

## **Remote Sensing Analysis of Recent Carbonate Platforms, East of Sabah: Potential Analogues for Miocene Carbonate Platforms of the South China Sea**

### ***Analisis Inderaan Jauh Anjungan Karbonat Resen, Sabah Timur: Analog Potensi bagi Anjungan Karbonat Miosen Laut Cina Selatan***

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#### **ABSTRACT**

Recent carbonate platforms may provide useful analogues for fossil platforms and reefs, and could allow the generation of quantitative tools for the prediction of facies distribution, reservoir volumes, and reservoir quality. Data from these modern analogues would greatly enhance our ability to construct more reliable and calibrated reservoir models for carbonate fossil fields, such as the Miocene carbonate platforms of Central Luconia Province, Sarawak. In this study, carbonate facies maps and quantitative reservoir data will be generated by using remote sensing techniques. Satellite imageries over the carbonate platforms east of Sabah have been acquired and processed for generating facies maps. In order to produce a reliable facies map, the composition and grain size distribution of the sediments that make up individual facies must be known in order to determine the classes that have been identified on the initial facies maps. Samples collected from the Gaya and Selekan platforms were analyzed and the results of grain size analysis are illustrated.

**Keywords:** carbonates, facies, platform, remote sensing, mapping

#### **SARI**

Anjungan karbonat Resen dapat menjadi analog yang berguna bagi anjungan fosil dan terumbu, dan memungkinkan peralatan kuantitatif dapat memprediksi distribusi fasies, volume reservoir, dan kualitas reservoir. Data dari analog modern ini akan sangat meningkatkan kemampuan kita dalam merekonstruksikan model reservoir yang terkalibrasi dan dapat diandalkan untuk lapangan fosil karbonat, seperti anjungan karbonat Miosen di Provinsi Luconia Tengah, Sarawak. Dalam studi ini, peta fasies karbonat dan data reservoir kuantitatif dihasilkan dengan menggunakan teknik indera jauh. Citra satelit atas anjungan karbonat di timur Sabah telah diperoleh dan diproses untuk menghasilkan peta fasies. Dalam upaya untuk membuat peta fasies yang dapat diandalkan, komposisi sedimen dan distribusi ukuran butirnya yang membentuk fasies individu harus diketahui untuk menentukan kelas yang telah diidentifikasi pada peta fasies awal. Percontoh yang didapatkan dari anjungan Gaya dan Selekan dianalisis dan hasil analisis ukuran butir didapatkan.

**Kata kunci:** karbonat, fasies, anjungan, indera jauh, pemetaan

## INTRODUCTION

Constructions of static reservoir models in oil and gas fields where carbonates make up the main reservoir usually rely on subsurface data. The accuracy of a model depends on the density of the sampling by wells, the quality of the seismic data, and the interpretation of facies distribution in the carbonate section.

Modern carbonate platforms may provide useful analogues to fossil platforms and reefs. The Miocene carbonate platforms of Sarawak, for instance, are likely to be comparable to the modern carbonate platforms of Sabah, as the main carbonate-producing organisms for both platform types are similar if not identical.

In this study, carbonate facies maps are generated from satellite images of present-day platforms east of Sabah, as well as quantitative data that will help predict facies distribution, reservoir volumes, heterogeneity, and quality in Miocene platforms. Data from these modern analogues will greatly enhance the ability to construct more reliable and calibrated static and dynamic reservoir models for fossil carbonate fields.

Satellite images provide data in different regions of the electromagnetic spectrum, allowing detection, identification, and characterization of recent carbonate facies on modern platforms. This study will mainly rely on techniques used to extract information layers and monitor historical changes of these carbonate facies using multi- and hyperspectral sensors (in the optical and thermal windows) in conjunction with field checking.

Remote sensing is a useful tool for obtaining information about an object from space, based on object's electromagnetic radiation (Lillesand and Kiefer, 1994). The recording data of electromagnetic radiations after interaction with an object can be interpreted as an image with single or multiple bands. This process has become possible due to data acquisition in limited and narrow spectral bands, near IR and thermal IR imaging and microwave imaging (Murai, 1993).

Remote sensing in geology and environmental fields is widely used because it provides a unique global view at different spatial scales and in different ranges of the electromagnetic spectrum (Mumby and

Edwards, 2002; Purkis and Riegl, 2005; Yamano *et al.*, 2006).

The study area is located east of Sabah, between 4° 25' and 4° 45' North, 118° 35' 26" - 118° 58' East as shown in Figure 1.

## METHODOLOGY

### Data Acquisition

The first satellite data received was from the Malaysian Remote Sensing Agency (MRSA) in Kuala Lumpur. It was a SPOT image data of 2.5 m resolution made up of 4 separate scenes, acquired on 17<sup>th</sup> December 2006. These images were geometrically corrected using GCP (Ground Control Point) from JUPEM (Series L 7030 Topographic map of 1 : 50,000) and terrain correction using SRTM (Shuttle Radar Topography Mission). The error was less than half a pixel.

The second type of data was QuickBird image data (0.6 m resolution as shown in Figures 2 and 3) which were acquired in 2006 and 2009 respectively covering seven platforms. The other image acquired was IKONOS satellite data with the resolution of 1 m.

### Facies Classification

For the preliminary facies maps, two isolated carbonate platforms, Selekan (Figure 3) and Gaya (Figure 4) banks, were selected.

A geometric correction process was performed for each image and the accuracy was less than half a pixel. The satellite images for Selekan bank, Maiga, Gaya, Sibuan, and Terembu Reef were classified using unsupervised classification in order to create different classes based on a grey level similarity. To verify the validity of this classification, sampling was performed on the various platforms and the samples were analyzed for composition and grain size distribution. Sediment classes obtained from this analysis will be superposed and compared with the satellite image-derived classification. Final maps will be generated from this superposition.

