Jobos Bay National Estuarine Sanctuary

Management Plan

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1983

U. S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
Office of Ocean and Coastal Resource Management
Sanctuary Programs Division
Washington, D.C. 20235

DEPARTMENT OF NATURAL RESOURCES
Commonwealth of Puerto Rico
Box 5887, Puerta De Tierra
San Juan, Puerto Rico 00906

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Jobos Bay National Estuarine Sanctuary

Management Plan

JULY 1983

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EXECUTIVE SUMMARY

The Commonwealth of Puerto Rico is greatly committed to maintain the productivity of its estuarine areas. Important coastal resource areas subject to serious present and potential use conflicts were evaluated by Puerto Rico's Coastal Zone Advisory Committee and listed in Puerto Rico's Coastal Management Program. After a careful viability analysis in which both, ecologic and economic realities were considered, the Jobos Bay site on the south coastal plain of Puerto Rico was selected as one of the most representative. In September 1981, the National Oceanic and Atmospheric Administration (NOAA) awarded a grant to the Department of Natural Resources, establishing Jobos Bay as the eleventh national estuarine sanctuary.

As specified in Section 315 of the Coastal Zone Management Act, the purpose of the estuarine sanctuary program is for "...acquiring, developing, or operating estuarine sanctuaries to serve as natural field laboratories in which to study and gather data on the natural and human processes occurring within the estuaries of the coastal zone..." NOAA provides financial assistance to states on a fifty percent matching basis for land acquisition and development of research, education, and resource protection programs for the estuarine sanctuary.

Consistent with NOAA Estuarine Sanctuary Guidelines, this Management Plan has been prepared for the Jobos Bay National Estuarine Sanctuary (JOBANES). The plan was developed to assure the protection, productivity and adequate management of JOBANES for the benefit of the scientific community, the general public and the ecosystem itself. The plan presents a management strategy which details natural resources management, educational, and research programs to achieve its goals.

I. INTRODUCTION

The idea of a national estuarine sanctuary program was conceived in the Commission on Marine Science, Engineering and Resource's Final Report entitled: Our Nation and the Sea, and the Department of the Interior's National Estuarine Study. Based on these reports, the Coastal Zone Management Act (CZMA) of 1972 (P.L. 96-583) was passed by Congress. The Act was amended in 1976 (P.L. 94-370) and 1980 (P.L. 96-464). Section 315 of the Act established the National Estuarine Sanctuary Program for "acquiring, developing, or operating estuarine sanctuaries, to serve as natural field laboratories in which to study and gather data on the natural and human processes occurring within the estuaries of the coastal zone...". This program is administered by the National Oceanic and Atmospheric Administration (NOAA), Office of Ocean and Coastal Resource Management (OCRM), Sanctuary Programs Division.

To ensure that the National Estuarine Sanctuary Program adequately represents regional and ecological differences, the Guidelines for the Estuarine Sanctuary Program establishes a classification scheme which reflects geographic, hydrographic, and biological characteristics. This system presently recognizes eleven biogeographic categories that are defined in the Guidelines. As defined in Section 304 of the CZMA, an estuarine sanctuary is "...a research area which may include any part or all of an estuary and any island, transitional area, and upland in, adjoining or adjacent to such estuary, and which constitutes, to the extent feasible, a natural unit, set aside to provide scientists and students the opportunity to examine, over a period of time, the ecological relationships within the area."

In September 1981, NOAA awarded a grant to the Commonwealth of Puerto Rico's Department of Natural Resources (DNR), establishing Jobos Bay as the eleventh national estuarine sanctuary. This sanctuary will ensure long-term productivity of Puerto Rico's second largest estuarine zone. Table 1 depicts main events that led to the establishment of the Jobos Bay National Estuarine Sanctuary (JOBANES).

The sanctuary is owned by DNR, which is financially assisted (through 50 percent matching funds) by NOAA in three ways: preacquisition, acquisition and development, and operation grants. The first two grants involve real estate appraisals, land acquisition costs, and the development of the management plan. The operation grants, which amount up to $50,000/year for five years, are for those costs necessary for monitoring the sanctuary, protecting the health of its ecosystem, and for the establishment and maintenance of educational and research programs. DNR will be responsible for fully financing JOBANES after the last operation grant is awarded.

The sanctuary site covers an area nearly 1,140 ha (2,800 acres). Included in this area are: 17 islets known as Cayos Caribes (67 ha, 155 acres); the mangrove forest of Mar Negro (490 ha, 1,200 acres) with its complex system of lagoons, mud and salt flats, and channels; the rest of the area consists of sand beaches, coral reefs, seagrass beds, and territorial waters. These components identify JOBANES with the West Indian biogeographic category.

TABLE 1

SUMMARY OF EVENTS CONCERNED WITH THE DESIGNATION OF JOBANES

DATE	EVENT
1974	-- First Commonwealth inquiries to NOAA to propose a site for an estuarine sanctuary.
1975	-- NOAA Office of Coastal Zone Management examined several sites in Puerto Rico.
April 1981	-- The Commonwealth confirms its intention to proceed with the proposal for the establishment of a National Estuarine Sanctuary (NES).
May 1981	-- DNR acquired Cayos Caribes. These 17 islets covering an area of 63 ha (155 acres) were appraised at $1,852,590.
August 1981	-- The Governor of Puerto Rico endorsed the proposal for the establishment of NES.
	-- NOAA environmental review on the proposed action on JOBANES finds that the action will not have a significant environmental impact.
September 1981	-- Public hearings on the establishment of JOBANES.
	-- Land acquisition award for $400,00 is granted to DNR for the acquisition of Mar Negro, former Lugo Vinas Farm. The 450 ha (1,000 acres) land was appraised at $542,370.
March 1982	-- NOAA grants DNR a $150,000 Supplemental Award to complete land acquisition.
May 1982	-- Sanctuary Advisory Committee is formed.
July 1982	-- Sanctuary Manager is hired.
August 1982	-- First Draft Management Plan was submitted to NOAA.
December 1982	-- First Operations Grant for JOBANES.

The sanctuary will serve two primary purposes: (1) to preserve relatively undisturbed areas so that a representative West Indian ecosystem will always remain available for estuarine research and education, and (2) to ensure the availability of such ecosystem for use as a control in the study of impacts of human activities in similar areas.

Consistent with NOAA Estuarine Sanctuary Program Guidelines, this management plan was developed for Jobos Bay. The plan was prepared to maintain the protection, productivity, and adequate management of JOBANES over a long period of time. The plan is divided into two main sections. The first generally describes sanctuary resources from a local and regional perspective, sanctuary administration and legal base for resource protection. The second section presents the sanctuary management strategy. It details goals, objectives, and activity programs for the natural resources, education, and research, indicating exactly how the overall management strategy will be implemented.

II. MANAGEMENT CONTEXT

A. Regional Perspective

Puerto Rico is the easternmost of the Greater Antilles, located between the U.S. Virgin Islands and the Dominican Republic (Figure 1). Its total area is approximately 9,000 km^2. Old volcanic mountains occupy nearly 75 percent of the islands's total area, giving it a rugged topography. A jagged insular shelf extends three to eight kilometers seaward. Bordering the coast is an interrupted band of alluvial plains and parallel to them, from east to west, are the Luquillo Mountains and the Central Cordillera. Its location, climate, hydrological conditions, and geographic features have created a unique marine environment which supports one of the world's most extensive coral reef systems, mangrove forests, and estuarine bays. The island also shelters some rare and endangered plant and animal species as well as a variety of marine mammals and species of fish.

The Jobos Bay National Estuarine Sanctuary (JOBANES) is located on the southern coastal plain of the island of Puerto Rico (Figure 2). The sanctuary covers an area of approximately 1,140 hectares (2,800 acres). The municipalities of Guayama (1980 pop. 40,187) and Salinas (1980 pop. 26,438) include the land of the region within approximately 15 km of the sanctuary. This region experiences seasonal population variations, particularly during summer weekends when visitors to nearby beaches number several thousands. Las Mareas, a low income coastal community of about 700 residents, lies to the west of the sanctuary. The northern limit abuts with lands owned by the Aguirre Corporation, currently used for sugarcane crops. East and west of JOBANES is the Aguirre State Forest. The ecological conditions of this forest are similar to those of the sanctuary, except that the forest has larger areas of xerophytic vegetation. Adjacent to the northeastern limit of the sanctuary lies the Aguirre Sugar Mill and the Aguirre Thermoelectric Power Plant (ATPP).

The sanctuary has a major access road, State Highway No. 3 (Figure 2). This road is reached through the Las Americas Turnpike. Highway 3 leads to two main access roads: Route 703 to Las Mareas and Route 710 to Punta Pozuelo, the closest land area to Cayos Caribes. The eastern part of Mar Negro can be reached through the Aguirre Thermoelectric Power Plant road. The sanctuary property lacks internal roads.

Jobos Bay is one of the best protected harbors of the south coast of Puerto Rico. Due to this fact, the area is attractive, not only for its natural environment, but also for heavy industry development as well. In the 1960's several studies were conducted to determine resources availability (particularly water) required to establish industries in the area. The Aguirre Thermoelectric Power Plant (ATPP) was built in 1973 to meet Puerto Rico's anticipated future energy needs. During the past ten years several petrochemical and pharmaceutical industries have been established near the bay, including Smith Kline and Freuch Company (Sk&F) and the Phillips Puerto Rico Core Petroleum Complex. A regional sewage treatment plant has been proposed and designed to meet the needs of these industries and nearby communities. The plant will be located 10 km east of the sanctuary.

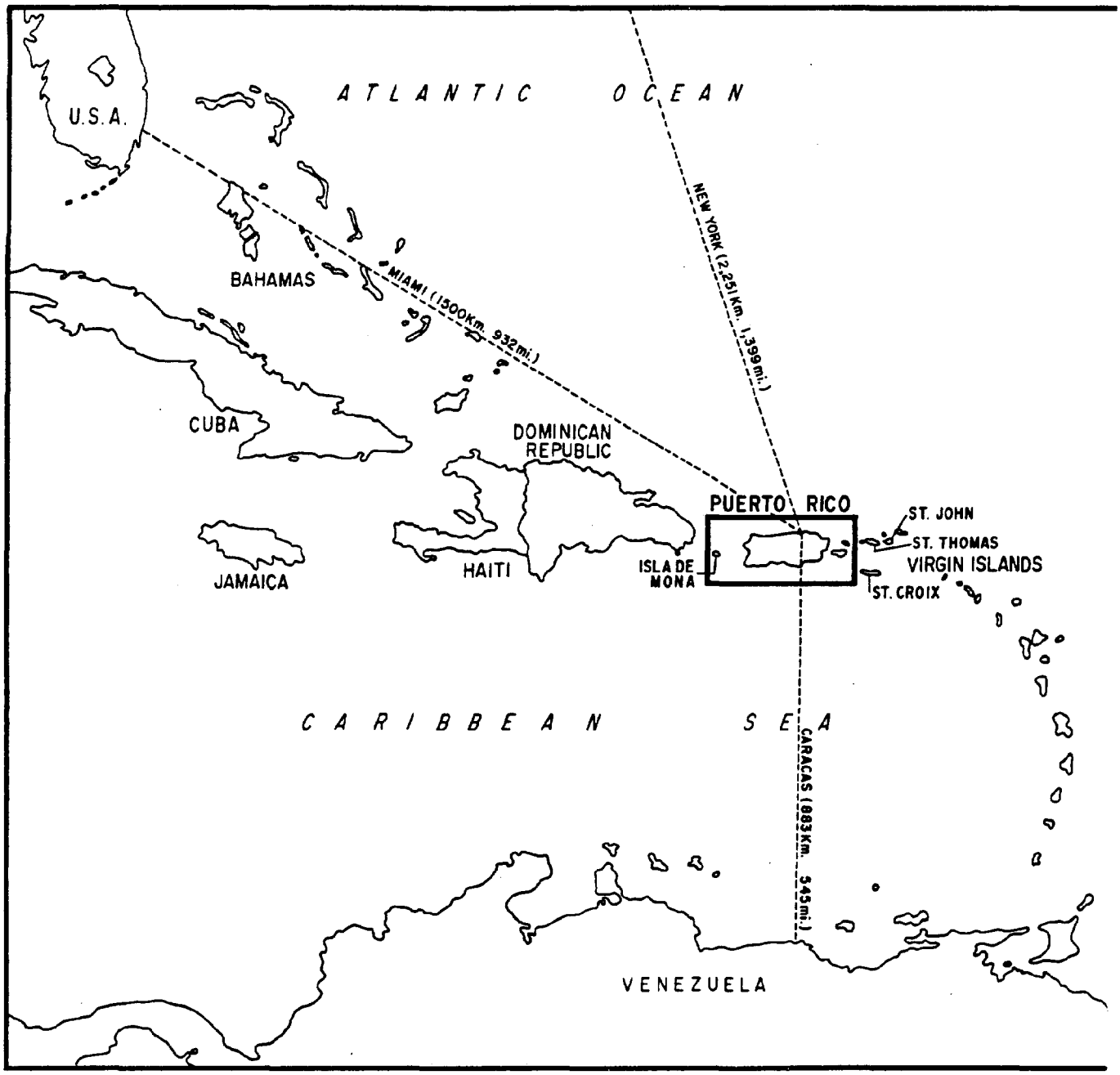


FIGURE 1. GEOGRAPHIC LOCATION OF PUERTO RICO

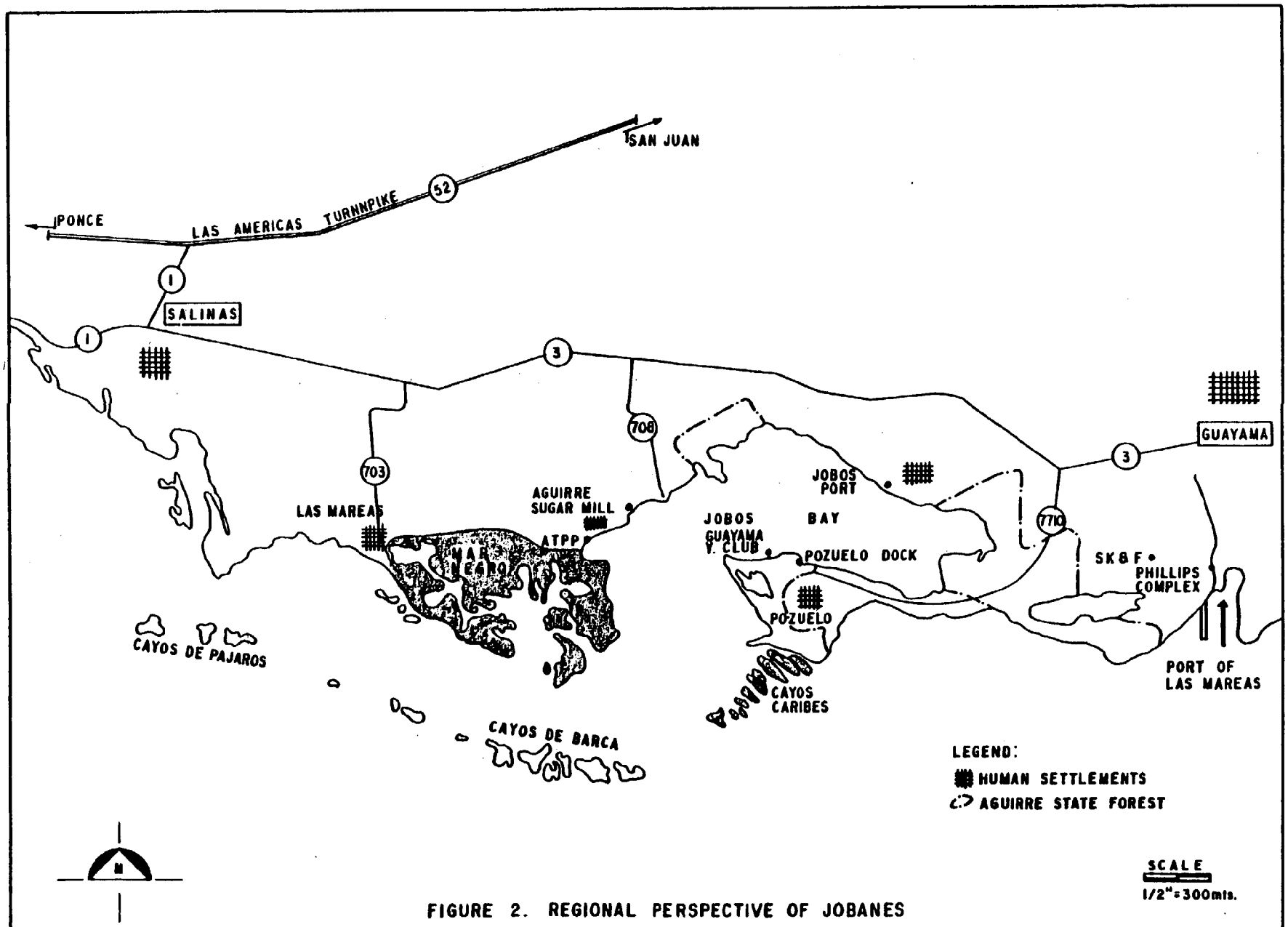


FIGURE 2. REGIONAL PERSPECTIVE OF JOBANES

Five docking facilities are located within the bay. These are: Jobos Port, Pozuelo Dock, Aguirre Sugar Mill Dock, Aguirre Thermoelectric Power Plant Dock, and the Guayama Yacht Club.

JOBANES is surrounded by a large student population, which comprises about 30 percent of the total population of Salinas and Guayama. During the school year 1981-1982, there was a total enrollment of 7,223 students in the public schools of Salinas and 10,400 in Guayama. In both cities 60 percent of the total enrollment was in elementary grades, 24 percent in junior high, and 16 percent in high school.

Two private institutions of higher education have regional colleges in Guayama: the Interamerican University and Catholic University. The first offers an Associated degree in Chemical Technology while the second offers a two-year basic program for Bachelor's degree candidates in natural sciences. Each college has an enrollment of approximately 1,200 students.

The University of Puerto Rico is the only institution on the island with graduate programs in natural sciences. The San Juan campus (69 km north of JOBANES) offers both masters and doctoral degrees in Chemistry, Physics and Biology. The Mayaguez campus (134 km west) offers a master's degree in Ecology and a doctoral degree in Marine Sciences. Also, the University operates the Center for Energy and Environmental Research, a professional scientific unit dedicated to the study of terrestrial and marine ecology and energy sources.

B. History of the Site

Although indians never settled the area, the sanctuary site was visited frequently to gather shells and for fishing and hunting. The archaeological sites within the sanctuary consist of two heaps of marine shells on campfire grounds. Shells have been associated with archaeological findings. At the present time, these two shell middens are not being worked and the Institute of Puerto Rico Culture has no plan to explore them.

C. Physical Features

1. Climate

The Jobos Bay National Estuarine Sanctuary lies within the Subtropical Dry Forest Zone described by Ewel and Whitmore (1973). Mean annual rainfall is 1,129 mm, September being the wettest month with an average rainfall of 152 mm.

Mean temperatures in JOBANES show little annual fluctuation. This is mainly due to the fact that the surrounding ocean has slight temperature changes. Another factor affecting the temperature regime is the geographic location of the island, which lies 1,770 km north of the Equator in the zone of maximum solar radiation. Temperature records of the Aguirre Sugar Mill indicate an average yearly temperature of 26.6°C. July is the hottest month, while January is the coolest. Winds within the sanctuary area blow regularly from easterly directions, averaging between six and seven knots.

