THE TRANSPLANTING AND SURVIVAL OF TURTLE GRASS, *Thalassia testudinum*, IN BOCA CIEGA BAY, FLORIDA[1]

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ABSTRACT

Turtle grass was transplanted to an unvegetated, dredged canal and a hand-cleared portion of a flourishing grass bed. Complete or partial success was attained in 7 of 14 methods used. The best method, in which short-shoots (rhizomes removed) were dipped in a solution of plant hormone (Naphthalene Acetic Acid) and attached to construction rods for transplanting, was 100% successful and may be suitable for general application.

Turtle grass, *Thalassia testudinum*, and other marine grasses are an invaluable asset to the marine ecosystem. They are primary producers and form an essential ecological niche in which a great number and variety of species find food and shelter. They are also important agents in the control of substrate erosion and the depositions of sediments (Stephens, 1966).

Uncontrolled dredging and filling of submerged lands have destroyed many turtle grass beds and their dependent fauna, some of which are economically important. An immediate need exists not only for sharply restricting further destruction of sea grass beds but also for replacing lost beds. One method of replacing them may be by transplanting sea grasses to areas that are suitable for their growth or to areas that are made favorable by soundly planned engineering (Phillips, 1960; Strawn, 1961). Areas surrounding spoil banks and finger-fill canals (dredged canals between filled land masses) would be suitable if they were constructed to supply zones of optimum depth for growth of marine grasses.

Unsuccessful earlier attempts to transplant turtle grass in Tampa Bay showed that the main problem was erosion by tidal currents. Turtle grass is buoyant, and new transplants tend to work free of the sediments and float to the surface when disturbed by water movement (Phillips, personal communication).[3] Another marine plant, eelgrass (*Zostera marina*), was transplanted successfully on the coast of Washington by Phillips (1967) and in the Aleutian Islands by Jones[4] and McRoy[5] (personal communication), but details on methods are not yet published. Successful growth of turtle grass under artificial conditions (Fuss and Kelly, 1969) led us to attempt transplanting it from one field location to another as described in the present paper.

Turtle grass spreads vegetatively by creeping rhizomes (long-shoots) buried in the substrate (Figure 1). Work by Tomlinson and Vargo (1966) showed that this growth is dependent entirely upon the vigorous activity of meristematic tissue in the apexes of rhizomes. The apex is also the only source of short-shoots (erect lateral branches) that develop from buds at this site. In the Miami area (Phillips, 1960) and tropical parts of its range, the plants also reproduce by flowering. Tampa Bay, however, is near the northern limit of the flowering capability of *Thalassia* (Phillips, 1960); thus, we

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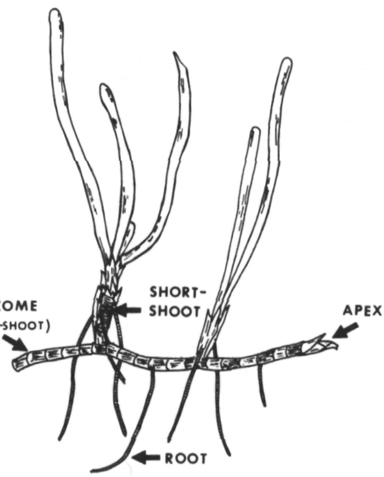

FIGURE 1.—External features of *Thalassia testudinum*.

confined our restoration studies to the transplantation of adult plants. This paper describes the procedures for and results of transplantation of turtle grass into modified environments.

DESCRIPTION OF TRANSPLANT SITES

All experiments took place in the southern end of Boca Ciega Bay, Fla., an elongate coastal lagoon joined to Tampa Bay and separated from the Gulf of Mexico by a line of barrier islands (Figure 2). The area it encompasses is a paramount example of grass bed destruction by hydraulic engineering (Hutton et al., 1956; Phillips, 1960; Taylor and Saloman, 1968).

