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PILOT EXPERIMENTAL SEAGRASS TRANSPLANTATION PROJECT

SOUTH SHORE, ST. CROIX
U.S. VIRGIN ISLANDS

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August 1987

PILOT EXPERIMENTAL SEAGRASS TRANSPLANTATION PROJECT

INTRODUCTION

Seagrass meadows provide one of the most important and productive habitats in tropical coastal waters. They serve as a major primary producer of food resources for a vast number of organisms and a nursery habitat for juvenile fish including many commercially valuable species. Seagrasses also serve to stabilize inshore areas by preventing erosion. Because seagrass habitats are so valuable, many local and federal agencies are requiring habitat restoration programs in nearby areas as mitigation for seagrass areas being destroyed by dredge and fill operations. This report describes the first large-scale seagrass transplant in the U.S. Virgin Islands.

A pilot experimental seagrass transplantation project was authorized by the Virgin Island Port Authority as mitigation for dredge and fill operations necessary for the construction of a liquid bulk terminal on the easterly side of the Martin Marietta Channel. The U.S. Army Corps of Engineers required that the Port Authority transplant seagrasses from the area to be dredged and filled to nearby shallow, unvegetated bottoms. The operation was begun on July 3, 1987 with donor and recipient site surveys. Phase I Report: Survey and Revised Methods is submitted as Appendix I of this report.

A survey of seagrass areas around the Third Port, South Shore, St. Croix, U.S.V.I. was conducted on July 3, 4, 9 and 10, 1987. The donor areas consist of the proposed dredge area and the proposed fill areas as shown in Figure 1. Recipient unvegetated areas were selected as transplant areas west and in the lee of Ruth Island. It was the only extensive area which seemed acceptable for receiving transplanted seagrasses. All other unvegetated areas found were unacceptable for a variety of reasons. The recipient site consisting of three acres is outlined in Figure 2.

Transplantation of seagrasses began on July 15, and ended on August 14, 1987. A total of 12 days was necessary to transplant 1,361 plugs and 10,816 sprigs for a total of 12,177 planting units to cover three acres (12,141 square meters).

DONOR SITE

The donor site that was most suitable for collecting plugs and sprigs of seagrass was found in fill area "C", Figure 1. Photographs, presented in the Phase I Survey Report (Appendix I), were taken of typical bottom areas with the aid of a 50 cm X 50 cm square marked off in 10 cm units to show the density of the bottom cover. Area "A", the proposed dredge area, contains dense beds of turtle grass, *Thalassia testudinum* Banks ex Konig, with very sparse patches of other seagrasses. Area "C", a second fill area, which is still open to the sea, has dense patches of shoalgrass, *Halodule wrightii* Aschers., manatee grass, *Syringodium filiforme* Kutzing, and occasional patches of *T. testudinum*.

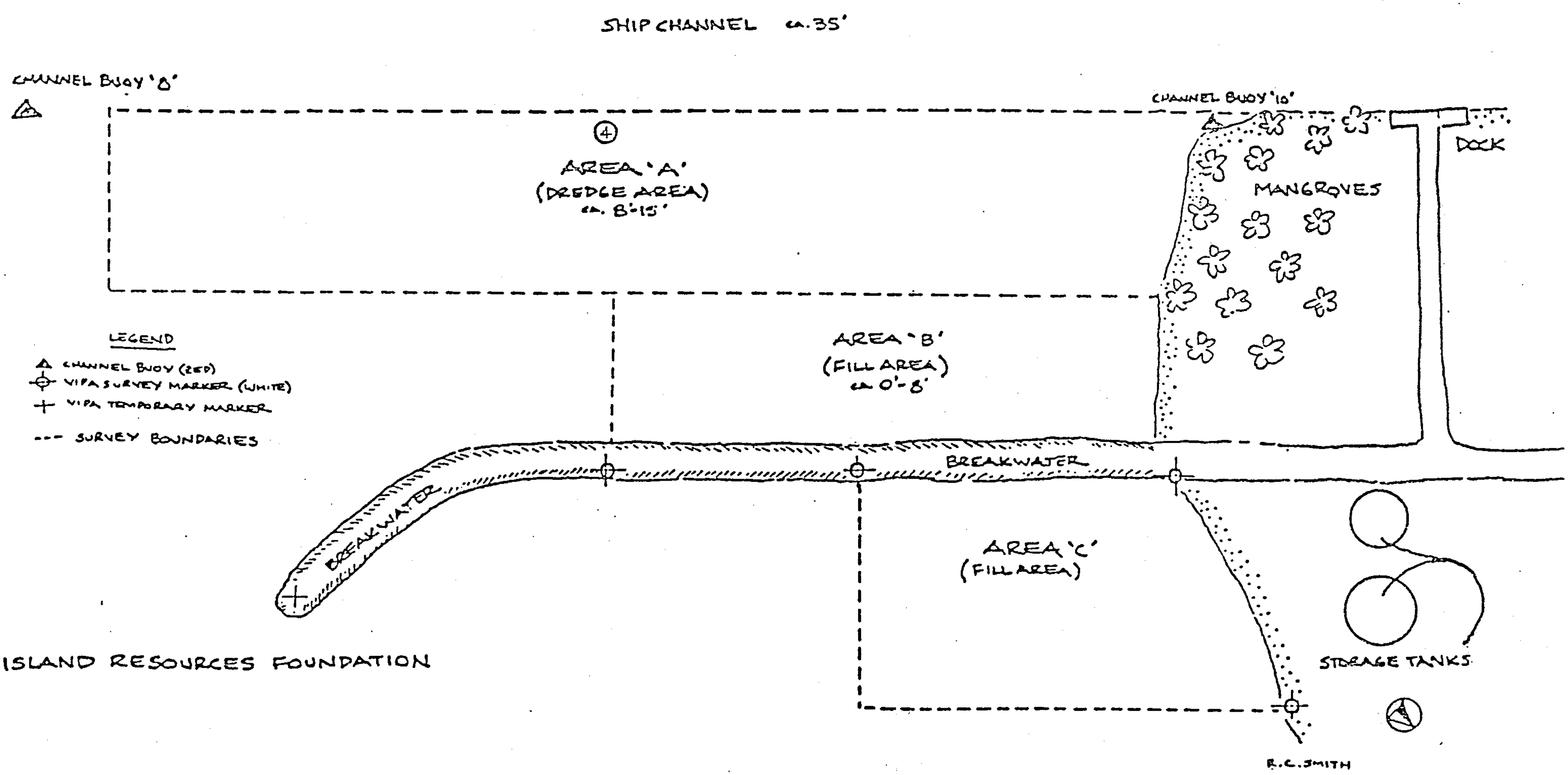

Figure 1. St. Croix South Shore VIPA Dredge Project Site Plan. Dredge and fill areas are outlined. Area 'C' is the major donor site for seagrasses for transplantation.

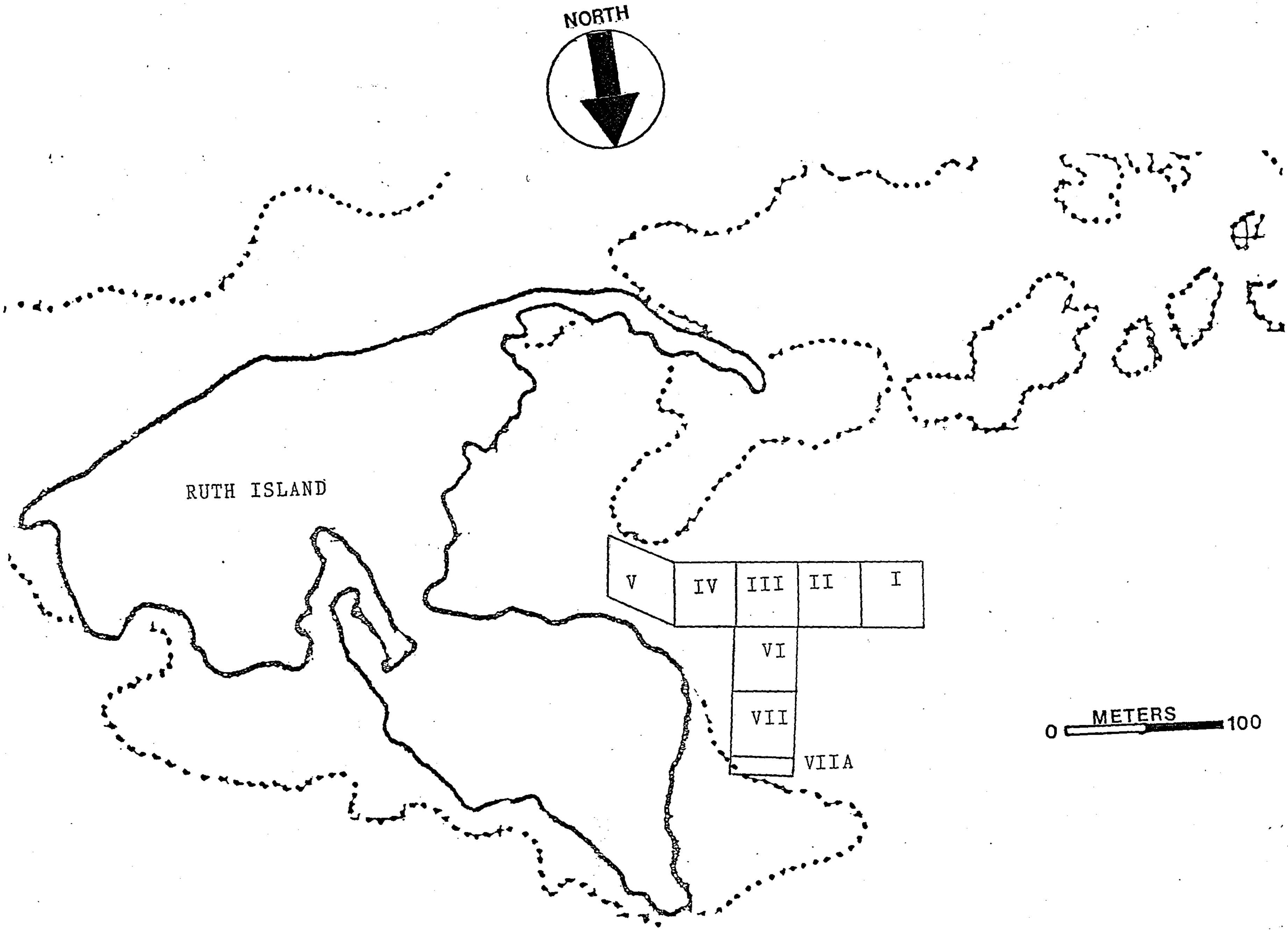

Figure 2. Planting Plots I through VII plus VIIA, the recipient area of three acrea.

Fill area "C", the major donor site, lies primarily between two jetties which create an almost parabolic reflector for waves and wakes coming from the south. On rough days during the project the reflected swells moving southward often felt stronger than the original wave. This effect apparently accounts for increased sediment resuspension and transport.

"Blow-outs", where grassbeds abruptly end and patches of relatively bare substrate are found, were scattered throughout the donor site. On the south side of the bare area the grassbed edge usually formed a "cliff" 6 inches to 2 feet high; dense tangles of seagrass roots, rhizomes and shoots extended as much a 1 1/2 feet past the edge. Most fish sighted were near these edges, which provided good cover (at least until they were cut for their excellent sprig supply). The northern edges of blowouts usually sloped more gradually into the plateaus formed by dense grassbeds, and the vegetation also shifted gradually from the sparse _Halimeda_, _Penicillus_ and _Caulerpa_ typical of the blowouts to the denser seagrass growth.

During rough days swells caused puffs of sediment to fly up at cliff edges and it was possible to see the circular scouring motions as vertical eddies drove down into the bare substrate and swirled up plumes of sediment, including even coarse _Halimeda_ fragments. However, there was not necessarily a net loss of seagrass beds; several of the cliff edges actually gained enough sediment to fill in the dangling roots and cover the grass so that just the blade tips showed. A week later the former cliff edges were still a gradual slope amd seagrass shoots had grown up through the sediment. Other cliff areas were further scoured by the rough weather. New areas of roots were often exposed and those rhizomes which had taken hold below the cliff washed loose, except where seagrass roots penetrated the holdfasts of _Halimeda_. It was also observed during the sprig-sorting process that seagrass roots and new shoots were particularly dense among the sediment balls of holdfasts. This was particularly true of _Halodule_, where 5 or 6 separate shoots could often be found almost inseparably bound in a _Halimeda_ holdfast.

Sediment composition in the area show great variation in patches often only a few meters apart. Particle sizes ranged from coarse shell fragments and/or calcareous algae residue to fine silts black with organic matter and smelling of hydrogen sulfide. Very fine silt overlay all the area and was stirred up even by slight water movements. Several different layers of sediment were frequently found within one 8-inch-deep plug. The impression was of an area subject to considerable sediment transport and strongly influenced in sediment composition and movement by the area's previous dredging operations.

The donor site was extremely heterogeneous, with each habitat patch often only a few meters in diameter. Several habitat types provided the basis for numerous variations. These included:

1. coarse rubble (coral rock, rip-rap and rock from fill);
2. finer rubble (_Porites_ fragments);
3. bare substrate;
4. relatively bare substrate with calcareous algae and epiphytes and sometimes sparse seagrass;
5. medium-density seagrass/calcareous algae beds;
6. high-density seagrass, with some calcareous algae, usually built up into plateaus above the rest of the seabed.

All types of sediment, from fine muds to coarse Halimeda fragments, were found in all habitats, with frequent sharp demarcations between sediment types, both horizontally (from patch to patch) and vertically (as shown in cores). Detailed analyses of the flora and fauna are beyond the scope of this project, but some species are included in the discussion where positive identifications were made. Where positive identifications have not been made, collections have been made for future analysis or for review by interested researchers.

Coarse rubble and rip-rap provided fish and Echinometra habitat along the western jetty. Towards shore the rubble extended further out from the jetty and was composed mostly of coral rocks so covered by epiphytes and boring organisms that they were unidentifiable, although the characteristic slopes of Acropora palmata were noted. The rubble and the calcareous algae between rocks provided substrates for numerous epiphytic algae, including Dictyota divaricata, Acanthophora spicifera, Spyridia filamentosa and Hypnea cervicornis. The latter alga was attached to rocks and Halimeda and in some cases floated free and formed dense patches as large as 10 meters across. A variety of filamentous forms covered rocks, algae and grasses and entrapped the fine silt so that much of the bottom appeared whitish. Thalassia testudinum was the most common seagrass among the rubble area.

The sea urchin Echinometra lucunter and the beaugregory (Eupomacentrus leucostictus) were the most common macro-organisms of the rubble zone. The fish observed included dusky damselfish (Pomacentrus dorsopunicans), juvenile jacks and grunts (Caranx spp. and Haemulon spp.), juvenile porkfish (Anisotremus virginicus), and assorted wrasses, primarily slippery dicks (Halichoeres bivittatus).

The finer rubble mounds of old finger coral reefs (Porites porites) occurred in patches throughout the site except close to the original shoreline. Most mounds were covered with dense seagrass beds, so that the rubble structure could only be seen at "blowout" edges. Thalassia testudinum, Syringodium filiforme and Halodule wrightii occurred alone and in all possible combinations. Seagrass species mixed both as adjacent patches and as individual blades of different species side by side. Where finger coral mounds were exposed beaugregories and other fish utilized the crevices provided.

The major vegetation in relatively bare patches was calcareous algae such as Halimeda incrassata, H. monile, Caulerpa prolifera, C. sertularioides, C. cupressoides, Penicillus capitatus and Udotea flabellum. These species were also interspersed with all densities of seagrasses.

Other fish observed included schools of fry (probably herring, Clupeidae and/or silversides, Atherinidae), squirrelfish (Holocentridae) hiding under root mats of seagrass with cubbyu (Equetus acuminatus), schoolmaster and gray snappers (Lutjanus apodus and L. griseus) and juvenile bonefish (Albula vulpes). Bucktooth parrotfish (Sparisoma radians) were fairly common and their bite marks were noted on many Thalassia blades. A few doctorfish (Acanthurus chirurgus) and bluehead wrasses (Thalassoma bifasciatum) were noted. One large sharpnose puffer (Canthigaster rostrata) was seen. Almost daily a small eagle ray (Aetobatus narinari) cruised near the surface.

Although a couple of thousand plugs were cut (some for sprigs) almost no benthic invertebrates were seen. Callianassa shrimp mounds were fairly common and some areas were paved with empty clamshells (probably Codakia orbiculata). One polychaete worm was seen, probably a nereid, and one sipunculid. Dark grey anoxic sediments were found throughout the site which may partly account for the extremely depauperate infauna. Continually high suspended sediment loads and a constantly shifting bottom would also discourage benthic filter feeders.

RECIPIENT SITE

The recipient site, in the lee of Ruth Island, is shown in Figure 2. It contains three acres divided into eight plots (numbered I through VII and VIIA). The area selected appeared to have the necessary characteristics of adequate light, low-turbidity clear water, suitable substrate and limited currents. A portion of Plot I had a patch of moderately dense S. filiforme (approx. 20 m^2) growing at one corner. Scattered throughout all the eight plots were occasional shoots of T. testudinum indicating that seagrass can grow in the area.

Other unvegetated areas throughout the port were examined and considered as possible transplanting sites. Areas in the Harvey Channel were rejected due to the deposit of deep fine sediments probably not capable of holding seagrasses. Areas near reefs (halos) are natural grazing areas and these areas were also not acceptable for transplants as they are heavily grazed by herbivores. Areas east of Ruth Island were very turbulent and transplanting would be difficult and would probably be uprooted by the surge. The area chosen was the only acceptable place within a reasonable distance from the donor site for seagrass transplantation.

All areas within the port, excluding the already dredged channels and the reef itself, were already populated with dense and healthy seagrasses and algae. These seagrass beds were conspicuously populated with macro-invertebrates including queen conch (Strombus gigas), helmet (Cassis tuberosa), solitary coral (Manicina areolata), anemones (Condylactis gigantea), ghost shrimp (Callianassa sp.), and sea stars (Oreaster reticulatus) as the most conspicuous species.

Several distinct habitats are found in the recipient area:

A. Fine sand densely populated with Cassiopeia frondosa.

This area had almost no vegetation except for patches of brown diatom scum. The sterile-appearing sand was fine and easily re-suspended. Dense populations of Cassiopeia (as many as 20 m^2) were found throughout the bottom. Many juvenile and a few adult conch (Strombus gigas) were found grazing the area along with adult West Indian fighting conch (Strombus pugilis). One specimen of hawk-wing conch (Strombus raninus) was found in this habitat.

B. Medium grain sand sparsely populated with the alga Halimeda incrassata and densely populated with Callianassa mounds.

This habitat was a sandy area dominated by the alga Halimeda incrassata interspersed with moderate amounts of brown algae (Dictyota divaricata and Dictyota sp.) and red algae (Liagora sp. and Hypnea sp.). Occasional Caulerpa cupressoides, C. sertulariodes, C. prolifera, Udotea flabellum, Avrainvillea nigricans, Penicillus capitatus were present. Many mounds of the ghost shrimp (Callianassa sp.) also occupied the recipient area along with many juvenile queen conch and the upside-down jellyfish (Cassiopeia frondosa). At the edge of Plot I, the seagrass Syringodium filiforme was already growing. Since seagrass had already established itself in an adjoining area we knew that conditions were most likely favorable for further grass growth and there was a reasonable chance of the success of the transplant.

Many invertebrates and fish were found associated with this habitat. Anemones (Condylactis gigantea and Stoichactis helianthus) were sparsely scattered throughout the area; molluscs (Strombus gigas, S. pugilis) were quite numerous and several were sighted only once (trumpet, Charonia variegata and Strombus rainius); polychaetes (fireworm, Hermodice carunculata) were conspicuous throughout the area; one species of sea urchin (Diadema antillarum) was found occasionally throughout the area.

Many species of juvenile fish were found occupying this habitat. Debris scattered throughout the area provided habitats for juvenile snapper, trumpetfish, grouper, soldierfish, and butterfly fishes. Over the sandy bottom were schools of herrings, mojarras, damselfish, wrasses, grunts, parrotfish and goatfishes. Planting seagrass plugs and sprigs brought an immediate influx of fish to the site. Juvenile fish (possibly bonefish) and goatfishes were continually nibbling at the transplanted grass, presumably eating microscopic organisms found in the exposed sediment, on the shoots or scattered in the water column during the seagrass movement.

C. Calcareous substrate (Halimeda dominated) with dense mats of Halimeda opuntia.

Areas in shallow water (6 to 10 ft) were dominated by a dense cover of Halimeda opuntia found in a mixed substrate of calcareous rubble. The ringed anemone, Bartholomea annulata were abundant and found protruding from many of the crevices between broken pieces of dead coral. Fireworms were also found throughout this area.

D. Coral rubble substrate with mixed calcareous sand with very little vegetation.

This habitat was found inshore on Plots VI and VII. There was very little vegetation among the coral rubble and small patches of sand. The occasional small live coral colony (Porites porites, Favia fragum, Agaricia agaricites and Siderastrea siderea) was found growing on pieces of coral rubble.

A diagram of the plots is shown in Figure 3 with depths, contours and habitat types. The area where Syringodium filiforme was found growing naturally is also shown. Habitat types are labeled according to the classification given above.

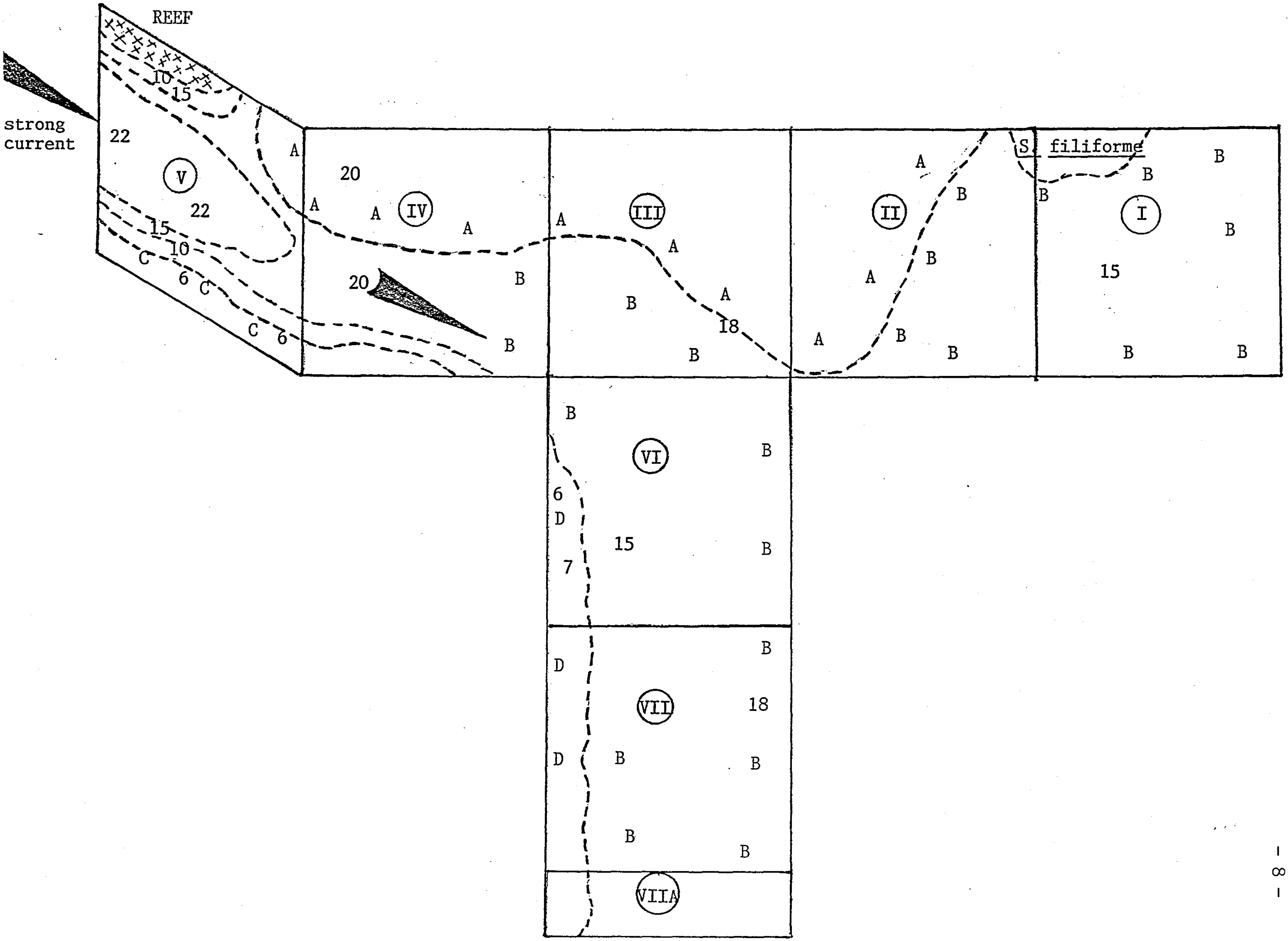

Figure 3. Characteristics of transplant plots showing depths and habitat types.

METHODS

Methods for transplanting seagrass have had varying degrees of success. Early experiments used short sprigs in a hormone dip which was more successful than a plug method (Kelly, et al., 1971). Later the plug technology was refined and transplants were more successful (Williams, 1987). The most recent work has been completed by Fonseca and his staff at the request of the Army Corps of Engineers (Fonseca, et al., in press). His methods and conclusions seem to provide the most cost-effective methods available for seagrass transplantation.

In this pilot study we have experimented with a number of techniques. Plugs 6 to 8 inches long of all three species were transplanted. Sprigs of all three species were also transplanted, but Syringodium filiforme sprigs were the easiest to obtain with growing tips and aerials and were used most frequently.