2. Geology

Berryhill (1960) mapped and described the geological formations and units in the Central Aguirre Quadrangle. All of the deposits within JOBANES are mainly Quaternary in age, and consist of lagoon and swamp deposits, beach deposits, and alluvial deposits.

Lagoon and swamp deposits cover most of the land of the sanctuary. They consist of unconsolidated clay, silt, and organic matter. Beach deposits occur along the western boundary, around Punta Colchones and in some of the islets of Cayos Caribes. They are composed of sand, gravel, volcanic rock cobbles, and shell fragments. Alluvial plain deposits lie north of JOBANES. They represent alluvial fans of unconsolidated soil. The presence of salt in these deposits indicates an ancient shoreline and/or ancient salt lakes.

According to the Puerto Rico Water Resources Authority (PRWRA)(1972) the Esmeralda fault which runs north of Jobos Bay represents an old system which has not moved in the last 25 million years. Calcite deposits tightly seal this system below weathering penetration.

No metallic mineral deposits of commercial value are found in the general area. Small amounts of hematite are found several kilometers northeast of Jobos Bay.

3. Hydrology

The Jobos Bay area is part of the watersheds of the Lapa, Majada, and Guamani rivers. These rivers created the coalescing alluvial fans which form the coastal flood plains of Salinas. Figure 3 is a schematic diagram of the hydrologic system, showing estimates of the amount of water that might move in and out of the Jobos area during an average year. Most of the water of the region is used for agriculture, although industrial demand has recently increased. Two major irrigation channels, Canal de Guamani Oeste and Canal de Patillas, supply water to the area. These channels run approximately 5 to 6 km north of the sanctuary. Several streams flow north of Jobos Bay. Two creeks, Quebrada de Aguas Verdes and Quebrada Coqui join and drain into Jobos Bay, approximately 3 km northeast of the sanctuary. McClymonds and Diaz (1972) state that these creeks flow through an area of soil high in saline content, which accounts for the high level of salinization of the water.

The Equatorial currents control the water movement in the West Indies. This current flows westward. Its magnitude and direction is a function of the seasonality of winds, the day-night effect, and the local coastal morphology. Figure 4 depicts the marine current pattern in the Jobos Bay area. The mean high tide of the bay is 0.33 m and the maximum height that waves can reach during a land falling hurricane is about five meters.

The water temperature in Jobos Bay is determined by the temperature of the Caribbean Sea, stream flow discharges, spring water upwellings in the

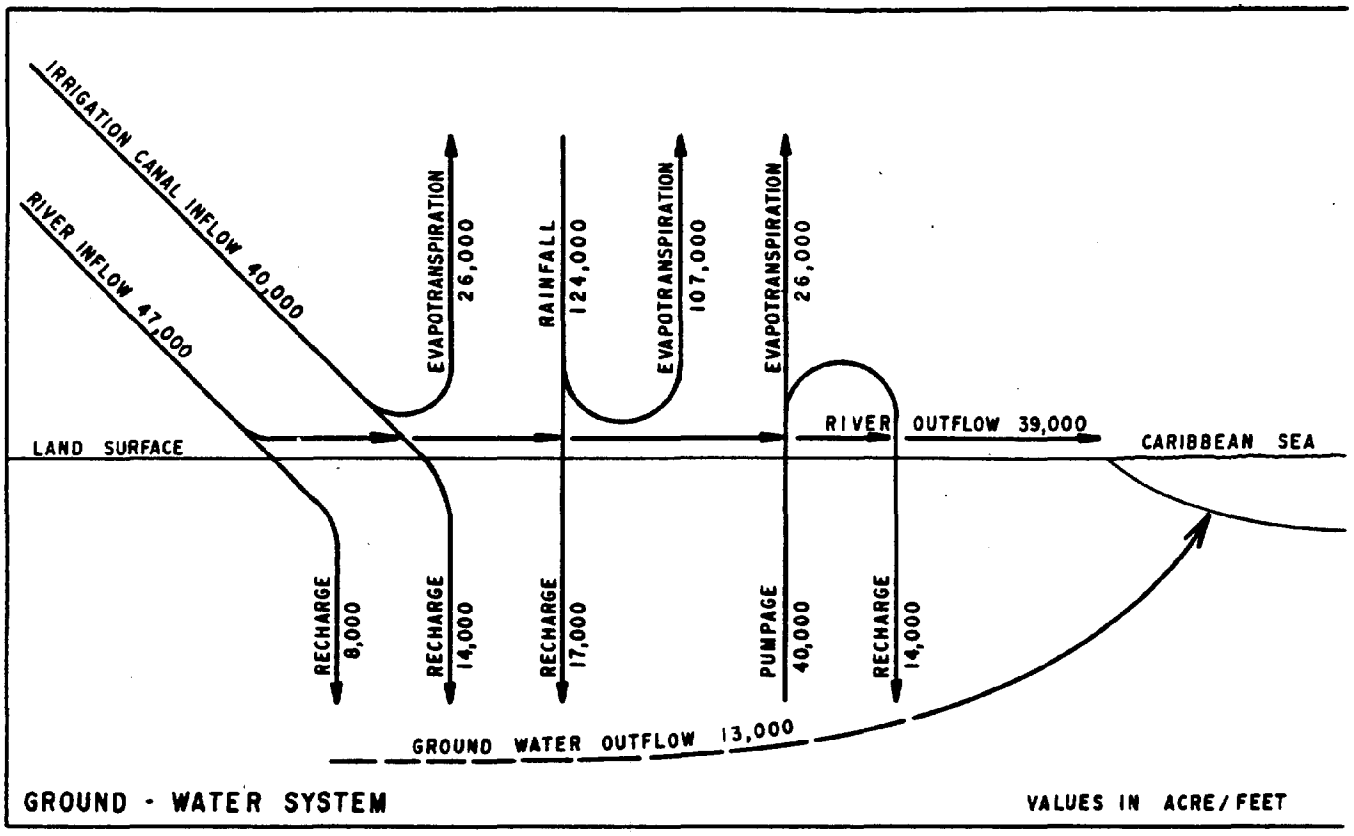


FIGURE 3. JOBOS BAY HYDROLOGIC SYSTEM AS ESTIMATED FOR A YEAR OF AVERAGE RAINFALL (McCLYMONDS AND DIAZ , 1972)

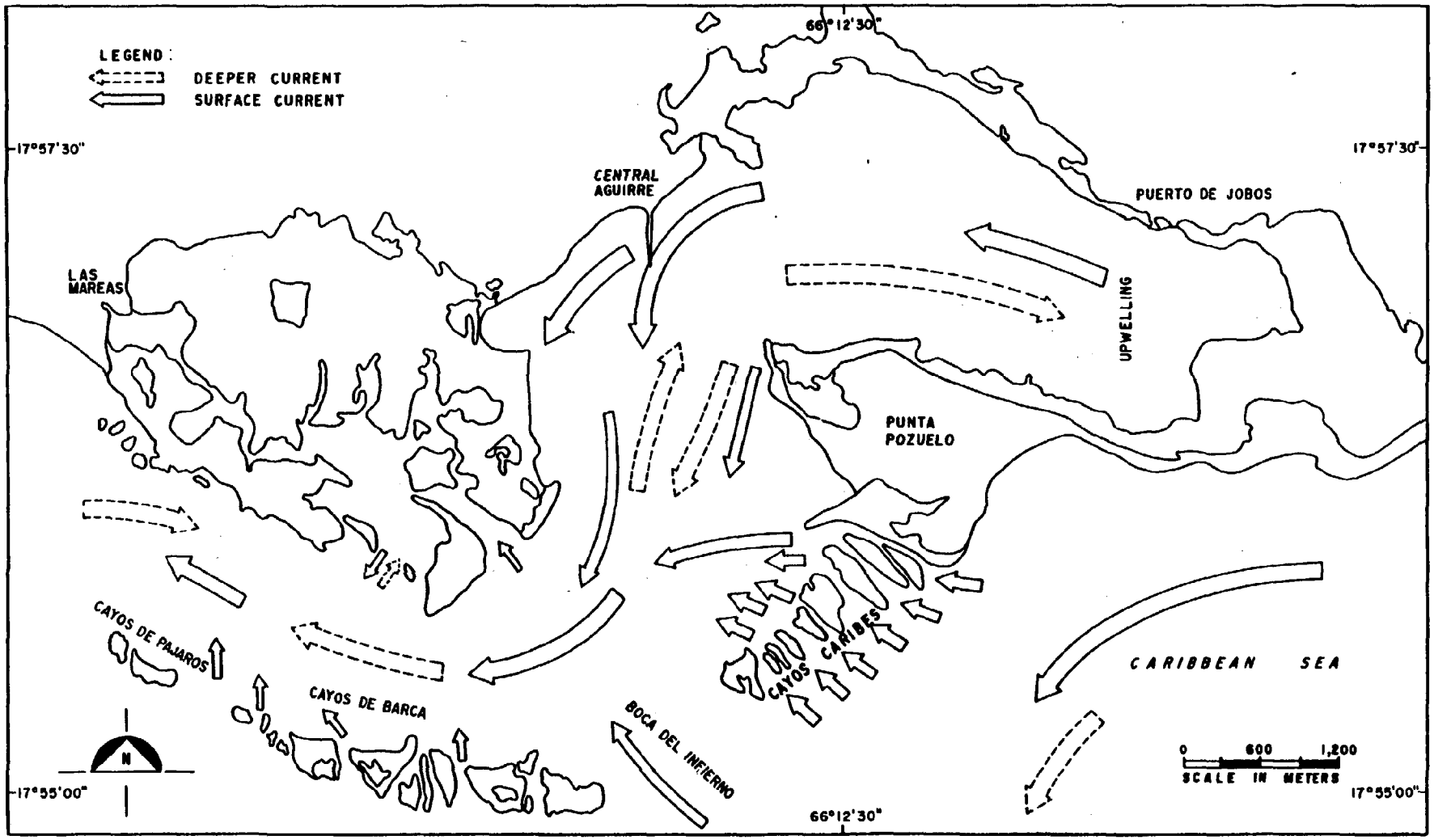


FIGURE 4. MARINE CURRENT PATTERNS IN THE JOBOS BAY WATERSHED

bottom of the bay, winds, and industrial discharges. Before the establishment of the ATPP, the mean temperature in the bay was 26.2°C with maxima about 30°C. Currently the mean temperature is 26.4°C with a recorded maximum of 37.75°C.

D. Habitats and Biological Features

1. Mangroves

The principal plant associations of JOBANES consist of mangroves and associated salt flats (Figure 5). The mangroves are sediment traps that retard water movement and trap suspended materials, gradually raising the land level and producing organic soil. Their rich protected substrate provides a habitat for a large variety of organisms, which in turn, serve as a food base for marine fauna. Some fish and shellfish found in the mangrove roots are of commercial value, while others spend part of their life cycle there breeding and spawning. Mangroves provide nesting sites for both native and migratory birds. In addition, mangroves offer an undeveloped recreational potential as well as an excellent research opportunity.

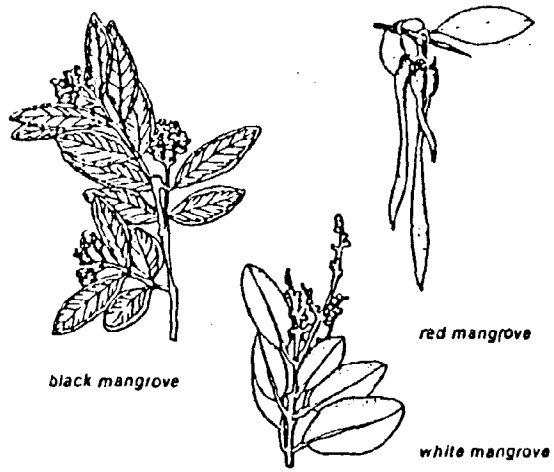
Four species of mangrove are found within the estuarine sanctuary. These are: red mangrove (*Rhizophora mangle*), white mangrove (*Laguncularia racemosa*), black mangrove (*Avicennia germinans*) and buttonwoods (*Conocarpus erectus*).

Of the five mangrove forest types described by Lugo and Snedaker (1974), all but the riverine and dwarf types occur within the sanctuary. These are: the fringe forest, the basin forest, and the overwash forest.

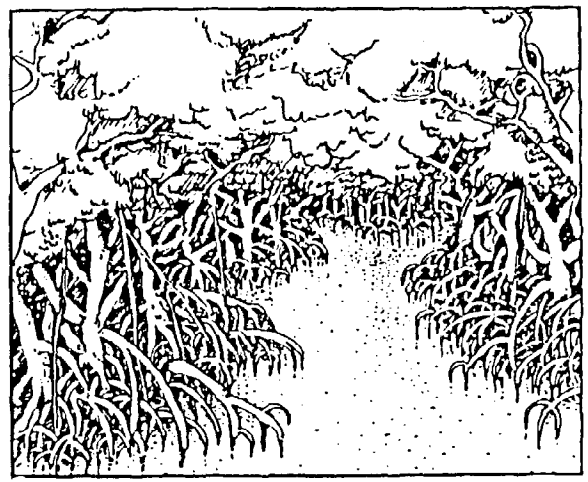
Fringe forests occur along the seaward edge and along the coastal lagoons and canals that connect the entire system with the open sea. The degree of structural development of these mangroves is primarily controlled by the quality of the soil in which they grow and the wave intensity. Fringe mangroves are usually exposed to the tides, a relatively constant salinity regime, low nutrient concentrations, wave action, strong winds, and salt spray. Based on tree density, the red mangrove comprises about 75 percent of the fringe and white mangrove, the remaining 25 percent (Cintron et al., 1978).

Associated with the submerged prop roots characteristic of the red mangrove is a rich community containing a wide assortment of organisims. Competition for space on these roots is high. Invertebrates present include crustaceans, molluscs, bryozoans, sponges, echinoderms, polychaetes, and coelenterates. Vertebrates include fish and a wide variety of tunicates. Algae from different taxonomic groups are also very abundant.

Emergent segments of the prop roots, as well as the stems of other mangrove species, are also used as substrate for invertebrates, especially crustaceans and molluscs. Associated with these diverse root and stem communities is a rich variety of abundant wildlife, especially birds.



Types of Mangrove



Mangrove Channel

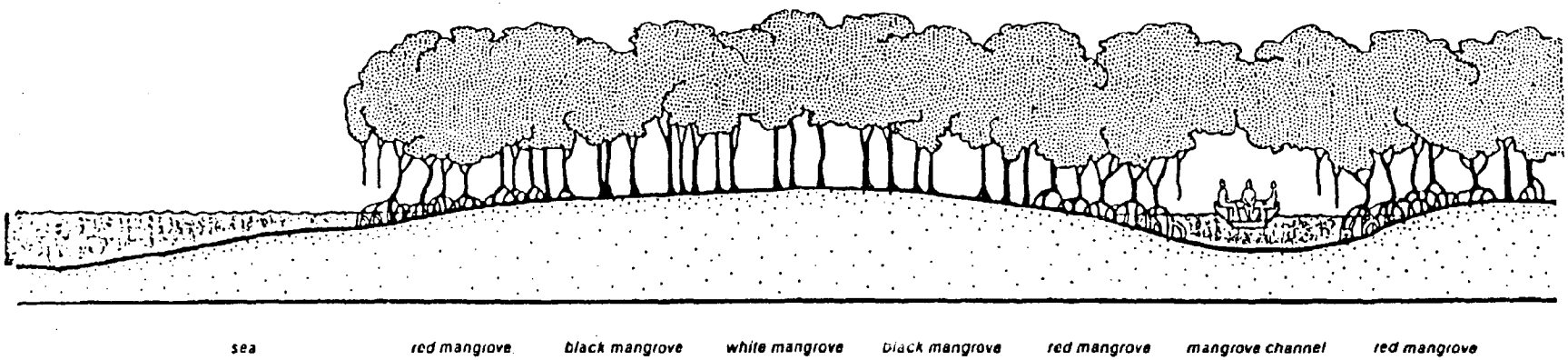


FIGURE 5. TYPICAL MANGROVE PROFILE OF THE JOBOS BAY AREA

Fringe mangroves, as well as other types, also serve as nurseries for many species of fish which migrate to adjacent coral reefs or seagrass beds during their life cycle. Dissolved and particulate organic material and other nutrients are also exported to these adjacent subtidal communities.

Because of their location and the land-sea interface, red mangroves play an important role in protecting coastal land. Mangrove stands act as buffers absorbing the force of wave energy, therefore attenuating and preventing coastal erosion.

Even though basin mangrove forests are much better developed along the north coast of Puerto Rico, they do appear in JUBANES in close association with the fringing forests. These forests are normally separated from direct contact with sea water except during very high tides or during stormy weather.

The dominant species is the more tolerant black mangrove and to a lesser degree, the white mangrove. Sometimes the buttonwood is found within the innermost reaches of the forest. Various species of decapod crabs are usually associated with either the soils or the tree stems of these forests, for example, the fiddler crabs of the genus Uca, the colorful Goniopsis cruentata, and others. Many birds also use these habitats.

Offshore, overwash mangrove forests develop over shallow platforms or islets (cays) within the inner shelf. These are overtopped daily or less frequently by high tides and extend laterally. With extensive prop root development, water circulation eventually is reduced within the inner zones. The inner red mangrove trees die due to salt accumulation from reduced water circulation (this species is not very tolerant to high salinities) and are replaced by stunted black mangroves, a species more tolerant to high salinities. Finally, salinity increases beyond the threshold tolerance of the black mangroves which die at the core of the islet. A hypersaline lagoon is then formed. This process may be set back by natural or human induced forces such as hurricanes or mangrove cutting, respectively (Cintron et al., 1978). All stages of this process are represented within the sanctuary, particularly in Cayos Caribes. These overwash mangroves also have associated prop root communities and commonly serve as bird rookeries within the area.

2. Salt Flats

Hypersaline lagoons and salt flats occur inland from the mangrove forests. They are formed as a result of reduced inland runoff, higher evaporation rates, and reduced rainfall (Martinez et al., 1979). Dead black mangrove trees are often seen within these lagoons. Where vegetation does exist, it consists mainly of salt plants (Batis maritima and Sesuvium portulacastrum). Both of these species have thick fleshy leaves adapted to water storage. Generally, these species are not found intermixed. Sesuvium appears to prefer drier soils and typically grows on higher grounds than Batis; the latter is often found in wetter substrates like those associated with the mangrove fringe (Silander, 1981).

3. Other Forest Types

Besides the mangrove and salt flats associated with them, the general area surrounding JOBANES contains other vegetation types such as marshes, evergreen littoral woodlands, secondary forests and agricultural lands. A small swamp forest is located in the northern portion of the Aguirre State Forest, north of Jobos Bay. Standing waters with salinities of 1 to 2 ppt were recorded during January and February 1981 (Silander, 1981). This forest consists of two tree strata. The pond apple (Annona glabra), almond (Terminalia catappa), ucar (Bucida buceras) and scattered white and black mangroves are the predominant species of overstory trees. The understory displays the same species along with red mangrove and the calabash tree (Crescentia cujete). The ground layer is characterized by the large mangrove fern (Acrostichuym aureoum) and the giant sedges (Cyperus alternifolius).

A coconut palm stand, composed by two isolated tracts of land, is located near the east-central region of Mar Negro. Probably it is a result of mangrove clear cutting to grow coconut palms (Cocos nucifera). Little is known about the history, ecology, and physiographic features of the area. The land crab (Cardisoma guanhumi) inhabits this area.

