An Examination of the Present Condition of Seagrass Meadows in La Parguera, Puerto Rico

Jose Gonzalez Liboy

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FINAL REPORT

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José González-Liboy

Study Objective: To describe the present condition of La Parguera's turtlegrass habitat.

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During the course of this study many people contributed their efforts to the success of this project. I am very greatful to Ken Dugger and Julio Cardona, who were directly involved during the initial stages of this study. Special thanks are due to Richard Bejarano for his valuable assistance in the field and laboratory.

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Gladys Rodríguez typed the manuscript and Héctor Berrios did part of the artwork.

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INTRODUCTION

The small village of La Parguera, administratively part of the municipality of Lajas, has traditionally been a center of commercial fishing for the local market. In recent years, sport fishing for shallow and deep-water marine species has become more popular as the area grew in importance as a resort. In addition, "Phosphorescent Bay" has long been a major tourist attraction. At the same time, the southwest area of Puerto Rico has suffered from unemployment which has become more acute as the sugar cane industry decreased in importance as a source of income. Consequently, increased pressures for development have been brought to bear upon the area.

The importance of La Parguera's marine resources and their sensitive and vulnerable nature has been the subject of several studies by government agencies. Among these are the Puerto Rico Industrial Development Corporation, the Puerto Rico Planning Board, the U.S. National Park Service and the Environmental Quality Board. In 1978, the Department of Natural Resources and the U.S. Army Corps of Engineers signed an agreement providing for the eventual government take-over of many illegal houses and structures that contribute to the pollution of La Parguera. The same agree ment provided strict pollution control and declared La Parguera a natural wildlife reserve. Since then, the Department of Natural Resources has been working on a new management plan for La Parguera as part of its Coastal Zone Management Program.

The marine area between Cabo Rojo and Punta Jorobado, on the western edge of the southern insular shelf of Puerto Rico, probably contains some of the most diverse and ecologically valuable marine systems found anywhere in the. immediate. vicinity of the main island. Within the above-mentioned area are found extensive coastal mangroves, shallow-water seagrass beds, sandy beaches and some of the finest coral reefs in Puerto Rico. Of these, the seagrass beds are the least studied in Puerto Rico. Because of their proximity to shore and shallow distribution, sea grass beds have been suggested as good indicators of man's intervention in the ecosystem.

Seagrasses have been extensively studied in Florida and considerable literature also exists on the meadows of Bermuda and Texas. Some of this literature describes the response of the grass beds to man-induced stresses such as siltation from dredging, domestic wastes and thermal stress. In Puerto Rico, several studies have been conducted on the effects of Power Plant effluents on benthic communities, including seagrasses. As far as La Parguera is concerned, very little is known about the possible consequences of man's increasing activity in that area may have on the overall condition of the grass flats. The study reported here was undertaken as an effort to determine the condition of seagrasses in La Parguera. Additional information on seagrass systems around Puerto Rico, Vieques and Culebra has also been included for co mparisons.

This final report is a Department of Natural Resources contribution to Project F-4, Puerto Rico Sport Fisheries Research and Survey. It includes the findings of Study VIII, "An Examination of the Present Conditions of Seagrass Meadows in La Parguera". The study was subdivided into four (4) research jobs which are described below.

Job 1. Distribution and mapping of the seagrass meadows in La Parguera.

Job 2. Water Quality and sensitivity of the seagrass meadows to man-induced stresses.

Job 3. Productivity of the *Thalassia* flats in La Parguera.

Job 4. Sport fisheries potential of the *Thalassia* flats in La Parguera.

The overall study objective was to describe the present condition of La Parguera's turtlegrass habitat. The results and findings of each of the individual jobs appear under the appropriate headings of this report. A general summary and conclusion describing the present condition of *Thalassia* beds in La Parguera, as well as some recommendations for management are included at the end of the report.

SEAGRASSES: AN OVERVIEW

Tropical seagrass beds are extensions of underwater vegetation that occur in shallow, clear tropical waters. Seagrasses are higher plants (Spermatophytes) which have been adapted to survive in the marine environment. As their terrestrial counterparts, they have an extensive root and rhizome system and reproduce vegetatively and sexually. The flowers are fertilized by waterborne pollen.

Seagrass beds are one of the most conspicuous shore communities, occuring in enormous quantities on certain places. A dense growth could represent over 4,000 plants per square meter and a biomass of over 7 kg/m2. Their productivity is considered among the highest in the marine environment.

Seagrasses perform a wide assortment of functions and act in various ways to control and modify the eco system. Wood, Odum and Zieman (1969) summarized the most important functions of seagrasses as follows:

1. They have a rapid growth rate, producing between 2.2 and 10 gramsof dry leaf per m2 per day. The high organic productivity of seagrasses compares favorably with the most intensive agricultural crops.
2. Although seagrasses directly supply food to a limited herviborous population (parrot fishes, conch and urchins) they contribute significant

amounts of detritus which provide a major energy input for other coastal ecosystems.

3. The leaves support large numbers of epiphytic organisms which are consumed extensively by fishes and invertebrates. This epiphytic component has a high biomass which in some cases is comparable to the weight of the seagrasses themselves.
4. Detrital matter of seagrasses initiates sulfate reduction and maintain an active sulfur cycle.
5. The leaves retard current velocity promoting sedimentation of organic and inorganic particles.
6. The roots and rhizome system of seagrasses bind sediments together, thus reducing erosion. Seagrasses have been known to persist during hurricanes.[1]

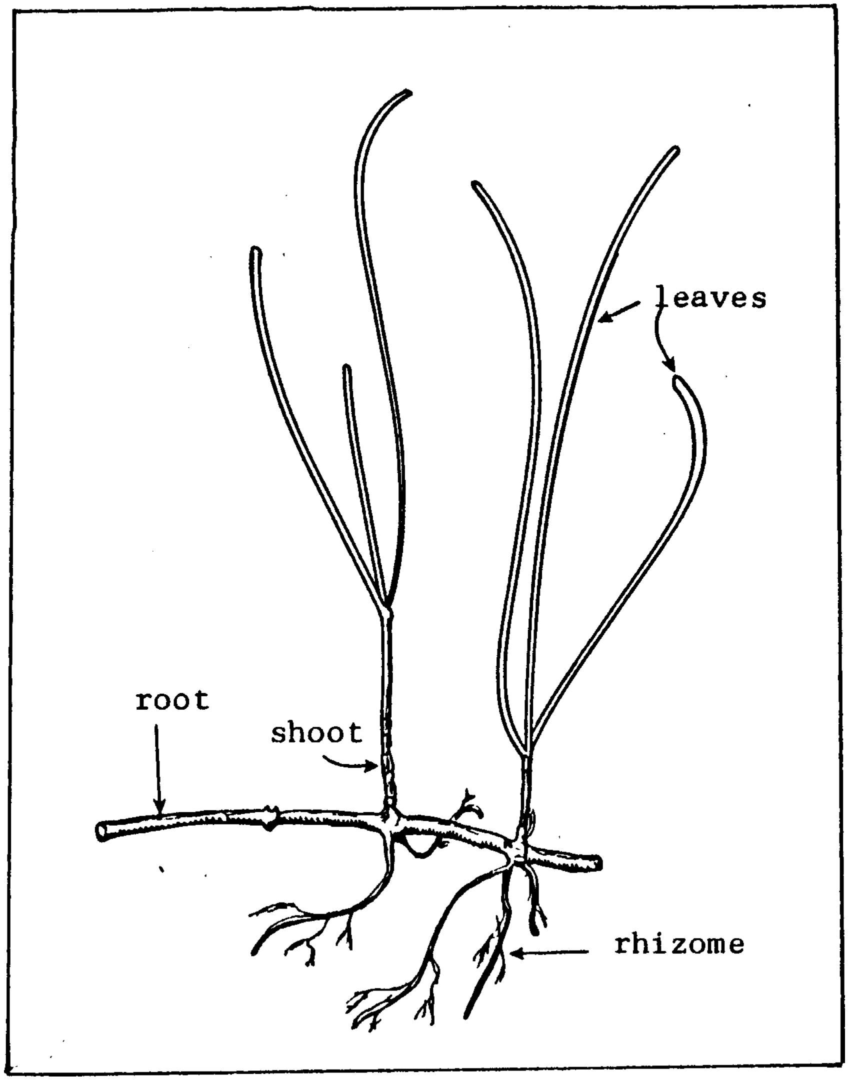
Seagrasses comprise a group of 49 species widely distributed throughout the shallow waters of every coastal sea except the-most polar (den Hartog, 1977). Of the 12 recognized genera, only four are found in the Caribbean and Puerto Rico. The local species are: Thalassia testudinum, Syringodium filliforme (=Cymodocea manatorum), Halodule (=Diplanthera) wrightii, Halophilla baillonis and Halophilla englemani.

1 Large arounts of T and Syringodium were washed ashore on Southwestern Puerto Rico during the passage of hurricane David (Sept. 1979). The author estimates that damage was considerable, although no quantitative measurements have been made yet.

Thalassia and *Syringodium,* commonly known as turtle grass and manatee grass respectively, are the most abundant and ecologically important seagrasses in Puerto Rico. These species can be distinguished by their leaf morpho logy. *Thalassia* has long flat leaves averaging 10 mm in width and 25 cm. in length. *Syringodium* has thin cylindrical leaves that may reach 30 cm in length. (FIG. 1)

Thalassia beds represent a climax community resulting from a series of progressive changes in bottom vegetation. Figures 2 and 3 summarize the seral stages of the *Thalassia* climax according to Margalef (1962) and Welch (1962). Both interpretations show that a terminal marine community dominated by *Thalassia* can originate from both sediment and solid surfaces.

The distribution of *Thalassia* is determined in great measure by a series of physical factors such as temperature, light availability, dessication, wave and current action, substrates and salinity. The optimum temperature for *Thalassia* ranges between 20° and 30°C (Phillips, 1960). Although the plants can survive temperatures of 15°C and 35°C for short periods of time, these extremes usually result in significant leaf kill. The availability of light for photosynthesis is related to depth and turbidity. The maximum depth at which *Thalassia* is normally found is around 10 m. However, the plants may occur at greater depths when the water transparency is extremely



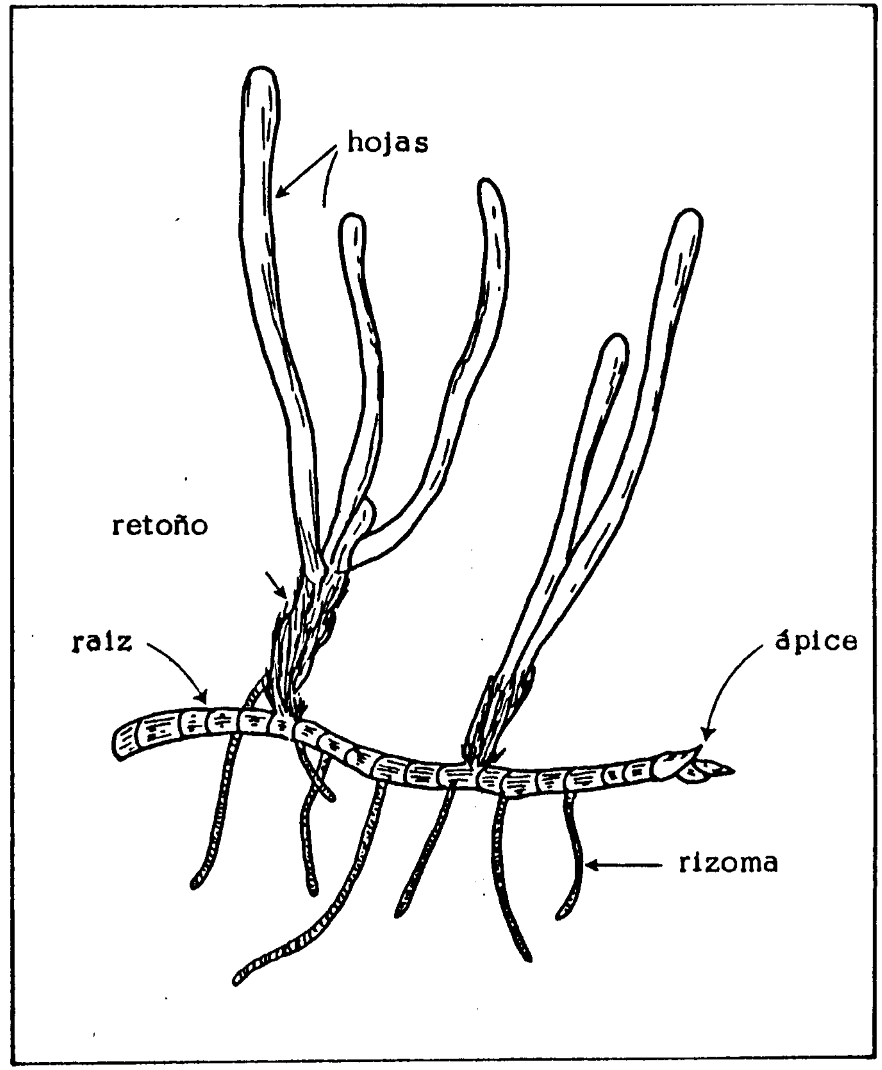


Fig. 1. External morphological features of Syringodium filliforme and Thalassia testudinum.

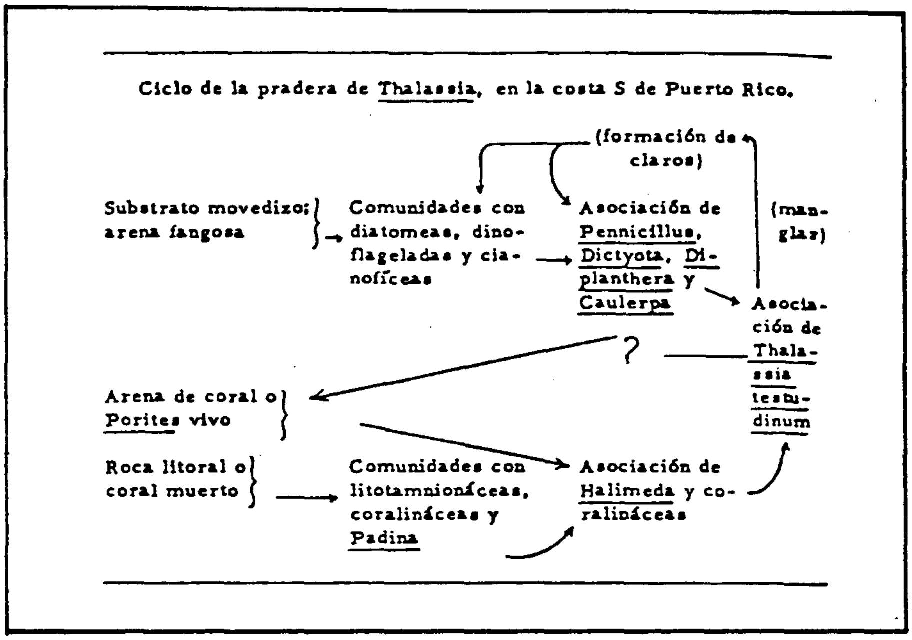


Fig. 2. Seral stages of the Thalassia climax (Margalef 1962)

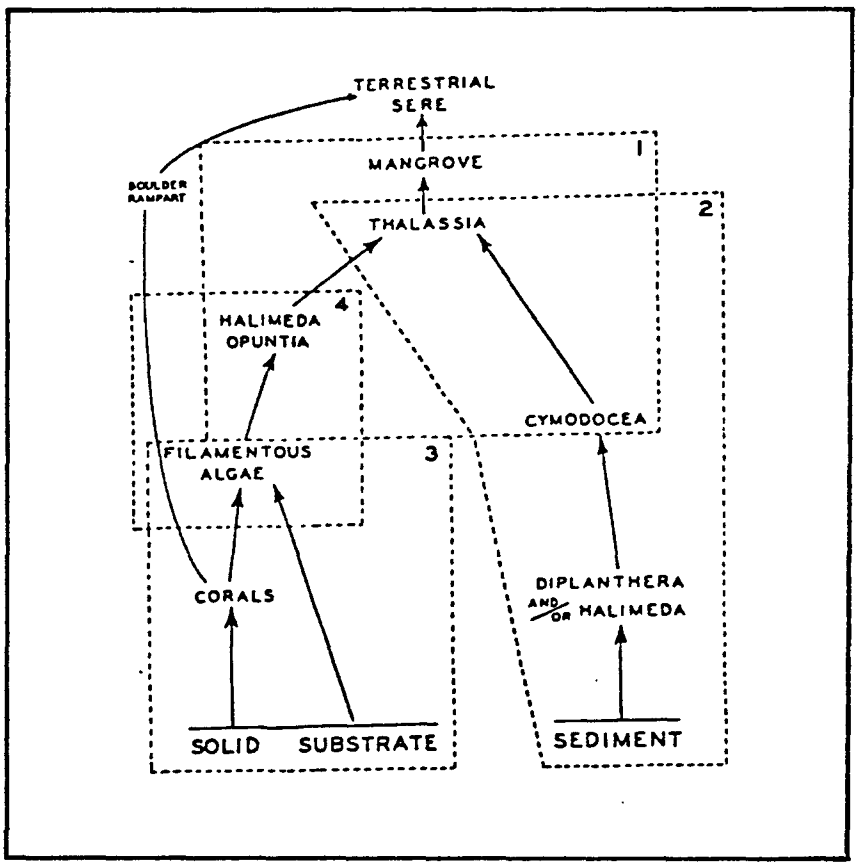


Fig. 3. Seral stages of the Thalassia climax (Welch 1962).

good and temperatures don't fall below 20 C. When exposed to air and high temperatures, the leaves of Thalassia loose their pigmentation and die of dessication. This is most likely to occur when aerial exposure is prolonged and becomes most severe during the spring tides when the tidal amplitude is greatest. Wave action and currents also have an effect on the distribution of Thalassia. For obvious reasons, Thalassia does not develop well on high energy coastlines with strong wave activity. The mechanical action of waves and sediments in motion pre vent the establishment of the plants. However, data from Odum and Hoskin (1958) and Strawn (1961) indicate that Thalassia requires at least some water movement around the plants in order to survive. Estimates from various authors place this water movement between 1 and 2 knots. Dr. William Hay (Fide, Jones 1968), pointed out that current velocities over 2 knots resulted in ripping out the plants. As far as sediment composition and grade distribution is concerned, Thalassia grows well on both muddy and sandy bottoms. Finally, Thalassia is an obligate marine plant and does not survive salinities lower than 20%.

GENERAL DESCRIPTION OF THE STUDY AREA

The southwest coast of Puerto Rico, between Bahia

Sucia and Punta Jorobado (Fig. 4), contains some of the most diverse and ecologically valuable marine habitats found in Puerto Rico. Within this area are found extensive coral reefs, mangrove forests, shallow channels and lagoons, sandy beaches and seagrass beds.

The insular shelf off La Parguera is relatively broad, measuring 8 to 10 km in width and with an average depth of 15 to 18 m from the nearshore to the shelf break (Morelock, Schneidernann and Bryant, 1977). Two row's of reefs roughly oriented from east to west occur between the shelf break and the shore. A sunken marginal reef grows at the shelf break, approximately 20 m deep. According to Margalef (1962) coral reefs in La Parguera belong to the marginal type whereas Almy and Carrion (1959) and Kaye (1959) agree that they represent "poorly formed barrier or ribbon reefs".

Coral growth in the area is favored by the local climatic and hydrographic conditions. La Parguera falls within the Sub-tropical Dry Life Zone (Ewel and Whitmore, 1973) and receives 800-1,000 mm rain annually. Evaporation is of the order of 1,900-2,200 mm per year. These conditions of low rainfall and high evaporation reduce runoff and turbidity and promotes coral growth. The mean annual surface temperature varies between 25 and 32°C. Salinity varies two to three parts per thousand during the year and averages 35.4 ppt (Coker and González, 1960).

