REINTRODUCTION OF OLIGOHALINE GRASSBEDS, MOBILE BAY, ALABAMA

Judy P. Stout and Kenneth L. Heck, Jr.
University of South Alabama
Dauphin Island Sea Lab
Dauphin Island, Alabama 36528

ABSTRACT

Oligohaline grassbeds dominated by wild celery (*Vallisneria americana*) experienced dramatic decline and disappearance along many shorelines of Mobile Bay during the period 1950-1970, coincident with intense shoreline development and shallow dredging within the bay. Subsequently, shell dredging has been discontinued, development activities have slowed and beds are reappearing at some former sites.

Transplants from local sources of wild celery were evaluated for use in reestablishment of grassbeds to enhance natural regrowth. Transplants exhibited survival rates of 87-100% in 0.5m of water, 19-26% at 0.75m and no survival deeper than 1.0m at the end of the growing season.

Limited quarterly sampling of plant biomass production, faunal abundance, species occurrence and size frequency distribution were compared between naturally occurring *Vallisneria* beds and transplanted beds. Transplanted plots exhibited more robust plant growth, and lower areal cover. Faunal utilization of grassbeds was by a similar suite of species, but abundance was lowest in the transplanted beds. Though data are limited by infrequent sampling, recruitment events were indicated in both natural and transplanted vegetation. Fewer individuals contributed to cohorts within transplanted beds, possibly due to lower recruitment or higher predation within the more widely spaced transplants.

Preliminary data suggest that transplants may provide a means of enhancing natural revegetation and may provide similar faunal habitats. Second year studies are currently underway.

INTRODUCTION

Submerged grassbeds are universally considered important, productive components of coastal ecosystems (Phillips 1980, 1982). The combined high levels of production of the plants and their associated epiphytes contribute significantly to estuarine food webs (Mann 1972; Kikuchi 1974). In addition, this complex community serves as "nursery habitat" for juvenile species such as speckled trout, blue crab and shrimp (Hooks et al., 1976; Heck and Orth 1980; Heck and Thoman 1984) and as a refuge from predation (Nelson 1981; Peterson 1982; Summerson and Peterson 1984; and Heck and Wilson 1987).

Stout, J. P. and K. L. Heck. 1990. Reintroduction of oligohaline grassbeds, Mobile Bay, AL. Pp. 180-199, in, F. J. Webb (ed.), Proc. 16th Ann. Confer. Creation and Restor. of Wetlands, Hillsborough Comm. Coll., Tampa, FL. 229 p.

Increased utilization of estuaries and their shorelines, as well as natural perturbations, have resulted in the decline or disappearance of submerged grassbeds in estuaries throughout the United States, often with dramatic impacts on harvests of other living resources with recreational and commercial value (Taylor and Saloman 1968; Godcharles 1971; Thayer et al., 1975; Orth 1976; and Rasmussen 1977). Wild celery and widgeon grass have been frequently reported as the dominant aquatics in the oligohaline reaches of coastal estuaries including the tidal Potomac River (Haramis and Carter 1983) Chesapeake Bay (Orth and Moore 1981), East Bay, FL (Purcell 1977) and Apalachicola Bay, FL (Livingston 1983).

In Mobile Bay, Alabama Borom (1975) found the following for epibenthic fauna: 1) Abundance was much greater on vegetated bottoms (grassbeds) than on bare bottoms, and 2) Within grassbeds, faunal abundance was directly related to seasonal patterns of plant growth and density. Some extensive grassbeds now occur in the shallow upper reaches of Mobile Bay; however, there are reports of past occurrences of well-developed beds on the western shore to a point south of Fowl River and on the eastern shore to Point Clear. The two most abundant .species were wild celery or tapegrass (*Vallisneria americana*) and widgeon grass (*Ruppia maritima*). South of the Mobile River mouth on the western shore of Mobile Bay and south of D'Olive Bay on the eastern shore, *Vallisneria* beds have almost completely disappeared (Stout and Lelong 1981; Stout et al., 1982). Rapid decline and disappearance were experienced between 1950-1970, during a period of intense shoreline development and dredging within the bay. Recreational and commercial fishermen coincidentally reported a decline in fishing success. Recent reports indicate scattered, small patches of grass reappearing in areas of the bay once supporting prolific grassbeds (Zolczynski 1987). Shoreline development has leveled off in this area, reducing sediment and stormwater runoff. Dredging operations for the removal of dead shell have been inactive for a number of years. It therefore seems likely that conditions for survival and success of grassbed species have improved.