4. Seagrass Beds

There are four species of seagrasses found within the sanctuary, which are: Thalassia testudinum or turtle grass, Syrinsodium filiforme, Diplanthera wrightii, and Halophila baillonis. Thalassia is the most abundant seagrass followed by Syringodium. Depth, irradiance, atmospheric exposure and wave action appear to be the most important factors affecting the distribution of these beds within the region. However, these species grow intermixed at some locations. Diplanthera only occurs in shallow areas while Halophila is typical of deeper areas (Vincente, 1975).

From the intertidal zone to depths of about 10m, Thalassia beds are present. Large, well-developed meadows have generally been observed at depths of 2m or less. These meadows occupy most of the shallow bottom just offshore the mangrove fringe. Dense growth of Thalassia has also been observed in semi-enclosed areas with good circulation and clear waters.

Thalassia is absent from the exposed reef front which continuously receives the impact of the incoming waves. However, on the innundated central portion of the reef flats Thalassia develops among the coral rubble. Thalassia is also present in the shallow lagoon side of the reefs where it occurs in a rather variable band just behind the reef flat.

Seagrass beds within the area display a high diversity which allow for a wide variety of organisms, some of which, like the queen conch, are of high local commercial importance. Other associated organisms include other mollusks, coelenterates (including isolated corals), echinoderms, sponges, fish, sea turtles, and manatees. Algae of different groups are also abundant and diverse (Glynn, 1964; Matthews, 1967). Many species of reef fish are entirely dependent on seagrass beds for nutrition and migrate daily for feeding purposes. The endangered hawksbill sea turtle (Eretmochelys imbricata) have been sighted in the seagrass beds within the sanctuary.

5. Coral Reefs

The islets of Cayos Caribes are fronted by a broad reef-flat terrace containing a dense mat of green zoanthid, Zoanthus sociatus. Seaward of this flat the coral reef begins to appear. The coral reef, together with the mangrove forest and the seagrass beds, forms one of the most complex, diverse, and productive coastal communities on planet Earth, typically inhabited by a wide variety of invertebrates (Appendix A).

The coral reef generally presents a marked zonation (Figure 6). Finger coral (Porites) characterizes the leeward or protected area of the coral reef. The reef flat area, usually less than 0.5 m and exposed at low tide, has fire coral (Millipora) and zoanthids almost exclusively as its components. The surge zone receives high wave energy. It ranges in depth from one to six meters. The prime species of this area is the elkhorn coral (Acropora palmata). The reef slope has some sharp dropoffs of 18 meters. The most abundant species of this zone are the brain coral (Diploria) and the star coral (Montastrea). Storms and sediments deposition are two natural phenomena that cause extensive damages to the coral reef.

6. Vertebrates

The Jobos Bay area was divided by Martin and Pathus (1975) into four zones to make a fish survey. A recent survey conducted by DNR in 1981 accounted for 68 families and 263 fish species (Appendix B). The most common sport and commercial fishes are whalebone anchovies, herrings, jacks, and parrotfishes.

Garcia and Rivera (1981) studied the lizard populations in the mangroves of the southern region of Puerto Rico. Anoles (Anolis cristatellus, A. pulchellus, and A. stratulus) and the ground lizard (Ameiva exsul) were the only lizards present in the Jobos Bay area. Tree frogs (Eleutherodactylus sp.) and the marine toad (Bufo marinus) are the only amphibians inhabiting JOBANES.

The relatively undisturbed mangrove ecosystem of Mar Negro makes the area a haven for pelicans, herons, shorebirds, and waterfowl. A total of 87 species have been reported within the sanctuary area (Appendix C). Four endangered birds have been sighted in Jobos Bay: the brown pelican, the peregrine falcon, the Puerto Rican plain pigeon, and the yellow-shouldered blackbird.

Two other endangered species can be found in JOBANES: the hawksbill sea turtle (Eretmochelys imbricata) and the West Indian Manatee (Trichechus manatus). The sea turtle forages in shallow waters and feeds on the bottom of reef areas and Thalassia beds. It has preference for invertebrates, algae, and submerged mangrove roots.

The manatee historically was found in shallow coastal waters and inland lakes throughout much of the tropical and subtropical regions of the New World Atlantic, including the Caribbean Islands. However, at the present time, manatees are now rare or extinct in most parts of their former range (Brownell, 1980).

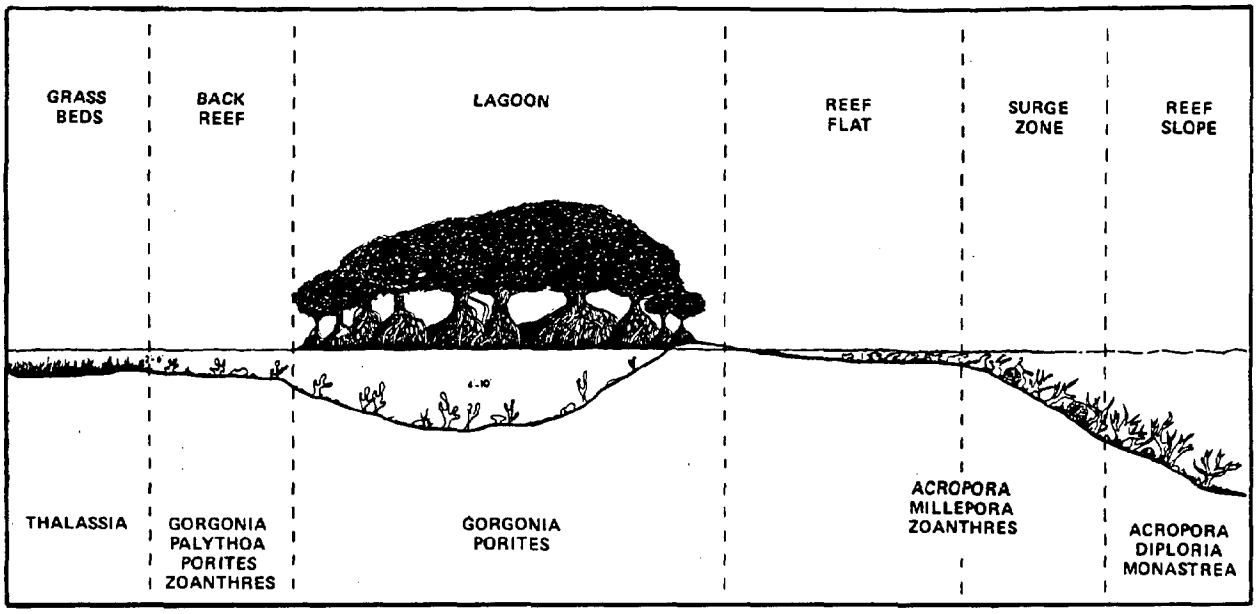


FIGURE 6. CROSS SECTION OF CORAL ZONATION AT JOBOS BAY

Even during the latter half of the 1800's, manatees were not common around Puerto Rico, although estimates of numbers are not available. Evermann (1900) stated that "the only marine mammal is the manatee (probably Trichechus latirostris), and it is of very rare occurence, owning no doubt, to the absence of broad sluggish rivers in which it finds its favorite environment." They are now less common. The decrease in the population is attributed to silting of rivers and hunting pressure. Recent surveys indicate a total Puerto Rican population of less than 100 animals. Small groups are frequently sighted on the south coast, and around the estuary of the Fajardo River. Current population trends are unclear. A small number of manatees are still being taken each year in fishing nets (Brownell, 1980).

E. Sanctuary Administration

The Department of Natural Resources (DNR) of Puerto Rico administers the Jobos Bay National Estuarine Sanctuary (Figure 7). The management of JOBANES is a duty of the Forest Service Area. Currently, this area is being reorganized to become the Area of State Forests, Sanctuaries, and Natural Preserves. This area will be responsible for the administration of JOBANES and other marine or estuarine sanctuaries that may be established. The Bureau of Sanctuaries and Natural Reserves (BUSANAR) will manage all of these sanctuary areas.

1. BUSANAR

The responsibilities of this bureau are listed below:

- Establish an Advisory Committee for each one of the sanctuaries;
  - -- Appoint or reappoint committee members.
  - -- Approve committee chairperson and vice-chairperson.
  - -- Assist sanctuary managers to convene Committee meetings and review and approve agenda of topics to be addressed.
  - -- Review committee recommendations and take appropriate action.
- Review the management plan for each sanctuary;
- Prepare program budget and cost benefit analysis of proposed or existing management activities;
- Coordinate federal and local government and private entities concerned with the protection and management of sanctuary resources;
- Ensure that onsite management activities are consistent with Federal and Commonwealth statutes;
- Act as direct liaison between the Commonwealth and NOAA on sanctuary-related issues;

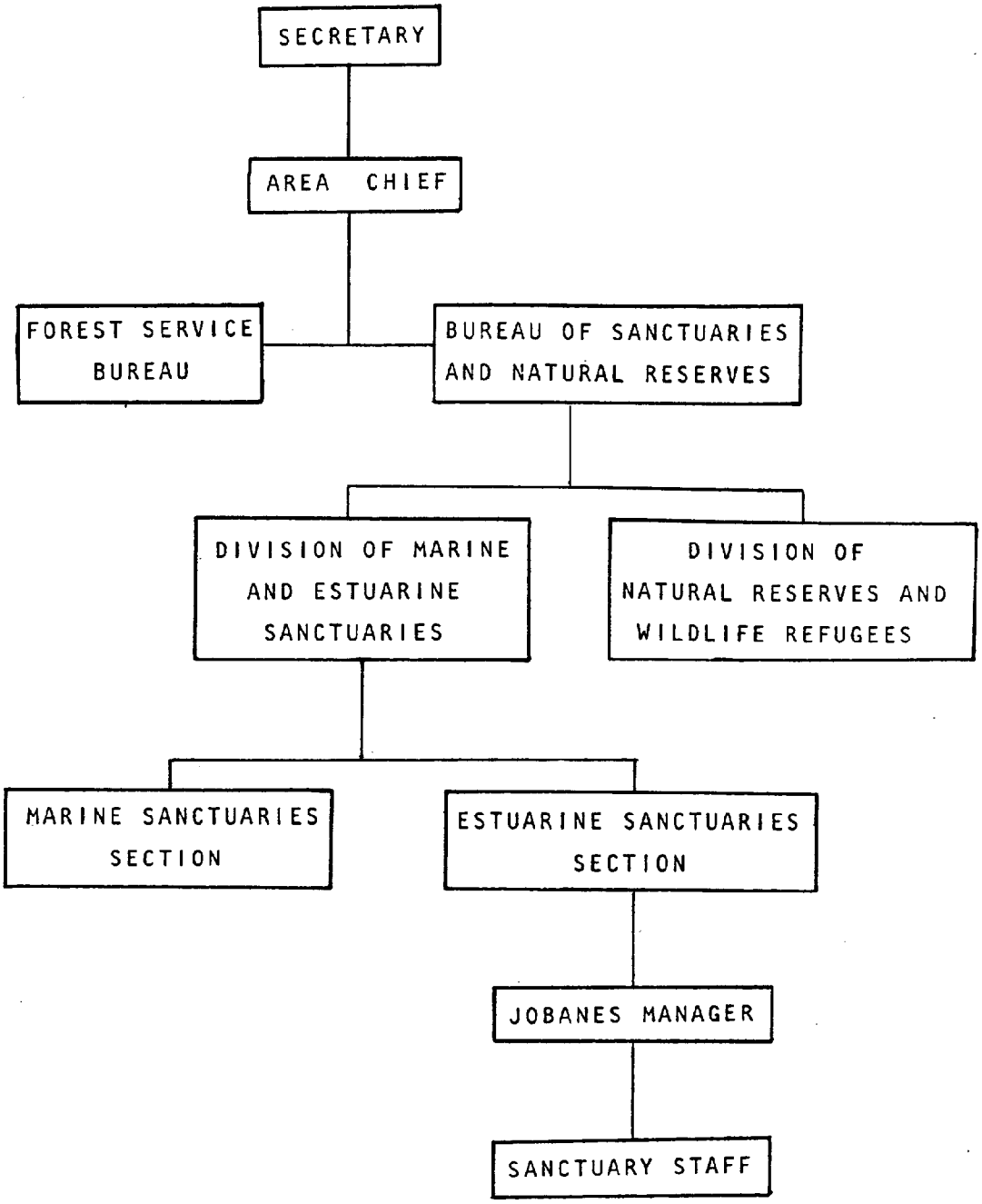


FIGURE 7. ORGANIZATIONAL CHART OF DNR'S STATE FORESTS, SANCTUARIES AND NATURAL PRESERVES AREA

- Coordinate among DNR and NOAA offices involved in sanctuary activities, and the individual sanctuary managers and the public;

- Disseminate information about the National Marine and Estuarine Sanctuary Programs to promote public support of sanctuaries;

- Review plans for land and water development that may affect JOBANES; and

- Oversee development of any facilities constructed for JOBANES, including awarding contracts and reviewing site analyses and design specifications, securing leases, easements, etc.

The bureau will have a Division for Sanctuaries, composed of a Marine Sanctuaries Section and an Estuarine Sanctuaries Section. Positions for this Bureau will be funded jointly by DNR and NOAA.

a. Sanctuary Manager

The manager is the primary spokesperson for JOBANES. The manager's role is multi-functional in scope. He is responsible for the overall administration of the sanctuary operations. Major responsibilities include:

- Development of the management plan;

- Day to day operations of JOBANES, including public relations, environmental education, ecological research, administrative functions, and some maintenance, construction, and law enforcement duties;

- Supervision of sanctuary staff and other DNR staff assigned to the sanctuary, including rangers, maintenance workers, and interpretive employees;

- Representing the sanctuary viewpoint on local issues and at public forums;

- Implementing a Volunteer Program to assist in the daily operations of the visitor center, maintenance of facilities and trails, and other projects as the need arises; and

- Encouraging research at the sanctuary. He will assist potential researchers in preparing the research proposal.

b. Sanctuary Technician

The Sanctuary Technician is the manager's aide. He will be involved with visitor center duties (contacts visitors, interprets exhibits, assists volunteers, and performs some maintenance and housekeeping roles). He will be responsible for collecting and maintaining meteorological data. He will assist researchers in surveying and monitoring activities as required.

c. Future Staff Needs

Management of JOBANES will depend heavily on the maximum use of the existing DNR personnel. However, some additional personnel must be hired, including permanent positions for an educational specialist, a secretary, and a maintenance employee.

The education specialist will assist the sanctuary manager with interpretive and educational programming, conducting public and student tours and workshops, development of educational materials and programs, and being responsible for the sanctuary library. The education specialist will coordinate his activities with the sanctuary volunteers.

2. Estuarine Sanctuary Advisory Committee (ESAC)

In order to receive maximum guidance and input from local fishermen, residents of Guayama and Salinas, educators, researchers, Commonwealth agencies, and others who would be interested in preserving the environmental quality of this area, an Estuarine Sanctuary Advisory Committee (ESAC) has been formed. This committee will assist DNR in preparing the annual report and in reviewing proposals for research and educational activities within sanctuary lands or waters. Appendix D lists the members of ESAC.

The Advisory Committee operates under the following guidelines:

- The membership is limited to between 10 and 15 persons, assuring a workable and productive body.
- Criteria for committee membership would require individuals who are experts in specific fields and/or represent sanctuary user groups and whose judgment would be objective, not subject to a conflict of interest due to a particular affiliation.
- Committee members will serve three-year terms with the initial appointments being staggered to ensure continual committee action and expertise. The committee chairperson and vice chairperson will be selected to serve one-year terms.
- The committee meets at least twice a year.
- The sanctuary manager maintains close contact with the committee. Committee members are advised of sanctuary activities through periodic mailings or meetings with the sanctuary manager.

3. Volunteer Program

On December 2, 1982, the Department of Natural Resources established CICA, a non-profit organization under the supervision of DNR's Scientific Research Area. It was created with the intention of involving young persons in scientific projects that will tend to stimulate their interest in the study of the natural resources of Puerto Rico.

CICA is the logo for "Cuerpo de Investigadores Cientificos Auxiliares," which means Scientific Research Auxiliary Corps.

CICA has a selected volunteer membership, particularly high school and college students. The purposes for the creation of CICA are:

- -- To assist DNR in public orientation and education on natural resources conservation;
- -- To facilitate the participation of its members in some of DNR's scientific research projects;
- -- To develop among its members a positive attitude toward the surrounding natural environment;
- -- To emphasize on its members the need to acquire scientific knowledge to understand nature;
- -- To instigate its members to pursue careers in natural sciences and in scientific research;
- -- To stimulate its members to become guardians of the natural legacy of Puerto Rico;
- -- To foment technical reading and writing abilities among its members; and
- -- To sponsor among its members their participation in scientific activities in and outside Puerto Rico.

Presently, there is a single chapter in DNR's Central Office in San Juan, known as the Founders Group. This group has a four-position staff.

CICA regulations provide for the creation of regional chapters. Given the relationship between CICA and JOBANES, a regional chapter is being organized in Guayama. This regional chapter will be under the guidance of the sanctuary manager. The chapter headquarters will be at the JOBANES visitors center. Its members will play a supporting role in monitoring and data collection activities and will be key elements for the educational program, assisting the sanctuary's education specialist.

To assist in the daily operation of the visitor center, maintenance of trails and facilities, and other projects as required, seasonal volunteers will be needed. Some possible manpower sources are the Boy Scouts, conservation groups, college interns, the local community, or even the U.S. Armed Forces Reservists. The sanctuary manager has the responsibility to seek sources of labor and to coordinate their activities at JOBANES.

F. Resource Protection

Puerto Rico, a Commonwealth of the United States, has a strong public policy governing the protection of its environment and the conservation and protection of its natural resources. The sanctuary ecosystem is protected

by Commonwealth and Federal statutes and regulations. Those laws and regulations that control activities which might impact the sanctuary are identified and discussed below. Several agencies are charged with implementing and enforcing these laws and regulations.

1. Commonwealth Entities and Statutes

Four Commonwealth entities are primarily responsible for planning and managing actions and for regulating private sector activities in coastal areas: The Environmental Quality Board, the Planning Board, the Regulations and Permits Administration, and the Department of Natural Resources. This section describes their organic laws, supplemental statutes, and regulations which affect JOBANES.

a. Environmental Quality Board (Law No. 9, June 18, 1970, as amended)

The Environmental Quality Board (EQB) has the following powers and duties relevant to the sanctuary:

- regulation and control of air and water, solid waste and noise;
- establishment of standards for air and water quality in coordination with other concerned agencies;
- establishment of policies for the handling and disposal of solid wastes; and
- granting of permit and licenses for the installation and operation of solid waste and treatment plants.

EQB has promulgated the following regulations:

- Regulation for Water Quality Standards;
- Regulation for Control of Atmospheric Pollution; and
- Regulation for the Control of Solid Waste.

b. Planning Board (Law No. 75, June 24, 1975, as amended)

The Planning Board (Board), initially created pursuant to the Planning and Budget Act (Law No. 213, May 12, 1942), was reorganized in accordance with its new Organic Law on July 1, 1975. The Board coordinates all government sector activity and guides private actions toward the integrated, balanced development of the Island's resources. The Organic Act provides for a variety of devices which, when adopted by the Board and approved by the Governor, have the force of law. Those that directly affect JOBANES are the following:

- Integral Development Plan, which sets forth policies and strategies for development. On January 26, 1976, the Board adopted a document entitled, "Integral Development Plan: Public Policies and Specific Objectives." The Governor gave his approval to the document on April 10, 1979.

- Land Use Plan, which provides specific guidance for physical development including public infrastructure.