Once the initial classification was performed, sampling points for each platform were selected based on the class color (17 points for Selekan bank and 14 points for Gaya) as partly shown in Figures 4 and 5. Each point is defined by its geographic coor-

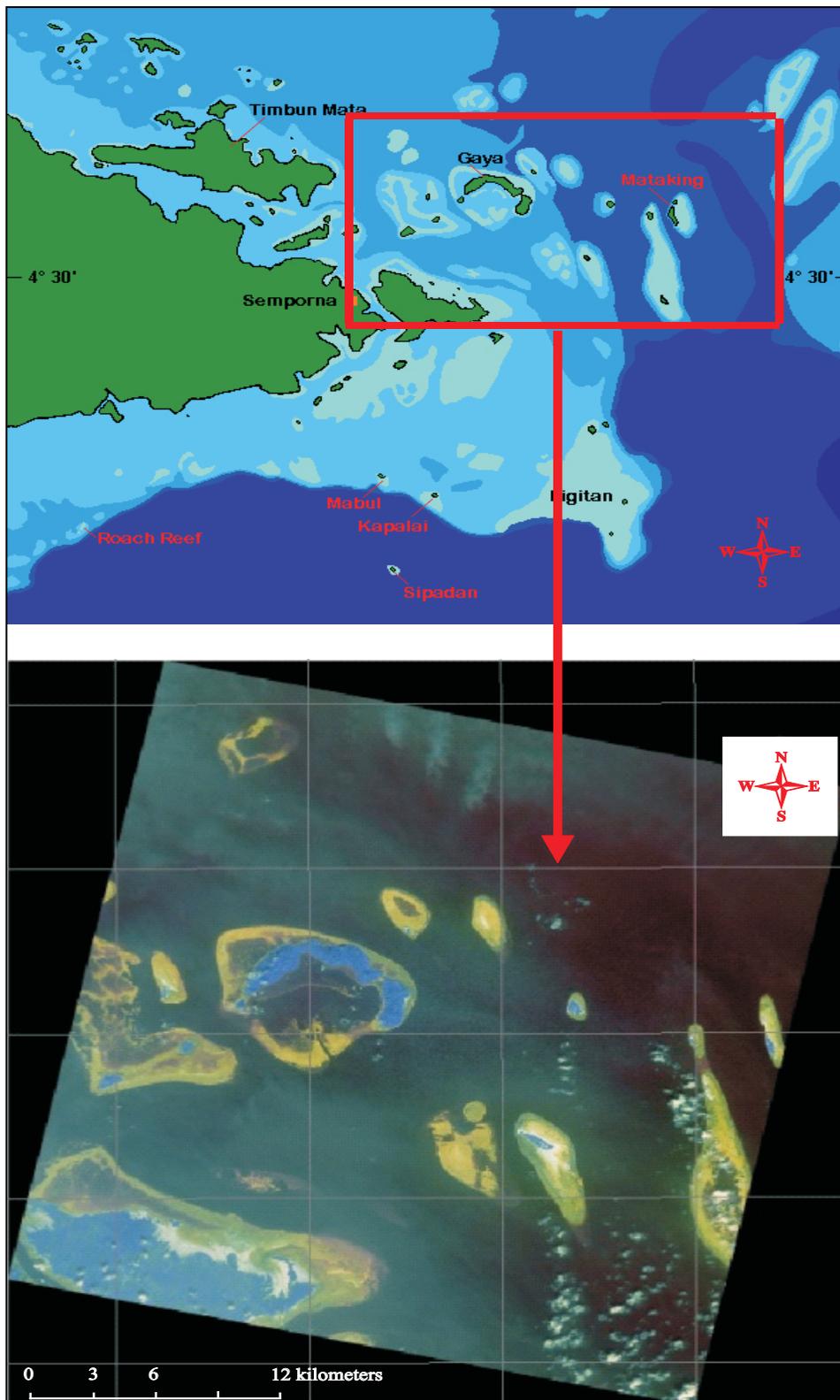


Figure 1. Locality map of studied area.

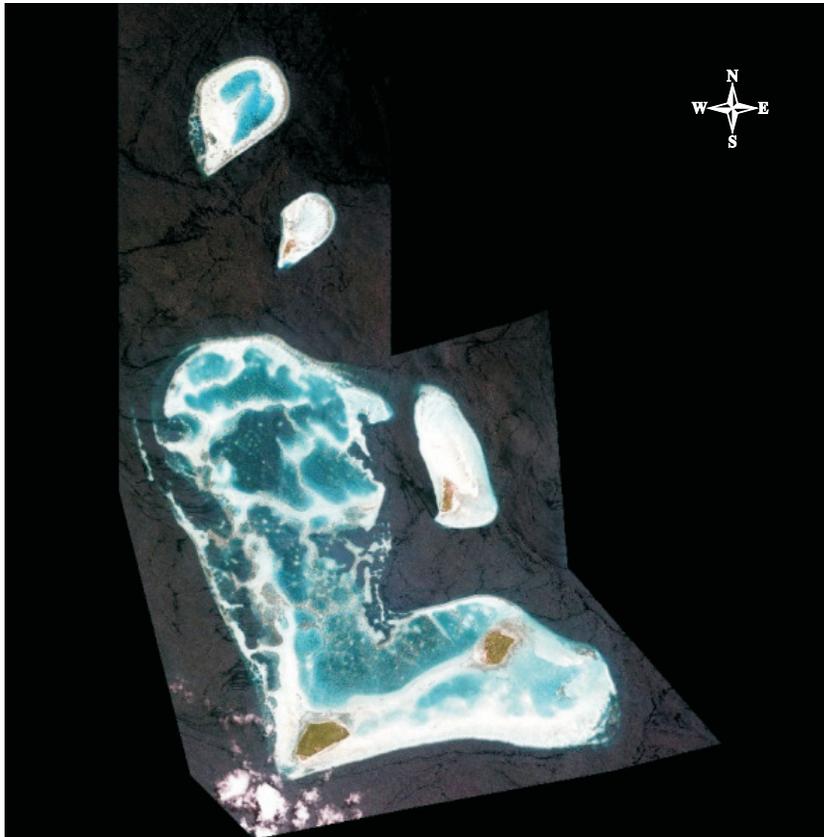


Figure 2. QuickBird image (0.6 m resolution), covering carbonate platforms.