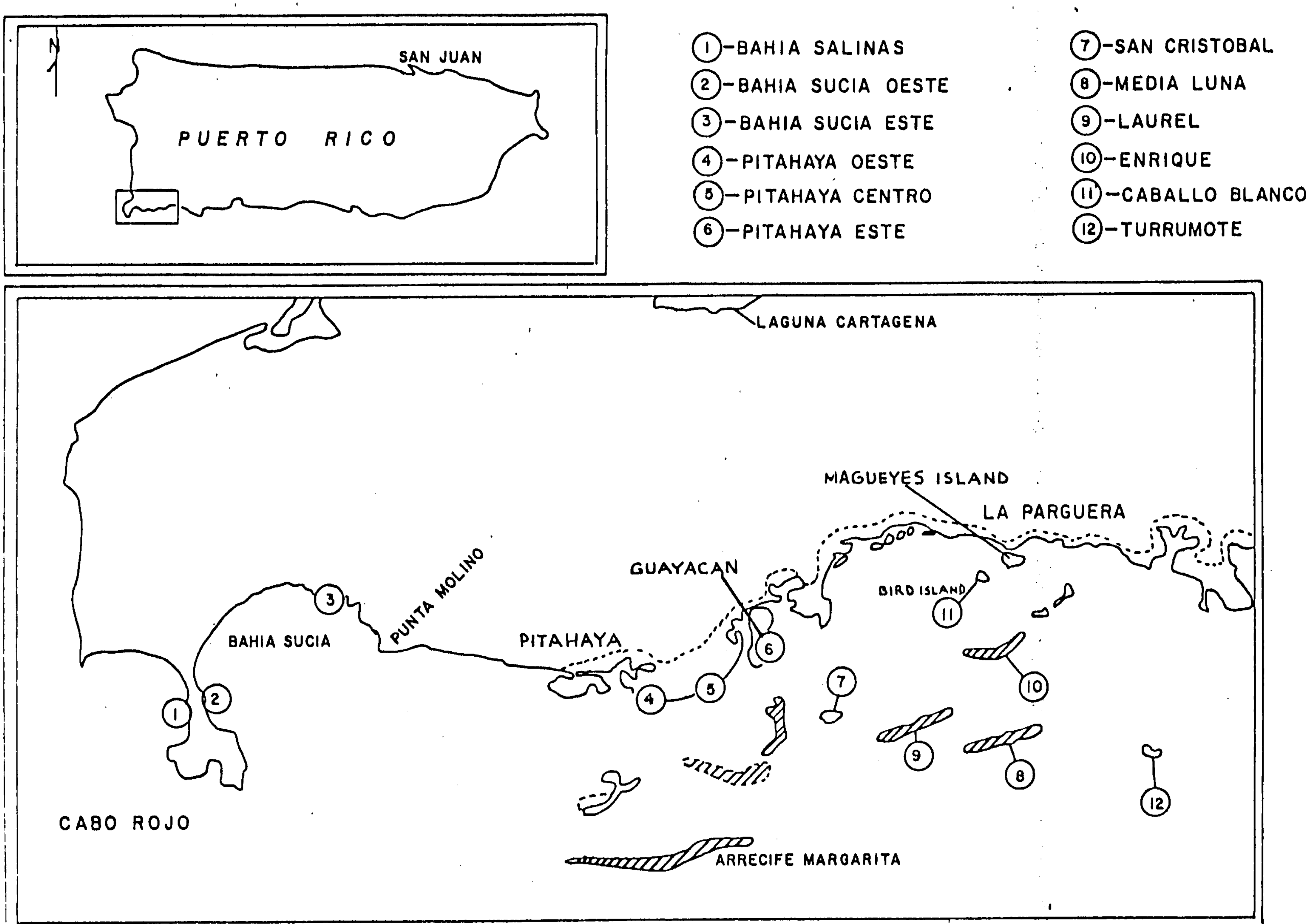


Figure 4. Southwestern Puerto Rico between Bahia Sucia and Punta Jorobado.

Mangrove forests border almost the entire coastline from Punta Jorobado to Punta Pitahaya. Mangrove islets are common inside the inner shelf (Cintron, Goenaga and González-Liboy, 1978). Mangroves growing on the mainland are subdivided into two associations, namely basin and fringe. The basin mangrove association lies landward of the fringe mangrove forest which comprises the largest association. The pioneer species is Rhizophora mangle, followed by Laguncularia racemosa and Avicennia germinans.

A quite extensive system of channels and shallow lagoons is found within the mangrove forest. The lagoons are inter-connected with each other by one or several shallow channels which in turn connect the entire system to open water. Salinities and temperatures inside the lagoons are generally higher due to the high evaporation rates and restricted circulation. Some lagoons are hipersaline. Mangrove-root communities are well developed along the channels and support large populations of algae and invertebrates.

From Punta Pitahaya to Bahia Sucia the coastline is characterized by sea cliffs which have developed on limestone outcrops. Geologically, this section of the coastline is composed of Tertiary rocks, mostly limestones and some volcanic. Bahia Sucia proper is considered a reverberation bay that comforms to the approaching diffracted wavefronts coming from the south

(Monroe, fide Fernández 1977). The bottom is covered by dense meadows of seagrasses in which natural "blow-outs" are very common. According to Fernández et al. (1977) these "blowouts" are linear scours up to 0.5 m deep, oriented perpendicular to the shoreline. Little or no vegetation grows inside the "blowouts", although dense vegetation of Thalassia is found on its sides. Large quantities of sand are found under the grass beds.

The beach at Bahia Sucia is composed of fine sands overlayed by large quantities of decaying seagrass. Beach sands are almost exclusively calcium carbonate with small amounts of quartz. The accumulated seagrasses reach one meter in thickness at the beach berm and extend more than 25 meters inland from the shore.

STATUS OF RELATED RESEARCH IN PUERTO RICO

As in most of the Caribbean, the dominant marine angiosperm in Puerto Rico (Lat. 18°N Long 66°W) is the turtle grass, Thalassia testudinum (Konig). Dense meadows of Thalassia occur on the eastern, southern and western coasts of the island as well as in the near-by islands of Vieques and Culebra. The meadows are less developed on the north coast, where the high wave energy regime and sedimentation interfere with bottom stability and light penetration.

Most of the scientific research on *Thalassia* and other marine angiosperms in Puerto Rico has been conducted in the vicinity of La Parguera, where dense meadows of *Thalassia* occur. Odum, Burkholder and Rivero (1959) studied the oxygen productivity of turtle grass and compared it to that of the coral reef. Burkholder, Burk holder, and Rivero (1959) investigated the stocks and chemical contents of *Thalassia* and supplied information about the standing crop and the influence of bottom sediments upon the ratio of roots and rhyzomes to leaves. Margalef (1962) described some of the main ecological aspects of *Thalassia* in La Parguera and found that chlorophyll "a" was most abundant at some distance behind the tip of the blade. Odum, McDonnell, and Abbot (1963), found concentrations of 0.43 g/m^2 of chlorophyl "a" in some beds in La Parguera. The levels of iron, manganese and nickel in the thalli and stems of *Thalassia* from La Parguera were investigated by Stevenson and Ufret (1966) who reported average values of 250, 49 and 20 g/g dry wt respectively.

Welch (1962) and Margalef (1962) studied aspects of ecological succession in La Parguera. They both concluded that a climax community dominated by *Thalassia* could originate from both sediment and solid surfaces. The general trend of succession on stable sediment surfaces is as follows: *Halodule wrightii* colonizes first, followed by *Halimeda,* then by *Syringodium filliforme* and finally by *Thalassia testudinum*.

The effects of hurricane Edith on the marine life in La Parguera were investigated by Glynn, Almodóvar and González (1964). They reported that beds of Thalassia were hardly affected by the storm, while near-by coral reefs suffered considerable damage.1

Delgado (1978) studied benthic macro-algae assamblages associated with *Thalassia* in La Parguera and found that species diversity was higher on protected areas than on offshore reefs. She also reported that the standing crop, biomass and blade length of *Thalassia* were higher in the infralittoral zone of protected areas than in the mesolittoral zone of offshore reefs. Standing crop values ranged from 480 g dry wt/m^2 at Isla Guayacán (protected) to 135 g dry wt/m^2 at Cayo Laurel. Maximum blade lengths at Isla Guayacán, Cayo Enrique and Cayo Laurel were 28.6, 28 and 12.3 cm respectively.

The impact of heated effluents on *Thalassia* beds in Puerto Rico was investigated by Vicente (1977) who found that structural differences in the community were related to the increased temperatures. Detailed accounts of the ecology of *Thalassia* in Jobos and Guayanilla Bays are given in Vicente (1975, 1977, 1979).

Zieman (1978) reported on the condition of the sea grass ecosystems of Vieques and found moderately productive

1 See footnote p.5.

seagrass beds on a variety of substrates and concluded that these were in no way atypical of seagrass beds throughout the Caribbean region.

METHODS AND MATERIALS

The general condition of Thalassia flats in La Parguera was assessed by a sampling routine which included both physical and biological measurements. The physical parameters studied included sediment size distribution, organic content of the sediments, water quality, sedimentation rates and water transparency. Biological measurements included morphometry of Thalassia blades, standing crop, biomass, leaf area index (LAI), turnover time, blade production, root diameter, and chlorophyll. In addition to La Parguera, grass flats in Vieques, Culebra, Fajardo, Ceiba, Salinas, Cabo Rojo, and San Juan were also studied (Fig. 5).

Sedimentation rates

Sedimentation on Thalassia beds was monitored continuously from September 1977 to April 1978. Sediment traps consisting of glass wide-mouth jars were placed at 5 locations in La Parguera and monitored monthly. The jars had a diameter of 6 cm (area = 28.27 cm^2) and

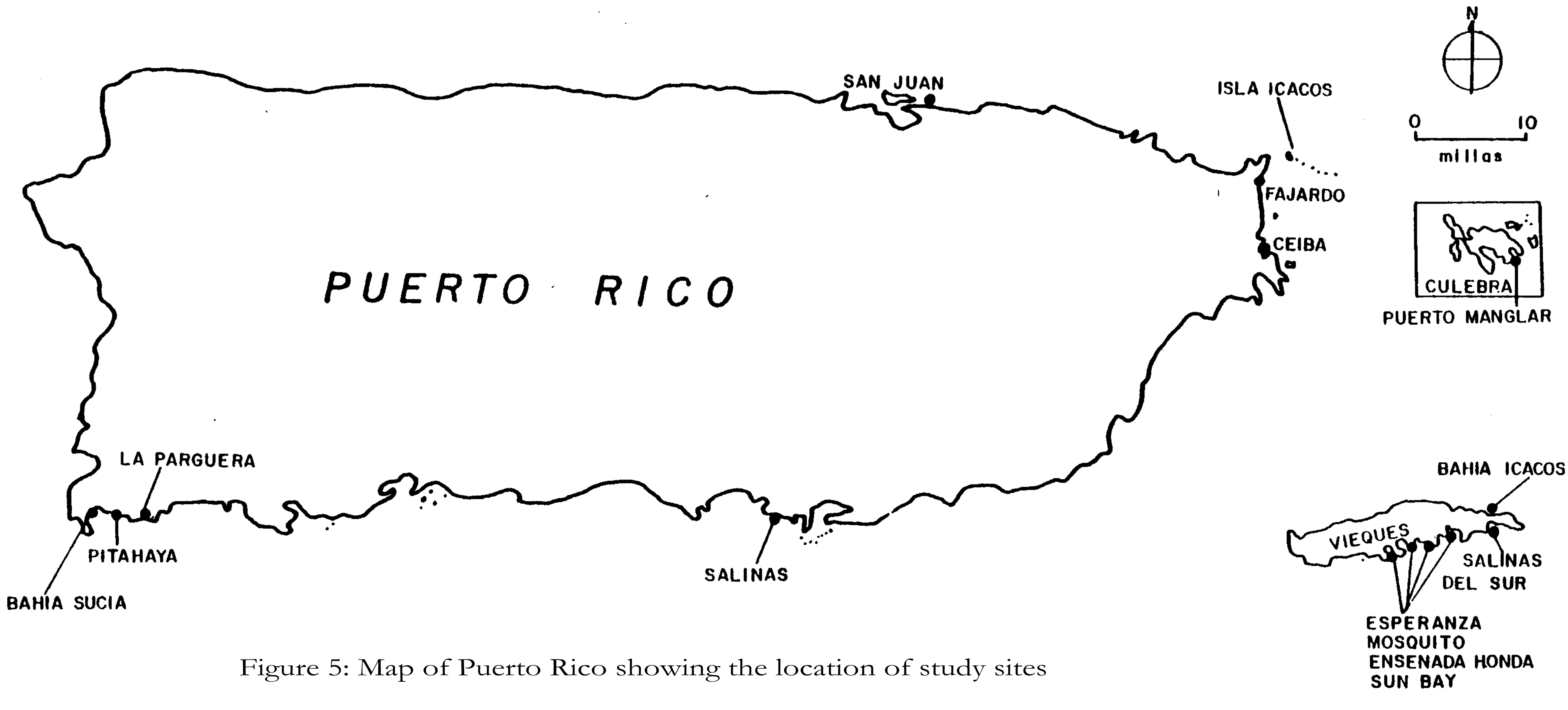


Figure 5: Map of Puerto Rico showing the location of study sites

a height of 18 cm. At each location the jars were tied and taped to a steel rebar which was driven into the substrate until the bottom of each jar was 5 to 10 cm from the substrate. The maximum depth at which the traps were placed was 1.5 m. The traps were left on station for periods of 26 to 30 days, after which they were capped underwater and brought to the laboratory for analysis.

The samples were processed following the method described in Rogers (1977). Excess water inside the jars was siphoned off until approximately 50 ml remained. Encrusting organisms and other debris were removed. The traps were then placed in an oven at 70°C until the sediments were completely dry. The following sequence of weighing and calculations was used to convert the values from each trap into mg/cm^2 day: a) wet weight of jar, seawater and sediments; b) dry weight of jar, salts and sediments; c) weight of water=(a-b); d) weight of salts= c (.035); e) weight of empty jar; f) dry weight of sediments=(g) b-(d + e); g) number of days in the field; h) sedimentation rate, f/(28.27) (g).

Water quality

Water quality in La Parguera was studied during September, October and November 1977. Ten sampling stations were established within the inner shelf of La Parguera and adjacent lagoons (Fig. 6). Samples were taken in Nalgene plastic bottles at a depth of 0.5 mm. Two litters of water were collected at each station. The samples were securely capped, placed under ice and transported to the laboratory for analysis. All the analyses were performed on the day following collection. The samples were analyzed for total phosphorus, phosphate, nitrate, nitrite, ammonia and pH. All determinations were made following the methods outlined in EPA (1976).

Water transparency

Water transparency measurements were performed at selected locations in La Parguera and other sites around Puerto Rico and Vieques. Secchi disc measurements were made with a white plastic circular plate 30 cm in diameter. Horizontal Secchi disc readings were taken in shallow area where the bottom could be seen from the surface.

A KAHLSKO underwater transparency meter was used to measure transparency in Vieques. This system, also known as alphameter, consists of a meter box (deck unit), an electrical cable which mates to the meterbox and under water sections, a cable clamp which suspends the underwater units on an optical track, and watertight housing which contain a light projector and photocell receiver. The photocell output is brought to the micrometer in the meter box which is calibrated in percent transparency.

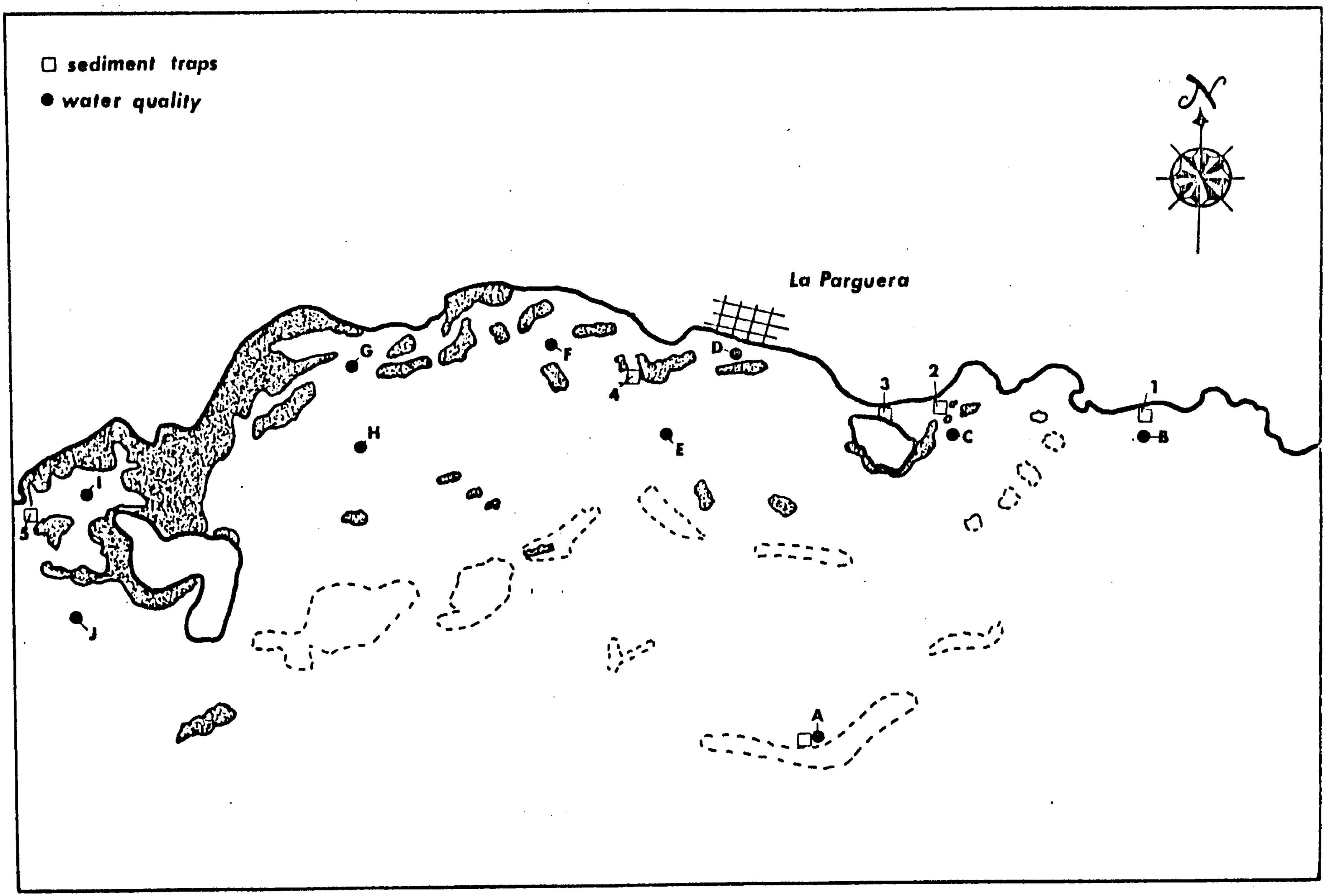


Figure 6. Location of sediment traps and water sampling stations in La Parguera.

Sediment analysis

Sediment samples collected on *Thalassia* beds were analized for grain size and organic matter. Mechanical analysis of the sediments for grain distribution were made according to Carver (1971). Calculation of statistical parameters were done with a Burroughs B 1700 digital computer. Statistical parameters included the percentages of gravel, sand, silt and clay as well as measures of central tendency and dispersion.

Total organic matter in the sediments was determined by hydrogen peroxide(H_2O_2) oxidation (Carver, 1971).

Morphometry of Thalassia blades

The morphometry of *Thalassia* blades was studied rather extensively in La Parguera and other sites around Puerto Rico, Vieques, and Culebra. Samples consisted of 100 randomly collected leaves. The length and width of the blades were measured while the leaves were still fresh or preserved in a 5% formaldehyde solution. Length measurements were made from the base of the leaf (pigmented area) to the tip of the blade (grazed or ungrazed). Widths measurements were made midway along the blade. The mean, standard deviation and standard error was calculated for each set of measurements.

Standing crop and biomass

The standing crop and biomass of Thalassia and associated macro-flora was studied in La Parguera, Salinas, Culebra, San Juan, Cabo Rojo, Fajardo, and Vieques. Samples for biomass were collected with two P.V.C. corers of different diameters (15 and 10.5 cm). Maximum penetration of the cores was about 22 cm. Additional measurements were made following the method described by Welch (1962). This method consisted of collecting five (5) bottom samples along each of two randomly selected 16-yard transect lines which lied at right angles to a 50-yard reference line in the middle of the community studied. Each sample covered an area of .01 m^2. The contents of the cores were preserved in formalin and later washed to remove sediment and other debris. The plant material was then separated according to species, dried at 70°C and wighted. The weight of each fraction, including leaves, roots and rhizomes of Thalassia and other macro-flora was expressed in grams dry weight per square meter.

Leaf Area Index (LAI)

The leaf area index (LAI) of Thalassia was measured in meadows from San Juan, Cabo Rojo, and Ceiba. A 1/16 m^2 frame was placed over the grass-covered bottom and all the Thalassia inside the frame was harvested at the sediment level. The material was preserved in formalin and transported to the laboratory where all the leaves were washed and placed over an acetate film and copied on a Xerox machine. The length and width of every blade was measured from the copies and the LAI calculated. Leaf area index was expressed as a unitless number representing the leaf area of Thalassia (in m^2) per square meter of bottom.