A rectangular area 8.2 by 21 m (27 by 7 ft) in a large turtle grass bed was cleared by hand to serve as the control site. Two other transplant areas of the same size were in two adjacent finger-fill canals in a large land-fill development.

Construction of houses had not begun along the canals selected, and none was built during the experiments. Boating in the canals was light, and during periodic inspections we saw no disturbance of the plants directly attributable to man.

Sediments from transplant sites were analyzed by particle size. A sample from the control site was 95.5% sand ($>62.5\mu$) and 4.5% silt and clay ($<62.5\mu$) on a dry weight basis. At the planted areas of the finger-fill canals, sediments averaged 98.6% sand and 1.4% silt and clay. No analysis of the carbonate fraction was made for these samples; however, all sites had shell fragments, which appeared to be more abundant in the canals than at the control site.

MATERIAL AND METHODS

The work was divided into two phases: Phase I extended from July 1966 through August 1967 and phase II from April through October 1967. In phase I, methods of deflecting and reducing the force of tidal currents and waves in the vicinity of transplants and of anchoring new transplants in the substrate were tested. Concrete building blocks were laid in parallel rows at both transplant sites to form enclosed areas for sheltering new transplants against the forces of moving water (Figure 3). Plugs of grass approximately 8 inches square (20 $\times$ 20 cm)

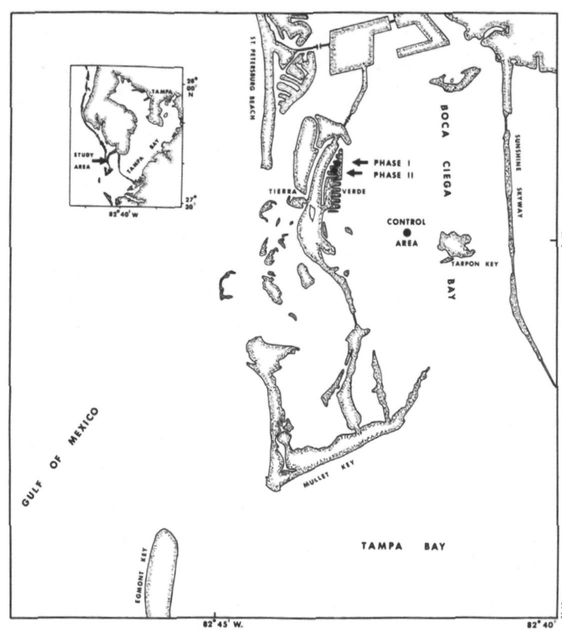

FIGURE 2.—Locations of experiments (phases I and II, and control area).

and containing four to five short-shoots were dug from natural beds adjacent to the control site. Three methods of transporting and anchoring the plugs were tried: (1) placing them in tin cans, (2) balling them in burlap, and (3) temporarily bagging the roots and rhizomes in polyethylene, which was removed just before planting.

A total of 120 plugs was transplanted — 60 at the control site and 60 at the finger-fill canal. At both locations, 30 were placed inside and 30 outside of enclosures. Each group of 30 plugs was planted three ways: 10 in cans, 10 in burlap, and 10 unanchored (Figure 3).

Phase II consisted of testing additional anchoring devices to hold individual sprigs of turtle grass in the substrate of the finger-fill canal. The devices were cast iron, 2-inch (5.1-cm) pipe, brick, and construction rod. Sprigs used in this study were single short-shoots with leaves, many roots, and with or without a portion of the parent rhizome. Also tested in phase II was the plant hormone, NAPH (Naphthalene Acetic Acid),[6] which is used for rooting grass stolons and plant cuttings.

Sixty sprigs, obtained from the same natural bed as the plugs in phase I, were washed and prepared for the experiment by breaking entire rhizomes from some, breaking only the apexes of rhizomes from others, and leaving the rhizomes attached and entire on others. Half of the sprigs were placed in a 10% solution of NAPH in seawater for 1 hr. The other half were left untreated. The sprigs were planted in groups to test various combinations of treatment and nontreatment with NAPH, presence and absence of apexes of rhizomes, presence and absence of rhizomes, and types of anchors (Figure 4).