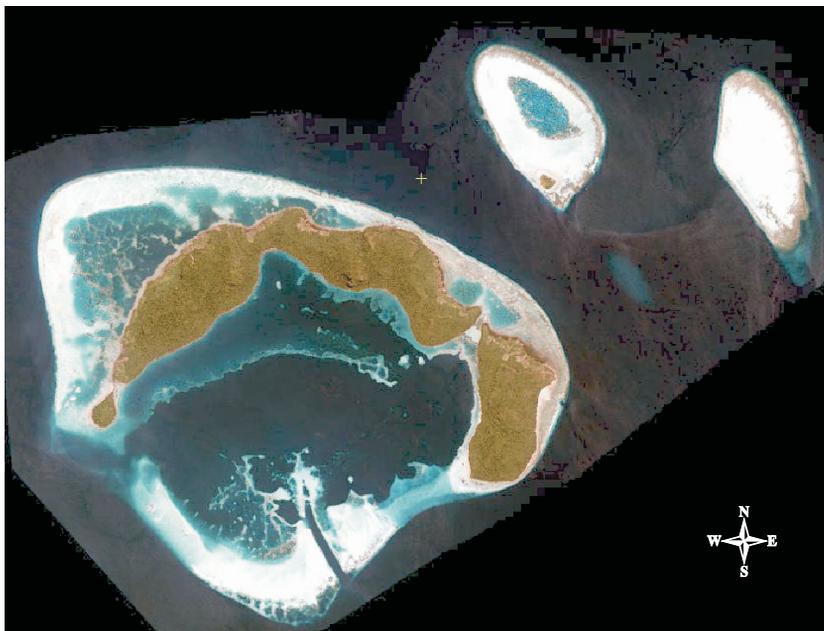


Figure 3. QuickBird image of Gaya Island, acquired in 2009, showing carbonate platforms.

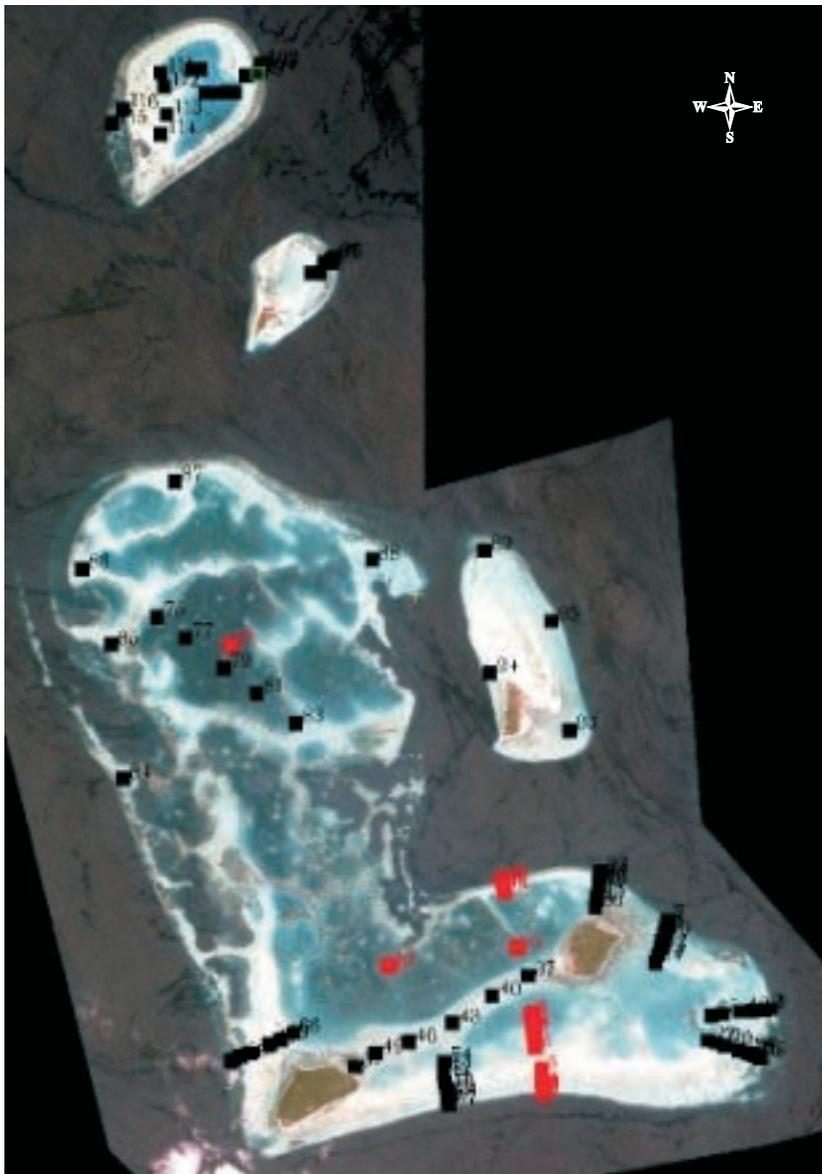


Figure 4. Sampling points (■) of the Selekan Island.

ordinates using PCI Geomatics which made sampling easier. First field trip to the study area was conducted on 12<sup>th</sup> to 15<sup>th</sup> November 2009.

Second field trip was carried out from 11<sup>th</sup> to 26<sup>th</sup> March 2010 with a collaboration of Sabah Parks to collect sediment samples and Universiti Malaysia Terengganu for bathymetry data acquisition. During this field trip, a total of 109 sediment samples were collected either by snorkeling or diving (64 points for Selekan bank, 7 points for Maiga, 7 points for

Sibuan, 12 points for Terembu Reef, and 19 points for Gaya) as shown in Figures 4 and 5.