- Four-Year Investment Program, which provides guidance to the government budget process, establishing fiscal limits and indicating priorities for operating expenditures and capital programs. This document is revised periodically and guides the Bureau of Management and Budget in the preparation of the annual executive budget which is submitted by the Governor to the Legislative Assembly.

Pursuant to the Organic Law, the Board adopted the Puerto Rico Coastal Management Program (PRCMP) as an element of the Land Use Plan on June 22, 1978. The Governor approved the PRCMP on July 12, 1978, making Puerto Rico eligible to receive continuing Federal assistance under the Coastal Zone Management Program for implementation of the program. One element of the PRCMP that relates to the sanctuary includes the Jobos Bay Special Planning Area.

The Planning Board exercises its authority over physical development directly through the initial review of all development proposals and through the adoption of major zoning district changes, and indirectly, through the promulgation of Planning Regulations which are implemented by the Regulations and Permits Administration, as described below. The Planning Board is also responsible for assuring consistency of all activity in coastal areas with the PRCMP.

c. Regulations and Permits Administration, (Law 76, June 24, 1975, as amended)

The Regulations and Permits Administration (ARPE) was created to relieve the Planning Board of the administrative effort related to the granting of permits and enforcement of the Planning Regulations. In addition to the responsibilities assigned under its Organic Law, ARPE may carry out other functions by delegation of the Board pursuant to formal resolution and in accordance with specific guidelines. ARPE issues permits for construction and for use of land and structures. It has a small team of building inspectors who work out of regional offices in major cities of the island. ARPE is responsible for prosecuting violations reported to it by other agencies, including the DNR rangers.

d. Department of Natural Resorces (Law No. 23, June 20, 1972, as amended)

The Department of Natural Resources (DNR) was established in accordance with its Organic Law on January 2, 1973. It represents the amalgamation of various powers and duties previously vested in the Department of Agriculture and the Department of Public Works, the Public Service Commission, and other agencies into a single jurisdiction with comprehensive responsibility for the planning and management of all natural resources. The Organic Law makes specific mention of the following: conservation and development of water resources; control over the extraction of materials from

the earth's crust; regulation of hunting and fishing; propagation and management of forests and wildlife; and coordination of several programs related to watershed protection that were sponsored by various Federal agencies.

The following statutes supplement the authority of the DNR Organic Law as it applies to JOBANES:

Law 83, May 13, 1936 (Fishing Law)

Law 113, July 1, 1975 (Forestry Law)

Law 70, May 30, 1976 (Hunting Law)

Law 1, June 29, 1977 (Marine Resources Development Corporation)

The Fishing Law, last amended in 1977, regulates all aspects of residential and non-residential commercial and sport fishing in territorial waters. It prohibits the use of explosives and certain types of equipment, and requires licensing for fishing activities within inland and coastal waters. A Fish Conservation Advisory Committee with one representative each from DNR, Tourism, the University of Puerto Rico, the commercial fishermen's association and sport fishermen's association is provided for under this statute.

The Forestry Law establishes public policy with regard to forestry and provides, among other things, that the Commonwealth will maintain, conserve, protect, and manage forest areas for the legacy of future generations. To this end, Article 9 of the Act prohibits certain activities without written authority of the Secretary of DNR. Prohibited activities include:

- damages to property -- cutting, killing, destroying, uprooting or injuring any tree;
- burning;
- pasturing cattle;
- unlawful tenancy; and
- removing or damaging signs.

The Aguirre State Forest is adjacent to the eastern margin of JOBANES. As a State Forest, the area is subject to the provisions and restrictions of Law No. 133, The Forestry Law.

The Hunting Law was developed to promote the conservation and intelligent handling of the wildlife resources of Puerto Rico from constantly being threatened and detrimentally affected by human activities. This law provides for regulation of the introduction of exotic species into the island, hunting activities, and wildlife conservation.

The Marine Resources Development Corporation (CODREMAR) is responsible for promoting the commercial development of marine resources in Puerto Rico. It administers elements of the Fisheries Law.

DNR was assigned the responsibility for developing the PRCMP and for its continuing implementation under Section 306 of the Coastal Zone Management Act. The PRCMP, as adopted by the Planning Board and approved by the Governor, sets forth public policies to promote the conservation, preservation, and wise use of Puerto Rico's natural environmental and cultural resources.

Routine checking of boundaries and regular patrolling of JOBANES by the sanctuary manager and law enforcement personnel will prevent illegal or unauthorized activities in the area. Penalties for violations of these regulations and laws provide for imprisonment or a fine, or both, at the discretion of the court. DNR regulations are enforced by the Ranger Corps (Cuerpo de Vigilantes) which operates through the Department's regional offices and detachments in the state forests.

2. Federal Laws

a. Clean Water Act (CWA) (33 U.S.C. 1251 et seq.)

The Clean Water Act (CWA) establishes the basic scheme for restoring and maintaining the chemical, physical, and biological integrity of the Nation's waters. The CWA contains two basic mechanisms for preventing water pollution: (1) the regulation of discharges from known sources, and (2) the regulation of oil and hazardous substances discharges. The Act also regulates the disposal of wastes from vessels and the discharge of dredged materials.

(1) Discharges

The CWA's chief mechanism for preventing and/or reducing water pollution is the National Pollutant Discharge Elimination System (NPDES), administered by EPA. Under the NPDES program, a permit is required for the discharge of any pollutant from a point source into navigable waters (which include State waters, the contiguous zone, and the ocean). EPA can delegate NPDES permitting authority to the State for state waters.

(2) Oil Pollution

Discharges of oil and hazardous substances in harmful quantities are prohibited by the CWA. When such discharges do occur, the National Contingency Plan (NCP) for the removal of oil and hazardous substance discharges, will take effect. The Coast Guard, in cooperation with EPA, administers the NCP, which applies to all discharges of oil in the contiguous zone and to activities under the Outer Continental Shelf Lands Act. The NCP establishes the organizational framework under which oil spills are to be cleaned up.

(3) Recreational Vessels

The CWA (33 U.S.C. §1322) requires recreational vessels with toilet facilities to contain operable marine sanitation devices. The regulations state that boats, 65 feet in length and under, may use either Type I, II, or III MSD's which must be certified by the Coast Guard. Types I and II are chemical treatment devices and Type III is a holding tank. The CWA requires non-commercial craft to comply with marine sanitation device regulations issued by EPA and enforced by the U.S. Coast Guard.

(4) Dredging and Discharging Dredged Materials

Section 404 requires permits from the Army Corps of Engineers (based on EPA developed guidelines), prior to filling and/or discharging dredged materials within three miles of shore including wet loads, or the transportation of dredged material for the purpose of dumping it into ocean waters.

b. Marine Mammal Protection Act of 1972 (MMPA) (16 U.S.C. 1361 et seq.)

The MMPA applies to U.S. citizens and foreign nationals subject to U.S. jurisdiction and is designed to protect all species of marine mammals. The MMPA is jointly implemented by the National Marine Fisheries Service (NMFS) of the Department of Commerce which is responsible for whales, porpoises, and pinnipeds other than the walrus, and the Department of the Interior, Fish and Wildlife Service (FWS), which is responsible for all other marine mammals, including the only other marine mammal present, the West Indian manatee. The Marine Mammal Commission advises these implementing agencies and sponsors concerning relevant scientific research. The primary management features of the Act include: (1) a moratorium on the "taking" of marine mammals; (2) the development of a management approach designed to achieve an "optimum sustainable population" for all species of population stocks of marine mammals; and (3) protection of populations determined to be "depleted."

c. Endangered Species Act of 1973 (ESA) (16 U.S.C. 1531-1543 et seq.)

The Endangered Species Act of 1973 provides protection for listed species of marine mammals, birds, fish, invertebrates, and plants. The FWS and NMFS determine which species need protection and maintain a list of endangered and threatened species. The most significant protection provided by the ESA is the prohibition on taking of listed species. The term "take" is defined broadly to mean "harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect or to attempt to engage in such conduct" (16 U.S.C. 1532 (14)). The FWS regulations interpret the term "harm" to include significant environmental modification or degradation and acts which annoy listed species to such an extent as to significantly disrupt essential behavior patterns (50 CFR 17.3).

The ESA also protects endangered species and their habitats. This is accomplished through a consultation process designed to insure that projects authorized, funded, or carried out by Federal agencies do not jeopardize the continued existence of endangered or threatened species or "result in the destruction or modification of habitat of such species which are determined by the Secretary (of the Interior or Commerce) to be critical" (16 U.S.C. 1536). Critical habitat for endangered species is designated by the FWS or NMFS depending on the species.

d. Coastal Zone Management Act of 1972 (16 U.S.C. 1451 et seq.)

In 1972, Congress passed the Coastal Zone Management Act (CZMA) in response to public concern about balancing needs for preservation and development in coastal areas. The Act authorizes a Federal grant-in-aid program to be administered by the Secretary of Commerce, who in turn

delegated this responsibility to the National Oceanic and Atmospheric Administration.

The CZMA was substantively amended on July 16, 1976 (P.L. 94-370) and on October 1, 1980 (P.L. 96-464). The Act and its amendments affirm a national interest in the effective protection and careful development of the coastal zone, by providing assistance and encouragement to coastal states (and U.S. territories) to voluntarily develop and implement management programs for their coastal areas. Financial assistance grants under Sections 305 for program development and 306 for program implementation were authorized by the CZMA to provide coastal states and territories with the means for achieving these objectives.

The basic requirements of the CZMA provide broad guidelines to states for developing their coastal management programs. The program development and approval provisions are contained in 15 CFR Part 923, revised and published March 28, 1979, in the Federal Register.

The Puerto Rico Coastal Management Program was approved in two stages. The approval of the plan for the Island of Culebra as a separate segment was granted on April 1, 1977. The Culebra plan was then integrated into a Commonwealth program upon the approval of the Puerto Rico Coastal Management Program on September 18, 1978. The Program is based on the island-wide land use plan established by the Puerto Rico Planning Board and adopted by the Governor on June 22, 1978. The Department of Natural Resources (DNR) is the agency designated to administer the coastal program. Other major agencies assisting in program implementation include the Puerto Rico Planning Board, which has statutory planning, zoning, and land use responsibilities; the Regulations and Permits Administration, and the Environmental Quality Board.

3. Enforcement Capabilities of Relevant Commonwealth and Federal Agencies

The JOBANES area is under the jurisdiction of several Commonwealth and Federal agencies. The Commonwealth agencies are the Marine Police, Puerto Rico Ports Authority, and the DNR Ranger Corps. The Federal agencies with law enforcement authority are the: U.S. Coast Guard, Army Corps of Engineers, and the Fish and Wildlife Service.

a. Commonwealth Police Marine Division

The Marine Division patrols coastal waters and enforces all regulations of Law No. 19 which is similar to the Federal Boat Safety Act of 1971. The Puerto Rican marine police, the DNR Rangers, and the U.S. Coast Guard help each other upon request or in specific instances of emergencies.

There is a marine police division with six personnel and two boats in the city of Arroyo (10 km east of JOBANES), and another division based at Ponce. These divisions receive their orders from the Regional Police Headquarters at Mayaguez and Ponce. The central offices in San Juan handle administrative, not operational, aspects of marine police enforcement.

b. DNR Ranger Corps

The Ranger Corps, created as the enforcement arm of DNR in 1978, performs the following:

- arrests for violation of the laws administered by the DNR, when this takes place in their presence. The rangers may patrol property and waters under state authority. Access to private properties requires previous permission from the owner except, when a crime is being committed in the Ranger's presence or during apprehension of a person who has violated the laws administered by DNR;

- demands presentation and inspects any permit, franchise, resolution, license, or document granted by the Secretary of DNR in which authorization is given for any activity or operation under the jurisdiction and powers of the DNR in public or private lands within the limits of the Commonwealth of Puerto Rico;

- emits cease and desist orders for any activity or operation that is taking place without the authorization of the Secretary of DNR and issues judical summons for violations of the laws administered by DNR;

- executes subpoenas issued for the examination, investigation, and processing of any violations to the laws administered by DNR;

- carries arms in accordance with the ordinances of the Police Superintendent and conducts searches related to violations of DNR laws in accordance with the Rules of Criminal Procedure of Puerto Rico that are in force.

- obtains and executes search warrants in accordance with the duties responsibilities, and obligations established by the law that created the Rangers Corp and confiscates and possesses any wildlife, marine life or land or forest component in possession or under the control of persons who intend to transport them by way of land, air, or water in violation of the laws administered by DNR; and

- confiscates and possesses any arms, machines, equipment or means of transportation that have been used in violation of the laws administered by DNR. Any confiscation will take place according to the dispositions of Law No. 39 of June 4, 1960, as amended.

The Guayama Ranger Office is responsible for patrolling the JOBANES area. The Office has one first lieutenant, one second lieutenant, one sergeant, and six rangers assigned to the Marine Division. Two rangers and a sergeant patrol the sanctuary and the Aguirre State Forest. A boat will be acquired for this detachment. Meanwhile, marine patrolling will be provided in coordination with the Police Marine Division unit at Arroyo.

The Ranger Corps has arrangements and agreements with the Immigration Division of the U.S. Department of Agriculture, the U.S. Coast Guard, the U.S. Fish and Wildlife Service, the Ports Authority of Puerto Rico, and the Department of Police, and appears to be the only law enforcement authority patrolling coastal and marine waters of the sanctuary area on a periodic basis.

c. U.S. Coast Guard

The Greater Antilles Section (GANTSEC) of the U.S. Coast Guard, which includes Puerto Rico, covers 1.2 million square miles. The agency is required to provide search and rescue, law enforcement, and marine navigation and support to and for all U.S. Coast Guard units. Both the U.S. Army Corps of Engineers and the U.S. Environmental Protection Agency rely on the U.S. Coast Guard to enforce their laws in marine waters.

With the limited number of units and the numerous responsibilities of these units, the U.S. Coast Guard will not be able to perform routine daily patrols for the sanctuary. They will be able to perform a one-time patrol of the area when and if they are in the area, on an as-needed basis, or provide emergency patrol of the sanctuary in the event of confirmed poachers, an oil spill, or other such emergencies.

d. U.S. Fish and Wildlife Service (FWS)

At the present time, there is virtually no FWS law enforcement presence in the JOBANES area. There is only one Resident Agent with enforcement authority in Puerto Rico and the U.S. Virgin Islands responsible for wildlife inspections and other duties associated with the Migratory Bird Treaty Act, ESA, and the MMPA. His primary responsibilities also include the preparation of legal cases to be tried under the various applicable Federal statutes. Two FWS Refuge Officers and one FWS Inspector assist the Resident Agent in enforcing applicable federal laws.

III. MANAGEMENT STRATEGY

In order to provide adequate management and efficient development of the sanctuary resources, the following management strategy has been developed. The strategy has three major management categories: resources protection, interpretation, and research.

Goal I. To protect and maintain the natural resources of the sanctuary so that scientists and students may have the opportunity to examine, over time, the ecological relationships within the area.

Objectives:

1. Develop and implement an interpretive program that will educate the public about the significance of these estuarine resources and the need for their protection;

2. Develop and implement management strategies for the sanctuary that provide for surveillance and enforcement of existing natural resource protection measures; and

3. Develop and recommend additional regulations for the sanctuary designed to minimize adverse impacts to important resources.

Goal II. To promote and coordinate scientific research to expand knowledge of significant estuarine resources and to improve management decision-making.

Objectives:

1. Provide an up-to-date compilation of resource information about the sanctuary;

2. Conduct scientific research to expand knowledge of the estuarine systems within the sanctuary;

3. Establish and utilize a system for interaction with recognized research institutions, offering the sanctuary as a natural field laboratory;

4. Gather information on the physical, chemical, biological, geological and meteorological processes occurring in the sanctuary; and

5. Assess the range and possible impacts of the various human activities within and surrounding the sanctuary.

Goal III. To enhance public awareness, understanding and educational use of the sanctuary's natural resources through an interpretive program.

Objectives:

1. Prepare a profile of present and potential sanctuary users that identifies their interests and backgrounds;

2. Prepare a list of resources that can be used to implement the interpretive program;

3. Design programs and exhibits that encourage conservation practices and which are in tune with visitors' profiles;

4. Inform the public about sanctuary programs and activities;

5. Inform visitors, users and participants in sanctuary activities of rules, regulations, safety procedures and conservation practices;

6. Prepare a year-round schedule for educational programs that provides for special interest groups as well as the general public;

7. Offer workshops that will provide teachers, volunteers and staff with information and techniques for interpreting the sanctuary to students, tour groups and potential supporters;

8. Establish and utilize a system for interaction with other National Estuarine Sanctuaries in the interest of exchanging information and educational material regarding the protection and management of estuarine ecosystems; and

9. Allow multiple recreational activities (such as fishing, hunting, or motor boating) that are compatible with sanctuary goals.

A management program for each one of the three major categories was created. The programs further detail a series of activities that will define the management strategy for JOBANES. These programs will be reviewed annually by the sanctuary administration and the Sanctuary Advisory Committee.

A. Resource Management

In order to provide adequate management and development of the sanctuary, the area has been divided into five management units (Figure 8): Mar Negro, Cayos Caribes, Seagrass Beds, Punta Pozuelo, and the manager's residence.

1. On-site Management Units

a. Mar Negro Unit

The Mar Negro area forms the bulk property of the sanctuary. It has an area of 405 ha (1,000 acres) of which nearly 55 percent are mangrove forests and associated vegetation. The remaining area consists of lagoons and channels.

Fringe and basin forests characterize the mangroves of Mar Negro. The mangrove fringe protects the shoreline. Martinez et al., (1979) reports that there is a strong horizontal gradient in topography, water turbulence, and tidal amplitude in the fringe. Tidal and wave energy decay rapidly inland, producing a salinity gradient. Toward the outer edge of the fringe, red mangrove becomes established, while inland the black mangrove is the dominant species. Since mangrove fringes are exposed, they are subject to periodic destruction by storm waves of scouring by strong currents. During storms, large amounts of debris may be deposited in the outer fringe, reducing circulation of the inner fringe and inland (Cintron et al., 1978). Mangrove fringes have important roles in organic matter export, water quality control, and as base for sessile organisms. The fringe is the preferred perching and roosting site for herons and pelicans.

Basin forests have sheet flows over wide areas of very small topographic relief and low salinity gradients. Black mangrove dominates those basin areas where high salinities (50+ ppt) prevail, while white mangroves dominate low salinity basins (30 - 40 ppt) (Martinez et al., 1979). Some basin forests are subject to higher natural stresses. The mangrove may defoliate through a stressful period, such as a drought, and flourish again when normal conditions are established.

The Mar Negro Unit is also characterized by three lagoons: Mar Negro, Zauta, and Chica. Mar Negro Lagoon lies close to the westerly limits of the sanctuary, adjacent to the community of Las Mareas. It has an area of 2.8 km^2 and maximum depths of around three meters. It serves as anchorage for local fishing boats. This lagoon receives raw sewage discharges from Las Mareas. Zauta Lagoon is smaller than Mar Negro, but reaches depths up to eight meters. Wildlife is more abundant in this lagoon, because of its lower level of human disturbances. Chica Lagoon is a very inaccessible area, almost in the middle of Mar Negro. It is a shallow lagoon with an area nearly one square kilometer. The great blue heron and the endangered brown pelican inhabit this area. No studies have been conducted in this lagoon.

