APÉNDICE K

ESTUDIO ARQUEOLÓGICO SUB-ACUÁTICO

SUBMERGED CULTURAL RESOURCES SURVEY
CENTRAL GUANICA ECO-RESORT
GUANICA BAY, PUERTO RICO

STAGE IA
BACKGROUND LITERATURE SEARCH
& FIELD INSPECTION

SUBMITTED TO:

CSA ARCHITECTS & ENGINEERS
MERCANTIL PLAZA, MEZZANINE SUITE
SAN JUAN, PUERTO RICO 00918
&
PUERTO ENSENADA DEVELOPMENT CORPORATION (PEDC)

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REQUESTED BY THE STATE HISTORIC CONSERVATION OFFICE
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Executive Summary

Submerged Cultural Resources Survey, Stage IA
Central Guánica Eco-Resort
Guánica Bay, Puerto Rico

Jesus Vega, Ph.D.

The Submerged Cultural Resources Survey, Stage IA, Central Guánica Eco-Resort, was conducted on behalf of CSA Architects and Engineers, per request of the State Historic Conservation Office and the Council for Underwater Archaeology, Commonwealth of Puerto Rico.

The purpose of the study was to evaluate the project's potential impact on submerged cultural resources, historic and prehistoric. The proposed project is the restoration and waterfront development of the Central Guánica, or the Historic Guánica Sugar Mill, including construction of a marina and yacht club, the excavation of a navigational channel on the W side of Punta Pera, a ferry dock and boat slip, sport diving and kayaking tours, etc. The proposed docking facilities will extend from the south side of Punta Pera, to the NW corner of Bahía Noroeste.

The evaluation was based on extensive historic and environmental background data, with a preliminary field photo-inspection. The study was completed on August 7, 2001.

Results:

Extensive coastal and maritime human activity has taken place at Guánica Bay and at the now submerged insular shelf since early prehistoric times.

Preliminary environmental reconstruction indicates that, as late as 6,000 yrs BP, Guánica Bay was a coastal valley of the Río Loco. These lands were probably oocupied by preceramic peoples. Afterwards, marine transgression created a huge, shallow, estuarine environment, almost certainly exploited by late preceramic peoples. The present configuration of the bay (excluding modern fill and dredging) probably occurred around 4,000 yrs BP, followed by the arrival of prehistoric ceramic peoples about 2,000 yrs BP.

Significant historic events include the exploration of the bay since1508; an incipient settlement and salt works in 1510; the aboriginal attack of 1580; the English attack of 1743, resulting in the shipwreck of a packet boat or paquebot; the entry of contraband vessels throughout the 17^{th}, 18^{th} and 19^{th} centuries, and the intensive shipping activity of the Central Guánica since1901. Construction of the Guánica sugar mill included an industrial pier, and the filling of the shallow channel between

Puercos Islet and the west coast of the bay (thus forming the shipping area of Punta Pera).

Other significant historic events include the escape of Ramón Emeterio Betances and Segundo Ruíz Belvis through Guánica Bay in 1867, and the U.S. invasion during the Spanish-American War in 1898.

The geoarchaeological and historical background data indicates that Guánica Bay is highly sensitive to submerged cultural resources, both historic and prehistoric.

In terms of actual sites within the Study Area, the previous conclusion simply states a high probability of potentially significant resources, potentially eligible to the National Register of Historic Places, including the following:

- Submerged prehistoric sites due to eustatic changes in sea level
- Aboriginal canoes, including prehistoric and historic eras
- Historic shipwrecks, 16^{th} to mid-20^{th} centuries
- Historic port discards, primarily early to mid-20^{th} century.

Recommendations:

In order to test the probability of submerged cultural resources within the Study Area, it is necessary to conduct a combined methodology of marine remote sensing, underwater coring and visual inspection.

The recommended primary instrumentation for the remote sensing is a proton magnetometer. This is the standard tool for locating historic shipwreck sites, by detecting magnetic anomalies caused by ferrous objects such as cannon, anchors, chains, and other iron items generally found in historic shipwrecks. Significant magnetic anomalies should be inspected with underwater cameras, hand-held metal detectors and other underwater survey tools.

For detecting aboriginal watercraft and submerged prehistoric sites, both lacking in iron objects, a combination of sub-bottom profiling, visual inspection and underwater coring is recommended. This methodology is also effective for detecting historic port discards, generally including bottles and glass fragments, ceramics, shell, bones, etc.

At present, the Study Area is polluted beyond safe levels of standard scuba diving. Therefore, dry suits are considered essential for diving work. Underwater coring in shallow areas (<3m) may also be conducted from a boat. This method has been used by the author for underwater archaeological coring at Condado Lagoon and at San Juan Bay.

The recommended methodology is part of the Stage I level of investigation, but is often labeled as Stage IB, in order to differentiate between the background investigation, which defines sensitivity or probability (Stage IA, this report), and the field testing which defines actual sites within the area of potential adverse effects.

In conclusion, the recommendations for the IB marine survey include a magnetometer and sub-bottom profile survey of the Study Area, followed by diving inspection of anomalies and underwater coring of selected areas, at 10m intervals.

1. Introduction

This report documents the methodology and results of the Submerged Cultural Resources Survey, Stage IA, Background Literature Search and Field Inspection, for the Central Guánica Eco-Resort, Guánica Bay, on the south coast of Puerto Rico (Figure 1).

The investigation reported herein was conducted on behalf of CSA Architects and Engineers, San Juan, Puerto Rico, per request of the State Historic Conservation Office and the Council for Underwater Archaeology, San Juan, Puerto Rico.

This report is limited to the study of submerged cultural resources, prehistoric and historic, with a separate report for terrestrial cultural resources. The separation between terrestrial and maritime cultural resources is strictly logistical, with possible integration of data as the evaluation process is narrowed down to specific historic periods and archaeological sites.