It is widely believed that the recovery of a plant base within a system results in recovery of the entire system. Consequently restoration and creation of vegetated habitats (grassbeds and marshes) is a promising method for managing and maintaining vital estuarine ecosystems (Fonseca and Kenworthy 1979; Thayer et al. 1985). Reintroduction of grassbed species will help accelerate natural recovery of areas which have been negatively impacted. Successful techniques for reintroduction of marine grassbed species (turtle grass, eelgrass, shoalgrass and manatee grass) have been developed (Thorhaug 1974, 1980; Thayer et al. 1982; Fonseca et al. 1984; Fonseca et al. 1985). Riverine and pond plantings of wild celery have met with exceptional success (Korchgen and Green 1985; Beno 1986), but attempts to restore this species in an estuarine setting are limited to a marginally successful attempt in the Potomac River estuary (Carter and Rybicki 1985).The success and cost/benefit analyses of a rehabilitation program must encompass more than the obvious successful establishment and growth of the plants. In particular, the function and coupling of the biota of these restored habitats with the estuarine system must be evaluated. Minimal assessments must include comparisons among natural beds, bare areas and restored beds of recruitment and utilization by juveniles of target species, availability of food items and growth of resident and nursery species. The current project examines the potential for grassbed reestablishment and provides initial data on the functional capability of artificially established *Vallisneria* beds in Mobile Bay, Alabama.

METHODS AND MATERIALS

STUDY SITES

The study was conducted near the head of Mobile Bay, Alabama's largest estuary (Figure 1). The Bay is approximately 30 miles long from its mouth on the Gulf of Mexico to the study areas. Freshwater inflows average 62,500 cubic feet per second into the upper bay. Salinities in the study areas ranged from 0-11 ppt., with higher readings coincident with drought conditions of summer 1988. Average depths are less than 2 m. in the study areas.

Transplant materials were collected from the north side of Highway 90, adjacent to the boat launches on the eastern side of the Tensaw River Bridge (Figure 1-S). At the time of transplanting, water depths in the source bed were approximately 50-75 cm and salinities were 0 ppt.

Reestablished beds, monitoring and control sites were located in Ducker Bay (Figure 1-DB) at Meaher Park, about 5 miles east of the source beds and south of Highway 90. Initial water depths were from 30-110 cm and there was no measurable salinity. *Vallisneria americana* was the only aquatic species present in Ducker Bay at the time of transplanting, though other species were subsequently found.

Additional small test transplant plots were established at Montrose (Figure 1-M) and at Fairhope just south of the Fairhope Yacht Club (Figure 1-F) on the northeastern shore of Mobile Bay. These test plots were monitored for success of transplants only. They are located in low traffic areas where tapegrass beds were once abundant, but are now absent.

All study sites were selected based on the following criteria. They were:

1. Shallow enough for light penetration to the bottom.
2. Deep enough to minimize duration of dewatering and winter exposure.
3. Formerly occupied by grassbeds.
4. Adjacent to existing grassbeds.
5. In locations with substrate adequate to support workers.
6. Available for year-round access.
7. In areas with limited human activity.

PRETREATMENT - DUCKER BAY SITE

Treatment and control plots were surveyed and marked at the corners with PVC pipe stakes. Two replicates each, 10m X 15m, were established for transplants and controls.

