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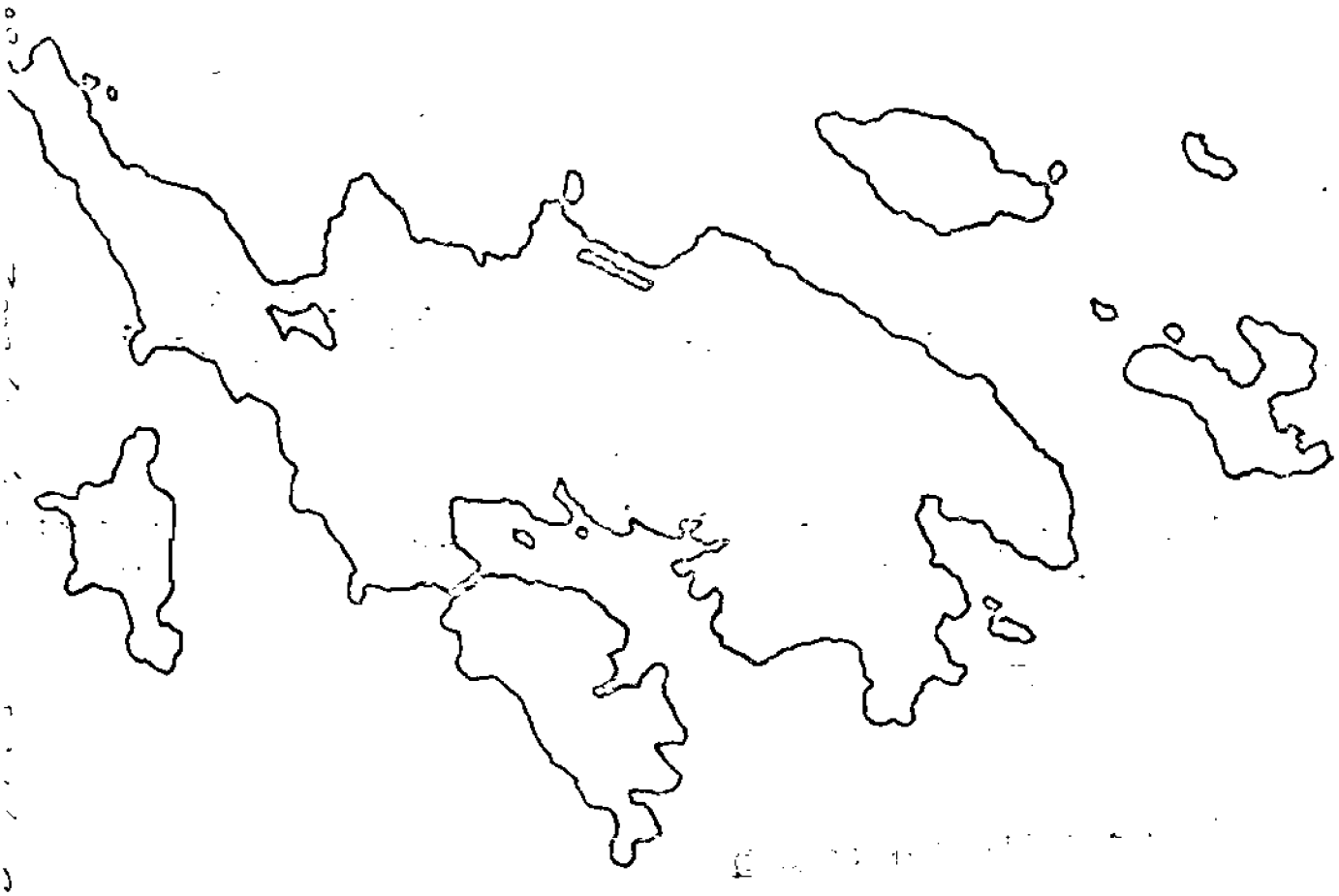
Environmental Quality Board



AN ISLAND IN TRANSITION

CULEBRA 1970

A STAFF REPORT ON THE ENVIRONMENT TO THE GOVERNOR'S SPECIAL COMMITTEE ON CULEBRA

COMMONWEALTH OF PUERTO RICO
OFFICE OF THE GOVERNOR
ENVIRONMENTAL QUALITY BOARD
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to the
Executive Director

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referring to this subject

February 10, 1971

Hon. Fernando Chardón
Secretary of State

Hon. Antonio Santiago Vázquez
Secretary of Public Works

Hon. E. .que Soler Cloquell
Chairman
Puerto Rico Planning Board

Gentlemen:

We submit herewith, in response to your request of November 1970, our report on the natural resources, developmental potential, and socio-economic aspects of Culebra.

The report resulted from a thorough review of prior documentation and a week of intensive site study and evaluation. The on-site work was carried out by a team of 17 scientists and environmental specialists representing eight Commonwealth agencies and four Federal departments, under the leadership of Mr. Robert Cassagnol of the Area of Natural Resources, Department of Public Works. The synthesis of various sections into a cohesive document was skillfully done by Dr. Kathleen Ochs, also of the Area of Natural Resources.

As we are all aware, mounting social and economic pressures are creating changes adverse to the natural beauty and ecology of Puerto Rico. In the small, offshore island of Culebra--an exceptional natural area— these usual pressures have been absent up to this time. However, with current changes being proposed in the status of Culebra, a unique opportunity is offered to the Commonwealth to plan properly by implementing environmental protective measures which will also yield maximum social and economic benefits. The over-all goal should be the evolution of a comprehensive plan which thoroughly coordinates measures for

environmental protection with initiatives in the developmental sector.

In view of the present situation we urgently recommend that any decisions and related commitments on the further development of Culebra be immediately suspended until the information and observations developed through this report can be inserted into the planning process. We would also strongly recommend that an executive order in this regard be issued by the Governor to all agencies concerned with Culebra.

Very truly yours,

Cruz A. Matos
Executive Director

Dr. Roberto Vázquez
Assistant Secretary of Public Works
Area of Natural Resources

INTRODUCTION

The Island

The island of Culebra lies approximately 17 miles east of Puerto Rico, 12 miles west of St. Thomas, and 9 miles north of the island of Vieques. Its total area is slightly less than 7,000 acres. It is characterized by irregular topography with hills of low elevation, the tallest being Monte Resaca, with an elevation of 650 feet. Due to Culebra's small size and low elevation, the trade winds are not exposed to corrective or orographic forces of great magnitude, causing a reduced rainfall pattern over the island. As a result, the climate of Culebra is slightly xeric and there are no permanent fresh water streams. Such conditions are very favorable for a profuse coral growth in the surrounding clear littoral waters where sedimentation is reduced to a minimum. Due to its long and intricate shoreline, Culebra presents a series of bays, peninsulas, and bars, some of which die in abrupt cliffs, sandy shores, or mangrove forests. The principal harbor is Ensenada Honda, which is considered one of the most secure and best hurricane harbors in the Leeward Islands.

The island is at present a United States Naval Defensive Sea Area and Airspace Reservation. Navigation by vessel other than those authorized by the Secretary of the Navy is prohibited within a three mile limit.

Purposes of the Study

At the request of the three-member Committee on Culebra appointed by Governor Ferre, the Environmental Quality Board organized an inter-disciplinary

group of professionals charged with the task or preparing a report on the natural resources, the development potential, and the socio-economic aspects of the island of Culebra. The participants in the study were:

Commonwealth agencies:
- Environmental Quality Board
- Department of Public Works
- Planning Board
- Department of Agriculture
- Economic Development Administration

Federal agencies:
- Geological Service
- Fish and Wildlife Service
- Soil Conservation Service
- National Oceanic and Atmospheric Administration

Others:
- Puerto Rico Nuclear Center
- University of Puerto Rico
- Agricultural Experiment Station

The Area of Natural Resources of the Department of Public Works directed the study. Specific areas evaluated included physical resources (climate, soils, minerals, and water), biotic resources (flora and fauna), coastal and marine resources (beaches, reefs, fish, ocean, etc.), and socio-economic resources.

Methods

Most of the information presented in this report was gathered during a week-long visit to Culebra which took place the week of November 30 to December 4, 1970. In addition, maximum use has been made of existing studies and expert knowledge of conditions in the region.

Transportation, both by jeep and by boat, was very kindly provided for several of the study groups by Culebra's Mayor Ramon Feliciano, and the United States Navy stationed there.

It must be stressed that the time allotted did not permit a truly comprehensive in-depth study. Many of the areas would repay careful extensive investigation. In some cases, this report merely provides the groundwork for more detailed evaluation of a particular feature. Nevertheless, it is believed that this report identifies the major factors which should be considered in any comprehensive plans for Culebra.

A summary of the highlights of the individual findings in each area, and a brief collection of some of the specific recommendations of the participating specialists, have been appended to the report.

Participants

Profuse thanks are due the individual specialists who participated in this study for their enthusiastic contributions of large quantities of time, effort, and personal facilities. Members of the group were:

STUDY LEADER
Robert Cassagnol, Area of Natural Resources

CLIMATE
Robert Calvesbert, National Oceanic and Atmospheric Administration

SOILS
Gabriel del Toro, Area of Natural Resources

MINERALS
Dennis Cox, U.S. Geological Service

MINERALS
Lisbeth Hyman, Area of Natural Resources

WATER
Henry Anderson, U.S. Geological Service

ECOSYSTEMS
Kathleen Ochs, Area of Natural Resources

FLORA
Roy Woodbury, Agricultural Experiment Station

FAUNA
Ricardo Cotte-Santana, U.S. Fish and Wildlife Service

BEACHES
Pedro Gelabert, Area of Natural Resources

COASTAL RESOURCES
Robert Ting, Nuclear Center, Mayaguez

REEFS
Frank Torres, University of Puerto Rico

FISH
Donald Erdman, Department of Agriculture

OCEANS
Jaime Biaggi, Economic Development Administration

SOCIO-ECONOMICS
Jose Cime de Villa, Area of Natural Resources

SOCIO-ECONOMICS
Miguel Santiago, Area of Natural Resources

SOCIO-ECONOMICS
Alejandro Candelario, Area of Natural Resources

I

NATURAL

RESOURCES

A

PHYSICAL TERRESTRIAL RESOURCES

1.

CLIMATE

Precipitation

The single factor which most determines the character of life on Culebra, whether plant, animal, or human, is the excessive dryness. Mean annual rainfall is only 39 inches, varying from 16 inches, in the drought year of 1967, to as high as 59 inches, in 1942. The year of 1970 has also been an exceedingly wet one, and this fact has undoubtedly colored the viewpoints of the investigators in this study. Forty-seven percent of this falls in the four month period from August through November (see Table 1.1.). The mean number of days per year in which 0.1 inch or more of rain will fall is 58. Only 19 days will have a half inch or more.

Temperature

No data on air temperature ranges on the island are available, but these are undoubtedly similar to temperatures on the east coast of Puerto Rico, which range from 74.4°F mean annual minimum to 85.7°F mean annual maximum, or from 62° to 93°, as two recorded extremes.

Humidity

Again, although no records have been kept on Culebra itself, the air masses reaching the island are very similar to those arriving on the east coast of Puerto Rico near Roosevelt Roads. There, the annual daytime mean is 67%, rising to 82% at night.

Table 1.1. Mean Monthly Rainfall on Culebra. *

January	1.90
February	1.52
March	1.29
April	2.53
May	3.41
June	3.67
July	3.15
August	4.06
September	5.26
October	4.71
November	4.43
December	3.02
Mean Annual Total	38.95 inches

* Data were collected at a single station, the command post of the U. S. Navy on Punta Flamenco, and averaged over a 23-year period.

2.

SOILS

Soils are formed through the interaction of climate, plants and animals, parent material, topography, and time. All these factors control the decomposition of rocks through time, resulting in what we know as soil. Since these factors vary greatly from place to place over the earth's surface, many different kinds of soil exist.

The classification of soils is based on internal and external characteristics, emphasizing especially those which influence the growth of plants. A soil type is defined according to the kind, thickness, and arrangement of soil layers. It is derived from a particular parent material. Soil types that differ only in surface texture---stony, gravelly, sandy, or silty---but are alike in other characteristics, are combined to form a soil series. These series are named after the geographic locations where they were first identified.

In order to study particular characteristics and determine potential uses, it is necessary to recognize the different soil types in an area and treat them separately. In this way they may be compared and their relations with the environment defined.

Soil Types on Culebra

The island of Culebra, owing to its small size, its rugged topography, and its uniform conditions of climate and temperature, has a limited number of soil

series. Seventy-five to eighty percent of its total area is covered by soils of the Descalabrado and Volcanic Rock series (see Table 2.1.), with a slope which fluctuates between 20-40%. This class of terrain has such severe limitations and danger of erosion that it may only be used for pasture, forest, or wildlife. A description of the most common soil series on Culebra and adjacent cays follows (see Figure 2.1, and Table 2.2.). Numbers refer to equivalent soil types in a report made by the Soil Conservation Service (2).

1) Descalabrado Clay Loam. (84C2, 84E2, 84F2) This series consists of shallow soils of volcanic origin, with good drainage, and of moderate to great slope. They are formed from fragments of volcanic rock of moderately fine texture. They occur principally on slopes of 5-60% in semi-arid regions with a mean annual rainfall of 30 to 45 inches and a mean annual temperature of 78-80°F.

These soils are poor for agriculture, due to their lack of depth, to the low arinfall in the area, and to the difficulty of irrigating them. Construction of artificial ponds and septic tanks is also difficult. They are not ideal for recreation areas. Highway construction , foundations of buildings, and the establishment of light industries are perhaps the most appropriate uses of these areas.

2) Jacana Clay. (89C2) This series consists of soils of moderate depth, with good drainage, on land of 2-20% slope. Texture is fine, as a result of its origin from sediments and fragments of volcanic rock. It occurs in semi-arid climates, with 79° mean annual temperature and about 35 inches of rain per year.

Table 2.1. Acres of Each Soil Series Available on Culebra.

SERIES (SYMBOL)	TOTAL ACRES	% TOTAL AREA
Cataño (331)	144	2.1%
Descalabrado (84)	2636	51.9
Amelia (89gr)	612	8.8
Fraternidad (187)	180	2.2
Coastal Beaches (334)	56	0.9
Marshes (360)	25	0.4
Mangroves (MS)	224	3.3
Volcanic Rock (508)	2123	30.4

Its limitations for agricultural purposes are only moderate. If properly managed and irrigated, it is quite suitable for cultivation of sugar cane, corn, fodder or pasture. However, for non-agricultural purposes, such as highway, artificial pond, septic tank, or light industry construction, or for recreation, these areas are poor.

3) Amelia Gravelly Clay Loam. (89C2 gr) These soils occur on gentle to steep slopes (2-20%), in alluvial fans, and at the bases of mountains. They are well-drained and deep. As are the previous two series, they are characteristic of semi-arid climates. A profile of the surface layer reveals a dark brown color and gravelly texture.

Agriculturally, these soils are restricted by the adverse climatological conditions, inability to retain water, and low fertility. They may be used for pasture. For construction purposes, they are unsuitable for artificial ponds, septic tanks, and recreation areas (due to the high concentration of rock fragments), but may be adequate as roadfill, building foundations, or light industry.

4) Fraternidad Clay. (187B1) These are very deep soils with moderately good drainage usually found on level terrain, such as the coastal plains, with slopes varying from 0-12%. Their texture is fine, derived from sediments of calcareous stones and volcanic rock. They also belong to semi-arid climates.

Agriculture is possible with proper irrigation and artificial ponds are feasible. Light industry, highways, recreation areas, and septic tanks are not suited to these areas.