On July 10, 1987, methods and equipment for transplanting were tried, evaluated and re-designed as need and efficiency demanded. Plug cutters measuring 8 inches in depth and 6 inches in diameter were used to obtain plugs of approximately the same size. Individual plugs were examined and found to contain numerous growing ends (apical meristems). The plugs were placed in floating trays until they were transported in plastic tubs to the recipient site. Upon arriving at the transplant site they were placed on the bottom until divers could dig holes and plant the plugs. Photograph 1 shows a diver removing plugs from a plastic tub for planting on the bottom. Photograph 2 shows the planting of a plug and photograph 3 is a transplanted plug of mixed Syringodium filiforme and Halodule wrightii. The site shown in the photographs is within Plot I and shows the typical bottom habitat (Type B) of sand dominated by the alga Halimeda incrassata and Callianassa mounds.

Additional photographs are provided to show the characteristics of the plugs that were transplanted. Photograph 4 is a plug of Thalassia testudinum transplanted into recipient Plot I. Row 3, Plot I was planted with plugs of Thalassia. The plugs were planted on one-meter centers during the early part of the study as shown in Photograph 5. Photographs 6-9 show plugs of various compositions of Syringodium filiforme, Halodule wrightii and algae. The photographs were taken on July 16, the day after the transplants had been done and the background is in Plot I, habitat type B.

Sprigs were obtained primarily from seagrass plugs taken from the donor site and separated in floating trays 5 ft X 3 ft constructed of white pine, 1/4 inch X 1/4 inch hardware cloth, and floats. The rhizome and root systems were extremely compact and separation was difficult and time-consuming. At the edges of several "blowouts", dense mats of roots, rhizomes and shoots provided more rapid sprig production while the supply lasted. Sprigs containing the proper characteristics outlined by Fonseca et al., 1984, were selected. These were sprigs with 3 to 4 short shoots, connected by their rhizome, with the apex of the rhizome intact or with an aerial runner. They were placed in mesh dive bags and transported to the site in tubs of seawater. The bags were placed on the bottom at the recipient site until planted by divers.

Also on July 10, 1987, the first recipient site (I) was set up. Initially the plot was 30 X 30 meters bounded on all sides by 1/4 inch line. This plot was extended to 40 X 40 meters to standardize the size of the plots.

Two lines, marked off at each meter using flagging tape, were placed on either side of the plot. Another line, also marked off at each meter, was constructed to be used as a moving line along the sides of the plot. Divers would work singly when planting plugs from the outside of the line towards the center. When the divers met in the center, after planting the line, they would swim towards the outside of the line and move the line to the next meter. The planting procedure would then be repeated.

On July 15, 1987 full scale transplanting began in Plot I. Figure 4 illustrates the planting plan that was completed for that plot. Initially the planting was done with all plugs as illustrated by the 31 X 18 plug matrix in Figure 4. Because of the time involved in cutting, transporting and planting plugs, the density of plugs was decreased until finally plugs were placed on four-meter centers. The remainder of Plot I was planted on August 14 to make the plot a uniform 40 X 40 meters. At that time sprigs were used to complete the plot.

Planting was done in an assembly line manner. For efficiency, only plugs or sprigs should be planted at a given time. If both are to be planted a larger team of workers is necessary. Therefore all plots were first planted with plugs on four-meter centers and when that was complete all plots were planted with sprigs on one-meter center (except where plugs had been planted). Illustration of the planting plan for Plots II-VII is found in Figure 5. In order to comply with the requirements of planting 3 acres an additional plot was added to the seven plots. This additional plot (Plot VIIA) contained 10 rows of 41 sprigs.

Planting units (plugs and sprigs) used:

	Plugs	Sprigs	
Plot I	635	1,046	
Plots II - VII	726	9,360	
Plot VIIA		410	
TOTAL	1,361	10,816	12,177 PLANTING UNITS

Each plug was marked with a wire staple with a small flag made of surveyors' tape. The flag insured that plugs could be identified when revisited. Sprigs were held in place with a wire staple. The sprig staples were 4 inches long and the plug stables 8 inches long.

RESULTS

Observations near the end of the transplanting, August 12-14, 1987 provide some very preliminary speculations on the success of the transplant.

Habitat type B, especially within Plots I and II, has many undisturbed, surviving, healthy-looking plugs. Some plugs within habitat type A are also undisturbed, surviving and appear healthy. Plugs in habitat types C and D, especially near the reef, have mostly been cropped by herbivores and it is uncertain if the roots and growing tips are surviving and will grow. It is uncertain as to what is cropping the seagrass. Many plugs that have been

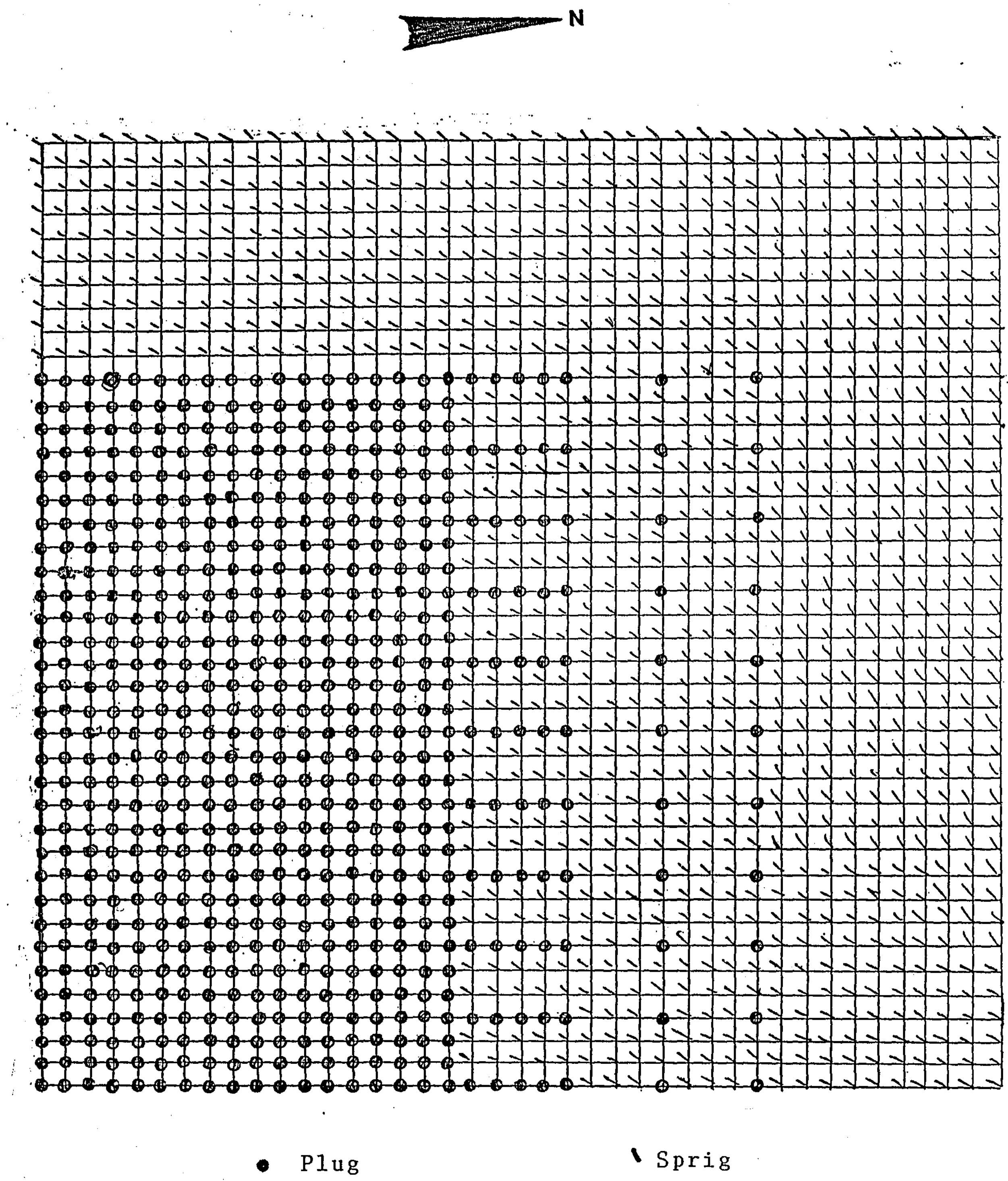

Figure 4 . The above grid represents the planting plan for grid I. The grid is a 41 X 41 m plot containing 635 plugs and 1046 sprigs on one meter square centers for a total of 1681 planting units.

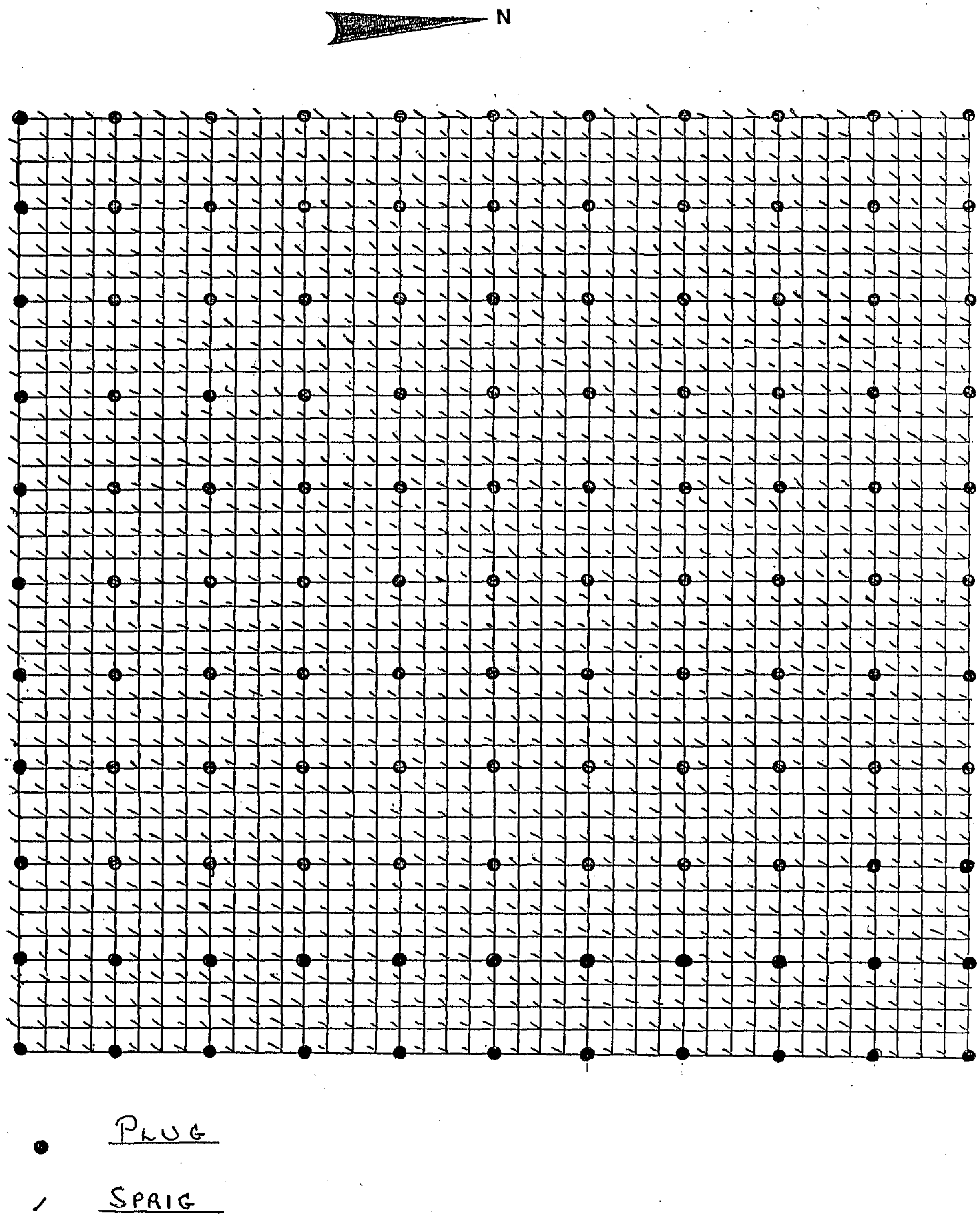

Figure 5. The above grid represents the planting plan for grids II through VII. Each grid is a 41 X 41 m plot containing 121 plugs on 4 m square centers and 1560 sprigs on one meter square centers, except where plugs are located, for a total of 1681 planting units per plot.

disturbed are totally cropped and even destroyed. Some plugs had only scattered substrate left with the shoot, rhizomes and roots absent, apparently eaten or uprooted by grazers in the area.

Williams (1987) attributes major organism disturbances to seagrasses from grazing by green turtles and uprooting by stingrays and bonefish. Each time a plug or sprig was planted during the present study many small grey juvenile fish (not positively identified because they were juveniles, but fitting many of the characteristics of bonefish) began attacking the planting unit. The fish were apparently not eating the grass, but uprooting it to find edible organisms. Goatfishes were also present and were observed on many occasions disturbing the newly planted seagrasses.

MONITORING

Transplanted areas will be monitored quarterly for the first year and annually for two additional years. The first year's monitoring will be mid-November, 1987, mid-February, mid-May, mid-August, 1988, with additional monitoring in mid-August, 1989 and 1990. Further details of the flora and fauna of the recipient site will be provided in monitoring reports.

During the monitoring phase additional environmental characteristics will be assessed in areas of successful transplantation. Much needed data will also be gathered on bioperturbations within the seagrass community as preliminary observations suggest that bioperturbations may be a key factor in the survival of transplanted seagrasses.

ACKNOWLEDGMENTS

I thank Carol Ehle-Jewett for her contribution to the writing, editing and biological sample preparation for the final report. Michael Herko provided all photographs. Marcia Gilnack and Marc Pacifico of Natural Resources and Planning, Government of the Virgin Islands inspected the transplant site.

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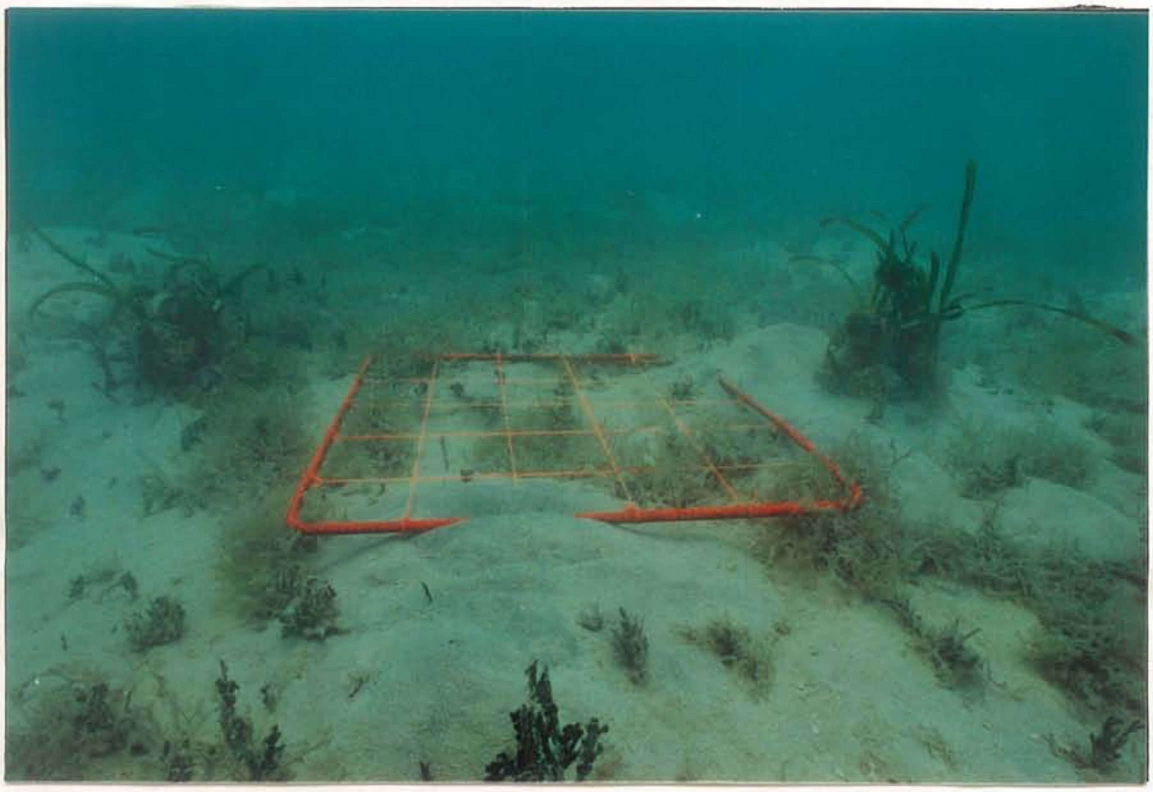
Photograph 1. Diver in Plot I removing 6-8 inch plugs from plastic containers to be planted.

Photograph 2. Diver planting a plug in Plot I.

Photograph 3. Diver points to a plug of mixed Syringodium filiforme and Halodule wrigtii planted in the sand in Plot I.

Photograph 4. Row 3, Plot I was planted with plugs of _Thalassia testudinum_ taken from the dredge site "A".



Photograph 5. Thalassia testudinum plugs planted in Plot I on one meter centers.

Photograph 6. A planted plug of mixed Syringodium filiforme and Halodule wrighii.

Photograph 7. A planted plug of mixed Thalassia testudinum and Syringodium filiforme.

Photograph 8. A planted plug of Halodule wrightii.

Photograph 9. A planted plug containing a mixture of seagrass and algae.

REFERENCES

Derrenbacker, J. and R.R. Lewis, III. 1982. Seagrass habitat restoration, Lake Surprise, Florida Keys. Pages 132-154 in R.H. Stoval [ed.]. Proc. 9th Ann. Conf. Wetlands Restoration and Creation. Hillsborough Community College, Tampa, FL.

Fonseca, M.S., W.J. Kenworthy, K.M. Cheap, C.A. Currin and G.W.Thayer. 1984. A low-cost transplanting technique for shoalgrass (Halodule wrightii) and manatee grass (Syringodium filiforme), Instruction Report EL-84-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS, prepared by National Marine Fisheries Service under contract to Environmental Laboratory. 16 pp.

Fonseca, M.S., W.J. Kenworthy and G.W. Thayer. In press a. Transplanting of the seagrasses Halodule wrightii, Syringodium filiforme and Thalassia testudinum for habitat development in the southeast region of the United States. Technical Report, U.S.Army Engineer Waterways Experiment Station, Vicksburg, Mississippi.

Fonseca, M. S., G.W. Thayer and W.J. Kenworthy. In press b. The use of ecological data in the implementation and management of seagrass restorations. Proceeding Thirty-sixth Annual Conference, American Institute of Biological Sciences, to be included in Florida Marine Research Publication Series, Durako M., Phillips, R.C. and Lewis,R.R., [eds.].

Fonseca, M.S., W.J. Kenworthy and G.W. Thayer. 1986. Restoration and Management of Seagrass Systems: A Review. Intl. Symp. Ecol. Mgt. of Wetlands, June16-10. College of Charleston, Charleston, SC.

Fonseca, M. S. and J. S. Fisher. 1986. A comparison of canopy friction and sediment movement between four species of seagrass with reference to their ecology and restoration. Mar. Ecol.Prog. Ser. 29: 15-22.

Kelly, J. A., Jr., Fuss, C. M. and J. R. Hall. 1971. The transplanting and survival of turtle grass, Thalassia testudinum, in Boca Ciega Bay, Florida. Fish. Bull. 69(2): 273-280.

Prince-Tams Joint Venture. 1984. Environmental Assessment Report for Third Port Project, South Shore - St. Croix - U. S. Virgin Islands, Vol. 1 & 2, Prep. V. I. Port Authority.

Thorhaug, A. 1981. Biology and Management of Seagrass in the Caribbean. Ambio 10: 295-298.

Thorhaug, A., B. Miller and B. Jupp. 1984. Seagrass restoration in Caribbean nearshore areas. Final Report U.S.A.I.D. Program. Dept. of Biol. Sci. Florida International Univ.

Williams, S.W. 1987. Assessment of anchor damage and carrying capacity of seagrass beds in Francis and Maho Bays for green sea turtles. VIRMAC III Research Series. Island Resources Foundation. St. Thomas.

APPENDIX I

PILOT EXPERIMENTAL SEAGRASS TRANSPLANTATION PROJECT

PHASE I REPORT

SURVEY AND REVISED METHODS

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PILOT EXPERIMENTAL SEAGRASS TRANSPLANTATION PROJECT

INTRODUCTION

The Virgin Islands Port Authority is proceeding with the development of the liquid bulk terminal on the easterly side of the Martin Marietta Channel. The U.S. Army Corps of Engineers has required that "the permittee shall transplant seagrasses from the area to be dredged and filled to nearby shallow unvegetated bottoms........and that such transplanting shall be done using 6-to-8 inch plugs." Our proposal submitted June 12, 1987, which was approved, requested a change in methodology to use only 6-to-8 inch plugs for a small proportion of the work but plant sprigs for the majority of the work as a cost saving method devised by Fonseca, et al., 1984. In view of our findings during the survey, and presented in this report, we request a revision of our original proposal to reverse the proportion of plugs to sprigs planted and use a majority of plugs and a smaller number of sprigs as originally requested by the U.S. Army Corps of Engineers.

A survey of seagrass areas around the Third Port, South Shore, St. Croix, U.S.V.I. was conducted on July 3, 4, 9 and 10, 1987. The donor areas consist of the proposed dredge area and the proposed fill area as shown in Figure 1. Recipient unvegetated areas were searched for throughout the entire port, areas west of Ruth Island and up the Martin Marietta Channel. The only extensive area which seemed acceptable as a transplant area was found in the lee of Ruth Island. All other unvegetated areas found were unacceptable for a variety of reasons. Recipient sites are also designated in Figure 1.

METHODS

Donor Sites. The donor sites were thoroughly surveyed using snorkeling gear. Photographs were taken of typical bottom areas with the aid of a 50cm X 50cm square marked off in 10cm2 units to show the density of the bottom cover. Area I, the proposed dredge area, contains dense beds of turtle grass, *Thalassia testudinum*, with very sparse patches of other grasses. Area II, the second fill area which is still open to sea, has dense patches of shoalgrass, *Halodule wrightii*, and manatee grass, *Syringodium filiforme*, and sparse patches of *T. testudinum*.

Sediment composition in the area shows great variation in patches often only a few meters apart. Particle sizes range from coarse shell fragments and/or calcareous algae residue to fine silts black with organic matter and smelling of hydrogen sulfide. Very fine silt overlays all the area and is stirred up even by slight water movements. Several different layers of sediment are frequently found within one 8in-deep plug. Dense seagrass patches often end abruptly within a 6in to 2ft drop to relatively unvegetated substrate. The impression is of an area subject to considerable sediment transport and strongly influenced in sediment composition and movement by the area's previous dredging operations.

Representative photographs of the donor sites are presented in Figures 2 through 5. They were selected as they represent typical bottom types from which seagrasses will be taken for transplanting. These photographs were taken on an atypical day when there was reasonable visibility. On most visits to the area there was usually zero to one foot visibility.

Recipient Sites. The seagrass beds of the entire area from the container dock westward past Ruth Island to the sewer outfall line, southward to the reef, and up the Harvey Channel to the turning basin were surveyed by towing a diver off the stern of a small power boat. All unvegetated areas were examined as possible transplanting sites. Areas in the Harvey Channel were rejected due to the deposit of deep fine sediments probably not capable of holding seagrasses. Areas near reefs (halos) are natural grazing areas and these areas are also not acceptable for transplants as they are heavily grazed by herbivores. Areas east of Ruth Island are very turbulent and transplanting would be difficult and would probably be uprooted by the surge. The only really acceptable place was in the lee of Ruth Island and a few small blow out areas along the shore west of the cut between Ruth Island and the mainland.

Almost all areas within the port, excluding the already dredged channels and the reef itself, are well populated with dense and healthy seagrasses and algae. These seagrass beds are well populated with macro-invertebrates including queen conch (*Strombus gigas*), king helmet (*Cassis tuberosa*), solitary coral (*Manicina areolata*), anemones (*Condylactis gigantea*), ghost shrimp (*Callianassa* sp.), and sea stars (*Oreaster reticulatus*)

The bottom characteristics found in the recipient areas can best be illustrated as shown in Figure 6. The area is sandy with the dominant algae being *Halimeda* sp. interspersed with moderate amounts of brown algae (*Dictyota divaricata* and *Dictyota* sp.) and red algae (*Liagora farinosa*), occasional *Caulerpa cupressoides* and several other species yet to be identified. Many mounds of the ghost shrimp (*Callianassa* sp.) also occupy the recipient area along with many queen conch and the upside-down jellyfish (*Cassiopea frondosa*). At the edge of planting area I, *Syringodium* is already growing. Since grass has already established itself in an adjoining area we know that conditions are favorable for further grass growth and there is a reasonable chance of the success of the transplant.

The transplant areas are relative calm with very little surge and current flow. The three recipient areas are at 15ft, 10ft, and 6ft depths with relatively clear water allowing transmission of sufficient light needed for photosynthesis to occur. All observable conditions seemed to be favorable for survival of seagrasses.

Transplant Methods. On July 10, 1987 methods and equipment for transplanting were tried, evaluated and re-designed as the need and efficiency demanded. Donor grass plugs were taken and separated in floating trays 5ft X 3ft constructed of white pine, 1/4in X 1/4in hardware cloth and floats. These trays are shown in Figure 7 at the area where seagrass is being collected.