Samples to establish physical and biological conditions prior to treatment were taken in each treatment plot on May 5, 6 and 7, 1988. Parameters sampled included sediment, infauna, epifauna, natant fauna, aboveground grass biomass, light, temperature and salinity (see Sampling below for details).

Control plots (2 each) were subjected to "simulated transplant disturbances" by opening and closing holes with a trowel as would be done for transplanting. Holes were on 0.5m centers.

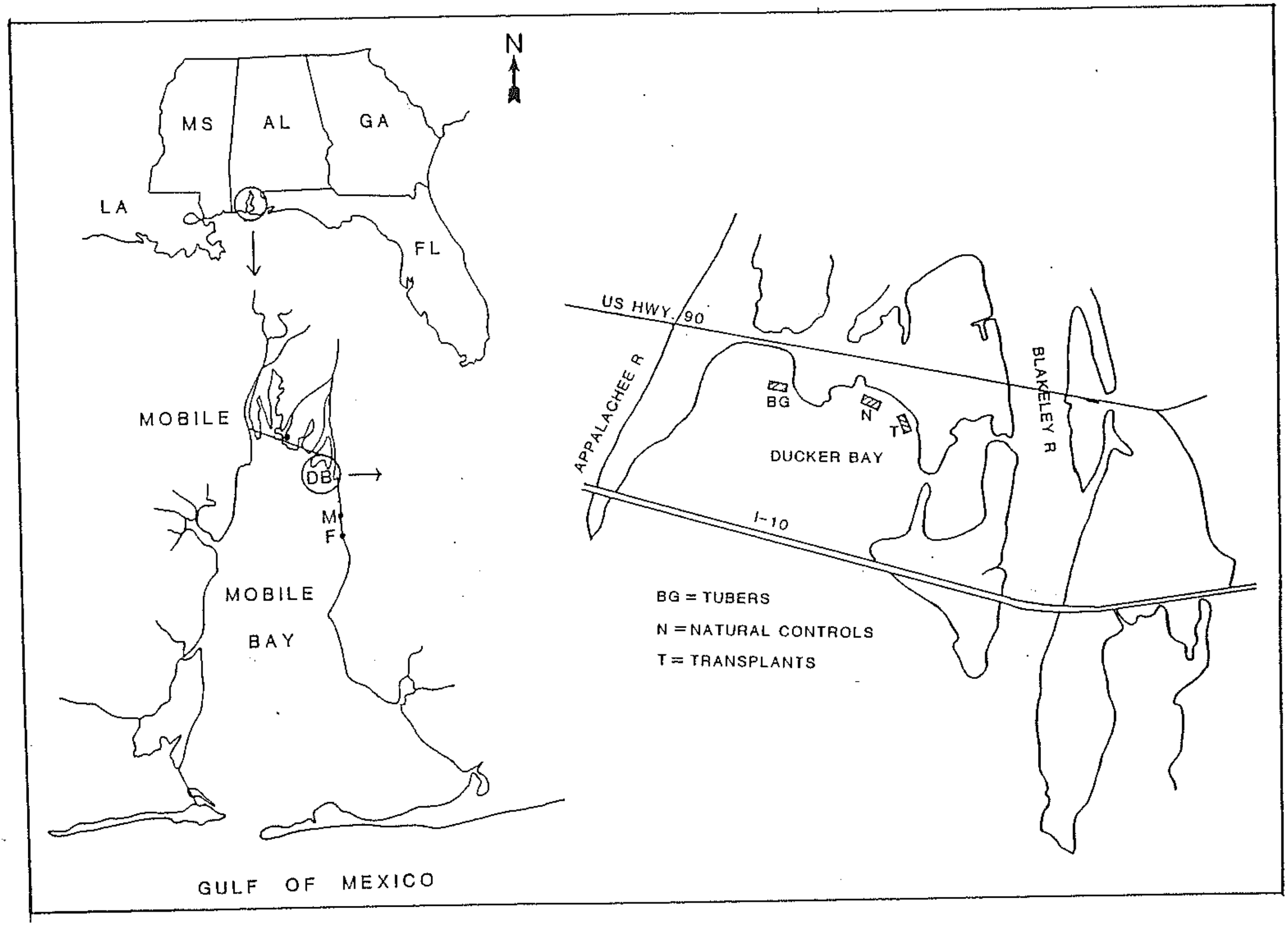

Figure 1. Location of source beds and study sites for transplanted *Vallisneria americana* in Mobile Bay, Alabama. (M = Montrose, F = Fairhope, S = source beds, DB = Ducker Bay, N = natural beds, T = transplant beds)

TRANSPLANTS

Transplant materials were dug, prepared, and replanted on May 6, and 9-12, 1988, in the Ducker Bay study site. Transplant units (TU) consisted of 4-5 bare-root plants bundled with a twist-tie around a 30cm long wire anchor. TU's were retained in ambient water until replanted with a maximum holding time of 14 hours before return to the sediment. Only robust plants with healthy root/rhizome systems were utilized. Transplants were made into study plots on 0.5m centers at sediment depths similar to their source condition (sediment surface at level of initiation of green photosynthetic tissue). Test plots at Montrose and Fairhope were transplanted on June 2,3, 1988. One hundred TU's were transplanted to each site on 0.5m centers.

SAMPLING AND SAMPLE ANALYSIS

Tuber and transplant survival was measured by counts of remaining plants or sprouts along 3 randomly selected rows within each replicate plot. Counts were made by swimming a taut line marked at 0.5m intervals.

Two replicate sediment cores (10cm deep X 9.62cm^2) were taken from each study plot. Samples were transported to the lab on ice and frozen until processed. Sediment texture (mud:sand) was determined by separation of a sediment slurry in dispersant ("Calgon") on a 63 micron mesh sieve (U.S. Stand. Testing No. 230), drying and weighing each fraction (modified from Folk 1980; and Lewis 1984). Percentage sediment organics was determined by loss on combustion in a muffle furnace (450^{o}C).