5) Cataño Loamy Sand. (331) Soils of the Cataño series are completely level (0- 5% slope), excessively drained, and deep. They are composed of sand mixed with rock fragments. Their coarse texture makes them exceedingly permeable.

Due to their low fertility and low water retention capability, their use for agriculture is severely limited. They may, however, serve as roadfill, or as the location for construction of highways, light industries, or recreation areas.

6) Coastal Beaches. (344) These formations consist of narrow belts of beach sands along the coast. They are heavily saturated with sea water and contain numerous shell fragments and skeletons of marine animals. In the main, the only vegetation there is coconut palms (Cocos nucifera), sea grape (Coccoloba uvifera), and bejuco de playa (Ipomoea pes-caprae). These soils have no agricultural value at all and are in fact limited solely to recreational purposes.

7) Marshes and Mangrove Swamps. (360, M3) Another group of areas with no agricultural value, and which as yet lack recreational value as well, is the mangrove and other swamps. Salt concentration is high and soil characteristics are such that no commercial plants can survive there.

8) Volcanic Rock. (508) These are soils in which rocky outcrops cover 50- 70% of the surface. Between these boulders, the soil is very shallow and mixed with loose stones, rendering it useless. This formation occurs principally on slopes of 60% or more, supporting only a weedy vegetation. It is best suited for wildlife and esthetic appreciation.

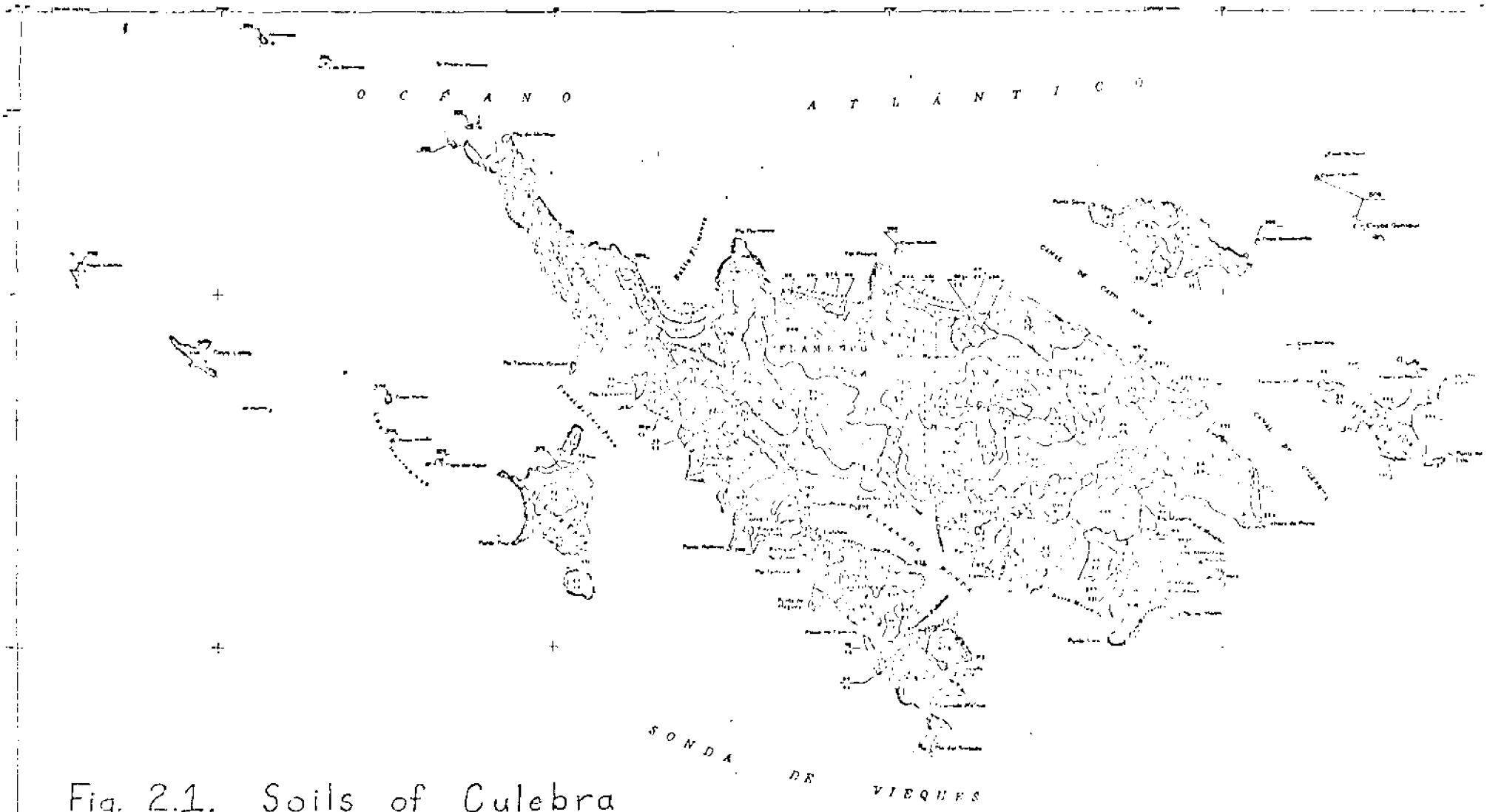

Fig. 2.1. Soils of Culebra

Land Capability

Soils may also be classified on the basis of their usefulness to man. Such groupings take into consideration both the climate and the soil characteristics in determining use, management, and potential productivity of an area.

Eight classes are recognized, from very cultivatable soils needing no conservation techniques whatever (Class I), to soils and formations good only for recreation or wildlife (Class VIII). The first four classes are capable of cultivation to some degree; the last four are not. Each of these classes may be divided into subclasses which indicate the principal problems of conservation in a particular area. The latter are designated by lower case letters following the class number; for example:

"e" - erosion
"w" - wetness
"s" - soil characteristics themselves
"c" - adverse climate
"gr" - gravel

Culebra (see Tables 2.2. and 2.3.) contains no soils in the two most cultivatable classes (I and II), and only 11% of the island's area falls into the next two categories (III and IV). Thus most of Culebra is not suitable for any kind of crop production and is restricted to pasture, woodland, or recreational uses. In fact, 35% is in Class VIII and will not even support pasture or forest.

SERIES (SYMBOL)	TEXTURE	EROSION	LAND CAPABILITY CLASS *	SLOPE	DEPTH TO BEDROCK	WATER TABLE
Descalabrado (34)	Clay Loam	Moderate	VI-e, VII-e,s	12-60% (moderate to very steep)	Shallow	Deep
Jacana (89)	Clay	Moderate	IV-e	Moderate	Moderately Deep	Deep
Amelia (99)	Clay with Gravel	Moderate	III-s	Moderate	Deep	Deep
Fraternidad (187)	Clay	Little	III-c	Moderate	Rock - Free	Deep
Cataño (331)	Loamy Sand	____	VI-s	____	Rock - Free	Moderately Deep
Coastal Beaches (334)	Sand	____	VIII-s	____	Very Deep	Shallow
Marshes (360)	____	____	VIII-w	____	____	____
Volcanic Rock (508)	____	____	VIII-s	____	____	____
Mangroves (MS)	____	____	VIII-s	____	____	____

* See text for interpretation

Table 2.3. Soil Characteristics.

SERIES (SYMBOL)	AVAILABLE WATER CAPACITY	CONTRACTABILITY	USEFULNESS AS TOPSOIL	PERMEABILITY	USEFULNESS AS ROADFILL
Descalabrado (84)	Very Low	Low	Poor	Moderate	Poor
Jacana (89)	____	____	Poor	____	Poor
Amelia (89)	Low	High	Poor	Moderate	Regular
Fraternidad (187)	Low	High	Poor	Moderate	Poor
Catano (331)	Very Low	Low	Poor	Low	Good
Coastal Beaches (334)	Very Low	____	None	High	None
Marshes (360)	____	____	None	____	None
Volcanic Rock (508)	____	____	None	____	None
Mangroves (MS)	____	____	None	____	None

Conclusion

In summary, the soils of Culebra are profoundly affected by the topography. Most are shallow and lack adequate nutrition to support plant life. Erosion is a major problem. Two thirds of the total area of the island possesses such severe limitations that it cannot be cultivated and must remain as pasture, forest, or parkland. Those areas which can support agriculture are in urgent need of the implementation of complex techniques of soil and water conservation.

3.

MINERALS

Geology

The geology of Culebra was studied by T.W. Donnely in 1959, (6). The geologic map (Figure 3.1) is mostly from his work but contains minor modifications resulting from the present study.

Culebra and adjacent islands are underlain by volcanic and intrusive rocks of probable Upper Cretaceous age. Andesite lava underlies most of the island and on many seacliff exposures exhibits pillow structure characteristic of lavas erupted under the sea. This structure is remarkably well-preserved at Punta Seria on Cayo Norte. The andesite lava contains many veins and interpillow fillings of quartz. Andesite lava breccia lies along the straight southwest coast of the island and on Luis Peña.

Andesite tuff overlies the lava along the north coast of Culebra. It is characterized by a prominent layering with beds ranging from a few inches to many feet of thickness. This layering may be seen along the seacliffs between Playa Brava and Playa Larga.

The tuff and underlying lava have been intruded by diorite in north central Culebra and by diorite porphyry on Luis Peña. The diorite weathers to rounded boulders several feet in diameter which cover much of the steep north central slope of Culebra. The sandy soil washed down the slope from between

these boulders has accumulated to form the small sand deposit behind Playa Brava.

Other alluvial deposits include fine coral sand and coarse gravel in beach deposits and fine sand and clay underlying mangrove swamps and lagoonal basins.

Locations of Particular Geologic Interest

The following points of geologic interest are believed to have considerable value.

Locality	Geologic Feature
1) Road cut on road to U.S. Navy Observation Point	Layered tuff deposited on pillow lava
2) Sea cliff immediately east of Playa Brava	Thick beds of tuff showing spheroidal weathering
3) Punta Seria, Cayo Norte	Large, well-preserved exposure of pillow lava

Geochemical Sampling and Analysis

Samples representative of large drainage areas were collected from stream beds wherever possible. Pebbles and cobbles showing the most intense iron staining or any traces of mineralization were selectively sampled from each stream. Samples of vein quartz were also collected wherever present. Samples were taken from road cuts or outcrops in areas where stream gullies were not present. Figure 3.2. shows the location of samples and the route of traverses made during the study.

Table 3.1. shows the results of semiquantitative spectrographic analysis. Due to the fact that there was no significant variation, the range of values is shown for each element. The values are given in parts per million except where