Test patches were removed to determine the easiest method for harvesting seagrass from the donor area. The rhizome and root systems were extremely compact and separation was difficult and time consuming. It seemed much less time-consuming to obtain a complete plug, transport it to the recipient site and plant it rather than to separate out sprigs containing the proper characteristics outlined by Fonseca et al., 1984. In examining individual plugs, numerous growing ends (apical meristem) were observed within each plug. For this reason we decided that using plugs was more efficient and probably would result in more successful survival of the transplants than using the sprig method. Therefore, we are planning to use more plugs than sprigs in the transplant program.

Plug cutters measuring 8in in depth and 6in in diameter were used to obtain plugs of approximately the same size. Figure 8 illustrates a typical plug. The plugs were placed in floating trays until they were transported in dishpans to the recipient site. Upon arriving at the transplant site they were placed on the bottom until divers could dig holes and place the plugs.

On June 10, 1987 the first recipient site (I) was set up. A plot (1/2 acre) was marked off on the bottom using line (30 meters) held down at the ends with rebar. In this first plot all four sides were marked off. A line, marked off at each meter using flagging tape, was constructed to be used as a moving line along the sides of the plot. The marked line was placed at the edge of the plot, plugs will be planted at each meter (31 per line) and the line moved at one-meter intervals with 31 plugs being planted with each move. A 1/2 acre plot will have 31 X 31 plugs for a total of 961 plugs per 1/2 acre. There will be variations in seagrass composition per plug, plugs vs sprig densities, and depth of the transplant plots.

Each plug or sprig will be held in place with a wire staple. Some staples will be flagged using a small piece of flagging tape. The sprig staples are 4in long and the plug stables 8in long.

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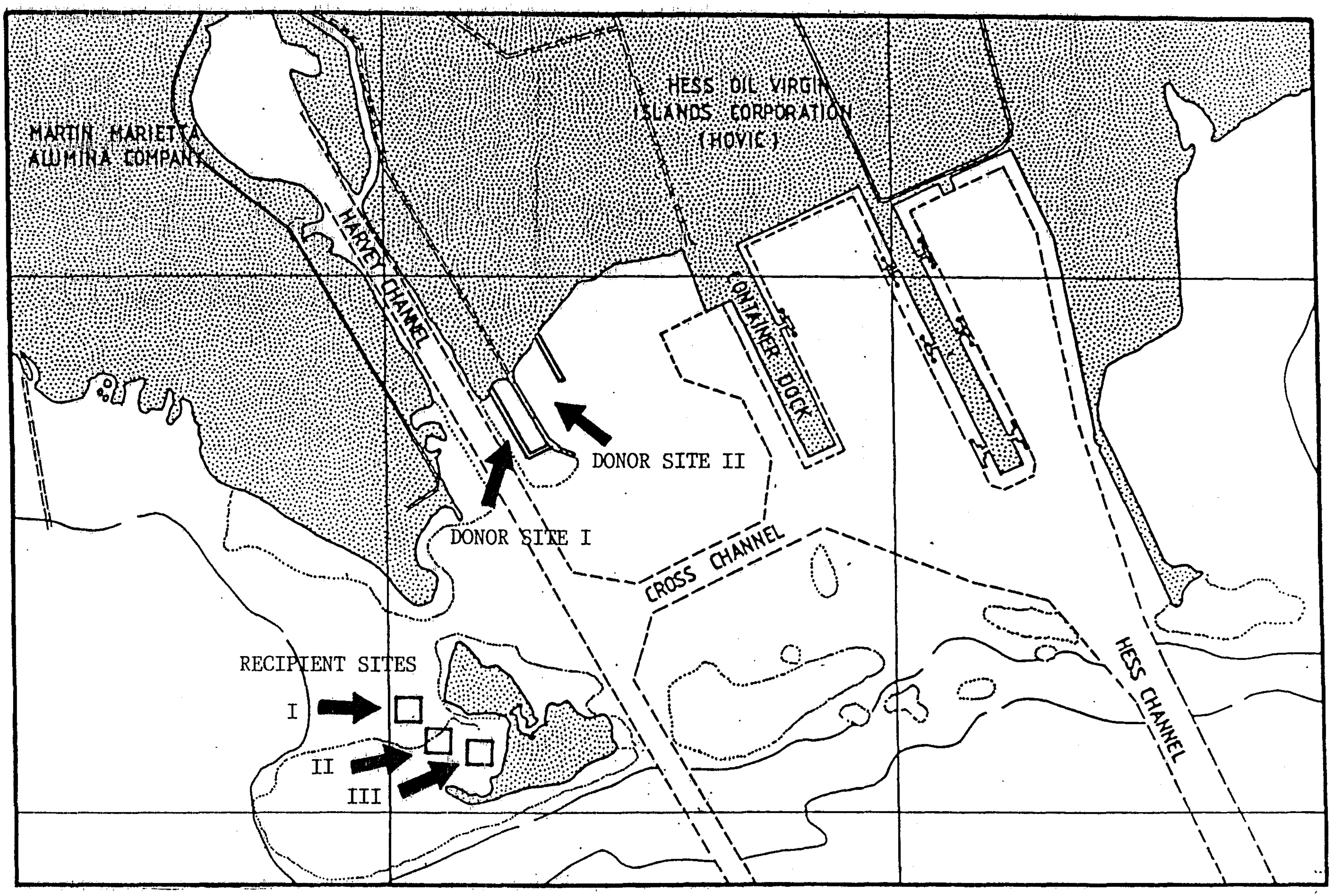

Figure 1. Project site showing donor sites I and II and recipient sites I, II, and III.

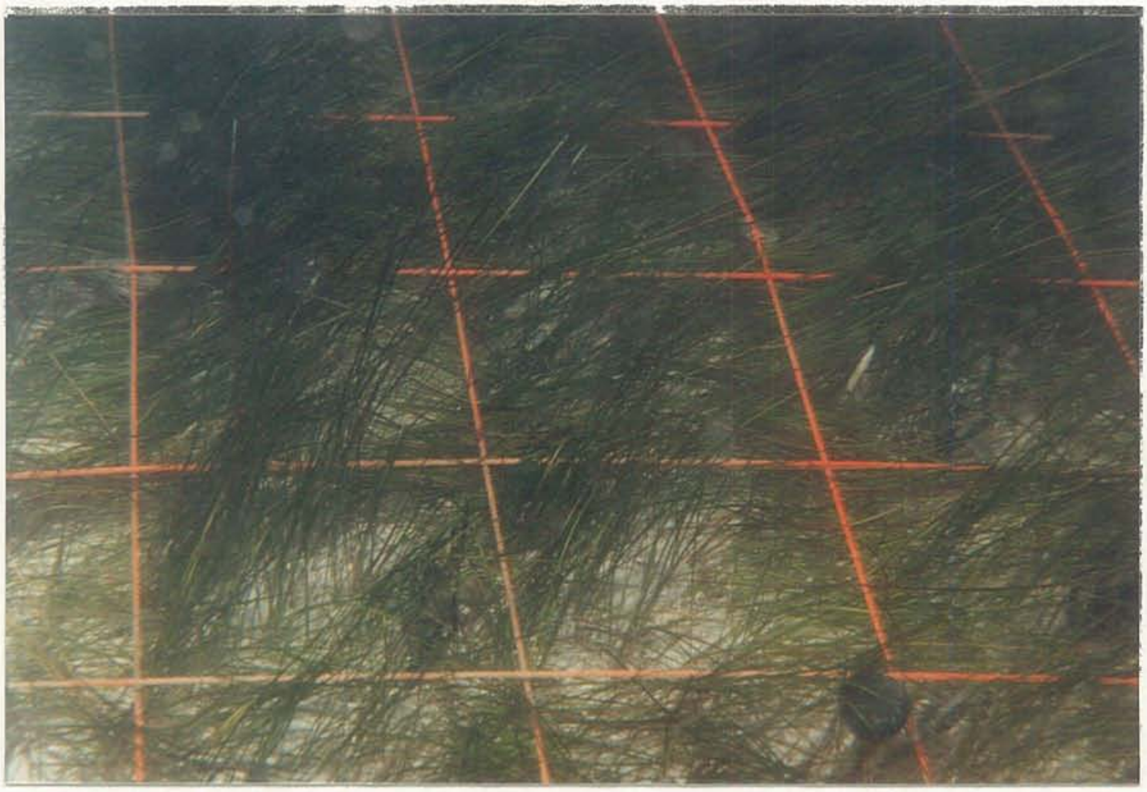

Figure 2. Proposed fill site seagrass bed. Almost a pure stand of *Halodule wrightii.*

Figure 3. Proposed fill site seagrass bed. Mixed stand of *Halodule wrightii* and *Syringodium filiforme*

Figure 4. Proposed fill site seagrass bed. An almost pure stand of Syringodium filiforme.

Figure 5. Proposed fill site seagrass bed. One of the scattered patches of Thalassia testudinum.

Figure 6. Recipient area for transplanting sea grasses. Callianassa mounds are seen in the background, the dominant algae, Halimeda sp. is conspicuous and the upside-down jellyfish Cassiopea frondosa, appears in the foreground.

Figure 7. Fill area where donor seagrass is being removed and placed in floating trays.

Figure 8. Sample plug 6in in diameter and 6 - 8in in depth. Plug contains a mixture of *Syringodium filiforme* and *Halodule wrightii*.

REFERENCES

Derrenbacker, J. and R.R. Lewis, III. 1982. Seagrass habitat restoration, Lake Surprise, Florida Keys. Pages 132-154 in R.H. Stoval [ed.]. Proc. 9th Ann. Conf. Wetlands Restoration and Creation. Hillsborough Community College, Tampa, FL.

Fonseca, M.S., W.J. Kenworthy and G.W. Thayer. In press a. Transplanting of the seagrasses Halodule wrightii, Syringodium filiforme and Thalassia testudinum for habitat development in the southeast region of the United States. Technical Report, U.S.Army Engineer Waterways Experiment Station, Vicksburg, Mississippi.

Fonseca, M. S., G.W. Thayer and W.J. Kenworthy. In press b. The use of ecological data in the implementation and management of seagrass restorations. Proceeding Thirty-sixth Annual Conference, American Institute of Biological Sciences, to be included in Florida Marine Research Publication Series, Durako M., Phillips, R.C. and Lewis,R.R., [eds.].

Fonseca, M.S., W.J. Kenworthy and G.W. Thayer. 1986. Restoration and Management of Seagrass Systems: A Review. Intl. Symp. Ecol. Mgt. of Wetlands, June16-10. College of Charleston, Charleston, SC.

Fonseca, M. S. and J. S. Fisher. 1986. A comparison of canopy friction and sediment movement between four species of seagrass with reference to their ecology and restoration. Mar. Ecol.Prog. Ser. 29: 15-22.

Kelly, J. A., Jr., Fuss, C. M. and J. R. Hall. 1971. The transplanting and survival of turtle grass, Thalassia testudinum, in Boca Ciega Bay, Florida. Fish. Bull. 69(2): 273-280.

Prince-Tams Joint Venture. 1984. Environmental Assessment Report for Third Port Project, South Shore - St. Croix - U. S. Virgin Islands, Vol. 1 & 2, Prep. V. I. Port Authority.

Thorhaug, A. 1981. Biology and Management of Seagrass in the Caribbean. Ambio 10: 295-298.

Thorhaug, A., B. Miller and B. Jupp. 1984. Seagrass restoration in Caribbean nearshore areas. Final Report U.S.A.I.D. Program. Dept. of Biol. Sci. Florida International Univ.

Williams, S.W. 1987. Assessment of anchor damage and carrying capacity of seagrass beds in Francis and Maho Bays for green sea turtles. VIRMAC III Research Series. Island Resources Foundation. St. Thomas.

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PILOT EXPERIMENTAL SEAGRASS

TRANSPLANTATION PROJECT

PHASE III

SEAGRASS MONITORING

FIRST QUARTER 11-12-87

Submitted by

Mary Lou Coulston, Ph.D.

Date: November 27, 1987

Cover: A patch of manatee grass, *Syringodium filiforme*, growing from a transplanted plug in Type B habitat. This type of habitat supports growth in transplanted seagrasses. The area has a depth of water of 15 ft with medium grained sand substrate sparsely populated with several species of algae with conspicuous ghost shrimp, *Callianassa* sp., mounds throughout the area.

Photo credit: All photographs were taken by Michael P. Herko
Diving Supervisor, Ocean Systems Research, Inc.

PILOT EXPERIMENTAL SEAGRASS

TRANSPLANTATION PROJECT

FIRST MONITORING 11-12-87

INTRODUCTION

A pilot experimental seagrass transplantation project, at the Third Port on the South coast of St. Croix, began on July 15, and ended on August 14, 1987. Three species of seagrass were used in the transplant: turtle grass (Thalassia testudinum), manatee grass (Syringodium filiforme) shoalgrass (Halodule wrightii). Twelve days were necessary to transplant 1,361 plugs and 10,816 sprigs for a total of 12,177 planting units from the donor site to cover three acres (12,141 square meters) in the recipient site. The recipient site, in the lee of Ruth Island, is shown in Figure 1. It contains three acres divided into eight plots (numbered I through VII and VIIA) which are shown in detail in Figure 2.

METHODS

On November 12, 1987 the recipient site of three acres was surveyed by swimming back and forth across the bottom guided by flags marking each row. Survival and growth of sprigs and plugs were noted and some of the successful transplants were photographed.

RESULTS

Four distinct habitats characterize the recipient area. There was very little change in the habitat description from three months ago when the seagrass was transplanted.

A. Fine sand densely populated with Cassiopeia frondosa.

This area had almost no vegetation except for patches of brown diatom scum. The sterile-appearing sand was fine and easily re-suspended. Dense populations of the up-side-down jellyfish (Cassiopeia sp.) were found throughout the bottom. Many sandy mounds constructed by the ghost shrimp (Callianassa sp.) were conspicuous throughout the area. Many juvenile and a few adult conch (Strombus gigas) were found grazing the area along with adult West Indian fighting conch (Strombus pugilis) and milk conch (Strombus costatus). One specimen of hawk-wing conch (Strombus raninus) was found in this habitat. A noticeable increase in the numbers of juvenile conch was evident during this visit.

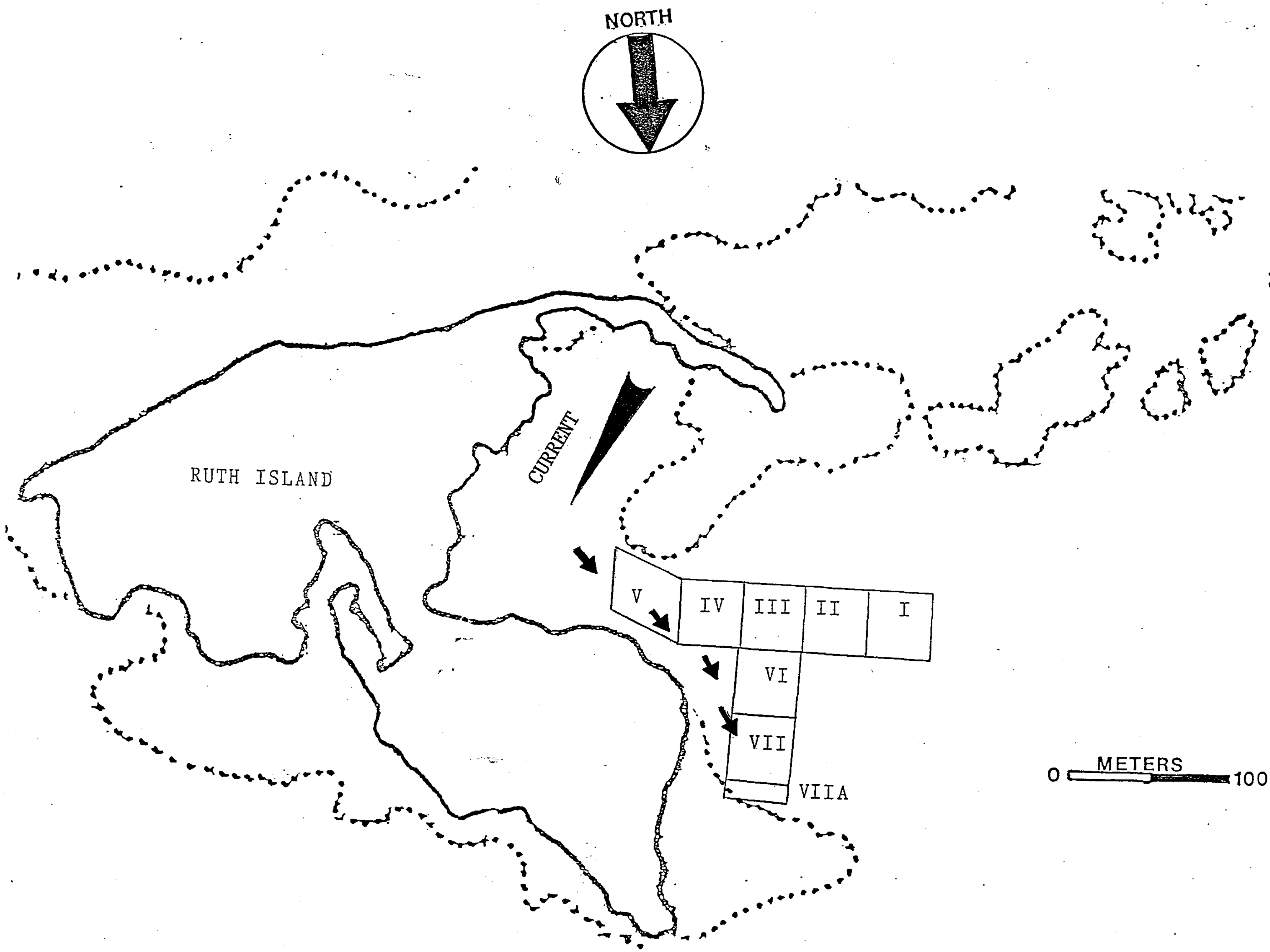

Figure 1. Recipient transplant area showing the location of Plots I through VII and VIIA. The area marked totals three (3) acres.

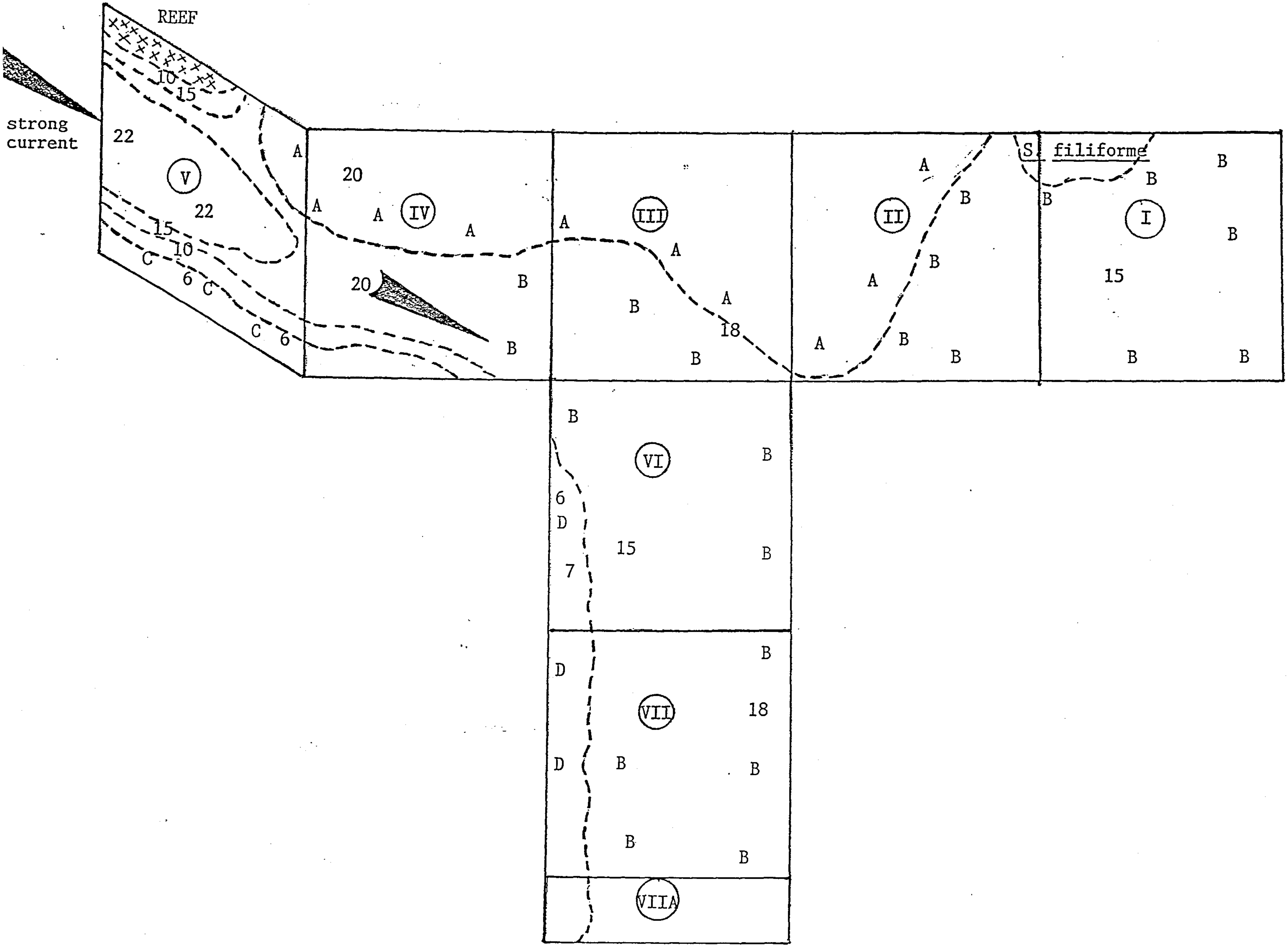

Figure 2. Characteristics of transplant plots showing depths and habitat types.

Figure 3 shows a successful sprig transplant growing in the sandy habitat. Close observation revealed that the shoots on the original cutting died, but the roots survived and grew out under the sand putting out many new shoots and aerials. All the shoots and aerials shown in the photograph are from a single spring originally having 4 to 5 shoots. The roots from the sprig have grown out and spread during the three month period. Most of the sprigs planted in this habitat are very similar in their growth and are spreading throughout the area.

Figure 4 shows the growth of plugs in the same habitat. These plugs of Syringodium filiforme are healthy and spreading throughout the sandy, formerly unvegetated, area. Most of the successful plugs are of S. filiforme. Several plugs of Halodule wrightii were found. They were healthy, but did not show any signs of lateral growth.

B. Medium grain sand sparsely populated with the alga Halimeda incrassata and densely populated with Callianassa mounds.

This habitat is a sandy area dominated by the alga Halimeda incrassata interspersed with moderate amounts of brown algae (Dictyota divaricata and Dictyota sp.) and red algae (Liagora sp. and Hypnea sp.). Occasional Caulerpa cupressoides, C. sertulariodes, C. prolifera, Udotea flabellum, Avrainvillea nigricans, Penicillus capitatus were present. Many mounds of the ghost shrimp (Callianassa sp.) also occupied the recipient area along with many juvenile queen conch and the up-side-down jellyfish (Cassiopeia frondosa).

Many invertebrates and fish were found associated with this habitat. Anemones (Condylactis gigantea and Stoichactis helianthus) were sparsely scattered throughout the area; molluscs (Strombus gigas, S. pugilis) were quite numerous and several other molluscs were sighted once (trumpet, Charonia variegate and Strombus rainius); polychaetes (fireworm, Hermodice carunculata) were conspicuous throughout the area; one species of sea urchin (Diadema antillarum) was found occasionally in the area.

Many species of juvenile fish were found occupying this habitat. Debris scattered throughout the area provided habitats for juvenile snapper, trumpetfish, grouper, soldierfish, and butterfly fishes. Over the sandy bottom were schools of herrings, mojarras, damselfish, wrasses, grunts, parrotfish and goatfishes. Planting seagrass plugs and sprigs brought an immediate influx of fish to the site. Juvenile mojarras and goatfishes were continually nibbling at the transplanted grass, presumably eating microscopic organisms found in the exposed sediment, on the shoots or scattered in the water column during the seagrass movement.

Figure 5 shows a successful sprig transplant into habitat Type B. In these new transplants a large number of aerials can be observed.

Figure 6 is one of the Thalassia testudinum plugs which were all planted in habitat Type B. All of the turtle grass plugs were alive, but they looked just like the one shown in the figure. They were cropped short with what appeared to be new, but short shoots. They had not spread at all.

Figure 3. A successful sprig transplant growing in the almost totally unvegetated fine sandy bottom habitat (Type A). The area has many ghost shrimp (<u>Callianassa</u> sp.) mounds and large populations of the up-side-down jellyfish (<u>Cassiopeia</u> sp.) not shown in this photograph. The bottom has mats of brown diatoms which are a food source for the many conch (4 species of <u>Strombus</u>) attracted to the area.

Figure 4. Healthy and spreading plugs of manatee grass (<u>Syringodium</u> <u>filiforme</u>) growing in the barren sandy habitat (Type A).

Figure 5. A successful sprig of Syringodium filiforme planted into habitat Type B. Note the large number of aerials which are used to rapidly spread throughout an area.

Figure 6. Turtle grass (Thalassia testudinum) plug located in habitat Type B. All turtle grass plugs were alive, but cropped and not spreading.

Figure 7. A representative habitat Type B bottom with one of the typical invertebrates, the giant Caribbean anemone (Condylactis gigantea) in the foreground. The arrows point to two successfully established and growing manatee grass plugs.

Figures 8 and 9 show examples of growing and spreading plugs of Syringodium filiforme. Figure 10 shows one example of the abundance of juvenile fish found among the debris on the bottom within the study area.

C. Calcareous substrate (Halimeda dominated) with dense mats of Halimeda opuntia.

Areas in shallow water (6 to 10 ft) were dominated by a dense cover of Halimeda opuntia and H. monile found in a mixed substrate of calcareous rubble. The ringed anemone, Bartholomea annulata was abundant and found protruding from many of the crevices between broken pieces of dead coral. Fireworms were also found throughout this area. It appeared that during this visit the algae had become even denser than when the transplant had been done. In addition the area of dense algae growth seems to have been extended.