#### Sample Analysis

Samples were collected from the surficial sediments on each platform depending on the depth of the sampling point that were guided and chosen by using GPS. In general, the depth of Selekan bank varies between 40 cm to 12 m, and Gaya depth can reach 27 m in the inner lagoon.

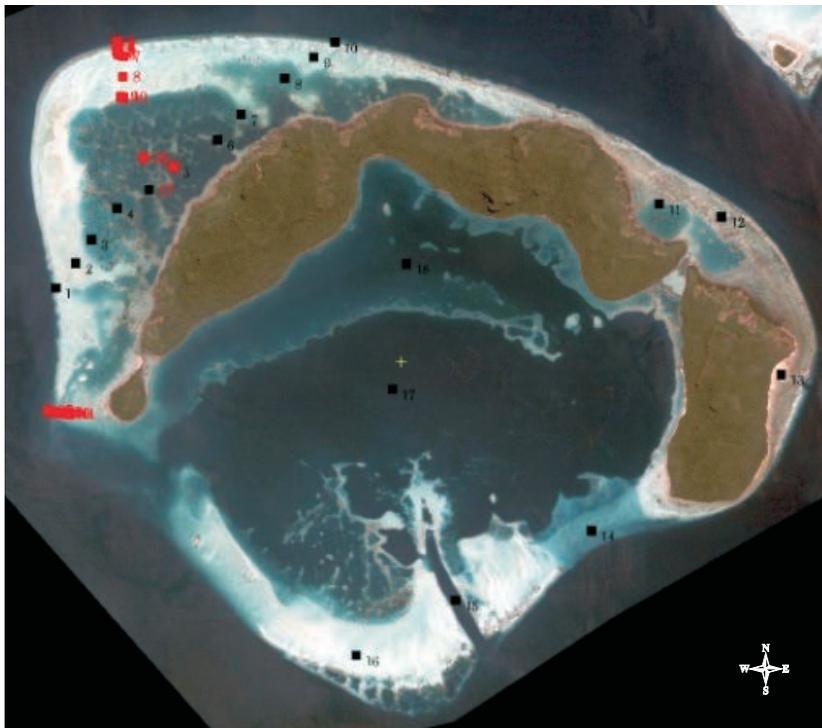


Figure 5. Sampling points (■) of Gaya Island.

A sample analysis procedure includes component identification and grain size distribution analysis. An initial identification of carbonate components was carried out at SEACARL. The sediment samples were washed using clorox to remove organic matter and reduce the strong smell of sea water, and then were dried before sieving. Grain size separation was carried out using sieves with sizes between  $63\ \mu$  to 2 mm and each sieve sample weighed ( $63\ \mu$ ,  $125\ \mu$ ,  $250\ \mu$ ,  $500\ \mu$ , 1 mm, and 2 mm).

## RESULTS and DISCUSSION

### Facies Maps

Satellite images covering the study areas generate facies maps of the Selekan and Gaya Islands as shown in Figures 6 and 7 respectively.

### Sample Analysis Results

The primary focus of this paper is to report the initial grain size distribution analysis for the samples collected from field visits to Selekan and Gaya banks

(Figures 4 and 5). The following observations can be extracted from Figures 8 and 9.

#### *Southern Margin of Selekan bank*

The area is presented in Figure 8. Points S0 to S3, close to the fringing reef, show a bimodal distribution, with a peak at  $250\ \mu$  and an upwards trend towards coarser grain sizes ( $>2\ \text{mm}$ ), probably representing large coral fragments.

In the back-reef area, point S4 shows a unimodal distribution with an almost perfect bell-shaped graph, centered on a peak value of  $250\ \mu$ . This suggests a lower proportion of large coral fragments. Going further to the North, away from the reef but still in the back-reef area, a grain size of  $500\ \mu$  is a characteristic of point S5. Further away from the reef reaching a more quiescent zone, the dominant grain size seems to decrease gradually. The histogram of S6 shows a high percentage of grains between  $125\ \mu$  and  $250\ \mu$ , whereas at point S7, the dominant grain size is  $250\ \mu$ .

#### *Center of Selekan bank*

In Figure 9, points S23 and S37 show a similar grain size distribution histogram, dominated by a

