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A SUSTAINABLE SHRIMP MARICULTURE INDUSTRY FOR ECUADOR

Edited by Stephen Olsen and Luis Arriaga







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The University of Rhode Island

Multi-temporal Study of Mangrove, Shrimp Farm and Salt Flat Areas in the Coastal Zone of Ecuador, Through Information Provided by Remote Sensors

Estudio Multi-temporal de las Areas de Manglar, Piscinas Camaroneras y Salitrales en la Zona Costera del Ecuador, Mediante Información Proporcionada por Sensores Remotos.

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Resumen

La comparación de datos estadísticos de dos series de mapas de la costa ecuatoriana, muestran que en 1969 había unas 203.695 ha de manglares, las cuales fueron reducidas a 182.107 ha, en 1984, lo que significa una disminución del 10,6%.

La causa principal del cambio en los manglares y salitrales es la actividad humana, incluyendo: (a) construcción de piscinas camaroneras, las que existían en pequeña escala en 1969, pero que en 1984 cubrían una superficie de 89.367 ha; y (b) expansión urbana hacia las áreas de manglares (Limones, Esmeraldas, Muisne, Guayaquil, Machala y Puerto Bolívar) que suman una pérdida de 1.200 ha.

Por otra parte, se observan cambios en la línea de costa, alrededor de las islas, especialmente en el Golfo de Guayaquil, debido a la acumulación de sedimentos transportados por los ríos Guayas, Jubones y otros ríos menores, y a la propagación natural del manglar en las áreas de sedimentación. Esta colonización expontánea de manglares suma unas 1.600 ha y está localizada principalmente al sur de la Isla Escalante, entre las Islas Malabrigo y Los Ingleses, y a lo largo de la línea de costa entre el rio San Pablo y Puerto Bolívar.

Los salitrales, antes de la construción de piscinas cubrían aproximadamente 51.495 ha (1969), mientras que en 1984 la existencia era de 20.024 ha, lo que indica que habrían sido utilizadas unas 31.471 ha entre tales años.

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Introduction

Utilizing information collected from remote sensors, radar images, infrared, black and white, and panchromatic aerial photographs, a series of thematic charts of the mangrove areas, shrimp farms and salt flats of the Ecuadorian coast were developed. The first series consists of 100 charts, which contain information (updated to November 1984) on mangrove areas, shrimp farms and salt flats. The second series consists of 98 charts containing historical information on mangrove areas and salt flats before the beginning of construction of shrimp farms, taking 1969 as the reference year. These charts also cover other land use categories such as brush, agricultural areas, forests and urban settlements.

Comparing the statistical data of the two series of charts showed that in 1969, coastal Ecuador contained approximately 203,695 hectares (ha) of mangrove area, which by 1984 was reduced to 182,107 hectares, or a reduction of 10.6 percent. The principal cause of this change in the mangrove and salt flat areas is human activity including:

- construction of ponds for shrimp mariculture, which in 1969 existed on a small scale, but by 1984 covered an area of approximately 89,367 ha.
- urban expansion: all human settlements located close to the mangrove areas have grown extensively, including Limones, Esmeraldas, Muisne, Guayaquil, Machala and Puerto Bolivar.
- Total urban expansion accounts for loss of approximately 1,200 ha of mangrove and salt flats.

There is also a definite change in the coastlines on the continental shores, around the islands and especially in the Gulf of Guayaquil because of:

- accumulation of sediments transported by the Guayas and Jubones Rivers, and other minor tributaries.
- natural propagation of mangrove, which spontaneously colonize areas covered by sedimentation. This spontaneous growth of mangroves accounts for an area of approximately 1,600 ha, and is located principally to the south of Escalante Island, between the islands of Malabrigo and Ingleses, and along the coast between the mouth of the San Pablo River and Puerto Bolivar.

Background

Coastal resources are becoming increasingly important. Rational, efficient and scientific management are fundamental for their conservation and optimal utilization. In Ecuador, an important coastal resource is the mangroves, which are a very complex structure due to the interaction of ocean, land and atmosphere, and the animal life which inhabits them.

Mangroves have been exploited to satisfy various human needs such as:

- pilings for construction
- charcoal
- tannic acid
- fish, crustaceans and mollusks used as food and in commerce

The raising of *Penaeus* shrimp began in Ecuador in 1966 in small natural lagoons left after spring tides. Due to the high profitability of this activity, artificial ponds for shrimp farming were built, originally in salt flat areas. But by 1978-79, shrimp farms started to expand to include mangrove areas, creating the need for basic cartographic documentation upon which to base coastal resource management decisions.

The Military Geographic Institute (CLIRSEN) decided to test the applicability of remote sensing technology to the preparation of thematic charts of the mangrove ecosystem, using a zone between Machala and Puerto Bolivar as a pilot site.

The objectives of the pilot study were to:

- determine whether tele-detection techniques used for qualitative and quantitative studies of the test site mangrove areas could be applied to the whole Ecuadorian coast.
- evaluate changes in coverage and land use caused by human activities.
- present multi-temporal cartographic documentation, which will serve as support for the investigation and management of this ecosystem.

The results obtained by this pilot study were completely satisfactory. The results also suggested that the study should be continued for the remaining coastline, with preferential use of infrared color photography. Therefore, the Subsecretaria de Recursos Pesqueros, Direccion de la Marina Mercante and CLIRSEN formed an agreement for technical cooperation to continue a full-scale remote sensing study of mangrove, shrimp farm and salt flat areas in the coastal zone of Ecuador. The following is a summary of that project.