A Keene Engineering, Inc., Model 440SP suction dredge was used to remove benthic epifauna trapped in a cylinder confining 3,019 cm^2 of the bottom. Samples were filtered through a 1/32" nylon mesh bag connected to the exhaust hose (see Orth and van Montfrans 1987). After the cylinder was sucked dry the sediment surface was raked with a dip net until no additional fauna were collected in three successive sweeps. Samples were kept live on ice and frozen at the lab until sorted. Thawed samples were sorted fresh (no stain or fixative), identified, counted and dominant taxa measured. Three replicates were taken haphazardly from each plot.

Aboveground plant biomass was determined from 3-0.1m^2 clip quadrats within the vegetated portion of each plot. Belowground biomass and infauna were sampled with 10cm deep cores, 73.89cm^2, 3 each for plants, and infauna from 2 of those cores. Samples were gently washed over a 0.5mm mesh screen. Fauna were removed, identified, measured and counted. Dry weight biomass of plant materials was determined by drying for 48 hours at 100^{o}C and weighing. Plant samples were sorted by species and separate biomass measurements recorded for each species present.

RESULTS

COSTS ANALYSIS OF PLANTING EFFORTS

Table 1 summarizes the man-hour effort and cost for transplanting. One thousand, three hundred and two planting units were installed on 0.5m centers. Work effort was almost evenly divided between digging, transplant preparation and transplanting although the latter consumed somewhat more time. Per unit costs would be reduced for larger efforts where one-time equipment costs could be spread over a greater number of units. Labor costs would also affect total and per unit costs.

Table 1. Effort and cost analysis for transplanting.