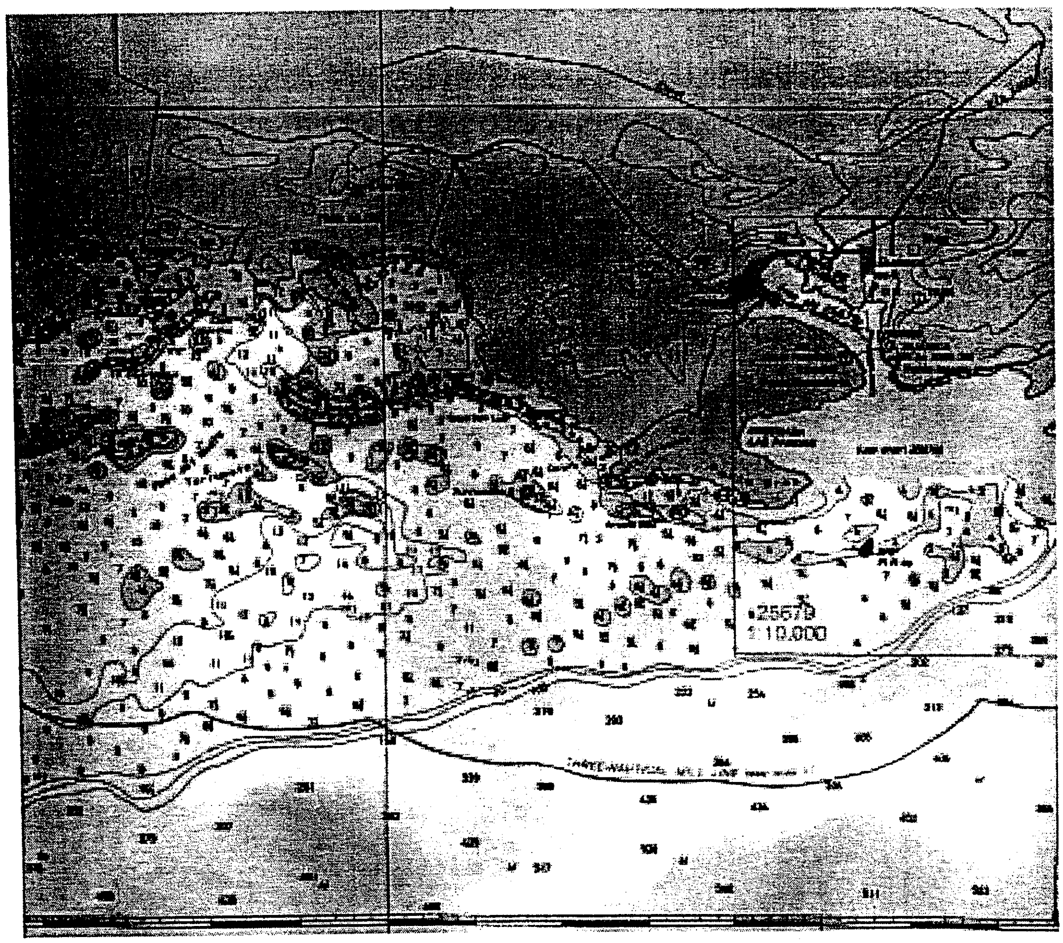

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Figure 1. Location Map, Guánica, south coast of Puerto Rico.
From left to right: Parguera, Bahía Montalva, Caleta Salinas, Ensenada Las Pardas and Guánica Bay. NOAA 25671,17th Ed., 1992.

1.1 Study Area

The Study Area includes the pier and submerged lands off the Central Guánica, from the south side of Punta Pera to the NW corner of Bahía Noroeste, on the west side of Guánica Bay, south coast of Puerto Rico (Figures 2 and 3).

The sediments at the Study Area are mostly fine sand and silt. The maximum existing depth at Guánica Bay is 29 ft. (8.8m). At present, the Study Area is polluted beyond safe levels of standard scuba diving. Therefore, dry suits are considered essential for diving work. An in-depth description of the Study Area is provided in subsequent sections of this report.

1.2 Proposed Project

The proposed project is the Central Guánica Eco-Resort, to be developed by Punta Ensenada Development Corporation (PEDC), San Juan, Puerto Rico. The project will preserve the historic zone of the Central Guánica, through the creation of a Marine Village along the west side of Bahía Noroeste and around Punta Pera. As presented in the PEDC Development Proposal, the Marine Village will include six (6) pier areas for yachts and smaller recreational vessels (Figure 4).

As part of the undertaking, the Central Guánica Eco-Resort must comply with all Commonwealth and Federal regulations, including the detection, evaluation and preservation of historic and archaeological resources.

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Figure 2. Guánica Bay, Topographic Map, Guánica Quadrangle, USGS 7.5 Minute Series,1966.