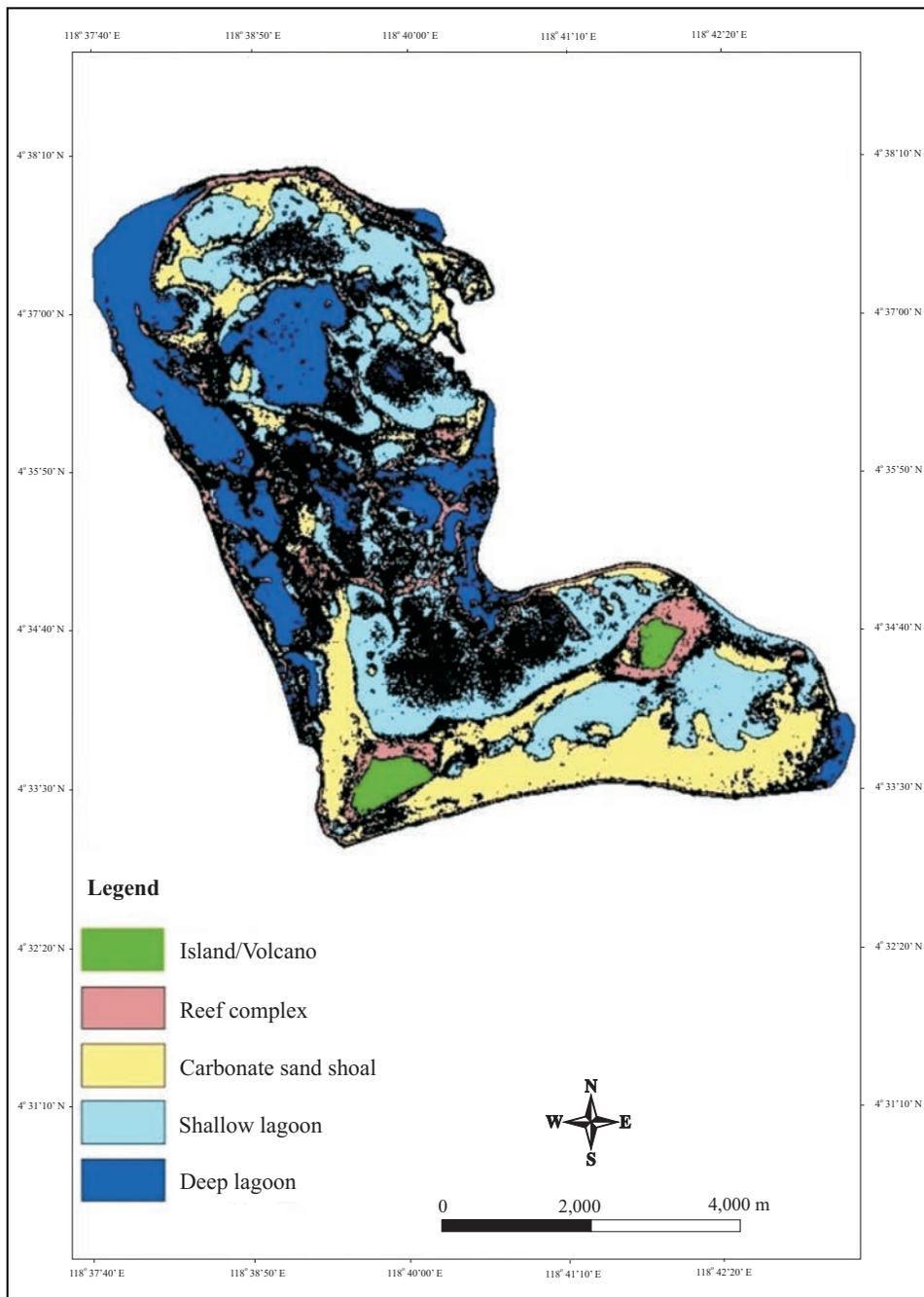


Figure 6. Unsupervised classification of the Selekan Island map.

fine fraction (less than  $63 \mu$ ). These points are both in lagoonal areas.

*Northern Margin of Gaya bank*

Figure 10 shows that the sampling point nearest to the fringing reef (point G1) indicates a similar bimodal

grain size distribution as in Selekan, with a peak at  $250 \mu$  and an upward trend towards coarser grain sizes ( $>2 \text{ mm}$ ), probably representing large coral fragments close to the carbonate factory.

Points G2 and G3 are on the reef flat, the zone of highest energy, and have no fine fraction. The

