RECONNAISSANCE GEOLOGIC MAPPING OF SAND AND GRAVEL RESOURCES IN CABO ROJO

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ABSTRACT: Geomorphic and anthropogenic variables operate in coastal causing complex changes. The integration of IKONOS and LANDSAT images and map allows identifying and analyzing the possible correlations between the variables that cause coastal changes. Image processing results and published maps were manipulated using ENVI software to recognize deposits of granular material under the sea.

Calibrations, Atmospheric Correction, elimination of water column, unsupervised and supervised classification result in identification of granular marine deposits in Cabo Rojo (Puerto Rico).

Image processing is a good choose to recognize materials under the sea.

1. INTRODUCTION

The population growth in Puerto Rico had caused developing of construction and recreation projects, for whose building had required sand and gravel resources. "[i]New resources of sand and gravel would allow beaches to be nourished and construction activities to be supplied". Location knowledge of these resources is useful for constructor and scientific to plan exploration and extraction of them.

There is a map the shelf of Puerto Rico that was prepared using seismic-reflection profiling augmented by bottom sampling. [ii]Three offshore sand and gravel deposits have been identified which may be economically important. The largest of these, known as Escollo de Arenas, extends off the northwest corner of the island of Vieques, and is estimated to contain 90 million cubic meters of sand and gravel. A second deposit, Cabo Rojo, lies in a shallow trough 1 kilometer offshore near the southwest corner of the main island and is estimated to be nearly as large. The third deposit, Isabela, off the northwest corner of Puerto Rico, may not be economically viable. The geometry and nature of each deposit was determined by seismic surveys, diver-operated Vibracores, surface sampling, and size analysis to determine their suitability for construction use.

2. OBJECTIVES

- Identify sediment bottom types based on composition and textural characteristics, using Thematic Mapper (TM) image and IKONOS image.
- Compare the results of processing with both sensors.

3. PROCEDURE

- Radiometric calibration:

For Thematic Mapper : Each band is affected for Equation No. 1.

Equation No. 1

$$\lambda_{calibred} = L_{\min\lambda} + \left(\frac{L_{\max\lambda} + L_{\min\lambda}}{Q_{cal\max}} \right) * Q_{cal}$$

Calibration values were taken for ETM sensor published after 1984.

The calibration values were obtained for all bands are:

Table 1. Calibration values from E T mapper sensor.

Band	Lmin	Lmax
1	-0.15	15.21
2	-0.28	26.68
3	-0.12	20.43

For Ikonos:

Each band is affected for Equation No. 2.

Equation No. 2

$$\lambda_{cal=} \frac{\lambda}{Calibration_{value}}$$

The calibration values were obtained in web page Ikonosimage.:

Table 2. Calibration values to Ikonos

Blue	Green	Red	NIR
633	649	840	746

Band Math equations (in Basic Tools)

For thematic mapper:

$$\lambda_{calibred} = L_{\min\lambda} + \left(\frac{L_{\max\lambda} + L_{\min\lambda}}{Q_{cal\max}} \right) * float(Q_{cal})$$

For Ikonos:

$$\lambda_{cal=} \frac{float(b1)}{Calibration_{value}}$$

allow introduce the Equation No. 1 and No. 2 such a:

- Atmospheric Correction: Local atmospheric corrections were made using a Dark Pixel Substract in Basic Tools.

- Masking: A separation between land and ocean was made to reduce the numbers of pixels involved in the image processing and to improve the identification of changes in digital values in the ocean that cannot be easily detected when land was included. In Basic Toos, there is an option “Masking” and build Mask. Region of Interest (ROIs) were used for building the mask.

- Remotion of Water column

Band Selection: Pairs of spectral bands are selected which have different bottom reflectance but good penetration of water. In Landsat TM and Ikonos were selected Red/Green, Red/Blue, Green/Red. The visible bands were further processed by linearizing the exponential depth dependence of the signal received by the satellite sensor. Lyezenga (1978) used the transformation:

$$\textit{Equation No.}\,3$$
$$\textit{Band for remotion}: Ln(\textit{Band selected})$$

- Plot of (transformed) band i against (transformed) band j for a unique substratum at various depths. Gradient of line represents the ratio of attenuation coefficients Ki/Kj. The ratio is the same irrespective of bottom type.
- Because of full atmospheric correction has been undertaken already the Equation No. 4 should be applied.

$$\textit{Equation No.}4$$
$$\textit{Band without column water} =$$
$$Ln(Bi) - Ki / Kj * KLn(Bj)$$

For Unsupervised Classification, Envi software has two options Kmeans or Isodata.