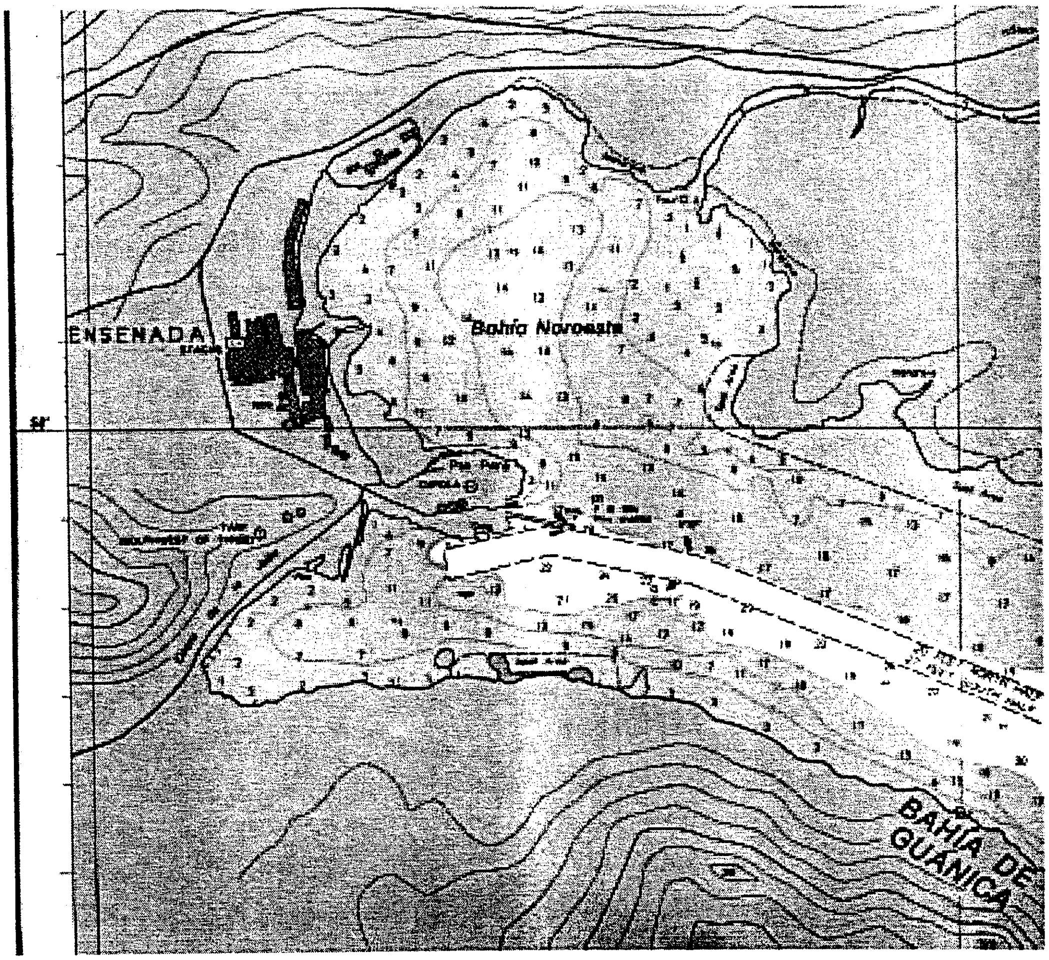

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Figure 3. Study Area, East Guánica Bay. NOAA 25679, Bahía de Guánica, 9th Ed., 1990. Soundings in Feet.

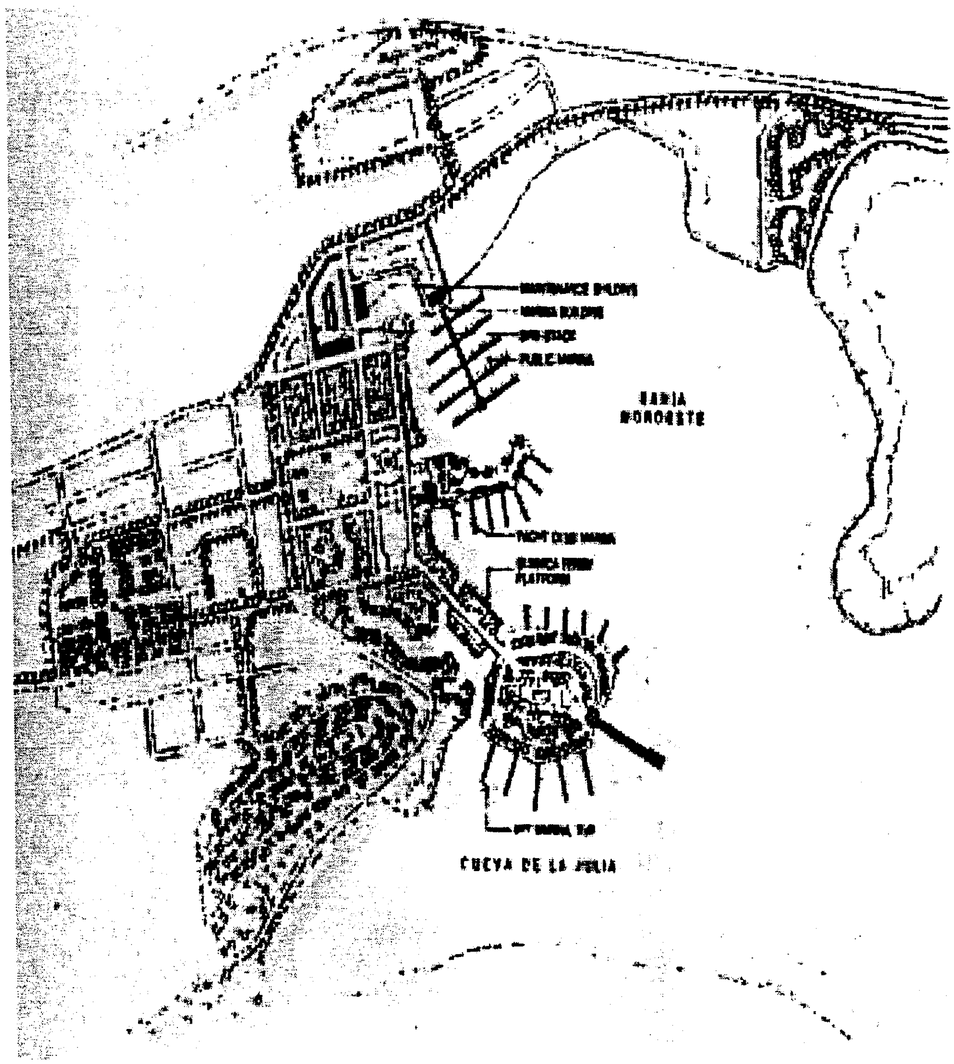

Figure 4. Preliminary sketch of marina facilities, Central Guánica Eco-Resort.

1.3 Objective of the Study

As part of the evaluation process of the Central Guánica Eco-Resort, and in compliance with Section 106 of the National Historic Preservation Act of 1966 as amended (16 U.S.C. 470) and Puerto Rico Law Number 10 of 1987, a Submerged Cultural Resources Survey, Stage IA, was conducted for CSA Architects & Engineers, per requirements of the State Historic Conservation Office and the Council for Underwater Archaeology, Institute of Puerto Rican Culture.

The purpose of the study was to conduct a background literature search on known and potential submerged archaeological sites, historic or prehistoric, within the Study Area, with a preliminary coastline inspection.

The information generated by the Stage I assessment determines the sensitivity of an area to specific types of cultural resources, providing a first-line research design or framework for cultural resource management (CRM), and recommending additional studies, if necessary.

The initial research may include a Reconnaissance Survey (Stage IB), designed to locate actual archaeological sites or features in the field. In most marine projects, the standard methodology involves a magnetometer survey with inspection of diving anomalies. This methodology is highly effective for detecting historic shipwreck sites, but will not detect prehistoric sites or aboriginal canoes, because these sites do not contain iron objects detected by the magnetometer. In order to account for both historic and prehistoric sites under water, predictive models are essential. Models help us define areas of high probability, as well as predict the probable size, shape and materials of our target sites. Armed with this theoretical information, researchers may then test the sensitive areas with a combination of remote sensing, visual inspection, and underwater coring.