A thorough survey of this habitat revealed that no seagrass survived in this habitat type. Many flags and staples were found, but not one trace of seagrass.

D. Coral rubble substrate with mixed calcareous sand with very little vegetation.

This habitat was found inshore on Plots VI and VII. There was very little vegetation among the coral rubble and small patches of sand. The occasional small live coral colony (Porites porites, Favia fragum, Agaricia agaricites and Siderastrea siderea) was found growing on pieces of coral rubble.

A thorough search was made throughout this habitat and no seagrass was found. Again the flags and staples were found but no seagrass.

Figure 11 shows the study area with arrows indicating the current pattern. It seems that where the current runs the strongest all of the transplanted seagrass had been washed away or smothered. A very distinct pathway, corresponding to the pattern of current flow, had no seagrass remaining. Also noticeable in this area was the lack of flags and staples. The transplanted seagrass had either been washed away or covered by sediment. In the illustration (Figure 11), a line is drawn approximating the edge of the seagrass growth. West of the line most of the seagrass plugs and sprigs are surviving, whereas, East of the line there was no seagrass found.

Figure 7. A typical habitat Type B bottom with one of the typical invertebrates, a pink tipped anemone (Condylactis gigantea) in the foreground. The arrows point to two successfully established manatee grass plugs.

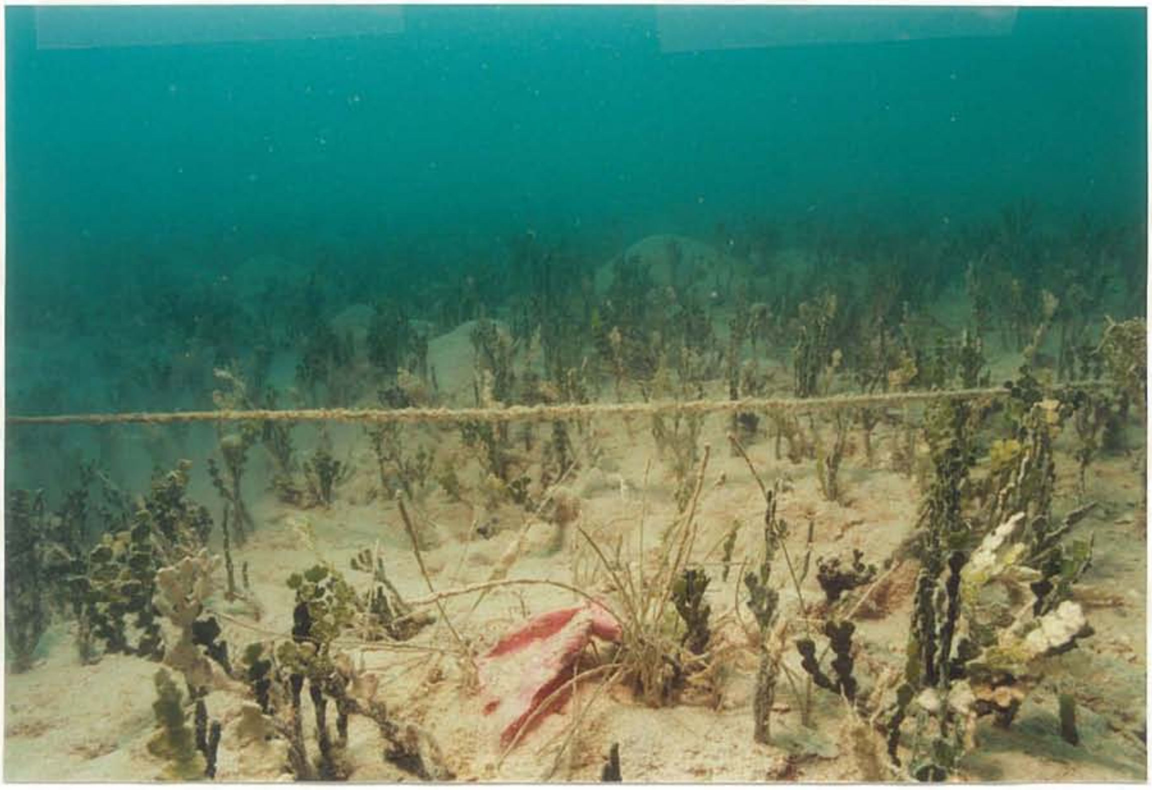

Figure 8. A plug transplant of manatee grass, (Syringodium filiforme), growing at the boundary of Plot 1. Note the boundary of the plot is marked with line. Each plug was marked with a staple and conspicuous flagging tape.

Figure 9. A healthy and spreading plug of manatee grass, (Syringodium filiforme), growing in habitat Type B.

Figure 10. Debris scattered throughout the bottom of the study site provide habitats for many species of juvenile fish.

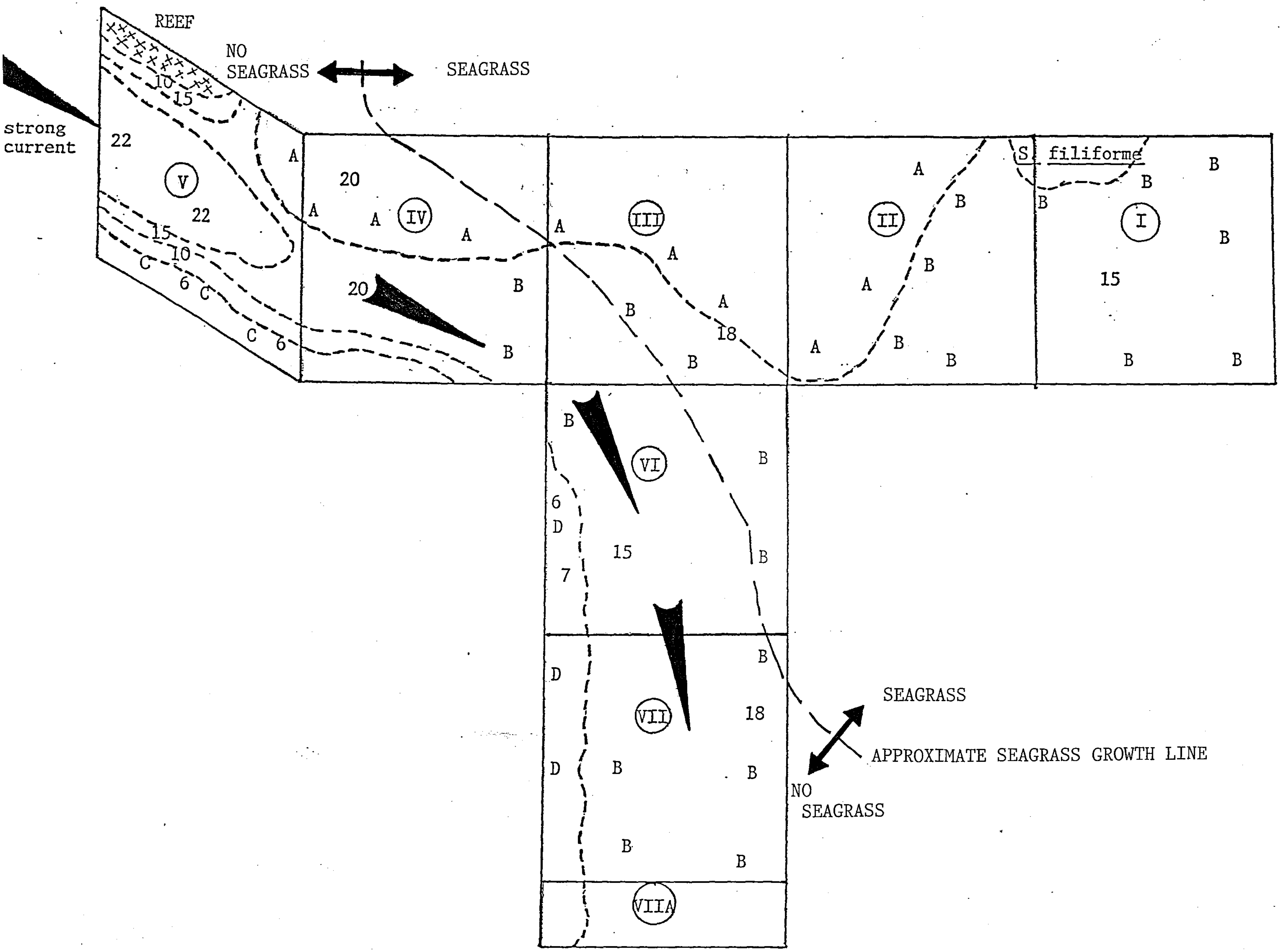

Figure 11. Recipient transplant plots showing areas where seagrass transplants were successful and areas where they were not.

DISCUSSION

Habitats Type A and B will support the growth of transplanted seagrass, whereas habitats Type C and D will not support seagrass growth. In addition, all areas that were subjected to current and sediment movement did not support the growth of seagrass. Habitats Type A and B have in common a fine sandy substrate and sparse algal growth. Habitats C and D have course coral rubble or calcareous substrate.

In areas of dense *Halimeda* growth, it seems that the *Halimeda* outcompetes the seagrass for space. Areas that had been cleared of *Halimeda* and seagrass sprigs or plugs planted, were grown over with *Halimeda* in the three month period since transplanting.

Specific ecological requirements are necessary for seagrass transplants to survive and grow. From the data already obtained it can be concluded that current, substrate and the presence of other organisms all influenced the ability of seagrass transplants to survive.

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PILOT EXPERIMENTAL SEAGRASS

TRANSPLANTATION PROJECT

PHASE III

SEAGRASS MONITORING

SECOND QUARTER 02-14-88

Submitted by

Mary Lou Coulston, Ph.D.

Date: February 14, 1988

Cover: A patch of manatee grass, _Syringodium filiforme_, growing from a transplanted plug. The habitat is type "B" as described in the text. This area has a water depth of 15 ft with medium grained sand substrate sparsely populated with several species of algae with conspicuous ghost shrimp, _Callianassa_ sp., mounds throughout the area.

Photo credit: All photographs taken during the November monitoring by Michael P. Herko, Diving Supervisor, Ocean Systems Research, Inc.

PILOT EXPERIMENTAL SEAGRASS

TRANSPLANTATION PROJECT

SECOND QUARTER MONITORING 02-14-88

INTRODUCTION

A pilot experimental seagrass transplantation project, at the Third Port on the South coast of St. Croix, began on July 15, and ended on August 14, 1987. Three species of seagrass were used in the transplant: turtle grass (Thalassia testudinum), manatee grass (Syringodium filiforme) shoalgrass (Halodule wrightii). Twelve days were necessary to transplant 1,361 plugs and 10,816 sprigs for a total of 12,177 planting units from the donor site to cover three acres (12,141 square meters) in the recipient site. The recipient site, in the lee of Ruth Island, is shown in Figure 1. It contains three acres divided into eight plots (numbered I through VII and VIIA) which are shown in detail in Figure 2.

Transplanted areas are scheduled to be monitored quarterly for the first year and annually for two additional years. The first monitoring was done in November, 1987. This monitoring, the second of a scheduled six monitoring periods, was done on February 14, 1988.

METHODS

On February 14, 1988 the recipient site of three acres was surveyed, using SCUBA, by swimming back and forth across the bottom guided by flags marking each row. The area was completely re-surveyed to re-affirm where surviving transplanted seagrasses were actually present. Survival and growth of sprigs and plugs were noted and some of the successful transplant areas were flagged for measuring during future monitoring visits.

HABITAT DESCRIPTIONS WITH CHANGES

Four distinct habitat types characterize the recipient area. There are some changes in the habitat description from six months ago when the seagrass was transplanted.

A. Fine sand densely populated with Cassiopeia frondosa.

This area, noted as "A" in Figures 2 and 3, had almost no vegetation during the planting phase and the first quarter visit except for patches of brown diatom scum. At this visit the area was completely covered with brown algae, *Dictyota* spp. Dense populations of the up-side-down jellyfish (*Cassiopeia* sp.) were still found throughout the bottom, however, they were more difficult to see as they were obscured by the increased algal growth. Many sandy mounds constructed by the ghost shrimp (*Callianassa* sp.) were still conspicuous throughout the area, but only the tops were visible as all the valleys between the mounds was carpeted with the brown algae. Many juvenile fish and many juvenile conch (*Strombus gigas*) were found grazing the area. The conch population varied from very small to large juveniles; no adults were found. There appeared to be a greater number of juvenile conch than found previously.

B. Medium grain sand sparsely populated with the alga *Halimeda incrassata* and densely populated with *Callianassa* mounds.

This habitat is a sandy area, marked by "B" in figures 2 and 3, dominated by the alga *Halimeda incrassata* interspersed and covered with overwhelming amounts of brown algae (*Dictyota divaricata* and *Dictyota* sp.). Occasional *Caulerpa cupressoides*, *C. sertulariodes*, *C. prolifera*, *Udotea flabellum*, *Avrainvillea nigricans*, *Penicillus capitatus* were present. Many mounds of the ghost shrimp (*Callianassa* sp.) also occupied this area along with many juvenile queen conch and the up-side-down jellyfish (*Cassiopeia frondosa*) obscured by the massive carpets of brown algae.

The *Thalassia testudinum* plugs, which were all planted in habitat Type B were still alive, but they had not spread out since the planting. They were cropped short with what appeared to be new, but short shoots.

C. Calcareous substrate (*Halimeda* dominated) with dense mats of *Halimeda opuntia*.

Areas, marked "C" in Figures 2 and 3, in shallow water (6 to 10 ft) were still dominated by a dense cover of *Halimeda opuntia* and *H. monile* found in a mixed substrate of calcareous rubble. The ringed anemone, *Bartholomea annulata* was abundant and found protruding from many of the crevices between broken pieces of dead coral. Fireworms were also found throughout this area. It appeared that during this visit the algae was as dense as the last visit. In addition, the area of dense algae growth seems to have been extended.

An additional survey of this habitat revealed that no seagrass survived. Many flags and staples were found, but not one trace of seagrass.

D. Coral rubble substrate with mixed calcareous sand with very little vegetation.

This habitat, marked "D" in Figures 2 and 3, are found inshore on Plots VI and VII. There was very little vegetation among the coral rubble and small patches of sand. The occasional small live coral colony (*Porites porites*, *Favia fragum*, *Agaricia agaricites* and *Siderastrea siderea*) was found growing on pieces of coral rubble.

A thorough search was made throughout this habitat and no seagrass was found. Again the flags and staples were found but no seagrass.

RESULTS

The only surviving seagrass transplants found during the February 14th visit were confined to Plot I and II and within habitat types A and B, but mostly in type B.

All of the *Thalassia* plugs were alive, but none of them were exhibiting lateral growth out from the original plug. They were not as luxuriant as when transplanted, but were surviving.

Figure 3 shows an outlined area marked "1". This is a large patch of *Syringodium filiforme* which appears to be growing outward. It obviously originated from either sprigs or plugs as no seagrass was found there before the transplant. None of the area surrounding this patch had any seagrass. Staples and flags could be found outside of this area, but there was no seagrass. It will be established whether this region increases or decreased in size and density at the next visit.

There is another similar area of *Syringodium* growth outlined in Plot I marked "2" in Figure 3. Distinct individual plugs were also able to be distinguished. There was also a patch of *Halodule* outlined in Plot I and marked "3" in Figure 3. The line of *Thalassia* plugs is also shown and marked by "T" in the same figure.

Figure 4 is a photograph taken during the November monitoring. It shows the *Syringodium* patch which is now much more extensive. This patch is designated #2 in Figure 3, which is habitat type B in plot I.

The areas described above were marked with flags and during the next monitoring, in May, they will be measured for rate of growth and shoot density. Most of the seagrass survival now seems to be confined to habitat type B only. During the May monitoring observations will be made to see if the brown algae growth decreases with a change of season and if the seagrass can spread from the present established patches.

Figures 5 and 6 are two photographs taken during the November monitoring period. They show the brown algae (*Dictyota* sp.) which has now formed a dominant mat over almost the entire areas of habitats types A and B. The *Dictyota* was examined and found to be both attached by holdfasts to the substrate and not attached and drifting.

DISCUSSION

Habitats Type A and B have supported, and continue to support, the growth of transplanted seagrass, whereas habitats Type C and D have not supported seagrass growth. In addition, all areas that are subjected to current and sediment movement do not support the growth of seagrass. Habitats Type A and B have in common a fine sandy substrate and sparse algal growth during the transplant phase, but now has a dominant cover of brown algae. Habitats C and D have course coral rubble or calcareous substrate.

With the additional growth of dense patches of brown algae, much of the seagrass sprigs that were alive during the November monitoring were no longer alive. Where distinctly large patches of seagrass have been established there is a good change that this growth might outcompete the brown algae growth. Where the seagrasses have been established the brown algal growth is not dense. Only future monitoring will determine which will be the successful competitor; the seagrass or the algae.

Specific ecological requirements are necessary for seagrass transplants to survive and grow. From the data already obtained it was concluded that current, substrate and the presence of other organisms all influenced the ability of seagrass transplants to survive. In addition, this survey revealed that certain algal species, flourishing seasonally, are able to outcompete the seagrasses.

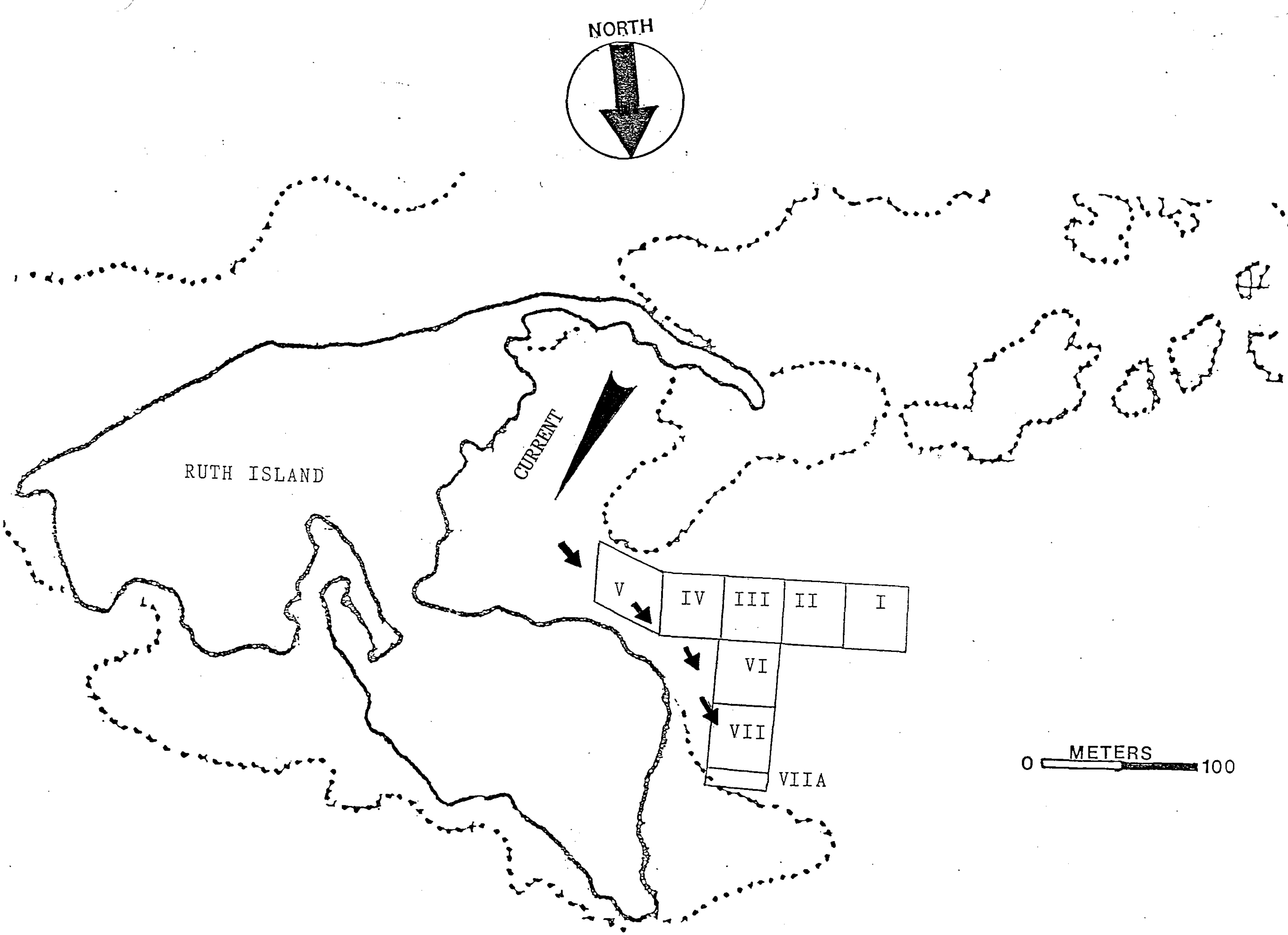

Figure 1. Recipient transplant area showing the location of Plots I through VII and VIIA. The area marked totals three (3) acres.

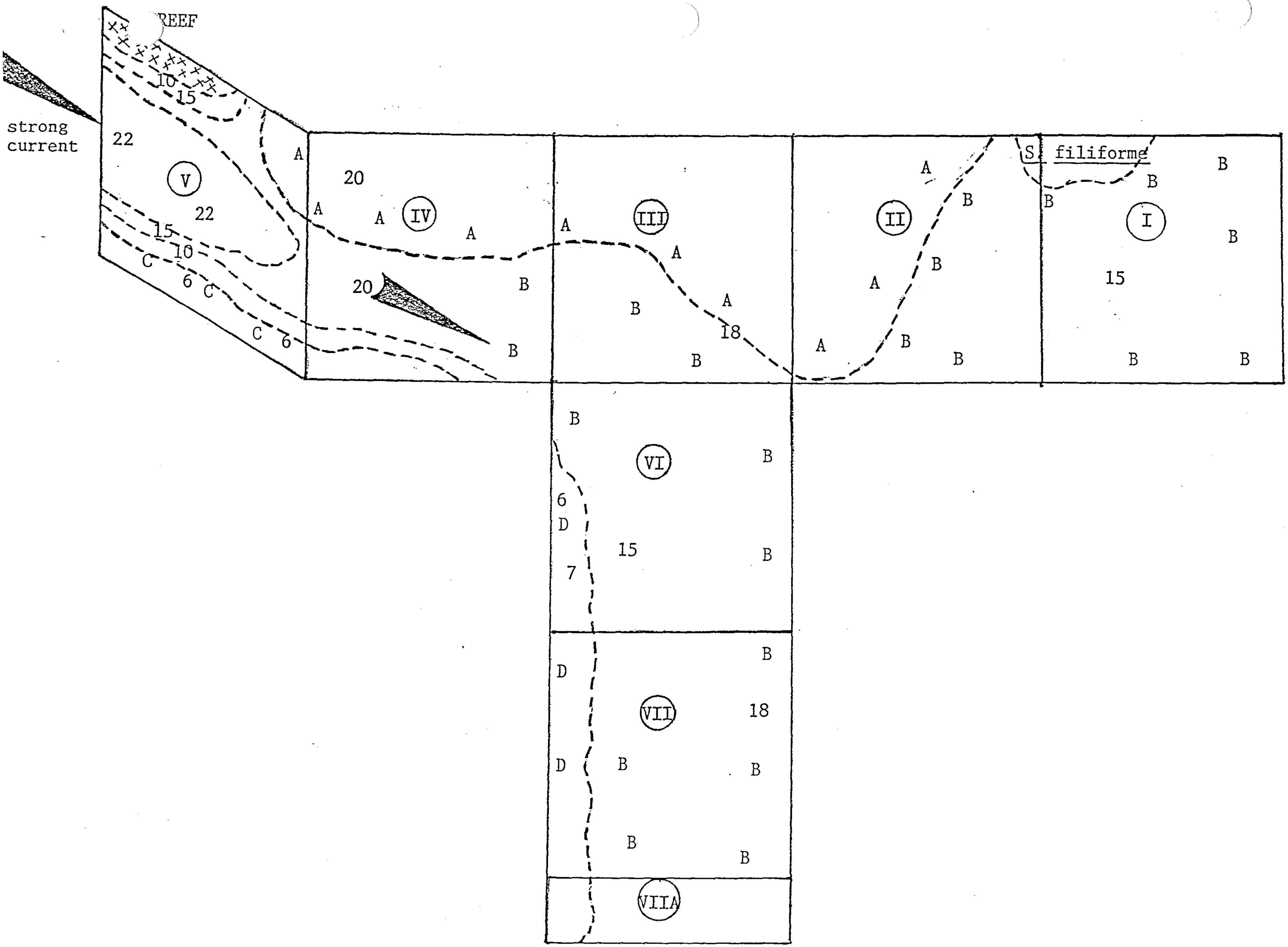

Figure 2. Characteristics of transplant plots showing depths and habitat types.