Sprigs anchored with construction rod had no rhizomes. Sprigs anchored with pipe had rhizomes that were buried in hand-dug holes; whereas, sprigs anchored with brick were simply placed on the surface of the substrate and their rhizomes held in contact with the sediment by the weight of the brick.

[6] Manufactured by Nutri-Sol Chemical Company, Tampa, Fla. 33609. References to trade names in this publication do not imply endorsement of commercial products.

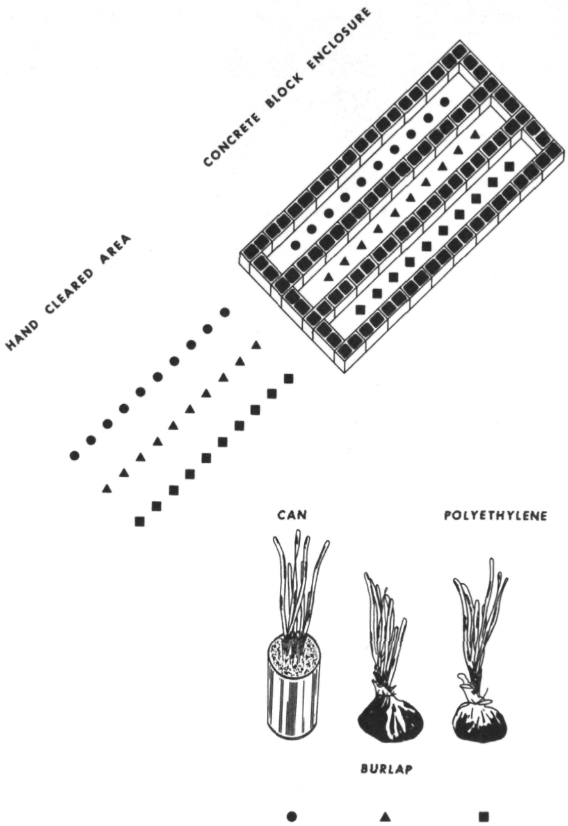

FIGURE 3.—Details of concrete-block wave and current barriers, tin-can anchors for plugs, and placement of transplants at planting sites.

RESULTS

Transplants were considered successful if they established themselves in the new environment and exhibited new rhizome growth (Figure 5). Individual sprigs met these criteria if short-shoots appeared healthy, had new roots, and had either given rise to a new rhizome or were still part of an old long-shoot with an active apex. Plug transplants (phase I) were considered successful if only one of the short-shoots met the above criteria.

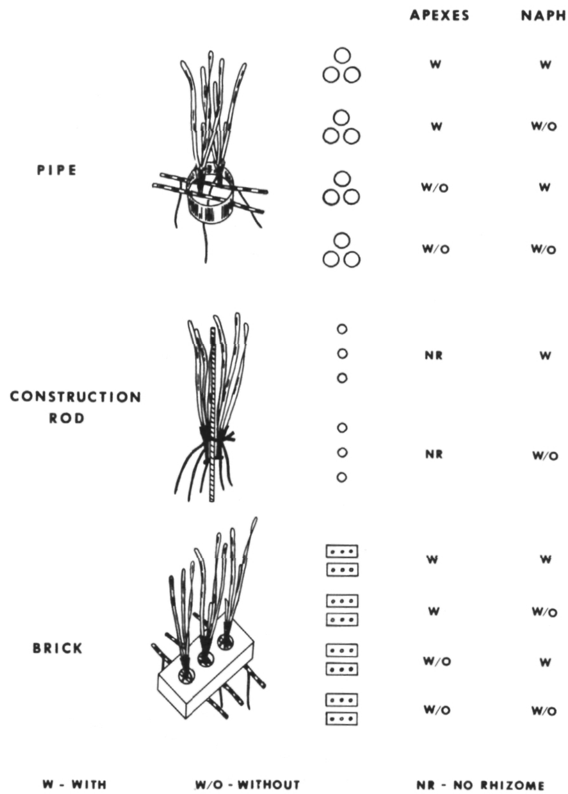

FIGURE 4.—Details and treatment of sprigs anchored by pipe, brick, and construction rod; and placement of transplants at planting sites.