Methodology

The methodology applied in the present study was an elaboration of that used in the pilot study of Machala--Puerto Bolivar. Information was collected on the mangrove areas in Ecuador from remote sensing data, radar images, infrared, black and white (b/w) and panchromatic aerial photographs. The Military Geographical Institute supplied base maps which were used as a basis for the transcription of the information obtained. Radar images were utilized in the form of 20 mosaics and 6 strips at a scale of 1:100,000. The photographs collected were 120 infrared b/w photographs of the Gulf of Guayaquil, 30 infrared photographs of the areas of San Lorenzo and Esmeraldas, and 910 aerial photographs (panchromatic), varying in scale between 1:10,000 and 1:60,000.

Procedure

The study procedure consisted of several substages. The first involved the preparation of thematic charts of mangrove areas, shrimp farms and salt flats with information updated to November 1984. The scale used was 1:25,000. For this part of the project, radar images and infrared photographs were utilized and interpretation was checked in the field. The next step was preparation of thematic charts of mangrove and salt flat areas before construction of shrimp farms, using 1969 as the reference year. Finally, the cartography was elaborated on a scale of 1:25,000, complimentary to the material acquired from the Military Geographical Institute. This process included:

- determination of thematic legend
- interpretation of radar images and aerial photographs
- preparation of preliminary maps
- field tests and readjustment of visual interpretation
- taking agricultural soil samples for analysis of salinity and quantifying mapped areas of mangrove, shrimp farms and salt flats

The following thematic legend was used:

- M1 mangrove, height exceeding 15m
- M2 mangrove, height between 5 and 15m
- M3 mangrove, height less than 5m
- C shrimp ponds, built or in construction
- S salt flats
- Ag agricultural areas
- M brush
- B natural forest, no mangrove

- V mixed forest with mangrove occupying approximately 60 percent of area (typical of San Lorenzo, Esmeraldas).
- U urban areas

Conventional procedures were used in the interpretation of the aerial photographs. For interpretation of the radar images, the fact that the images were taken on the X-band, 3.2 cm wavelength were taken into account. With the visual interpretation, prints were made which were used in the preparation of the preliminary maps. During the ground truthing, the preliminary maps were utilized and necessary readjustments of photo interpretation were made. These tests were made from the ground, water and from the air, and the results used to refine the maps updated to 1984. Results of areas quantified with the final maps are shown in Table 1.

Results

Cartographic Results

A series of 100 thematic maps (1:25,000) of mangrove areas, shrimp farms and salt flats were prepared, with data updated to November 1984. Another series of 98 maps of mangrove and salt flat areas were prepared using 1969 as reference, (see "Estudio Multi-temporal de Manglares, Camaroneras y Areas Salinas de la Costa Ecuatoriana, Mediante Informacion de Sensores Remotos," CLIRSEN, 1986, pg. 40-42).

Results of Soil Analysis

Results obtained show no incidence of salinity originating from shrimp ponds in agricultural lands. The results can only be accepted as reference and it is recommended that additional tests be made at different times of the year to obtain more reliable information.

Discussion

Analysis of the statistical data indicates that the areas covered by mangrove in Ecuador suffered a reduction of approximately 21,587 (ha), or 10.6 percent, between 1969 and 1984. In general, the reduction of mangrove covered areas is caused principally by construction of shrimp ponds, and to only a minor degree by urban expansion (Table 2). The province most affected is Manabi, with a loss of 38 percent, caused exclusively by the construction of shrimp farms.

Urban expansions during the 15 year study period cover approximately 1,152 ha, distributed as follows:

•	Limones	24 ha
•	Atacames	51 ha
•	Muisne	7 ha
•	Guayaquil	1,010 ha
•	MachalaPuerto Bolivar	60 ha

Urban expansion also extends into salt flat areas, particularly in Guayaquil and Machala.

In general, mangrove covered areas are continuing to diminish. But it must also be noted that new areas are being colonized, especially around islands and along the coastline of the Gulf of Guayaquil (Table 3). This process of mangrove colonization will increase with sedimentation in the areas along the Guayas, Jubones and Canar Rivers and other minor tributaries.

 Table 1

 Changes Produced in the Coverage and Soil Use of the Mangrove Ecosystem

	MANGROVE		SALT FLATS				
	1969	1984	Dif.	1969	1984	Dif.	
GUAYAS	125,613.33	119,526.162 95.15%	6,087.168 4.85%	40,898.8	17,340.091 42.4%	23,558.709 57.6%	
EL ORO	33,633.5	24,455.8 72.715	9,177.7 27.29%	9,781.5	2,520.006 25.77%	7,621.494 74.23%	
ESMERALDAS	32,032.55	30,152.58 94.13%	1,879.97 5.87%	-	_	-	
MANABI	12,415.75	7,973.414 64.22%	4,442.336 35.78%	815	163.75 20.1%	651.25 79.9%	
TOTALS	203,695.13	182,107.956 89.4%	21,587.174 10.6%	51,495.3	20,023.847 38.9%	31,471.453 61.1%	

Table 2Utilization of Mangrove Areas for Urban Expansion

Approximate Figures

Guayaquil	1.010 ha
Machala Pto. Bolivar	60 ha
Atacames	51 ha
Limones	24 ha
Muisne	<u>7 ha</u>

TOTAL

1.152 ha

Table 3Colonization of Mangrove (New Growth)Aproximate Figures

Isla Puna Isla Malabrigo e isla de los Ingleses Sur Islas Escalante	56 ha 510 ha 289 ha
Linea de Costa entre San Pablo y Pto. Bolivar	<u>745 ha</u>
TOTAL	1,600 ha

Before the beginning of shrimp pond construction and urban expansion (circa 1970), salt flats covered approximately 51,495 ha. In 1984, some 20,023 ha were still available, which indicates that 31,471 ha have been utilized in the intervening years.

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