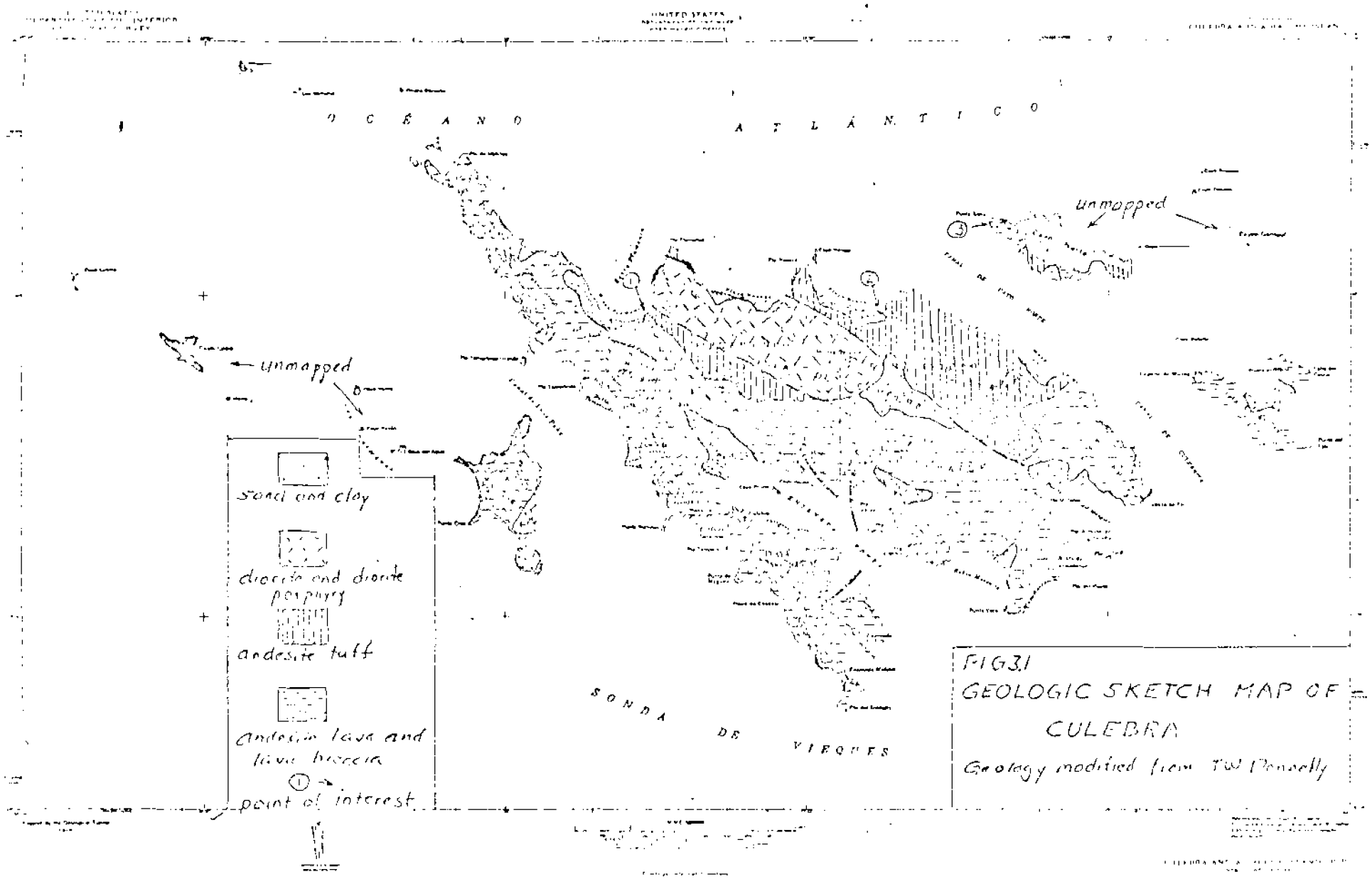

FIG 3.1
GEOLOGIC SKETCH MAP OF CULEBRA
Geology modified from TW Donnelly

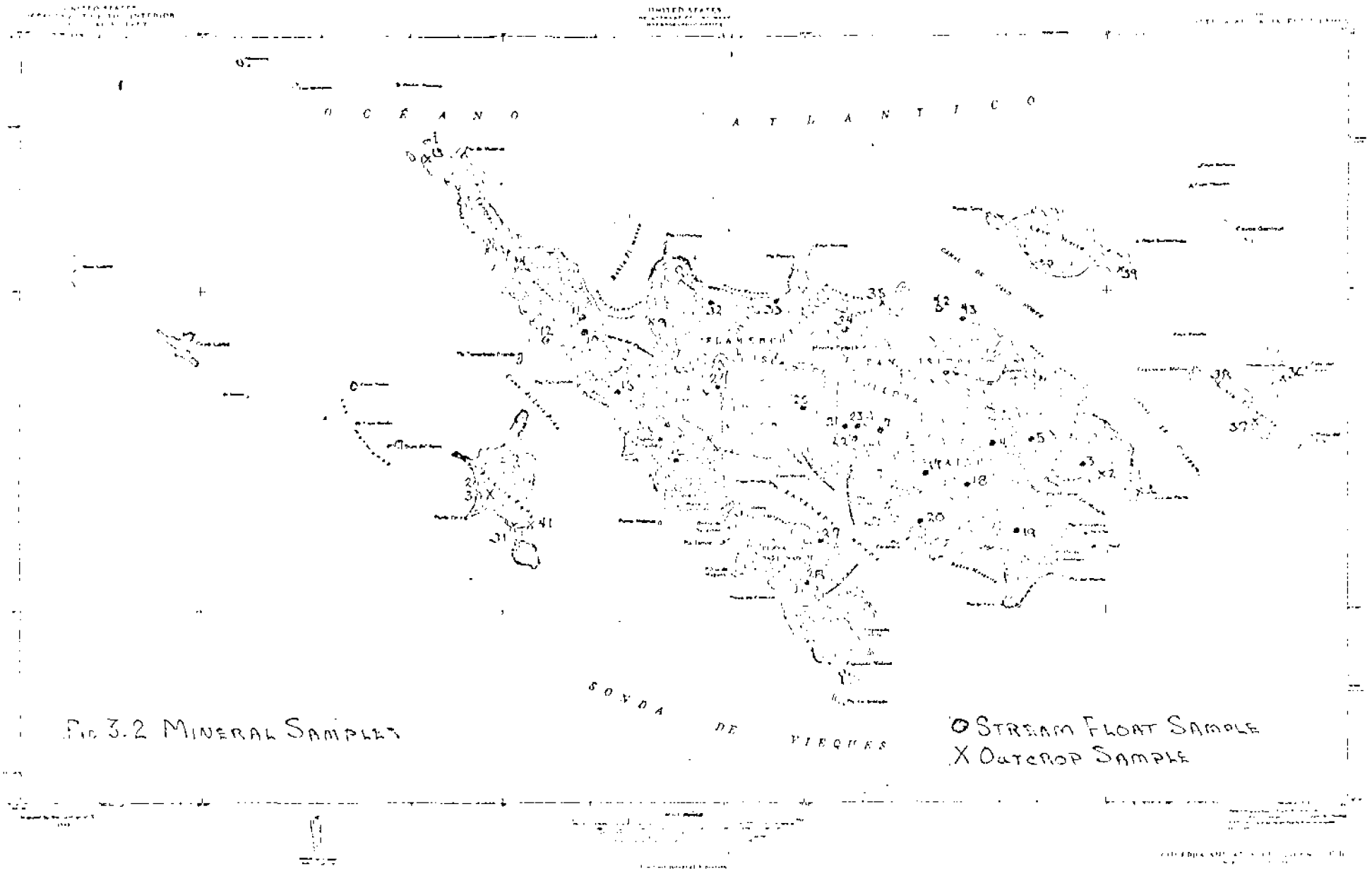

FIG 3.2 MINERAL SAMPLES

Table 3.1. Concentrations of Certain Minerals in Rock Samples from Culebra and Surrounding Islands. *

Iron	0.7-7%	Beryllium	<1-1
Magnesium	.05-2%	Bismuth	<10
Calcium	0.3-10%	Cadmium	<20
Titanium	.05-0.7%	Cobalt	<5-2?
Manganese	70-1500	Chromium	<20-7?
Silver	<0.5	Copper	20-3??
Arsenic	<200	Lanthanum	<20
Gold	<10	Molybdenum	<5
Boron	<10-70	Niobium	<10
Barium	<20-2000	Nickel	<5-2?
Lead	<10-20	Antimony	<100
Scandium	<5-30	Tin	<10
Strontium	<100-1500	Vanadium	50-5??
Tungsten	<50	Yttrium	<10-5?
Zinc	<200	Zirconium	20-1??

* Due to the fact that there was no significant variation, the range of values is shown for each element. The values are given in parts per million except where otherwise noted.

otherwise noted. They are considered normal for volcanic and intrusive rocks of the type found on Culebra.

The samples were also analyzed for gold by atomic absorption spectrophotometry. One sample of quartz from veins in diorite porphyry from Luis Peña was found to contain minute traces of gold (0.05 parts per million). The other samples contained less than 0.02 parts per million gold.

Development Potential

The islands of Culebra, Culebrita, Cayo Norte, and Luis Peña were examined and 41 samples of bedrock and stream float were collected and analyzed by emission spectrography and atomic absorption methods. No features common to metallic mineral deposits were noted and no anomalous metal values were detected in the samples collected. The islands have no history of mineral exploitation or prospecting.

It is concluded that under present and forseeable economic and technological conditions metal mining can be ruled out as a source of wealth and employment for Culebrans.

Construction materials are present in limited quantities. Crushed rock for construction can be produced from the volcanic rocks of the island and riprap might be quarried from some areas underlain by diorite. Calcareous sand is abundant on the many beaches of Culebra and Culebrita but may not be extracted without damage to the island's shoreline. Small amounts of feldspathic sand containing some boulders could be extracted from the small coastal plain near Playa Brava without disturbing the beach.

4.

FRESH WATER

Comparatively speaking, the hydrologic and geologic conditions on Culebra are similar to St. Thomas and St. John in the Virgin Islands. The rocks are for the most part igneous in nature, being volcanic andesite on the one hand and a diorite intrusive rock on the other. Ground water is stored and transmitted principally in cracks and small fractures of the rock.

Precipitation

Hydrologically, Culebra is somewhat drier than the Virgin Islands and Puerto Rico. The average annual precipitation measured since 1938 is about 36 inches. Of this average more than 90% of the water is returned to the atmosphere as evapotranspiration. The evaporation potential for open water surfaces is about 70 inches per year. The water surplus then (the amount available for runoff and infiltration to the water table) is less than 3.6 inches, of which an estimated one inch of water may infiltrate to the water table. On a per square mile basis this amounts to 17 million gallons per year, or for Culebra's 18 square miles as a whole about 300 million gallons per year.

The soil can hold about two inches of rainfall so consequently there is very little surface runoff unless individual, widely-spaced rains exceed this amount. During severe storms the surface runoff may account for 20 to 75% of the runoff.

Sources for Human Consumption

The town of Dewey gets its municipal supply from a field of drilled wells about 3.5 kilometers east of Dewey. Of the four wells that are operative only numbers "2" and "3" are used extensively because of the high salinity of the others. Well yields are about 20 gallons per minute per well. On November 27, for example, the chloride content of water from the Number "2" well was 440 parts per million. U.S. Public Health Service recommended maximum is 250 parts per million.

Formerly rain catchments were used. However, since the rainfall is so undependable, particularly in the drought years 1961-69, this method is now more or less a backup supply. The storage tanks at these catchments are 129,000; 162,000, and 110,000 gallons, for a total of 400,000 gallons, enough to supply Dewey for 14 days. This does not include drinking or cooking water, which is usually supplied by household cisterns.

Salinities

On the trip of November 30 to December 2, 48 water sampling sites were visited and specific conductance measurements were taken (see Figure 4.1.). At 20 sites the water was considered relatively fresh, containing less than 500 milligrams per liter chlorides. Six of 15 dug wells, 3 of 13 springs, 1 of 10 swamps and lagoons, 4 farm ponds, and 2 out of 4 drilled wells were considered to have reasonably fresh water.

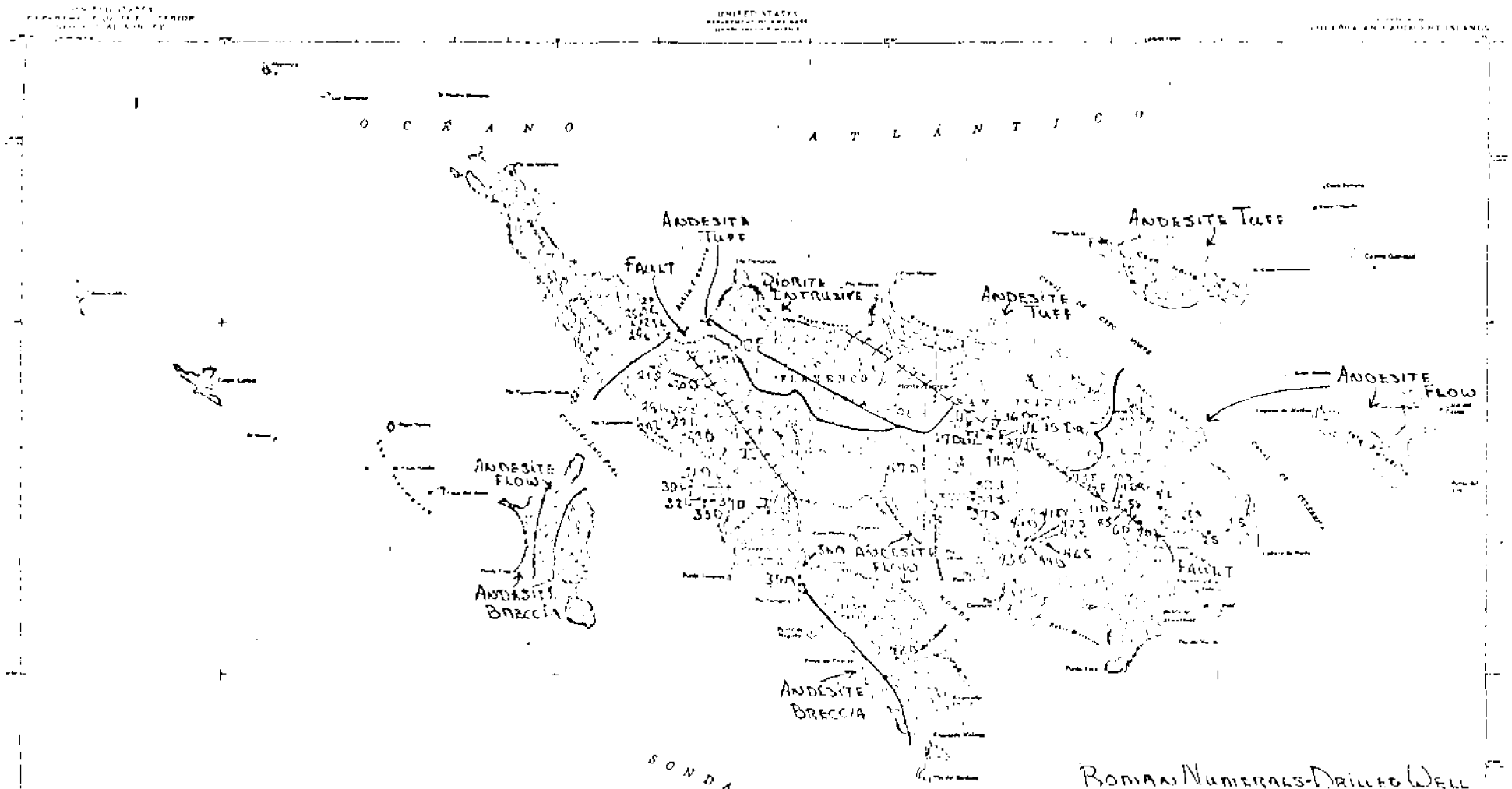

Fig 4.1 Water Resources & Geology of Culebra

Roman Numerals-Drilled Well
Arabic Numerals- Sample Site
D-Dug well Dr.-Drilled well C-Tanks
L-Lagoon F-Farmpond M-Municipal supply

Table 4.1. Specific Conductances of Sampling Sites Shown in Figure 4.1. *

Legend:

D - Dug Well
Dr - Drilled Well
S - Spring
L - Lagoon
F - Farm Pond
M - Municipal Supply

1 S	1365	17 Dr	2266	33 D	2000
2 S	509	18 F	194	34 D	302
3 S	506	19 L	11000	35 M	2287
4 L	45500	20 D	3500	36 M	2500
5 S	4905	21 S	10000	37 S	1632
6 D	4500	22 L	50000	38 S	4692
7 D	2000	23 L	3728	39 S	3500
8 S	4905	24 L	2832	40 D	850
9 Dr	3740	25 L	2400	41 D	720
10 S	4810	26 L	5000	42 S	3876
11 D	5000	27 L	15000	43 D	561
12 F	388	28 L	6000	44 D	788
13 F	437	29 D	3000	45 S	6082
14 M	2781	30 L	22000	46 S	6500
15 Dr	3400	31 D	816	47 D	5500
16 Dr	2266	32 L	20000	48 D	750

* Conductances are underlined where sample water is fresh.

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7 D	2000	23 L	3728	39 S	3500
8 S	4905	24 L	2832	40 D	850
9 Dr	3740	25 L	2400	41 D	720
10 S	4810	26 L	5000	42 S	3876
11 D	5000	27 L	15000	43 D	561
12 F	388	28 L	6000	44 D	788
13 F	437	29 D	3000	45 S	6082
14 M	2781	30 L	22000	46 S	6500
15 Dr	3400	31 D	816	47 D	5500
16 Dr	2266	32 L	20000	48 D	750

* Conductances are underlined where sample water is fresh.

Conclusions

Some of the leading conclusions that can be drawn from the survey follow.

1) Dug wells, numbering more than 25 on Culebra, are located along the coastal lowlands of the island. The freshest wells were usually in the lower slopes of valleys but inland and on higher ground than the coastal beach deposits. Dug wells tap water largely from the valley alluvium, talus, and weathered bedrock materials and are used primarily for watering stock. Cattle can tolerate fairly high salinities in their drinking water. Some crop plants (rice, sugar cane) are also salt-resistant; others are very sensitive to salt. The main fresh water valley was located in Fraile district in a valley leading to Ensenada Honda.

2) In the few springs and creeks examined, the salinity of the water seems to increase going upstream. The explanation is not readily apparent since the normal condition is for salinity to increase downstream. Except for a few rain seeps all the springs tested were too salty to be used for consumption.

3) Drilled wells on Culebra, totalling about 8, yield small quantities of water, 10 to 40 gallons per minute, from cracks and fractures in the bedrock aquifer. Drilled wells yield water with the chloride content ranging from 364 to 1,995 milligrams per liter. The depth of the wells is from 54 to 94 feet.

4) Without exception the farm ponds contain fresh water, usually runoff from rainfall. Lagoons, near the coasts, contain brackish or salty water.

5) The Dewey well field, located in a drainage basin of 0.94 square miles, receives an estimated 16.5 million gallons of recharge to the water table annually.

The present water demand, based at 40,000 gallons per day for Dewey, is 14.6 million gallons annually. Consequently the present pumpage of the well field is nearing the capacity of the basin to yield water.

6) A more comprehensive investigation of the possible water resources of Culebra should be made. Water is scarce and future development on the island will depend on the solution of this problem.

B

BIOTIC TERRESTRIAL RESOURCES

5.

ECOSYSTEMS

Inventory

The island of Culebra and its surrounding waters and cays contain an exceptionally large variety of ecosystems for such a small area. Most of these have been affected in more or less major ways by the presence of man. Only remnants are left of many of the original communities of interacting plants and animals, although these small areas may be representative of former conditions (several types of forest in particular). Other features are the direct result of human intervention (wide savannahs, a channel separating Playa Sardinas II from the rest of the island, the cleared peninsula where the terns nest, coconut groves, and the town itself). Some of the most obvious ecosystems existing at present and meriting consideration in future plans for the island are:

1) Village
2) Main valley
3) Hilly savannah, from grassland through pasture to sparse forest
4) Beach forest (lower east edge of Flamenco Peninsula)
5) Hilly forests, from dry to moist (ridge of hills above north coast, small area on Flamenco Peninsula, Cabeza de Perro, Luis Peña, others)
6) Intermittent stream beds (four or five run from center down to south coast)
7) Lagoons (at least seven, most behind beaches)

9) Marshes (around lagoons and ponds, depending on rainfall)

9) Mangrove swamps (around Ensenada Honda, Puerto del Manglar, and lagoons; also behind beach flats)

10) Beaches (Flamenco, Resaca, Brava, Larga, Cayo Norte, Culebrita, Tamarindo, north of Cabeza de Perro)

11) Coconut groves (behind some beaches, especially by Cabeza de Perro; also scattered)

12) Points (Tamarindo, Tamarindo Grande, Melones, Tampico, Maguey, Soldado, Molinos, across from Molinos, Flamenco, Resaca, Cabeza de Perro, del Viento, Vaca)

*13) Larger cays (Luis Peña, Cayo Norte, Culebrita)

*14) Smaller outer cays

*15) Smaller inner cays (Piratas, Luis Peña, Pelaíta)

16) Reefs

17) Harbors

18) Fishing grounds

The first two (village, rain valley) and last three (reefs, harbors, fishing grounds) categories are of prime importance for Culebra, but are covered in detail in other sections. Two of the larger cays and all of the smaller cays were unfortunately not visited.