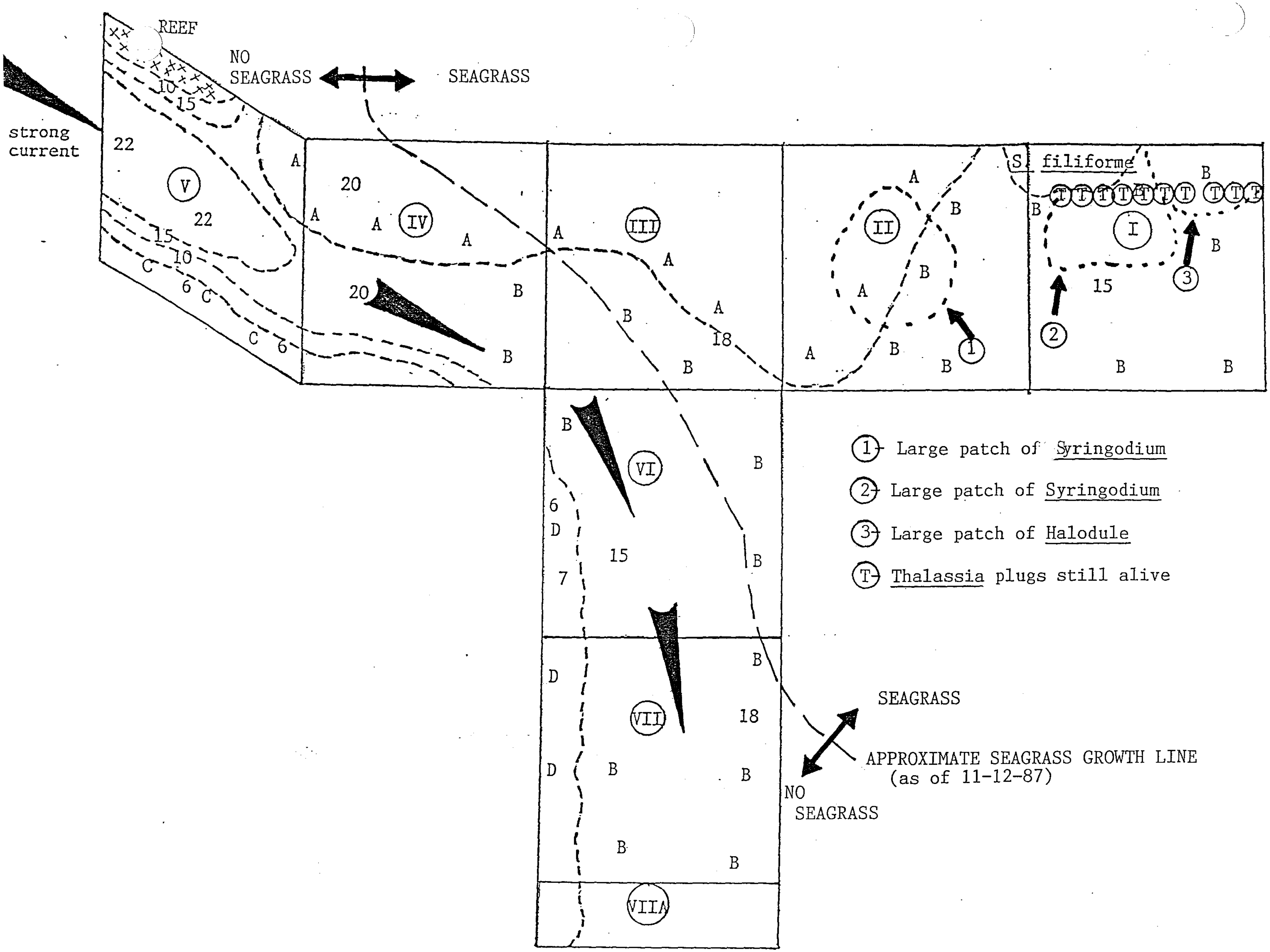

Figure 3. Recipient transplant plots showing areas where seagrass transplants were successful and areas where they were not.

Figure 4. An extensive patch of Syringodium filiforme. The photograph was taken during the November, 1987 monitoring and exhibited a much more extensive lateral growth during the February monitoring. The patch in the photograph corresponds to the area marked #2 in Figure 3. The area is in plot I and is the characteristic habitat type "B" described in the text.

Figure 5. In the foreground are clumps of the brown algae, Dictyota. A single juvenile conch is shown grazing the area. This photograph was taken in November and shows the sparse distribution of the algae. During the February visit, this algae literally covered and buried the entire area where no grass was growing. However, the seagrass patches had almost none of this algae present.

Figure 6. Off to the left of the photograph is shown an extensive patch of the brown algae, Dictyota. A surviving seagrass plug of Thalassia testudinum is shown in the foreground. Pink flags indicate where plugs were placed. A pink flag was place in the center of all transplanted plugs and one can be seen in the photograph along with surviving seagrasss.

REFERENCES

Derrenbacker, J. and R.R. Lewis, III. 1982. Seagrass habitat restoration, Lake Surprise, Florida Keys. Pages 132-154 in R.H. Stoval [ed.]. Proc. 9th Ann. Conf. Wetlands Restoration and Creation. Hillsborough Community College, Tampa, FL.

Fonseca, M.S., W.J. Kenworthy, K.M. Cheap, C.A. Currin and G.W.Thayer. 1984. A low-cost transplanting technique for shoalgrass (*Halodule wrightii*) and manatee grass (*Syringodium filiforme*), Instruction Report EL-84-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS, prepared by National Marine Fisheries Service under contract to Environmental Laboratory. 16 pp.

Fonseca, M.S., W.J. Kenworthy and G.W. Thayer. In press a. Transplanting of the seagrasses *Halodule wrightii*, *Syringodium filiforme* and *Thalassia testudinum* for habitat development in the southeast region of the United States. Technical Report, U.S.Army Engineer Waterways Experiment Station, Vicksburg, Mississippi.

Fonseca, M. S., G.W. Thayer and W.J. Kenworthy. In press b. The use of ecological data in the implementation and management of seagrass restorations. Proceeding Thirty-sixth Annual Conference, American Institute of Biological Sciences, to be included in Florida Marine Research Publication Series, Durako M., Phillips, R.C. and Lewis,R.R., [eds.].

Fonseca, M.S., W.J. Kenworthy and G.W. Thayer. 1986. Restoration and Management of Seagrass Systems: A Review. Intl. Symp. Ecol. Mgt. of Wetlands, June16-10. College of Charleston, Charleston, SC.

Fonseca, M. S. and J. S. Fisher. 1986. A comparison of canopy friction and sediment movement between four species of seagrass with reference to their ecology and restoration. Mar. Ecol.Prog. Ser. 29: 15-22.

Holtz, S. 1986. Tropical Seagrass Restoration. Restoration & Management Notes 4 (1): 4-11.

Kelly, J. A., Jr., Fuss, C. M. and J. R. Hall. 1971. The transplanting and survival of turtle grass, *Thalassia testudinum*, in Boca Ciega Bay, Florida. Fish. Bull. 69(2): 273-280.

Prince-Tams Joint Venture. 1984. Environmental Assessment Report for Third Port Project, South Shore - St. Croix - U. S. Virgin Islands, Vol. 1 & 2, Prep. V. I. Port Authority.

Thorhaug, A. 1981. Biology and Management of Seagrass in the Caribbean. Ambio 10: 295-298.

Thorhaug, A., B. Miller and B. Jupp. 1984. Seagrass restoration in Caribbean nearshore areas. Final Report U.S.A.I.D. Program. Dept. of Biol. Sci. Florida International Univ.

Williams, S.W. 1987. Assessment of anchor damage and carrying capacity of seagrass beds in Francis and Maho Bays for green sea turtles. VIRMAC III Research Series. Island Resources Foundation. St. Thomas.

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PILOT EXPERIMENTAL SEAGRASS

TRANSPLANTATION PROJECT

PHASE III

SEAGRASS MONITORING

THIRD QUARTER 06-19-88

Submitted by

Mary Lou Coulston, Ph.D.

Date: June 22, 1988

Cover: A patch of turtle grass, *Thalassia testudinum*, growing from a transplanted plug. This area has a water depth of 15 ft with medium grained sand substrate sparsely populated with several species of algae with conspicuous ghost shrimp, *Callianassa* sp., mounds throughout the area.

Photo credit: All photographs were taken June 19, 1988 by Michael P. Herko.

PILOT EXPERIMENTAL SEAGRASS

TRANSPLANTATION PROJECT

THIRD QUARTER MONITORING 06-19-88

INTRODUCTION

A pilot experimental seagrass transplantation project was conducted at the Third Port on the South coast of St. Croix from July 15 to August 14, 1987 (Coulston, 1987b). Three species of seagrass were used in the transplant: turtle grass (*Thalassia testudinum*), manatee grass (*Syringodium filiforme*) and shoalgrass (*Halodule wrightii*). It took twelve days to transplant 1,361 plugs and 10,816 sprigs, for a total of 12,177 planting units from the donor site to cover three acres (12,141 square meters) in the recipient site. The recipient site, in the lee of Ruth Island, is shown in Figure 1. It contains three acres divided into eight plots (numbered I through VII and VIIA) which are shown in detail in Figure 2.

The study requires that transplanted areas be monitored quarterly for the first year and annually for two additional years. The first monitoring was done on November 12, 1987 and the second monitoring on February 14, 1988 (Coulston 1987c and 1988a). This monitoring, the third of a scheduled six monitoring periods, was done on June 19, 1988.

METHODS

On June 19, 1988 the recipient site of three acres was surveyed by divers, using SCUBA, by swimming back and forth across the bottom guided by flags, stakes and lines marking each section. The area was completely re-surveyed to re-affirm where surviving transplanted seagrasses were actually present. Survival and growth of the various species of seagrasses were noted. Additional sites of expanding growth were flagged for measuring during future monitoring visits.

Representative photographs were taken of each species of seagrass showing the expanded growth and of the underwater habitats for descriptive and comparative analyses.

RESULTS

The most noticeable and remarkable observation was the increased growth and expansion of seagrasses *H. wrightii* and *S. filiforme*. The area outlined and shaded in Figure 3 (labeled 4) shows the area of growth of both of these species. Most of this area was covered with a mixture of both species. A typical extensive patch of shoalgrass (*H. wrightii*) is shown in Figure 4 and a

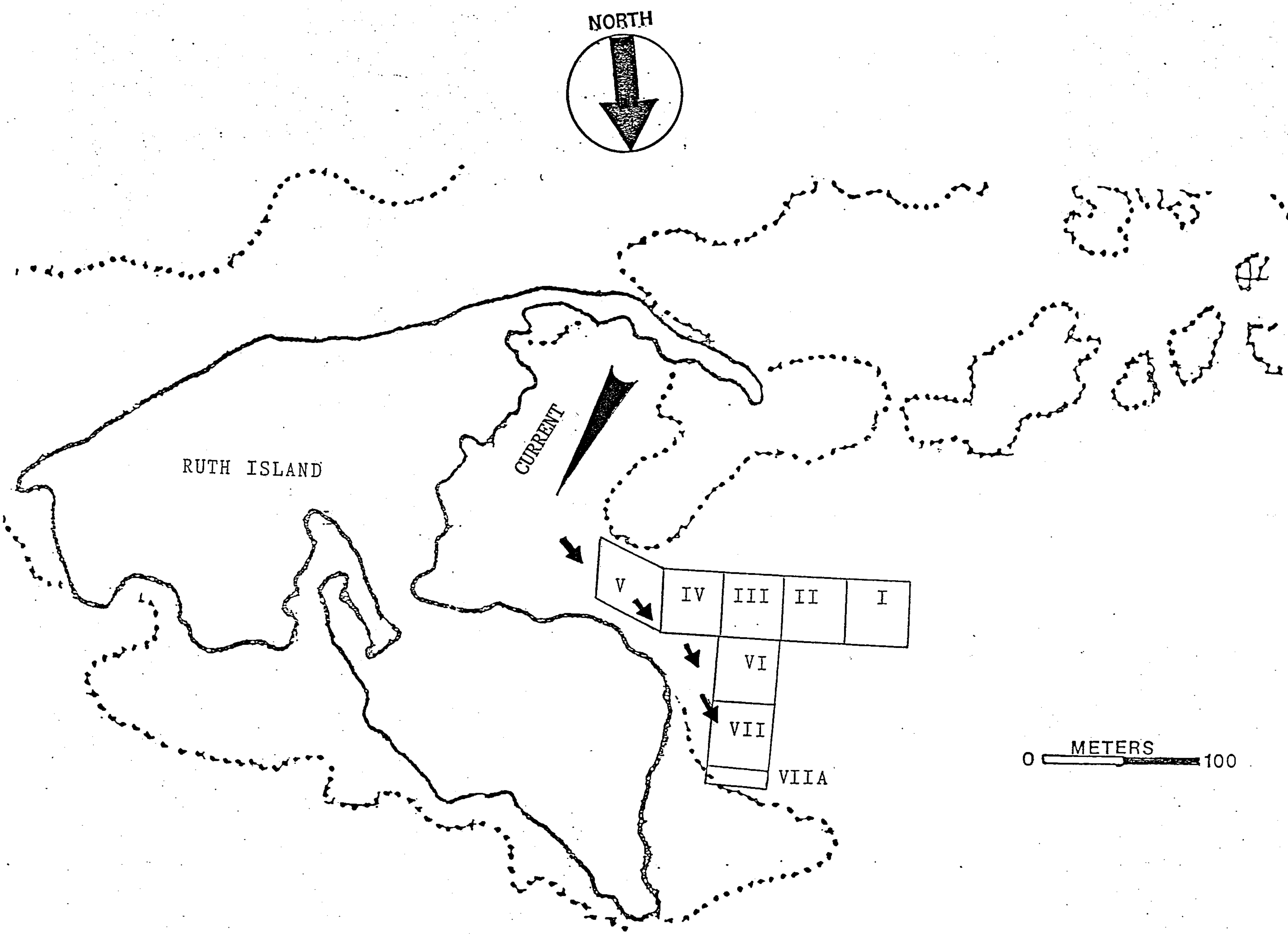

Figure 1. Recipient transplant area showing the location of Plots I through VII and VIIA. The area marked totals three (3) acres.

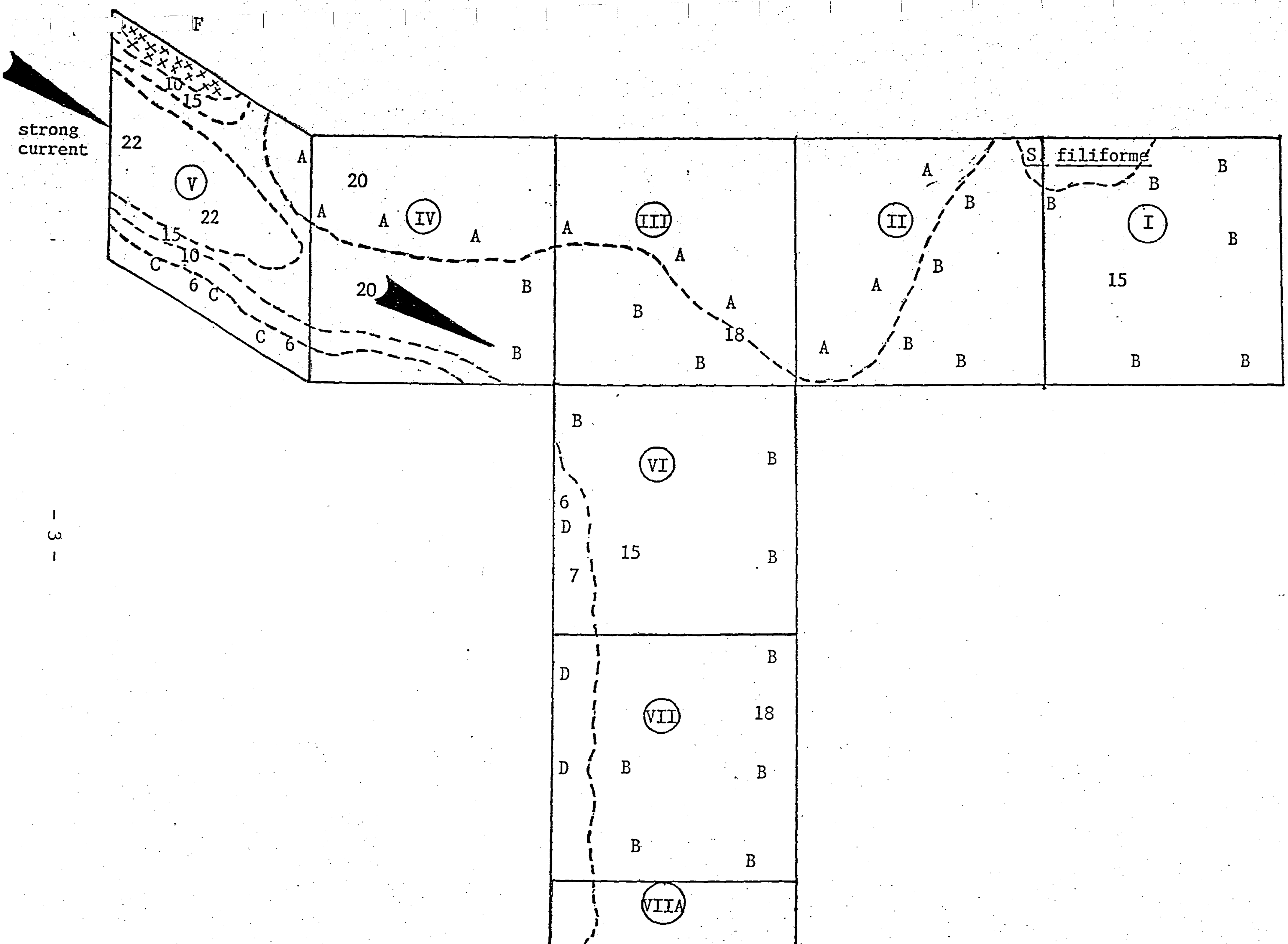

Figure 2. Characteristics of transplant plots showing depths and habitat types.

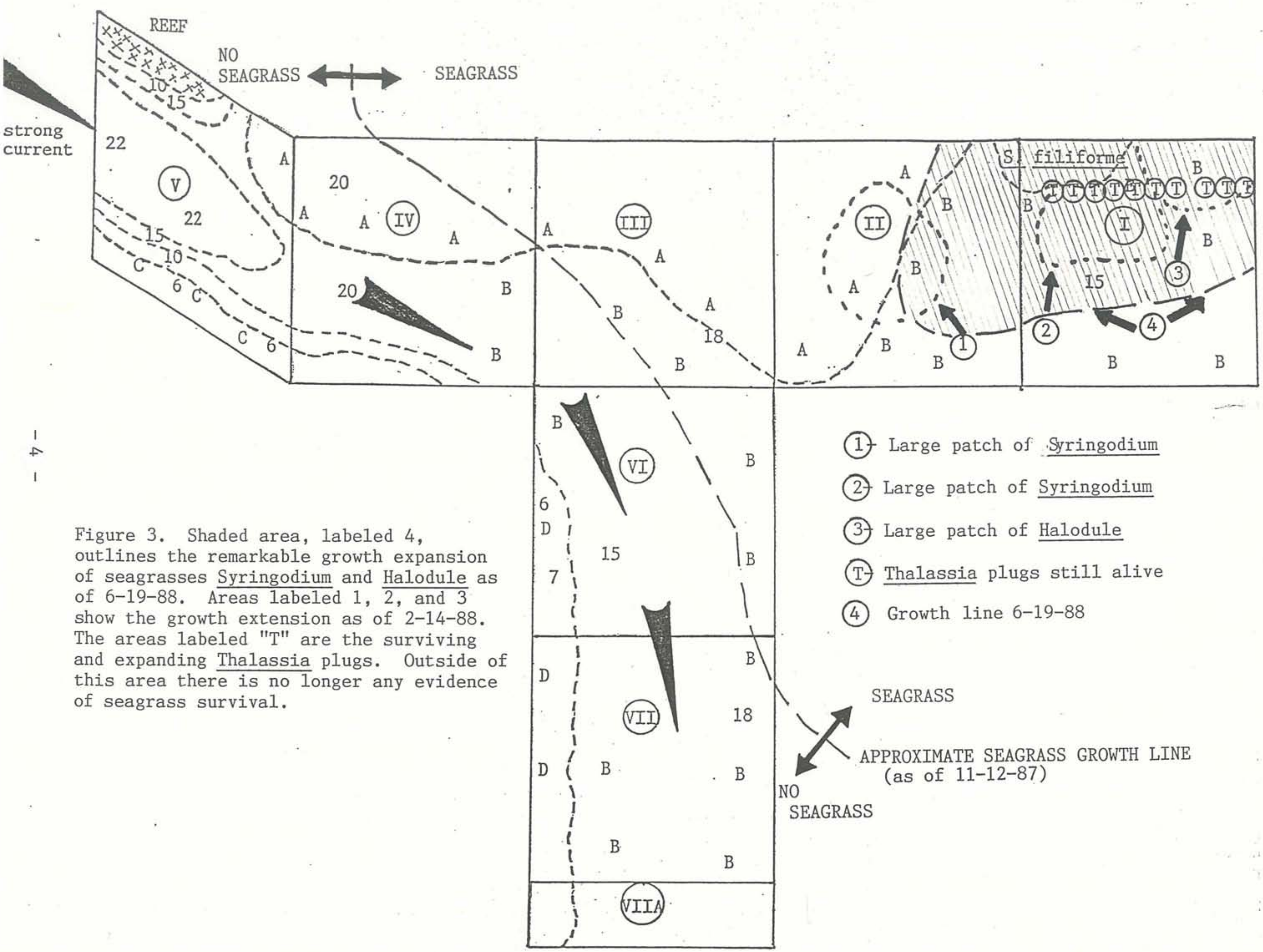

Figure 3. Shaded area, labeled 4, outlines the remarkable growth expansion of seagrasses Syringodium and Halodule as of 6-19-88. Areas labeled 1, 2, and 3 show the growth extension as of 2-14-88. The areas labeled "T" are the surviving and expanding Thalassia plugs. Outside of this area there is no longer any evidence of seagrass survival.

broad, but less dense, patch of manatee grass (S. filiforme) is found in Figure 5. Because of the recent extensive lateral growth of these two species, it was impossible to distinguish where plugs or springs had originally been placed. The only evidence of the center of a plug or the location of a former sprig was the occasional wire staple (used to hold springs in place) and a wire staple with a flag (used to designate the center of each plug).

The turtle grass (T. testudinum) plugs were also beginning to show lateral growth. These were easy to relocate as only one row of turtle grass plugs were planted and many of them still had the staple and flag in the center. Figure 6 shows a transplanted plug of turtle grass which has expanded laterally. Most of the blades are whole, healthy and with little evidence of bite marks from grazers. Another transplanted plug showing lateral growth is shown in Figure 7. Manatee grass is seen interdispersed among the turtle grass blades. The outer edges of growth are shown marked with flags. These flags were put in place so that during future monitoring increased growth can be measured.

Four distinct habitat types characterize the entire recipient area. These are described in detail in previous reports (Coulston, 1987b). Only one habitat type continues to support the growth and expansion of seagrasses. It was confirmed, during this monitoring period, that the other habitats had no surviving seagrass transplants. In future monitoring it will not be necessary to survey confirmed non-growth areas but to concentrate on measuring the rate of expansion within the successful growing area.

The habitat supporting seagrass growth and expansion is a sandy area, marked by "B" in figures 2 and 3 and shown in Figure 8. This area was dominated by overwhelming amounts of drifting brown algae (Dictyota divaricata and Dictyota sp.) as can be observed in Figure 9. Halimeda incrassata was conspicuous throughout the area with occasional Caulerpa cupressoides, C. sertulariodes, C. prolifera, Udotea flabellum, Avrainvillea nigricans, Penicillus capitatus also present. Many mounds of the ghost shrimp (Callianassa sp.) also occupied the bottom habitat along with many juvenile queen conch (Strombus gigas).

There was a remarkable increase in the number of queen conch throughout the area. The queen conch were all juveniles but ranged in age from less than one year to almost sexually mature (probably over two years of age), where the lip was just beginning to turn outward. There were no mature adults found.

At the outer boundary of the seagrass growth, in plot II, there was a rapid habitat change. The bottom was sandy with many Callianassa mounds and littered with up-side-down jellyfish (Cassiopeia). There was a very distinct difference and a noticeable boundary between these two habitat types. Figure 10 shows this habitat at the edge of seagrass growth. During the last monitoring, occasional seagrass shoots were surviving in this habitat. After a careful survey, seagrass was no longer found in this area.

DISCUSSION

Ten months after the original transplantation of seagrasses it has been confirmed that all three species have successfully become established in selected areas of the recipient site.

Only one habitat type was successful in supporting the establishment of seagrasses. This habitat is characterized by already having a fairly diverse but sparse populations of algal growth. The area is sandy supporting significant populations of both invertebrates and vertebrates. The area is also calm and away from the general current flow pattern. At this time of monitoring, the bottom was covered with masses of tan drift algae gathering in clumps leaving only the tips of the shrimp mounds protruding. This concentration of drift algae confirms that there is little current action sweeping the area. The concentration of drift algae is an indicator of possible concentration of sediments and nutrients necessary to support the growth of seagrasses.

Shoalgrass seems to be the most successful at expanding throughout the area with the manatee grass almost equal in area covered, but much less dense than the shoalgrass. Turtle grass exhibits the slowest growth. All the plugs that were transplanted are surviving with increased growth being evident only during this last visit.

A rough estimate indicates that seagrasses have successfully become established, within a ten months of transplanting, in about 15% of the transplanted area. A seagrass community has been established where one previously did not exist. Considering the value of the seagrass community, if this seagrass community persists and hopefully expands, the transplantation can probably be shown to be well worth the effort.

Seagrass beds provide shelter and feeding grounds for many marine organisms. The seagrass itself provides a substrate for a great diversity of epiphytes which also serve as food for grazing marine organisms. Seagrasses trap and concentrate sediments providing a rich sources of nutrients while at the same time slowing down bottom erosion.

During the next monitoring period, one year after transplantation, estimates will be made on actual biomass, productivity and a dollar value calculated on the worth of moving seagrass to a seagrass barren area.

Figure 4. One of the typical extensive patches of shoalgrass, (Halodule wrightii), grown from transplanted plugs and/or sprigs now found in the successful transplant area as defined in Figure 3.

Figure 5. A representative patch of manatee grass, (Syringodium filiforme), typically found throughout the successful recipient area as defined in Figure 3. Note the pink marker flag in the right hand corner of the photo, indicating the location of a transplanted plug.