Total Plants	Total* Units	Average Shoot Density (m^2)	Total Costs ($)	Cost Per Plant ($)	Cost Per Unit ($)
5,208	1302	17.36	978.00	0.1878	0.75

BREAKDOWN

Labor	- Digging and transporting plants from donor beds		35.6	man/hours
	- Construction of planting units (4-5 shoots each)		42.	man/hours
	- Installing planting units and setting up rows		49.	man/hours
	- Total Labor		126.6	man/hours
	- Total Labor cost @ 5.75 hour		$727.95	
Expendables	- Coat hangers for anchors	(434 @ .03)	$13.02	
	- 3 X 5 index cards		3.00	
	- Paper twist ties	(1,300 @ 00.26)	3.43	
	- Gas for truck	(approximated)	10.00	
	- Total expendables		$29.45	
Equipment	- Tubs w/floats	(6 @ 21.97)	$131.82	
	- Shovels	(4 @ 14.97)	59.88	
	- Trowels	(10 @ 1.89)	18.90	
	- Swim line	(60 @ 0.17)	10.20	
	- Total		$220.80	

*Planting Units - installed on 0.5 m centers in two 10 X 15 m plots
- 4-5 shoots per planting unit

SURVIVAL OF TRANSPLANTS

Swimming transect surveys 1 week and 1 month after planting indicated survival in excess of 80% in Ducker Bay transplants. Surveys of small pilot plots were made 3 weeks after establishment. At Montrose, plants were still erect and exhibited about 75% survival. However, many leaves had died and a large number were recumbent on the sediment. Salinities had risen from 5% to 10%. At Fairhope, only plant bases remained. Salinity was 11%.

August surveys located no remaining transplants at Fairhope and only 7 survivors at Montrose. Dense growth of *Chaetomorpha* and poor visibility impeded swim counts in deeper transplant rows in Ducker Bay. Best estimates indicated 100% survival in Row 1 (shallowest), 75% in Row 3 and 81% in Row 5 (deepest). Plants appeared healthy, many with fruits near the surface.

During the September Ducker Bay survival survey, all other competitive algal and spermatophyte species had disappeared and only *Vallisneria* remained. Transplant survival declined with increasing depth with very few transplants remaining in waters deeper than 0.7 m (Table 2). Approximately 60-70% of the survivors appeared robust and healthy. The remainder were smaller. There were no survivors found at Fairhope or Montrose.

In November, survivorship had declined and no plants were found deeper than 0.7m.

Table 2. Transplant survival, Ducker Bay.

	Mean % Remaining		
Depth	August*	September**	November**
Shallowest (45 cm)	100	94	68
Mid-depth (62 cm)	75	73	44
Deep (70 cm)	81	23	24
Deepest (>70 cm)	?	3	0

* = estimates   ** = actual counts - see text

PLANT BIOMASS

Plant biomass (g dry wt./m^2) by species is in Table 3. Throughout the summer, the plant community was comprised of three co-dominants, a filamentous green algae (*Chaetomorpha*), southern naiades (*Najas guadalupensis*) and tapegrass. Other species present included *Chara*, Eurasian watermilfoil (*Myriophylum spicatum*), pondweed (*Potamogeton pusillus*), widgeon grass (*Ruppia maritima*) and horned pondweed (*Zanichellia palustris*).

The three dominant species contributed over 90% of the biomass produced in all months (92-99%) with algal production equal or greater than vascular plant biomass in May and June. The dense canopy of algal biomass resulted in severe shading and may have affected success of other species. By fall (September), beds were almost monospecifically tapegrass. Summer heat and seasonal growth patterns had resulted in senescence of other species.

Biomass production of our target species, tapegrass, was higher in natural beds than in transplanted beds in June, one month after planting, but was similar in both plots in September and November (Figure 2). It should be noted, however, that this represents production only within vegetated areas and does not include portions of the beds which were bare of vegetation. Thus it represents success of the transplants in growth, but not cover. Cover estimates and total plot biomass (g/m^2) will be determined in the second growing season. It should also be noted that transplants were taller and broader bladed than naturally occurring plants and comparisons in the first growing season may not be valid.