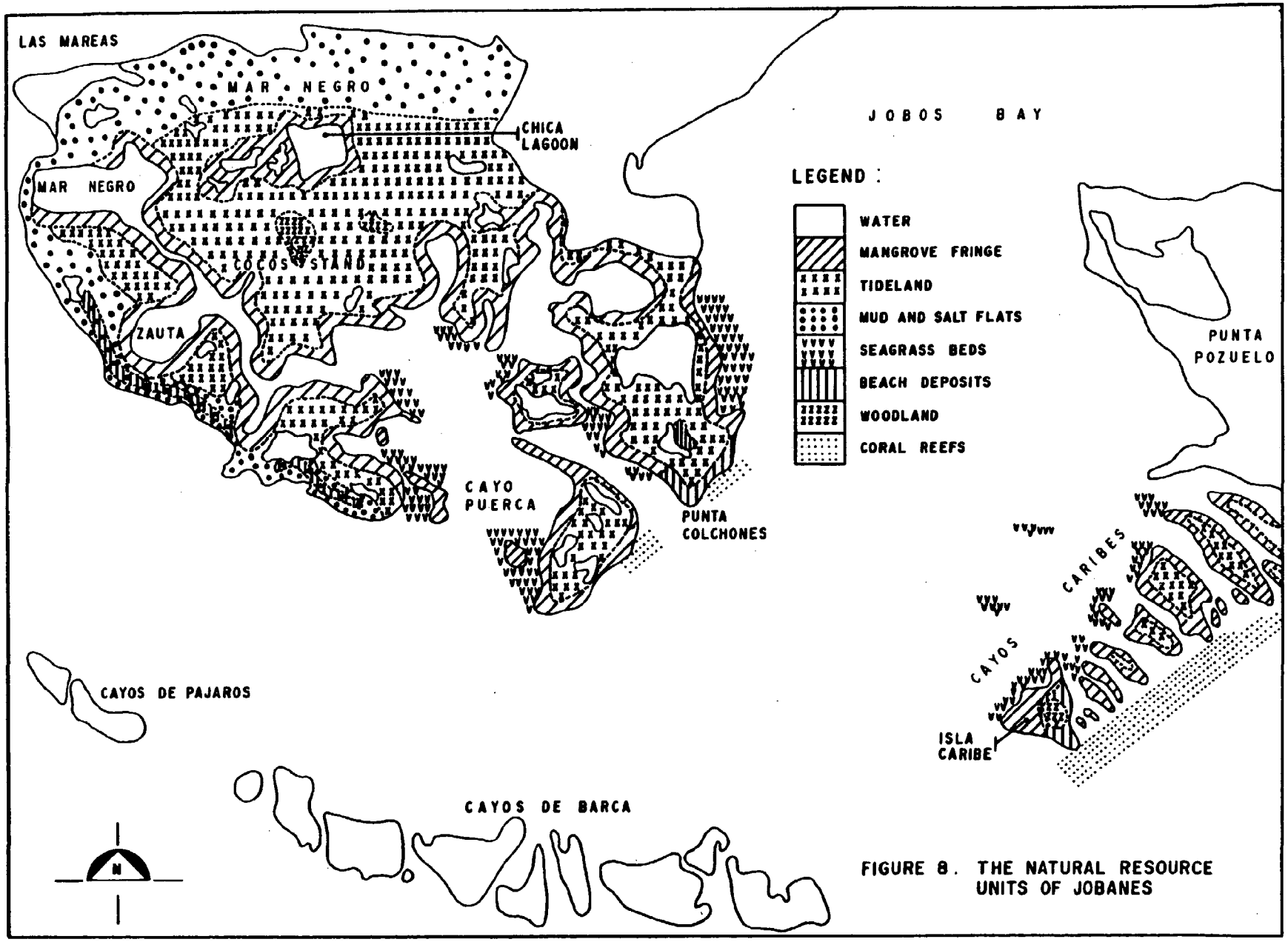


FIGURE 8. THE NATURAL RESOURCE UNITS OF JOBANES

Seasonal lagoons are formed during flood periods, typically from April to November. Their transitional phase represents a brackish or hypersaline lagoon, which produces mud flats or salt flats, respectively.

There are two isolated coconut palm stands south of Chica Lagoon. Land crabs (Cardisoma guanhumi) are known to inhabit the area.

Management Actions

a. Remove debris to assist in the natural regeneration of the area;

b. Regulate public access to bird perching and roosting sites on mangrove fringes;

c. Construction within fringes and basin forests will be on pilings to maintain adequate water flow and drainage with sufficient undisturbed stands left between structures;

d. Avoid road construction within mangrove basins;

e. Evaluate the impact of raw sewage in Mar Negro Lagoon to assess management measures for the conservation of the lagoon components;

f. Establish research/monitoring plots to conduct scientific projects; to be completed by 1984;

g. Provide access to research plots and restrict public access to these areas;

h. Build a docking facility and/or ramp in Las Mareas to provide adequate access to the western margin of JOBANES by 1984;

i. Maintain Chica Lagoon in its present undisturbed conditions to allow for its natural succession;

j. Identify suitable hunting areas to select and designate a hunting reserve within the Mar Negro Unit. To be completed by early 1984;

k. Construction of an interpretive boardwalk/trail in the hypersaline lagoon ecosystem west of Zauta Lagoon by 1984; and

l. Establish a boundary system to delimit the sanctuary property, to provide public orientation, and to identify research/monitoring plots and critical wildlife areas.

b. Cayos Caribes Unit

Cayos Caribes are a chain of 17 tear-shaped islets, 1.8 km long. They are about 2 km southeast of Mar Negro and adjacent to Punta Pozuelo of the Aguirre State Forest. These islets are separated by scour channels reaching depths up to six meters. Cayos Caribes are of particular interest because of the proximity and interactions between seagrass beds, mangroves, and the coral reef. The West Indian manatee has been reported foraging close to this area (Belitsky, 1979). Most of these islets are covered by mangrove, although some contain small areas of evergreen littoral woodland and/or secondary vegetation. There are five species of trees, four species of shrubs, three species of vines, and two species of herbs found in these littoral woodlands and among the mangroves. All four species of mangrove occur on these islands.

Some of the islets of Cayos Caribes can be classified as "overwash mangrove islands." A principal feature of these islets is that they are subject to the daily influence of the tides. The wave regime regulates to some extent the structural development of the vegetation, especially mangroves. Observed differences in leaf areas, biomass and productivity of the mangroves on these islands are probably due to variations in the degree of wave exposure, salinity and nutrient concentrations.

Other islets within the Cayos Caribes chain contain hypersaline lagoons. These lagoons represent an advanced stage in a series of successional events brought about by changes in topography and salinity of the soil. As soil salinities inside the islands increase due to restricted water circulation and high evaporation, death of Rhizophora leads to colonization by Avicennia. As salinities continue to increase, the growth of black mangrove becomes stunted and the island assumes an "annular" appearance with a ring of red mangroves around the inner core of stunted Avicennia (Cintron et al., 1978). Eventually, conditions become so restrictive that no trees can grow in the core and a depression and lagoon are formed.

Management Actions

a. Build a 10 m. tower for wildlife and landscape observation in Punta Caribe, the last outer islet of Cayos Caribes, by 1985;

b. Evaluate the ecological features of Punta Caribe to develop a xerophytic forest and mangrove nature trail and a boardwalk with sections in the coral platform, mangrove fringe, and a hypersaline lagoon;

c. Assess the islet channels and leeward lagoons to develop an underwater trail; and

d. Construct adequate sanitary facilities for visitors and investigators.

c. Seagrass Beds

The general climatic and oceanographic features of the Jobos Bay watershed, the low incidence of waves, and the protection afforded by offshore islets and reefs, all tend to produce extensive seagrass development within the area. The primary function of these beds is as a photosynthetic agent providing carbon complexes and producing oxygen for the marine biota.

Thalassia is the dominant seagrass in Jobos Bay. It is a sessile vascular plant similar to long slender grass. It covers near 35 percent of the bay floor where the depth is less than two meters. In areas less than one meter, Thalassia covers abut 70 percent of the bottom, and its condition is fair. It has a biomass around 250 grams dry weight/m^2 and about 40 grams of associated species. Once the depth increases beyond 1-6 m; the grass becomes quite sparse and contains about one-tenth as much biomass (PRWRA), (1972).

The ecological importance of Thalassia is that it provides a habitat for benthic organisms that depend on this plant for food and coves, such as sea turtles and manatees.

Management Actions

a. Identify shallow seagrass areas;

b. Assess the disturbance from speeding motor boats in seagrass beds; and

c. Determine measures for protecting seagrass areas.

d. Punta Pozuelo Unit

This area is part of the Aguirre State Forest and it is the closest point to Cayos Caribes. A site suitability analysis was was done to determine the location of the visitor/research center Appendix E). The selected site was an old gravel runway, 500 m. north-east of Cayos Caribes. The environmental conditions in Pozuelo are similar to those of JOBANES. The site was chosen for five major reasons: the land is owned by DNR; surrounding lands are government property; its soils have the capacity to support a structure; it has good road access; and it is close to the proposed interpretive area in Cayos Caribes.

Management Actions

a. Build a visitor/research center to provide for public orientation and education and research facilities for local and visiting investigators.

The preliminary design for the center was drawn by the the U.P.R. Graduate School of Architecture. The center will be a three story hexagonal building 910 m^2 in area,

of concrete and wood (Figure 9). The first story will be 380 m^2. It will include: a reception/information counter, an exhibition room, an auditorium with seating for 52 persons, a research/monitoring laboratory, a library, staff offices, storage areas and restrooms. The second story will be 260 m^2. It will have three dormitories with 12 bunk beds, two bathrooms, a fully-furnished kitchen, and a living room. Both stories will be surrounded by a balcony. The third story will hold an observation deck. The building is estimated to cost about $120,000. Construction is proposed to start early in 1984.

b. Construction of a 250 meters long interpretive boardwalk.

c. Manager's Residence

The sanctuary manager's residence is located on Route PR-3 in the community of Puente Jobos, four kilometers north of Cayos Caribes and six kilometers east of Mar Negro. This two acre site has a house with an office and a workshop, and parking for five vehicles. Utilities include tap water, electricity, telephone, and a septic tank. The house is owned by DNR's Forest Service.

Management Actions

a. Reconditioning the structure to provide a temporary residence/office for the sanctuary manager until the visitor/research center is built.

b. Maintain the residence in good condition.

2. Off-site Management Considerations

It is expected that the sanctuary will not change existing activity uses adjoining the site. Agriculture is the predominant surrounding land use. The coastal plains are used mainly for sugarcane cultivation, cattle grazing and dairy farming. There are two industrial sites and a residential community adjacent to the sanctuary.

When the Aguirre Thermoelectric Power Plant (ATPP) was under construction in 1973, an effort was made to ensure that Jobos Bay and the existing mangrove forests in the area would be minimally affected. This environmental concern continues through a monitoring program by the ATPP and the Environmental Quality Board.

The power plant's operations contribute to air pollution with emissions of sulphur dioxide, nitrous oxides, and particulates. However, the calculated ground level concentrations in the area of the sanctuary meet the National Ambient Air Quality Standards. Smoke plumes generated by the power plant do not detract from the sanctuary's aesthetic beauty since the prevailing winds generally blow out of the south-southeast.

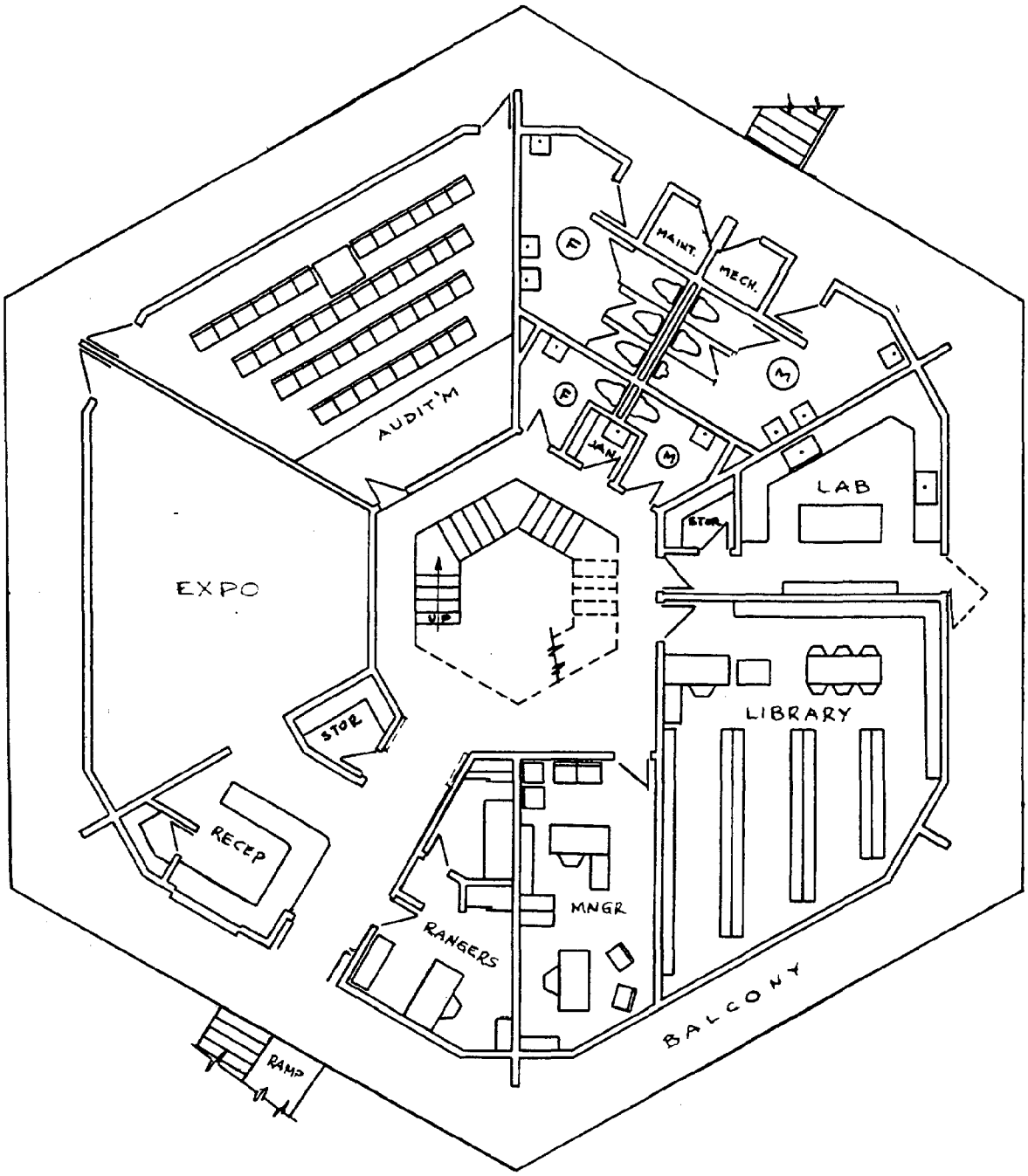


FIGURE 9. FIRST STORY OF THE JOBANES VISITOR CENTER

Cooling water for the ATPP is drawn from central Jobos Bay, close to the plant, and until recently was also discharged at a point close to the plant where prevailing currents carry the thermal effluent away from the sanctuary. However, ATPP was advised by the Environmental Protection Agency that, in order to keep the plant's thermal discharge within legal limits, a 1.6 km long pipe would be required to discharge the blowdown from a cooling tower. On July 1981, the pipe was put into use. Data taken by the ATPP show the average increase in temperature from the discharge to be 4-5°C over ambient water temperature. The outlet pipe was slanted into a seven meter deep navigation channel which will substantially minimize any effect of the mangroves on Punta Colchones, the closest point in the sanctuary to the pipe.

The power plant complex was constructed so that in the event of the rupture of large Bunker C oil storage tanks, no oil would spill into the surrounding mangrove areas. A concrete curb was built around the pier facility where barges deliver oil for the power plant complex. This concrete curb facilitates easy clean up of oil spilled during transfer operations. Safeguards in the form of equipment and personnel are available in the event of an oil spill in the navigation channel or at the oil transfer facility.

The other nearby industry is the Aguirre Sugar Mill that reduced operations two years ago. Approximately 100 ha (240 acres) of mangroves in the northeast corner of the Mar Negro area were killed by waste pulp discharges over a period of 20 years. This area, which now belongs to the ATPP, has stabilized and is not within the sanctuary boundaries. The Aguirre Sugar Mill waste products, such as bagasse, are now burned in the mill and do not impact the Mar Negro sanctuary area.

The Las Mareas community discharges some of its domestic wastes directly into Mar Negro. The extent of environmental damage is considered to be minimal due to the size of the population. A primary sewage treatment plant with ocean discharge has been proposed for Las Mareas.

Growth of the area can be forseen with the establishment of JOBANES. The major threat expected from future development within the sanctuary periphery can be associated with waste disposal.

Residential and commercial waste water producers would be required to connect to sewer lines planned for the proposed regional sewage treatment plant in Guayama. Septic tanks are required in all permanent houses and vacation dwellings in Las Mareas. Soil filling on wetlands should meet local regulations on sediment control. Developers will be encouraged to prevent sediment runoff that could affect the estuary. Solid wastes must be collected on a regular sevice schedule in the Las Mareas and Pozuelo communities.

The Department of Natural Resources will develop a management plan for the Jobos Bay Special Planning Area (from Rio Nigua to Rio Guamani). This management plan will include specific management policies and techniques, to avoid uses that would destroy, alter or significantly affect the natural resources in the area.

B. Research Program

1. Introduction

The primary purpose for establishing JOBANES is to promote and coordinate research to expand knowledge of the estuarine ecosystem and to improve management decisionmaking. Research is an essential part of long-term, comprehensive, and effective sanctuary management. The great diversity of natural components of JOBANES provides an excellent natural laboratory in which research needed for understanding and interpreting estuarine processes will be undertaken. The fundamental pursuit to research at the sanctuary is to provide data base, guidance, and facilities to scientists, thus permitting research projects that will augment the scientific information available related to the estuary. Projects will include, but will not be limited to, multidisciplinary studies on living estuarine and marine resources (species composition, abundance, diversity, etc.); community structure and function; and physical, chemical, geological and meteorological conditions within the sanctuary. Information generated from these investigations will be used to further understanding of the importance of coastal resources and to develop sound coastal ecosystem management practices. Management-related research will address practical, use-oriented or "cause-and-effect" studies. Long-term monitoring and its resultant data base will provide the foundation for interpreting or predicting natural or man-induced events in the sanctuary and related areas. Management areas which could be explored might include: (1) carrying capacity of a given system to withstand varying types and levels of human contact or stresses; (2) the adequacy of protective buffer areas; (3) the effects of different types of development or activities on particular resources such as coral, mangroves, seagrass beds, fisheries, manatees, and seabirds.

Flexibility in the design of research projects is crucial and will be determined by the specific concerns of the individual investigators. This program is not intended to achieve specific projects on a rigid schedule, nor does the program specify individual project design. The program provides research opportunities and guidance within a scope of practical flexibility.

Table 2 outlines the scope for a long-term research program for JOBANES. A wide range of potential project topics is listed to motivate the scientific community to focus research activities within the estuarine ecosystem of Jobos Bay.

2. Facilities and Equipment

The availability of research facilities and equipment in JOBANES will be a key element for motivating the scientific community to conduct projects within the area. The visitor/research center (Figure 9) will be the on-site research facility in the sanctuary. This building will have three large bedrooms, a living room, a kitchen, a library, and a laboratory for chemical and biological analyses. The laboratory will be equipped with the following basic scientific equipment: compound and dissecting microscopes; salinity refractometer; tide level gauge; herbarium cabinet; plant presses; drying oven; study skin cabinet; small freezer; refrigerator; simple centrifuge; mechanical balance; chart recorder; electronic calculator; hot plates; magnetic stirrers; pH meters; a small water distillation system; and basic laboratory supplies. The center will be provided with a meteorological station.