Blade production and turnover

Experiments were conducted to determine the standing crop, blade production and turnover time of Thalassia testudinum in La Parguera. Production, or the amount new material (leaves) produced per unit time was measured using the technique developed by Ziemen (1974). Leaves within a 200 cm metal frame were marked with a staple just above the meristematic tissue and allowed to grow for 14-15 days. The leaves were then harvested at the sediment level using ordinary garden clippers. The harvested material was separated into 3 categories:

1) old growth, or the material above the staple;
2) new growth, or the material below the staple; and
3) new leaves, or material without staples. The lengths of the leaf fragments in each category was then measured to obtain the rate of growth. The collected material was then placed in 5% Phosphoric acid to remove. carbonates

and adhered epiphytes. After acid decalcification, the samples were washed in fresh water and dried to constant weight at 70°C. Finally, the weights of each category were used to calculate the standing crop, leaf production and replacement rate. The standing crop was calculated by adding the weights of category 1 and 2 and expressing this sum on a m^2 basis. The amount of new material produced was calculated by summing the weights of categories 2 and 3, expressing it on a m basis and then dividing by the number of days between marking and collection. Turnover was calculated by dividing the standing crop by the production value. For more information and detailed description of this method the reader is referred to Zieman (1968, 1974).

RESULTS AND DISCUSSION

<u>Distribution of Thalassia beds in southwestern Puerto Rico</u>

It is generally recognized that temperature, depth, irradiance, exposure, salinity and wave action are among the most important factors affecting the distribution of *Thalassia.* Temperature appears to limit the geographical distribution of *Thalassia* while depth, wave action, turbidity and salinity are important ecological factors affecting local distribution.

The 14 mile stretch of coast between Punta Jorobado to Cabo Rojo contains numerous cays, islets, reefs, and mangrove lagoons (Fig. 4). These physical features have contributed to the establishment of large seagrass meadows in the area.

The climatic and oceanographic characteristics of the area have an important influence on the occurrence of Thalassia within this zone. Precipitation is low, averaging 900 mm annually. Evaporation is of the order of 1900-2200 mm per year. These conditions tend to reduce runoff and generally maintain good water transparency and stable salinities which are basic requirements for the growth of Thalassia.

The low incidence of powerful waves, coped with the protection offered by offshore islets and reefs also promotes sea grass development. For example, short pe riod waves (< 5 sec) and moderate period waves (6-9 sec) dominate 42% of the time. Wave periods indicative of swell (>9 sec) only occur 4% of the time. Wave hight inside the inner shelf is less than 0.3 m due to the mo- difying effect of the offshore reefs.

The westernmost corner of our study area (Bahia Sucia, Fig. 8) is less protected by reefs than La Parguera. Nonetheless, extensive Thalassia flats occur in that area. As open sea waves approach this sector of the coastline, they are refracted by the relatively wide shelf (11 km) and also diffracted by Margarita reef. As the waves tra- vel landward over the progressively shallower shelf, they

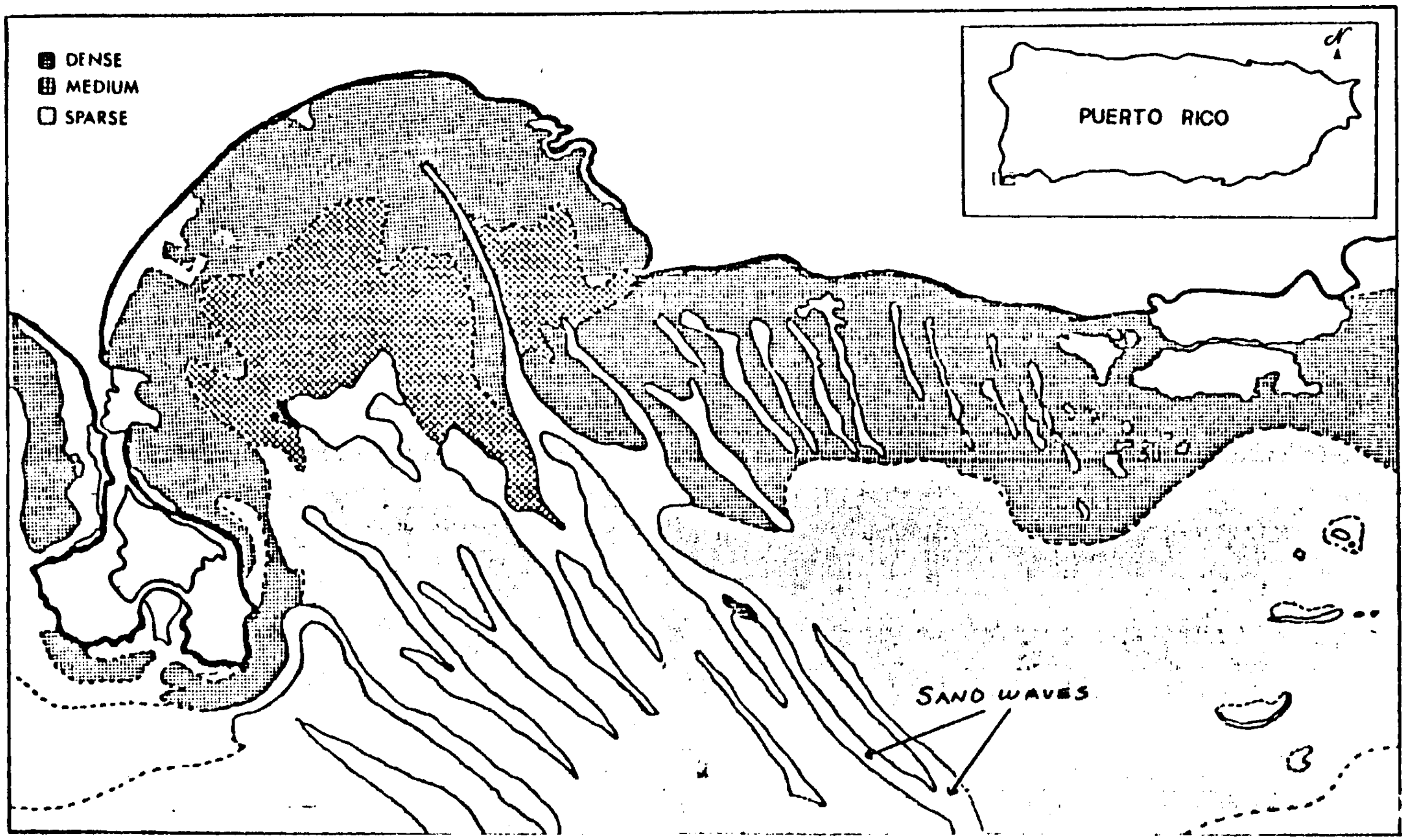
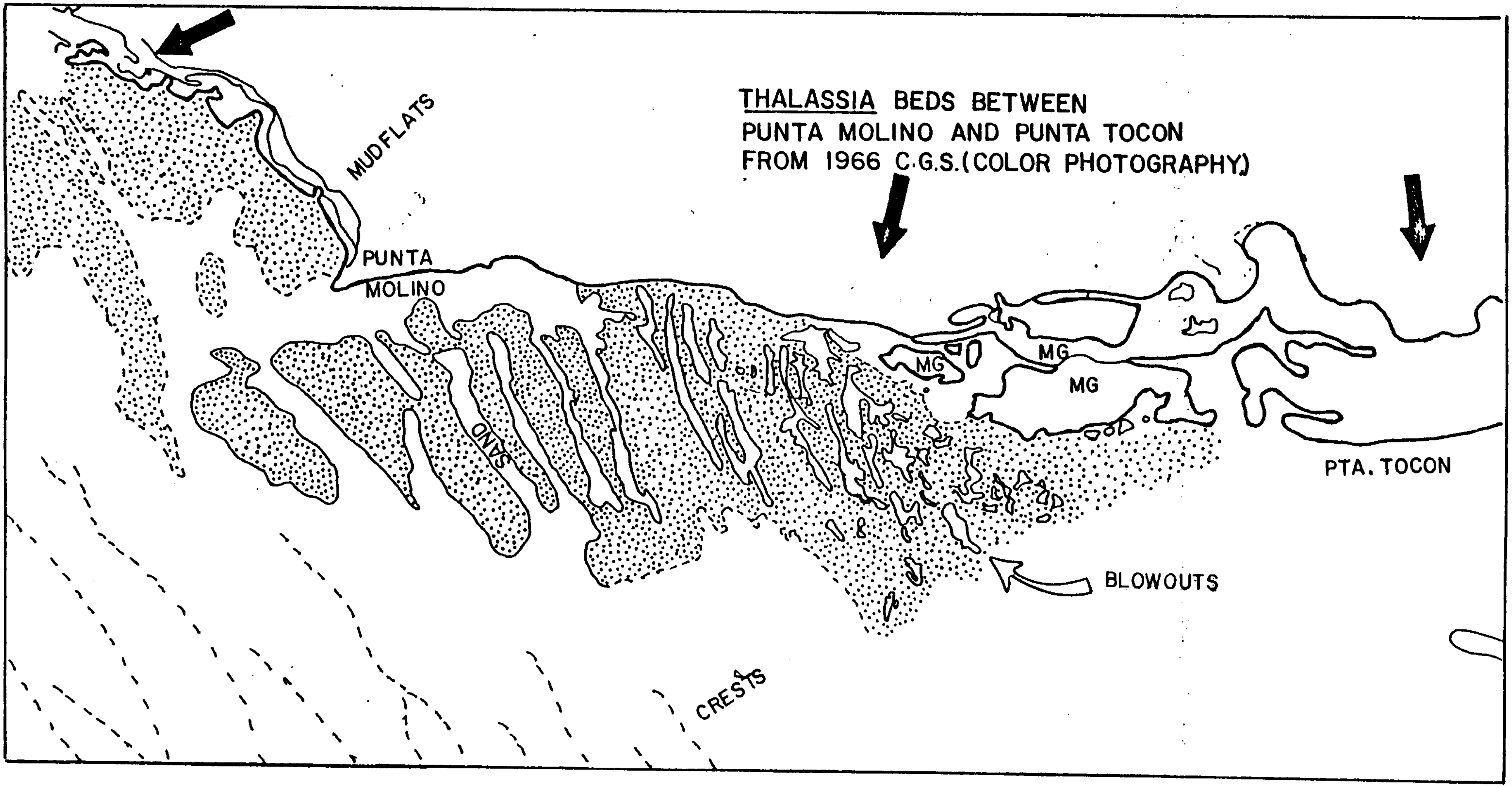


Figure 7a. Distribution of seagrasses in southwestern Puerto Rico.

Figure 7b. Distribution of <u>Thalassia</u> beds between Punta Molino and Punta Tocón, southwestern Puerto Rico.



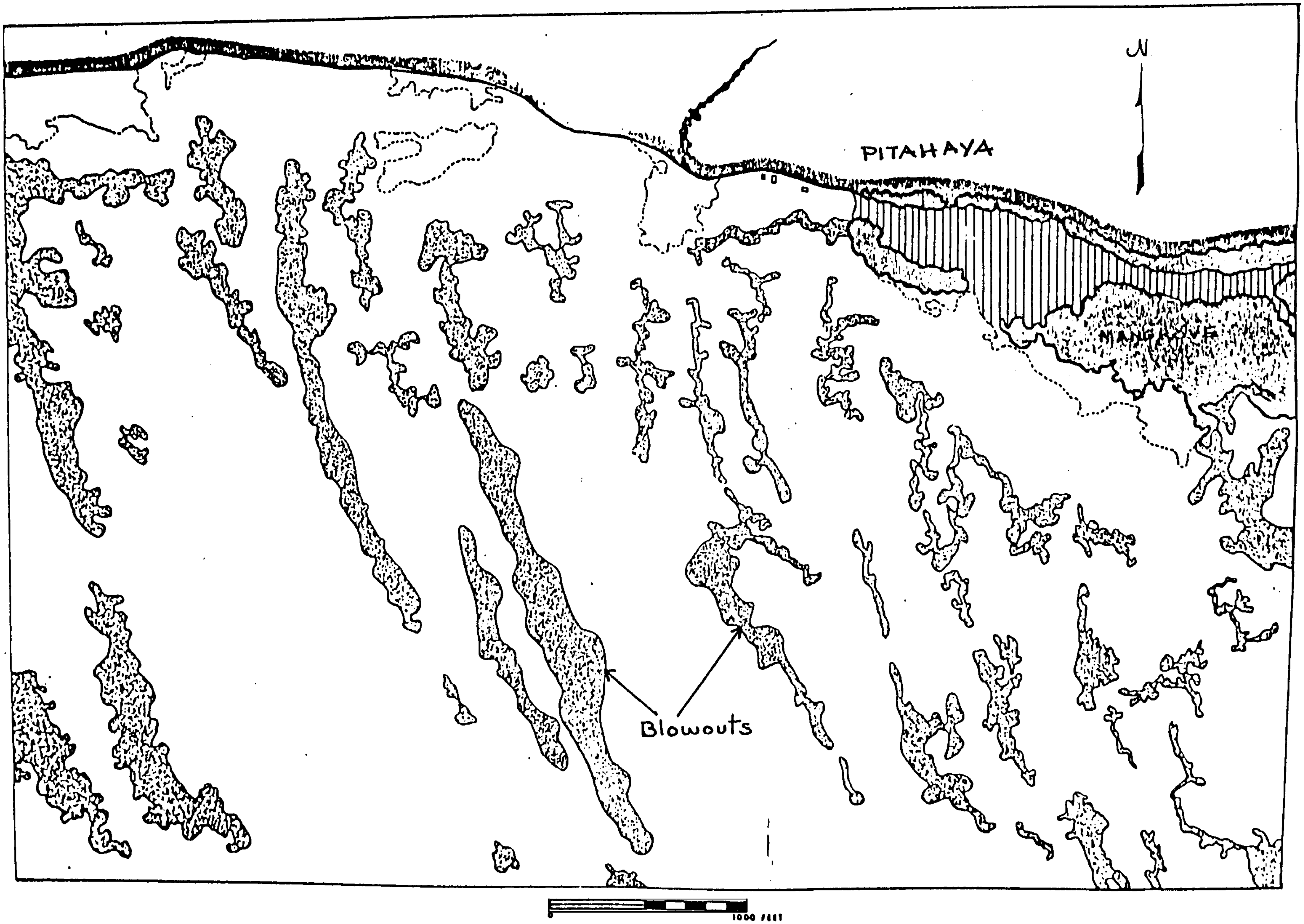


Figure 7c. Blowouts South of Punta Pitahaya. Shaded areas represent zones of bare sand.

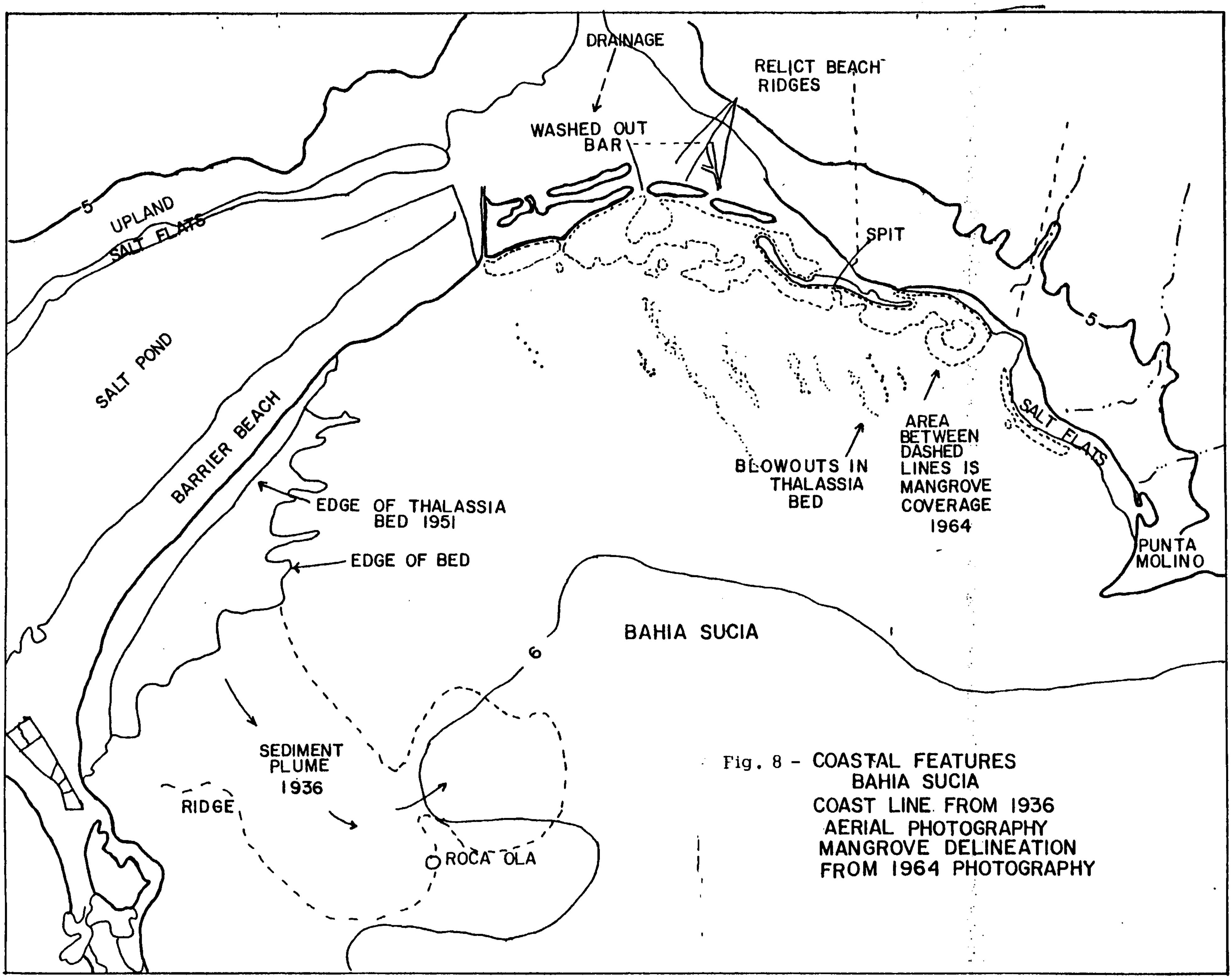


Fig. 8 - COASTAL FEATURES
BAHIA SUCIA
COAST LINE FROM 1936
AERIAL PHOTOGRAPHY
MANGROVE DELINEATION
FROM 1964 PHOTOGRAPHY

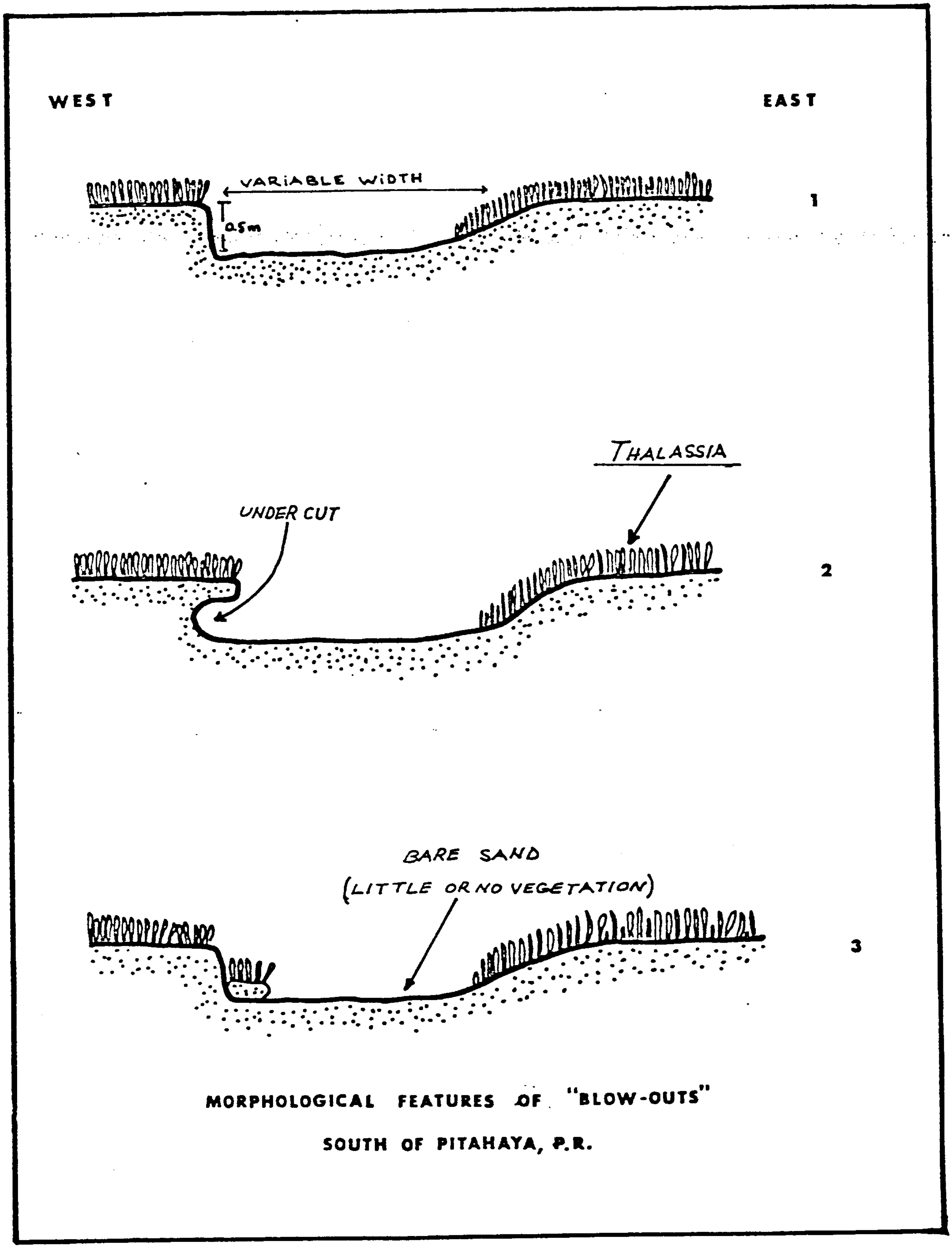
loose force allowing the necessary bottom conditions required for Thalassia growth.