Plugs in phase I planted July 1966 were removed from the sites late in August 1967, approximately 13 months after planting. Six of the 40 transplants at the canal area and 16 of the 40 at the control area were successful (Table 1).

Planting individual sprigs of turtle grass in phase II yielded similar results. Of the 60 sprigs planted in the second canal in April 1967 and removed in mid-October 1967 (about 6 months after they were transplanted), 11 were successful (Table 2).

Successful new growth of rhizomes represented 15 and 18% of the number of transplants made in the finger-fill canal in phases I and II, respectively, and 40% of the transplants made in the control bed (Tables 1 and 2). Transplant attempts made with burlap in phase I were not included in the above percentages because all failed within 1 month.

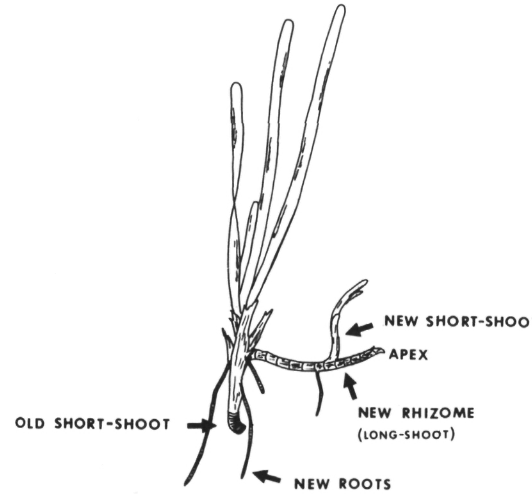

FIGURE 5.—New rhizome, root, and short-root growth on a sprig of turtle grass transplanted without an intact rhizome apex.

EROSION CONTROL

Results of planting plugs within concrete-block enclosures were completely different in the finger-fill canal and grass bed locations (Table 1). In the canal the only successful transplants grew within the protection of the block enclosures; none planted without this protection survived, and most of the latter failed within the first 6 months of the experiment. Most of the successful plugs placed in the control area were planted outside the concrete blocks and, throughout the study, appeared to be in better condition than those inside the enclosures. The enclosures fulfilled their purpose in the canal but appeared detrimental in the control area. In the latter region, surrounding grass beds apparently provided sufficient protection from water movement. Enclosures in

TABLE 1.—Surviving transplants, successful transplants, and seasonal mortality of transplanted plugs of *Thalassia* in the finger-fill canal and the control site, phase I, July 1966 through August 1967.

Method of protecting and anchoring	Transplants	Surviving plants			Mortality			
		Unsuccessful[1]	Successful[2]		Fall	Winter	Spring	Summer
	No.	*No.*	*No.*	*%*	*No.*	*No.*	*No.*	*No.*
			Finger-fill canal site					
Inside concrete block enclosures:								
Anchored in cans	10	0	3	30	3	4	0	0
Unanchored	10	0	3	30	2	4	0	1
Total	20	0	6	30	5	8	0	1
Outside concrete block enclosures:								
Anchored in cans	10	0	0	0	9	1	0	0
Unanchored	10	0	0	0	10	0	0	0
Total	20	0	0	0	19	1	0	0
Grand total	40	0	6	15	24	9	0	1
			Control site					
Inside concrete block enclosures:								
Anchored in cans	10	1	3	30	5	1	0	0
Unanchored	10	2	0	0	4	1	2	1
Total	20	3	3	15	9	2	2	1
Outside concrete block enclosures:								
Anchored in cans	10	1	7	70	0	1	0	1
Unanchored	10	2	6	60	1	1	0	0
Total	20	3	13	65	1	2	0	1
Grand total	40	6	16	40	10	4	2	2

[1] Transplants survived but did not exhibit new rhizome growth.
[2] Transplants exhibited new rhizome growth.

the control area often filled with a heavy accumulation of light-robbing algae, dead grass, and other detritus, which quickly resulted in burial and death of the entire transplant.