K-Means

Group of n-dimensional data are classificated into their natural spectral classes. The cluster data are selected arbitrarily. Using the links between displays it is possible to make comparisons between original image and classificated image.

Isodata

With minimum distances techniques the IsoData unsupervised classification calculates class means evenly distributed in the data space. The procedure continue until the number of pixels in each class changes by less than the selected pixel change threshold or the maximum number of iterations is reached. Using the links between displays it is possible to make comparisons between original image and classificated image.

For Supervised Classification, Envi Software has Parallelepiped, Maximum Likelihood, Minimum Distance, Mahalanobis Distance, Binary Encoding, and Spectral Angle Mapper options but in this report Maximum Likehood and Minimun distances showed the best result.

Supervised classification requires that the user select training areas for use as the basis for classification.

The first step is definition of region of Interest (ROI), typically used to extract statistics for classification, masking, and other operations

Maximum likelihood classification assumes that the statistics for each class in each band are normally distributed and calculates the probability that a given pixel belongs to a specific class.

The **minimum distance** classification uses the mean vectors of each ROI and calculates the Euclidean distance from each unknown pixel to the mean vector for each class.

4. RESULTS

The image processing was realized in the Laboratory of Geology in University of Puerto Rico, Mayagüez Campus.

Original Images

Image 1 Sub-set of Cabo Rojo using Landsat Image

Image No. 2 Cabo Rojo Ikonos Image

Radiometric Calibration

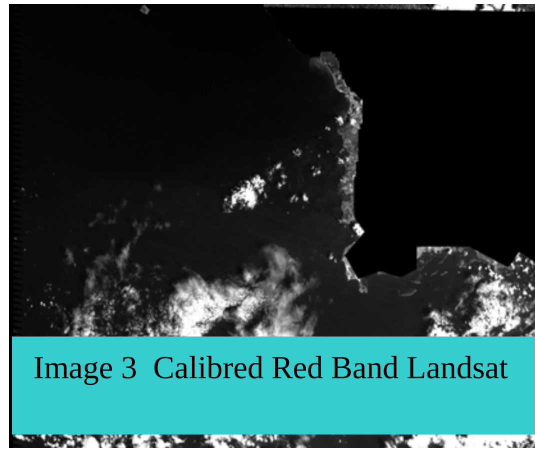


Image 3 Calibred Red Band Landsat

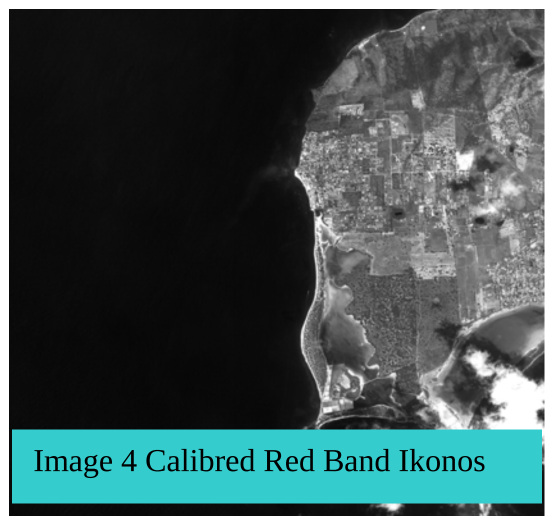


Image 4 Calibred Red Band Ikonos

Calibration Green Band

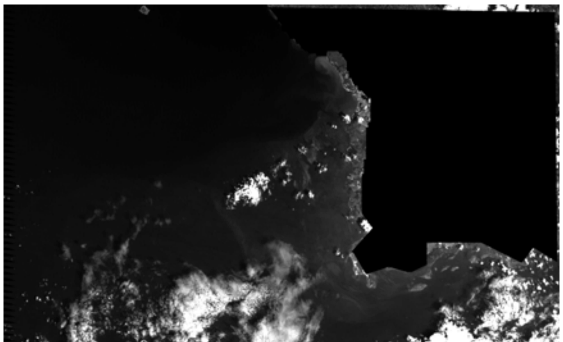


Image 5 Calibred Green LandSat

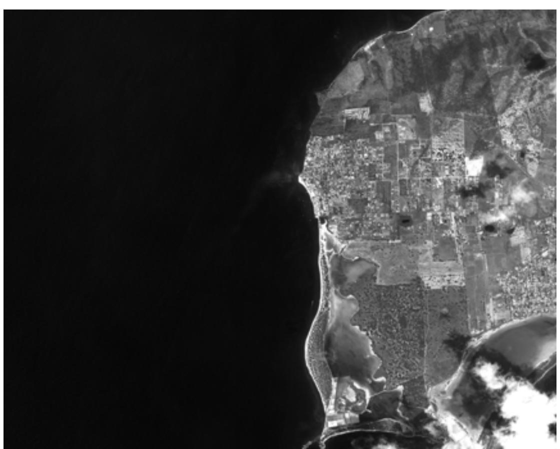


Image 6 Calibred Green Ikonos

Calibration Blue Band

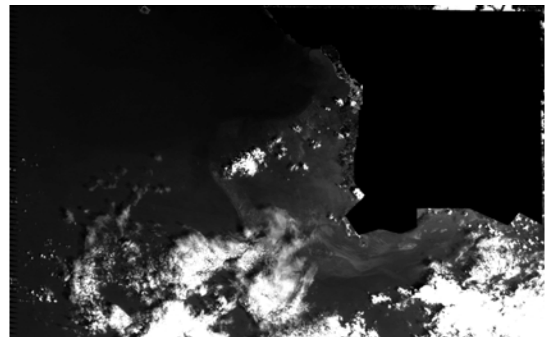


Image 7 Calibred Blue Band Landsat

Image 4 Calibred Blue Band Ikonos

Atmospheric Correction

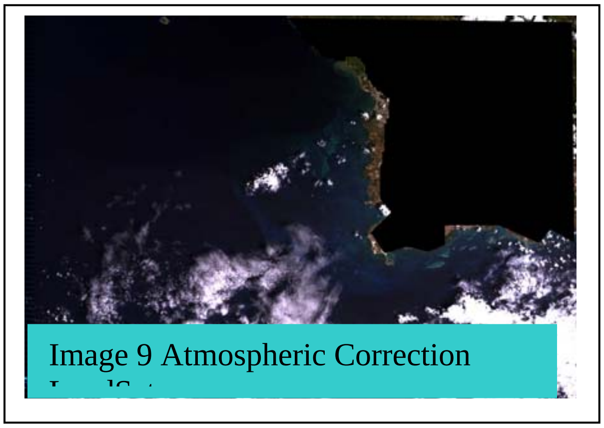


Image 9 Atmospheric Correction

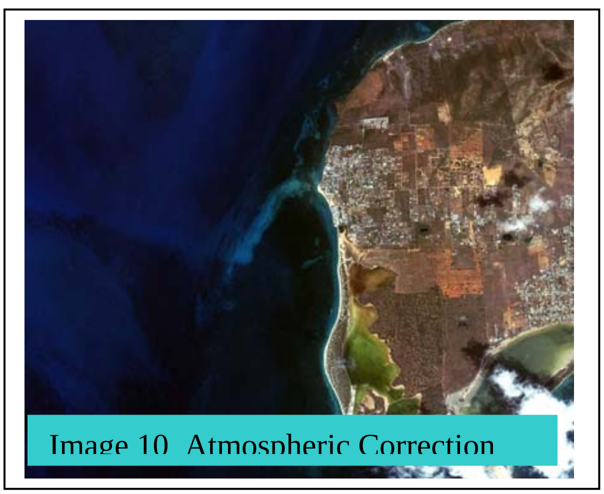


Image 10 Atmospheric Correction

Masking and Correction

Image 11 Masking Landsat

Image 12 Masking Ikonos

Water Column Correction