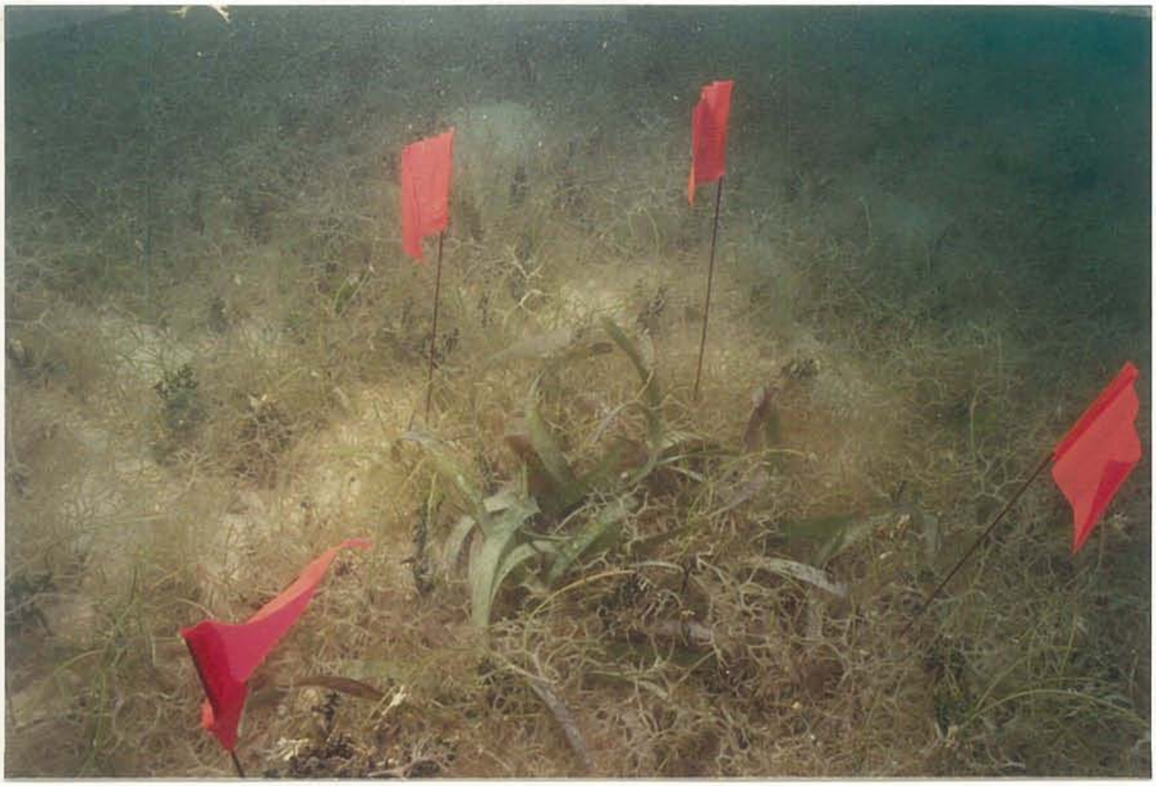

Figure 6. A transplanted plug of turtle grass, (Thalassia testudinum), which has grown laterally. The blades are whole, healthy and show few bite marks from grazers.

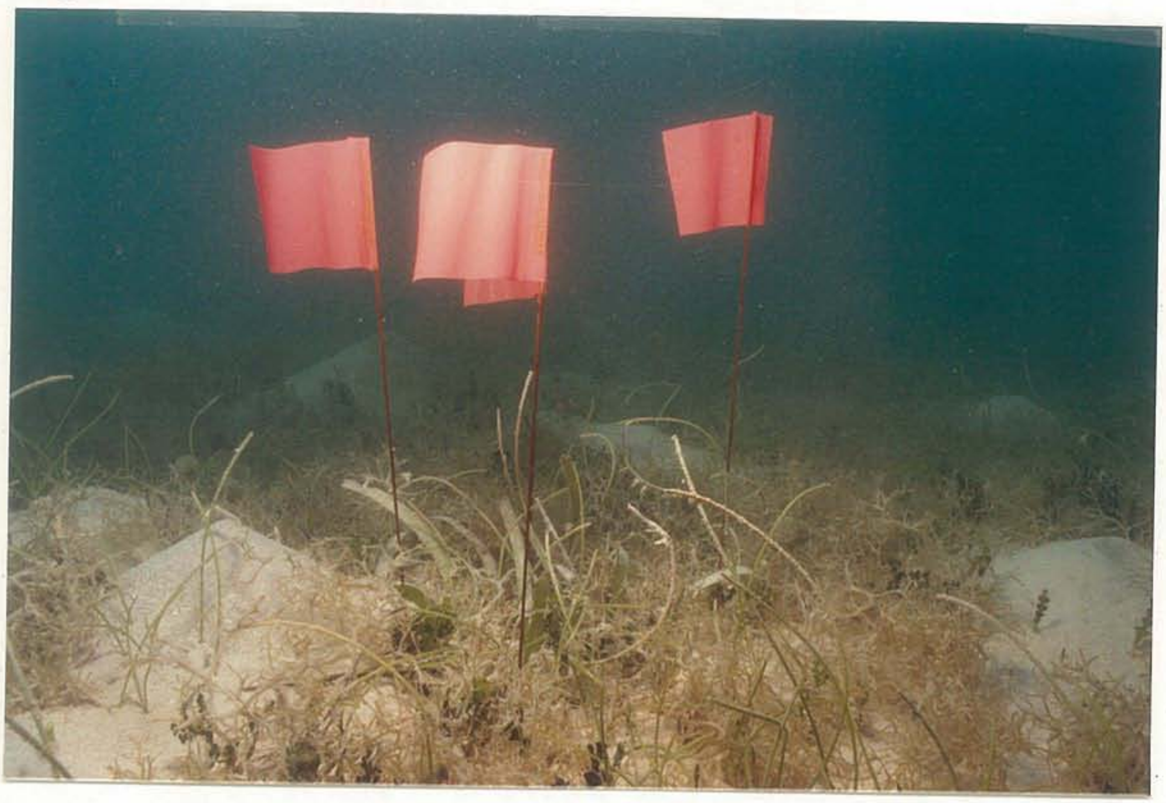

Figure 7. Another transplanted plug of turtle grass, (Thalassia testudinum), that has also grown laterally. Manatee grass, (Syringodium filiforme), is seen interdispersed with the turtle grass.

Figure 8. A representative view of habitat type "B". This habitat type is the only one supporting the growth of all three transplanted species of seagrasses. The many mounds created by ghost shrimp can be seen throughout the area. In the foreground is one of the many juvenile queen conch also found in this area. The seagrass, Halodule wrightii, is prominent as are clumps of tan drift algae.

Figure 9. A transplanted plug of turtle grass, (Thalassia testudinum), that still has live creeping rhizomes and roots buried in the substrate with very few visible shoots. Note the abundance of tan drift algae.

Figure 10. The habitat, type "A", found at the edge of lateral growth of the transplanted seagrasses. This habitat has the many ghost shrimp mounds characteristic of habitat type "B", but lacks any seagrass growth and the diversity of algae species found in the area of successful seagrass transplantation. Characteristic of this area is the abundance of up-side-down jellyfish, brown diatom scum covering the sand, and grazing conch.

REFERENCES

Coulston, M.L. 1987a. Pilot Experimental Seagrass Transplantation Project Phase I. Survey and Revised Methods. Prep. for Island Resources Foundation under contract to V.I. Port Authority.

Coulston, M.L. 1987b. Pilot Experimental Seagrass Transplantation Project Phase II. Seagrass Transplantation. Prep. for Island Resources Foundation under contract to V.I. Port Authority.

Coulston, M.L. 1987c. Pilot Experimental Seagrass Transplantation Project Phase III. Seagrass Monitoring First Quarter 11-12-87. Prep. for Island Resources Foundation under contract to V.I. Port Authority.

Coulston, M.L. 1988a. Pilot Experimental Seagrass Transplantation Project Phase III. Seagrass Monitoring Second Quarter 2-14-88. Prep. for Island Resources Foundation under contract to V.I. Port Authority.

Derrenbacker, J. and R.R. Lewis, III. 1982. Seagrass habitat restoration, Lake Surprise, Florida Keys. Pages 132-154 in R.H. Stoval [ed.]. Proc. 9th Ann. Conf. Wetlands Restoration and Creation. Hillsborough Community College, Tampa, FL.

Fonseca, M.S., W.J. Kenworthy, K.M. Cheap, C.A. Currin and G.W.Thayer. 1984. A low-cost transplanting technique for shoalgrass (Halodule wrightii) and manatee grass (Syringodium filiforme), Instruction Report EL-84-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS, prepared by National Marine Fisheries Service under contract to Environmental Laboratory. 16 pp.

Fonseca, M.S., W.J. Kenworthy and G.W. Thayer. In press a. Transplanting of the seagrasses Halodule wrightii, Syringodium filiforme and Thalassia testudinum for habitat development in the southeast region of the United States. Technical Report, U.S.Army Engineer Waterways Experiment Station, Vicksburg, Mississippi.

Fonseca, M. S., G.W. Thayer and W.J. Kenworthy. In press b. The use of ecological data in the implementation and management of seagrass restorations. Proceeding Thirty-sixth Annual Conference, American Institute of Biological Sciences, to be included in Florida Marine Research Publication Series, Durako M., Phillips, R.C. and Lewis,R.R., [eds.].

Fonseca, M.S., W.J. Kenworthy and G.W. Thayer. 1986. Restoration and Management of Seagrass Systems: A Review. Intl. Symp. Ecol. Mgt. of Wetlands, June16-10. College of Charleston, Charleston, SC.

Fonseca, M. S. and J. S. Fisher. 1986. A comparison of canopy friction and sediment movement between four species of seagrass with reference to their ecology and restoration. Mar. Ecol. Prog. Ser. 29: 15-22.

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Kelly, J. A., Jr., Fuss, C. M. and J. R. Hall. 1971. The transplanting and survival of turtle grass, *Thalassia testudinum*, in Boca Ciega Bay, Florida. Fish. Bull. 69(2): 273-280.

Prince-Tams Joint Venture. 1984. Environmental Assessment Report for Third Port Project, South Shore - St. Croix - U. S. Virgin Islands, Vol. 1 & 2, Prep. V. I. Port Authority.

Thorhaug, A. 1981. Biology and Management of Seagrass in the Caribbean. Ambio 10: 295-298.

Thorhaug, A., B. Miller and B. Jupp. 1984. Seagrass restoration in Caribbean nearshore areas. Final Report U.S.A.I.D. Program. Dept. of Biol. Sci. Florida International Univ.

Williams, S.W. 1987. Assessment of anchor damage and carrying capacity of seagrass beds in Francis and Maho Bays for green sea turtles. VIRMAC III Research Series. Island Resources Foundation. St. Thomas.

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PILOT EXPERIMENTAL SEAGRASS

TRANSPLANTATION PROJECT

PHASE III

SEAGRASS MONITORING

FOURTH QUARTER 08-15-88

Submitted by

Mary Lou Coulston, Ph.D.

Date: August 22, 1988

PILOT EXPERIMENTAL SEAGRASS

TRANSPLANTATION PROJECT

FOURTH QUARTER MONITORING 08-15-88

INTRODUCTION

Seagrass meadows provide a variety of ecological habitats for many fish and invertebrates especially juveniles. Seagrass is also an important food source for many organisms. The seagrass blades provide a substrate for a great diversity of epiphytes which also serve as food for grazing marine organisms. In addition, seagrasses stabilize sediments along the coastal areas collecting sediment and nutrients between the roots, rhizomes and blades which are anchored to and cover the surface. Seagrass provides many important functions, and the protection of such areas is essential to the health and quality of our tropical coastal environments.

It is critical that areas slated for development, requiring the destruction of seagrass, utilize this seagrass for restoration or transplantation to barren areas. Restoration is the most practical approach as it re-establishes seagrass in areas where this stabilizing growth has been removed. Transplantation is less practical and more risky, as it is uncertain whether a transplant will be successful since no seagrass was found there originally. However, because of the high economical value placed on seagrass habitats, transplanting of potentially wasted seagrass should be tried with the hope that a new seagrass area will become established.

A pilot experimental seagrass transplantation project was conducted at the Third Port on the South coast of St. Croix from July 15 to August 14, 1987 (Coulston, 1987b). Three species of seagrass were used in the transplant: turtle grass (Thalassia testudinum), manatee grass (Syringodium filiforme) and shoalgrass (Halodule wrightii). It took twelve days to transplant 1,361 plugs and 10,816 sprigs, for a total of 12,177 planting units from the donor site to cover three acres (12,141 square meters) in the recipient site. The recipient site, in the lee of Ruth Island, is shown in Figure 1. It contains three acres divided into eight plots (numbered I through VII and VIIA) which are shown in detail in Figure 2.

The study required that transplanted areas be monitored quarterly for the first year and annually for two additional years. The first monitoring was done on November 12, 1987, the second monitoring on February 14, 1988 and the third monitoring June 19, 1988 (Coulston 1987c, 1988a and 1988b). This monitoring, the fourth of a scheduled six monitoring periods, was done on August 14 and 15, 1988.

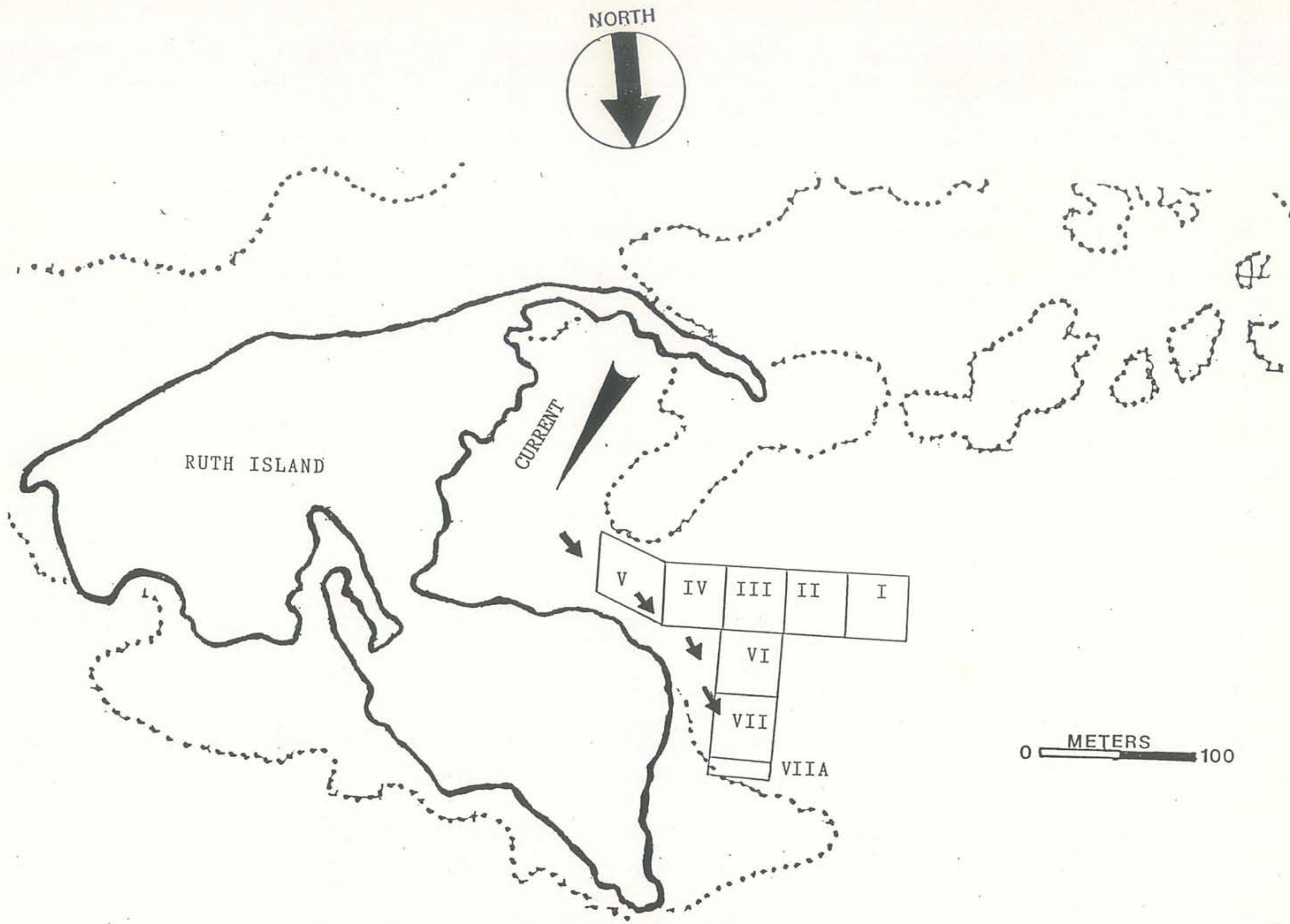


Figure 1. Recipient transplant area showing the location of Plots I through VII and VIIA. The area marked totals three (3) acres.

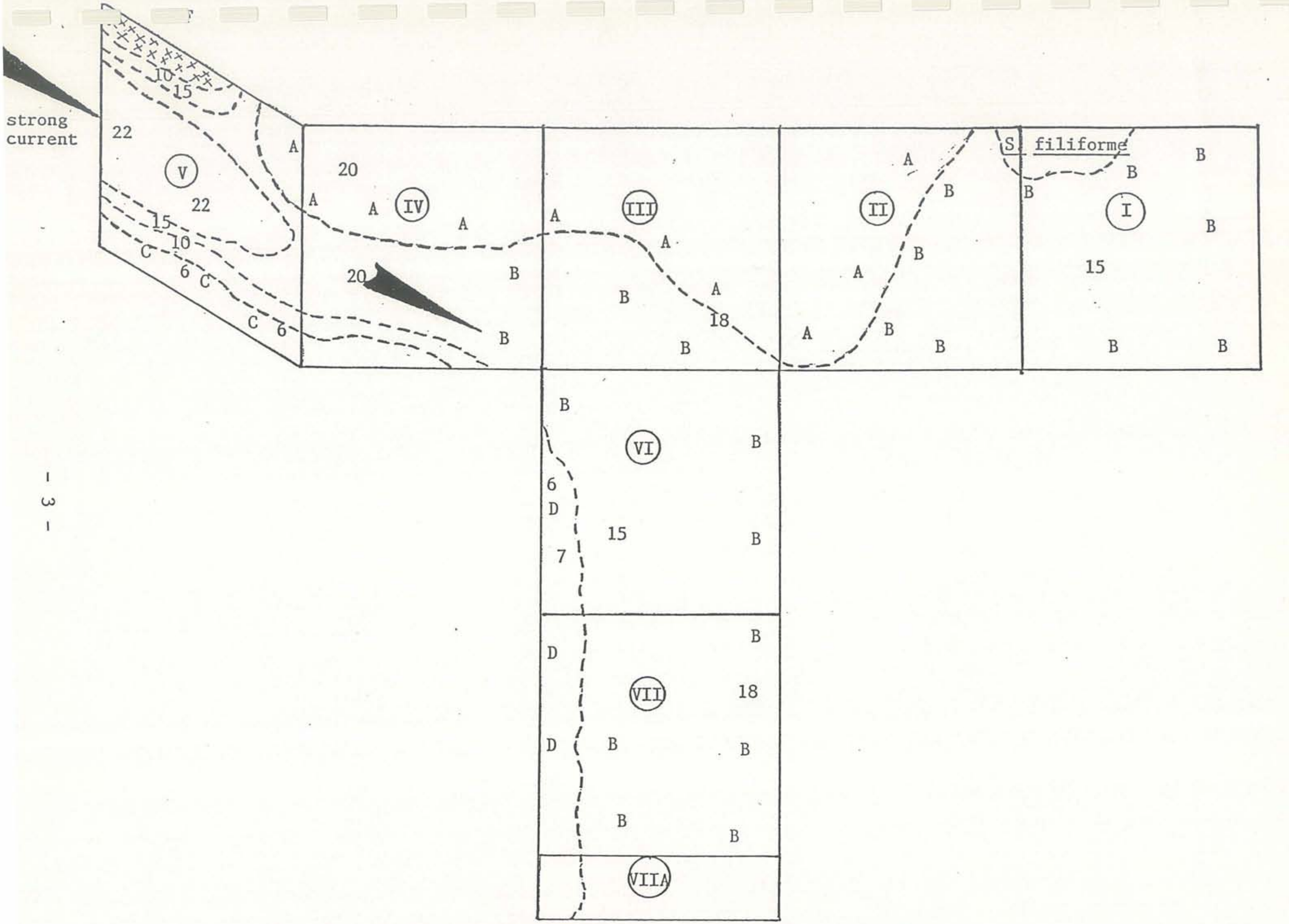


Figure 2. Characteristics of transplant plots showing depths and habitat types.

METHODS

On August 14th the area was surveyed by two divers. In order to make some approximation of the extent of growth, the area of dense seagrass cover was partially marked into meter squares by placing flags at each corner of each meter square. The number of square meters containing any seagrass growth was counted. ~~Figure 3 shows several of the meter square plots marked with flags.~~ *Thalassia* can be seen in the first plot in the foreground. This growth was established from a plug. ~~The plug can be identified by the pink flag, which was used initially to mark each transplanted plug, and is marked with an arrow on the photograph.~~

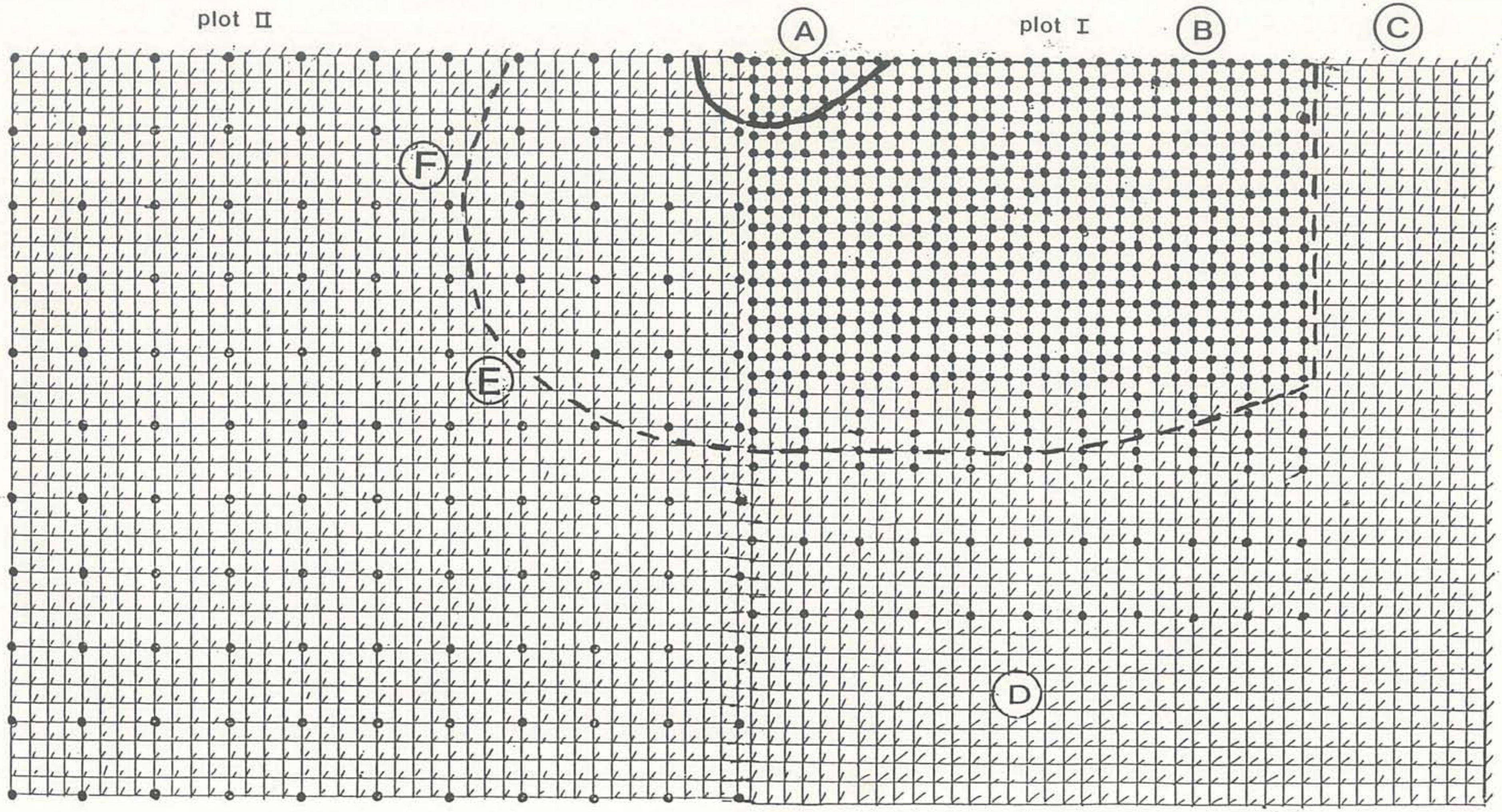
On August 15th selected areas were photographed. Marking of square meters was continued and additional flags were used to mark the edges of seagrass growth. The flags that were used to mark the edge on 6-19-88 were moved outward to mark the new edge of seagrass expansion.

RESULTS

The most noticeable observation was the continued increased expansion of seagrasses *H. wrightii* and *S. filiforme* along with an increase in density. Expansion was easily documented as flags had been placed along the borders of growth on 6-19-88. Flags had to be moved outward to again mark the edge of expanded growth. Increased density was not easily documented as no time was allotted in the study for counting seagrass blades. However, observations by two divers, working on the project from its inception, have noted the increased density in the seagrass cover of *H. wrightii* and *S. filiforme* with each visit to the site.