1.4 Dates of the Study

Library and archival research was conducted through the month of July, 2001. The initial field inspection was conducted on August 6, 2001. The Final Report was completed on August 7, 2001.

1. Environmental Background

This section provides environmental data on the Study Area, with emphasis on physical geography, coastal geomorphology, and oceanography. Environmental information is essential to archaeology, both to understand present conditions and their potential for preserving or destroying the archaeological record, and as the first step for reconstructing past environmental conditions. As a general rule, the further we travel into the past, the greater the possibility of environmental changes.

All human activity, past or present, occurs within a dynamic biophysical setting, involving a complex interrelationship of solar radiation, climate, geological structures and rocks, ocean currents, rivers, soils, plants, animals, microorganisms, etc. From the perspective of the environmental sciences, all of these organic and inorganic variables may be grouped within four basic components: atmosphere, hydrosphere, lithosphere and biosphere (Butzer 1982:16). By considering all past human activity within these four components, archaeology becomes an extremely complicated and difficult discipline, with nearly unlimited questions about how our species interacts with the world around us.

2.1 Physical Geography of Puerto Rico

Puerto Rico is approximately 161 km (100 miles) long and 56 km (35 miles) wide. The island is divided north-south by a central mountain chain of volcanic and plutonic igneous rocks. About 40% of Puerto Rico is mountain terrain, with 35% hill and 25% level (Picó 1974:26). The highest elevation is Cerro Punta, towards the center of the island, with an altitude of 1,338m (4,390 ft.). Prominent peaks also rise on the northeastern section of the island, at the Luquillo Range, reaching a maximum elevation of 1,074 m (3,532 ft.).

Although the size and elevation of islands might seem like "hard facts" which remain constant through time, in fact both are relative to the global or eustatic sea level. As discussed in detail in section 3 of this report, periods of lower sea level imply larger islands with higher peaks. Thus, even something as "simple" and "well known" as the size and elevation of Puerto Rico, will not apply to the prehistoric environment of 10,000 years ago.

Puerto Rico's insular shelf is narrow off the north (N) coast, and wide off the east (E) and southwest (SW) coasts. The composition of the coastline ranges from unconsolidated sediments, to limestone and igneous rock formations. Of 740 km of coastline, 20% are beaches, which are generally short and divided into separate systems with little interaction (Morelock and Trumbull 1985:187). Tides average about 30 cm (1 ft.). Shorelines exhibit great variation, with five generalized types in six separate sections (Kaye 1959:51).

The north coast is characterized by high energy beaches and limestone cliffs. In contrast, the south coast is mostly low-energy mangrove. Both the east and west coasts exhibit fault control (Morelock and Trumbull 1985).

Sea surface temperatures range from 82.5°F in September, to 77.9°F in February. Largely due to the moderating effect of the sea, Puerto Rico's median temperature of 79°F at sea level varies within the relatively narrow range of 5.9°F through the year. This narrow temperature range leads many people, archaeologists included, to the idea that Puerto Rico lacks seasonal variation: the land of eternal summer. On the contrary, if we try to reconstruct the lifeways of people who were navigators, fishermen, hunters, gatherers or planters, we must recognize significant seasonal variations in winds, currents, waves, air and sea temperatures, rain, etc. This is true both for the aboriginal peoples of prehistory, and for the Spanish and criollo farmers and fishermen of history.

Most rainfall and river discharge is to the north, with a semi-arid south coast. Rain is most abundant at El Yunque Rain Forest on the northeast, with over 5 m (200 inches) of annual rainfall. The southwest is the driest part of the island, with an average annual rainfall pf 1 m (40 inches).

Puerto Rico's position on the northeast corner of the Caribbean Basin exposes it to the mainstream of the Great Northern Equatorial Current (GNEC). This powerful ocean current originates off the West African coast and crosses the Atlantic Ocean in clockwise fashion, veering north as it touches the Caribbean.

The influence of the GNEC provides an additional element of humidity to the island's tropical climate. The sea-land breezes generally blow offshore at night and a dawn (when the land is cooler than the surrounding ocean), ad inshore during the daytime (when the sea is cooler).

The island is also affected by hurricane winds, which are frequent in the Caribbean during the warmest months, from June to November. In general, hurricanes follow the WNW path of the trade winds.

From the perspective of maritime archaeology, hurricanes are extremely important as a primary cause of shipwreck. In fact, the earliest known historic shipwrecks potentially found in Puerto Rico's waters, are the ships of Francisco de Bobadilla's fleet of 1502, with up to sixteen vessels destroyed by hurricane winds somewhere within Mona Passage, between Puerto Rico and the Dominican Republic (Cardona 1989:23-39).

Puerto Rico has approximately 1,300 streams, of which seventeen (17) form true river systems. The largest rivers flow to the north, where low drainage results in swamps and march lagoons. At face value, there appears to be a spatial relationship between rivers and aboriginal chiefdoms, or *cacicazgos*. Many of the primary settlements were located near large rivers, which provided water, diverse sources of food and natural "water roads" between the coast and the interior. Consider, for instance, the names Bayamón, Loíza, Canóbanas, Turabo, Humacao, Maunabo, Guaraní, Guayanilla, Yauco, Guanajibo, Gurabo, Yagüez, Guajataca, Camuy, Tanamá, Arecibo, Manatí and Cibuco, all names of rivers associated with aboriginal *caciques*.

Puerto Rico's soils show great variation. Only about 6% or 129,000 acres are classified at present as first rate. About 75% of the island's soils are considered of inferior quality, located mostly in the mountainous interior (Picó 1974:214).

2.2 The South Coast

The south coast of Puerto Rico is mostly indented, low energy, with alternating limestone headlands and alluvial embayments. Beginning on the SE at Punta Guayanés and moving west, the south coast includes the bays of Yabucoa, Patillas, Jobos, Salinas, Rincón, Ponce, Tallaboa, Guayanilla, Guánica, Montalva, Parguera, Sucia and finally Salinas at the SW tip of Puerto Rico.