An extensive system of blowouts occur south and southwest of Punta Pitahaya (Figs. 7a, b, c). According to Fernández, (1977), these blowouts are linear scours up to 0.5 m deep oriented perpendicular to the shoreline. The blowouts themselves are devoid of vegetation while the surrounding bottom is densely vegetated mainly by Thalassia (Fig. 9). Patriquin (1975), working in Barbados and Carriacou in the West Indies, defined blowouts as grass-free depressions within seagrass beds which are typically crescent-shaped in plain view with the convex side seaward, and which are characteristic of elevated seagrass meadows in regions of moderate to strong wave action.

Punta Pitahaya's blowouts differ from those described by Patriquin (1975) in several ways. First, they are oriented perpendicular to the shore rather than parallel to it. They also occur deeper, extending from the nearshore up to 10 m or more; as opposed to 3 to 4 m in Barbados and Carriacou. Aerial photograph analyses also show that Pitahaya's blowouts are considerably larger in size reaching up to 100-150 m in width and 1 km in length.

A field of large sand waves occurs west of Pitahaya and seaward of Bahia Sucia (Fig. 7a). The average wave length is about 350 m and heights range between 2 and 3 m (Grove and Trumbull, 1978). Some of these sand waves

Figure 9. Morphological features of blowouts in southwestern Puerto Rico



reach 2,500 m in length. Moderate growth of _Thalassia_ is characteristic of this area, especially along the wave crests. Grove et al. (1978) showed that between 1904 and 1968, the sand waves migrated to the southwest at an overall rate of 1.4 m per year. The blowout area east of the sandwave field seems to be more stable in this respect as evidenced by the denser coverage of _Thalassia_. Although no studies on the migration of blowouts have been conducted in this area, Fernández (1977), theorized that the surge of tropical storms within the inner shelf appears to be the most likely origin for both the blow outs in the grassbeds and the migration of the sand wave field. Migration of smaller blowouts (Barbados type) appear to be associated with "normal" wave action which tends to erode the seaward side of such formations. It is reasonable to assume that in the Bahía Sucia-Pitahaya area, " normal" wave action is not the main force contro-lling blowout migration and formation. This can be attributed to the depth at which the blowouts occur, which is well out of the influence of these forces. Also, the crest surfaces of blowouts in Pitahaya contain syme-trical ripples which are suggestive of inactivity during " normal" coastal energy conditions (Fernández, 1977).

A group of smaller blowouts, much similar in morpho logy and orientation to those studied by Patriquin (1975) occurs at a short distance from shore just east of Punta

Pitahaya (Fig. 10). These show the typical crescent shape configuration with the convex side seaward. These blow-outs occur in shallower water (2-3 m) and receive protection from Margarita reef.

The seagrass beds between Bahía Sucia and Punta Pita haya are well developed and extend from close to shore to depths of 10-11 m (See Figs. 7a, b, c). They become less dense as depth increases and occupy a great deal of the inner shelf bottom. Thalassia is the dominant sea grass, although Syringodium is also very common. Samples of dead seagrass leaves piled up at the beach at Bahía Sucia consisted of 52% (dry wt.) Thalassia and 48% Syringodium. Mixed stands of Thalassia and Syringodium grow a short distance from the beach while isolated patches of Holodule are commonly found between the beach and the Thalassia-Syringodium association. Shallow meadows of Thalassia on the western end of Bahía Sucia are quite dense consisting of 900 plants per m^2 with a leaf area index of 15.4. The importance of high LAI values has been discussed in the literature (Gessner 1971, McRoy, and McMillan, 1977) and is suggestive of some adaptation to the lower light levels of the submarine environment as compared to terrestrial systems.

Basin and fringe mangroves dominate the coastline between Punta Pitahaya and La Parguera. A rather intricate system of channels, islets, cays and lagoons is characteristic of this zone. Two elongate reef systems divide

Figure 10. Blowouts in <u>Thalassia</u> beds near Punta Pitahaya, southwestern Puerto Rico.

the insular shelf into an inner, middle, and outer shelf (Morelock et al., 1977). The shelf itself is relatively uniform in depth (20 m). Seagrass beds occupy large areas of this shelf. The meadows are generally dense in sha llow water and become sparce and patchy at about 10 m Thalassia is the dominant seagrass. Syringodium is less abundant and usually grows mixed with Thalassia. Small patches of Holophila occur on the inner shelf province at 7 m. Holodule is the least common seagrass in La Parguera.

In La Parguera, Thalassia was found growing from the intertidal zone to depths of about 10 m. Large, well developed meadows were generally observed at depths of 2 m or less. These meadows occupy most of the shallow bottom just offshore of the mangrove fringe (R. mangle) characteristic of La Parguera's shoreline. Off Punta Guayacán, for example, Thalassia and Syringodium grow close to the submerged mangrove roots. The above-ground biomass of Thalassia in this area ranged between 245 and 512 g/m^2, decreasing on one progressed seaward. Grazing by a large population ($1.5/m^2$) of the urchin Diadema antillarum probably accounts for the sparcer growth offshore.

Dense growth of Thalassia was also observed in semi-enclosed areas with good circulations and clear waters. Two examples are the meadows north-east of Magueyes island and around Cueva island. These areas are protected by mangrove islets and have an average depth of 2 m. The sea condition is generally calm allowing for good transparency. Water transparency measured horizontally near the Cueva and Magueyes sites was 6.5 m. These conditions of clear waters appear to prevail throughout most of the year, except during periods of very heavy rainfall and runoff (October and November). Thalassia growing on these semi-protected areas usually displayed a longer blade length than those growing in more exposed areas. The average blade lengths for the Magueyes and Cueva sites were 27 and 22 cm respectively, while off Punta Guayacán the average was 16 cm. Differences in water depth between sites appear to influence to some extent the lengths of the blades. Very shallow meadows (0.5 m) usually contained shorter leaves (Fig. 11 and Table 1).

In La Parguera Thalassia grew over coral rubble, sand, and mud. Table 2 is a summary of the per cent fractions of gravel, sand, silt, and clay of samples where Thalassia was found. The data suggests a wide range of sediment grades in which Thalassia can be found. Margalef (1962) noted that although the number of rhizomes of Thalassia appear to be higher in coarser sediments, Thalassia grows in sediments of different grade composition. He also stated that the stages prior to succession lead to an appropiate substrate of sand and mud.

Zieman (1972) described the relationship between sediment depth and blade length of Thalassia. He found that Thalassia in Florida was able to grow in sediments

Figure 11. Range and mean blade lengths of Thalassia in La Parguera, Puerto Rico.

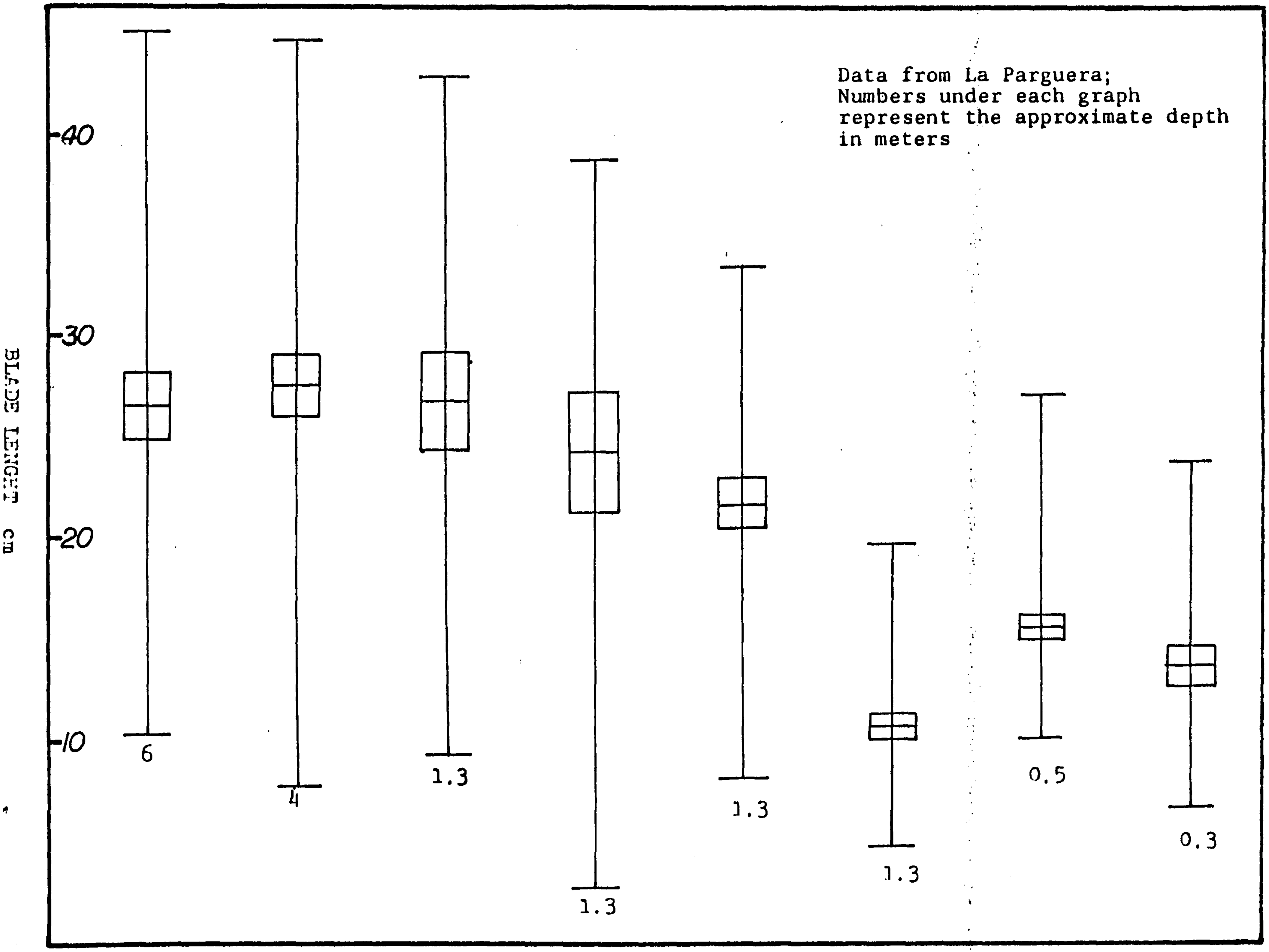


Table 1. Blade length statistics of *Thalassia testudinum* from various locations in Puerto Rico, Vieques and Culebra.

Location	Approx. Depth	Range (cm)	Mean (cm)	Sta. Deviation
Medio Mundo (Ceiba)	0.2	3.5-20.3	9.5	3.2
Bahía Sucia	0.3	8.2-45.0	30.8	9.1
San Juan	1.3	6.0-45.1	28.5	9.3
Culebra	1.3	4.5-33.5	19.3	6.0
Esperanza	1.3	4.0-26.0	14.8	4.0
Bahía Icacos	1.5	4.7-27.5	13.0	5.6
Sun Bay	1.5	1.9-37.5	15.5	7.8
Salinas	2.0	6.0-24.7	15.2	4.3
Pt. Canalejo	2.3	6.5-30.0	15.2	4.6
Pitahaya	2.3	1.2-31.0	18.1	6.9
Salinas de Sur	3.0	9.0-37.5	20.4	5.3
Cayo Icacos	5.0	5.5-31.0	18.0	5.1

Table 2. Summary of the percent fractions of gravel, sand, silt and clay where *Thalassia* was found.

Location	gravel (%)	sand (%)	silt (%)	clay (%)	organic matter (%)	insoluble residue (%)
Enrique reef	57.2	42	0.8		4.99	1.64
Enrique reef	61.1	37.0	1.2		4.12	7.29
Guayacán (I)	14	79	3	3	8.02	5.34
Guayacán (II)	14	68	8	10	8.52	6.66
Pitahaya		98.4	1.6			
Club Nautico (La Parguera)	3.0	51.7	23.0	21.9	11.09	38.35
Club Nautico (La Parguera)	2.8	45.5	27.0	24.5	11.14	37.37
West Magueyes (I)	4.0	66.2	18.3	9.8	7.17	30.81
West Magueyes (II)	3.6	63.4	20.6	9.5	8.63	49.20
Northeast Magueyes (I)	10.3	43.5	16.3	29.6	20.55	39.12
Northeast Magueyes (II)	8.5	39.1	18.5	33.4	17.91	28.47
Propeller trench	5.5	23.0	24.1	47.0	18.27	34.90
Mangrove channel		93.6	3.45	2.94	30.24	N/A
Mangrove channel		18.1	43.2	38.7	43.29	N/A
Puerto Manglar (Culebra)	20.1	63.1	6.0	11.0	10.45	13.23
Puerto Manglar (Culebra)	12.6	67.0	8.0	12.0	8.54	29.10
Ceiba I	14.0	40.4	20.0	24.7	16.89	22.88
Ceiba II	5.3	53.4	17.0	23.6	17.87	22.85
Icacos island (Fajardo)	3.2	78.2	14.3	3.3	19.36	6.57
Playa Canalejo (Fajardo)	6.8	93.0	0.2		N/A	1.50

N/A - Data not available

less than 1 cm deep, but reached maximum blade lengths at sediment depths of 25-30 cm. Although we did not study this relationship, we observed a tendency towards longer blade lengths in sediments with high percentages of silts and clays and sediment depths in excess of 25 cm. One such station (northeast of Magueyes island) consisting of 41% sand, 17.5% silt, and 32% clay had a maximum blade length of 43 cm. A station in Enrique reef (48% gravel, 48.5% sand and 3% silt) showed a maximum blade blade length of only 24 cm. Although not conclusive, this trend in our observations indicate that maximum blade length of *Thalassia* in La Parguera is governed to some extent by sediment composition and depth.

The distribution of *Thalassia* near offshore reefs, islets, and mangrove islands in La Parguera is generally restricted to the lee (north) side of these formations. Exceptions to this are the meadows growing around mangrove islands within the inner shelf province. Protection offered by the rather large system of offshore reefs allow *Thalassia* to colonize both the leeward and windward sides of these islands. Where *Thalassia* is present on the more exposed side of these islands, it commonly occurs in association with coral species such as *Millepora complanata* and *Acropora cervicornis*.

Numerous coral islets mainly consisting of *Porites* are also found within the inner shelf of La Parguera.

According to Welch (1962) these _Porites_ cays illustrate the growth of a coral reef and its transformation via _Halimeda opuntia_ and _Thalassia_ to a mangrove island. As with the mangrove islands, _Thalassia_ may be present on all sides of these formations. The zonation of a _Porites_ cay at three different developmental stages is given in Figure 12 (Welch, 1962). The occurrence of _Thalassia_ along these may vary from cay to cay but generally is more evident in the fore and hind sections. _Thalassia_ is less abundant on the crest of these cays, where _Porites_ dominates.

The outer reefs of La Parguera are roughly oriented parallel to the coast. _Thalassia_ is absent from the exposed reef fronts which continuously receive the impact of the incoming waves. On the innundated central portion of the reef flats _Thalassia_ develops among the coral rubble. It is not uncommon to find _Thalassia_ competing for space with the anemone _Zoanthus_ which forms dense mats that spread laterally . _Thalassia_ is also present in the shallow lagoon side of the reefs where it occurs in a rather variable band just behind the reef flat. In contrast to the meadows growing on the reef flat, _Thalassia_ growing on the lagoon side are seldom exposed to air. Large areas of _Thalassia_ in the reef flat are periodically exposed to air resulting in massive loss of pigmentation and leaf kill.

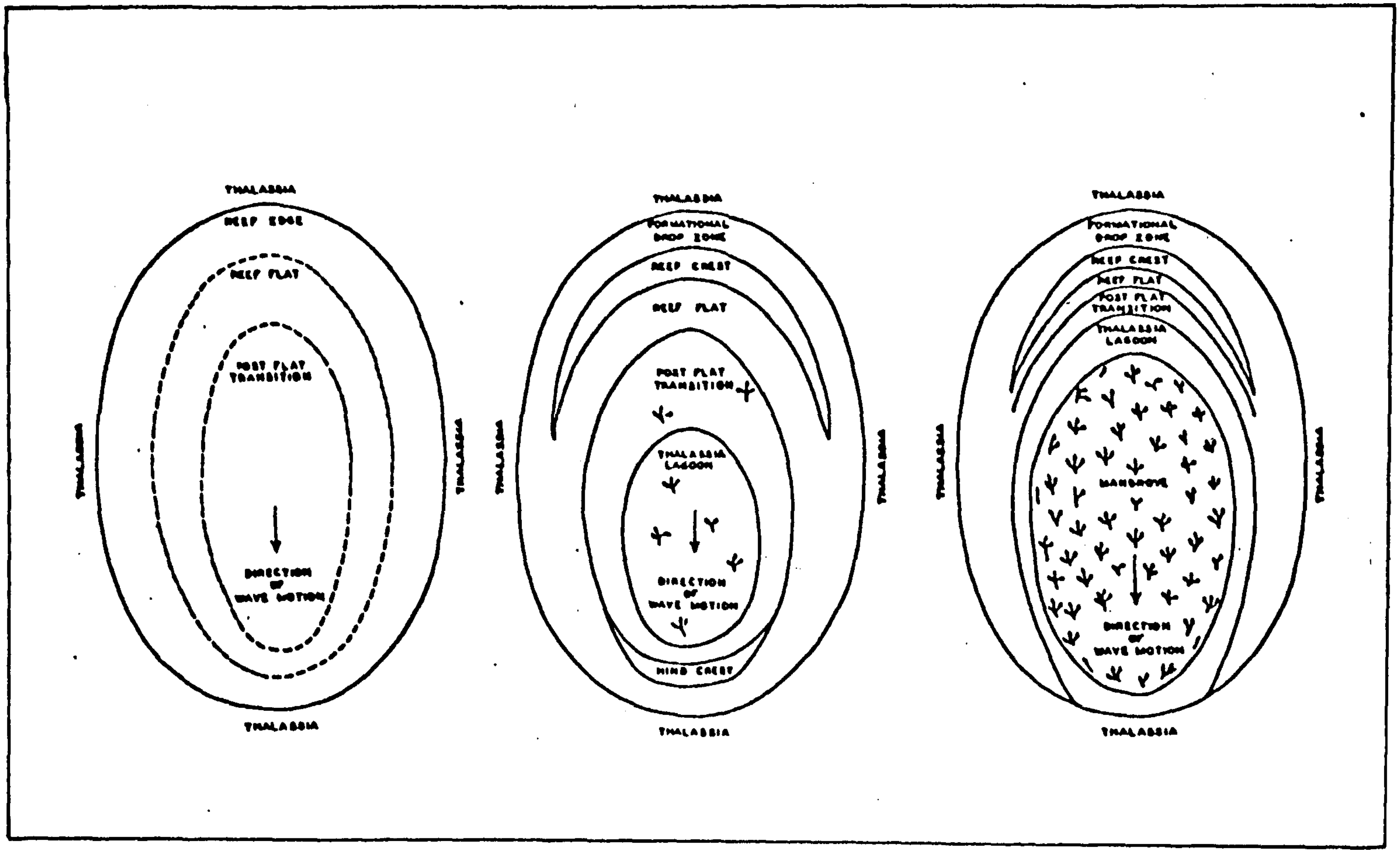


Figure 12. Zonation of a <u>Porites</u> cay at three developmental stages (Welch, 1962).