Mean total plant biomass for all species increased in the summer (N = 152 g/m^2; T = 162 g/m^2) and declined in the fall with the loss of species other than tapegrass (N = 48 g/m^2; T = 39 g/m^2 and was almost negligible in the early winter (N = 1.3 g/m^2, T = 4.5 g/m^2) (Figure 2). Natural and transplanted grassbeds provided similar amounts of plant biomass within vegetated areas.

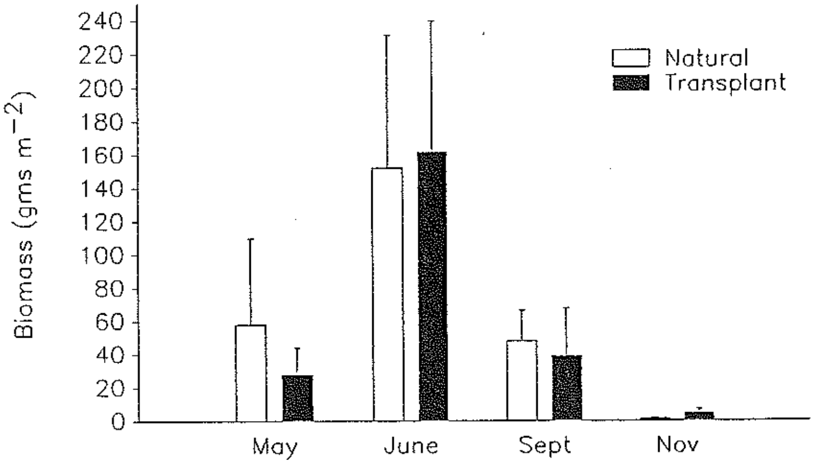

Figure 2. Monthly total aboveground biomass of plants in natural and transplanted beds.

Table 3. Aboveground biomass by taxa, date and treatment (N=natural, T=transplants).

		BIOMASS (G M^{-2})							
	MONTH	5		6		9		11	
TAXON	TREATMENT	N	T	N	T	N	T	N	T
CHARA		0.12	2.00	0.00	0.00	0.00	0.00	0.00	0.00
FILAMENTOUS GREEN ALGAE		50.32	10.87	41.97	67.30	0.00	0.00	0.00	0.00
MYRIOPHYLLUM SPICATUM		0.00	0.00	0.00	0.00	0.28	0.13	0.00	0.09
NAJAS GUADALUPENSIS		5.57	20.5	93.12	92.42	0.25	0.10	0.00	0.00
POTAMOGETON PUSILLUS		0.00	0.00	0.35	1.55	0.00	0.00	0.00	0.00
RUPPIA MARITIMA		0.93	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VALLISNERIA AMERICANA		0.30	11.62	16.55	0.55	47.57	38.62	1.24	4.41
ZANNICHELLIA PALUSTRIS		0.65	1.45	0.00	0.00	0.00	0.00	0.00	0.00