Developmental Principles

As a result of two factors, its small size and its excessive dryness, Culebra probably cannot exist as a self-contained system, even with the small

*These cays are mostly forested or have subsystems similar to those on the main island. However, they should be considered separately because islands are unique ecological units in themselves, dependent on their size, isolation, and distance from sources of colonization.

pulation it now contains. It is too dry for much agriculture. Cattle die in years of less than average rainfall. The fishing grounds, even if the U.S. Navy were not present, are not sufficiently extensive. However, Culebra possesses two features, a very long intricate coastline and, as mentioned above, a wide variety of ecosystems, which make it ideal for attracting visitors from outside. These will use it as leisure time facilities, bringing money from elsewhere.

This development of tourism will occur whether the Puerto Rican government facilitates it or not. It is only a question of controlling it (by zoning, regulating, suggesting, and preserving) in order to make the greatest number of attractive features available for as long as possible to the greatest number of people. Once this major goal is adopted, decisions as to the best use of each area are relatively easy and may be quite flexible, as long as some overall plan is followed and enforced.

Four major problems should be solved no matter what type of development occurs. With centralized planning, they can be solved efficiently, more cheaply in the long run, and with less damage to the environment, than if they must be "solved" independently by private developers. Culebra cannot support any further population without: (1) finding a source of water; (2) insisting on sewage treatment, not only in the town of Dewey, but all along the coasts, and even by yachts using the harbors; (3) building access roads and trails; and (4) developing air transportation to the island.

Conservation Priorities

Much of the land on Culebra is unsuited for agriculture, incapable of supporting cattle populations (due to climate) commensurate with the area currently in pasture, possessing no valuable mineral resources, and impractical (due to expense of transportation) for the establishment of industry. For these reasons, it is probable that recreational uses will be emphasized as the island develops. If so, certain sections of Culebra should definitely be set aside and preserved, in one way or another, in order to insure that development remains worthwhile. The idea behind this protection of selected features should be to guarantee that these remain not only enjoyable but also accessible to all who wish to appreciate them. Ideally, some or all in each of the following categories should be kept public and protected.

1) Culebrita and the reefs south of it
2) Other reefs
3) Fishing grounds
4) Part or all of the wooded ridge of hills just back of the north coast, including especially Monte Resaca and going east to Cerro Balcón
5) Beach forest on east side of Flamenco Peninsula
6) All beaches and low coastal areas
7) Lagoons behind the beaches
8) Some of the mangroves around the lagoons, all borders of Puerto del Manglar, and some north borders of Ensenada Honda (especially north of Punta Cabras)
9) Tip of Flamenco Peninsula where sooty terns nest
10) Most of the points (see earlier list)
11) Streams and their borders, if they are not needed for drinking water systems
12) Cayo de Luis Peña (this should be left forested)
13) Cayo Norte
14) All smaller cays, inner and outer

6.

FLORA

Inventory

This study on the vegetation of Culebra also includes the three smaller islands (Cayo de Luis Peña, Isla Culebrita, and Cayo Norte). The flora, in general, consists of an arid to dry type, but the valleys and upper slopes support an interesting semi-moist forest of trees to 50 feet tall and as much as 3 feet in diameter. The average trees are, however, much smaller. Two visits of seven days total have produced a known flora of 372 species of indigenous plants and many introduced species. As the introduced flora undergoes a constant change, this study will deal only with the indigenous flora. The two visits were June 8-11, 1966, and November 30-December 4, 1970.

The 372 species seen represent 156 genera and 76 families. They may be further subdivided to represent 111 tree species, 104 weedy species, and 10 epiphytes, 3 of which are orchids, 3 bromeliads, and 4 parasites. When Culebra's flora is compared with that of other islands such as Mona, it is rich and diverse. Thirty- three (33) species are rare or unique, being found only on Culebra or a few of the other small islands. Of these rare species 3 are endemic (found only on Culebra) and another species is also found in Tortola but has not been seen recently.

The palm (Coccothrinax argentea) produces another unique forest type which is fast disappearing due to man's efforts. This type is found on only a few of the neighboring islands to the east of Culebra. This type is commonly associated with the moister heavily-wooded north slopes and ridges.

The cactus scrub association produces 7 species of cacti including the rare snow cactus (Mammillaria nivea) and the tall pipeoyan cactus (Lamarocereus histrix).

The flora can be divided into three major groups which can be further subdivided into the following:

	Number of Species
1) Coastal formations (evergreen)	
a) Sandy unstable association	19
b) Coastal hedge to scrub associations	55
c) Beach forest	114
d) Mangrove swamp	7
e) Salt flat	10
2) Seasonal formations (ridges, slopes, and valleys)	
a) Semi-evergreen forest	99
b) Deciduous forest or woodland	143
c) Thorn scrub	93
d) Cactus scrub	90
3) Degraded formations	
a) Prosopis associations	40
b) Acacia	44
c) Croton scrub	33
d) Randia, Croton, and Acacia scrub	61
e) Indigofera scrub and old fields	114
f) Grasslands	15

The most important of these associations according to number of species are: deciduous forest (143 species), Indigofera scrub and old fields (114), semi-evergreen (99), thorn scrub (93), and cactus scrub (90). The mangrove and salt flat associations have the lowest number of species with 10 or fewer.

Conservation Priorities

There are several features of the flora which make it rather unique and different from the vegetation of the island of Puerto Rico. The large boulders of Monte Resaca produce an unusual park-like open forest of Cupey and Jaquey displaying their numerous stilt roots. The boulders themselves are hosts to beautiful natural plantings of orchids, bromeliads, and the endemic Peperonia (P. Wheeleri). This association is like no other association I have ever seen except on Virgin Gordo. This alone should be set aside for future generations.

Another unusual association, found in the same area and also on the slopes northwest of Playa Flamenco, north of Punta Tamarindo Grande, north of Laguna de Cornelio, and in the Cabeza de Perro area, is unique in that the tallest trees are represented by the fan-leaved palm (Cocothrinax argentea). This type of forest is fast disappearing due to man.

7.

FAUNA

Inventory

1) Birds. The most striking life form on Culebra, besides the reef fishes, is the birds. Several species of oceanic birds build up great nesting colonies on the offshore cays and on the northwest tip of Flamenco Peninsula (Punta Molinos). This peninsula, the three large inshore islands, and seventeen island groups were closely examined on August 23, 1970. Sooty terns were more abundant on four islands with the largest colony located on the Culebra mainland. This colony covered over 800 acres of land. Brown boobies, laughing gulls, sooty terns, bridled terns, and noddy terns are known to breed on Cayo Lobito, Cayo Yerba, Cayo Raton, Los Gemelos, Punta Molinos islets, Cayo Sombrerito, Cayo Geniqui, and Peninsula Flamenco.

In the marsh ponds and mangrove swamps, the rare and endangered Bahama pintail, the masked duck, and the ruddy duck nest and thrive. These are fully protected by law. The lagoons constitute the most important wintering grounds for migratory waterfowl on the island.

Considerable populations of white-crowned and red-necked pigeons are resident on Culebra. These supply the game birds for hunters on Vieques and in eastern Puerto Rico, when the pigeons migrate out of Culebra. Other species of upland birds are included in the list in Table 7.1. This list is by no means

Table 7.1. List of Common Birds from the Island of Culebra.

	SPANISH NAME	ENGLISH NAME
1.	Tigua	Least Grebe
2.	Pampero	Audubon's Shearwater
3.	Tijerilla	Frigate-bird
4.	Pamperitos	Leach's and Wilson's Petrel
5.	Chirre	Yellow-billed Tropic Bird
6.	Alcatraz	West Indian Brown Pelican
7.	Boba	Brown Booby
8.	Rabijunco	Hurricane Bird
9.	Garzon Blanco	Great White Heron
10.	Garzon Cenizo	Great Blue Heron
11.	Martinete	Green Heron
12.	Garza Azul	Little Blue Heron
13.	Garceta Africana	Cattle Egret
14.	Garza de Cuello Rojo	Louisiana Heron
15.	Yaboa Real	Black-crowned Night Heron
16.	Yaboa Pinta	Yellow-crowned Night Heron
17.	Martinetito	Least Bittern
18.	Pato Quijada Colorada	Bahama Pintail Duck
19.	Pato Zarcel	Blue-winged Teal
20.	Pato Cabeciblanco	Bald Pate Duck
21.	Pato Turco	Lesser Scaup
22.	Pato Chorizo	Ruddy Duck
23.	Guaraguao	Red-tailed Hawk
24.	Falcon Comun	Puerto Rican Sparrow Hawk
25.	Aguila de Mar	Osprey
26.	Pollo de Mangle	Clapper Rail
27.	Gallareta	Antillean Gallinule
28.	Ostrero	Oyster Catcher
29.	Playero Sabanero	Killdeer
30.	Playero Turco	Ruddy Turnstone
31.	Playero Guineilla Grande	Greater Yellow-legs
32.	Viuda	Black-necked Stilt
33.	Gaviota Comun	Common Tern
34.	Gaviota Cabecinegra	Laughing Gull
35.	Gaviota del Paraiso	Roseate Tern
36.	Gaviota Monja	Bridled Tern
37.	Bubi of Golondrina de Mar	Sooty Tern
38.	Cervera	Noddy Tern
39.	Paloma Cabeciblanca	White-crowned pigeon
40.	Paloma Turca	Red-necked pigeon
41.	Tortola Cardosantera	Zenaida Dove
42.	Rolita	Ground Dove

43.	Perdiz	Key West Quail Dove
44.	Pajaro Bobo	Mangrove Cuckoo
45.	Mucaro	Screech Owl
46.	Querequeque	Night Hawk
47.	Zumbador de Pecho Azul	Doctor Bird
48.	Zumbadorcito	Antillean Crested Hummingbird
49.	Martin Pescador	Belted Kingfisher
50.	Carpintero	Puerto Rican Woodpecker
51.	Pitirre	Petchary or Gray Kingbird
52.	Clerigo	Loggerhead Kingbird
53.	Golondrina de Cuevas	Cave Swallow
54.	Ruisenor	Mockingbird
55.	Zorzal Pardo	Pearly-eye Thrasher
56.	Julian Chivi	Black-whiskered Vireo
57.	Canario de Mangle	Yellow Bird
58.	Reinita	Bananaquit
59.	Tordo	Glossy Cowbird
60.	Mozambique	Greater Antillean Grackle
61.	Turpial	Troupial
62.	Chambergo	Bobolink
63.	Chamorro	Yellow-face Grassquit
64.	Gorrion Negro	Black-face Grassquit

complete; it comprises those birds most readily seen on the island. The rather rich bird fauna is an indicator of the healthy habitat conditions still existing outside of the populated areas there.

2) Reptiles. Several species of lizard are noticeable; among them are Anolis cristatellus (lagartijo comun), A. stratulus (lagartijo manchado), A. pulchellus (lagartijo rayado), and Ameiva exsul (called "iguana"). Two species of snakes are also present. These are similar to their Puerto Rican counterparts. From the oceans surrounding the island, Hawk's bill turtles and loggerhead turtles come to nest on the beaches.

3) Mammals. In July, 1966, four white-tail deer (one male and three females) were introduced by the Commonwealth government. Recently eight deer were reported by one informant to have been seen near the eastern end of the island, indicating that reproduction has taken place. It is probable that Culebra could support some limited seasonal hunting without endangering the supply of wildlife.

Other mammalian fauna on the island consists mainly of a few bats of the genera Artibeus and Molossus and possibly the fisheating bat Noctilio. No rodents other than the Norway rat and the house mouse have reached Culebra, and the mongoose (Herpestes) is also absent.

4) Farm Ponds and Lagoons. Eighteen farm ponds have been constructed in Culebra. They vary in surface acreage from 0.05 to 1.5 acres. The average size is just under 0.5 acre. Most of the soil in Culebra is full of small stones and rocks so that the water holding capacity of ponds is not as good as

on mainland Puerto Rico. With the possible exception of the one large pond (1.5 acres), none of the ponds appears to have any considerable potential value for fishes. They are all stock ponds with some value for wildlife, since we even saw a Bahama duck on a small quarter acre pond.

The largest lagoon is Flamenco, on the north coast. When flooded this lagoon almost covers 100 acres, but it almost dries up in the dry season and it is very shallow. It has no significant fishery value, but it has considerable value for waterfowl, especially for numbers of Bahama ducks.

C

COASTAL AND MARINE RESOURCES

8.

BEACHES

The beaches of Culebra and adjacent cays consist of narrow strips of sand extending along the coasts between the sea and the steep slopes of the coastal hills. The majority of these beaches are only 10 to 20 feet wide, but those of the east and north coast are somewhat more extensive, reaching 50 feet in width in some places. The best developed are Flamenco, Resaca, Brava, Larga, Cabeza de Perro, and Culebrita.

Composition

The mineralogical composition of almost all the beaches on the islands is similar, but particle size varies from coarse bits to very fine sand. The mixture is composed of about 80% calcareous material, 10% quartz, and 10% volcanic rock. The calcareous material comes from the mechanical destruction of the hard calcareous parts of marine organisms by wave action. The quartz is derived from erosion of the many veins of quartz apparent on the islands. The rock particles are derived from erosion of the abundant outcroppings of volcanic and plutonic rock. The best developed beaches, on the north and east, consist of material ground fine by the erosive action of the unobstructed waves from the Atlantic. Those on the south and west are composed principally of coarser material.

Owing to lack of rainfall, the rivers seem to have remained in an early stage of development, where the valleys are "V" shaped, with steep slopes and narrow flood plains. Transport of sediments by these rivers is very poor

and slow, so the material which eventually reaches the coasts is almost insignificant. For this reason, beach sands are predominantly calcareous, derived almost exclusively from the marine environment.

Origin

The main beaches of the islands have evolved as small harbors have become enclosed. A bank of sand accumulates across the harbor, producing a coastal lagoon behind the sand barrier. This barrier widens into a sand dune by wind action, which accumulates the finest sand along the border of the lagoon. As vegetation begins to increase, mangroves develop inside the lagoon. Then fine sediments being washed toward the beach are trapped in roots of the mangroves and the characteristic black soil of a mangrove swamp begins to appear. Eventually, organic material from the vegetation combined with the fine sediments form in time a viscous muck which virtually fills the old lagoon. Playa Flamenco is an example of this type of evolution in which the lagoon is still present.

The marine littoral zone contains large colonies of corals forming valuable reefs around the islands, such as the one south of the island of Culebrita. As waves destroy certain parts of the reef, the beach across from it receives calcareous material produced by its disintegration. Wave action polishes this material, breaking it into smaller and smaller pieces until the particles are reduced to the size of fine sand. This littoral material is transported along the coast until it becomes trapped between two rocky coastal protuberances. The movement is controlled by waves from the northeast breaking on the shore. Thus the sand moves from east to west along

the north and south coasts, and south along the east and west coasts. Because the waves are smaller along the south and west coasts, mangrove swamps tend to develop there.