ANCHORING METHODS FOR PLUGS

Of the plugs anchored with tin cans, 50% were successful at the control site, but only 15% in the canal (Table 1). None of the plugs planted in cans outside of the concrete-block enclosures survived. Cans were thus ineffective against currents unless used in conjunction with the concrete-block current barrier.

Plugs transported in polyethylene bags and then directly transplanted served to evaluate the effect of tin cans. We noted no adverse effects from the metal in the cans. The ratio of successes of unanchored to anchored transplants was 3:5.

The reasons for the rapid failure of plugs with roots and rhizomes wrapped in burlap is unknown. Possibly decomposition products of the decaying burlap, such as H_2S, or toxic chemicals in the material caused the plants to die.

ANCHORING METHODS FOR SPRIGS

In phase II sprigs were planted with added anchoring devices but without the aid of the wave and current barriers.

Construction rod was the most effective device used to anchor sprigs. It was the easiest to handle because all sprigs fixed to it were transplanted without rhizomes and were simply fastened to the rod with plastic-coated wire and inserted into hand-dug holes in the substrate. Of the 12 sprigs anchored with rod, only the 6 that had been treated with the hormone NAPH became established (Table 2). Sprigs that did not survive failed early in the experiment and simply disappeared, probably because they were dislodged by water movement in the canal before roots were developed.

TABLE 2.—Surviving transplants, successful transplants, and monthly mortality of transplanted sprigs of *Thalassia* in a finger-fill canal, phase II, April through October 1967.

Method of anchoring and treating	Transplants	Surviving plants			Mortality[1]				
		Unsuccessful[2]	Successful[3]		May	July	Aug.	Sept.	Oct.
	No.	*No.*	*No.*	*%*	*No.*	*No.*	*No.*	*No.*	*No.*
Pipe[4]									
With apexes, with NAPH	6	0	0	0	6	0	0	0	0
With apexes, without NAPH	6	0	0	0	0	6	0	0	0
Without apexes, with NAPH	6	2	2	33.3	0	0	0	2	0
Without apexes, without NAPH	6	5	1	16.7	0	0	0	0	0
Total	24	7	3	12.5	6	6	0	2	0
Brick[5]									
With apexes, with NAPH	6	4	2	33.3	0	0	0	0	0
With apexes, without NAPH	6	0	0	0	0	6	0	0	0
Without apexes, with NAPH	6	0	0	0	0	6	0	0	0
Without apexes, without NAPH	6	0	0	0	3	3	0	0	0
Total	24	4	2	8.3	3	15	0	0	0
Construction rod[6]									
With NAPH	6	0	6	100.0	0	0	0	0	0
Without NAPH	6	0	0	0	0	4	2	0	0
Total	12	0	6	50.0	0	4	2	2	0
Grand total	60	11	11	18.3	9	25	2	2	0

[1] Mortality not observed in June.
[2] Transplants survived but did not exhibit new rhizome growth.
[3] Transplants exhibited new rhizome growth.
[4] Rhizomes were buried; two sprigs per anchor.
[5] Rhizomes were not buried; three sprigs per anchor.
[6] Rhizomes were removed before planting; two sprigs per anchor.

Pipe and brick were poor anchors. The sprigs anchored with pipe were transplanted with their rhizomes and special care was required in burying them to avoid breakage. Almost half of the 24 sprigs held with pipe lived to the end of the experiment, but only 3 exhibited new rhizome growth (Table 2). Sprigs secured to the bottom with brick were not buried but were simply laid on the bottom and the substrate was scooped over them by hand. They were also transplanted with their rhizomes but were difficult to handle because of their tendency to slip out from underneath the brick before they were finally set in place. Six of the 24 sprigs lived for awhile, but only 2 were successful. Sprigs that were anchored with brick and failed did so shortly after they were planted. Water movement probably eroded away enough sediment to allow the buoyant sprigs to float from under the brick.

