Proceedings of the 6th International Coral Reef Symposium, Australia, 1988, Vol. 2

SPOT IMAGES FOR CORAL REEF MAPPING IN NEW CALEDONIA. A FRUITFUL APPROACH FOR CLASSIC AND NEW TOPICS.

W. BOUR

Institute Frangais de la Recherche Scientifique
pour le Development en Cooperation.
Centre ORSTOM de Noumea.
B.P. A 5 NOUMEA New Caledonia.

ABSTRACT

High-resolution images produced by the French SPOT satellite can, after processing of the remote-sensed data, provide a most useful tool for assessing and managing the living coral reef resources. This was already demonstrated in New Caledonia through simulated SPOT data.

The following step described in this paper is the processing of real SPOT images for the same scope but extended to great areas of New Caledonian lagoon. LATICAL, a multi-purpose remote sensing laboratory, was set up in March 1988 at ORSTROM Center of Noumea. The image processing package TEIS was used to classify the pixels of the barrier reef in front of the Baie de St. Vincent. In particular, the Tetembia reef, exploited for trochus and living corals was processed to cartography the different biotope of these resources and the surface areas.

Although SPOT spectral bands are designed for terrestrial observations, they can be processed for water depth mapping. In order to find the depth penetration range of SC 1 channel, a topographic map of the lagoon grounds nearby Tetembia reef was performed. Some features, located in the 25-30 m range, could be detected with clear water condition.

Remote sensing cannot completely replace field sampling, but helps minimise the need for costly reef survey stations. SPOT thus offers a new approach to the interpretation of bionomic and topographic features of reef environments.

INTRODUCTION

The coral reefs of the South-West Pacific, including the Australian Great Barrier Reef and the ring of reefs surrounding New Caledonia, have been studied by remote sensing methods for some years now. The generally clear waters which cover the reef formations make it possible to explore them by satellite techniques that were originally developed for mapping of emerged land areas. Since 1986, the images supplied by the French SPOT satellite have been proving extremely useful for continuation of these studies, because SPOT's high resolution - the best available at present - makes it easier to interpret the thematic maps obtained by processing of the digital satellite images.

DATA

A study carried out in 1985 (Bour et al., 1986) showed that it was possible, by processing of image data, to produce thematic maps of a portion of barrier reef and to identify the type of environment likely to contain an economically valuable gastropod, trochus (Trochus nilliticus). This study used data from a SPOT simulation campaign conducted in New Caledonia in 1983. The simulated SPOT data were acquired by radiometric methods using an airborne "Daedalus" radiometer. Resolution was equivalent to that of SPOT, but the ground area analysed was much smaller.

SPOT was launched in 1986, and it thus became possible to acquire the scene comprising the area surveyed by simulation. Then, in 1988, a remote sensing laboratory (LATICAL) was set up at the ORSTOM Centre in Noumea. By bringing the image processing facility much closer to the study area it has enabled mapping to be completed for the whole of Tetembia reef, only a small part of which had been mapped at the time of the simulation.

Tetembia reef is a section of the barrier reef which surrounds the main island of New Caledonia (Figure 1). It lies opposite St. Vincent's Bay, not far from Noumea. It is 20 km long and forms a bionomic entity between two lagoon passes. This reef was chosen for study because it is the only one where extraction of faviid corals is authorised for the handicraft and tourist trade. Faviidae corals are very slow-growing (Joannot and Bour, 1988) and it is therefore most important, for proper management, to know the biomasse of the exploitable fraction of the stock.

Like many new Caledonian reefs, Tetembia has an outer reef flat that is very suitable for trochus, a gastropod (Trochus niloticus) which is exploited for its nacreous shell. Hundreds of tonnes of trochus shells are exported from New Caledonia each year, to Europe and Asia. Here again, thematic mapping enabled the trochus habitat to be identified and its surface area to be estimated. Trochus density was then found by ground sampling at representative stations and multiplication of total habitat area by average density gave a good idea of the total trochus biomass present on Tetembia reef.

The SPOT scene used has the following specifications:

- numbers in the SPOT grid: K=413, J=394
- viewing date: 18 Sept. 1986, 1007h local time
- viewing angle: 8°
- mode XS (three colour channels)
- resolution: 20m
- pre-processing level 2: correction on a topographic map, scale 1/100 000.

METHOD

The topographic map of deep grounds (Figure 2) was obtained by stretching and thresholding of XS 1 colour channel.