The south coast is also characterized by numerous islets and shallow reefs, including, moving east to west, Arrecife Sargent, Arrecife Guayama, Bajo Guilarte, Arrecife Mareas, Cayos Caribes, Cayos de Barca, Cayos de Pájaros, Cayo Morillo, Cayos de Ratones, Arrecife Media Luna, Cayo Alfeñique, Cayos de Caracoles, Cayos Cabezazos, Cayo Berbería, Isla Caja de Muertos, Isla del Frío, Isla de Cardona, Cayo Arenas, Isla de Ratones, Cayo Parguera, Cayo Caribe, Cayo Río, Cayo Palomas, Cayo María Langa, Arrecife Guayanilla, Arrecife Fanduco, Arrecife Unitas, Cayos de Caña Gorda, Arrecife Baúl, Turrumote II, Cayo Don Luis, Arrecife Romero, Arrecife Enmedio, Turrumote I, Arrecife Media Luna, Isla Magueyes, Arrecife Margarita, El Palo, isla Guayacán, Isla Cueva, and other minor, nameless reefs and islets. Most of these islets and reefs are potential locations of archaeological sites, including historic shipwrecks and submerged or intertidal shell middens. Prehistoric archaeological sites on the south coast and offshore islets are discussed in section 3, followed by historic ports in section 4, and historic shipwrecks in section 5.

Unlike the north coast, which is characterized by a prevalence of eolianite and beachrock, the south coast has no reported eolianite and only a minor presence of beachrock on the present shoreline (Kaye 1959:67-101).

Eolianite is wind-deposited sand cemented by calcium carbonate (CaCO3). In Puerto Rico, eolianite or cemented dunes may reach a height of 30 m (100 ft.) or more. On the north coast, San Juan's fortresses of El Morro and San Cristobal rise atop eolianite, of which four generations of cemented dunes are recognizable (E1-E4), each separated by a layer of ancient soils or peleosols.

Beachrock is cemented sand or shingle. As in eolianite, the cementing agent is calcium carbonate, with rare instances of cementation by iron oxides. Beachrock forms a hard pavement along the shore. When found under water, it clearly indicates that marine transgression or has taken place. The pavement generally dips at a slight angle towards the sea, and may reach a width of 60 m (200 ft.) or more. Frills or grooves perpendicular to the shore are often formed on the pavement, produced by mechanical abrasion.

Both brachrock and eolinaite are associated with high energy coasts, which appears to be the best explanation for their absence or limited presence on the south coast, which is mostly low-energy. Other geomorphological and biological factors might also be involved in this significant difference between Puerto Rico's Atlantic north coast and the Caribbean south coast.

The south coast of Puerto Rico generally consists of a narrow plain, often associated with faults and folds of sedimentary rocks. This is in marked contrast to the wide coastal plain of the north coast. Thus, the distance from shore to the hills tends to be smaller along the south coast, and the hills tend to be steeper as well (Bush et al. 1995:1-6).

The geology of the south coast consists primarily of Quaternary alluvial deposits and Miocene to Oligocene limestone, with Tertiary and Cretaceous volcanic deposits towards the west end of the island (Morelock 1978; Morelock and Trumbull 1985).

The geology of Guánica is characterized by the Juana Diaz Formation and the overlying Ponce Limestone (Tpj), undivided at present, and the Parguera Limestone (upper member Kpu and lower member Kpl). The Juana Diaz Formation and Ponce Limestone are dated in the Miocene and Oligocene Epoch of the Tertiary Period, roughly 25 to 30 million yrs BP. The Parguera Limestone is dated in the Cretaceous, about 66 million yrs BP.

The Juana Diaz Formation is reddish-brown to reddish-orange, ith interbedded sand and medium-to-coarse grained gravel, sand and cobbles, poorly cemented with calcite and hematite, generally overlain by sandy mudstone grading into limestone and chalk, and underlain in angular unconformity by volcanic and sedimentary rocks.

The Ponce Limestone is yellowish-white to yellowish-orange, made up of poorly cemented calcidurite and calcarenite, rich in oyster shells, with minor corals and gastropods. A layer of caliche or calcium carbonate crust (1-3m) is common, generally containing fragments of the underlying calcidurite and calcarenite.

The Parguera Limestone is exposed south of the Lajas Valley. This formation lies on serpentines, cherts and amphibolites of the Bermeja Complex, and locally on volcanic rocks of the Lajas Formation and Boquerón Basalt.

The Río Loco controls the hydrology of Guánica. Originating in the hills of Sabana Grande, the Loco River is about 22km long. This river originally flowed into Guánica Lagoon, which dried out after constructin of the Lajas Valley Irrigation Works in 1949. At present, the Río Loco flows into the Caño de Los Negros, which connects to the NE corner of Bahía Noroeste. The Loco River Dam was built in 1954, in Lajas.

The Loco River was called the Guánica River in the 16th century, the cacique River in the 19th century, the Susua River in the early 20th century, and finally Loco or "Crazy River" in modern times (Rivera Fontán 1995:8).

According to local folklore, the river's name is due to its erratic behavior, presumably changing course at least once.

The final run of the Loco River along the east side of the Abra Hills is a significant feature, exposing outcrops of the Juana Diaz Formation, eroding various prehistoric archaeological sites, providing a natural barrier on the west side of the river, and increasing the flood potential to the east of the river, including the towns of Guánica and La Luna. The alluvium deposits of the Loco River consist of clay, sand, gravel and boulders of volcanic rock (Monroe 1977).

2.3 The South Insular Shelf

The insular shelf is the submerged land that extends from the shoreline to the insular slope, where the coastal waters more or less abruptly deepen into the open ocean. The frontier between the relatively shallow shelf and the slope is sometimes called the shelf break. In Puerto Rico, the shelf break may be defined from about 50 to 100 m. To the north, the slope descends steeply towards the Puerto Rico Trench, the deepest area of the Atlantic Ocean. Ninety-five miles north of Puerto Rico, the Trench reaches a depth of 9,219 m (30,245 ft.), with enough vertical space to accommodate Mount Everest. To the south, the Puerto Rico slope descends towards the depths of the Venezuelan Basin, among the deepest areas of the Caribbean Sea, with an average depth of 5000 m.

The insular shelf must not be confused with the territorial sea, which is measured at three nautical miles from the shoreline. The territorial sea is a legal and geopolitical concept, where nations have exclusive rights to marine resources. In some areas, the territorial sea and the insular shelf might coincide, but the latter is an oceanographic concept.