Thalassia meadows in La Parguera are subject to damage from motor boats. This damage is most common in shallow waters, especially near the village and mangrove channels. Severe damage was observed near Isla Cueva and northeast of Magueyes island (Figs. 13 and 14). When a boat crosses over a shallow bed, not only are the blades severed but the rhizome and root system can be affected. According to Zieman (1976), *Thalassia*, although highly productive, do not recover rapidly from physical disturbance of the rhizome system. Tracks from propeller damage have been observed to persist for 5 years (Zieman, 1976). We have observed tracks in La Parguera persist for longer periods, probably due to constant disturbance that does not allow regeneration. Close inspection of some of these tracks in La Parguera showed scars 8-10 m in length and 0.5 to 0.75 m in width. In the channel between Magueyes island and mainland Puerto Rico, damage is so severe that tracks are not recognizable and *Thalassia* simply appears as scattered patches. Considerable amounts of the blue-green alga *Microcoleus lyngbyaceus* accumulate on the barren sediment between the patches. According to Almodovar (pers. com.) this alga is an indicator of pollution. Although it can be found throughout the entire study area, this alga appears to be omnipresent in the Magueyes channel. It certainly competes with *Thalassia* for sunlight and frequently covers the few remaining patches of the seagrass in that location.

Figure 13. Distribution of Thalassia near La Parguera.

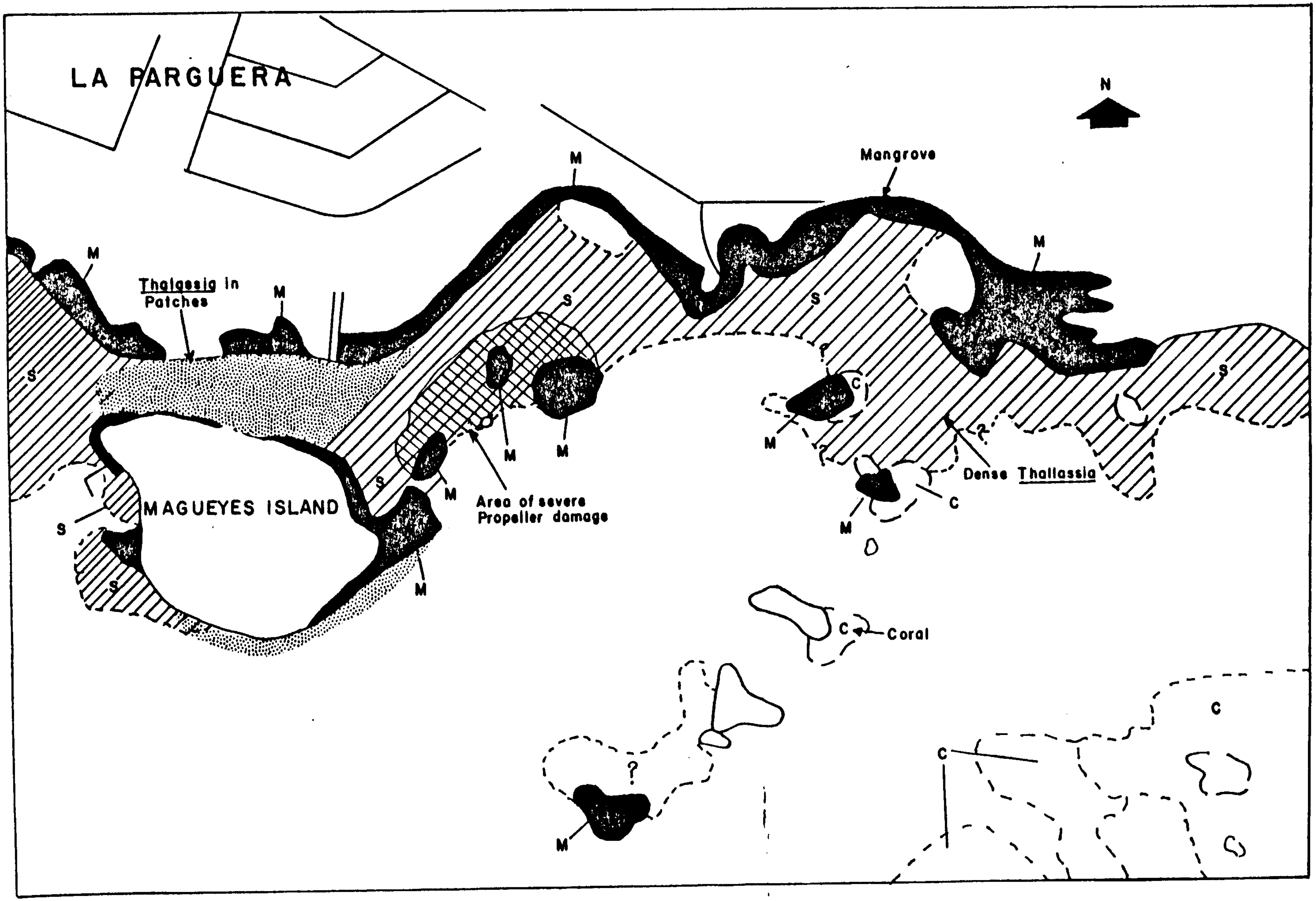
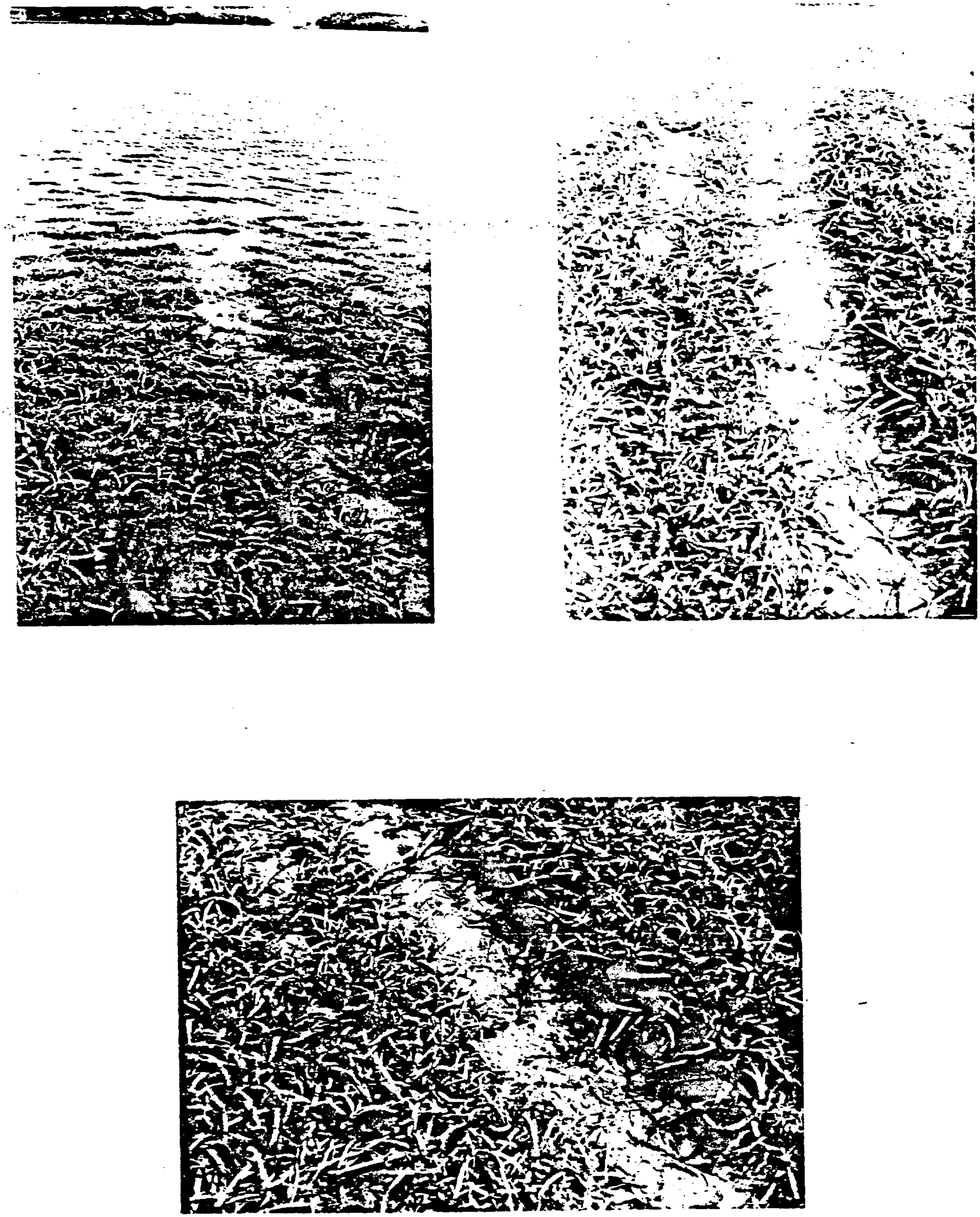


Figure 14. Physical damage from motor boats on Thalassia beds in La Parguera.

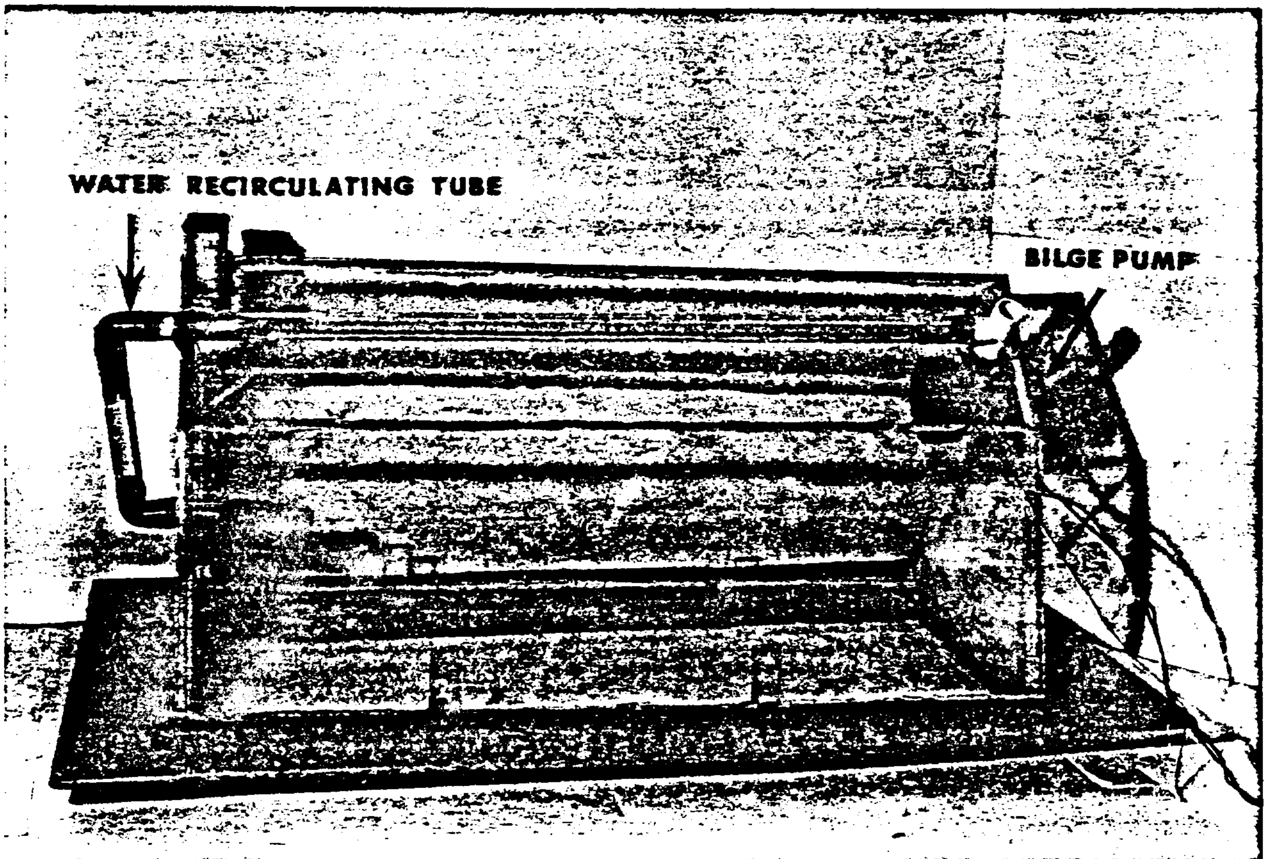


Seagrass Productivity

Submerged vascular aquatic plants are characterized by a number of anatomical and physiological specializations, one of which is a network of air chambers within the tissues of the plant (Hartman and Brown, 1967). The retention of metabolic gases within this lacunal system complicates the problem of estimating production of aquatic vascular plants, especially when the measurements are based on oxygen production. Captive methods such as the benthic chamber of Jones (1968) and the flowing water techniques of Odum and Hoskin (1958) have been questioned because of the retention of gases within the lacunal system.

Acknowledging the problems associated with using oxygen as an indicator of productivity of *Thalassia*, a benthic respirometer (Fig. 15) was constructed for the sole purpose of comparing our data with results obtained through similar techniques. The function of the chamber was to enclose and recirculate water above a small section of the bottom where biological activity within the chamber changed the oxygen content of the recirculating water. By measuring the change in oxygen concentration, estimates of the rates of productivity and respiration were made. This type of chamber has been successfully used for measuring the respiration of sediments in lake bottoms (Lucas and Thomas, 1970), for measuring productivity and respiration

Figure 15. Benthic respirometer used to monitor oxygen evolution over <u>Thalassia</u> beds.



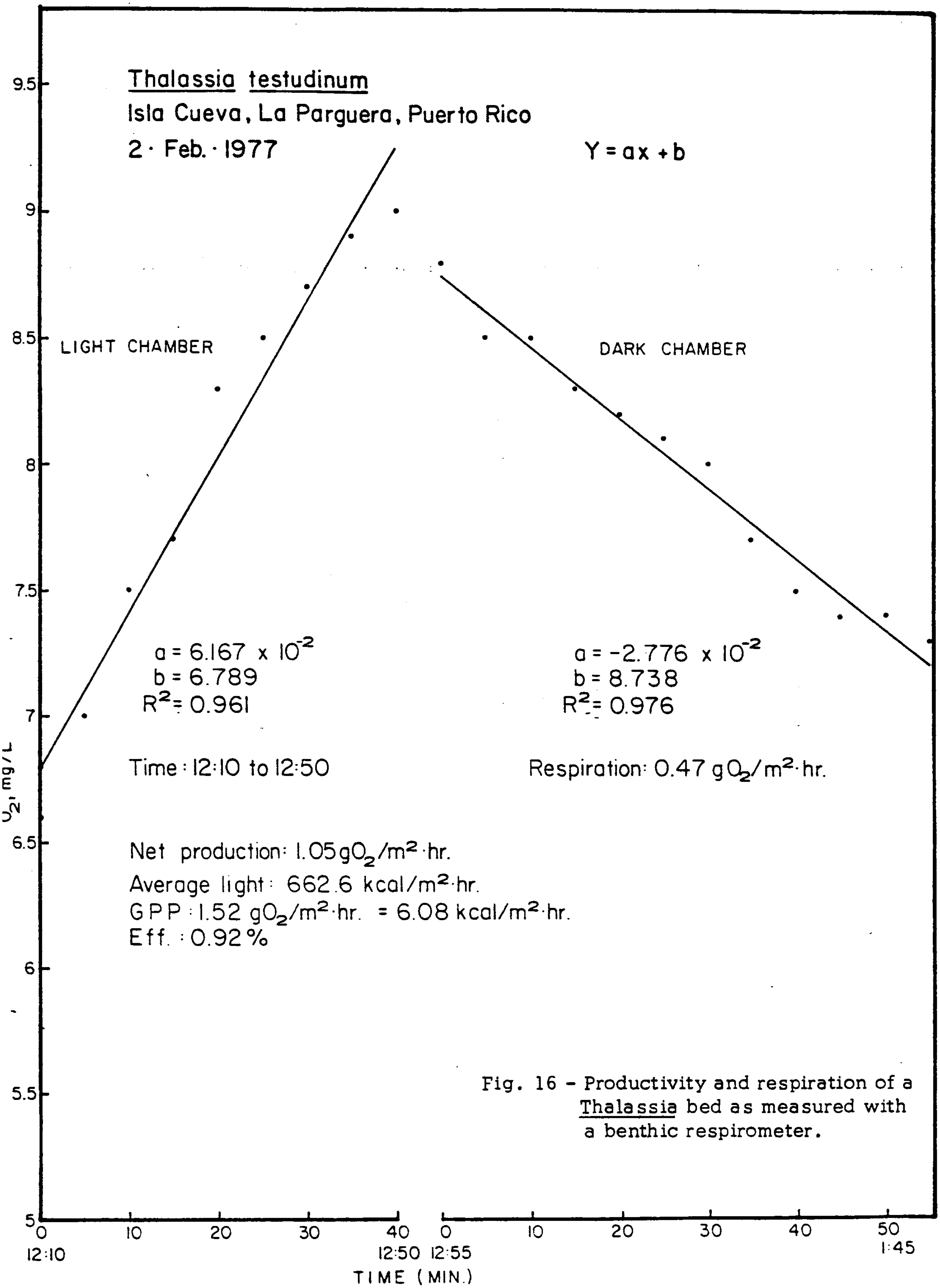


Fig. 16 – Productivity and respiration of a *Thalassia* bed as measured with a benthic respirometer.

in estuaries (Carter et al., 1973), and for productivity of fresh water plants (Vollenweider, 1969).

Figure 16 is a graph of the oxygen concentration in the water of the chamber when it was placed over Thalassia, in La Parguera. Depth was 1.2 m. During the first half of the run, sunlight was allowed to pass through the chamber, and photosynthesis predominated as evidenced by a net increase in oxygen concentration. During the second part of the run, the chamber was covered with black plastic to block-out most of the light. The result was a steady decrease in oxygen concentration due to respiration and reduced photosynthesis.

Table 3 is a summary of productivity, respiration, water depth, biomass, transparency of the water, tempe rature, and turbidity in Isla Cueva, La Parguera. Although preliminary, these results give an idea of the magnitude of certain parameters which influence the energy balance of this system. The productivity value compares favorably with those reported by Odum (1956), Odum, Burkholder, and Rivero (1959), Odum (1967) and D'Croz et al. (1975). Calculated on a daily basis, respiration (11.28 g O_2/m^2 day^{-1}) approached gross primary productivity (11.41 O $^{-1}$). The high level of organization of the Thalassia community requires a high energy expenditure, thus the energy fixed tends to be balanced by the energy used in respiration. This indicates a climax community. Successional stages described by Margalef (1962) (Figure 2) were not evident

Table 3. Summary of various ecological parameters at Isla Cueva, La Parguera, Puerto Rico.

Net Productivity ($gO_2/m^2.hr$)	Respiration ($gO_2/m^2.hr$)	Biomass (g/m^2 dry wt.)	Sechii Disc Transparency (m)	Per Cent Surface Reflection
1.05	0.47	23.8	6.5	15

*Light Extinction (k)	Temperature C	Solar Radiation $kcal/m^2.hr$	Depth (m)	**Light at Bottom $kcal/m^2.hr$
-0.2107	26.5	662.6	1.2	437.4

* "k" as in $Lx = Lo\ (e^{kx})$ where "Lx" is light at depth x and "Lo" is light at depth zero which is light at the surface minus reflection.

** Assuming $Lx = (Ls)^{kx}(1 - Rf)$ ( ) where "Ls" is light reaching the surface and "Rf" is the fraction reflected, here assumed to be 0.15 based on Hutchinson, 1957.

in the immediate vicinity of the Isla Cueva site where the measurements were made, suggesting that a mature community exists there.

The technique developed by Zieman (1974) has been used effectively to monitor Thalassia blade populations without disturbing the plants and to determine leaf growth and net production of the blade. This technique was recommended by the International Seagrass Workshop (McRoy, 1973). Production measurements using the Zieman (1974) technique were made in 7 stations in La Parguera and one station in Ceiba (east coast of Puerto Rico). The values of standing crop, leaf production, turnover, and growth rates are given in Table 4. Standing crop values averaged 142 gms dry wt/m^2, which is lower than the mean values reported by Margalef and Rivero (1959), Burkholder, Burk holder and Rivero (1959) and Vicente (1975) for other locations in Puerto Rico. The lower value is probably due to acid decalcification of the leaves (see section on Methods) which eliminates epiphytes and other calcareous materials from the leaves. Most values of standing crop of Thalassia reported in the literature include the epiphytic component of the leaves and therefore tend to be higher. Additonal measurements of standing crop without decalcification were performed for comparison purposes and are presented later in this report.