Potential

The white calcareous sand, the lack of suspended sediments, the clarity of the water, the development of corals and of mangroves, and the interesting configuration of the coast all make the beaches of Culebra areas of great esthetic, touristic, and scientific value. The clear water is ideal for scuba diving, snorkeling, and spear fishing. Owing to its preservation in its more or less natural state, the coast of Culebra is of great interest to marine biologists, marine geologists, and physical oceanographers. Its tourist and scientific potential is of incalculable value at the present time.

In spite of its natural beauty, however, there are a few forces already in progress, tending to detract from this valuable resource. The beaches are contaminated by lumps of oil scattered uniformly along the coast. Moreover, several holes are apparent, resulting from illegal removal of sand (see Figure 8.1.). Finally, the beaches are being eroded in some places, principally in the central part of Playa Flamenco. As human use of the islands increases, these destructive forces will become stronger, unless specific measures are adopted to reduce them.

9.

LITTORAL COMMUNITIES

The island of Culebra and its fringing cays and rocks are located in the Vieques Passage between the island of Puerto Rico and the U. S. Virgin Islands (Latitude 18°18' N and Longitude 65°18' W). The island group is composed of 26 islands, cays, and rocks and covers approximately 11 square miles of surface area.

Although a literature search showed that no faunistic survey, especially pertaining to the marine organisms occurring around the island group, has been carried out in the past, there is no reason to believe that these are drastically different from those occurring around the islands of the Greater and Lesser Antilles.

A preliminary survey of the marine benthic animal communities surrounding the island group was carried out during the three-day period between November 30 and December 2, 1970. The limited time, personnel, and logistic support available, and also the weather and sea conditions at the time of survey, precluded the possibility of undertaking a thorough quantitative investigation of the diverse benthic communities surrounding the island group. However, every effort was made to study as much area and as many different types of habitat as possible.

Observations were made from boats, from the shore, and by snorkelling.

CORAL REEFS

As a result of the low rainfall on Culebra, the island has no permanent fresh water streams. Such conditions are very favorable for a profuse coral growth in the clear littoral waters surrounding it, where sedimentation is reduced to a minimum. Eighty percent of Culebra's coasts are covered by coral reefs.

Classification of Reefs

Reefs are divided into four categories according to stage of development. These are the following:

Reef type 1) Young reef, submerged and patchy, with areas devoid of coral where substrate is exposed (usually sand).

Reef type 2) Young reef, submerged, extensive covering of all the substrate, with low or no dead coral heads. This is considered to be the most productive and beautiful reef type.

Reef type 3) Mature reef. A part of the reef is exposed or nearly exposed to the surface and the wave action has destroyed part of it. Large masses of coral head have been carried to the shallowest part (plateau).

Reef type 4) Senile or decadent reef, usually exposed, with very few live colonies. Productivity is low and mangrove communities may arise here.

Description and Analysis of Culebra Reefs

1) Cayo de Luis Peña. The southern coast of this cay is formed by great boulders of pillow lava extending from shore to about eight feet in depth. On these boulders isolated coral colonies are growing: in particular, the elk horn coral (Acropora palmata) and various sea fans and other soft

corals (Gorgonians). Northward towards Punta Cruz the reef is better developed, falling in the category of reef type "1", not extending more than 100 feet from shore. The rest of the bottom is covered by extensive turtle grass meadows (Thallassia testudinum). The southeast of Luis Peña has a more abundant coral growth, most of it to be classified as reef type "4" and considered therefore not very productive.

2) Punta Flamenco. This peninsula has an extensive area of reef type "2". Large massive heads of corals, especially brain corals and Montastrea, are very abundant, providing a fairly irregular bottom with great boulders of coralline growth reaching nearly to the surface from depths of 15- 20 feet. The presence of many sea fans and other soft corals as well as a large variety and abundance of tropical fish enhances the beauty of the extensive coral formation.

During the investigator's visit to this area, the results of ordnance disposal by the U. S. Navy were observed. According to Navy officials, ordnance, ranging from 1000-pound to 5-inch shells, has been accumulating on the bottom in the littoral zone surrounding the peninsula for a period of about 30 years. As a result of disposal activities, many dead fish were collected following a blasting on December 2. The following morning, frigate birds (Fregata magnificencis) were feeding upon dead fish which presumably rose to the surface during the night as they began to decompose. A quick survey revealed at least 20 more medium size specimens (groupers, snappers, parrot fish, and others) still trapped on the bottom by coralline debris.

Here a total destruction of the coralline mass was observed over an area of about 50 feet in diameter, cutting through a calcareous deposition of about 10 feet thick down to the sandy basement. Partial destruction was evident over a radius of about 200 feet, where large pieces of corals, particularly Acropora palmata, were broken down.

Sedimentation and silting were evident in this area where the loose sandy substrate had been exposed to the wave action. This may present a threat to the coralline colonies adjacent to the damaged area. Corals here are growing in crystal clear water where coralline secretions have stabilized the substrate. Now with the loose substrate exposed, silt and coarser particles could be picked up by the wave action and bury the adjacent corals, extending the actual damage. The rapid erosion of the exposed coralline rock will also increase sedimentation and these waters may no longer be clear.

Some of the dangers of these disposal activities might be minimized if all ordnance deemed safe to remove was transferred to bare sandy bottoms devoid of corals before demolition.

3) Puerto del Manglar. This area is characterized by reef type "4" and some areas of reef type "3". The shallow basins devoid of corals are covered by turtle grass. The reef surrounding Cayo Pelá is an extensive monotypic reef formed almost exclusively by the finger coral Porites porites furcata. The growth form of this colony creates an extensive interstitial lattice which houses very large numbers of invertebrates. Many crabs, shrimps, brittle stars, sponges, annelids, and others are sheltered here.

4) Cayo Norte. The area studied here is characterized by reef type "3" extending all the way to shore. The extreme southeast has areas of reef type "4" with very few and small living colonies. The southwestern half portion of the island is characterized by large boulders with channels running perpendicular to the shore. The very irregular formation here has created a relatively large and complex underwater cave system. Small lobsters and a grouper with an approximate weight of 40 pounds were observed here.

5) Culebrita. The southwest region is characterized by an excellent beach followed by a submerged reef type "2" which extends a few hundred yards from shore. Rich coralline growth is characteristic of this region which, although not as extensive as that of Peninsula Flamenco, is somewhat similar in beauty and profusion. However the bottom is not as irregular as that around Flamenco. Various large lobsters and some medium size fish were observed here.

6) The Culebrita Reef. This is the most extensive coral formation around the island. It was not completely studied due to lack of time but it seems to offer examples of all the reef types mentioned above. The areas observed showed a rich growth of Acropora palmata (elk horn coral), Millepora alcicrevis (fire coral), Porites porites (finger coral), and various brain and soft corals. This area must be further studied since it is the largest coral reef and could very well be an excellent site for a submarine park.

Reef Fishes

An abundance of small reef fishes of many species was found associated with all the reefs visited near Culebrita, Punta Melones, Punta Tamarindo Chico, and Luis Peña. Although the reaction of the fish to the diver indicated that they have had few previous encounters with humans, only a few large individuals could be found in all the areas surveyed. This might be indicative of some spear fishing being carried on in the area, or, alternatively, might be simply a result of the depths being investigated. A list of the species of fish encountered during the course of this study is presented in Table 9.1. This should not be construed as a complete list of species present.

Potential

It is virtually impossible to overestimate the importance of the coral reef community in tropical waters. Tropical oceans are among the least productive marine communities. However, littoral communities, when fringed by coral, are the most complex and productive marine ecosystems. They support many commercially important fish, lobsters, and molluscs. They also provide the widest variety of species and the largest number of organisms per unit area of any marine environment. Virtually all the organisms present enrich the planktonic life through a large number of larval stages. A single lobster could release between 500,000 to 1,000,000 larvae, which all become part of the plankton temporarily. Many of these larval stages serve as part of the food chain of pelagic organisms such as mackerel, tuna, bonito, and other commercial fish.

Scientific Name	Common Name
Dasyatis americana	Southern stingray
Actobatis narinari	Spotted eagle ray
Gymnothorax moringa	Spotted moray
Aulostomus maculatus	Trumpetfish
Holocentrus spp.	Squirrelfish
Adioryx spp.	Squirrelfish
Sphyraena barracuda	Great barracuda
Ephinephelus striatus	Nassau grouper
Hypoplectrus unicolor	Butter hamlet
Grammaloreto	Fairy bässlet
Remora remora	Remora
Caranx fusus	Blue runner
Lutjanus spp.	Snapper
Ocyurus chrysurus	Yellowtail snapper
Haemulon aurolineatum	Tomtate
Haemulon chrysargyreum	Smallmouth grunt
Haemulon sciurus	Bluestripe grunt
Mulloidichthys martinicus	Yellow goatfish
Pseudupeneus maculatus	Spotted goatfish
Opistognathus aurifrons	Yellowhead jawfish
Opistognathus spp.	Jawfish
Chaetodon capistratus	Foureye butterflyfish
Pomacanthus arcuatus	Gray angelfish

Pomacanthus paru	French angelfish
Holacanthus tricolor	Rock beauty
Eupomacentrus planifrons	Yellow damselfish
Holacanthus isabelita	Blue angelfish
Eupomacentrus leucostictus	Beau gregory
Chromis spp.	Chromis
Thalassoma bifasciatum	Bluchead
Halichoeres spp.	Wrasse
Hemiteronotus spp.	Razorfish
Sparisoma spp.	Parrotfish
Scarus spp.	Parrotfish
Acanthurus coeruleus	Blue tank
Acanthurus chirurgus	Doctorfish
Lactorhys triqueter	Smooth trunkfish
Lactorhys bicaudalis	Spotted Trunkfish

Not only is the reef highly productive but it also forms effective barriers which protect the coast from erosion and provide many protected beaches and lagoons of calm waters. Where coral growth is abundant, it stabilizes the substrate and thus increases the visibility in waters around it. Since the main island of Puerto Rico is characterized by a limited coral growth, particularly in northern, western, and southeastern waters, due to the high degree of sedimentation by our rivers, the coastal waters of Culebra may compensate in part for these limitations.

Dangers

At the present time, Culebra's reefs are threatened by two factors. First, increasing amounts of untreated sewage and solid wastes dumped into Ensenada Honda and the clearing of vegetation on adjacent hill slopes represent imminent dangers of severe pollution to the bay. The water exchange of the bay in each tidal cycle will disperse the contaminated water throughout the coast line of Culebra, damaging the reefs.

Second, the ordnance disposal procedures in use during the course of this investigation have been demonstrated to possess the potential of totally destroying the finest reef of the island, depending upon the magnitude of these operations.

1. TURTLE GRASS BEDS

Turtle grass beds are usually found all around the island group in water shallower than 30 feet deep where light penetration is sufficient for photosynthesis and usually interspersed with stretches of sandy bottom or coral reefs. The north and northwest sides of the island group are the exception because of heavy surf action caused by swells from the Atlantic Ocean.

Species Present

By far the most common plant found in the turtle grass beds is turtle grass, Thalassia testudinum. As in the turtle grass beds in Puerto Rico or the Virgin Islands, slender manatee grass, Cymodocea manatorum, and algae, Halicystis osterhoutii, Caulerpa spp., Avrainvillea spp., Udotea spp., and Padina spp. were also found. The most common echinoderms were sea urchins, Diadema antillarum, Tripneustes esculentus, and Lytechinus variegatus, and occasionally the sea cucumber Holothuria mexicana. The most common gastropods found were queen conchs, Strombus gigas, and occasionally helmet shells, Cassias tuberrosa and Cerithium litteratum.

Few fish were visible in most of the beds, except occasional pelagic fish such as jacks and barracudas.

Locations

1) Southwestern Side of Culebrita. There were many relatively small patches of turtle grass beds distributed throughout the area, interlaced between broken shells and coral sand bottom. These turtle grass beds

were only sparsely populated and only a few conchs and helmet shells were seen. However, there was no evidence of human exploitation.

2) Northeastern Side of the Town. The turtle grass beds are distributed throughout Ensenada Honda with the exception of the middle channel. The growth is extremely thick and blades of the grass were wide and very green. They gave an appearance of being very healthy, although the bottom of the bay near the shore in the vicinity is heavily littered with discarded bottles, cans, and other debris resulting from human activities. Also, untreated raw sewage is directly discharged into the bay on the turtle grass beds.

Only a few queen conchs were found, but there were many sea urchins, Lytechinus variegatus, and a few Diadema antillarum. One jelly fish, Cassiopea frondosa, was also seen on the bottom.

3) Bahías Taría and Tamarindo. The turtle grass beds in the two bays are located in water 10 to 30 feet in depth, and are one continuous bed spread in the center of the bays. The blades of grass and the density of the plant appear less healthy than the bed in Ensenada Honda. There were many juvenile queen conchs from two to seven inches long. Only one adult size conch was found. There were also many patches of 7 to 20 sea urchins (Diadema antillarum). Fan shells, Pinna carnea, were also found occasionally.

4) Southeastern Side of Luis Peña. There is one continuous turtle grass bed in this bay which extends from a depth of 10 feet to 30 feet in the

center of the bay. The queen conchs here are very abundant. The bottom is literally covered with juveniles less than eight inches long. The density ranged from three to ten per square meter. Only a few sea urchins were visible. According to a local fisherman, this bed is always full of small conchs. If so, both this area and Tarja and Tamarindo could be nurseries for this species.

c. MANGROVE SHORES

The mangrove forests cover much of the shoreline in Ensenada Honda, and to a varying degree on the southeastern coasts of the island. Close examination of the animals encrusted on the roots of the mangrove trees near San Ildefonso showed that the predominant ones were flat tree oysters, Isognomon alatus, and to a lesser extent edible mangrove oysters, Crassostrea rhizophorae. The density of encrustation was not high in most cases, and most of the roots appeared to be clean. Several small crabs, Aratus pisonii, were seen above the water on roots and branches. Only a few polychaete worms, Sabellastarte and Sabella, were found. On the bottom, several blue crabs, Callinectus danae, and starfish, Oreastra reticulatus, which are usually found on turtle grass beds, were found. On the land side, holes made by the land crab, Cardisoma guanhumi, were also seen.

At the end of Ensenada Honda, a large area of mangrove forest has been cut down and the cleared swamps have been filled. These unauthorized activities contribute to the decrease in mangrove swamp area.

3. ROCKY SHORES AND BOTTOMS

Numerous rocky substrates are present throughout the island and cays. The north end and southeastern parts of the island, the north and south sides of Luis Peña, and Cayo del Agua are all rocky coasts. Diving at the south end of Luis Peña showed that the species of fish found are similar to those in coral reefs except that they are less abundant. Edible gastropods such as Cittarium pica and Astrea caelata were found, and they are often harvested by divers. Limpets, Acmaea leucopleura and Fissurella nodosa, were found in the intertidal zone. The most common echinoderms found were the sea urchin Echinometra lucunter and the sea cucumber Holothuria glaberrina.

Rocky beaches on the north side of Bahía Sardinas were investigated by both diving and working along the shore. The area was altered considerably by filling or large rocks and some cans and bottles were visible. However, there were some species of reef fish and some of the rocks were carpeted by clusters of small hermit crabs, Calcinus tibicen.

e. SANDY BEACHES AND BOTTOMS

Sandy beaches and bottoms were found throughout the island group. They are interspaced with turtle grass beds or coral reefs in water shallower than 30 feet. They give an appearance of desert and the concentration of biomass is the lowest of all the habitats surveyed. Only a few algae and Padina spp. and Avrainvillea spp. were found. Digging into the sand bottom yielded small clams, Diplodonta nucleiformis and Codakia pectinella. Those in the intertidal zone on the southwestern shore of Luis Peña yielded more visible organisms.