From a geoarchaeological perspective, the insular shelf may be defined as the submerged lands that were exposed during the Wisconsin glacial maxima, and were actually or potentially occupied by prehistoric peoples whose sites were later flooded by the rising sea level.

From the perspective of historical archaeology, the insular shelf is where most historic shipwrecks were lost, mostly due to groundings, storms and hurricanes, battles or fire. Although many important sites lie in deep waters, the insular and continental shelves are likely to remain the primary areas of undersea archaeological research during the 21st century.

According to the marine geologic map for the Puerto Rico Insular Shelf, Guánica to Ponce (Trías1991), the insular shelf off Guánica is defined at the 50 m contour. For this area, the most prominent feature of the insular shelf is the Guayanilla submarine canyon system.

The Guayanilla submarine canyon system includes Guánica, Guayanilla, Cuchara and Muertos Canyons (Trumbull and Garrison 1973). The system is also fed by the smaller, tributary canyons of Punta Ventana and Tallaboa Canyons (Trías 1991). All of these submarine canyons are found opposite existing rivers on the south coast.

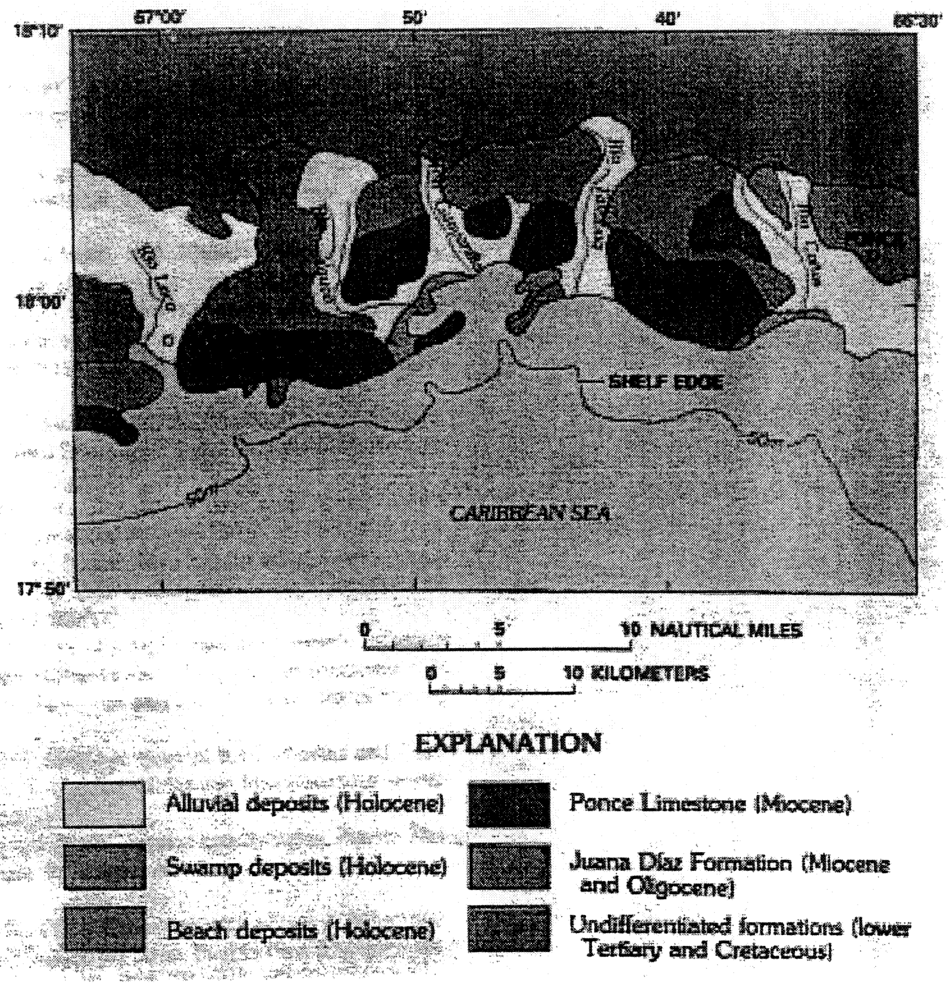

Figure 5. Generalized geology of Guánica and Ponce. Marine Geology Map of the Puerto Rico Insular Shelf, Guánica to Ponce Area (Trías 1991).

Trumbull and Garrison (1973) have postulated that the shallow parts of the submarine canyons have a subaerial origin, formed when the insular shelf was exposed by a lower sea level of the Wisconsin glaciation. At that time, Puerto Rico's shoreline was located on the present insular shelf. Cuchara Canyon may be an older extension of the Río Cañas system, but was closed by uplift.

At the west end of the submarine canyon system is Guánica Canyon. This canyon is presumed to be the submerged extension or paleo-channel of the Loco River in Guánica. During the Wisconsin glaciation and early to mid-Holocene, Guánica Bay was a coastal valley with the Río Loco running through it.

The presence of the Guayanilla submarine canyon system is highly significant to this investigation, for it provides clear, geomorphological evidence that Puerto Rico's insular shelf was exposed during the Wisconsin glaciation and inundated in the Holocene Epoch. The secondary influence of tectonic uplift is also suggested, but on a much smaller scale than the eustatic or global sea level changes. The archaeological implications of these processes are discussed in section 3 of this report.

2.3 Guánica Bay

Guánica Bay is regarded as one of the best hurricane harbors in Puerto Rico. Located 16 nautical miles east (E) of Cabo Rojo Light, Guánica Bay is protected by an elevated coast on the east and west sides, and by coastal hills to the north. To the east is Cerro Caprón, to the west is Monte Las Pardas, and to the north is the Cerro de Abra, which is known to archaeologists as an area of numerous prehistoric sites.

Guánca Bay is the only pouch-shaped harbor in Puerto Rico. This type of bay is particularly common in Cuba. Some researchers have suggested that pouch-shaped bays are the product of drowned river mouths (Kaye 1959:53).

The entrance to the bay is located about 2km south of the town of Guánica, and is protected by the steep shores of Punta Meseta to the east, and Punta Pescadores to the west. The most prominent cultural feature at the entrance is Guánca Light (17°57.2'N., 66°54.3'W.), and 132 ft. (40.23m) above mean sea level (MSL). A second, abandoned lighthouse tower is located about 100m SE of the operating light (NOAA 1991:312-313). Another operating light is found at the northeast end of the bay, at Playa de Guánica.

