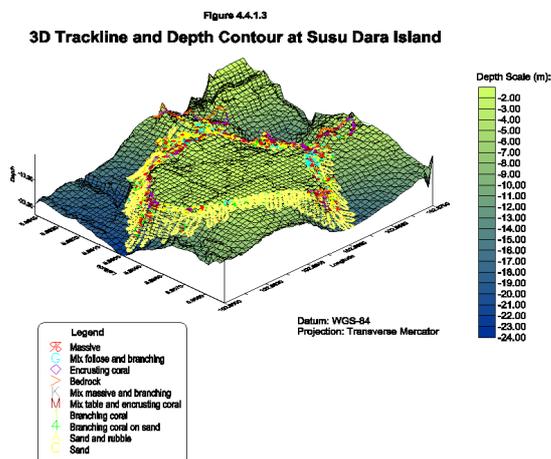


Figure 3a: 3D model of the seabed classification done at Pulau Susu Dara, Pulau Perhentian in year 2001.

In executing the rapid coral mapping assessment via hydro-acoustics approach within the Marine Parks of Malaysia, our main objective is to collect an informative baseline

data on the coral types and its distribution. These baseline data is used by relevant research bodies from the government and private sectors for detailed classification studies to determine the coral species and its diversity.

Conclusion

The utilization of the hydro-acoustic method in coral mapping has provided a whole new dimension in obtaining crucial coral reef baseline information. Although this approach has proven to be cost effective, reliable and rapid assessment tool as compared to other methods in coral mapping, however, information obtained via this approach should not be taken as the sole method in determining the actual coral distribution in any area. Nevertheless, the hydro-acoustic approach is now increasingly popular amongst researchers and will continue to be a useful rapid assessment tool.

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