The preliminary survey of the littoral communities which surround the island group has shown that most of the turtle grass beds, coral reefs, rocky shores, and sand bottom communities are free of human abuse and exploitation at the present time. The areas adjacent to the town of Culebra are exceptions. Compared to the same ecosystems in La Parguera, located on the southwest coast, and Negro Reef, on the west coast, of Puerto Rico, it appears that the various communities around the island group are composed of approximately the same species, but the individuals in a given species are far more numerous for a given location here than off the main island.

Without a doubt, the island group probably constitutes one of the very few areas in Puerto Rico where human activities have not yet altered natural conditions to a significant extent. Earnest effort must be made to maintain the diverse ecosystems in the area in present condition or, better yet, reduce the present human activities so that the natural state can be preserved.

19.

FISHES AND FISHERIES

Commercial Fishing

In general, trap fishing for lobsters and fish is carried out in the deeper waters off Culebra, although several traps were found while diving in Bahía Tamarindo and floats attached to traps were found in Bahía de Almódovar. The traps found in Bahía Tamarindo were without buoys and contained a large number of reef fish, some of which had been dead for some time. Such wasteful practices are a drain on a marginal industry and should be discontinued.

Pelagic fish such as Spanish mackerel (Scomberomorus maculatus), king fish (Scomberomorus cavalla), jacks (Carangidae), dolphin (Coryphaena hippurus), marlins (Makaira spp.), and others are taken by trolling by both fishermen from the island and sport fishermen from other areas. Most of those fish are transient and do not stay in one place for any length of time. Gill nets are also used.

Queen conchs (Strombus gigas) and helmet shells (Cassina tuberosa) are captured for consumption as well as for decoration by the fishermen and sportsmen. Although fishing intensity could not be ascertained during the period of the stay, judging from the abundance of conchs on the beds, it is not great at the present time. The lack of adult size conchs on all the bottoms surveyed is puzzling.

Data on the annual (1969) yields to Culebra fishermen, in pounds and in dollars, of the most important commercial species are presented in Table 10.1. Specific data on the spiny lobster catches in 1969 and 1970, as compared with those from 1948 to 1959, are shown in Table 10.2.

According to the files on record in the Department of Agriculture, there are a total of 22 fishermen in Culebra, 4 regular and 18 casual. A total of 14 boats are registered, from 17 to 33 feet in size. Most of the boats are equipped with outboard motors from 15 to 40 horsepower. The average number of fish pots for each of 8 of the larger boats is 21 lobster pots plus 17 fish pots. Four of the regular fishermen are also fish buyers.

In terms of fishing port facilities, the government, through the Department of Agriculture, has recently constructed three wooden buildings just east of Canal Loco east of Dewey. The facilities are not yet being used by fishermen because of access problems. If a simple pipe pier were constructed from the shore to water of three- to four-foot depth near the east side of the channel, fishing boats could come alongside to unload. Dredging will be expensive and would probably have to be repeated because of the strong southward currents in this small channel.

In view of the present naval maneuvers on the northwestern and central northeastern coasts of Culebra, prospects for further development of the coastal commercial fisheries are severely limited. Although increasing prices and greater consumer demand have improved market conditions for the

Table 10.1. Present Status of Commercial Fisheries Including Most Important Fish Species in 1969. *

FISH		POUNDS	VALUE
Barracuda	Picua	749	$ 216
Grouper	Mero	3,710	924
Hogfish	Capitan	764	208
Kingfish	Sierra	1,863	505
	Chopa	1,138	326
Snapper	Pargo	707	181
Muttonfish	Sama	908	235
Silk snapper	Chillo	1,043	299
Yellowtail	colirrubia	938	236
Trunkfish	Chapin	1,608	477
Second class	Segunda	8,506	457
Third class	Tercera	2,163	276
Shellfish			
Conch	Carrucho	415	$ 202
Spiny lobster	Langosta	28,939	22,816
Octopus	Pulpo	97	36
Trash fish	Brosa	353	21
Other	Otras	58	10

* Reported fish production at Culebra in 1969, from p. 12 of Juhl & Suárez-Caabro, 1970 Bol. Informativo 1969, Vol. III, No. 2, Marzo, Depto. de Agricultura.

Table 10.2. Spiny Lobster Catches in 1969 and 1970 Compared with Those from 1948 to 1950.

Total, 1948 - 1949	93,239 lbs.
Total, 1949 - 1950	109,605
Estimated Total, 1969	48,231
Estimated Total, 1970	30,285

detonations killed an undetermined number of fish and damaged corals off the western coast of Culebra on the afternoon of December 2, 1970, (Rafiz (19)).

Sport Fishing

The sport fishery in Culebra is still in a developing state. The southeastern barrier reefs from Punta Soldado northeast to Dolphin Head at the north entrance to Puerto del Manglar are probably the best bone-fishing reefs in Puerto Rico. Gray snapper and tarpon occur in the mangroves. Barracuda and bar jacks are abundant on the reefs in this area, which is south of the firing range of Culebrita and Botella Cays. These reefs should be protected in their present natural state.

A pelagic sport fishery exists north of Culebra at the edge of the 100-fathom-curve where sailfish, tuna, dolphin, and amberjack have been caught.

Diving, spear fishing, and hook-and-line fishing are most commonly used to catch queen conchs, helmet shells, West Indian top shells, and other species of gastropods. Spiny lobster (Panirulus argus) and octopus are the most popular species taken from the reefs. Larger reef fish such as groupers (Epinephelus spp.) and snappers (Lutjanus spp.) are also popular among the fishermen.

Even with naval maneuvers, especially if they desist from firing on Saturdays, Sundays, and holidays, the sport fishery is capable of considerable

further development. There are several lacks, however: the island occasionally runs out of fuel, and ice is extremely limited in supply. The nearest block ice available is on the island of Vieques, nine miles to the south.

Saltwater Aquarium Fish Collection

One resident has been collecting reef fish and shipping them to tropical fish outlets in the States for the last three years. The fish he is interested in are labrids, pomacentrids, grammids, chaetodontids, mullids, opisthognathids, and others which are small and colorful. They have little or no value to commercial or sport fishermen. At the present time he is the only one who is carrying out such a venture and the rate of removal is not significant. Drop nets and sometimes chemicals are used to trap or stun the fish.

Water Pollution

Since there are no sewage treatment facilities on the island, waste water and sewage are directly discharged into the sea and bays. On the east side of Dewey, where there are a number of residences along the shore, there was no indication of the harmful effects of water pollution. The bottom for the most part is covered by a healthy growth of turtle grass and there were no traces of dying animals. However, the bottom is littered with bottles, cans, and other debris.

The canal which separates the southwest part of the island from the northwest contains little vegetation and few bottom dwellers except for a

polychaete tube worms, mangrove oysters, and flat tree oysters. The
ttom is muddy and the water is murky. The bay inside of the canal has all
e indications of severe water pollution from the houses surrounding it.
e bottom is composed of black mud. No bottom fauna were found. Although
here are strong currents which flush back and forth through the canal, the
ater circulation within the bay is sluggish.

In Bahía de Sardinas, where the municipal dock is located, the bottom is
uddy and no benthic animals were found. It is littered with cans, bottles,
nd other debris.

11.

OCEANOGRAPHIC OBSERVATIONS

Preliminary data on currents, salinities, temperatures, and dissolved oxygen concentrations in the ocean waters around Culebra were collected during a two-day visit, December 1 and 2, 1970. Due to U.S. Navy activities along the northern side of the island, it was impossible to gather data along the northern shore during this stay.

Temperature, salinity, and dissolved oxygen determinations were obtained from 20 stations (see Figure 11.1) along the southern and western portions of the island. The sampling was done aboard the Public Works Department vessel "MAROJO", using a Hydrolab II A recorder made by Applied Research Austin, Inc., for temperature and dissolved oxygen measurements and an American Optics refractometer for salinities. The latter instrument is not ideal for oceanographic work and estimates are rather crude.

Rhodamine-B dye was employed in two locations within Ensenada Honda to obtain a general idea of the current pattern in that area.

Prior to the trip to the island, an attempt was made to obtain oceanographic data for the island and surrounding waters from other governmental agencies. Agencies contacted were: (1) Captain R. Fenley - Assistant Chief of Staff for Plans and Operations of the U. S. Navy in Puerto Rico; (2) R. Admiral W.W. Behrens - Oceanographer of the Navy, Washington, D. C.;

(3) Nilo Iriede - Federal Water Quality Administration, Puerto Rico; (4) Frank G. Lowman - Director, Marine Biology Division, P. R. Nuclear Center, Mayaguez, Puerto Rico; (5) National Oceanographic Data Center, Washington, D. C.

Surprisingly, there are no oceanographic data available for Culebra from any of the above agencies. Such data are of prime importance for any future development of the island, as well as for general environmental information. It is suggested that at least two permanent stations should be set up in the area for the gathering of such data.

Salinities

At all 20 stations along the southern portion of the island (see Table 11.1), we found an oceanic salinity of 36%. These measurements are by no means representative, especially inside of Ensenada Honda. It is expected that during the rainy season runoff water from the hills around this bay tends to reduce the salinity considerably. Also, the instrument available for salinity measurements was not as accurate as would be desirable for a study of this kind.

Temperatures

Usually, in a shallow bay like Ensenada Honda, temperatures are expected to be somewhat higher than in the waters outside the bay. The results of our study proved this not to be true in this case. The temperature of the waters inside of the bay were sometimes up to one degree lower than those outside of the bay. This may perhaps be explained by the overcast skies during the time

of study. Also, in the winter season, when air temperature usually drops, the cool air blowing across the shallower bay may tend to absorb some heat from its waters.

As in the case of salinities, these results cannot be taken as representative, since during the summer months the reverse would be expected. Stations 15 and 16, inside the shallow lagoon in the narrow strip of land dividing Bahía de Sardinas and Ensenada Honda, as expected, had higher temperatures, since this lagoon is not affected as much by winds and warm water from houses in the surrounding area emptied directly into it.

Dissolved Oxygen Concentrations

The results of the dissolved oxygen determinations came out as expected. Oxygen concentration tended to be higher inside the bay than outside. The bay harbors a luxuriant growth of algae and Thallassia beds and these produce oxygen during the day making the dissolved oxygen in the waters of the bay higher than that for outside of the bay. Here again, these measurements are not representative since they will vary during the summer months. Also, a reduction of oxygen concentration during the night is expected, when green plants use up oxygen instead of producing it. Stations 15 and 16 showed a decrease in dissolved oxygen, due most probably to the high amount of organic matter being decomposed and using up available oxygen there.

Currents

Currents may be defined as a horizontal transport of a water mass which may be either periodical, such as tidal currents, or non-periodical, such as wind drift and density currents.

FIG 11.1 OCEANOGRAPHIC OBSERVATIONS

The purposes of measuring currents are many and diverse. In order to fully understand the general oceanic circulations, a knowledge of currents is of vital importance. This knowledge is necessary for navigation and for fisheries research and development. An understanding of the currents is also helpful and may be of extreme importance for studies of pollution and water control.

Although the temperature and salinity distribution in an area are directly influenced by the area's climate, the currents modify the distribution of the above parameters and also play a role in the distribution of dissolved gases in the water. Thus, the current may also be a determining factor influencing the distribution and abundance of many marine organisms. In general, the most important factors influencing currents are the tides and the energy transferred to the water by the wind.

The day-to-day currents in the oceans are very variable and the general current trend in any small region cannot be determined until there are enough observations to be representative of all the variations, both in direction and rate, which can occur in that region. Thus a comprehensive study was impossible during the short period of this survey. The data which follow came from direct observations of fish pot buoys, interviews with fishermen of the area, and published reports (14).

In the vicinity of Puerto Rico, there exist two large coastal currents, both flowing in a west-northwesterly direction. These large oceanic currents, which are both part of the North Equatorial Current, are the Antilles Current,

which flows along the northern coast of Puerto Rico, and the Caribbean current, which flows along the southern coast. The Caribbean current has a ramification which flows north between Puerto Rico's mainland and the island of Vieques until it meets the Antilles Current at the northeastern part of the island. Under the influence of these currents, the coastal and nearshore currents around the island of Culebra flow mostly northwesterly with occasional tidal currents set southeasterly, (see Figure 11.2).

Close to shore, these general oceanic currents may be deflected and modified and local currents of entirely different kinds may be set up by the many influences that prevail along a shore, such as wave and surf characteristics, bottom irregularities, and the configuration of the shoreline itself. As is the case for the northern coast of Puerto Rico, the tides are chiefly semidiurnal and the periodic range is around one foot, the actual fluctuation in the water level depending largely upon the winds and other meteorological conditions.

In Canal de Luis Peña, the southeastward current is deflected northward from Bahía Tarja and then sets toward the south end of Cayo de Luis Peña. The currents are weak off the entrance to Bahía de Sardinas, where the town and pier are located. The northwestward current sets directly through the channel. The current is rather strong, being approximately of 2 knots. This channel is considered hazardous for sailing vessels.

The north coast of Culebra has sandy beaches between rocky bluffs for 2 miles, then the shoreline becomes generally bold and rocky, with sandy beaches in the coves. Culebrita, Cayo Norte, and the coral reef extending between them

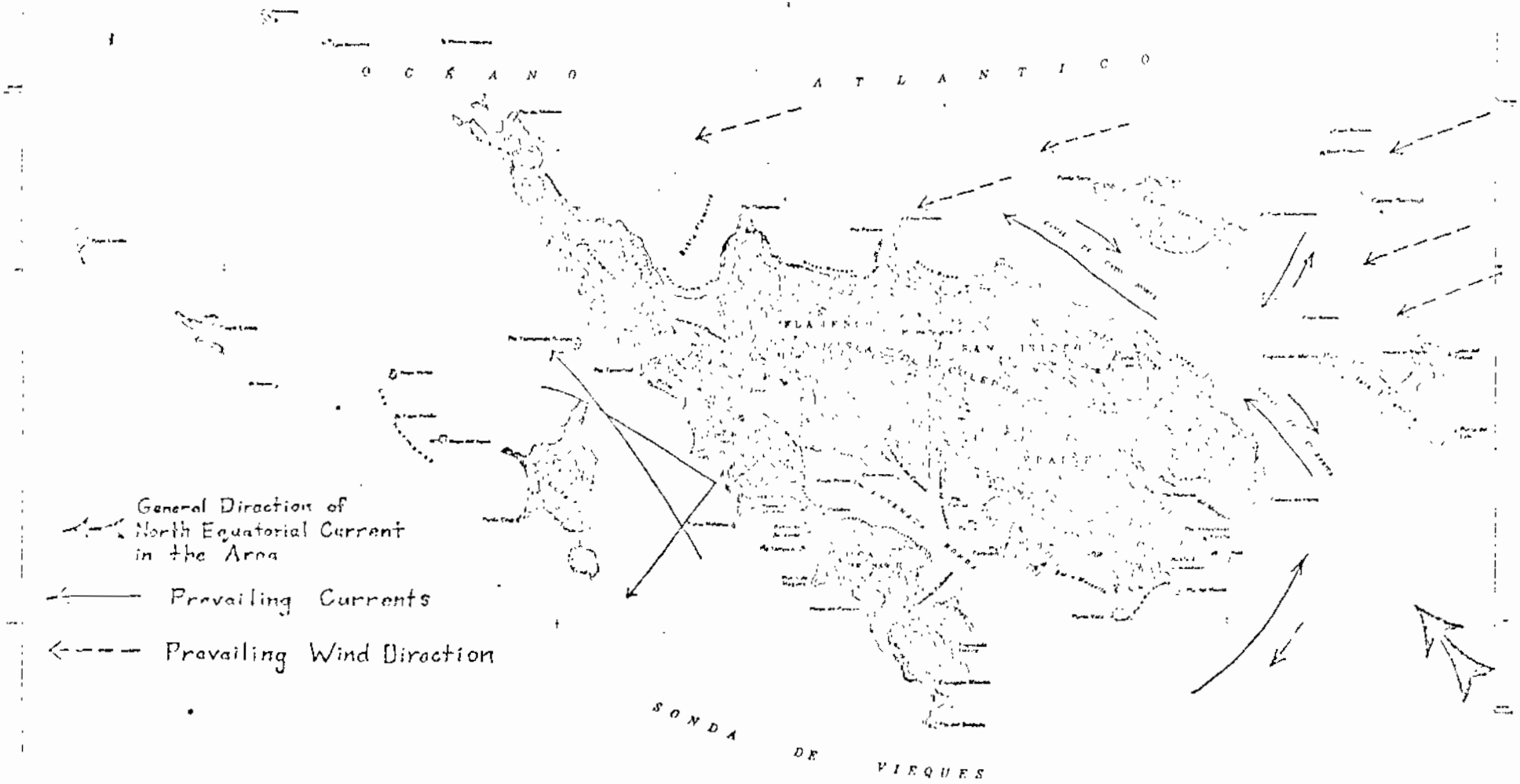

Fig. 11.2. Currents Near Culebra

[illegible] protection to the northeastern part of Culebra. This explains [illegible] the island of Culebra has these two miles of rather uneroded beach front. [illegible] currents in Canal de Culebrita and Canal de Cayo Norte usually flow to [illegible] northwest with occasional tidal currents in the opposite direction (see figure 11.2). Small and large rocky headlands on the north and northeastern side of Culebra act as groins and the eroded material carried by the currents is deposited on the leeward side creating the most developed beaches in the area.