TREATMENT OF TRANSPLANTS IN PHASE II

The effect of NAPH on marine grasses is apparently similar to its effect on terrestrial plants, primarily inducing rapid and heavy rooting. Ten of the 11 sprigs producing new rhizomic growth were treated with it (Table 2). Because of the small number of transplants attempted and successes achieved, we cannot definitely establish the significance of NAPH in such experiments. Our results indicate to us, however, that NAPH was one of the main factors contributing to transplant success.

Particular care was taken to avoid damaging rhizomes and rhizome apexes of sprigs before and during transplanting. No apparent advantage was gained from this care; invariably old rhizomes withered away and were replaced by new ones developing from the bases of the shortshoots.

MORTALITY OF TRANSPLANTS

Visual checks made throughout the year showed that the most critical period for the survival of turtle grass was during the first 3 months after transplanting. In phase I, mortality of plugs planted in the canal was 60% through the third month (October), 22.5% through the sixth month (January), zero through the 3-month period February-April, and 2.5% during the remainder of the study. Losses in the control area for the same time intervals were 25, 10, 5, and 5%, respectively.

Mortality experienced during phase II was also high. Over half (57%) of the sprigs transplanted in April failed before the end of the third month (July) and 7% from August to October. Additional failures within this phase might have occurred had the experiment continued through the winter.

CONCLUSIONS AND RECOMMENDATIONS

Our experiments resulted in the first successful field transplantation of turtle grass. All new short-shoots produced by transplants were from the new rhizome apexes (Figure 5). This finding supports the observations of Phillips (1960) and Tomlinson and Vargo (1966) that buds on the rhizome apex are the only source of short-shoots. It is also in agreement with findings in the tank culture of *Thalassia* (Fuss and Kelly, 1969). Continuous growth of turtle grass depends on the activity of vigorous rhizome apexes, but the apexes do not contain the only meristematic tissue in the plant. New rhizomes can be produced from residual meristematic tissue present in the old short-shoot. Phillips (1960) observed such branching in the field and stated that it could account for the continued growth of turtle grass if the apex of the rhizome were damaged or lost, but believed that the frequency of this branching was small. Tomlinson and Vargo (1966) also reported that vegetative branching in short-shoots occurs and indicated that it is rare.

Undamaged leaves may not be required for sprig transplanting. Further studies are needed to determine, for example, if the leaves could be cut back to reduce the surface area and buoyancy of the sprig. Results of investigations in Boca Ciega Bay by Prest, Saloman, and Taylor[7] show that turtle grass leaves clipped as much as 50% of their original height (about 26 cm) would regrow as much as 3 to 4 cm (1.2 to 1.6 inches) per week. It would thus appear that physical damage to leaves is quickly overcome by regrowth of the plant.

We have shown that turtle grass can be transplanted in the field and that it will grow in an area denuded by coastal dredging. A simple transplant method using only the short-shoots of this grass, the hormone NAPH, and construction rod was 100% successful (six transplants) in a land-fill finger canal (Table 2). This method has value for use in restoring *Thalassia* to estuarine environments when conditions favorable for plant growth exist or can be artificially created. We must emphasize however, that no large-scale transplant program has been attempted. Moreover, recent observations (November 1970)[8] of vegetative growth into our original control site indicate that turtle grass spreads at an annual rate of only 20 cm (8 inches) or less.

[7] Unpublished data on file National Marine Fisheries Service Biological Laboratory, St. Petersburg Beach, Fla. 33706.

[8] Unpublished data on file National Marine Fisheries Service Biological Laboratory, St. Petersburg Beach, Fla. 33706.

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