The average standing crop (decalcified) of Thalassia from La Parguera was higher than the average reported by

Table 4. The standing crop, leaf production, turnover time and growth rate of _Thalassia testudinum_ (blades) in La Parguera, P.R.

STATION	Standing Crop (g/m^2) *	Leaf Production (g/m^2.day)	Turnover Time (days)	Turnover (%)	Growth Rate cm/day
Cayo Enrique	136	4.38	31	3.2	0.56
Bird Island	129	5.71	23	4.4	0.55
Punta Guayacán	* 24.5	7.29	34	3	0.48
Magueyes Island (North)	61.2	2.13	29	3.4	0.79
Magueyes Island (West)	127.5	5.47	23	4.3	0.78
South of Guayacán Island	122	6.05	20	4.9	0.61
Magueyes Island (North-east)	173	3.84	45	2.2	0.51
Ceiba (Punta Medio Mundo)	281	10.7	26	3.8	0.29
Average **	142	4.98	29.3	3.63	0.61

* This material was acid-washed to remove all foreign material adhered to the leaves; values appear lower from others reported in the literature and elsewhere in this report.

Does not include the Ceiba data.

Zieman (1978) for Vieques (78.6 g/m^2, Vieques - 142 g/m^2, La Parguera). Seagrass communities in general vary widely in density. In La Parguera the meadows were densest in waters of less than 2 meters. The maximum amount of above ground leaf material found by Zieman. (1979) in Vieques was 121 g/m^2. In La Parguera this value was 245 g/m^2. Although these data show that the standing amounts of *Thalassia* in La Parguera is double that of Vieques, this difference does not appear to be very significant since the range of standing crop of *Thalassia* is considerably wider. In addition, no attemps were made neither in Vieques nor La Parguera to actually determine the maximum values.

Leaf production in La Parguera was slightly double than in Vieques. However, the average value for La Parguera (4.98 g/m^2 day) was practically the same as that reported by Zieman (1975) for *Thalassia* in Florida. These differences and similarities are probably a function of seasonality. For example, Zieman (1978) found that the period of maximum production of *Thalassia* in St. Croix was 236% of minimum production and maximum standing crop was 230% of minimum standing crop. The yearly minimas - of leaf production in St. Croix were in the June-August period. The Zieman data from Vieques was obtained during the summer months which would correspond to the minimum production period. Our data from La Parguera, which showed higher values of leaf production than Vieques, was obtained during January and February, which according to the St. Croix information corresponds to the period of maximum production. Although seasonality is a function of many interacting factors, the minimum values for Thalassia production usually coincide with the peak production of reproductive structures such as fruits and flowers (Zieman; 1975; Vicente, 1975). During this period, large amounts of fixed energy are diverted from vegetative production and used for the production of flowers and fruits. This diversion of energy explains why leaf production is low during the summer when Thalassia is in flower.

The turnover of Thalassia in La Parguera during January-February varied from 2.2% to 4.9%. This value represents the percent of standing crop that is replaced each day. The average turnover was 3.6% (Table 4). The inverse of turnover or turnover time, represents the time required to completely reproduce the observed standing crop. This value averaged 29.3 days for La Parguera.

If that value was maintained throughout an entire year, the community would produce 12.5 crops per year. Turnover values as high as 4.9% (18.25 crops/year) were measured in La Parguera. Zieman (1975) found that seagrass communities in Florida showed an average turnover rate of 1.9% per day (7 crops/yr.) which is considerably lower than the average for La Parguera (turnover time = 29.3; 12.5 crops/yr). These differences may be attributed to differences in the growing season of Thalassia in La Pa rguera and Florida. Subtropical zones such as Florida have a net growing season of only 250 days.

The values of biomass and standing crop of Thalassia from various locations in Puerto Rico are summarized in Tables 5 and 6. The amounts given are from samples which were carefully cleaned and washed but not decalcified, and therefore include the epiphytic component of the leaves. McRoy and McMillan (1977) reported that Thalassia is capable of attaining a biomass of over 8 kg dry wt/m². The highest recorded biomass of Thalassia in Puerto Rico (7.35 kg dry wt/m²) was reported by Burkholder, Burkholder and Rivero (1959) while studying seagrasses in La Parguera. Biomass values obtained during this study ranged from 0.4 to 2.3 kg dry wt/m², with a mean value of 1.1 kg/m² which is comparable to the mean value reported by McRoy and McMillan (1977).[1] The same authors suggested that maximum biomass in any seagrass meadow appears to be related to density as a function of leaf size, which through shading becomes a controlling factor. Figure 17 shows the relation of above ground biomass to leaf area index (LAI). The maximum LAI reported for Thalassia is 18.6 for a dense meadow near Cumana, Venezuela (Gessner, 1971). This same meadow had an above ground biomass of 608 g/m². Our data showed LAI values as high as 16.8, with a total dry weight of leaves of 616.1 g/m². Judging from Figure 17, the maximum standing crop of Thalassia occurs at leaf area indices

[1] Wide variations in the range of total biomass of Thalassia and other seagrasses may be attributed to differences in penetration of the cores used to sample the roots and rhizomes.

Table 5. Summary of biomass and standing crop of selected locations in Puerto Rico and Vieques.

Location	Biomass (g/m²)		Standing Crop (g/m²)		Reference
	Range	Mean	Range	Mean	
West Las Palmas	3609-4909	(2802)*		825	Burkholder, Burkholder and Rivero (1959)
East Las Palmas	2712-4102			498	
East of La Parguera	538-694			138	
Bahía Fosforescente	829-1098				"
La Cueva, West	1300-5761				
La Cueva, North	3945-7375				
La Parguera	243-1334	773			Margalef and Rivero (1959
Cayo Laurel		476	76-165	108	Delgado Hyland (1978)
Cayo Enrique		468	44.8-256	131.0	"
Guayacán		907	126.8-412	245.7	
Jobos Bay	10-5550	1655	10-690	250	Vicente (1975)
La Parguera	243-1334	772	150-220	186	Margalef (1962)
Bahía Icacos (Vieques)			88-776	209	Vicente (1978)
Salinas del Sur (Vieques)			50-144	78	
Ensenada Honda (Vieques)			37-74	54	
La Parguera	2400-46200	11326	351-2533	1292	Welch (1962)
Guayanilla Bay ?	-725	330			Vicente (1977)

* Mean of 5 sites in La Parguera

Table 6. Summary of biomass and standing crop of <u>Thalassia</u> from selected sites in Puerto Rico, Vieques and Culebra.

Location	Biomass (g/m²)		Standing Crop (g/m²)		Reference
	Range	Mean	Range	Mean	
Enrique Reef *	467-1286	892	113-375	229	This report
North East Magueyes *	1145-2341	1660	350-862	586	"
"Salinas, P.R.			159-371	260	
"Icacos Island	713-1676	1181	54-449	43	
"Punta Guayacán *	1605-2352	1986	245-816	512	
Puerto Manglar (Culebra)			49-289	174	"
"Bahia Sucia *			300-904	551	
"Isla Cueva *	378-722	532	133-303	240	
Salinas del Sur (Vieques)			33-224	88	
Bahia Icacos (Vieques)			88-451	234	
Mosquito Bay (Vieques)	832-1606	925	100-440	294	
Esperanza (Vieques)	105-1191	632	70-614	230	

* Southwestern Puerto Rico

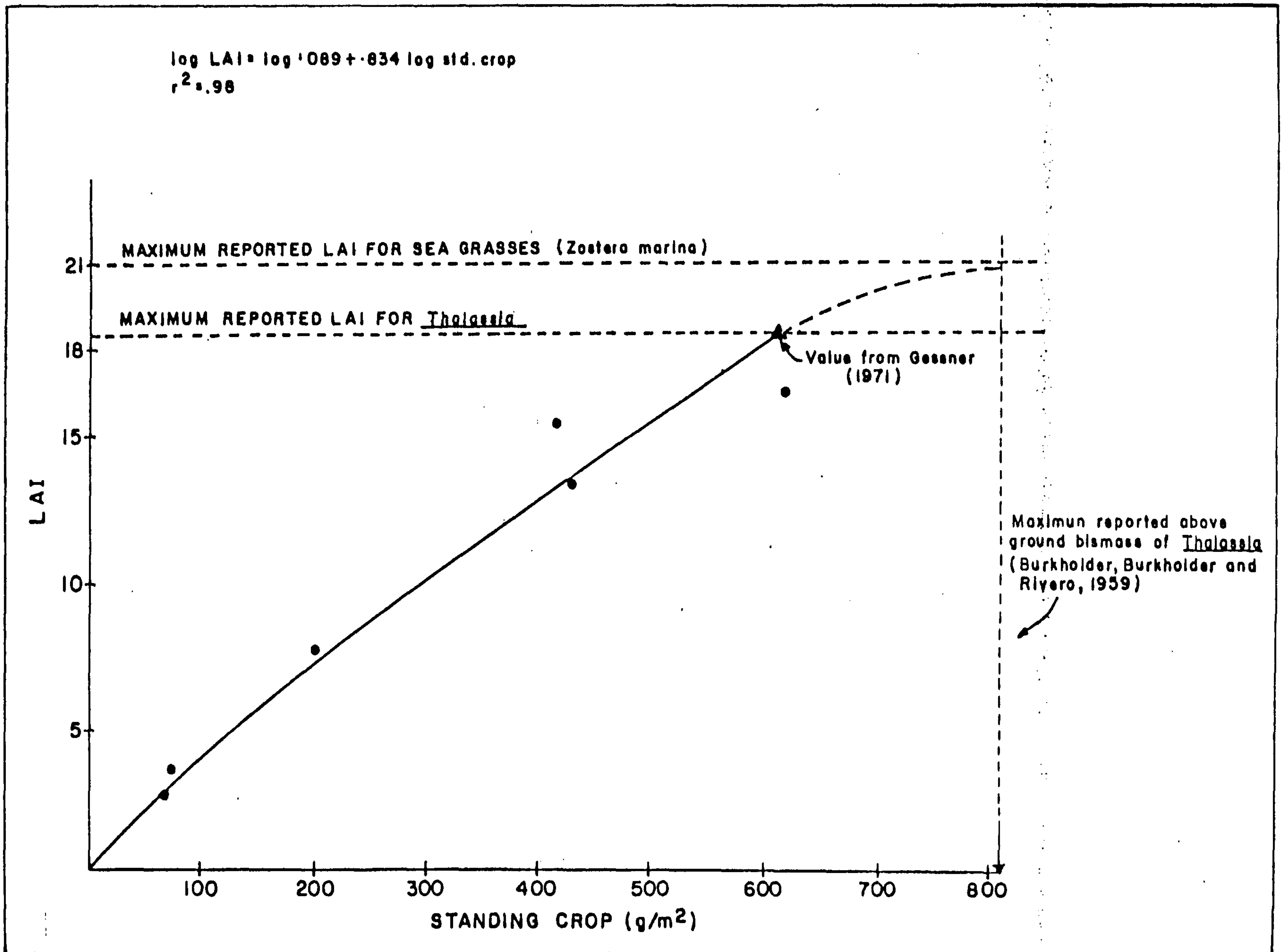


Figure 17. Relation between Leaf Ava Index (LAI) and Standing up of *Thalassia testuderin* from various locations in Puerto Rico.

between 18 and 19. It appears that at those densities the self-shading effect of the leaves becomes a controlling factor of standing crop.

Meadows with low standing crops displayed high growth rates of individual leaves (Fig. 18). This may be due to the fact that the density (LAI) of these meadows is low and the self-shading effect is minimal. As the meadows progressively get denser (LAI and leaf length increase) the growth rate of leaves decreases. Similarly, the growth rates of individual leaves decrease with leaf age (Patri quin, 1973).

Net production of the *Thalassia* community (expressed as grams dry weight of leaves produced per m^2 per day) was highest in meadows with high standing crops (Fig 19). These meadows were characterized by high leaf area indices and low growth rates of individual leaves. Although the individual growth rates were low, the availability of more surface area for photosynthesis undoubtedly contributes to increase the production rate.

Sedimentation and Water Quality

Various aspects dealing with water quality and sediments in La Parguera were investigated during this study. These included measurements of total nitrogen, nitrites, nitrates, ammonia, pH, total phosphorus, and phosphate as well as measurements of the rate of sedimentation of

Figure 18. Relation of growth rate of <u>Thalassia</u> to abov e-ground biomass.

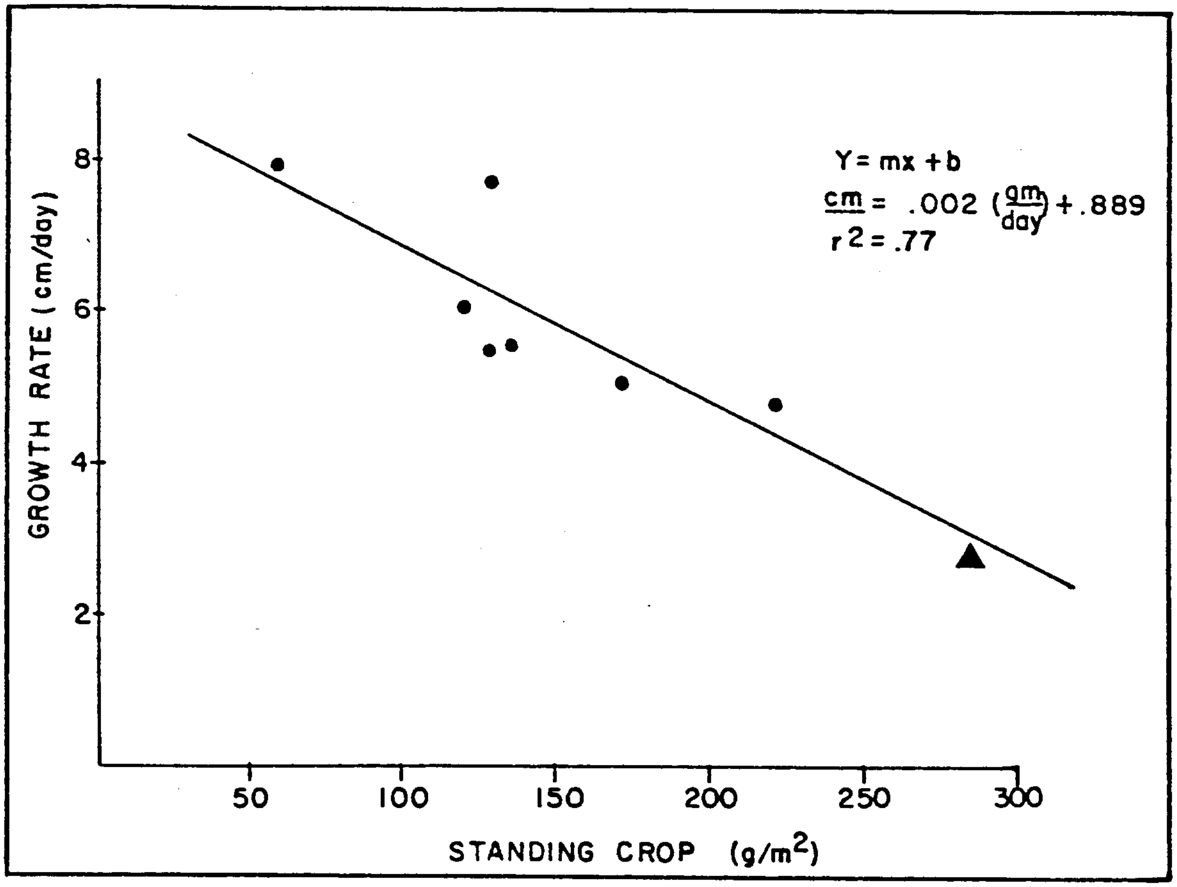
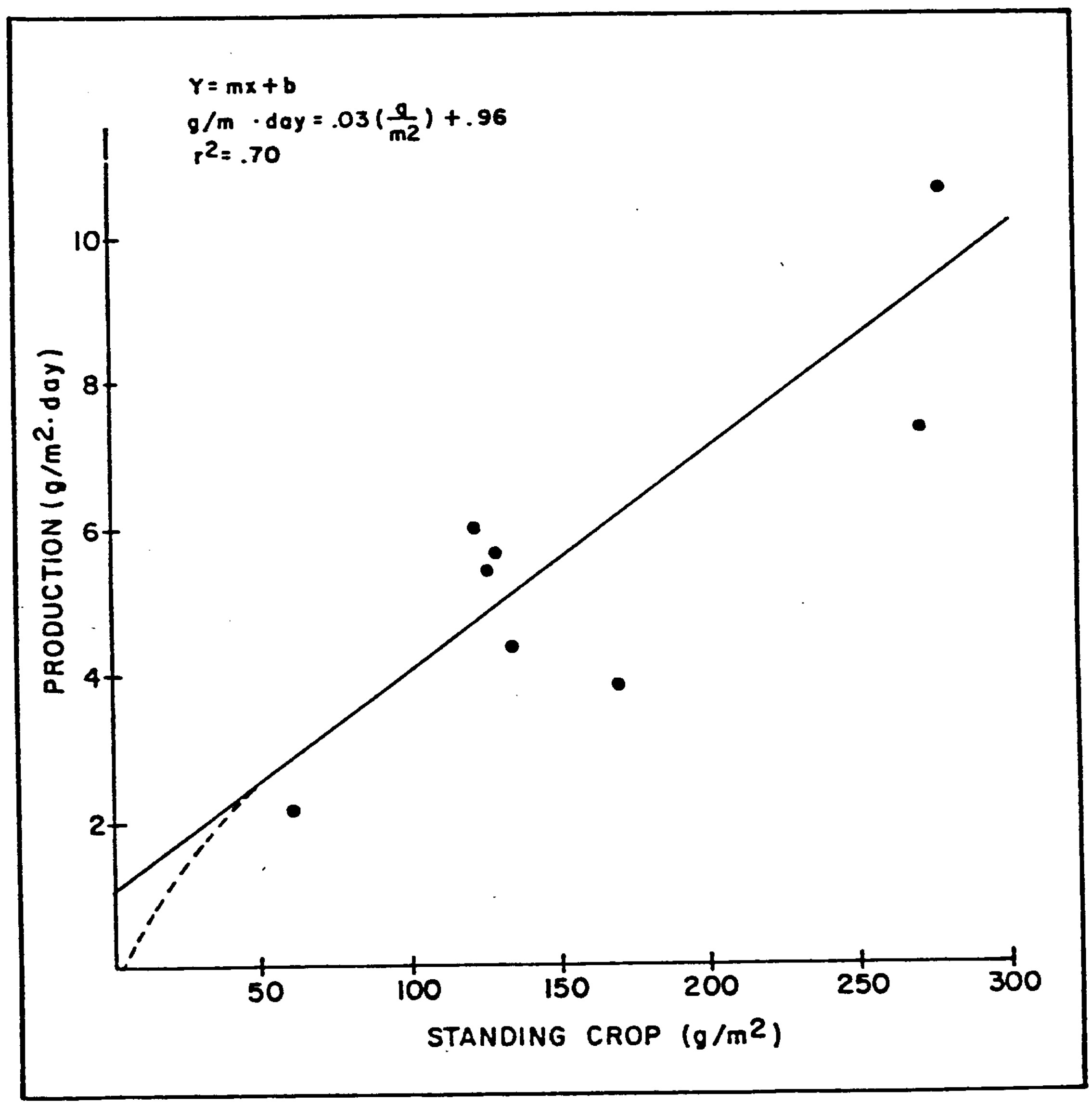


Figure 19. Net production of Thalassia as a function of standing crop.



selected sites within the study area. Grade distribution and organic content of the sediments was also investigated.