Between the bluff of Punta Vaca on the east and Punta del Soldado on the west we find the most secure anchorage in the area, Ensenada Honda. The harbor is about 1.5 miles in length and in some parts 0.5 miles wide. It is of rather irregular shape with several small shallow bays indenting the shore. Only small boats can make a landing at the west end of Ensenada Honda. Large vessels calling at Culebra must use Bahía de Sardinas.

A narrow strip of land divides Ensenada Honda and Bahía de Sardinas. A small lagoon is located in this strip of land with a channel connecting both bodies of water. Rhodamine dye was released in the channel near Bahía de Sardinas. At the time of release the current was flowing towards Bahía de Sardinas at approximately one foot per second. As soon as the dye reached the bay, it moved in a straight westerly direction towards Punta Tampico where it was no longer discernible. The behavior of the waters in this channel needs further study since the direction of flow is very unpredictable. It changes in direction almost every half hour and many times water is flowing in

both directions. Another dye release was made at the entrance of Ensenada Honda. Due to the lack of time and other facilities to track the trajectory of the dye from the air we were unable to fully assess its trajectory but at the time of release it was observed moving towards the bay in a very slow fashion.

Waste Disposal Problem

The town of Dewey lacks any sort of sewer system or treatment plant. Raw human wastes were seen floating in the water around the small lagoon between Bahía de Sardinas and Ensenada Honda. A sanitary survey was not possible at this time but the Escherichia coli counts are expected to be very high, in this lagoon and in both receiving bodies of water. Swimming in this area could be hazardous to the health and if this condition is not remedied it could contaminate all of Ensenada Honda and Bahía de Sardinas. The rapid proliferation of small houses on the shores of Ensenada Honda will increase this problem unless zoning regulations are made and enforced, or an effective sewage treatment plant built.

II

SOCIO-ECONOMIC CONDITIONS

This analysis of Culebra's social and economic assets and problems has been divided into two parts. In the first section, which is more descriptive, changes registered by standard socio-economic indicators are evaluated: municipal growth, attitudes, physical layout, and values. Available government statistics are included.

The second section presents the results of a survey of one third of the households on the island. The emphasis here is on the residents' perception of their situation. Valuable information toward understanding Culebra's real problems was obtained in this way. Naturally, there will be some discrepancies between the field data collected for this analysis and figures published by other Commonwealth agencies. Also, the treatment of some aspects is necessarily superficial due to the limited time available.

A

DESCRIPTIVE EVALUATION

12.

SOCIAL CHARACTERISTICS

Population

According to official data of the Puerto Rican Planning Board, taken from the 1970 Census, the population of Culebra in 1970 was 726 individuals. Population density for the island as a whole is 0.11 persons per acre. However, 2,700 acres of uninhabited U. S. Navy property plus a large acreage owned by non-residents increase the effective density to 4.48 persons per inhabited acre.

The actual number of inhabitants at present is not significantly different from the number in 1899, when there were 704 residents. However, this stability is more apparent than real. Table 12.1 shows the large fluctuations in population size from decade to decade. These irregularities are not reflected in the population growth rates for the rest of Puerto Rico.

Educational Services

From 1967 to 1970 elementary school registration rose from 137 to 186 students (see Table 12.2). Classroom facilities did not increase during this time period and the number of teachers available rose from 6 to 7. As a result, different grades must attend classes in the same room in many cases. Also, at present there is no English language teacher. A similar situation holds for the night sessions. These conditions force students at high school level or above to leave the island for St. Thomas, St. Croix, Vieques, or Puerto Rico.

Table 12.1. Population Size and Growth Rates on Culebra.

Year	Population	Growth Rate
1899	704	-----
1910	1315	87%
1920	839	- 36%
1930	847	1%
1940	860	2%
1950	887	3%
1960	573	- 35%
1970	726	27%

Table 12.2. Students Graduating from Each Grade Level in 1967 and 1970. *

LEVEL	1967		1970	
Elementary School	No. of Students	Percent	No. of Students	Percent
1st. grade	23	17 %	29	16 %
2nd. grade	23	17	28	15
3rd. grade	17	12	27	15
4th. grade	15	11	18	10
5th. grade	13	9	24	13
6th. grade	16	12	15	8
Intermediate School				
7th. grade	13	9	17	9
8th. grade	6	4	12	6
9th. grade	11	8	8	4
High School				
Grades 10, 11, 12	--	--	8	4
Totals	137	100%	186	100 %
Classroom	6		6	
Teachers	6		7	

*Information was provided by the P. R. Department of Instruction.

degree of social and family associations. Few crimes are committed, and probably fewer still are reported. Violation of public and private property rights is common and generally ignored. Juvenile delinquency and drug addiction are not serious problems. Most violations are misdemeanors.

From January to November, 1970, 16 serious crimes and 32 misdemeanors were reported. Theft and robbery represent 75% of the serious violations. The misdemeanors included 10 traffic violations, 8 minor assaults, 10 disturbances of the peace, and 4 property damage cases.

Values and Attitudes

Since 1965, Culebrans have been involved in a dramatic conflict of attitudes. Many citizens are afraid to express opinions about existing problems openly. There is no common interest or philosophy toward the future and social division is high. Some feel the solution to all problems lies in the complete withdrawal of the U.S. Navy; for others such a withdrawal would be a catastrophe for the island. The degree of divisiveness is so high that the municipal administration is unable to communicate with Navy representatives.

The attitude of Culebrans toward the rest of Puerto Rico is very negative. They feel forgotten and ignored. The Commonwealth government and the municipal administration are blamed for inadequate facilities on the island.

Organizations

In this community, every aspect of life seems to be subject to political exploitation. The only active social organizations are political groups. In

the general elections, in 1968, six political parties participated: the Popular Democratic Party, the State Republican Party, the New Progressive Party, the P. R. Independence Party, the Democratic Party, and the Authentic Party.

There is also a community committee with a political leadership, "Pro-Rescate de Culebra". This committee uses consultant services of the Legal Services Corporation, VESPRA, the Civil Rights Commission, and the Board of Lawyers. It holds meetings and puts out leaflets.

In addition, a fishermen's organization has been formed with the stated purpose of improving conditions for fishermen and their families. Membership includes both full-time and occasional fishermen. This group has the support of the mayor.

Besides these political groups, there are only two more organizations with limited activities: the Farmer's Association and the Sports Committee. The lack of social groups with no political interests reflects in part the deterioration of existing social interactions within the community.

13.

ECONOMIC CHARACTERISTICS

The economy of Culebra is based upon importation, due to its low productive capacity and the scarcity of its resources. According to the Planning Board it is not considered to be an industrial economic unit. The government sector generates 50% of the adjusted internal income; unclassified activities the other 50%. The total adjusted internal income was only $400,000 in 1969, the lowest of all municipalities in Puerto Rico. The income per capita for that year was $551.00.

All products and articles of consumption, except those from the sea, are imported from Puerto Rico and nearby islands. Imports include building materials and meat although these might conceivably be available on Culebra. The main farming industry is beef cattle, but there are no slaughterhouse facilities. For this reason, the beef is sold on the main island for processing and then meat for consumption is imported.

Municipal Finances

Culebra is very poor. It is estimated that for 1970-71 the municipality will receive a total of $143,274, $88,874 from ordinary Commonwealth funds and $54,400 from municipal subsidy funds. Local taxes generated only $353.50. Since 1951 the municipal budget has increased as follows:

1951	$23,100
1955	29,302

1959	$40,900
1963	80,373
1967	138,533
1970	143,276

In 1969 Culebra elected its first municipal assembly, to deal with its problems with a higher degree of autonomy. This is reflected in the rise in the budget in succeeding years. A summary of municipal finances in 1955, 1960, and 1969 is shown in Table 13.1.

Agriculture

According to the Federal Agriculture Census, in 1964, Culebra had 33 farms with a total of 4,456 acres of land (see Table 13.2). Only 2 of these farms (14 acres) included land under cultivation; the others contained 3,034 acres of cultivated pasture, 1,286 acres of uncultivated pasture, and the rest unusable for agriculture.

All farms are dedicated mostly to raising stock. Distribution of income from various sources in 1964 is:

Dairy	$8,666
Horses, Pigs and Goats	1,062
Cattle	124,415
Fruits and Vegetables	1,105
Total	$135,248

The average income per farm is $4,098.

During 1964, 29 (88%) of the 33 farms were managed by their owners, 2 (6%) were leased, and 2 (6%) were handled by managers.

Products are marketed both locally and on Puerto Rico. Fresh milk is sold locally but is not pasteurized, so most citizens prefer milk imported from

Table 13.1. Municipal Finance.

	1955	1960	1969
Tax Property Value	$329,000	$329,000	$335,000
Credit Capacity	16,000	17,000	17,000
Credit Margin	16,000	16,000	16,000
Total Collections	89,000	149,000	188,000
Expenditures	92,000	95,000	166,000
Municipal Property Value	74,000	118,000	170,000
Capital Property	74,000	118,000	170,000
Real Estate	-------	-------	-------

Table 13.2. Farm Usage.

	1959	1964
Total Number of Farms	31	33
Acreage	3,609	4,456
Acres under Cultivation	----	14
Cultivated Pastures (Acres)	737	3,034
Acres for Grazing Cattle	2,067	1,286
Acres not for Grazing Cattle	692	90
Acres for Public Use and Lakes	113	32

the island. There is a small fresh cheese industry. Fruit and vegetable products are consumed locally. Cattle is exported and sold in Vieques and eastern Puerto Rico. Most is slaughtered at the Naguabo Regional Slaughterhouse.

Cattle production has been aided by the development of artificial lakes and the planting of drought-resistant pastures. Other than this, the potential for development of agriculture in Culebra is poor, due to dry climate, topography, and poor soil. The drought of 1965 provides an excellent index of these limitations. From 1965 to 1970, the number of cattle dropped from 6,000 head to 2,000 head. The latter figure, 2,000 head, is probably the maximum capacity of Culebra's land.

Industry

The only industry in Culebra, "Manor Research South", closed in November, 1970. Reasons for its failure include:

1) Death of the president
2) Lack of a good water supply
3) Lack of adequate power
4) Lack of skilled labor
5) Inadequate transportation
6) Poor government facilities

Most of these factors reflect the inadequacy of the economic subetructure to promote further industry as a source of income and employment for the inhabitants.

Commercial

At present there are 34 commercial establishments on Culebra, most

operated by their owners (see Table 13.3). There are no drug stores, bakeries, dental care, or doctors' offices. Only 21 of the 34 are officially registered, operate more than four hours per day, and pay municipal taxes. Eleven of the 21 enterprises are only three years old or less. At the time of the interview, none of the owners was interested in selling his property. Annual business sales totalled $162,861. Depending on this income was a total of 95 persons.

Tourism

The potential for development of a tourist industry is excellent, once access to beaches, good fishing areas, and reefs is assured. At present there are two hotels and one guest house. All are of the commercial family type and provide only minimum facilities. Lack of a good water supply limits better hotel facilities at present. The water tastes salty and is turned off from 9:00 AM to 3:00 PM. No regular employment is offered by the hotels.

Construction

In 1969, a construction permit was issued by the Planning Board for the construction of a government building. Since that date no other permits have been issued. Nevertheless, there is much illegal construction along the shore of Esmeralda Woods. These are recreational in nature and are not owned by Culebrans. Other buildings are under construction on Commonwealth property in Clark Township.

In 1970, the Planning Board has received five proposals for new projects. Within the last five years, proposals have also been submitted for an industrial complex (by Eurocato), a desalination plant, a slaughterhouse, a government center, and a health center. Only the last has been approved.

Table 13.3. Commercial Enterprises.

TYPE	NUMBER
Bars	5
Hardware Stores	4
Night Clubs	3
Markets	3
Meat Markets (fish)	3
Construction Material Stores	2
Bazaars	2
Barber Shops	2
Moving and Transport Services	2
Public Vehicles	2
Beauty Parlor	1
Garage (Tin Shop)	1
Gas Station	1
Boating (Transportation)	1
Airlines	2
	34

Government

There are eleven Commonwealth public agencies that have partial offices and services in Culebra. They are:

Aqueduct and Sewer Authority
Health Department
Police Department
Port Authorities
Fire Department
Department of Instruction
Communications Authority
Department of Social Services
Parks and Recreation Administration
Department of Public Works
Internal Revenue

Government offices employ 30 persons with an annual payroll of $100,000. Quality of services to the residents ranges from poor to average, but is expected to improve. Currently, a large expenditure of public funds has been recommended for several projects (see Table 13.4.).

Table 13.4 Special Programs and Permanent Improvement Programs.

LISTING OF PROJECTS	COST	UNDER CONSTR.	PENDING CONSTR.	APPROVAL DATE
Public Works Dept.				
A) Street Reconstruction (Parcelas Clark and Airport Road)	$16,000.	X		1968
B) School Building Improvements, Muñoz Rivera School	8,000		X	1970
Public Building Authority				
A) Police Headquarters	43,350		X	1968
Parks & Recreation Adm.				
A) Urban Park, Cyclone Fence	10,000		X	1970
Dept. of Health				
A) Health Center	50,000		X	1966
(Total Cost $312,000)	100,000		X	1970
Aqueduct and Sewer Auth.				
A) Rural Aqueduct in Clark	30,000		X	1967
(Total Cost $192,000)	130,000		X	1968
	32,000		X	1969
B) Aqueduct Extension in Sardina II, Sector Villa Bohemia	21,000		X	1970
Port Authority				
A) Install Lighting and Finish Construction at Airport	100,000		?	1970
Municipal Activities				
A) Development of Various Municipal Projects	54,169		?	1970
B) Power Generator	80,000		?	1970
C) Operation and Maintenance of Electrical System	40,000		?	1970

14.