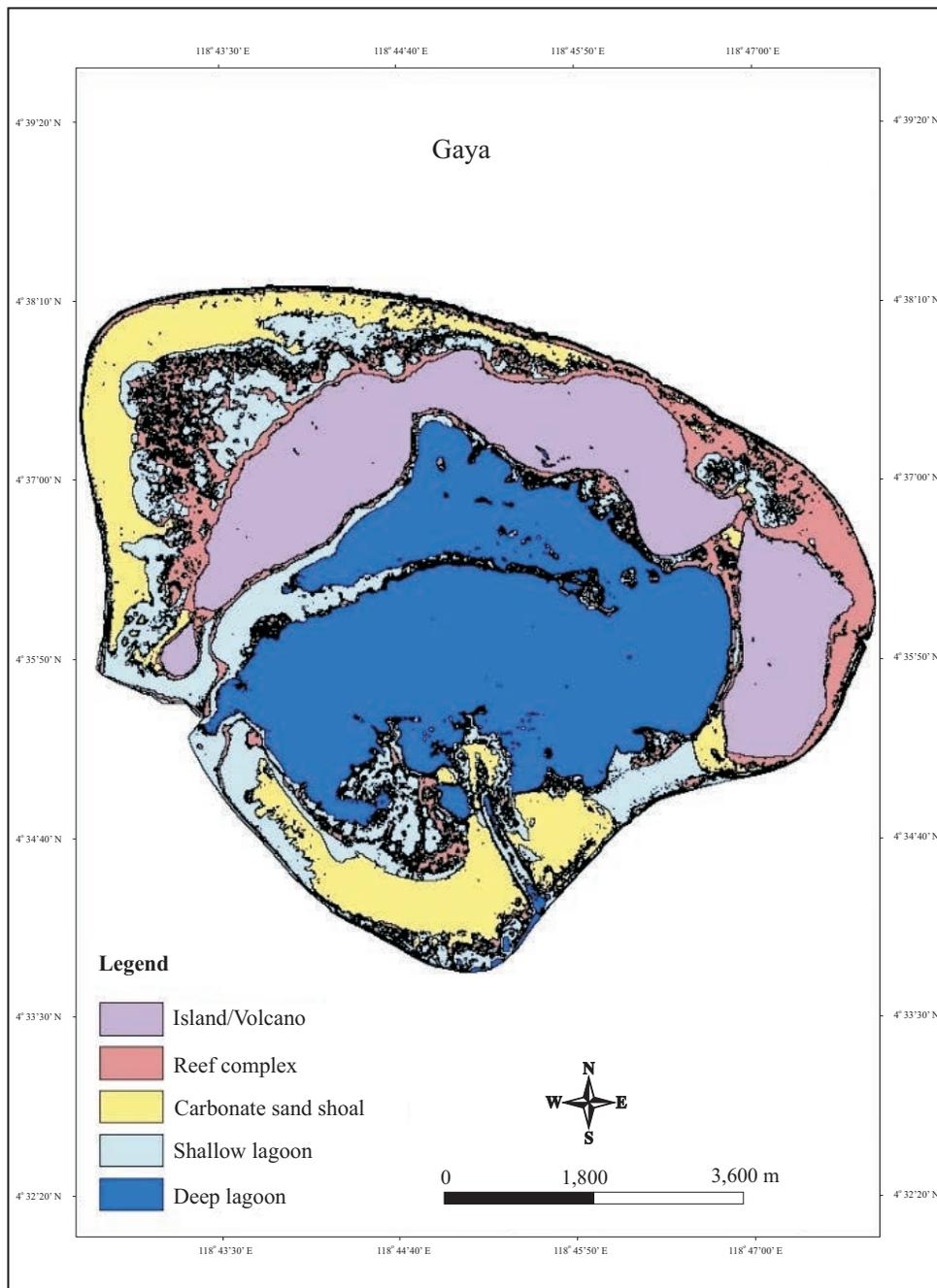


Figure 7. Unsupervised classification of the Gaya Island map.

sediments here are coarser than 2 mm. Point G4 is already in the back-reef, seemingly more quiescent zone and is dominated by grain sizes of 500  $\mu$  to 1 mm. Points G5, G6, G7, and G8 show comparable histograms, with a peak at 125  $\mu$ . These points are in quiescent lagoon areas.

#### *Western Margin of Gaya bank*

The carbonate sand is medium to coarse at G37, near the western margin of Gaya bank. G40 is within the lagoonal area east of point G37. It has a symmetric histogram centered on 250  $\mu$  (Figure 11).

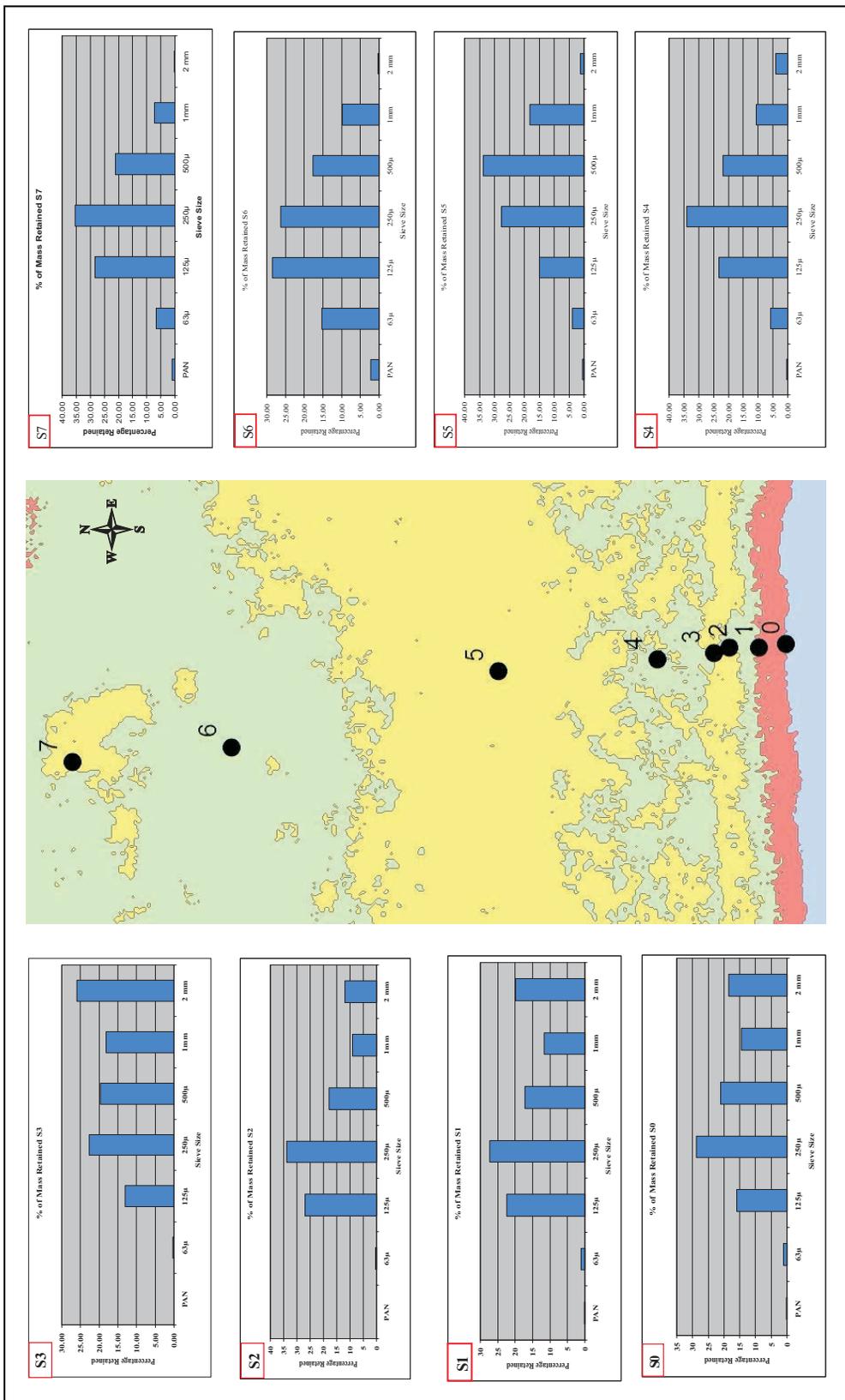


Figure 8. Histograms of Selekkan sampling analysis of southern margin of the Selekkan bank.