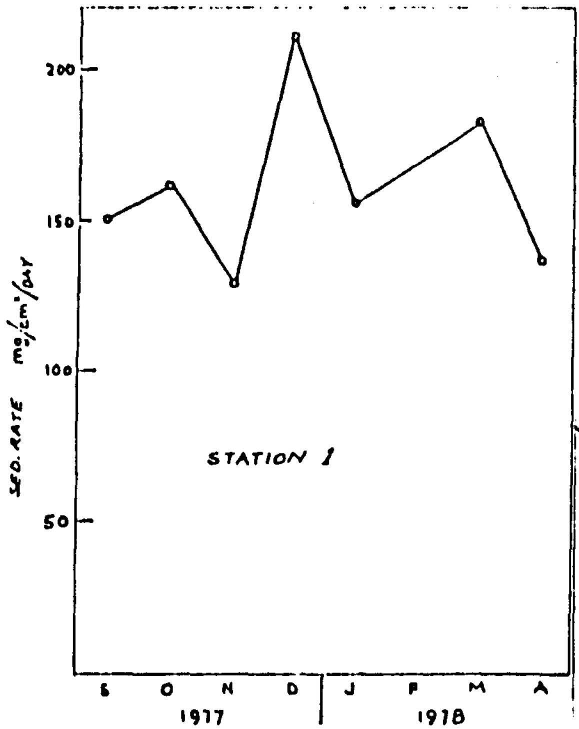
A 1972 Environmental Quality Board study on the water quality of La Parguera concluded that "water quality standards generally were not violated in the greater part of the samples taken" and that "the waters of the La Parguera area were not found to have widespread low quality." However, most of the 125 or so beach houses still empty their raw sewage into the adjacent waters. The same study concluded that bacteriological standards were violated once....but were satistactory elsewhere.

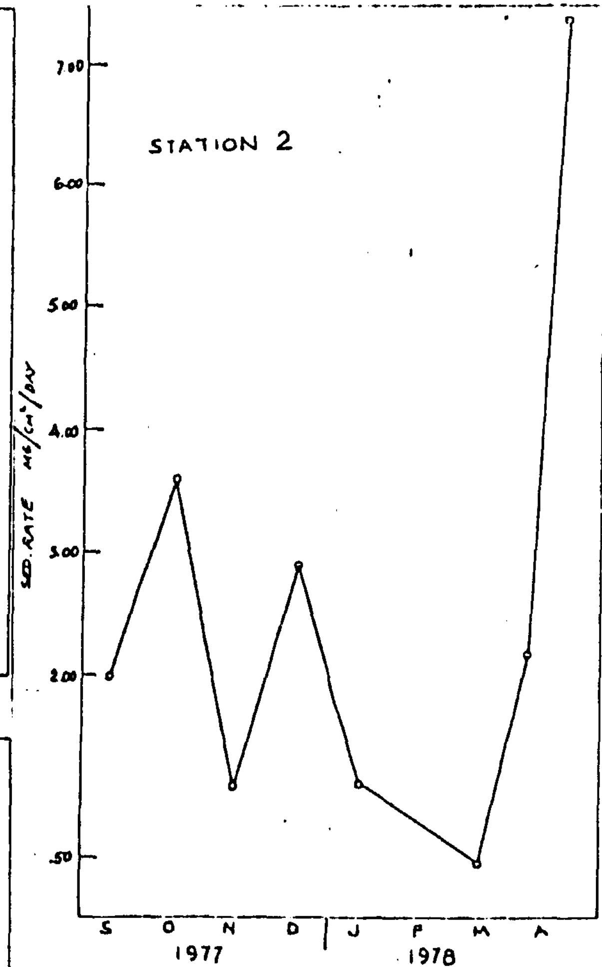
Recently, the Department of Natural Resources and the Army Corps of Engineers signed an Agreement providing for the eventual government take-over of many of the houses and structures that contribute to the pollution of La Parguera. The Agreement provided for strict pollution control and declared La Parguera a reserved natural wildlife area.

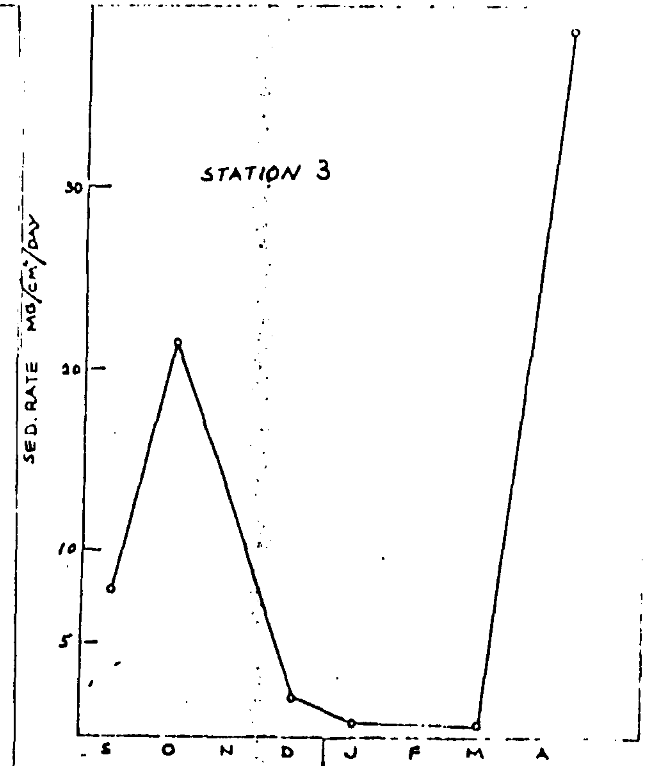
The direct impact of these activities (discharge of raw sewage) upon the near-by turtle grass is difficult to assess because no base line studies exist which describe the condition of the Thalassia prior to such activities. It is possible, however, to make some general comments relating to this problem. Plankton blooms may arise as a result of these discharges and block light penetration necessary for photosynthesis. A reduction in water transparency limits the growth of _Thalassia_ to shallow water. Areas which are turbid most of the time show an occasional patch of _Thalassia_ or none at all. _Thalassia_ seems to survive in murky water only at very shallow depths, usually less than 1 meter.

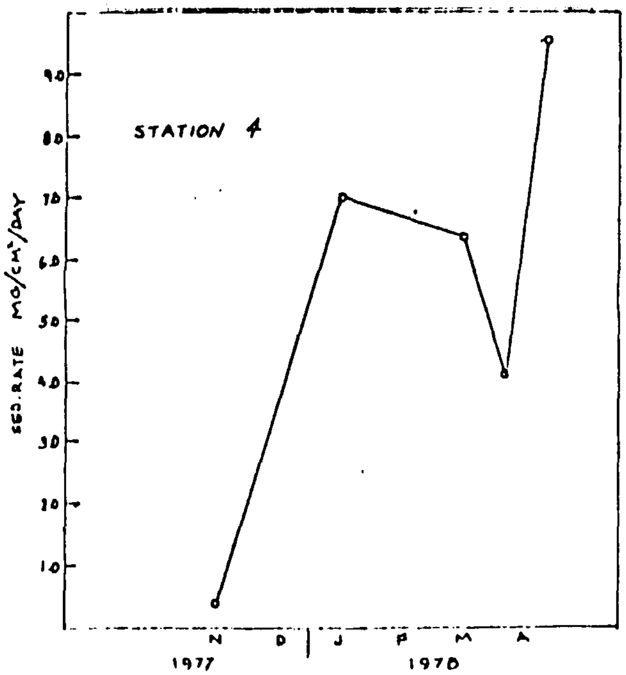
In addition to plankton blooms that may cut light penetration, the transparency of the water is also affected by re-suspension of sediments during normal weather conditions. Re-suspension of sediments in shallow water is common in La Parguera. During unusual calm periods sediments settle and the water is more transparent, but this condition only lasts for several days.

Data from sediment traps placed in shallow water show that the high sedimentation rates observed are probably due to the constant re-suspension of sediments rather than to sediments from other sources, i.e. effluents or discharge of terrigenous material (Fig. 20). Rainfall in La Parguera is not evenly distributed and a well-defined rainy season occurs towards the end of the year (Fig. 21). Heavy rains bring terrigenous sediments to the inshore areas and reduce water transparency and affect color. However, events like these only occur few times during the year and do not seem to alter significantly the condition of seagrasses in La Parguera. Most of the heavy discharges occur in areas where the mangrove fringe has been cut or eliminated. Except for the area surrounding the i mmediate vicinity of the village of La Parguera, the









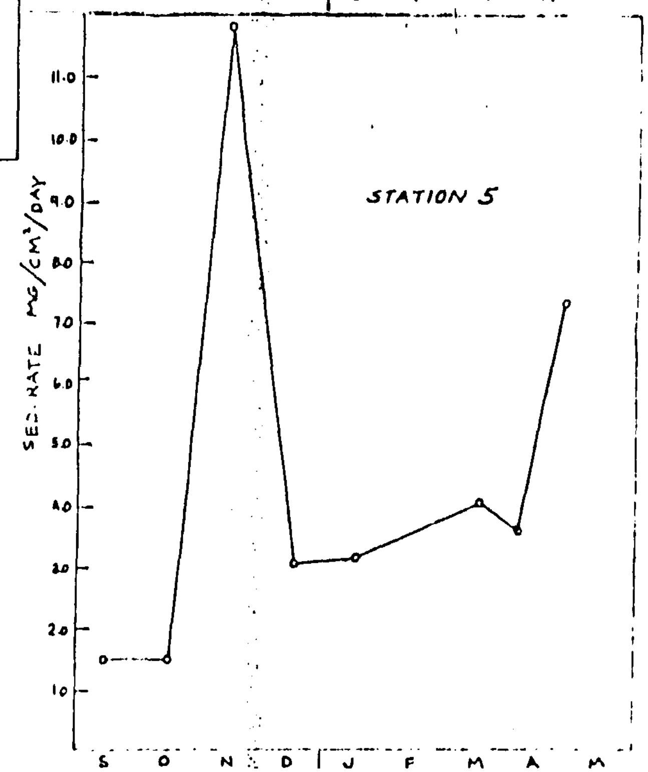


Fig. 20 - Sedimentation rates on shallow beds of Thalassia in La Parguera. The high rates are indicative of re-suspension and re-settlement of sediments.

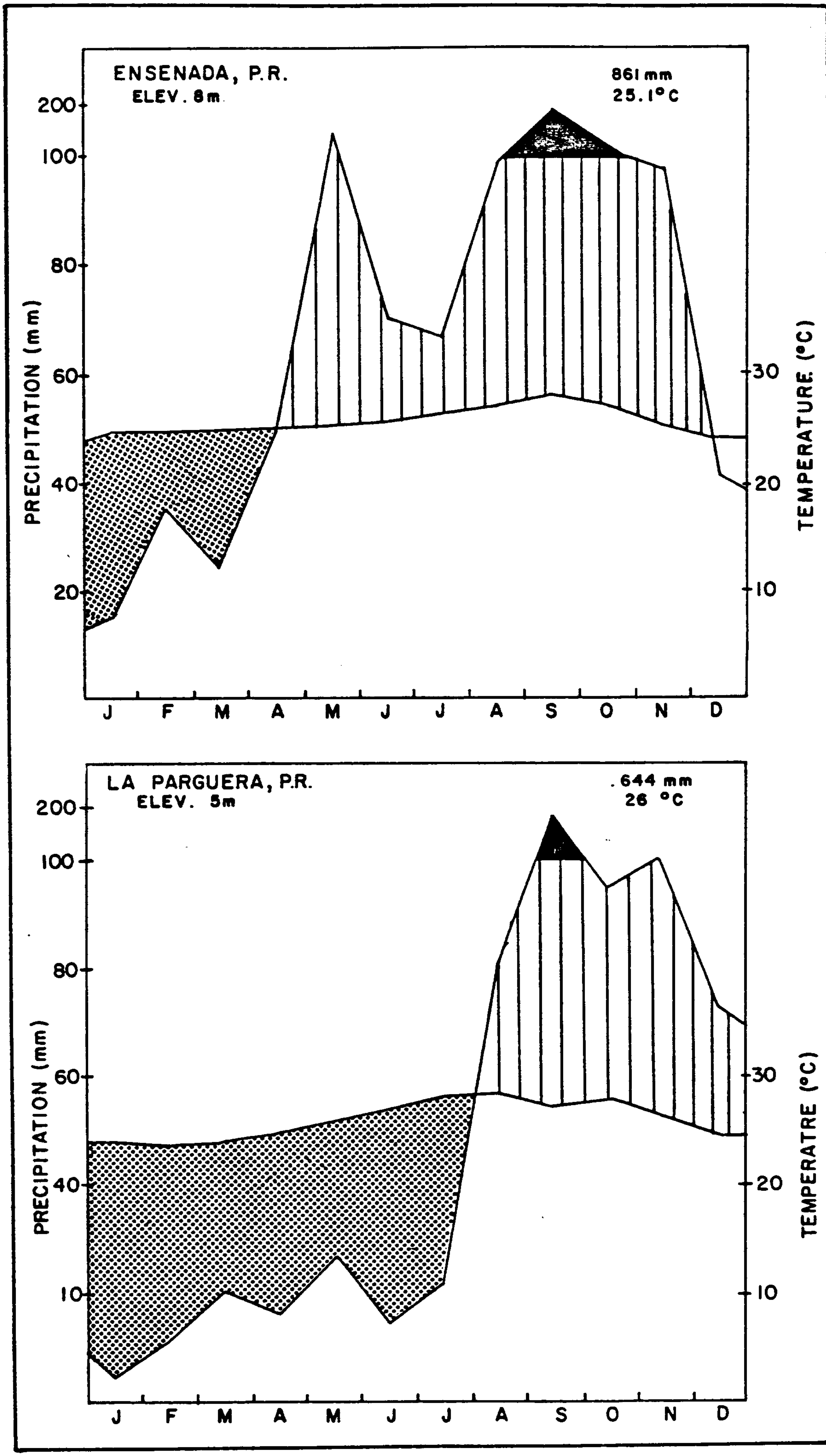


Fig. 21 - The climatic regime of La Parguera and nearby Ensenada, Puerto Rico. Dotted areas below the temperature curve represent periods when evaporation exceeds rainfall. When the rainfall curve is above the temperature curve, rainfall exceeds evaporation. Dark solid blocks represent times when rainfall exceeds 100 mm.

mangrove fringe of the entire study area is pretty much in its natural state. These mangroves serve as buffers between land and the sea and contribute to reduce runoff by providing a natural barrier, behind which large amounts of sediments are deposited

Odum (1974) noted in Texas that seagrasses were killed when smothered under 30 m of silt, (from dredging) but were stimulated to greater growths in the remaining part of the year where the settling sediments did not bury the blades. He also found that productivity and chlorophyll values were higher after the dredging operation. One explanation for this was postulated by Ingle (1952) who suggested that dredging may stimulate by adding nutrients to the system. Tables 7 and 8 show the concentration of various nutrients in La Parguera. No exceptionally high values were found. We are of the opinion that the mangrove fringe in La Parguera acts as control valve that allows just the right amounts of sediment (and nutrients) to enter the adjacent seagrass communities. These "controlled" imputs constitute a subsidy to the system. When the mangrove fringe is eliminated or severely disturbed, large amounts of sediments may enter the nearshore environment and consequently smother the seagrasses. In La Parguera, this was evidenced by the absence or patchy distribution of Thalassia near sections of the coastline where mangroves have been absent for long periods of time.

Table 7. The concentrations of various nutrients and other paameters in La Parguera.

Station No.	Total P (mg/l)	PO_4^{-3} (mg/l)	$N\text{-}NO_3$ (mg/l)	$N\text{-}NO_2$ (mg/l)	$N\text{-}NH_3$ (mg/l)	pH
Sept. 1977						
A	0.059	<.010	0.0070	0.0023	<.05	8.0
B	0.028	"	<.0005	0.0014	"	7.9
C	0.011	"	"	0.0023	"	8.3
D	0.020	"	"	0.0017	"	8.2
E	0.016	"	"	0.0005	"	8.3
F	0.107	"	"	0.0011	"	8.2
G	<.005	"	0.0012	0.0012	"	8.2
H	0.108	"	<.0005	0.0005	0.09	8.2
I	0.007	"	"	0.0027	<.05	8.0
J	<.005	"	"	0.0014	"	8.0
Oct. 1977						
A	0.010	<.010	0.0050	0.0035	<.05	8.0
B	<.005	"	<.0005	0.0007	"	8.0
C	0.019	"	"	<.0005	"	8.1
D	<.005	"	"	0.0006	"	8.1
E	<.005	"	"	<.0005	"	8.1
F	<.005	"	"	0.0006	"	8.0
G	<.005	"	"	0.0007	"	8.1
H	0.021	"	"	0.0006	"	8.1
I	0.011	"	"	0.0019	"	8.0
J	<.005	"	"	<.0005	"	8.0
Nov. 1977						
A	<.005	<.010	0.0016	0.0005	<.05	
B	0.023	"	<.0005	<.0005	"	7.73
C	0.077	"		"	"	7.91
D	0.011	"	0.0019	"	"	8.75
E	<.005	"	<.0005	"	"	8.73
F	<.005	"	"	"	"	8.75
G	0.049	"	"	"	"	7.81
H	<.005	"	"	"	"	8.77
I	<.005	"	0.0041	"	"	8.80
J	0.008	"	<.0005	"	"	7.68

Table 8. The concentration of various nutrients on other parameters in La Parguera, P.R. (Carvajal, 1976)

PARAMETROS	Número de la estación		
Características físicas	1	2	3
1 - Salinidad (5‰)	35	35	35
2 - pH - Unidad	8.25	8.10	8.11
3 - Alcalinidad - mg/l	138	138	140
4 - Turbiedad - Sechi en metros	1.430	0.57	.862
5 - Solidos suspendidos (mg/l)	125	33	35.3
Nutrientes (mcg/l)			
6 - Nitratos - NO_3	0.7	1.0	10.2
7 - Nitritos - NO_2	0.1	0.2	0.1
8 - Orto-fosfato PO_4^{-3}	0.9	6.64	9.53
10 - P total	17	31	33
Clorofilas g/m^3			
11 - a	0.93	2.80	0.02
12 - b	0.29	0.46	1.58
13 - c	0.36	0.26	0.18
14 - Clorofilidos	0.56	0.09	5.69

An increase in the intensity of sedimentation above a certain level will undoubtedly lead to greater energy drains and loss of stability of the system. Consequently, seagrass systems which suffer this kind of stress revert to an earlier successional stage or a less desirable flora.

Fisheries Potential of Thalassia beds in La Parguera.

The importance of *Thalassia* beds as nurseries and habitat for a variety of fish and invertebrates has been well documented in the literature (Phillips 1960, Stephens 1966, Wood, Odum and Zieman 1969, Carr and Adams 1973, den Hartog 1974). The vast extensions of *Thalassia* found in tropical waters provide habitat to an endless number of life forms many of which have commercial and/or sport fishery value. Some of these forms, although not restricted to the beds themselves, contribute to the over all diversity of the community.

Healthy *Thalassia* beds like those found in La Parguera possess certain structural features which are of great significance for its associated fauna, including species of sport fishery and commercial value. Among these

a) The dense meadows increase the available substrate surface for epiphytic algae which constitute an important source of food for many fish and invertebrates.

b) "Differentiation of the plant body into leaves, stems and rhizomes increases the diversity of microhabitats and results in an increase of ecological niches for associated biota" (Kikuchi and Péres, 1977)

c) The leaf canopy protects the bottom from insolation thus permiting a shaded micro environment to develop at the base of the vegetation (Kikuchi and Péres, 1977). Consequently, this feature protects many of the seagrass beds inhabitants.

d) The high photosynthetic rates of Thalassia and other seagrasses provide an oxygen rich environment which support high densities of animal life.

e) Dense growth of seagrasses (including Thalassia) provide protection from predators to many of its i nhabitants allowing many species to reproduce in safety within the community.

According to Kikuchi and Péres (1977), the interaction of these features is responsible for the seagrass bed to function as a spawning or nursery ground for many fish and other forms, even some usually living in other habitats.

Most of the coastal sport fishing in Puerto Rico is restricted to the shallow insular shelf where a variety of productive coastal ecosystems exists. Among these are extensive mangrove forests, coral reefs and seagrass beds. These systems interact and create the appropriate ecological conditions which support the local fisheries. Many, if not the majority of the species with a sport fishery value in Puerto Rico also have some economic importance, or at least are used as food for human consumption. Jühl (1977) stated that around 300 species of reef fish are commonly found in Puerto Rican waters and that about 15% of these comprise the bulk of commercial and recreational fishing catch. According to the Caribbean Fishery Management Council (1979) a majority of the reef fishes (of commercial or recreational value) use the man grove areas and mangrove lagoons as nursery grounds. Extensive seagrass beds which are found closely associated with these systems also play the same role, and therefore constitute an important resource which helps to sustain these fisheries.

The distribution of seagrass meadows in Puerto Rico is remarkably similar to the distribution of the major fishing areas of the island (Fig. 22). In Puerto Rico, seagrasses are widely distributed along the eastern, southern and southwestern coasts. The seagrasses of southwestern Puerto Rico are probably the best developed. This area also shows the highest fish production of the island. For example, during 1974, southwestern Puerto Rico produced 1,621,994 pounds of fish and shellfish versus 212,940 east coast; 239,446 south coast; and 84,302 north coast (Rolón, 1975).