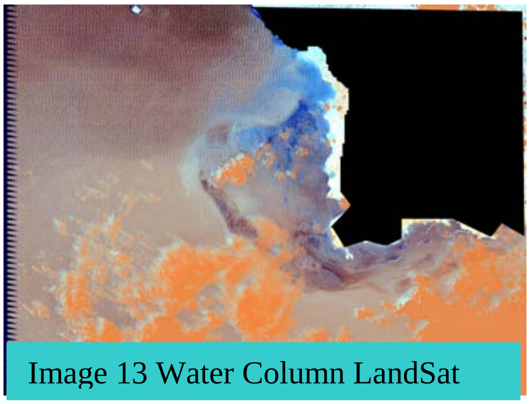


Image 13 Water Column LandSat

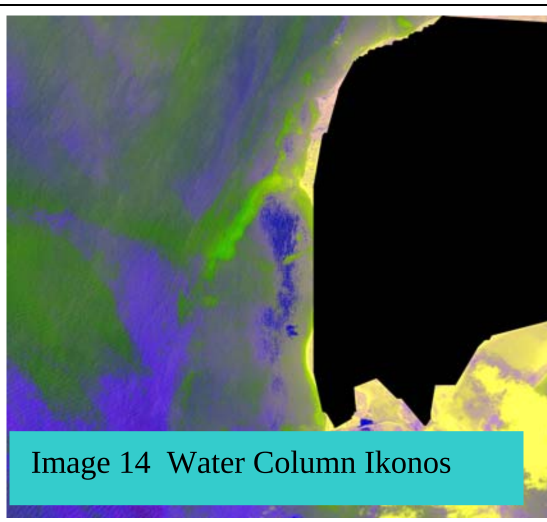


Image 14 Water Column Ikonos

Unsupervised Classification

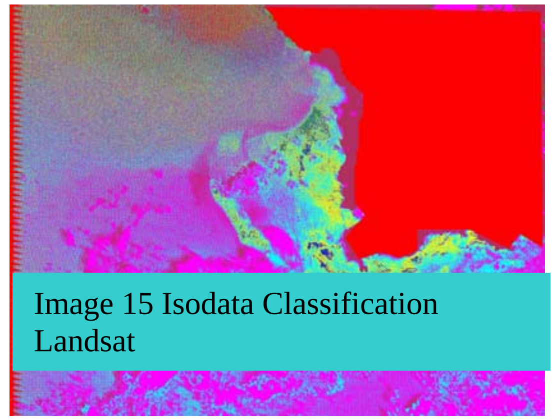


Image 15 Isodata Classification Landsat

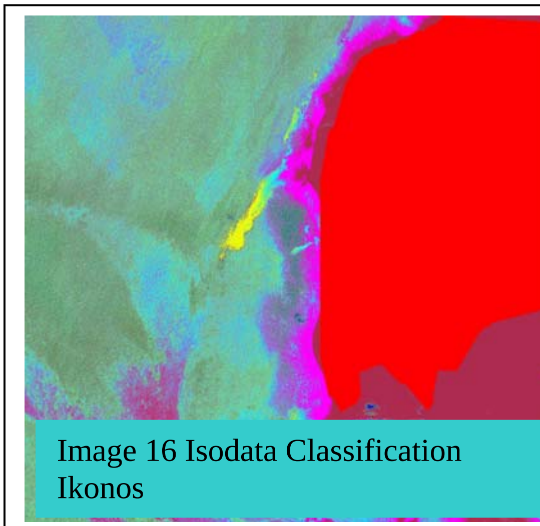


Image 16 Isodata Classification Ikonos

K Means Unsupervised Classification

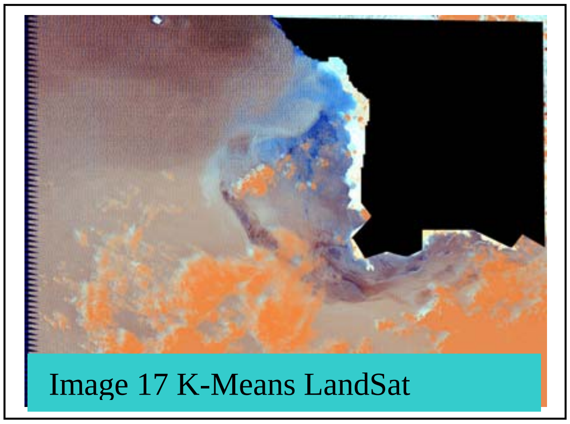


Image 17 K-Means LandSat

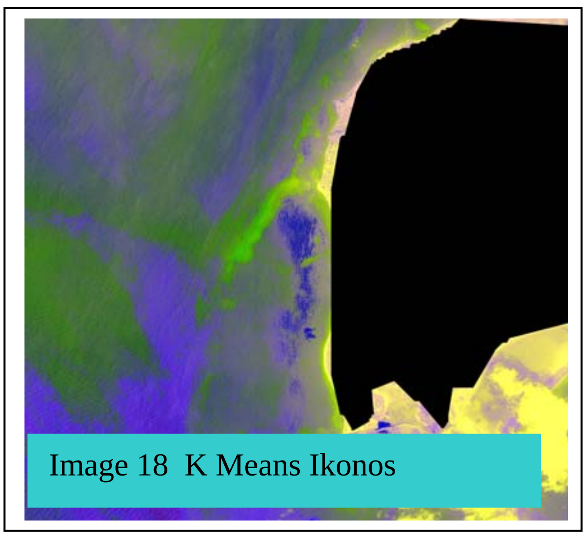


Image 18 K Means Ikonos

Minimum Distance supervised Classification

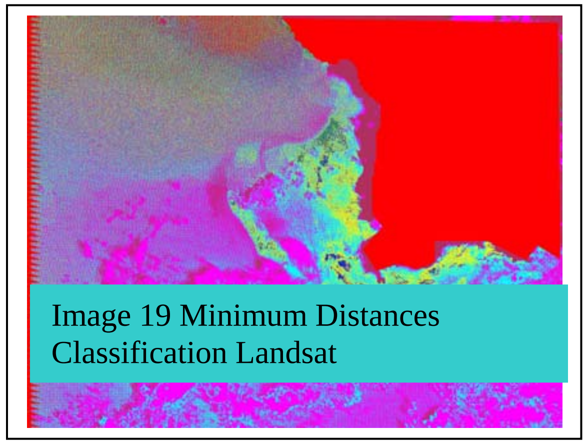


Image 19 Minimum Distances Classification Landsat

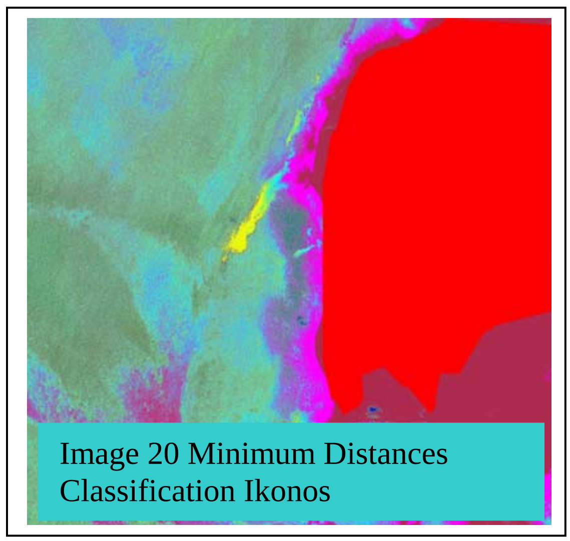


Image 20 Minimum Distances Classification Ikonos

Maximum Likehood Classification

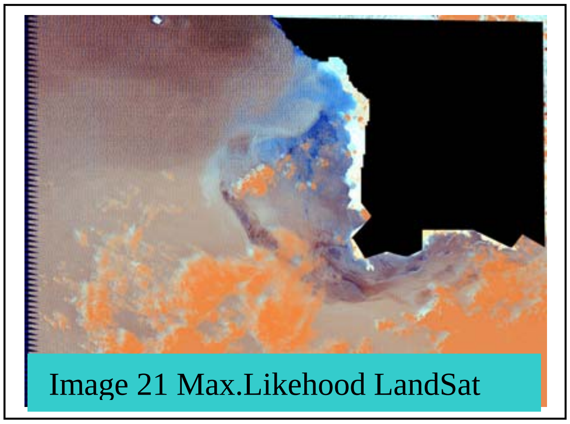
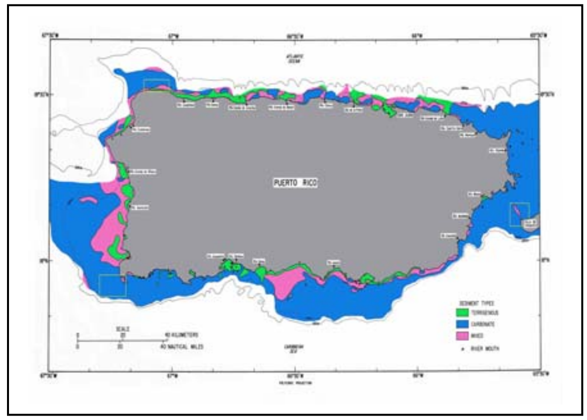