In the 6-19-88 report a figure was presented (Figure 3, Coulston, 1988b) showing the growth line. This growth line was only an approximation as measurements were not take. In the present monitoring evaluation, a much better estimate of seagrass cover was made. This detailed analysis is shown in Figure 4. Counts on the number of meter squares having seagrass growth were taken and are shown in this figure. Note that seagrass is only found in plots I and II. Section "A", outlined on Figure 4, is an area where sparse *S. filiforme* was originally found growing. The initial selection of the recipient site was based on the finding of this seagrass and establishing the plot at the edge of this growth. Section "B" is the area containing seagrass growth established through transplants. Section "C", planted with sprigs near the end of the transplant phase, to make the site contain exactly 3 acres, shows no sign of seagrass survival. It is quite obvious from the figure, that the area of successful growth centers around the area where plugs were most numerous and planted on meter square centers. It is not conclusive that plug transplants and not habitat type are responsible for the seagrass survival success in this area, but there is certainly no doubt that successful growth is in the area of high plug density.

Figure 3. Area containing seagrass was marked off into meter square plots for determining percent cover. Shown is a Thalassia plug, marked by a pink flag (see arrow), and in the center of the plot additional Thalassia blades can be seen, probably from expanded growth from the transplanted plug.



● Plug ∖ Sprig

Figure 4. Plots I and II are shown above with plug (●) and sprig (∖) transplants noted. Area "A" is where sparse S. filiforme was originally found prior to the transplants. Area "B" is the area where seagrass was found growing. Area "C" is still in plot I, but an area where sprigs were planted, and now has no surviving seagrass. Area "D" is the location of dense growth, dominated by the algae, Halimeda incrassata. Area "E" is a new habitat type dominated by the algae, Acanthophora spicifera. Area "F" is the sandy bottom habitat containing no seagrass or algae growth covered by numerous Cassiopeia jellyfish and Callianassa shrimp mounds.

Utilizing the information obtained by counting the number of meter squares that contain seagrass, it was possible to calculate the percent of the recipient area that had a successful seagrass growth after one year. There were 913 plots of the 11,560 plots that had been planted that had seagrass growth. About 8% of the area planted had seagrass well established.

Transplant effort was calculated as follows:

Collecting	245 man hours
Planting	425 man hours
Transport	109 man hours
TOTAL	779 man hours to plant 3 acres containing 1,361 plugs and 10,816 sprigs

An additional 235 hours were spend in preparation of equipment, survey of potential sites for transplanting, and write-up of results.

The total cost of labor was $12,942 with approximately $9,948 actually spent on the transplanting phase. Administrative and equipment costs were not figured in these totals.

Other observations noted the formation of a definite boundary between the areas of seagrass expansion and the community surrounding the seagrass (see Figure 4, section "D"). In past the algae of this area had been sparse and diversified. At the boundary the Halimeda had become very dense and dominant and there was a definite line between the seagrass and algae. Figure 5 shows this community adjacent to the seagrass expansion (labeled "D" in Figure 4). The dense Halimeda surrounding the seagrass could probably prevent the seagrass from further expansion. This area was originally described as habitat type "B". It has changed extensively from the original transplant to now and is more like habitat type "C" (Coulston, 1978b), where transplanted seagrass failed to survive. It now contains Halimeda incrassata which is dense and dominant.

There were two other communities at the edge of seagrass expansion. At the area marked "E" in Figure 4 there were large patches of the algae, Acanthophora spicifera. ~~This new habitat type can be seen in Figure 6.~~ At the outer boundary of the seagrass growth, in plot II (Figure 4, section marked "F"), the bottom was sandy with many Callianassa mounds and littered with up-side-down jellyfish (Cassiopeia). There was a very distinct difference and a noticeable boundary between these two habitat types and seagrass growth areas.

Also observed were many long aerial runners of Syringodium. Figure 7 shows an example of one of these long runners. The presence of numerous long runners indicate the potential for rapid colonization and expansion of this seagrass.

The turtle grass (T. testudinum) plugs were also continuing to show lateral growth. These were easy to relocate as only one row of turtle grass plugs were planted and many of them still had the staple and pink flag in the center. Figure 8 shows a transplanted plug of turtle grass which has expanded

Figure 5. Dense patch of the algae, Halimeda incrassata, found at the edge of seagrass expansion (see Figure 4, area "D").

Figure 6. Another community found at the edge of seagrass expansion (see Figure 4, area "E") with the dominant algae, Acanthophora spicifera.

Figure 7. Syringodium filiforme showing the presences of a long runner, indicating the potential for rapid colonization and expansion.

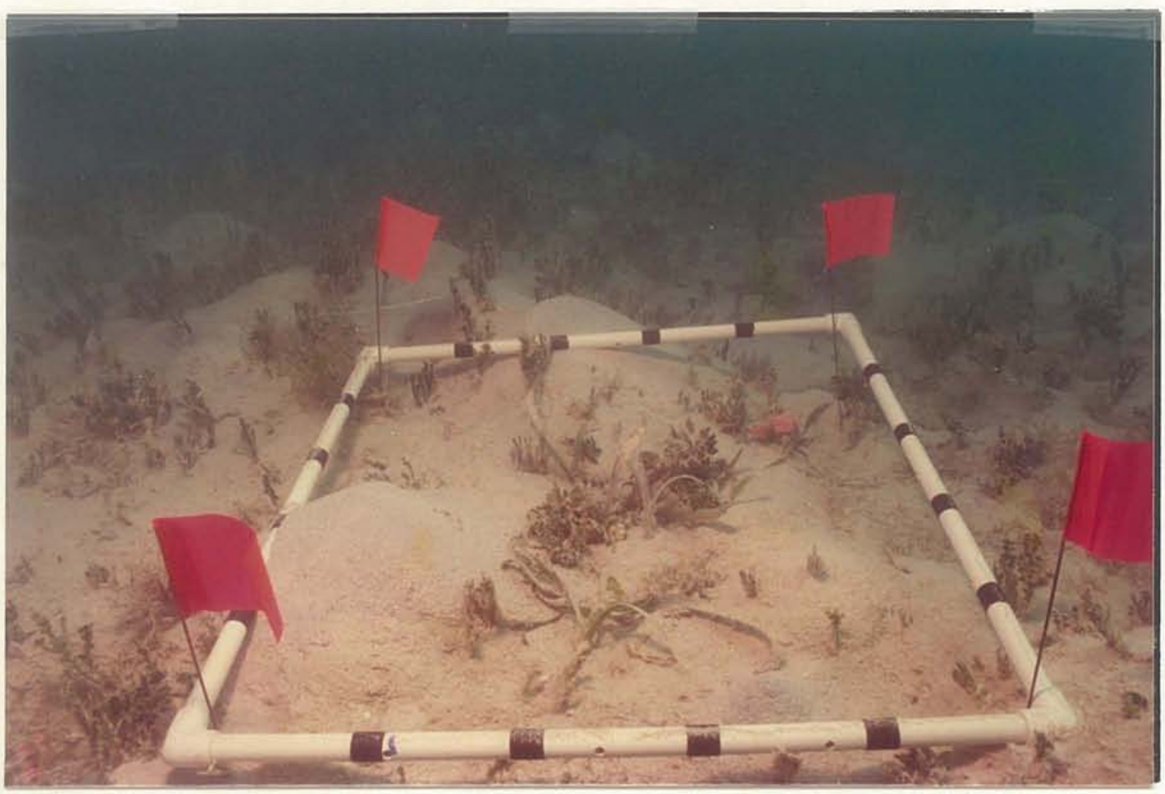


Figure 8. Transplanted plug of Thalassia testudinum showing location of original plug (pink flag) and expansion within a 1/4 m^2 frame.

laterally. Most of the blades were whole, healthy and with little evidence of bite marks from grazers. Another transplanted plug showing lateral growth is shown in Figure 9. Manatee grass is seen interdispersed among the turtle grass blades. The outer edges of growth are shown marked with a 1/4 meter square and flags. These flags were put in place so that during future monitoring increased growth can be measured.

The massive amount of the drift algae, Dictyota divaricata, that had covered the bottom in June had almost all disappeared from the area.

There was a remarkable increase in the number of adult queen conch throughout the area. The queen conch were all juveniles during the last survey ranging in age from less than one year to almost sexually mature (probably over two years of age), where the lip was just beginning to turn outward. During this survey many young adults were found. Figure 10 shows one of the conch typical of those found throughout the area. These are probably the same conch observed during the last survey, but now have matured just in the last two months with the lip completely formed.

DISCUSSION

Twelve months after the original transplantation of seagrasses, it has been confirmed that all three species have successfully become established in selected areas of the recipient site.

Shoalgrass seems to be the most successful at expanding throughout the area with the manatee grass almost equal in area covered, but much less dense than the shoalgrass. Turtle grass exhibits the slowest growth. All the plugs of turtle grass that were transplanted are surviving with increased lateral growth being evident only during this and the last visit.

A fairly accurate survey indicates that seagrasses have successfully become established, within one year of transplanting, in about 8% of the transplanted area. A seagrass community has been established where one previously did not exist.

Transplanting three (3) acres of three (3) different types of seagrasses involved a direct labor cost of $9,947., or about $3,300./acre. Regretably, only about 8% of the areal extent of the transplanted plugs and sprigs (some intermixed as per Figure 4) has become well established and is colonizing adjacent barren areas. Obviously reducing the failure rate would reduce the net cost. The present study clearly identifies the type of habitat that allows for successful colonization of seagrass and future transplanting efforts are expected to be much more successful and very much less costly. With the experience gained from the present study, more suitable areas for seagrass transplants will be easier to identify.

A complete evaluation of the cost of successful transplantation cannot be done effectively at present. The final evaluation can only be done when it is determined if the present rate of expansion will increase, decrease or stablize. The August, 1989 monitoring should provide us with this information.

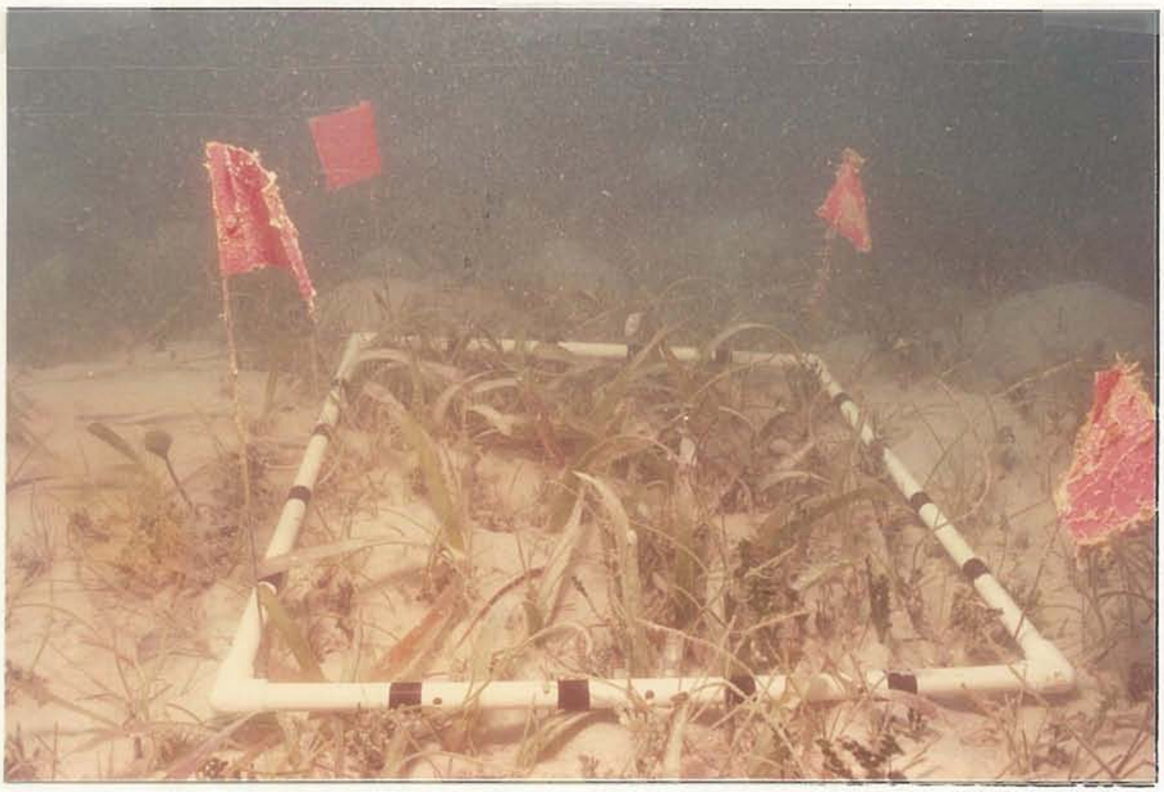


Figure 9. Manatee grass (Syringodium filiforme) is interdispersed among turtle grass (Thalassia testudinum), both originating from seagrass that was transplanted

Figure 10. Queen conch (Strombus gigas) found throughout the area. Most conchs found were of the type shown, approximate $2\frac{1}{2}$ to 3 years of age.

REFERENCES

Coulston, M.L. 1987a. Pilot Experimental Seagrass Transplantation Project Phase I. Survey and Revised Methods. Prep. for Island Resources Foundation under contract to V.I. Port Authority.

Coulston, M.L. 1987b. Pilot Experimental Seagrass Transplantation Project Phase II. Seagrass Transplantation. Prep. for Island Resources Foundation under contract to V.I. Port Authority.

Coulston, M.L. 1987c. Pilot Experimental Seagrass Transplantation Project Phase III. Seagrass Monitoring First Quarter 11-12-87. Prep. for Island Resources Foundation under contract to V.I. Port Authority.

Coulston, M.L. 1988a. Pilot Experimental Seagrass Transplantation Project Phase III. Seagrass Monitoring Second Quarter 2-14-88. Prep. for Island Resources Foundation under contract to V.I. Port Authority.

Coulston, M.L. 1988b. Pilot Experimental Seagrass Transplantation Project Phase III. Seagrass Monitoring Third Quarter 06-19-88. Prep. for Island Resources Foundation under cotract to V.I. Port Authority.

Derrenbacker, J. and R.R. Lewis, III. 1982. Seagrass habitat restoration, Lake Surprise, Florida Keys. Pages 132-154 in R.H. Stoval [ed.]. Proc. 9th Ann. Conf. Wetlands Restoration and Creation. Hillsborough Community College, Tampa, FL.

Fonseca, M.S., W.J. Kenworthy, K.M. Cheap, C.A. Currin and G.W.Thayer. 1984. A low-cost transplanting technique for shoalgrass (Halodule wrightii) and manatee grass (Syringodium filiforme), Instruction Report EL-84-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS, prepared by National Marine Fisheries Service under contract to Environmental Laboratory. 16 pp.

Fonseca, M.S., W.J. Kenworthy and G.W. Thayer. In press a. Transplanting of the seagrasses Halodule wrightii, Syringodium filiforme and Thalassia testudinum for habitat development in the southeast region of the United States. Technical Report, U.S.Army Engineer Waterways Experiment Station, Vicksburg, Mississippi.

Fonseca, M. S., G.W. Thayer and W.J. Kenworthy. In press b. The use of ecological data in the implementation and management of seagrass restorations. Proceeding Thirty-sixth Annual Conference, American Institute of Biological Sciences, to be included in Florida Marine Research Publication Series, Durako M., Phillips, R.C. and Lewis,R.R., [eds.].

Fonseca, M.S., W.J. Kenworthy and G.W. Thayer. 1986. Restoration and Management of Seagrass Systems: A Review. Intl. Symp. Ecol. Mgt. of Wetlands, June16-10. College of Charleston, Charleston, SC.

Fonseca, M. S. and J. S. Fisher. 1986. A comparison of canopy friction and sediment movement between four species of seagrass with reference to their ecology and restoration. Mar. Ecol. Prog. Ser. 29: 15-22.

Holtz, S. 1986. Tropical Seagrass Restoration. Restoration & Management Notes 4 (1): 4-11.

Kelly, J. A., Jr., Fuss, C. M. and J. R. Hall. 1971. The transplanting and survival of turtle grass, Thalassia testudinum, in Boca Ciega Bay, Florida. Fish. Bull. 69(2): 273-280.

Prince-Tams Joint Venture. 1984. Environmental Assessment Report for Third Port Project, South Shore - St. Croix - U. S. Virgin Islands, Vol. 1 & 2, Prep. V. I. Port Authority.

Thorhaug, A. 1981. Biology and Management of Seagrass in the Caribbean. Ambio 10: 295-298.

Thorhaug, A., B. Miller and B. Jupp. 1984. Seagrass restoration in Caribbean nearshore areas. Final Report U.S.A.I.D. Program. Dept. of Biol. Sci. Florida International Univ.

Williams, S.W. 1987. Assessment of anchor damage and carrying capacity of seagrass beds in Francis and Maho Bays for green sea turtles. VIRMAC III Research Series. Island Resources Foundation. St. Thomas.

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PILOT EXPERIMENTAL SEAGRASS TRANSPLANTATION PROJECT
THIRD PORT, BULK LIQUID TERMINAL DOCK
DREDGE AND FILL AREA
SOUTH SHORE, ST. CROIX
U.S. VIRGIN ISLANDS

PHASE III
SEAGRASS MONITORING
ANNUAL SITE RESURVEY REPORT

PREPARED BY
Mary Lou Coulston, Ph.D.
RESEARCH ASSOCIATE

PREPARED FOR
THE VIRGIN ISLANDS PORT AUTHORITY
UNDER CONTRACT DATED JUNE 25, 1987

December 1, 1990

Cover: Area Where seagrass was transplanted. Both turtle grass (wide blade) and manatee grass (thin blade) are shown. The flagging stake placed to identify where plugs were transplanted is now covered with a white bushy algae (Acanthophora spicifera) and the flag is no longer visible. Several species of alga along with sandy Callianassa shrimp mounds.

Photo credit: All photographs in this report were taken on April 5, 1990, by Henry Tonnemacher.

PILOT EXPERIMENTAL SEAGRASS TRANSPLANTATION PROJECT
THIRD PORT, BULK LIQUID TERMINAL DOCK
DREDGE AND FILL AREA
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PREPARED FOR
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BY
Principal Investigator
Mary Lou Coulston, Ph.D.

Island Resources Foundation
Red Hook Box 33, St. Thomas
Charlotte Amalie, VI 00802
December 1, 1990

FORWARD

Seagrasses, just like more terrestrial beach grasses and field grasses, stabilize the sediments in which they grow against the subtle, erosive forces of fluids in motion. In the Virgin Islands, as with most other tropical island coastlines, unconsolidated sandy bottom sediments in shallow inshore areas are largely anchored in place by one or more of the several species of seagrasses commonly known as turtle grass, shoalgrass and manatee grass. These submerged grass beds, some expansive like meadows, others patchy and clumpy, many with a mixture of more than one species, serve as a primary producer of nutritious food for a large number of marine organisms. Additionally, they provide a favorable nursery habitat for juvenile fish including many touristically important and commercially valuable species. Seagrasses are, in sum, a very important part of an island shoreline providing a subtle, fringe-like, energy-absorbing storm barrier between arriving ocean storm waves and easily eroded, sandy coastal beaches.

But there is trouble in paradise! Even a hasty inspection of coastal aerial photographs from three to four decades ago compared with those shot just before Hurricane Hugo suggest drastic losses in seagrass areas. The photos confirm what every keen diver, active fisherman, coral reef scientist and regular local recreational snorkeler has, for some time now, been reporting with alarm -- namely, that seagrass beds on the Virgin Islands inshore platform are being diminished in scope, contiguity and density, and probably productivity as well.

As for the probable causes of this insidious decline in coastal vegetation biomass, the list is depressingly long -- sediments from excessive dredging, siltation from upland watershed runoff, direct boat anchor damage, non-point-source pollution, algal blooms, turbidity, nutrient overloads, and broken ocean outfalls discharging untreated sewage. None of these are easily remedied in the short run. But what can be done to mitigate the loss process? What should be done to compensate?

The answer is, whenever possible, repair damaged sea grassbeds and when anticipated losses are an inevitable consequence of development activity deemed important, salvage some or all of the doomed seagrass stock and transplant it to nearby damaged areas, or protected areas, likely to accept the transplant. Learning how to accomplish these tasks and do them efficiently is what this project was all about. We know that it works on the south shore of St. Croix. The Virgin Islands now needs to find ways to accomplish the same task under differing conditions and at a lower unit cost.

Dr. Edward L.Towle
President
Island Resources Foundation

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ISLAND RESOURCES FOUNDATION FOR THE VIRGIN ISLANDS PORT AUTHORITY
ANNUAL MONITORING 04-05-90

INTRODUCTION

A pilot experimental seagrass transplantation project was conducted at the Third Port on the south coast of St. Croix from July 15, to August 14, 1987 (Coulston, 1987b). Three species of seagrass were used in the transplant: turtle grass (*Thalassia testudinum*), manatee grass (*Syringodium filiforme*) and shoalgrass (*Halodule wrightii*). It took twelve days and eight people to transplant 1,361 plugs and 10,816 sprigs, for a total of 12,177 planting units from the donor site to cover three acres (12,141 square meters) in the recipient sites in the lee of Ruth Island, as shown in Figure 1. The recipient site contains three acres divided into eight plots (numbered I through VII and VII-A) which are shown in detail in Figure 2.

The project required that the transplanted areas be monitored quarterly for the first year and annually for two additional years. Monitoring was done on November 12, 1987 (Coulston, 1987c), February 14, 1988 (Coulston, 1988a), June 19, 1988 (Coulston, 1988b), and August 15, 1988 (Coulston, 1988c). The first annual monitoring was scheduled to take place in August of 1989. It was delayed by adverse weather and sea conditions in August and further postponed by Hurricane Hugo which hit St. Croix on September 17-18 of 1989. During the following year, other, higher priority environmental survey tasks kept intruding on the periodically rescheduled and the canceled return visit to the Ruth Island seagrass transplant area.

The site was finally resurveyed by the original principal investigator on April 5, 1990, some two years and eight months after the original seagrass transplant exercise. That significant portions of the original experimental seagrass transplant areas and many of the original plug marker flags and plot boundary lines survived the effects of Hurricane Hugo was surprising to all investigators associated with the project and suggests a far more rapid and successful rooting process prevailed than had earlier been assumed to be the case.

METHODS

On April 5, 1990, the target transplant area west of Ruth Island on the south shore of St. Croix, was surveyed by Dr. Mary Lou Coulston and research technician/photographer, Henry Tonnemacher. The area was first examined to determine the extent of seagrass growth before proceeding with a more detailed evaluation. The last "quarterly" survey was conducted on August 18, 1988, and the results of that survey are summarized in Figure 3.

After determining the new boundary of surveying moderately dense seagrass growth, a guideline, measured off in meters, was placed along the side of Plot I, beginning at Line 9 within the plot extending to the end of the plot (Figure 4). Original plot stakes and plot lines could all be re-located leaving no doubt about relocating the area of original transplant. Area "C" in Plot I (Figure 3) still had no seagrass growing; therefore the evaluation began east of that plot.

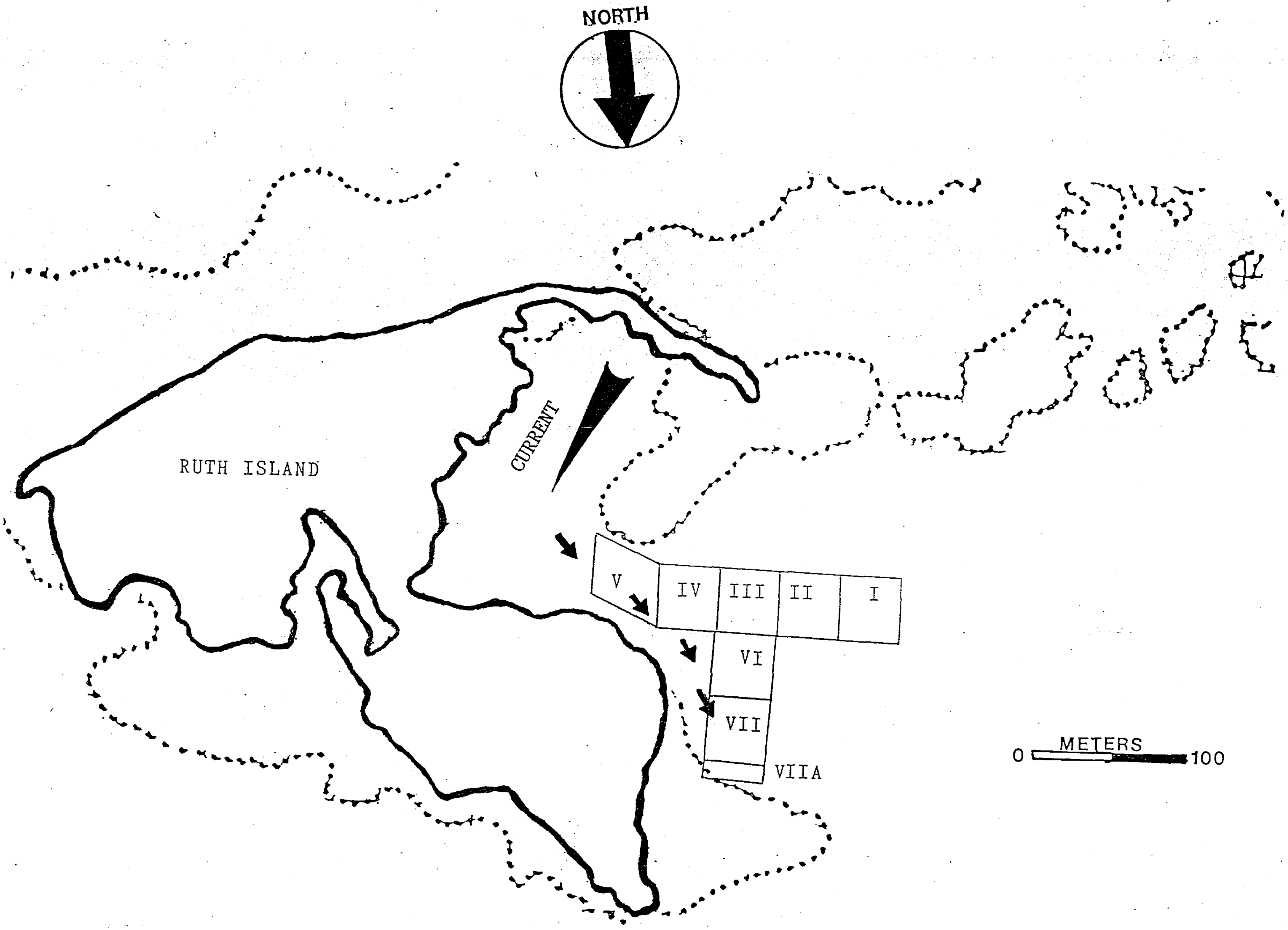

Figure 1. Recipient transplant area showing the location of Plots I through VII and VIIA. The area marked totals three (3) acres.