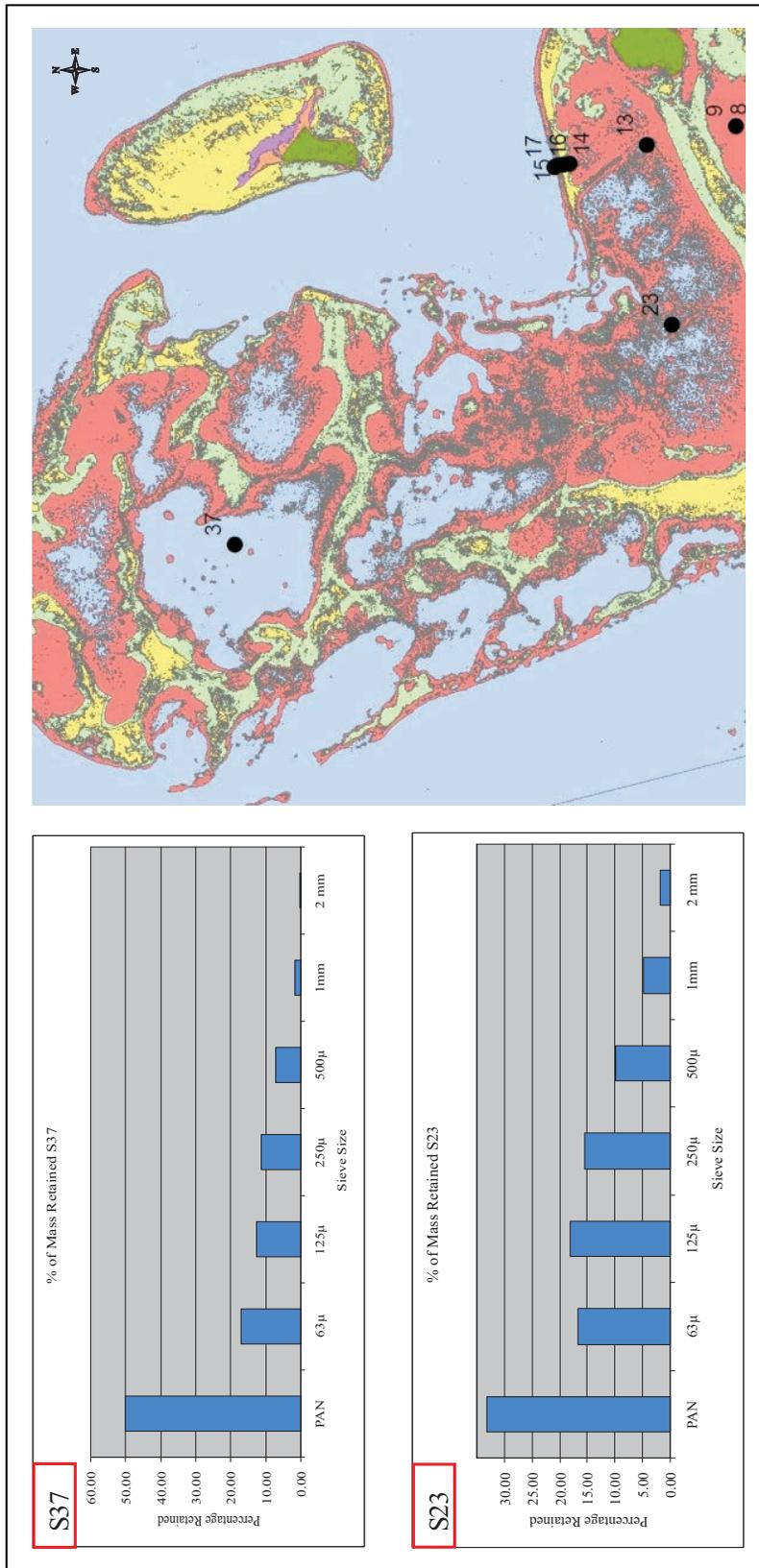


Figure 9. Histograms of Selekan sampling analysis of center of the Selekan bank.