Table 2.

RESEARCH SCOPE FOR JOBANES

I. PHYSICAL AND CHEMICAL ASPECTS

A. GEOLOGY

1. Regional Geology
2. Shelf Topography
3. Bottom Sediment Types
4. Reefs

B. HYDROLOGY

1. Water Temperature
2. Salinity
3. Dissolved Oxygen
4. pH
5. Turbidity and Transparency
6. Currents and Tide Dynamics
7. Sediment Transport

C. CLIMATE

1. Rainfall
2. Temperature
3. Relative Humidity
4. Wind Speed
5. Solar Radiation
6. Microclimates

D. CHEMISTRY

1. Major Nutrients
2. Organic Compounds
3. Hydrocarbons
4. Heavy Metals

II. BIOLOGICAL ASPECTS

A. FLORA

1. Phytoplankton
2. Algae
3. Seagrasses

B. FAUNA

1. Zooplankton
2. Higher Invertebrates
3. Vertebrates - a. Anurans b. Fishes c. Lizards d. Birds e. Bats f. Endangered Species g. Hunted Species

III. DISTURBANCES

A. NATURAL DISTURBANCES

1. Hurricanes
2. Extraordinary Tides
3. Plankton Blooms
4. Floods

B. MAN INDUCED DISTURBANCES

1. Chemical Pollution
2. Domestic Pollution
3. Thermal Pollution
4. Dredging
5. Coastal Eutrophication

C. RESPONSE TO NATURAL STRESSORS

D. RESPONSE TO MAN INDUCED STRESSORS

E. ENERGY FLOW

Researchers and students will be able to use the field laboratory for on-site, rapid cleaning, sorting, identification and processing of field specimens and for first-cut tabulation and data reduction. The laboratory's collections and guidebooks will assist in the identification of specimens. One of the early goals of sanctuary management will be to accumulate study specimens of representative species of flora and fauna to aid visitors in this task. The laboratory will also offer a good "staging area" for field work, where equipment can be checked out and minor repairs made. It will not be practicable, due to laboratory space and instrument limitations, to carry out complex procedures at the visitor center, but complete biological, chemical and geological analytical laboratories are available at DNR Headquarters at San Juan. Additionally, some visiting scientists with their own equipment may make use of the line voltage and counter space of the laboratory to set up their own instruments temporarily.

There are several chemical analyses that require highly sophisticated equipment that would not be available at the center. However, DNR's Research Area has a well-equipped laboratory that provides analytical support for the Marine, Terrestial, and Geologic Divisions within the Research Area. This laboratory is equipped with an atomic absorption spectrophotometer, an emission spectographer, and UV spectographer, and a gas chromatographer. The laboratory conducts analysis on sedimentation dynamics, nutrients, heavy metals, phenols, pesticides, hydrocarbons, and bioassays among other tests.

A multipurpose 17 foot Boston Whaler boat, equipped with a trailer and a 70 hp engine, has been acquired for JOBANES. This unit is available for aquatic sampling and research and for passengers and equipment transportation. In addition, the DNR's Research Area has a 65 foot oceanographic exploration vessel, the Jean A. This vessel is fully sound and its crew has extensive experience in oceanography and diving.

3. Data Management

Effective management relies to a great extent on an efficient data classification, storage, and retrieval system. Such a system is essential for day-to-day management as well as for future planning and future resource problem solving. At present a moderate amount of information exists on Jobos Bay and surrounding environs. It is anticipated that this information base will expand significantly with the establishment of the estuarine sanctuary. A data management system therefore is needed to handle this information effectively so that proper management of the Sanctuary could be achieved.

The Natural, Cultural and Environmental Resources Inventory (NCERI) of the Department of Natural Resources is a data management system which has been in operation since 1973. It has the capability to accept most of the data base for the sanctuary. With certain modifications the system can be expanded to accept additional information.

A study is needed to evaluate the existing data management system within DNR in terms of its compatibility with the sanctuary data/information management needs. Specifically, the existing data banks and information on JOBANES could be incorporated into the existing NCERI.

The proposed library for the visitor/research center will function as a complement to the data bank. The library will hold a collection of books, reprints, documents, and photographs that can enhance the educational and research programs of JOBANES.

Other off-site libraries that can provide investigators updated information related to estuarine ecosystems are: DNR's library, the libraries of the Center for Energy Environmental Research, the Environmental Quality Board, Department of Marine Sciences of the University of Puerto Rico (UPR), Mayaguez campus, and the library of the College of Natural Sciences of the UPR, San Juan campus with one of the larger scientific collections in Latin America.

4. Monitoring Program

The absence of a long-term data collection system justifies the establishment of a monitoring program in JOBANES. This is a most important research activity and will provide a data bank for the Sanctuary. The program will be divided into four phases: photographic monitoring, water quality, meteorological, and biological monitoring. To support the monitoring program, permanent research/monitoring plots will be established. The sanctuary staff and personnel from DNR's Scientific Research Area will be responsible for the monitoring program.

The photographic monitoring phase intends to document changes in vegetation structure and composition, changes in land and water as a product of alterations of existing environmental conditions, natural succession, and changes during critical events, such as oil spills, hurricanes, floods, or a severe drought. Permanent ground-level stations will be selected. An aerial photograph survey of the Jobos Bay watershed will be conducted in February and August, (the climax months for climatic extremes), every two years or during critical events. Infrared photography will be encouraged, particularly for vegetation analysis.

In 1980, the Environmental Quality Board established four water monitoring stations within the Jobos Bay watershed. Parameters currently being monitored include temperature, dissolved oxygen, pH, color, salinity, nitrates, nitrites, total phosphorous, turbidity, total nitrogen, fecal coliforms, oil and grease, and heavy metals. These parameters are monitored every two months. The water quality monitoring phase will be expanded to include more stations within JOBANES and other parameters, such as pesticides, suspended solids, phenols, and tidal level fluctuations.

Selected meteorological equipment will be installed to monitor temperature, precipitation, wind velocity, solar radiation, and relative humidity. This equipment will enhance the meteorological monitoring phase by providing important new kinds of data. The sanctuary technician will be in charge of this phase. The meteorological station located at the visitor/research center will also serve in the interpretive program.

The biological monitoring program will include plankton and invertebrate sampling, fish population sampling, and measurement of the plant communities, including algae, seagrasses and mangroves. Surveys for presence of toxic substances in fish, birds and phytoplankton may be performed. Population studies of endangered and hunted species will be encouraged.

5. Research Prospectus

The sanctuary staff is committed to attract the scientific community to JOBANES. Investigators will be encouraged to utilize the site for their research studies by offering them: an on-site laboratory and housing facilities; an expanding data bank; guidance and assistance in project design and implementation; and the relatively undisturbed study area of the coastal estuarine ecosystem of Jobos Bay. The only studies that will not be encouraged are manipulative studies that affect the nature of the estuarine system.

The sanctuary manager and his Advisory Committee will provide guidance in the design of research proposals. They can provide background information on JOBANES, alert the research proponent about specific site conditions that may affect the research, suggest ways to reduce living expenses, and identify potential funding sources. The sanctuary staff will provide field assistance as needed by the investigator.

All research proponents must complete the DNR's Scientific Research Area research application prior to the beginning of the project. The permit holder must submit a report of his/her research to the Area within 90 days after the permit expiration date or when a publication first becomes available. It is hoped that the investigator will provide the sanctuary with raw data collected and/or published reports.

6. Research Priorities

The following research topics were ranked as priority projects for JOBANES.

-----The effect of microclimates on mangroves

-----Long-term ecophysiology of mangroves

-----Growth rate of mangroves under environmental stress

-----Determination of population sizes of game birds and land crabs

-----Microbiology of the mangrove root faunal community

-----Assessment of the nesting status of birds

-----Identification of migratory chronology of birds

-----Distribution and status of the West Indian Manatee

-----Sedimentation effects in coral reefs

-----Growth rate of seagrass beds

-----Fish population studies

C. Interpretive Program

1. Introduction

The Jobos Bay National Estuarine Sanctuary will provide suitable educational activities to facilitate information to universities, schools, other organizations, and the general public. The goal of this program will be to present the nature of the ecosystem components and their values to man and nature.

This section of the management plan establishes a framework for the Interpretive Program for JOBANES. As an island community, Puerto Rico's population can benefit from an estuarine-oriented interpretive program. The program will be administered in close cooperation with the local communities and users of the sanctuary to encourage a better appreciation of the island's coastal resources.

Interpretation of this complex environment will enhance visitor appreciation and enjoyment of the sanctuary and generate concern for the protection of its vital resources. Audiovisual materials, publications, exhibits, activities, and interpreters will provide information that leads to increased knowledge and understanding of this relatively unspoiled and significant ecosystem. The mangrove boardwalk tour and the media presentation will focus the public's attention on the value of the mangrove system to fishing productivity, wildlife, and protection of coastal property. Boat tours to Cayos Caribes and Mar Negro, exhibits, lectures and the audiovisual program will focus on the importance of the system and its fragility. The information on endangered species (manatees, turtles, pelicans, and other important species) will be related to habitats (grassbeds, mangroves, and reefs) and provide a holistic understanding of the relationship of individual species and habitats to the ecosystem.

This interpretive program will include off-site and on-site activities. The projected visitor center will be the focus for educational activities.

2. Off-Site Educational Activities

Lectures will be presented by the Sanctuary Manager or his designated personnel to organizations such as schools, ecological societies, or youth groups.

News media will be encouraged to provide information about the Sanctuary to the public. Such coverage will include newspaper and magazine articles, and radio and television programs. WIPR, the Commonwealth public broadcasting radio and television station, will play an important role in this objective.

The sanctuary manager and his staff will be encouraged to sponsor and advise nature oriented groups, programs and workshops.

3. On-Site Educational Activities

a. Hiring an Education Specialist and Recruiting Volunteers

An Education Specialist will be hired in January 1985 to be responsible to develop, coordinate, and implement the interpretive program for JOBANES. This person will recruit, train, and supervise sanctuary volunteers as needed. This specialist will work in conjunction with the sanctuary manager and DNR personnel responsible for information activities.

The sanctuary staff will encourage a volunteer program at JOBANES. This will be an active program where volunteers will fulfill specific tasks.

b. Public Orientation

A visitor orientation system is required to orient the public to get to and to move within the sanctuary. This system will be composed of two major units: signs and the visitor center.

Signs indicating main entrances to the sanctuary will be posted in each direction on Highway 3, one kilometer before road 703 to Mar Negro and road 710 to Punta Pozuelo. Signs will identify other sanctuary facilities such as trails, camping and picnic areas, rest rooms, parking, exits, and educational devices. All trails will be named according to a relevant feature of the site, such as Great Blue Heron, Red Mangrove, Fiddler Crabs or Zoanthus Trails.

The visitor center will be the main Sanctuary unit for orientation and education. The center will have:

-- A scale model of the sanctuary showing all the natural areas and facilities.

-- A large aerial photograph of the sanctuary.

-- A wall-sized schematic map illustrating in detail all the sanctuary facilities.

-- An auditorium for lectures, meetings, and audio-visual presentations.

-- An exhibit room designed to display a museum collection of shells and local faunal specimens, and photographs and information plates of some abiotic and biotic elements of the sanctuary ecosystem.

-- A research/reference library of the cultural, biological, chemical and physical features of JOBANES and the surrounding region.

-- An information counter attended by volunteers to provide public orientation and educational materials.

c. Publications

The sanctuary staff, in coordination with the DNR Office of Education and Publications, will publish a series of leaflets, as necessary, to describe the sanctuary structure, components, and facilities. Among the leaflet topics are:

(1) A Self-guided Tour to the Jobos Bay National Estuarine Sanctuary

(2) The Mangroves of JOBANES

(3) Marine Flora and Fauna of JOBANES

These leaflets will be available to the public at the visitor center.

-- A sanctuary newsletter, published bimonthly, will be developed by 1983.

-- A large schematic map (approximately 100 cm X 100 cm) showing the sanctuary facilities and points of interest will be published. Its main purpose will be orientation. The map will be available at the visitor center. A pocket-sized checklist of the sanctuary land flora and fauna will be available upon request at the visitor center.

d. The Sanctuary Emblem and Uniform

To symbolize the main elements integrating the nature of the sanctuary ecosystem, an emblem was created (Figure 10). The emblem shows a red mangrove with its aerial roots, a great blue heron, one of the bird species that forage in all types of water bodies within the sanctuary, the fiddler crab, a typical inhabitant of mud and tidal flats, the West Indian manatee and the sea turtle, two endangered species that frequent the waters of Jobos Bay, and two fishes and the coral reef, which represent the marine environment. The NOAA symbol has been integrated into this emblem. The sanctuary emblem will be carved in a 100 x 150 cm mahogany panel and will be displayed in front of the visitor center.

All sanctuary personnel and non-CICA volunteers will wear a representative uniform, consisting of a light beige shirt/blouse, a sky blue pant/split skirt or shorts, a black baseball cap with the sanctuary logo (JOBANES) embroidered in yellow letters, and black shoes. Socks can be either white, black or navy blue. A patch of the sanctuary emblem will be embroidered on the upper right side of the shirt/blouse, and DNR emblem will be attached to the upper left side of the shirt. This uniform will be used during working hours in on-site and off-site activities.

e. Student Programs

Students at different educational levels will be invited to examine the sanctuary ecosystem, the socio-cultural impact of the establishment of JOBANES, and the effect of urban and industrial development upon the area. Local school science clubs will be incited to develop science projects within the sanctuary.

FIGURE 10. THE SANCTUARY EMBLEM

f. Interpretive Devices and Trail System

To promote educational/recreational benefits to visitors of the sanctuary and to make their visit a pleasant one, it will be necessary to build a system of interpretive devices and trails (Figure 11). The main goal of this system will be educational, but considerable overlapping with recreational objectives may be present. Self-guided tours to the facilities will be encouraged, but guide tours managed by volunteers will be available to the public. The following interpretive devices are planned to be built or acquired with sanctuary funds:

-- An observation tower, 10 m. high, to be built in Punta Caribe.

-- A glass-bottomed boat with capacity for 20 persons.

-- A 200 m. boardwalk system, interconnecting the last four islets of Cayos Caribes.

-- A 10 m. long dock in Mar Negro.

-- Interpretive plates along trails.

Trails will be developed or reconditioned to show particular ecological or physiographical features of the area. Among the trails to be developed are:

-- A xerophytic vegetation trail in Punta Caribe.

-- A hypersaline lagoon ecosystem trail in the Zauta Lagoon area.

-- A mangrove trail in the Mar Negro area.

-- A self-guided underwater native trail in the southern margin of Punta Caribe.

4. Recreational Considerations

Hiking trails and a rustic camping area will be evaluated as possible recreational facilities.

Intensive recreational activities are not the main objectives of the sanctuary. However, there are multiple use activities that are compatible with the objectives of the National Estuarine Sanctuary Program. Passive recreation opportunities could be achieved with some of the educational units to be established in the sanctuary. Almost all of the outdoor educational system units overlap with recreational activities. Interpretative nature trails, the observation tower, self-guided snorkel trails, and the glass-bottomed boat will have a great extent of recreational experiences.

Sailing and canoeing will be permitted in all sanctuary waters; motor boating will be restricted to some areas to be designated. Small scale amateur and commercial fishing is allowed in all territorial waters within the sanctuary. Hunting will be permitted according to current hunting standards. Different areas in Mar Negro will be evaluated to designate a hunting reserve. Hunting will be prohibited in Cayos Caribes.

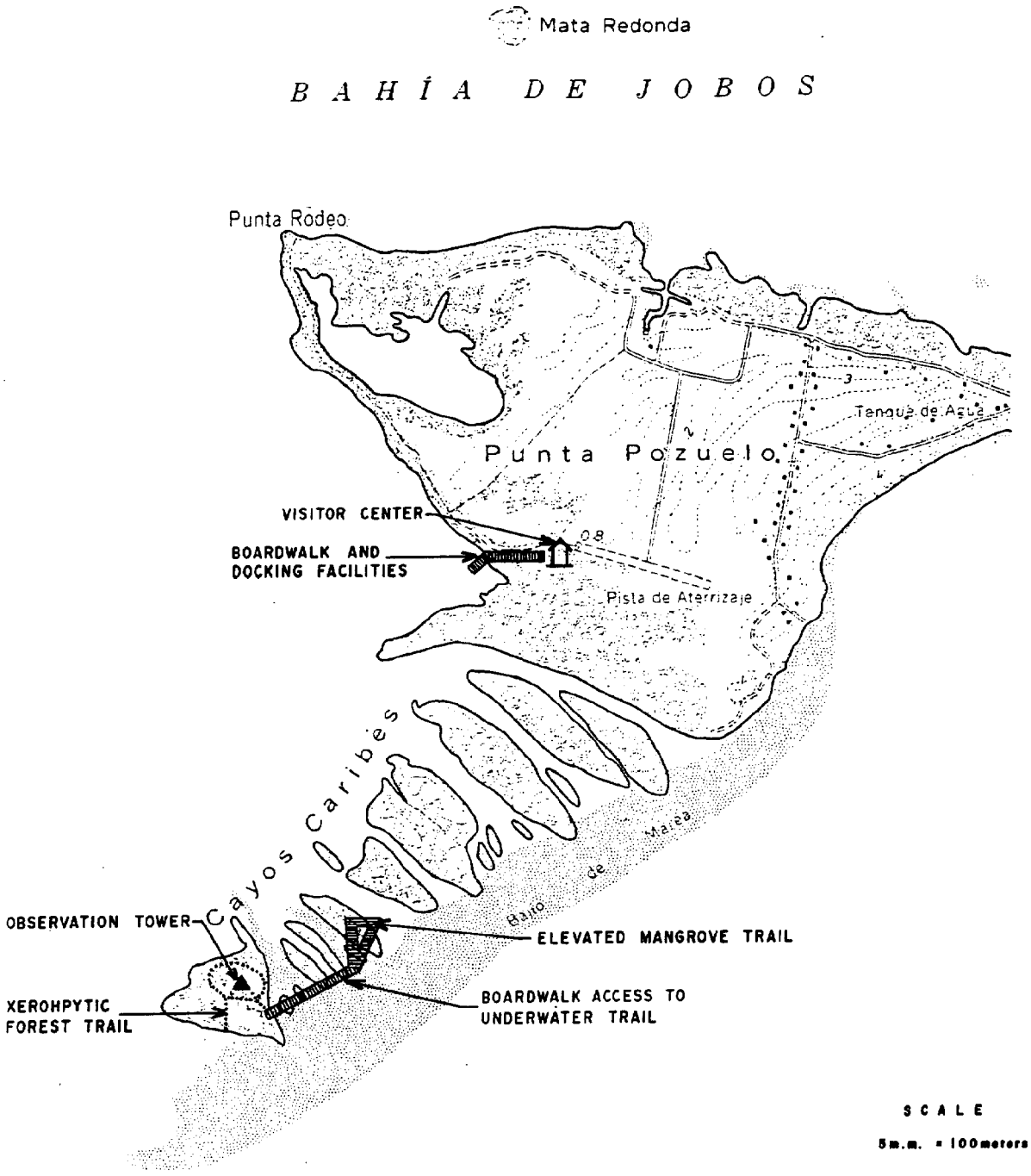


FIGURE II. INTERPRETIVE UNITS FOR CAYOS CARIBES AND PUNTA POZUELO

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APPENDIX A

APPENDIX A. PARTIAL SPECIES LIST FOR ORGANISMS INHABITING THALASSIA BEDS AND THE CORAL REEF

THALASSIA BEDS

Algae:
- *Acanthopora spicifera*
- *Coulerpa racemosa*
- *Udotea flabellum*
- *Penicillus capitatus*
- *Halimeda opuntia*
- *Dictyota divaricata*
- *Bostrychia sp.*