The thematic map of Tetembia reef consists of supervised classification on the XS1 and XS2 SPOT channels. A bi-dimensional histogram of all the pixels of the reef displays a "boomerang" structure, which was already observed in the study using the simulated data (Bour et al., 1986). This structure results from decorrelation of XS1 and XS2 caused by differential penetration through the water layers covering the reef; absorption of the red channel XS2 increases (in other words, reflectance decreases) very rapidly with depth. This fact has another, less useful, consequence in that it limits discrimination of themes to a depth of about 10 metres; at depths greater than 10 m its information can no longer be linked with that supplied by the much more penetrating XS1 channel, for differentiation of the themes. However the reef considered is amply contained within the accessible depth range and its thematic study is therefore possible.

The supervised classification used requires that it is possible to define the thresholds of radiometric classes on both the channels; thresholding relies on the spectral signatures of the themes being sought. For this purpose, a dozen "control plots" were first picked out on the ground and then identified on the SPOT image. For each plot, the bidimensional histogram was calculated. A few examples are given in figure 3.

RESULTS

The figure 2 demonstrate the ability of SPOT first colour channel to provide topographic lagoon features up to 25-30 m depth range. The depth scale was calibrated using marine charts.

Figure 4 shows the thematic map obtained; each theme is identified by an arbitrarily chosen colour. Six themes are represented: three are hard coral bottoms, the other three are soft sandy bottoms. Their depth range and their surface area are also shown.

The results of two earlier studies can be used to illustrate the usefulness of thematic mapping for assessment of living reef resources.

Total biomass of trochus on the reef

Trochus densities for all reefs in New Caledonia were published by Bour and Hoffschir in 1985.

The themes identifying environments suitable for trochus are:

- Theme 2: Reef flat with rubble and living corals (818 ha)
- Theme 3: Reef flat with rubble and sand (220 ha)

The sum of these two themes is an area of 1038 ha; the mean density of trochus on Tetembia is 45 shells per hectare; the mean weight per trochus on this reef, obtained through sampling, is 418 g. The weight of trochus per hectare is therefore 18, 8 kg, and the total trochus biomass present on Tetembia reef was 19.5 tonnes in 1984 (when the ground sampling was done).

Exploitable Faviidae biomass

The ball-shaped corals of the faviidae family are exploited by local companies for manufacture of decorative objects that are brought by tourists. A recent study (Joannot and Bour, 1988) found faviid corals to be very slow-growing: their diameter increases by only about 2 cm a year. For proper management of faviid stocks, it is therefore essential to know the biomass available.

The themes identifying environments suitable of Faviidae are:

- Theme 1: Dense living corals (331 ha)
- Theme 2:Reef flat with rubble and living corals (818 ha)
- Theme 4: White sandy bottom with pinnacles - depth >5m (1837 ha)
- Theme 5: White sandy bottom with pinnacles - depth <5m (371 ha)

Transect ground sampling carried out showed mean weight of exploitable faviid stocks to vary with bottom type:

Hard bottoms (Themes 1 and 2): 2 tonnes per hectare
Soft bottoms (Themes 4 et 5): 0.3 tonnes per hectare

The total exploitable biomass on Tetembia reef is therefore 2298 tonnes (hard bottoms) plus 662 tonnes (soft bottoms), which is just on 3000 tonnes. Good management would permit about one tenth of this biomass to be removed per year, i.e. 30 tonnes per year. With 180 tonnes harvested in 1987, the current rate of exploitation is obviously far too high.

CONCLUSION

The examples given show how easy it is to estimate the biomass of living reef resources using satellite images, provide one also has some ground sampling data. Processing of digital high-resolution SPOT images can provide biologists, resource managers and economic planners with an invaluable information base for understanding of coral reef environments, which are often difficult to explore by conventional means. The work undertaken on Tetembia reef will be continued on all the reefs of New Caledonia; the final product will be a thematic atlas of the vast New Caledonian lagoon.

REFERENCES

Bour, W., Hoffschir, C. 1985. Evaluation et gestion de la resource en trocas de la Nouvelle-Caledonie ORSTOM report, Noumea, New Caledonia: 28 pp.

Bour, W., Loubersac, L., Rual, P. 1986. Thematic mapping of reefs by processing of simulated SPOT satellite data: application to the Trochus niloticus biotope on Tetembia Reef (New Caledonia). Mar. Ecol. Prog. Ser. 34: 243-249.

Joannot, P., Bour, W. 1988. Estimation de la biomasse de la famille des Faviidae d'un recif exploite de Nouvelle Caledonie. Workshop of Pacific inshore fishery resources. SPC. Noumea. 12 pp.