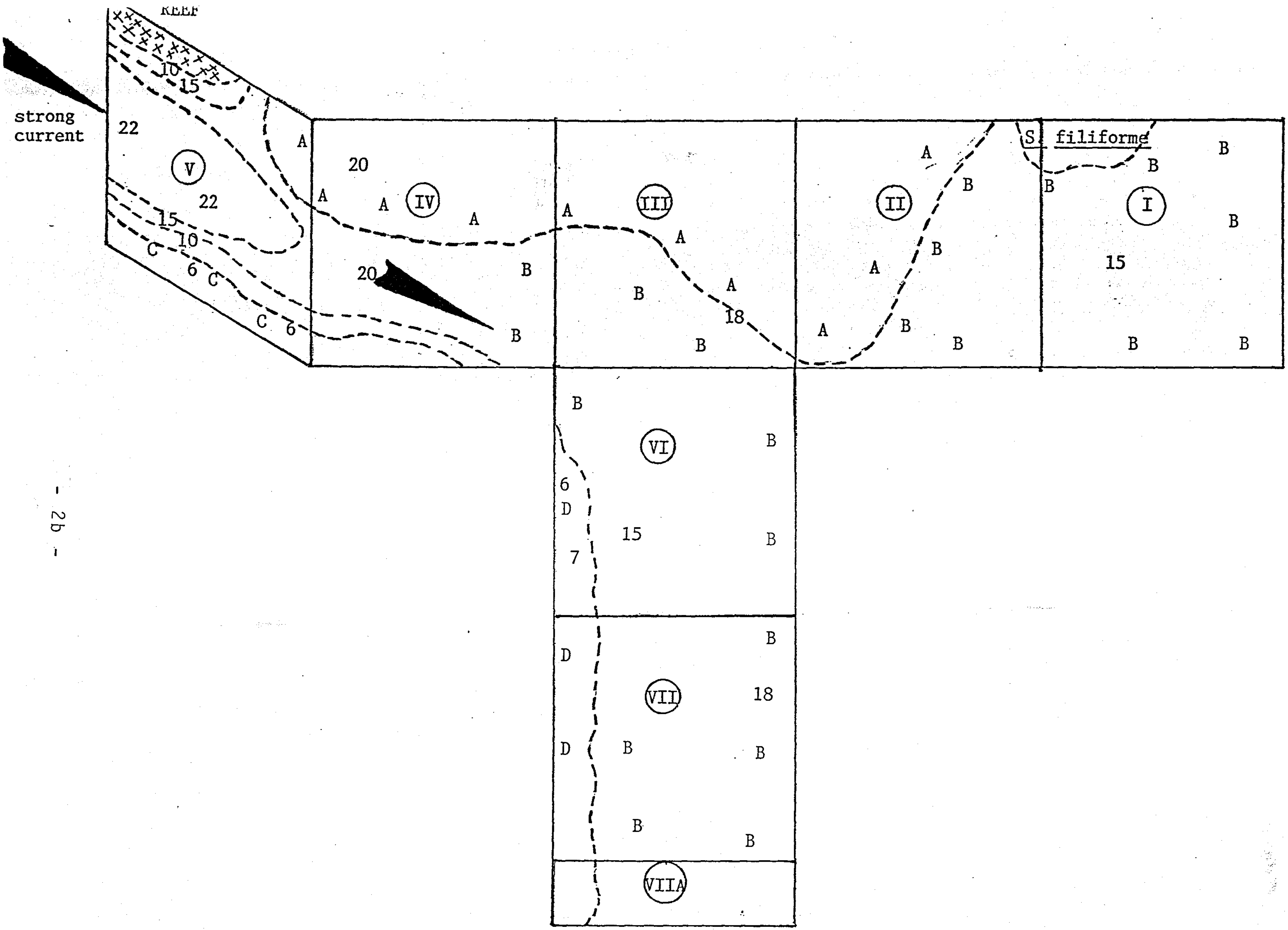

Figure 2. Characteristics of transplant plots showing depths and habitat types.

The divers moved along the guideline, meter by meter. A meter-long piece of PVC, marked off in 10 cm increments, was moved along the line and placed perpendicular to the line (Figure 5). In this manner a meter square could be defined and evaluated. Within each meter the percent cover of shoalgrass (Table 1), manatee grass (Table 2), and number of sprigs of turtle grass (Table 3) was estimated or counted. When the first line was completed, the guideline (marked off in meters) was moved laterally one meter and the evaluation repeated. The exact area surveyed is outlined in Figure 4.

RESULTS

Percent cover by shoal grass is presented in Table 1, percent manatee grass cover in Table 2 and the number of sprigs of turtle grass for each meter is found in Table 3. Since such an in-depth analysis was not done in the past it is difficult to determine with any assuredness if the grass density is increasing or declining. What is certain is that all three species of seagrasses are still present and surviving well in the area.

Recent lateral expansion of seagrass, compared to past monitoring, is difficult to determine. There is new seagrass outside the defined study plot, but it would have taken another day of surveying to determine the extent of this expansion. This was not included in the Port Authority contract.

Table 2 shows that manatee grass is exhibiting the greatest density and percent cover of the largest area among the three grasses. Turtle grass is still present, but the distribution is scattered and clumped (Table 3). The highest density is still in the areas where the original turtle grass plugs were planted. Shoal grass, once thought to be the most successful colonizer of the area, is now (post Hurricane Hugo) showing reduced densities (see Table 1).

DISCUSSION

Seagrass meadows provide a variety of ecological habitats for many fish and invertebrates, especially juveniles. Seagrass is also an important food source for many organisms. The seagrass blades provide a substrate for a great diversity of epiphytes which also serve as food for grazing marine organisms. In addition, seagrasses stabilize sediments along the coastal areas, collecting sediment and nutrients between the roots, rhizomes and blades which are anchored to and cover the surface. Seagrass provides many important functions, and the protection of such areas is essential to the health and quality of our tropical coastal environments.

When shallow inshore seagrass areas are slated for development, and the activity involves the destruction of seagrass, this healthy but doomed seagrass should, as far as possible, be utilized as "nursery stock" for restoration of barren or damaged areas which previously had seagrass "meadows." Transplantation is the most practical approach as it re-establishes mature seagrass in areas where this stabilizing growth has been removed.

The case is certainly strong supporting the conclusion that a successful transplant was accomplished in the dredge and fill area mitigation experiment for the Third Port, bulk liquid terminal dock (Coulston, 1990). Ten acres of seagrass was lost forever when the area was dredged and filled, but some of that seagrass was used to establish a new seagrass bed, now approximately 1/2 acre off of Ruth Island. The seagrass is well established, although after only one post-Hugo resurvey, it is uncertain if density and expansion are currently increasing or decreasing. What is known is that three species were successfully transplanted and are still present in one, approximately 1/2-acre plot. It is noteworthy that those transplanted areas nearest the channel, with even its mild wind and tidal-driven currents, are the areas which fared the worst. And even the force of Hurricane Hugo did not noticeably disturb the seagrass bed segments deep under the lee of Ruth Island and in its westerly facing embayment. And the rope line defining the area (Figures 6 and 7) and flags marking transplanted plugs also remained in place after the storm (Figures 8 and 9).

RECOMMENDATIONS

With special care to select suitably low-energy recieving environments, additional experimental seagrass "salvage," or mitigation transplantation projects, should be carried out with a view to improving local target site selection criteria.

Benthic sediment chemistry should be investigated on the next transplant project as part of the recovery site selection process.

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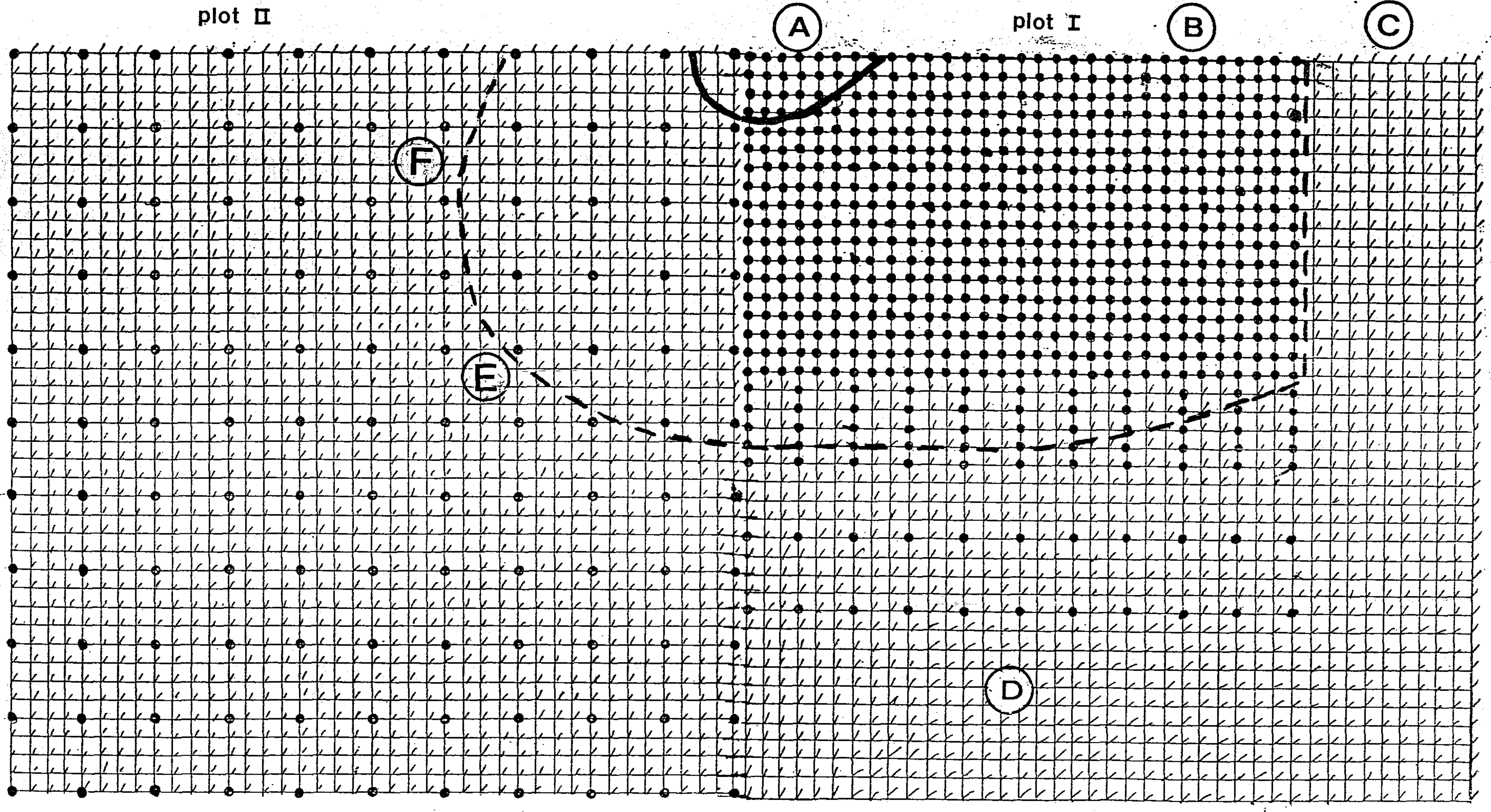

● Plug

\ Sprig

Figure 3. Plots I and II are shown above with plug (•) and sprig (\) transplants noted. Area "A" is where sparse S. filiforme was originally found prior to the transplants. Area "B" is the area where seagrass was found growing. Area "C" is still in plot I, but an area where sprigs were planted, and now has no surviving seagrass. Area "D" is the location of dense growth, dominated by the algae, Halimeda incrassata. Area "E" is a new habitat type dominated by the algae, Acanthophora spicifera. Area "F" is the sandy bottom habitat containing no seagrass or algae growth covered by numerous Cassiopeia jellyfish and Callianassa shrimp mounds.

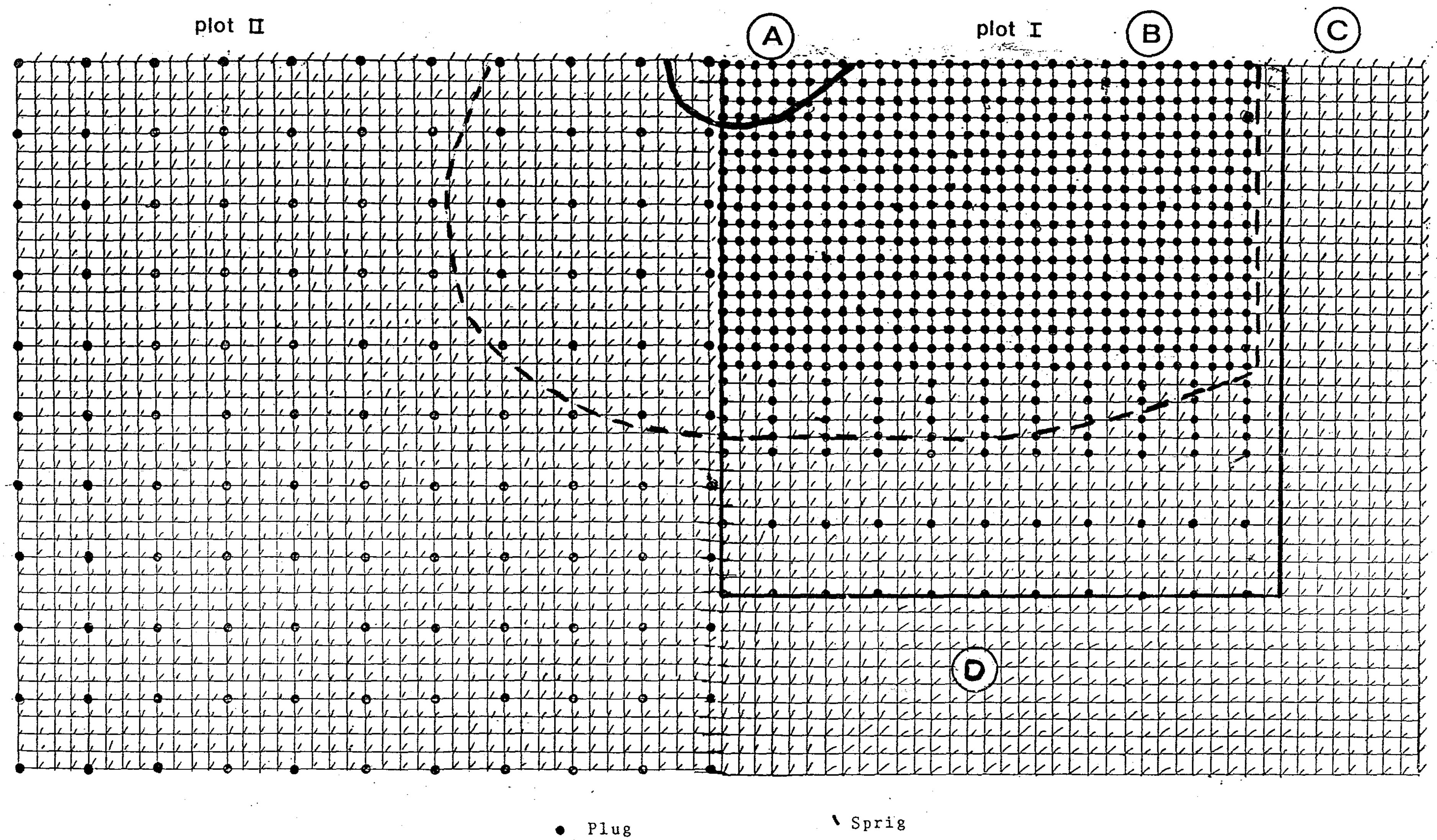

Figure 4. Plots I and II as shown in Figure 3. The intensely surveyed area is outlined. Data was taken within each meter square of the outlined areas for percent cover of shoalgrass and manatee grass and the number of blades of turtlegrass. Seagrass cover was also observed east of the area and northeast of the area, but was sparce and density not estimated. There was still no seagrass cover in areas "C" and "D".

ROWS EAST AND WEST

	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
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Table 1. Estimated percent cover of shoalgrass for each meter square./p

	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
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28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30	30	60	0	0	60	20	60
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26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	80	60	20	50	20	60	40	40	40
25	0	0	0	0	0	0	0	0	0	0	0	0	0	10	30	0	0	0	0	0	0	10	40	50	30	40	10	30	80	70	70	70
24	0	0	0	0	0	0	0	0	0	0	0	0	0	10	70	20	0	0	0	0	0	0	10	40	30	50	50	60	60	30	30	30
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	70	50	0	0	0	0	0	0	0	0	10	40	60	80	80	50	50
22	0	0	0	0	0	0	0	0	0	0	0	0	20	0	0	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	10	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	50	60	10	10	10	10	0	80	10	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	40	60	80	60	40	40	30	20	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	50	80	70	80	60	50	30	30	20	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	50	50	20	40	30	20	20	40	30	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	50	40	20	20	20	20	10	20	10	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	30	20	10	0	0	0	0	10	30	50	20	40	50	50	20	10	0	0	10	0	0
12	0	0	0	0	0	0	0	0	10	30	50	20	30	0	0	0	0	20	30	10	20	10	20	80	50	0	0	0	0	0	10	0
11	0	0	0	0	0	0	0	0	0	10	40	70	50	10	10	0	0	0	0	10	10	10	10	10	20	90	30	0	0	10	0	0
10	0	0	0	0	0	0	0	0	0	0	10	40	60	90	50	10	10	0	0	0	0	0	10	10	70	20	50	50	0	40	0	0
9	0	0	0	0	0	0	0	0	0	50	90	70	70	50	10	0	0	0	0	0	10	10	20	20	50	60	10	0	20	10	0	0
8	0	0	0	0	0	0	0	0	20	80	80	60	10	20	10	20	10	0	0	0	0	0	10	40	30	30	50	60	60	10	20	20
7	0	0	0	0	0	0	0	30	70	60	80	60	20	20	10	0	0	0	0	0	0	0	20	30	80	70	60	10	20	10	0	0
6	0	0	0	0	0	0	0	0	0	20	40	60	50	30	20	20	10	0	10	0	0	0	0	10	20	30	30	10	0	30	10	50
5	0	0	0	0	0	0	0	0	0	0	0	10	60	60	50	30	20	10	0	10	0	0	0	10	10	20	60	30	10	0	0	0
4	0	0	0	0	0	0	0	0	0	0	10	10	60	70	80	20	20	20	10	0	5	5	20	30	30	60	70	20	10	0	0	0
3	0	0	0	0	0	0	0	0	0	30	70	90	20	90	50	10	20	20	10	20	50	80	80	70	70	80	10	0	0	0	0	0
2	0	0	0	0	0	0	0	0	10	30	20	50	90	50	90	70	40	30	10	20	50	50	80	90	80	30	30	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0	30	20	20	5	10	60	90	60	90	90	90	50m	100	80	20	0	10	0	0	0	0	10

Table 2. Estimated percent cover of manatee grass for each meter square.

NUMBER OF SPRIGS OF THALASSIA TESSTUDINUM FOR EACH METER SQUARE OF PLANTED BOTTOM

	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0	0	0	0	0	5	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0	0	0	0	0	13	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	31	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	27	0	0	0	0	0	0	0	2	0	0	0	0	0	25	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	45	21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	7	10	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	10	0	0	0	0	0	0	19	0	8	34	22	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	46	26	0	0	0	0	0	0	11	4	0	0	0	0	0	0	0
3	5	4	10	4	1	0	0	0	0	0	0	0	0	42	52	8	5	0	9	0	14	10	21	3	20	11	19	0	0	0	0	0
2	18	8	8	1	0	0	0	3	10	0	3	0	0	9	5	0	10	4	11	0	7	1	11	0	0	13	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	4	14	1	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 3. Number of blades of turtle grass per square meter.

photographs

Figure 5. A meter length of PVC pipe, marked off in 10 cm segments, was placed perpendicular to a guideline (not shown) marked off in meters. Divers then used this meter and the meter marked of on the guideline to define a meter square in order to estimate percent cover and count grass blades within each plot.

Figure 6. Flags originally put in to mark the transplanted plugs are still visible throughout the area even though they are covered with algae growth.

Figure 7. Flag shown covered with algae growth, but still in place despite the pounding from Hurricane Hugo. All lines and many flags were still found on the bottom after the storm.

Figure 8. One of the original lines defining the plot; north side of plot I.

Figure 9. Original lines defining plot I; the northwest corner.

Figure 10. A patch of *Thalassia testudinum*, turtle grass in the transplanted area.

Figure 11. A patch of *Syringodium filiforme*, manatee grass.

Figure 12. View of seagrass transplant area.

Figure 13. View within seagrass transplant area showing a pink tipped anemone, *Condylactus giganteus*.

REFERENCES

Coulston, M.L. 1987a. Pilot experimental seagrass transplantation project. Phase I. Survey and Revised Methods. Prep. for Island Resources Foundation under contract to V.I. Port Authority.

______. 1987b. Pilot experimental seagrass transplantation project. Phase II. Seagrass transplantation. Prep. for Island Resources Foundation under contract to V.I. Port Authority.

______. 1987c. Pilot experimental seagrass transplantation project. Phase III. Seagrass monitoring first quarter 11-12-87. Prep. for Island Resources Foundation under contract to V.I. Port Authority.

______. 1988a. Pilot experimental seagrass transplantation project. Phase III. Seagrass monitoring second quarter 2-14-88. Prep. for Island Resources Foundation under contract to V.I. Port Authority.

______. 1988b. Pilot experimental seagrass transplantation project. Phase III. Seagrass monitoring third quarter 6-19-88. Prep. for Island Resources Foundation under contract to V.I. Port Authority.

______. 1988c. Pilot experimental seagrass transplantation project. Phase III. Seagrass monitoring fourth quarter 8-15-88. Prep. for Island Resources Foundation under contract to V.I. Port Authority.

______. 1991. Seagrass meadows: pasturelands of the sea. Agrifest Bulletin 1991. V.I. Dept. of Agric. and Univ. of V.I. CES and AES.

Derenbecker, J. and R.R. Lewis, III. 1982. Seagrass habitat restoration, Lake Surprise, Florida Keys. Pages 132-154 in R.H. Stoval [ed.]. Proc. 9th Ann. Conf. Wetlands Restoration and Creation. Hillsborough Community College, Tampa, FL.

Fonseca, M.S., W.J. Kenworthy, K.M. Cheap, C.A. Currin and G.W. Thayer. 1984. A low-cost transplanting technique for shoalgrass (Halodule wrightii) and manatee grass (Syringodium filiforme), Instruction Report EL-84-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS, prepared by National Marine Fisheries Service under contract to Environmental Laboratory. 16 pp.

______, W.J. Kenworthy and G.W. Thayer. In press. Transplanting of the seagrasses Halodule wrightii, Syringodium filiforme, and Thalassia testudinum for habitat development in the southeast region of the United States. Technical Report, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

REFERENCES, cont....

Fonseca, M.S., G.W. Thayer and W.J. Kenworthy. In press. The use of ecological data in the implementation and management of seagrass restorations. Proceeding Thirty-sixth Annual Conference, American Institute of Biological Sciences, to be included in Florida Marine Research Publication Series, Durako M., Phillips, R.C. and Lewis, R.R., [eds.].

___________, W.J. Kenworthy and G.W. Thayer. 1986. Restoration and Management of Seagrass Systems: A Review. Intl. Symp. Ecol. Mgr. of Wetlands, June 16-10, College of Charleston, Charleston, SC.

___________ and J.S. Fisher. 1986. A comparison of canopy friction and sediment movement between four species of seagrass with reference to their ecology and restoration. Mar. Ecol. Prog. Ser. 29: 15-22.

Kelly, J.A., Jr., Fuss, C.M. and J.R. Hall. 1971. The transplanting and survival of turtle grass, *Thalassia testudinum*, in Boca Ciega Bay, Florida. Fish. Bull. 69(2): 273-280.

Prince-Tams Joint Venture. 1984. Environmental Assessment Report for Third Port Project, South Shore - St. Croix - U.S. Virgin Islands, Vol. 1 & 2, Prep. V.I. Port Authority.

Thorhaug, A. 1981. Biology and Management of Seagrass in the Caribbean. Ambio 10: 295-298.

___________, B. Miller and B. Jupp. 1984. Seagrass restoration in Caribbean nearshore areas. Final Report U.S. AID Program. Dept. of Biol. Sci., Florida International Univ.

Williams, S.W. 1987. Assessment of anchor damage and carrying capacity of seagrass beds in Francis and Maho Bays for green sea turtles. VIRMC III Research Series. Island Resources Foundation, St. Thomas, USVI.