Tracheophyta (Angiosperms)
- *Thalassia testudinum*
- *Cymodocea monotorum*

Porifera:
- *Haliclona rubens*
- *Tidania ignis*
- *Ircinia strobilina*
- *Chondrilla nucula*

Coelenterata:
- *Manicina areolata*
- *Oculina diffusa*
- *Porites furcata*
- *Bartholomea anulata*
- *Myrionema ambiosnense*
- *Siderastrea siderea*
- *Agaricia agaricites*
- *Favia fragum*
- *Porites asteroides*
- *Acropora cervicornis*
- *Pseudopterogorgia americana*
- *Plexaurella dichotoma*
- *Plexaura flexuosa*
- *Condylactis gigantia*

Echinodermata:
- *Holothuria mexicana*
- *Oreaster reticulatus*
- *Astropecten duplicatus*
- *Diadema antillarum*
- *Tripneustes esculentus*
- *Lytechinus variegatus*
- *Ludioigothuria mexicana*
- *Microthele parvula*
- *Ophiocoma echinata*
- *Echinometra lucuntic*

Gastropoda:
- *Strombus gigas*
- *Cassia sp.*
- *Cerithium litteratum*

Pelecypoda:
- *Tellina sp.*
- *Pinna carnea*

Crustacea:
- *Balanus eberneus*
- *Amphipoda sp.*
- *Panulirus argus*
- *Calappa flammea*
- *Paleomonetes sp.*
- *Clibonarius sp.*
- *Synalpheus brevicarpus*

Pisces
- *Ginglymostoma cirratum*
- *Galeocerdo cuvieri*
- *Sphyrno lewvini*
- *Aetobatus narinari*
- *Megalops atlanticus*
- *Albula vulpes*
- *Opisthonema oglinum*
- *Hermiramphus brasiliensis*
- *Sphyraena guachancho*
- *Mugil trichodon*
- *Polydactylus oligodon*
- *Caranx latus*
- *Trachinotus falcatus*
- *Lutjanus opodus*
- *Lutjanus grieseus*
- *Hoemulon sciurus*
- *Ulaema bifroyl*
- *Chaetodipterus fabu*
- *Thalassoma bifasciatum*
- *Scarus sp.*
- *Acanthostracion sp.*

Tunicata:
- *Ecteinascidio turbinata*

Mamalia:
- *Trichechus*

CORAL REEFS

Algae:
- *Halimeda opuntia*
- *Valonia ventricosa*

Porifera:
- *Pellina carbonifia*
- *Zoanthus pulchellus*
- *Tethya sp.*

Annelida:
- *Hermodice carunculata*

Coelenterata:
- *Porites furcata*
- *Millipora alciocornis*
- *Montastrea annularis*
- *Zoanthus sociatus*
- *Gorgonia flabellum*
- *Acropora prolifera*
- *Diploria labyrinthiformes*
- *Zoanthus pulchellus*
- *Bartholomea anulata*
- *Isophyllia sinuosa*
- *Siderastrea siderea*
- *Agaricia agaricites*
- *Favia fragum*
- *Porites asteroides*
- *Acropora cervicornis*
- *Pseudopterogorgia americana*
- *Plexaurella dichotoma*
- *Plexaura flexuosa*
- *Plexaura tourneforti*
- *Condylactis gigantea*

Echinodermata:
- *Holothuria parvula*
- *Diadema antillarum*
- *Ophiothrix angulata*
- *Ludwigothuria mexicana*
- *Echinometra lucunter*

Gastropoda:
- *Cassia sp.*

Pelecypoda:
- *Pinna carnea*

Amphineura:
- *Chiton sp.*

Crustaceae:
- *Balanus eberneus*
- *Panulirus argus*
- *Mithrax sculptus*
- *Clibanarius sp.*

Pisces
- *Ginglymostoma cirratum*
- *Galeocerdo cuvieri*
- *Negaprion brevirostris*
- *Sphyrna lewini*
- *Aetobatus narinari*
- *Opisthonema oglinum*
- *Aulostomus maculatus*
- *Sphyraena barracuda*
- *Polydactylus oligodon*
- *Epinephelus striatus*
- *Caranx latus*
- *Lutjanus apodus*
- *Lutjanus griseus*
- *Chaetodipterus faber*
- *Holocanthus ciliaris*
- *Pomacanthus paru*
- *Lachnolaimus maximus*
- *Bodianus rufus*
- *Thalassoma bifasciatum*
- *Scarus sp.*
- *Balistes vetula*
- *Acanthostracion sp.*
- *Diodon hystrix*

Mammalia:
- *Trichechus*

APPENDIX B

Appendix B. Fish Families and Species found in Jobos Bay

		DISTRIBUTION			
		I	II	III	IV
CHONDRICHTHYES					
Orectolobidae					
Ginglymostoma cirratum	nurse shark; gata nodriza	X	X	X	X
Carcharhinidae					
Carcharhinus acronotus	blacknose shark; tiburón hocico negro			(X)	
Carcharhinus perezi	reef shark; tiburón coralino			X	
Galeocerdo cuvieri	tiger shark; tigre, tintorera			X	
Negaprion brevirostris	lemon shark; tiburón limón			(X)	
Rhizoprionodon porosus	Atlantic sharpnose shark; cazón, chino	(X)			
Sphyrnidae					
Sphyrna lewini	scalloped hammerhead; cornuda		(X)		
Dasyatidae					
Dasyatis americana	southern stingray; raya	X	X	X	X
Myliobatidae					
Aetobatus narinari	spotted eagle ray; chucho	X	X	X	X
OSTEICHTHYES					
Elopidae					
Elops saurus	ladyfish; piojo, macabí	X	(X)	(X)	X
Megalops atlanticus	tarpon; sábalo		X		(X)
Albulidae					
Albula vulpes	bonefish; macaco, conejo	X	(X)	(X)	(X)
Moringuidae					
Moringua edwardsi	spaghetti eel; anguila spaghetti			(X)	
Muraenidae					
Echidna catenata	chain moray; morena de cadena			(X)	
Gymnothorax funebris	green moray; morena verde	(X)	(X)	X	(X)
Gymnothorax moringa	spotted moray; morena moteada		(X)		
Gymnothorax vicinus	purplemouth moray; morena purpurina		(X)	X	
Muraena miliaris	goldentail moray; morena brillante	(X)	(X)		
Ophichthidae					
Ahlia egmontis	keyworm eel; anguila llave		(X)	(X)	(X)
Myrichthys acuminatus	sharptail eel; anguila puntiaguda			(X)	
Myrichthys oculatus	goldspotted snake eel; anguila manchada			X	
Myrophis punctatus	speckled worm eel; anguila pecosa			(X)	(X)

		I	II	III	IV
Clupeidae					
Harengula clupeola	false pilchard; cascarúa	X	X	X	X
Harengula humeralis	red-ear sardine; machuelo	X	(X)	X	(X)
Jenkinsia lamprotaenia	dwarf herring; minjúa			X	
Opisthonema oglinum	threadfin herring; arenque	X	X	X	X
Sardinella aurita	Spanish sardine; sardina española		(X)		
Engraulidae					
Anchoa cubana	Cuban anchovy; anchoveta cubana				(X)
Anchoa hepsetus	striped anchovy; bocua		X		
Anchoa lamprotaenia	longnose anchovy; anchoveta ojona		(X)	(X)	
Anchoa parva	small anchovy; anchoveta pequeña		(X)		
Anchoviella perfasciata	flat anchovy; anchoveta	(X)	(X)	(X)	
Cetengraulis edentulus	whalebone; rabo amarillo	X	X	X	X
Synodontidae					
Synodus foetens	galliwasp; doncella, lagarto		X	X	(X)
Synodus intermedius	sand diver; doncella, lagarto			x	(X)
Gobiesocidae					
Arcos amplycirrhus	southern emerald clingfish; renacuajo			(X)	
Arcos rubiginosus	red clingfish; renacuajo rojo		(X)	(X)	
Antennariidae					
Histrio histrio	sargassumffsh; pez sargaso			(X)	(X)
Ophidiidae					
Ogilbia sp.			(X)	(X)	
Carapidae					
Carapus bermudensis	pearlfish; pez perla				(X)
Exocoetidae					
Hemiramphus balao	balao; balajú	X			
Hemiramphus brasiliensis	Ballyhoo; balajú	X	(X)	X	
Hyporhamphus unifasciatus	halfbeak; pico fósforo			(X)	X
Belonidae					
Strongylura notata	redfin needlefish; agujón rojo			X	
Strongylura timucu	timucu; agujón timucu			X	
Tylosurus acus	agujon; agujón				X
Tylosurus crocodilus	hound needlefish; agujón perro	X	X	X	
Cyprinodontidae					
Rivulus marmoratus	rivulus; rivulo				(X)

		I	II	III	IV
Poeciliidae					
Poecilia vivipara	one-spot livebearer; guppy				(X)
Atherinidae					
Atherinomorus stipes	hardhead silverside; cabezón, pejerreye			X	
Holocentridae					
Holocentrus ascensionis	longjaw squirrelfish; gallito		X	X	X
Holocentrus marianus	longspine squirrelfish; gallito colorado			X	
Holocentrus rufus	squirrelfish; gallito				
Holocentrus vexillarius	dusky squirrelfish; gallito oscuro			X	
Myripristis jacobus	blackbar soldierfish; candil colorado		X	X	
Aulostomidae					
Aulostomus maculatus	trumpetfish; cornetero		(X)	X	
Syngnathidae					
Cosmocampus brachycephalus	crested pipefish; trompetero			(X)	
Hippocampus reidi	longsnout seahorse; caballito de mar			X	
Syngnathus dunckeri	pugnose pipefish; trompetero			(X)	
Syngnathus elucens	shortfin pipefish; trompetero			(X)	
Syngnathus pelagicus	Sargassum pipefish; trompetero			(X)	
Syngnathus rousseau	Caribbean pipefish; trompetero		(X)	(X)	
Centropomidae					
Centropomus ensiferus	swordspine snook; róbalo machuelo			(X)	
Centropomus pectinatus	tarpon snook; róbalo tablado	(X)			
Centropomus undecimalis	snook; róbalo flamasón	(X)	X		
Serranidae					
Epinephelus adscensionis	rock hind; cabra mora			X	
Epinephelus guttatus	red hind; cabrilla			X	
Epinephelus itajara	jewfish; mero grande, sapo			X	
Epinephelus striatus	Nassau grouper; mero cherna			X	
Hypoplectrus puella	barred hamlet; vaca arrayada			X	
Mycteroperca bonaci	black grouper; meró negro		X		
Mycteroperca tigris	tiger grouper; cuna gata, tigre			X	
Serranus baldwini	lantern bass; merito linterna			X	
Serranus tigrinus	harlequin bass; merito tiza, guaseta			X	
Grammistidae					
Rypticus saponaceus	greater soapfish; jaboncillo	X		(X)	
Rypticus subbifrenatus	spotted soapfish; jabón			(X)	
Rypticus sp.	soapfish; jaboncillo			X	(X)

		I	II	III	IV
Grammidae					
Gramma loreto	fairy basslet; gramma			X	
Priacanthidae					
Priacanthus arenatus	bigeye; catalufa, sol,toro			X	
Priacanthus cruentatus	glasseye snapper; toro catalufa			X	
Apogonidae					
Apogon maculatus	flamefish; cardenal flamasón		(X)	X	
Apogon quadrisquamatus	sawcheek cardinalfish; cardenal			(X)	
Astrapogon puncticulatus	blackfin cardinalfish; cardenal		(X)	(X)	(X)
Astrapogon stellatus	conchfish; cardenal conchero				X
Phaeoptyx pigmentaria	dusky cardinalfish; cardenal oscuro		(X)		
Echeneidae					
Echeneis naucrates	sharksucker; pega, remora	X		X	(X)
Remora remora	remora; remora	X			
Carangidae					
Caranx bartholomaei	yellow jack; guaymén amarillo			X	
Caranx crysos	blue runner; cojinua, medregal		(X)	(X)	X
Caranx hippos	crevalle jack; jurel	X		(X)	(X)
Caranx latus	horse-eye jack; jurel ojón	X	X	X	X
Caranx ruber	bar jack; cojinua, cibí			X	(X)
Chloroscombrus chrysurus	Atlantic bumper; casabá	X	X	X	X
Decapterus punctatus	roundscad; caballa pintada			X	
Oligoplites saurus	leatherjack; cueriduro	X	X	(X)	X
Selene setapinnis	Atlantic moonfish; corcobado		(X)		X
Selene vomer	lookdown; jorobado		X		(X)
Trachinotus carolinus	pompano; pompano	X			(X)
Trachinotus falcatus	permit; pompano		X		(X)
Trachinotus goodei	palometa; palometa	X		(X)	X
Lutjanidae					
Lutjanus analis	mutton snapper; sama		X	X	(X)
Lutjanus apodus	schoolmaster; pargo amarillo		X	X	(X)
Lutjanus cyanopterus	cubera snapper; pargo guasinuco			X	
Lutjanus griseus	gray snapper; pargo prieto	X	X	X	X
Lutjanus jocu	dog snapper; pargo colorado	X	X	X	
Lutjanus mahogoni	mahogony snapper; rayado de yerba			X	(X)
Lutjanus synagris	lane snapper; manchego, arrayado	X	(X)	X	X
Ocyurus chrysurus	yellow snapper; colirubia	X		X	X

		I	II	III	IV
Lobotidae					
Lobotes surinamensis	tripletail; dormilona				(X)
Gerreidae					
Diapterus auratus	Irish mojarra; mojarra	(X)	(X)		X
Diapterus plumieri	striped mojarra; mojarreta	(X)			(X)
Diapterus rhombeus	rhomboid mojarra; mojarra	X	X	X	X
Eucinostomus argenteus	spotfin mojarra; mojarra blanca	(X)		(X)	(X)
Eucinostomus gula	silver jenny; blanquilla	X	X	X	X
Eucinostomus jonesi	slender mojarra; mojarra	X	X	X	X
Eucinostomus lefroyi	mottled mojarra; muniama		(X)	(X)	
Eucinostomus melanopterus	flagfin mojarra; muniama			(X)	
Gerres cinereus	yellowfin mojarra; muniama	X	X	X	X
Haemulidae					
Anisotremus surinamensis	black margate; vieja			X	
Anisotremus virginicus	porkfish; canario			X	
Haemulon aurolineatum	tomtate; mulita	X		X	X
Haemulon bonariense	blackgrunt; ronco prieto	X		X	
Haemulon carbonarium	Caesar's grunt; ronco carbonero			X	
Haemulon chrysargyreum	smallmouth grunt; saboga, mulita			X	
Haemulon flavolineatum	French grunt; condenado		X	X	X
Haemulon macrostomum	Spanish grunt; colombiano			X	
Haemulon melanurum	cottonwick; jenigua			(X)	
Haemulon parrai	sailor's choice; arrayado		X	X	
Haemulon plumieri	white grunt; boquicolorado		(X)	X	(X)
Haemulon sciurus	bluestriped grunt; ronco amarillo	X	X	X	X
Pomadasys crocro	burro grunt; burrito	X	X	X	X
Sparidae					
Archosargus rhomboidalis	sea bream; chopa amarilla	X	X	X	X
Calamus bajonado	jolthead porgy; pluma ojona		(X)	(X)	(X)
Calamus calamus	saucereye porgy; pluma				(X)
Calamus penna	sheepshead porgy; pluma		X	X	X
Calamus pennatula	porgy; pluma			X	
Sciaenidae					
Bairdiella ronchus	ground drummer; corvino	X	(X)		X
Bairdiella sanctaeluciae	striped croaker; corvino		(X)	(X)	(X)
Cynoscion jamaicensis	mongolar drummer; dientón	X	(X)	(X)	
Equetus acuminatus	high hat				X

		I	II	III	IV
Sciaenidae- cont.					
Equetus lanceolatus	jackknife-fish; corvino				X
Larimus breviceps	shorthead drum; corvino	X	(X)		
Menticirrhus martinicus	jewsharp drummer; corvino	X	(X)		
Micropogonias furnieri	whitemouth croaker; corvino	X	X		(X)
Odontoscion dentex	reef croaker; corvino de arrecife			X	
Ophioscion adustus	snake croaker; corvino	X	(X)		(X)
Stellifer stellifer	small drum; corvino				(X)
Mullidae					
Mulloidichthys martinicus	yellow goatfish; salmonete amarillo			X	
Pseudopeneus maculatus	spotted goatfish; salmonete colorado			X	X
Pempheridae					
Pempheris schomburgki	glassy sweeper; barredor, barrigón			X	
Kyphosidae					
Kyphosus incisor	yellow chub; chopa amarilla			X	
Kyphosus sectatrix	Bermuda chub; chopa blanca			X	
Ephippidae					
Chaetodipterus faber	Atlantic spadefish; palometa		X	X	X
Chaetodontidae					
Chaetodon capistratus	foureye butterflyfish; mariposa		(X)	X	
Chaetodon striatus	banded butterflyfish; mariposa rayada			X	(X)
Pomacanthidae					
Holacanthus ciliaris	queen angelfish; isabelita			X	
Holacanthus tricolor	rock beauty; catalineta			X	
Pomacanthus arcuatus	gray angelfish; palometa			X	(X)
Pomacanthus paru	French angelfish; palometa			X	
Cichlidae					
Tilapia mossambica	tilapia; tilapia mosambica				X
Pomacentridae					
Abudefduf saxatilis	sargeant major; sargento			X	
Abudefduf taurus	night sargeant; vieja prieta			X	
Chromis multilineata	brown chromis; burrito marrón			X	
Chromis cyanea	yellowtail damselfish; damisela			X	
Pomacentrus diencaeus	longfin damselfish; damisela		(X)	X	
Pomacentrus dorsopunicans	dusky damselfish; damisela chamuscada		(X)	X	
Pomacentrus leucostictus	beaugregory; gregorio			X	
Pomacentrus partitus	bicolor damselfish; damisela bicolor			X	
Pomacentrus planifrons	threespot damselfish			X	
Pomacentrus variabilis	cocoa damselfish; damisela cocoa			X	

		I	II	III	IV
Cirrhitidae					
Amblycirrhitus pinos	redspot hawkfish; halcón			X	
Labridae					
Bodianus rufus	Spanish hogfish; perro colorado			X	
Doratonotus megalepis	dwarf wrasse; doncella enana			(X)	
Halichoeres bivittatus	slippery dick; doncella resbaladiza			X	
Halichoeres garnoti	yellowhead wrasse; doncella amarillenta			X	
Halichoeres maculipinna	clown wrasse; payaso			X	
Halichoeres poeyi	blackear wrasse; doncella ojinegra		(X)	X	
Halichoeres radiatus	puddingwife; capitán de piedras			X	
Lachnolaimus maximus	hogfish; capitán	(X)	X	X	
Thalassoma bifasciatum	bluehead wrasse; rabone, cabeza azul			X	
Scaridae					
Scarus coeruleus	blue parrotfish; brindao			X	
Scarus croicensis	mottlefin parrotfish; bullón		(X)	X	
Scarus guacamaia	rainbow parrotfish; guacamayo			X	
Scarus taeniopterus	princess parrotfish; loro princesa			X	
Scarus vetula	queen parrotfish; vieja, reina			X	
Sparisoma aurofrenatum	redband parrotfish; loro			X	
Sparisoma chrysopterum	redtail parrotfish; loro		(X)	X	(X)
Sparisoma radians	bucktooth parrotfish; loro	(X)	(X)	X	X
Sparisoma rubripinne	redfin parrotfish; cotorro	X	X	X	
Sparisoma viride	stoplight parrotfish; loro verde	(X)	(X)	X	
Mugilidae					
Mugil curema	white mullet; jarea	X	X	X	X
Mugil trichodon	fantail mullet; liza	(X)	(X)	X	
Sphyraenidae					
Sphyraena barracuda	great barracuda; picua	X	X	X	X
Sphyraena guachancho	guaguanche; picua parda	X	X	X	(X)
Sphyraena picudilla	southern sennet; picuilla	X	X	X	X
Polynemidae					
Polydactylus virginicus	barbu; barbú	X	(X)	X	X
Opistognathidae					
Opistognathus maxillosus	mottled jawfish; pez quijú		(X)		
Dactyloscopidae					
Dactyloscopus tridigittatus	sand stargazer; dardo de agua	(X)			