Both sides of the entrance have inshore reefs. The entrance channel was privately dredged for the Central Guánica, which operated from 1901 to 1981 (Ramos 1999). The channel's controlling depths for 1970 were 21 ft. in the turning basin, 26 ft. for the north channel leading towards the town of Guánica, and 2t ft. for the west channel towards the Central Guánica's pier at Punta Pera (ibid.).

The principal anchorage is 0.6 mile E of the Central Guánica pier. The fishing pier is located at Playa de Guánica. Parts of the south shore of Cueva de la Julia, about 300m S of Punta Pera, have been informally occupied by house boats, gradually creating an anhorage of recreational boats. The pilots and boats of Guayanilla Bay also serve Guánica Bay.

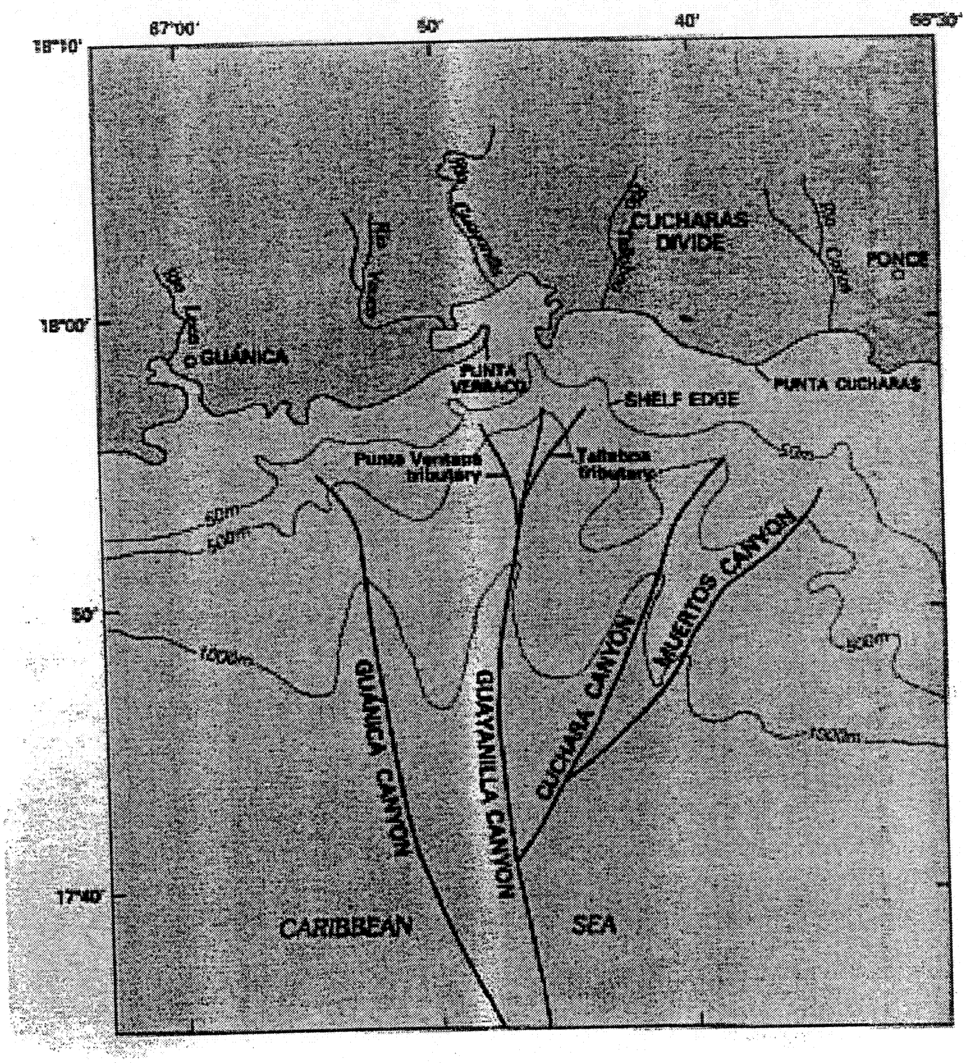

Figure 6. Guayanilla submarine canyon system (Trías 1991). Notice Guánica Canyon leading towards the entrance of Guánica Bay. This canyon is presumed to be the paleo-stream of the Río Loco during the Wisconsin Glaciation, across the now submerged insular shelf. Just as prehistoric ceramic sites clustered around the Río Loco, preceramic sites probably clustered around its paleo-stream, then running along Guánica Bay and into the insular shelf.

The bottom sediments within Guánica Bay are primarily silt and clay (Unit 1) and silt and fine sand (Unit 2). Unit 1 contains fine rock fragments, and carbonate constituent such as pelecypods and echinoderms (Trías 1991).

Dangers to navigation include the Cayos de Caña Gorda and Arrecife Coral, both located E of the entrance; Corona La Laja, located SSE of the entrance; the reefs at Ensenada Las Pardas, W of the entrance, and the inshore reefs on both sides of the entrance itself. Some of these reefs offer good to excellent locations for scuba diving, as well as the possibility of historic shipwrecks.

Punta Pera has two small wharves on the south side, as well as pipelines for water, fuel and molasses, and a conveyor system for bulk sugar. The long pier off the E end of Punta Pera is called the Dominican Dock by the U.S. Coastal Pilot, and was built specifically for loading sugar cane from the Central Guánica, on ships bound for the Dominican Republic.

3. Submerged Prehistoric Sites

This section addresses the probability of submerged prehistoric sites within Guánica Bay, including the separate but related topic of aboriginal watercraft. Submerged terrestrial sites may include shell middens, lithic quarries and workshops, human burials, post molds of thatched houses, hearths, or the remnants of entire villages, originally built on the coast and subsequently flooded by the rising sea.

Archaeological modeling and field research indicate the possibility of submerged prehistoric ceramic sites in shallow water (tidal zone to 3 m), as well as older, preceramc sites (tidal zone to 20 m+). The maximum age of preceramic sites in Puerto Rico is unknown, since most of these sites are presently under water and the first one was only recently discovered off the north coast.