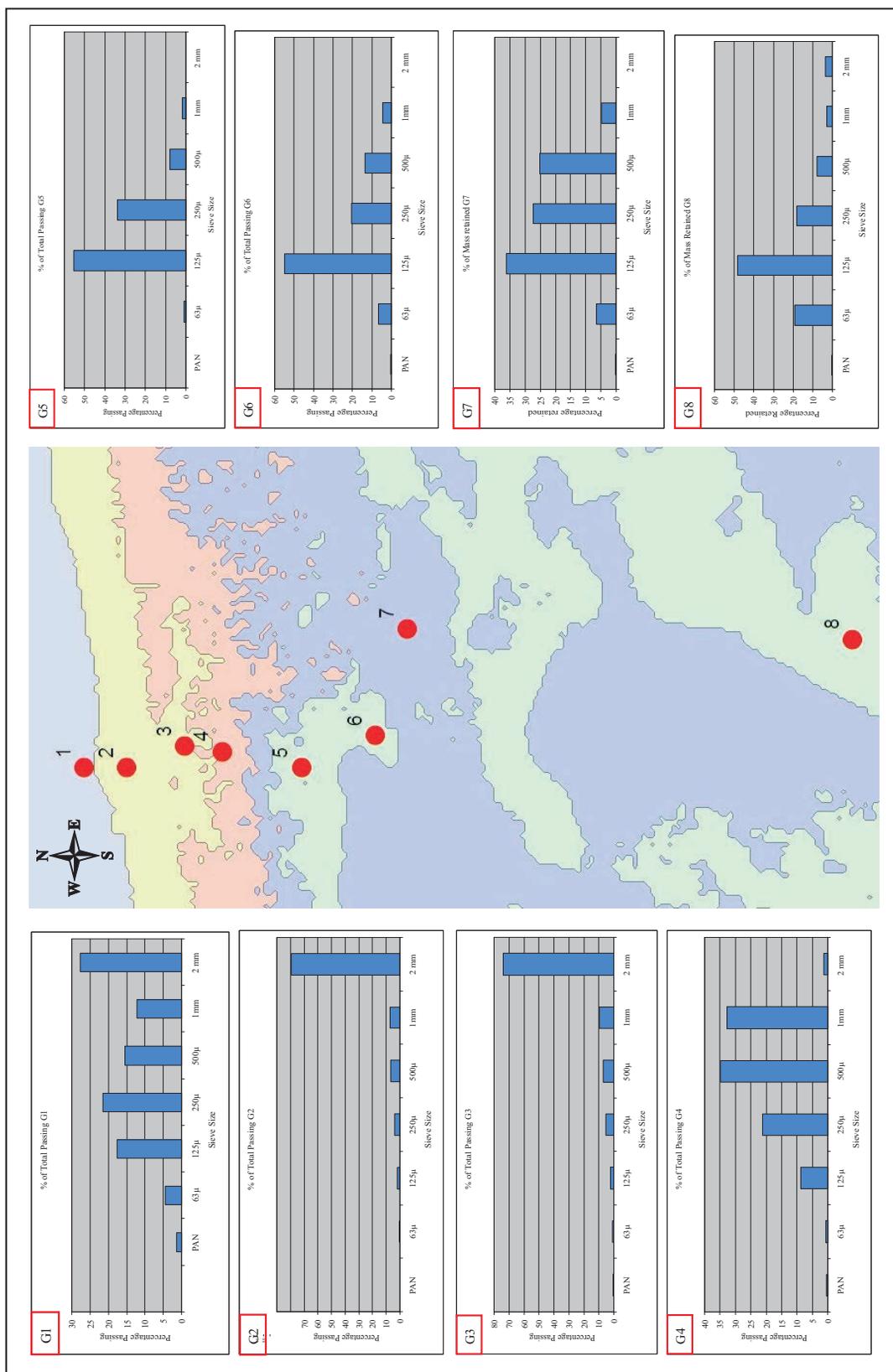


Figure 10. Histograms of Gaya Sampling Analysis of northern margin of the Gaya Bank.

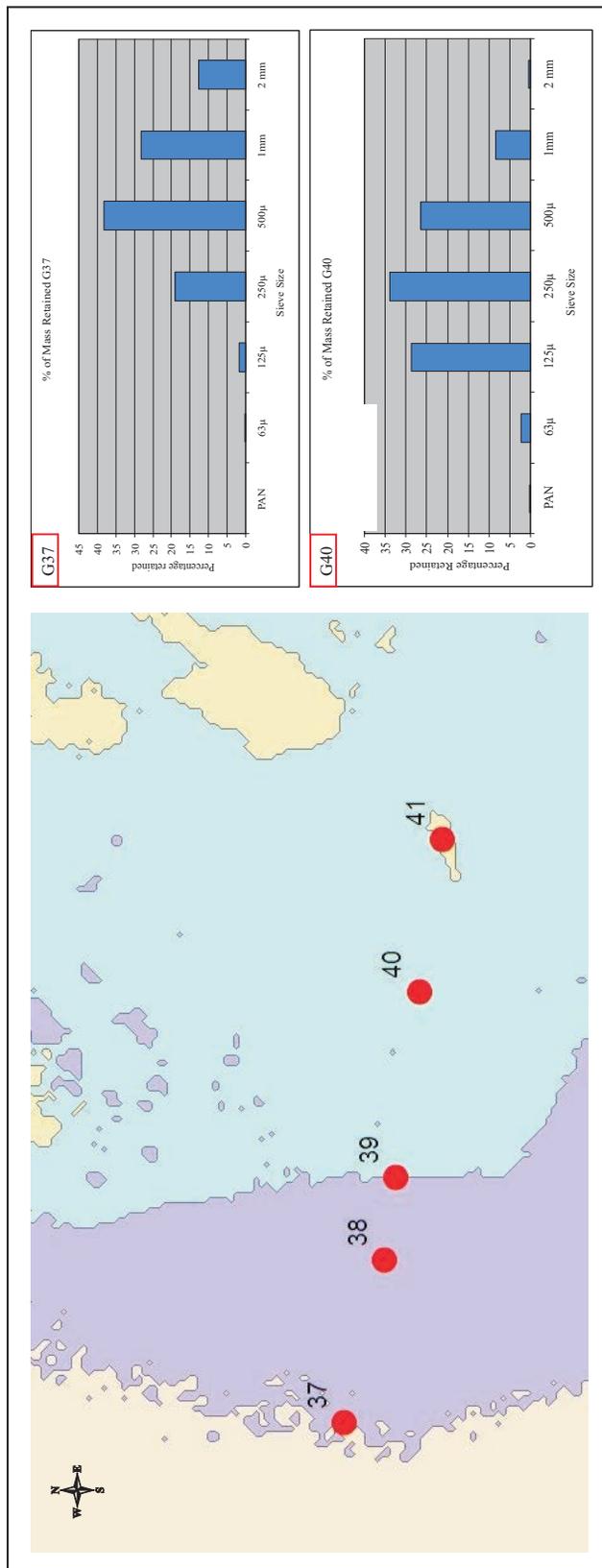


Figure 11. Histograms of Gaya Sampling Analysis of western margin of the Gaya bank.

## CONCLUSIONS

The grain size analysis of carbonate sands on Selekan and Gaya banks is an important early step to illustrate the variation and distribution of carbonate sand on the platforms. From this analysis, a few points can be noted:

1. Carbonate grain sizes at platforms Selekan and Gaya are closely related to the location of samples with respect to the reef (carbonate factory). The carbonate grain size increases towards the reef and decreases away from it.
2. High energy, currents, and storms are the main factors in managing the distribution of carbonate sand. The samples taken in high energy zones are devoid of a fine fraction, whereas samples collected in low-energy zones contain no coarse fraction.
3. Unsupervised classification is a useful method to classify the area in order to choose the sampling points.
4. The facies classification obtained through sample analysis does not perfectly match the unsupervised classification obtained from satellite imagery processing.
5. A combination between unsupervised classification and a classification derived from component identification and grain size analysis will be needed to modify facies maps accurately.

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