Image 21 Max.Likehood LandSat

Map with information
Source: Sediment type map.
USGS web page



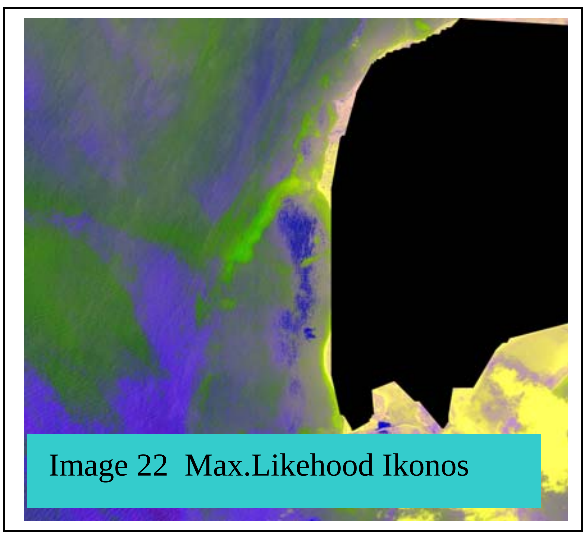


Image 22 Max.Likehood Ikonos

5. DISCUSSION

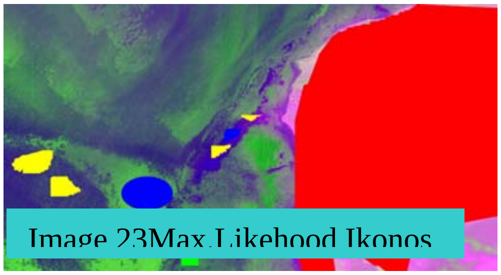


Image 23Max.Likehood Ikonos

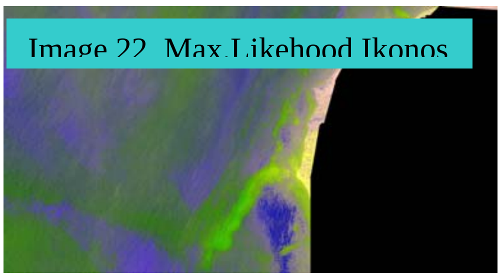
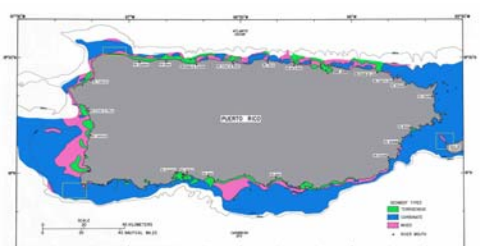


Image 22 Max.Likehood Ikonos



Map with information
Source: Sediment type map. USGS web page

TM spatial resolution was not appropriate for recognizing types of granular materials (special resolution less than 30 meters). For this technical proposes to use Ikonos images with better spatial resolution would improve the identification of more data with small radiance ranges.

The analyst of the image can use the unsupervised classification to have an idea about the choosing of ROI. But, field recognize give more information about the study area.

For this image, unclassified classification did not give enough information about recognition of interest areas.

It is also possible that using an image with higher spectral resolution would improve the identification of sediment bottom features on areas with small radiance ranges. USGS web page

6. CONCLUSION

TM spatial resolution was not appropriate for recognizing types of granular materials (less than 30 meters). For this technical propose to use Ikonos images with better spatial resolution allowed to improve the identification of more data.

Unsupervised classification allows identifying of Region of Interest in both images.

For both image, unclassified classification did not give enough information about recognition of interest areas.

Image Processing with ENVI allow the identification of granular materials of soils.

More that one hundred of data are required for correction of column water. In this case, only were taken around forty points.

7. REFERENCE

[i] Rafael Rodriguez, U.S. Geological Survey, Guaynabo

[ii] Rafael Rodriguez, U.S. Geological Survey, "Sand and Gravel Resources of Puerto Rico"

Envi Manual

Lectures Notes of Dr. Fernando Gilbes

Barreto M., Morelock J., AN INTEGRATED MAPPING AND DATABANK SYSTEM FOR COASTAL PAR A. WEST COAST PUERTO RICO. 1994