		I	II	III	IV
Clinidae					
Acanthemblemaria aspera	roughead blenny; viejita, blenio			(X)	
Acanthemblemaria spinosa	spiny head blenny; viejita, blenio			(X)	
Coralliozetus cardonae	twinhorn blenny; viejita, blenio		(X)	(X)	
Enneanectes boehlkei	roughhead triplefin; viejita, blenio			X	
Labrisomus buccifer us	puffcheek blenny; viejita, blenio		(X)	(X)	
Labrisomus gobio	palehead blenny; viejita, blenio			(X)	
Labrisomus guppyi	mimic blenny; viejita, blenio			(X)	
Labrisomus haitiensis	longfin blenny; viejita, blenio			(X)	
Labrisomus nigricinctus	spotcheek blenny; viejita, blenio			X	
Labrisomus nuchipinnis	hairy blenny; viejita, blenio		(X)	X	(X)
Malacoctenus aurolineatus	goldline blenny; viejita, blenio		(X)	(X)	
Malacoctenus delalandii	Brazilian blenny; viejita, blenio				(X)
Malacoctenus erdmani	imitator blenny; viejita, blenio			(X)	
Malacoctenus gilli	dusky blenny; viejita, blenio		(X)	(X)	(X)
Malacoctenus macropus	rosy blenny; viejita, blenio		(X)	(X)	(X)
Malacoctenus triangulatus	saddled blenny; viejita, blenio			X	
Paraclinus cingulatus	coral blenny; viejita, blenio			(X)	
Paraclinus fasciatus	banded blenny; viejita, blenio			X	
Paraclinus nigripinnis	blackfin blenny; viejita, blenio			(X)	
Stathmonotus stahli	eelgrass blenny; viejita, blenio			(X)	
Blenniidae					
Entomacrodus nigricans	pearl blenny; blenio perlado			X	
Hypleurochilus aequipinnis	oyster blenny; blenio ostra			(X)	
Hypleurochilus springeri	orangespotted blenny; blenio				(X)
Ophioblennius atlanticus	redlip blenny; blenio			X	
Eleotridae					
Erotelis smaragdus	emerald sleeper; guavina esmeralda			(X)	(X)
Gobiidae					
Bathygobius curacao	notchtongue goby; gobio		(X)	(X)	(X)
Bathygobius mystacium	island frillfin; gobio, guaseta				(X)
Bathygobius soporator	frillfin goby; gobio		(X)	(X)	
Coryphopterus dicrus	colon goby; gobio			X	
Coryphopterus glaucofraenum	bridled goby; gobio			(X)	
Ginsburgellus novemlineatus	ninelined goby; gobio			(X)	

		I	II	III	IV
Gobiidae- *cont.*					
Gobionellus boleosoma	darter goby; gobio			(X)	(X)
Gobiosoma dilepis	orangeside goby; gobio			X	
Gobiosoma evelynae	sharknose goby; gobio			X	
Gobiosoma prochilos				X	
Quisquilius hipoliti	rusty goby; gobio		(X)		
Acanthuridae					
Acanthurus bahianus	ocean surgeon; médico			X	
Acanthurus chirurgus	doctorfish; médico	X	(X)	X	
Acanthurus coeruleus	blue tang; cirujano			X	
Trichiuridae					
Trichiurus lepturus	cutlassfish; machete	X	X	(X)	
Scombridae					
Scomberomorus cavalla	king mackerel; carita	(X)	(X)	X	
Scomberomorus regalis	cero; alasana	X	X	X	X
Euthynnus pelamis	skipjack tuna; bonito			X	
Stromateidae					
Nomeus gronovii	man of war fish; pastor			(X)	
Peprilus alepidotus	harvestfish; papito		X	(X)	
Scorpaenidae					
Scorpaena bergii	gousehead scorpionfish; rascana			(X)	
Scorpaena grandicornis	grass scorpionfish; rascana		X	(X)	
Scorpaena plumieri	spotted scorpionfish; rascana			(X)	
Triglidae					
Prionotus roseus	bluespotted sea robin; gallina				(X)
Dactylopteridae					
Dactylopterus volitans	flying gurnard; gavilán			(X)	
Bothidae					
Bothus lunatus	peacock flounder; lenguado		(X)	X	
Syacium micrurum	channel flunder; lenguado		(X)		
Soleidae					
Achirus lineatus	lined sole; lenguado				(X)
Gymnachirus nudus	naked sole; lenguado			(X)	

		I	II	III	IV
Balistidae					
Aluterus schoepfi	orange filefish; lija anaranjada			X	
Aluterus scriptus	scrawled filefish; lija garrapateada			X	
Balistes vetula	queen triggerfish; peje puerco			X	
Cantherhines pullus	orangespotted filefish; lija			X	
Monacanthus ciliatus	fringed filefish; lija frangeada		(X)		
Monacanthus setifer	pigmy filefish; lija			(X)	
Ostraciidae					
Lactophrys bicaudalis	spotted trunkfish; chapín			X	
Lactophrys polygonia	honeycomb cowfish; chapín			X	
Lactophrys quadricornis	scrawled cowfish; chapín			X	
Lactophrys trigonus	buffalo trunkfish; chapín			X	(X)
Lactophrys triqueter	smooth trunkfish; chapín			X	
Tetraodontidae					
Canthigaster rostrata	sharpnose puffer; tamboril			X	
Sphoeroides greeleyi	Caribbean puffer; tamboril		X		
Sphoeroides spengleri	bandtail puffer; tamboril			(X)	
Sphoeroides testudineus	checkered puffer; tamboril	(X)	(X)	(X)	(X)
Diodontidae					
Diodon holocanthus	ballonfish; guanábano			X	
Diodon hystrix	porcupinefish; guanábano			X	X

(X) --- Fish Species Observed by Martin and Patus (1973)

I --- Interior Bay

II --- Central Bay

III --- Reef and Offshore Islets

IV --- Mar Negro Area

APPENDIX C

Appendix C. Birds of the JOBANES Area

Pelícano Pardo - Pelecanus occidentalis - Brown Pelican

Boba Parda - Sula leucogaster - Brown Booby

Tijerilla - Fregata magnificens - Magnificient Frigatebird

Garzón Cenizo - Ardea herodias- Great Blue Heron

Martinete - Butorices viescens - Great Heron

Garza Azul - Florida caerulea - Little Blue Heron

Garza Ganadera - Bulbulcus ibis - Cattle Egret

Garza Real - Casmerodius albus - Great Egret

Garza Blanca - Egretta thula-- Snowy Egret

Garza Pechiblanca - Hidranassa tricolor - Louisiana Heron

Yaboa comun Nyctanassa violacea - Yellow-crowned Night Heron

Coco Prieto - Plegadis falsinellus - Glossy Ibis

Pato Quijada Colorada - Anas bahamensis - Bahama Duck

Pato Zarcel - Anas discors - Blue-winged Teal

Aguila de Mar - Pandion haliaetus - Osprey

Falcón Peregrino - Falco peregrinus - Peregrine Falco

Falconcito - Falco sparverius - American Kestrel

Pollo de Mangle - Rallus longilostris - Clapper Rail

Gallareta Común - Gallinula chloropus - Common Gallinule

Playero Acollardo - Charadrius semipalmatus - Semipalmated Plover

Playero Blanco - Charadrius alexandrinus - Snowy Plover

Playero Marítimo - Charadrius wilsonis - Wilson's Plover

Playero Sabanero - Caharadrius vociferus - Killdeer

Playero Turco - Arenaria interpres - Ruddy Turnstone

Playero Pico Corvo - Numenius phaecopus - Whimbrel

Putilla - Actitis macularia - Spotted Sandpiper

Playero Guineilla Grande - Tringa melanoleuca - Greater Yellowlegs

Playero Guineilla Pequeña - Tringa flavipes - Lesser Yellowlegs

Playero Aliblanco - Catoptrophorus semipalmatus - Willet

Playero Gordo - Calidris canutus - Red Knot

Playero Manchado - Calidris melanotus - Pectoral Sandpiper

Playerito Menudo - Calidris minutilla - Least Sandpiper

Playero Patilargo - Micropalama himantopus - Stilt Sandpiper

Viuda - Himantopus mexicanus - Black- necked Stilt

Gaviota - Larus argentatus - Herring Gull

Gaviota Cabezinegra - Larus atricilla - Laughing Gull

Gaviota Pico Corto - Gelochelidon nilotica - Gull - billed Tern

Gaviota - Sterna hirundo - Common Tern

Gaviota pequeña - Sterna albifrons - Least Tern

Gaviota Real - Sterna maxima - Royal Tern

Gaviota de Pico Agudo - Sterna sandvicensis - Sandwich Tern

Cervera - Anous stolidus - Noddy Tern

Paloma Cabeziblanca - Columba leucocephala - White - crowned Pigeon

Paloma Turca - Columba squamosa - Scaly - naped Pigeon

Paloma Sabanera - Columba inornata - Puerto Rican Plain Pigeon

Tórtola - Zenaida aurita - Zenaida Dove

Tórtola Aliblanca - Zenaida asiatica - White - winged Dove

Tórtola Rabilarga - Zenaida macroura - Mourning Dove

Rolita - Columbina passerina - Common Ground Dove

Cotorra Dominicana - Amazona ventralis - Dominican Parrot

Pájaro Bobo Menor - Coccyzus minor - Mangrove Cuckoo

Judío - Crotophaga ani- Smooth - billed Ani

Mucarito - Otus nudipes - Puerto Rican Screech Owl

Querequequé - Chrodeiles minor - Common Nigthhawk

Zumbadorcito - Chlorostilbon maugeus- Puerto Rican Esmerald

Zumbador Verde - Anthracothorax viridis - Green Mango

Zumbador de Pecho Azul - Sericotes holoscericeus- Green throated Carib

Martín Pescador- Megaceryle alcyon - Belted Kingfisher

Carpintero - Melanerpes portoricenses- Puerto Rican Woodpecker

Pitirre - Tyrannus dominicensis - Gray Kingbird

Juí - Myiarchus antillarum - Puerto Rican Flycather

Bobito - Contopus latirostris- Lesser Antillean

Juí Blanco - Elaenia martinica - Caribben Elaenia

Golondrina de Horquilla - Hirundo rustica - Barn Swallow

Golondrina de Cuevas - Petrochelidon fulva - Cave Swallow

Golondrina de Iglesia - Progne dominicensis- Caribbean Martin

Ruiseñor - Mimus poliglottos- Mockingbird

Zorzal Pardo - Margarops fuscatus- Pearly-eyed Thrasher

Julián Chiví - Vireo altiloquus - Black-whiskered Vireo

Reinita - Coereba flaveola - Bananaquit

Reinita Trepadora - mniotilta varia - Black and White Warbler

Canario de Mangle - Dendroica petechia - Yellow Warbler

Reinita Rayada - Dendroica striata- Blackpoll Warbler

Reinita Galana - Dendroica discolor - Prairie Warbler

Reinita Pechidorada - Parula americana - Northern Parula

Pizpita Dorada - Seirus aurocapillus - Ovenbird

Reinita Picatierra - Geothlypis trichas - Common Yellowthroat

Candelita - Setophaga ruticilla - American Redstart

Diablito - Lonchura cucullata - Bronze Mannikin

Mariquita - Agelaius xanthomus - Yellow- shouldered Blackbird

Chango - Quiscalus niger - Greater Antillian Grackle

Gorrión Barba Amarilla - Tiaria olivacea - Yellow-faced Grassquit

Gorrión Negro - Tiaris bicolor - Black- faced Grassquit

APPENDIX D

Appendix D. Jobos Bay National Estuarine Sanctuary Management Advisory Committee Members

1. Mr. Javier Blanco
   Executive Director
   Conservation Trust of Puerto Rico

2. Ms. Bárbara Cintrón
   Department of Natural Resources

3. Dr. Ariel Lugo
   Project Leader
   Institute of Tropical Forestry

4. Dr. Manuel Hernández Avila
   Director
   Department of Marine Sciences
   University of Puerto Rico

5. Mr. Donald Erdman
   Scientific Advisor
   CODREMAR

6. Dr. Braulio Jiménez
   Director
   Office of Environmental Studies

7. Mr. Sean Furniss
   Refuge Manager
   Caribbean Islands Refuges

8. Mr. Orlando Collazo
   President
   Pozuelo Fishing Association

9. Mr. José Rivera
   President
   Aguirre Fishing Cooperative

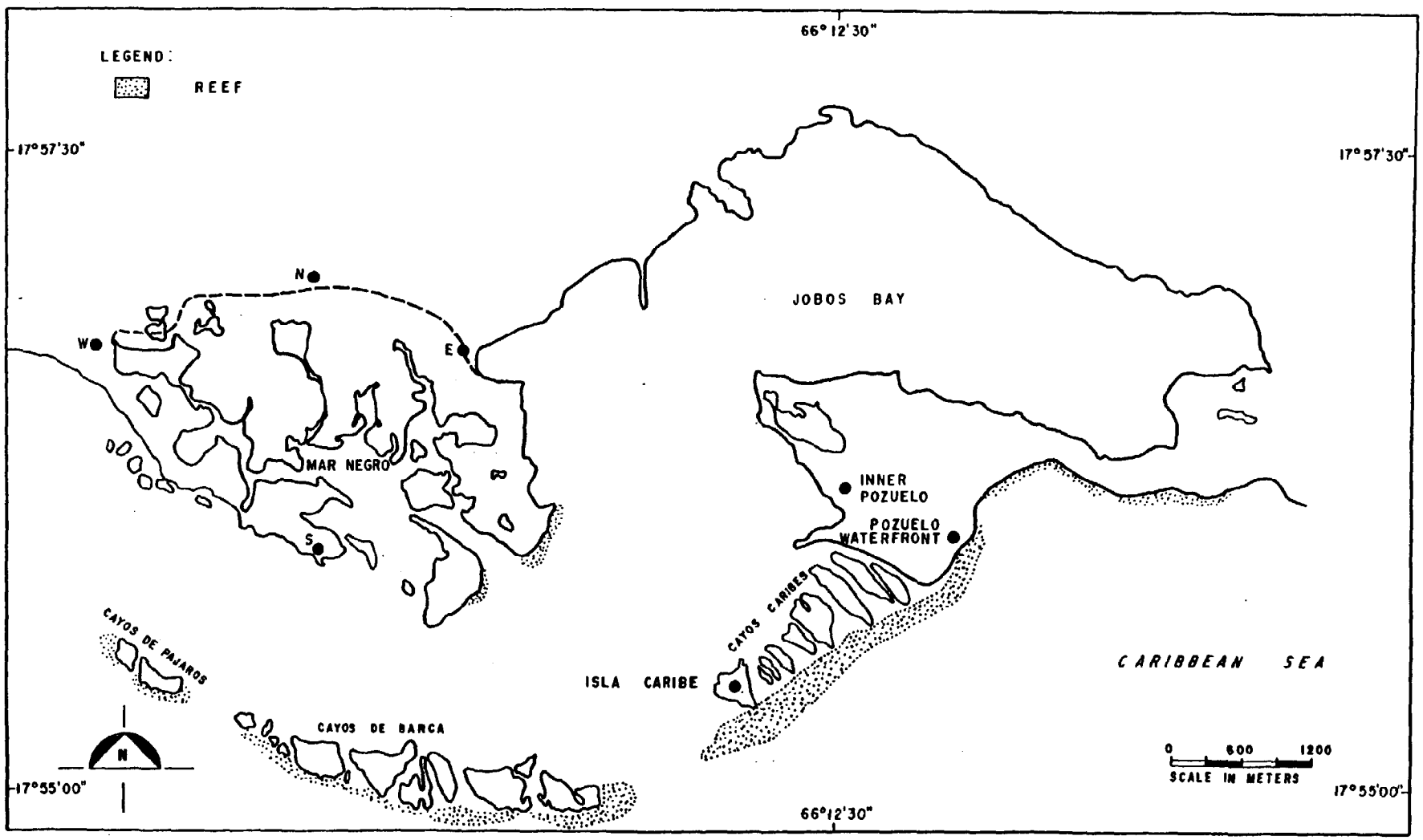
10. Dr. Eugene Crommett
    Director
    Graduate School of Architecture
    University of Puerto Rico

APPENDIX E

Appendix E- Suitability index of possible sites for the construction of the JOBANES Visitor Center

Suitability Rating --- 0 = none, 1 = low/a,poor, 2 = regular, 3 = high/a,good								
CRITERIA BASED ON EXISTING CONDITIONS ONLY	Ideal Site	Pozuelo Waterfront	Inner Pozuelo	Isla Caribe	Mar Negro			
					N	E	S	W
Road access	3	3	3	0	1	2	1	3
Road quality	3	2	2	0	1	3	1	2
Construction suitability of soil	3	2	3	3	3	1	1	1
Amount of soil's filling required	3a	2	3a	3a	3a	1a	1a	1a
Protection from waves	3	1	3	1	3	2	1	3
Property obtainability	3	3	2	3	1	1	3	3
Environmental quality								
a. Air	3	3	3	3	1	1	3	2
b. Noise	3a	3a	3a	3a	3a	1a	3a	2
c. Water	3	3	3	3	2	2	3	1
Landscape aesthetic	3	3	3	3	1	1	3	1
Wildlife	3	3	3	3	1	2	2	1
Existing trails	3	2	3	3	2	1	1	1
Population density	3a	3a	3a	0	3a	3a	3a	1a
Accessibility to								
a. Electricity	3	3	3	0	2	3	1	3
b. Tap water	3	3	3	0	2	2	1	3
c. Telephone	3	2	2	0	2	2	1	3
d. Sewage	3	1	1	0	2	2	1	1
Fast food/rest. facilities	3	3	3	0	1	1	1	2
Docking facilities	3	0	1	0	0	3	1	2
Possibility for pier	3	1	3	3	0	3	3	2
Boats density	3a	3a	1	2	0	1a	2	3a
Visitor's number control	3	3	3	2	2	3	3	1
Proximity to hospital, firehouse, and police	3	2	2	1	1	1	1	2
Total rating / Suitability Percent	69 / 100%	54 / 78%	59 / 86%	36 / 52%	37 / 54%	42 / 61%	41 / 59%	44 / 64%

APPENDIX E1.



APPENDIX E1. CANDIDATE SITES MAP FOR THE LOCATION OF THE VISITOR CENTER

DEPARTMENT OF COMMERCE
UNITED STATES
NOAA COASTAL SERVICES CENTER LIBRARY
3 6668 00000 5217