Table 9 summarizes the findings of Almodóvar and

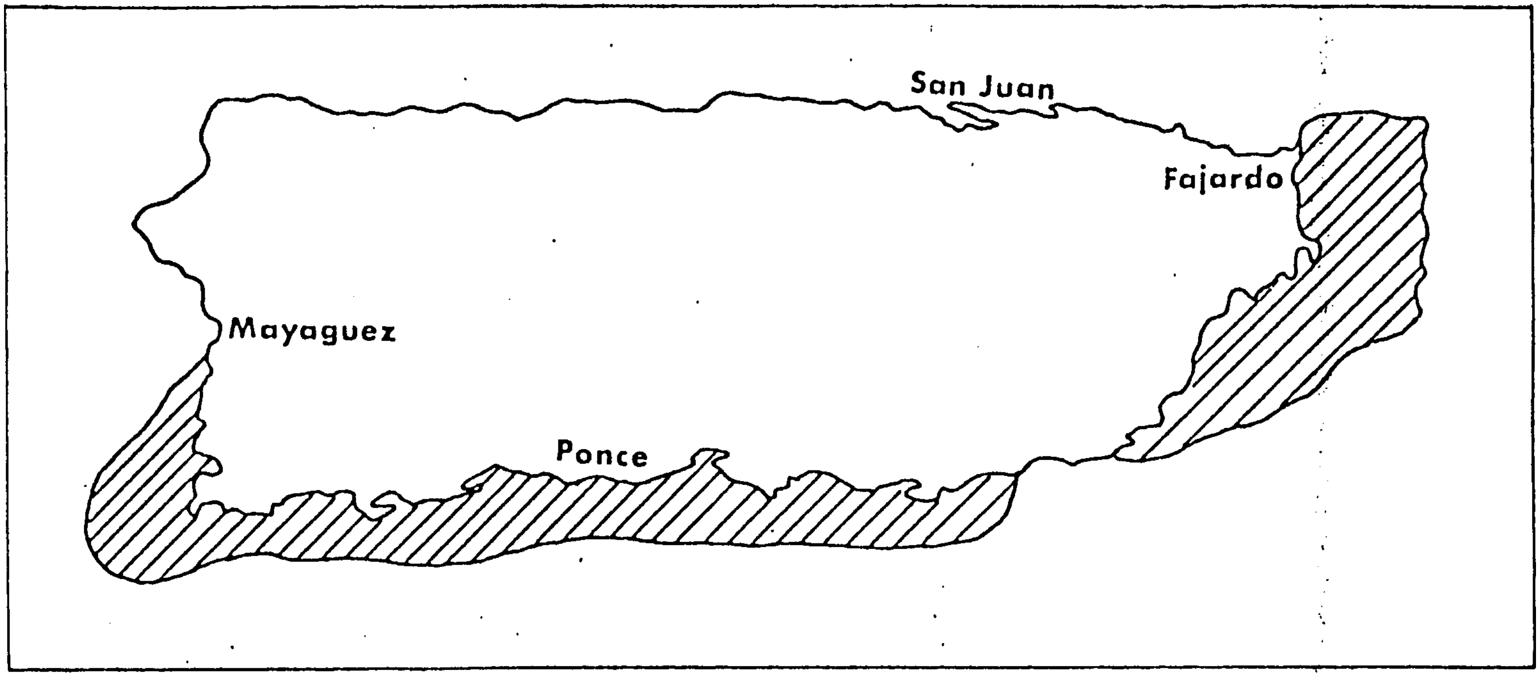


Figure 22. Major fishing areas of Puerto Rico according to Iñigo and Juhl (1967).

Table 9. Fishes associated with the <u>Thalassia</u> beds in Puerto Rico.

FAMILY	SCIENTIFIC NAME	COMMON NAME	REPORTED BY:
Myliobatidae	Actobatis narinari		b,d
Elopidae	Elops saurus	Ladyfish	d
	Megalops atlanticus	Tarpon	b,d
Albulidae	Albula vulpes	Bonefish	d
Clupeidae	Jenkinsia lamprotaenia	Dwarf Herring	a
	Harengula humeralis	Red-ear Sardine	a,b,d
	H. clupeola	False pilchard	d
	H. pensacolae		d
	Ophistonema oglinum	Thread Herring	d
Engraulidae	Cetengraulis edentulus		d
Synodontidae	Synodus sp.	Lizardfish	c
Moringuidae	Moringa edwardsi	Spaghetti eel	b,c
Xenocongridae	Chilorhinus suensoni	Seagrass eel	c
Moraenidae	Gymnothorax funebris	Green moray	c
Congridae	Conger triporiceps	Manytooth Conger	a
Ophichthidae	Myrichthys oculatus	Goldspotted eel	c,d
	Ahlia egmontis	Key worm eel	c
Belonidae	Strongylira timucu	Timucu	a,d
	S. notata	Redfin Needlefish	d
	Plathybelone argalus	Keeled Needlefish	d
	Tylosurus crocodilus	Houndifish	d
Hemiramphidae	Hemiramphus brasiliensis	Ballyhoo	d
	Hyporhamphus unifasciatus		b

a. Almodovar and Pagán (1971)   c. Zieman (1979)

b. Austin (1971)   d. This report

Table 9 cont.

FAMILY	SCIENTIFIC NAME	COMMON NAME	REPORTED BY:
Fistularidae	Fistularia tabacaria	Cornetfish	d
Sygnathidae	Sygnathus dunckeri	Pugnose Pipefish	b,c
	S. elucens	Shortfin Pipefish	c
	Corythoichyghys brachycephalus	Crested Pipefish	c
Holocentriade	Adioryx coruscus	Reef Squirrelfish	c
Atherinidae	Atherinomorus stipes	Hardhead Silversides,	b ,d
Brotulidae	Ogilbia sp. Ogilbia cayorum		a,b
Mugilidae	Mugil curema	White Mullet	a,b
Sphyranidae	Sphyraena barracuda	Great Barracuda	a,b,d
	S. guachanche		d
	S. picudilla	Southern Sennet	d
Serranidae	Epinophelus striatus	Nassau Grouper	d
Centropomidae	Centropomus undecimalis	Snook	a,b
Apogonidae	Astropogon stellatus	Conchfish	c,d
	A. puncticulatus		d
Carangidae	Caranx ruber	Bar Jack	d
	C. fusus	Blue Runner	d
	C. latus	Horse-Eye Jack	d
	C. hippos	Crevella Jack	a,d
	C. bartholomei	Yellow Jack	d
	Oligoplits saurus	Leather jacket	d
Scombridae	Scomberomorus regalis	Cero	d
	S. cavalla	King Mackerel	d

Table 9 cont.

FAMILY	SCIENTIFIC NAME	COMMON NAME	REPORTED BY:
Lutjanidae	Lutjanus analis	Mutton Snapper	d
	Ocyurus chysurus	Yellowtail Snapper	c,d
	L. jocu	Dog Snapper	a,b
	L. apodus	Schoolmaster	a,b
	L. griseus	Gray Snapper	a,b
Pomadasyidae	Haemulon flavolinestum	French Grunt	a,d
	H. plumieri	White Grunt	c,d
	H. sciurus	Bluestriped Grunt	a,b,d
	H. chrysargyreum	Smallmouth Grunt	d
	H. bonairiense	Black Grunt	a
	H. album	Margate	b
Sparidae	Archosargus unimaculatus		a
	A. rhombaidales	Sea Bream	b
Sciaenidae	Equetus acuminatus	High hat	c,d
Gerridae	Eucinostomus gula		a,b
	Gerres cinereus	Yellowfin Mojarra	a,b
	Diapterus rhombeus	Rhomboid Mojarra	a
	D. plumieri	Striped Mojarra	a,b
Bothidae	Bothus ocellatus	Eyed Flounder	c,d
Opistognathiadae	Opistognathus whitehursti	Dusky Jawfish	c
Scorpaenidae	Scorpaena grandicornis	Grass Scorpionfish	b,d
	S. inermis	Mushroom Scorpionfish	c
	S. bergi	Goosehead Scorpionfish	c

Table 9 cont.

FAMILY	SCIENTIFIC NAME	COMMON NAME	REPORTED BY:
Callionymidae	Callionymus bairdi	Lancer Dragonet	c
Chaetodontidae	Chaetodon capistratus	Foureye Butterflyfish	a,c,d
	C. striatus	Banded Butterflyfish	d
Pomacentridae	Eupomacentrus variablis	Cocoa Damselfish	d
	E. leucostictus	Beau Gregory	d
	E. fuscus	Dusky Damselfish	d
Labridae	Halichoeres poeyi	Blackear Wrasse	c
	H. bivittatus	Slippery Dick	c
	Hemipteronotus martinicensis	Straight-Tail Razorfish	c
	H. splendens	Green razorfish	c
	Doratonotus megalepsis	Dwarf Wrasse	c
Pomacanthidae	Pomocanthus paru		d
Scaridae	Sparisoma radians	Bucktooth parrotfish	c,d
	S. rubripinne	Yellowtail parrotfish	d
	S. chrysopterum	Redtail parrotfish	a,d
	S. aurofrenatum	Redband parrotfish	d
	Scarus croicensis	Striped Parrotfish	a,c
	Cryptotomus roseus	Rosy parrotfish	c
Clinidae	Paraclinus fasciatus	Banded blenny	c
	Malacoctenus macropus	Rosy blenny	c
	M. gilli	Dusky blenny	c
	Chaenopsis limbaughi	Yellowface pikefish	c
Acanthuridae	Acanthurus coerulens	Blue Tang	d
	A. bahianus	Ocean surgeon	c,d
	A. chirugus	Doctorfish	c,d

Table 9 cont.

FAMILY	SCIENTIFIC NAME	COMMON NAME	REPORTED BY:
Monacanthuridae	Monocanthus ciliatus	fringed filefish	c
Ostraciontidae	Acanthostracion quadricornis		d
	A. polygonius		d
	Lactophrys trigonus	Buffalo Trunkfish	d
	L. triqueter		d
Tetraodontidae	Sphaeroides testudineus		a,b,d
	S. spengleri	Bandtail puffer	c,d
	S. greeleyi	Caribbean Puffer	d
Canthigasteridae	Canthigaster rostrata	Sharpnose Puffer	c,d
Deodontidae	Diodon holacanthus	Balloonfish	c

Table l0. Thalassia-feeding Reef Fishes of the West Indies

S cientific Name	Common Name
Harengula humeralis	(red-ear sardine)
Hemiramphus brasiliensis	(Ballyhoo)
Mugil curema	(white mullet)
Scarus coelestinus	(midnight parrotfish)
Scarus guacamaia	(rainbow parrotfish)
Scarus taeniopterus	(painted-tail parrotfish)
Scarus vetula	(queen parrotfish)
Sparisoma chrysopterum	(redtail parrotfish)
Sparisoma radians	(bucktooth parrotfish)
Sparisoma rubripinne	(redfin parrotfish)
Sparisoma viride	(stoplight parrotfish)
Acanthurus bahianus	(ocean surgeon)
Acanthurus chirurgus	(doctorfish)
Aluptera scripta	(scrawled filefish)
Cantherhines pullus	(orange-spotted filefish)
Monacanthus ciliatus	(tringed filefish)
Acanthostracion quadricornis	(cowfish)
Lactophrys bicaudalis	(spotted trunkfish)
Lactophrys trigonus	(trunkfish)
Sphaeroides spengleri	(bandtail puffer)

* Adapted from Randall, 1967

Pagán (1971), Austin (1971), Zieman (1979), and this report in relation to the fishes associated with Thalassia beds in Puerto Rico. Many of the 104 species reported also occur in the coral reef and mangrove areas. Of the total number of species, 20 have been reported to feed directly on Thalassia (Table 10) while others feed on ephiphytic algae growing on the leaves of this seagrass. Carnivores such as Sphyraena barracuda include in their diet fish that are commonly found in the seagrass meadows. Among these: Acanthurus bahianus, Atherinids, Caranx fusus, Diodon sp., Harengula clupeola, Jenkinsia sp., Ocyurus chysurus and S. picudilla.

The genus Sphyraena or "picua" as it is locally known, is widely fished in La Parguera both for food and recreation. Three species are represented in Puerto Rico (S. barracuda, S. picudilla and S. guachanche), These are quite abundant around mangrove channels and Thalassia-covered bottoms. A typical day's catch (5.5 hr) in La Parguera on September 28, 1978 consisted of 28 specimens with an average length of 326.25 mm. The largest specimen collected (fished) was 560 mm and the smallest 240 mm. The catch represented a catch per unit effort of 5.6, which is better than one fish per 15 minutes. Appendix I gives a general (layman's) description of the methods and techniques used in fishing for barracuda in La Parguera.

SUMMARY AND CONCLUSIONS

In attempting to describe the present condition of *Thalassia* beds in La Parguera and southwestern Puerto Rico, a number of ecological parameters were measured and ana lyzed. The results obtained from these measurements provided basic data which was used to characterize the seagrasses and establish comparisons with other similar systems.

Our results show that *Thalassia* beds in La Parguera and southwestern Puerto Rico are structurally well developed and hold high biomass and leaf area indices (LAI). Their net production is higher than other beds in Puerto Rico. They have high turnover values and are capable of producing 18 crop per year, which compares exceptionally well with some of the most productive land cultivated crops.

Their distribution in southwestern Puerto Rico is almost continuous from Cabo Rojo to Punta Jorobado and represents one of the largest seagrass areas on the island. A large system of grass-free blowouts occur offshore from Bahía Sucia and Punta Pitahaya. These blowouts are dynamic formations which respond to the wave regime of the area. They occur perpendicular to the coast and may reach 1 km in length. These grass-free depressions appear to be migrating slowly to the west while being recolonized on the opposite side.

Seagrasses in La Parguera are subject to sedimentation during heavy rain storms. The magnitude of this input appears to be regulated to some extent by the pre sence or absence of the mangrove fringe that borders most of the study area. Mangroves form barriers that contribute to the deposition of sediments behind the fringe and thus reduce the sediment loads to the seagrasses.

Damage to seagrasses by boat propellers is most evident in shallow waters with heavy boat traffic. Permanent damage occurs when the root and rhizome system of Thalassia is severed or cut. Long scars in the seagrass may remain for five years or more as long as traffic continues. In La Parguera, damage to Thalassia by boat propellers is most critical in the shallows northeast of Magueyes island, near the village itself; and in the mangrove channels which are extensively used for fishing and recreation.

Based on a 1972 Environmental Quality Board study and on our own data, the water quality in La Parguera is within the accepted standards for swimming and outdoor recreation. Occassional plankton blooms occur which may reduce light penetration and affect the productivity of the grass beds. However, these are generally localized and of short duration, and do not have a significant impact upon the grass beds of the region.

The seagrass beds of southwestern Puerto Rico harbor a rich an varied fauna. Some 100 fish species have been reported associated with Thalassia in Puerto Rico. Many of these, although not permanent residents of the meadows, spend time and search for food there. *Thalassia* itself directly supplies food to some 20 reef fishes of the region. The interaction of the seagrass system with the mangroves and coral reefs of the area provide conditions which are favorable to sport fisheries. The combined effect of these conditions makes La Parguera and southwestern Puerto Rico an ideal location on which these activities could be further developed.

Our observations show that the *Thalassia* beds in southwestern Puerto Rico are in good condition. Except for localized areas near the village of La Parguera, where some above-normal sedimentation may be occurring and heavy boat traffic is commonplace, no indications of permanent or irrevocable damage to the seagrass beds were observed. It is difficult at this moment to predict how much stress will be required before the seagrasses of the area will begin to be seriously affected. Restoring the original mangrove fringe where it has been cut or destroyed and restricting boat traffic will certainly contribute in maintaining these productive and functional seagrass systems.

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APPENDIX I

LA PESCA DEPORTIVA DE LA PICÚA EN PUERTO RICO

Por: Richard Bejarano

Hay tres especies de picúa que habitan las aguas alrededor de nuestra isla. Se caracterizan por tener un cuerpo alargado y cilíndrico en el cual predomina el color plateado. Tienen una cabeza y ojos grandes y la boca está provista de muchos dientes largos y filosos. Las dos aletas dorsales están muy separadas.

La especie más conocida y temida es la picúa brava o picuda Sphyraena barracuda. Esta es la más grande y puede crecer hasta aproximadamente 6 ½ pies. El record mundial en línea y anzuelo pesó 103 libras y midió 5 ½ pies. Se conocen alrededor de 30 ataques de picúa a humanos y estos en su gran mayoría han ocurrido en agua turbia en donde posiblemente la picúa, al no distinguir bien, atacó creyendo que era un pez. También hay casos de ataque cuando un buzo la provocó como por ejemplo, arponeándola.

Generalmente los juveniles se encuentran entre las algas y yerbas marinas o al lado de las raíces de los mangles, mientras que los adultos se encuentran sobre las praderas marinas, planicies de arena, arrecifes o mar afuera.

El mejor método de captura es usando un pez vivo como carnada con un anzuelo 4-005-0. Este se puede enganchar por el lomo o por la boca para lastimarlo menos. También se puede usar una sardina o jarea muerta o un filete de estos y lanzarlo con una potala pequeña como de ¼ de onza, dejándola suspendida a media agua. Si se esta corriendo la silga en bote el anzuelo se mete por la boca y se saca por la parte ventral del pez. Esto es para ayudar en la hidrodinámica, para que el pez se desplace como la haría naturalmente y no se desgarre.

En cuanto a señuelo los más exitosos son la plumilla blanca, la platina con una plumilla amarilla en el rabo o la combinación de platina con filete de jarea. Estos se pueden tirar con caña desde la orilla y recoger rápidamente ó corriendo la silga en bote.

Como esta especie de picúa, al igual que las otras, tienen dientes grandes y filosos, se recomienda una ber guilla de por lo menos 1 ½ pies de longitud.

Dado el tamaño que puede alcanzar esta especie se recomienda se use un hilo de por lo menos 15 libras prueba con un carrete que tenga una capacidad de ppr lo menos 100 yardas. Si se está lanzando la carnada o señuelo desde la orilla, u n carrete de "spinning" es el más adecuado ya que el de "bait casting" tiende a enredarse. Corriendo la silga se prefiere el uso del "bait casting". También se debe usar una caña de pescar fuerte por razones obvias.

Sphyraena barracuda se diferencia de las otras dos especies por su tamaño y por la presencia de manchas negras a los costados.

La picudilla Sphyraena picudilla es la especie de picúa más pequeña en nuestras aguas. Alcanza un largo total de solo 1 ½ pies. Se puede encontrar desde cerca de la orilla en fondos llanos hasta lejos de la costa a p rof undidades de por lo menos 200 pies. Prefiere fondos fangosos. Tiende a formar grandes escuelas. Esto es de gran ventaja para el pescador ya que una vez encontrado el cardumen, si se tiene el equipo y carnada apropiada, se puede capturar un gran número de ellas. Un pez pequeño vivo, una plumilla blanca o una platina con plumilla amarilla son ideales para la captura de esta especie. El anzuelo debe ser un 2-0. Hilo de 6 libras prueba y caña pequeña son aceptables.

La picúa guachanche Sphyraena guachanche aparentemente es la menos abundante en Puerto Rico. Crece hasta 3 pies de largo y al igual que la picudilla forma escuelas. Se encuentra en agua turbia sobre fondos fangosos, especialmente en la vecindad de los estuarios de los ríos. El método de captura es igual al de la picudilla pero ya se debe usar un anzuelo 3-0. Guachanche se diferencia fácilmente de picudilla por la posición de las aletas pectorales en relación a las ventrales o pélvicas se extienden hasta una posición superior a la base de las pélvicas mientras que en picudilla las pectorales y las pélvicas estan bien separadas.

Para limpiar las picúas se utiliza un escamador, y agarrando el pez por la cabeza se pasa este en contra de la dirección de las escamas (hacia la cabeza). Luego se hace un corte partiendo desde las agallas hasta el poro anal. Se separan las agallas del cuerpo dejandolas uni das al intestino. Se halan las agallas en dirección hacia el rabo despegando los intestinos y luego se corta la parte del intestino que queda adherida al pescado.

Para filetear la picúa se hace un corte transversal detrás de la aleta pectoral hasta llegar al espinaso. Se corta bien pegado a la aleta dorsal hasta el espinazo longitudinalmente hasta llegar a la base del rabo. Se hace otro corte transversal hasta la parte inferior de la base del rabo y se corta en forma longitudinal y pegado al espinaso hasta chocar con las costillas. Con cuidado se levanta el cuchillo y se corta la carne sobre las cos tillas. El filete de carne se desprenderá al llegar al punto del primer corte transversal.