INFRASTRUCTURE AND SERVICES

Transportation and Communication

External Transportation. Transportation and communication with other municipalities off the island are limited. Schedules are irregular and costs are high, so Culebrans use available means of transportation (ferry and small plane) infrequently. Only one round trip to Puerto Rico (Fajardo) by ferry is scheduled daily. Two airlines serve the island, each with three or four round trips daily. Maximum capacity of the planes is nine passengers. Other boats visit the island for sport, recreation, or scientific activities.

Internal Transportation. There are two rental car agencies and one moving company in Culebra. No public vehicles are registered. In 1969, 74 motor vehicles were registered: 43 private cars, 22 private trucks, 4 government vehicles, 4 motorcycles, and 1 truck. There is one vehicle for every 12 residents.

The urban and rural zones are connected by some roads. Only three kilometers of municipal roads are paved. Access roads to and within Navy property are not paved.

Communication. The municipality has telegraph services and 44 telephone units. Nine belong to the government and 35 to private individuals.

Power Supply

Power is provided by a generator plant operated by the local administration. Facilities of the Water Resources Authority are not used. This service brings in an annual income to the municipality of $20,000 and a profit of about $4,000. Electrical power is almost total on the island, but the service is frequently off for brief periods. It has been proposed that additional power be supplied by the Water Resources Facility through a submarine cable from Fajardo.

Water and Sewage

In Culebra water is vital and scarce. Water from dug wells is brackish and thus not used for human consumption. Many families have their own cisterns. Some still lack water entirely.

There is no sewage disposal system, either in Dewey or in Clark. Wastes are dumped directly into Ensenada Honda or the sea. Outhouses are still common. Lack of water increases this problem.

Recreational Facilities

As of December, 1970, the reconstruction of the baseball park and basketball court was almost finished. There are no private sport facilities. The resources of this island stand in great need of development in this direction.

Land Distribution

The island of Culebra has an area of 6,743 acres. Forty percent (2,700 acres) are under the control of the Navy, 28% (1,900 acres) are owned by

four families, 17% (1,156 acres) are owned by seven families, and 6% (419 acres) by seven more families. The ownership of land by people off the island is very common (latifundio and absentism). A total of 410 acres was sold to enterprises from outside. Control of 3585 of the 4,043 acres not in Navy possession is in the hands of 23 families. Thus 13% of the families control 96% of the land.

Housing and Structures

Although Culebra is not a slum, physical planning has so far been very poor. This is perhaps the municipality's greatest need. Space and beaches are poorly used. The illegal development of 75 lots along Ensenada Honda is an excellent example of this lack of overall program.

In terms of housing, there are 272 units on 61 acres of land in Dewey and Clark. Seventeen of these are under construction and 78 are in a sub-standard condition (see Table 14.1.). There are 103 concrete houses, 84 wood, and 18 of mixed construction. Deterioration is of course more common in the wooden structures. Sixty-seven percent of the latter are in poor condition, compared to 11% of those in concrete.

Public Administration

Culebra has been regulated, since 1900, by a local municipal assembly and a mayor. Both are elected. As in other Commonwealth municipalities, the assembly carries the legislative responsibilities and the mayor the task of enforcement.

Table 14.1. Condition of Houses and Structures.

TOTAL NUMBER	UNITS	CONDITION GOOD	CONDITION POOR
203	Houses	127	78
23	Business Stores	22	1
17	Under Construction	17	--
27	Institutions	22	5
272	TOTAL	198	84
	Concrete Structures		
103	Houses	92	11
17	Under Construction	17	--
120	TOTAL	109	11
	Mixed Structures		
18	Houses	7	11
	Wood Structures		
84	Houses	28	56

The U.S. Navy does not at present contribute significantly to development of the community or to the economy of the island, although it does employ about 30 Culebrans at an average salary of $2.00 per hour. Navy access roads have not been paved. Electricity and water are provided by the municipality but this represents no source of income to the local administration.

One of the most critical problems faced by the administration is the provision of medical services and air transportation. Both require state subsidies from the Commonwealth of significant size.

B

SOCIO ECONOMIC SURVEY OF INHABITANTS

Method

A survey of one third of the households was conducted by direct interview during the first week of December, 1970. The necessary information was obtained by questioning adult members of the family present at the time of the interview. The sample included both populated areas (Dewey and Clark) but not the rural areas, which do not contain a significant portion of the population.

Results

1) Estimated population size for December, 1970, according to this survey, was 956 persons. This is 200 more than those registered by the 197 census, and about 50 more than those registered by the Health Department in 1968. Obviously statistics pertaining to a rural municipality are very variable, depending on the surveying agency. Nevertheless, comparisons made within any one survey such as this one are presumably valid.

2) Fifty-two percent of family members are dependents, 22% male heads of families, 19% married females, and 7% other relatives.

3) Of these persons 18 years old or older, 95% are married, 2% divorced, and 3% widowed.

4) Most householders (87%) have lived in Culebra more than 21 years and all prefer to remain there. Reasons given were the tranquility of life, without social disturbance, and admiration of the natural beauties around them.

5) The degree of family cohesion is high. Mutual cooperation in obtaining food, building houses, and providing services is common.

6) Eighty-two percent of the homes belong to their inhabitants. Of these, 54% had two bedrooms, 44% had three, and 11% had four.

7) In 95% of the homes there were refrigerators and radios; in 79%, televisions; and in 38%, washing machines.

8) Electrical power is almost universal in Culebra. It is provided by the municipal administration. Unfortunately, service is not continuous due to deficiencies in the system, and perishable products frequently spoil.

9) Drinking water is available in 84% of the houses. Service is complete in Dewey, but 37% of homes in Clark still lack drinking water. All the families of Culebra expressed dissatisfaction with the discontinuation of the water service between 9:00 AM and 3:00 PM every day.

10) There is no sanitary sewage disposal system. All wastes are dumped untreated into the sea. In Clark, 93% of the dwellings use latrines, and about 10% of these are in poor condition.

11) Television is the basic form of recreation for Culebrans. Sixty-four percent of those interviewed watch it; 49% read newspapers and listen to radio. Baseball and visiting bars are also popular uses of leisure time.

12) Sixty-six percent of those interviewed do not belong to any kind of group or organization. Of the other 34%, 12 persons participate in a religious group, 1 in a cooperative, 2 in a commercial betterment group, 4 in committees, and 2 in other groups.

13) Only 57% of the potential labor force belongs to the labor group. Sixteen percent claim themselves to be unemployed. Only 4% are employed in technical or professional work and 12% in the fishing industry. Seventy

percent of the workers perform unskilled labor. The rest are farmers, administrators, farm workers, or clerks.

14) The average annual income per household is $3,320. This is $1,530 less than the average annual income in Puerto Rico in 1967---$4,850. However, 58% of the households receive an income of less than $3,000 annually.

15) Of those interviewed, 33 persons (54%) felt that lack of water and sewage facilities was the greatest limiting factor for Culebra; 20 persons (33%), the presence of the Navy; and 19 (31%), the lack of transportation.

16) For 35% of the respondants, scarcity of employment is the principal social lack ("desventaja"). Others listed scarcity of medical services (30%), scarcity of food (14%), and scarcity of places for recreation (16%).

17) The critical condition of Culebra at present is blamed on the government of Puerto Rico by 54%, on the U.S. Navy by 6%. Fifty-two percent of those believing problems exist feel they can do nothing about them personally; of the 48% who feel they can act, 25 (86%) believe the mechanism of action is to unite in order to protest and demand aid, while the other 4 (14%) insist that the solutions are in the hands of the government.

18) The symbol of leadership in Culebra is totally political. When asked to name candidates for a commission which could help to resolve the problems of the island, the interviewees recommended the following leaders.

Leader	Number
The Mayor	33
The Leader of PNP	9
The Most Wealthy Culebran	4
The President of the Fishermen	7
The Most Important Businessman	8
The School Principal	1
The Ex-School Principal	3
Others	4

percent of the workers perform unskilled labor. The rest are farmers, administrators, farm workers, or clerks.

14) The average annual income per household is $3,320. This is $1,530 less than the average annual income in Puerto Rico in 1967---$4,850. However, 58% of the households receive an income of less than $3,000 annually.

15) Of those interviewed, 33 persons (54%) felt that lack of water and sewage facilities was the greatest limiting factor for Culebra; 20 persons (33%), the presence of the Navy; and 19 (31%), the lack of transportation.

16) For 36% of the respondants, scarcity of employment is the principal social lack ("desventaja"). Others listed scarcity of medical services (30%), scarcity of food (14%), and scarcity of places for recreation (16%).

17) The critical condition of Culebra at present is blamed on the government of Puerto Rico by 54%, on the U.S. Navy by 7%. Fifty-two percent of those believing problems exist feel they can do nothing about them personally; of the 48% who feel they can act, 25 (86%) believe the mechanism of action is to unite in order to protest and demand aid, while the other 4 (14%) insist that the solutions are in the hands of the government.

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Leader	Number
The Mayor	33
The Leader of PNP	9
The Most Wealthy Culebran	4
The President of the Fishermen	7
The Most Important Business Man	8
The School Principal	1
The High School Principal	3
Others	4

III

RECOMMENDATIONS

The following suggestions for guiding the imminent development of Culebra, as well as for limiting its use, were submitted by the individual participating specialists. In some cases, they will appear contradictory; in others, unanimous agreement was reached by the group as a whole.

In general, much of the group sensed a potential for recreational use of overriding importance in the economic future of the island. How much of this recreational use will be in each form, from grand hotels to tiny pensions, from parks and maintained campgrounds to inaccessible wilderness areas, remains debatable. Some of the specific suggestions follow.

Climate

At least one, preferably more, permanent weather stations should be set up to monitor temperature, humidity, etc., as well as rainfall, according to recognized standards.

Water Resources

A more comprehensive investigation of the water resources of the island should be made (possibly also to include Vieques), in order to:

1) inventory all dug and drilled wells and springs;

2) collect water samples for chemical analysis;

3) test-pump selected dug wells to determine yield and water quality under pumping conditions;

4) explain (a) the apparent increase in salinity of springs upstream, and (b) the flowing drilled well located in a fault zone area;

5) collect basic data in regard to ground water level fluctuations, rainfall, recharge, and runoff relations.

One favorable site for an observation well is the Number "1" well, now abandoned, in the Dewey well field.

Should the preliminary investigation so warrant, a test drilling program may be justified to determine any differences in the well yield between flow rocks, breccias, tuffs, and the diorite pluton; differences in salinity of ground water and estimates of potential yield; and amount of ground water in storage in the aquifers. It is estimated that from 10 to 15 test holes 100 to 200 feet deep can determine the quantity and quality of ground water reserves under the island.

Several potential dam sites exist, one in the valley below the Dewey well field; another in the valley east of it, draining into Puerto del Manglar. These sites and possibly others should be further investigated to see if they can add to the water reserves of the island or if they can be used to recharge wells.

Should the comprehensive inventory and/or test drilling program fail to turn up adequate water supply for the future, then consideration must be given to: (a) desalinization of either sea water or brackish lagoon water, or (b) a pipeline, once proposed to run from Puerto Rico to the Virgin Islands using Culebra as a pumping station. According to some experts the latter plan is becoming more feasible as the Virgin Islands' demands increase to many millions of gallons a day. Costs for the first solution may reach $2.00 per 1,000 gallons; cost estimates for the second solution are down to $1.00 per 1,000 gallons.

Fishing

A metal pipe piling wood dock should be constructed from the shore near the three fishing facility buildings out to the channel in about three to four feet of water.

It is also recommended that the barrier reefs from Punta Soldado north to Dolphin Head be protected in their present natural state. These reefs could afford both commercial and sport fishing activities.

Sewage Treatment

Some kind of sewage treatment facility must be put into operation on the island, to prevent or control pollution of the surrounding waters, especially Ensenada Honda. Legislation regulating waste disposal should also be drawn up, passed, and enforced. There is great urgency in this problem.

Buildings

The town itself is essential and will grow as demands on it are increased. The possibility of creating a second town in addition, somewhere on the east side of the island, might be investigated. The coasts of both towns should be zoned commercial, to provide services (marine equipment, gas, restaurants, laundries, supermarkets, bathing facilities) for people coming by boat to this superlative harbor area.

Perhaps the ideal tourist accommodations would be seasonal cottages (for rent by day, week, or month), small hotels, or guest houses. Most of these should be on the coasts or on points or higher slopes looking out over the

coast. All beaches however should remain public. More private hotels could be allowed in the inner part of the island. This space will also be very valuable, once public access to the coast is assured.

Social Services

Besides water and sewage systems, improvement in the supply of electrical power is needed. Not only do private citizens complain, but it is also mandatory for the attraction of possible industries from outside. For the same reasons, communication and transportation off the island must be made cheaper, more frequent, faster, and more dependable. Similarly, many more access roads will be necessary within the island, if development is to progress in the future.

The educational system is completely lacking beyond ninth grade. The possibility of a local high school might be considered, as well as a vocational school in the evenings. Meanwhile, a few more classrooms and teachers are needed just to make it possible to separate the students into separate grade levels. There is no English language teacher available at present.

The need for more extensive health services has been discussed elsewhere. The proposed new Health Center should be begun.

Security forces are probably adequate, but should be encouraged to enforce laws against illegal construction on private, public, and Navy property.

There is very little source of recreation on Culebra, other than the sea which is considered a livelihood more than an avocation. Aside therein

would probably be a good diversion, both for the local populace and for visiting tourists.

Agriculture

Rehabilitation of the agricultural industry, although limited, is possible to some degree. Improvements would include building artificial ponds, pasture resistant to drought, possibly construction of a local slaughterhouse, increasing the market for the local cheese industry, and especially encouraging a more even distribution of land with an enforced reduction of absentee landlordism.

Industry

It is vital and urgent that Culebra attract some local manufacturing, to provide sources of income and employment. It might be wise to capitalize on local talents in fishing and farming when deciding what types of industry to import. Some suggestions are factories to make boots, fishing equipment, or agricultural supplies. An apprentice system would be very useful. Of course, tourism is another viable industry that could become very big on Culebra.

Conservation

The areas deemed most worthy of protection by the majority of the group were: Culebrita and the reefs south of it, including some adjacent lands on the eastern side of Culebra; various beaches, especially Flamenco; and the Monte Resaca area in the north, with its unique forest and huge boulders. The coral reefs near Culebrita and Isla Pelada are as beautiful as those in

the national parks of St. Croix and St. John, in the U. S. Virgin Islands. It is extremely desirable to maintain the present condition by preventing people from removing any kind of animals or plants and, furthermore, preventing them from littering the ocean bottoms. Otherwise, these areas may come to resemble other reef areas off the coast of Puerto Rico, most of which are heavily exploited and polluted.

In addition, great consternation was expressed at the destruction of valuable living coral reefs, which have required centuries to develop to their present state, by the methods of ordnance disposal in use by the U.S. Navy. Although the continuation of military activities will depend on requirements for national security, much of their impact could be reduced by exclusively using dummy bombs and shells.

Creation of an Overall Developmental Plan

It must be stressed again that the most important factor in determining the successful development of Culebra is the creation and enforcement of a detailed integrated developmental plan. All possible factors should be taken into consideration in drawing up this plan; yet it must be prepared and adopted quickly. A balance between many complex interacting factors must be arrived at and maintained. It is understood that the Puerto Rican Planning Board is in the process of preparing such a plan. It is to be hoped that this report will serve as a base for it.

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