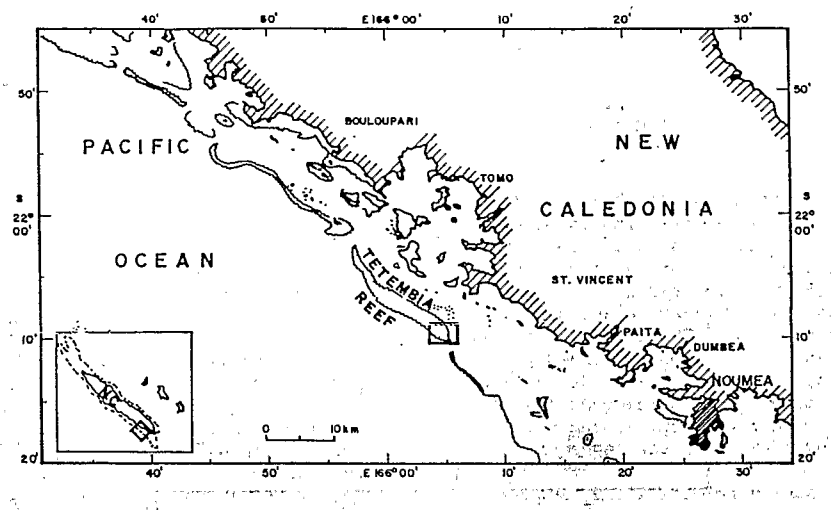

Figure 1 : Carte de situation
Location map

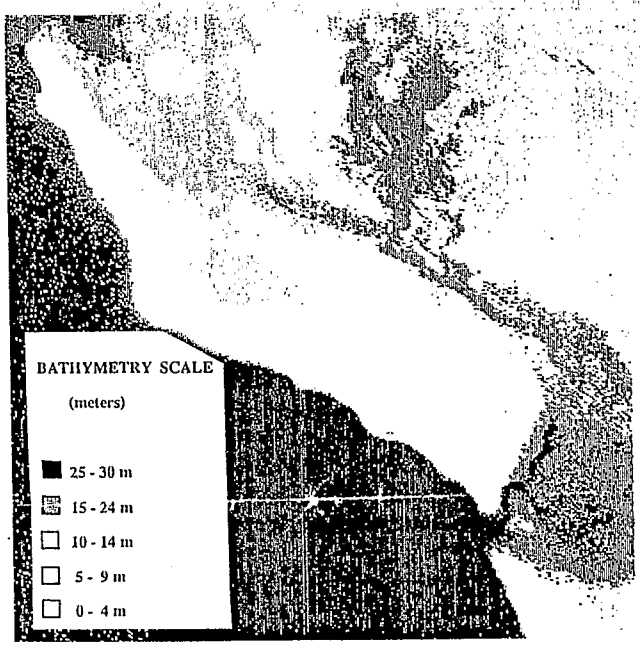

Figure 2 : Deep lagoon bathymetry

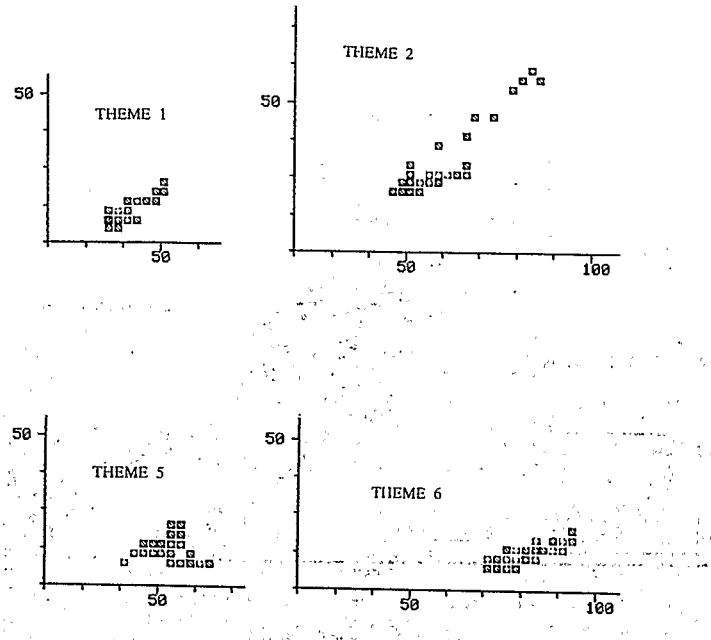

Figure 3 : Exemples d'histogrammes bi-dimensionnels
representatifs de divers themes
Sample of bi-dimensional histograms
representative of various themes

Figure 4 : Carte thematique du recif TETEMBIA (Nouvelle-Caledonie)
Thematic map of TETEMBIA reef (New Caledonia)