3.1 Changing Levels of Land and Sea

Marine transgressions, the technical term for the flooding of coastal areas by the sea, may occur due to a variety of local, regional, or global processes. Land may be eroded or subside due to tectonic movement, isostatic depression or sediment compaction. In higher latitudes, postglacial rebound may gradually lift the coast.

Sea level may rise due to changes in the volume of ocean water or ocean ridges (Donovan and Jones 1979). Following current theory, the major agent of coastal change has been a global or eustatic sea level rise due to the melting of land-blocked ice, resulting from cyclical variations in the earth's orbit (Hays et al. 1976:1121).

According to the glacio-eustatic model, low sea levels are associated with land ice advances called stadials, while high sea levels are associated with the retreat of land ice sheets called interstadials. The more ice on land, the lower the sea level.

Numerous ice ages have occurred as far back as 93 million years ago, but our concern is with the last ice age so far. Beginning about 80,000 yrs BP (before the present), the more recent ice age is defined as the Wisconsin glaciation in North America, and the Würm glaciation in Europe. This glacial episode played a central role in the migration of our species, *Homo sapiens sapiens*, to the principal archipelagoes of the world, including the Caribbean, by reducing the distances between continental masses and offshore islands world-wide.

There is general consensus that the sea was near its present level by about 35,000 yrs BP. Then the sea level began to drop as the Laurentide and other Pelistocene ice sheets expanded over the Northern Hemisphere.

By 20,000 to 15,000 yrs BP, sea level reached its lowest point in the Wisconsin glaciation. Estimates for this lowest sea level stand include minus 60 m (Blackwelder et al. 1979), minus 85-90 m (Morner 1971), and minus 130 m (Milliman and Emery 1968).

Around17,000 to 15,000 yrs BP, the Holocene marine transgression began. During the most rapid stage of deglaciation, beginning about 10,000 yrs BP, sea level probably rose at a rate of 10mm per year. By 7,000 yrs BP, sea level may have been some 10 m (32 ft.) below present level (Shepard 1963). By that time, much of the Caribbean Archipelago had been reached by preceramic navigators.

From 7,000 yrs BP onwards, the sea continued rising at a much slower pace. At this stage, there are significant disagreements among researchers. Van Andel and Laborel (1964), Fairbridge (1961) and others have proposed sea level oscillations with higher-than-present sea levels in the late Holocene, while Curray (1961), Scholl and Stuiver (1969), Shepard (1963) and others have reported evidence of a smooth sea level curve approaching the present level by about 4,000 to 2,000 B.P. Indirect corroboration from oxygen isotopic analysis of glacial history supports slightly higher, late Holocene sea levels than at present, but the problem remains an open question.

The rising seas were marked by interruptions or stillstands. These periods of stationary sea levels allowed the development of marine terraces, which may be observed under water. Prominent submarine terraces are found in the Caribbean, the Gulf of Mexico, and the Pacific Ocean at the average depths of 15 m (49 ft.) and 40-45 m (130-165 ft.). The depth of marine terraces may vary due to local tectonism, so that Pleistocene terraces may be found in shallower water, and even above present sea level.

Stillstands also allowed the formation of sea caves, beaches, and associated geomorphological features. From an archaeological perspective, stationary sea levels also made possible the formation of permanent, or semi-permanent, stratified coastal sites (Vega 1990, 1995).

Since the early 1930's, archaeologists speculated that prehistoric peoples lived on portions of the now submerged, continental and insular shelves. However, most researchers assumed that such sites would have been destroyed by the rising seas of the Holocene transgression. Today, the archaeological community has finally begun to realize that the traditional "sand castle hypothesis" is false (Vega 1990). During the last three decades, diving researchers have proven that submerged land sites of virtually any age may survive inundation in both fresh and salt-water environments, and be systematically studied under water.

Submerged land sites of prehistoric, classical or historic cultures have already been found world-wide, including Florida, California, Maine, Canada, Jamiaca, Puerto Rico, Cuba, Virgin Gorda, Nevis, St. Eustatius, Denmark,, Russia, Yugoslavia, Sweeden, France, England, Spain, Portugal, Gibraltar, Italy, Greece, Turkey, Israel, Lebanon, Tasmania, The Philippines, etc. (Masters and Flemming 1983; Muckelroy 1980, etc.).

Searching for submerged prehistoric sites was first proposed in the United States by Goggin (1960), with early discussions by Solecki (1961), Shepard (1964), Emery and Edwards (1966), Salwen (1967), Bullen (1969) and Warren (1964). During this time, the archaeological community was not ready for diving and sea level research, and the problem remained more theoretical than practical.

In the Caribbean, the search for submerged prehistoric sites was first proposed by Nicholson (1976a), following a survey of Antigua, which indicated that shell middens on the NE coast are undergoing marine transgression, while middens on the SW coast are now inland.

More recently, Ruppé (1980b) has also encouraged a search for drowned Caribbean sites, based on his own successful underwater research in West Florida.

The first excavation of a submerged prehistoric site in the Caribbean was conducted by the author, at isle Verde Site, off Puerto Rico's north coast (Vega 1981, 1982). Geoarchaeological modeling indicates that all four coasts of Puerto Rico may yield submerged prehistoric sites, with the highest probability off the NE coast (Vega 1990b). Another submerged prehistoric site has been identified off Joyuda, off the W coast (Vega 1995).

More recently, a submerged preceramic site, probably the first in the Caribbean, was detected off Condado Beach, San Juan, Puerto Rico (Vega 1999).

3.1 Prehistory of Puerto Rico

According to Rouse and Allaire (1978:465), people started migrating into the West Indies as early as 7,000 yrs BP. This entry is backed by Pina (1971), Veloz and Ortega (1976), and others. Raggi (1973) suggests a possible entry between 6,000 and 15,000 yrs BP. Nicholson (1976) suggests possible migrations as early as 17,000 yrs BP.

Regardless of the time and reasons of the first Caribbean migrations, it is clear that the first prehistoric explorers used some type of watercraft to cross the passages from the mainland(s), and then from island to island. The first West Indians were navigators in a semi-enclosed sea.

The earliest inhabitants of Puerto Rico and the Caribbean were preceramic peoples. Although there are significant variations within the preceramic cultures, the following criteria are applicable to most groups:

- small population units (<100 individuals per band)
- tendency towards nomadism
- hunting, coastal gathering and fishing
- no use of agricultue
- watercraft without sails
- often assocated with coastal middens.