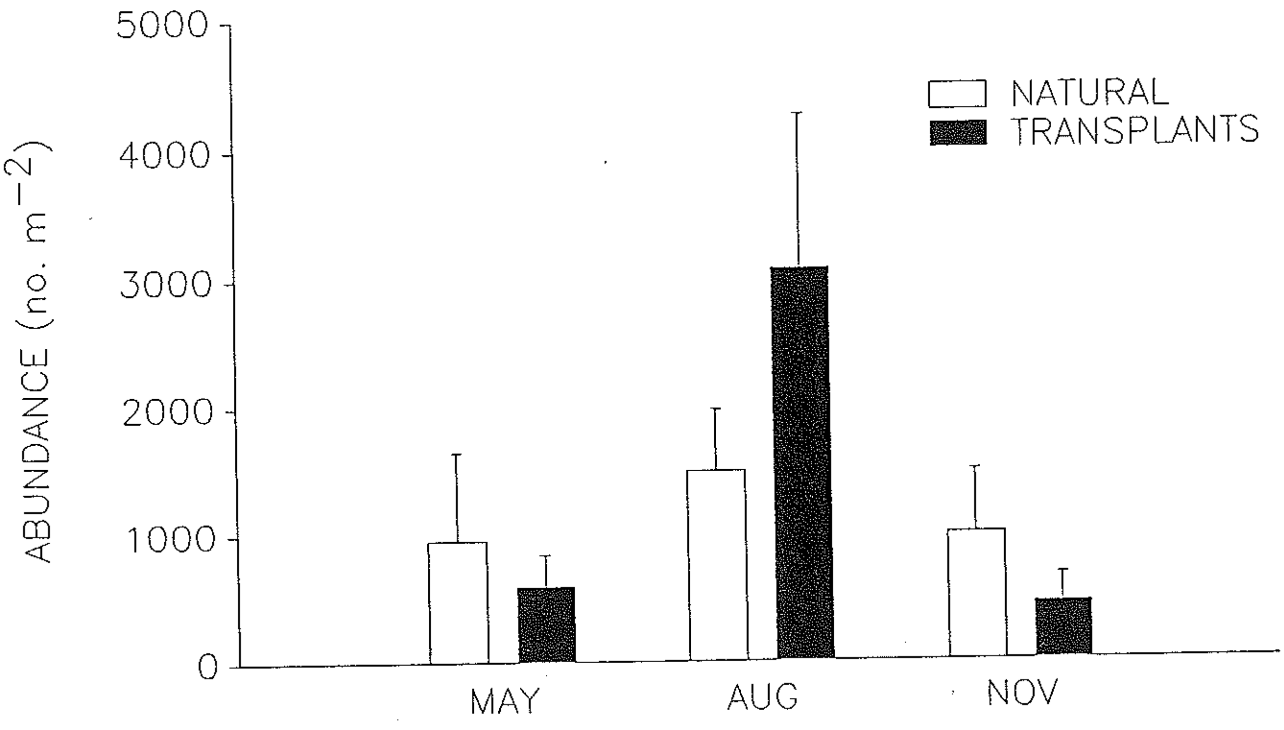

Figure 3. Monthly mean faunal abundance from suction samples.

SUCTION SAMPLES

Twenty-six taxa were identified from suction samples. Of these, 8 were found in only one sample (Table 4). Nine of the thirteen faunal taxa collected in May were present in both the natural and the transplant sites, and 4 of the 5 most abundant taxa in each habitat were shared. However, the most abundant species in the natural habitat was the coot clam (*Rangia cuneata*) while chironomids were most abundant in the transplant sites, with coot clams second in abundance. Mean abundance was almost 40% greater in the naturally vegetated area in May, with densities approaching 1000 inds/m^2 (Figure 3).

In August, 16 of 19 species were shared among the natural and transplant sites, and three of the five most abundant species were common to each site (Table 4). Amphipods were ranked first at both sites and chironomids were next in abundance at both, although the total abundance of midges was more than five times as great at the transplant site. Other obvious differences between sites were the much greater abundance of the bivalves, especially *Mytilopsis leucophaeta*, and of the parasitic gastropod *Sayella fusca* at the transplant site (Figure 4 and 5). Total abundances were much greater in August at both sites, but at the transplant site mean abundance was nearly twice as great as at the naturally vegetated site (Figure 3).

Of 21 taxa collected in November, 15 occurred in both natural and transplanted beds and of the 5 most abundant taxa, 4 (amphipods, *Neritina*, polychaetes and *Callinectes sapidus*) were of the same rank in abundance for both treatments. Total faunal abundance in natural beds was over two times that of transplant beds. Notable declines were seen in previously abundant chironomids, *Sayella* and *Mytilopsis* (Figure 4). Significant increases in abundance of polychaetes and blue crabs may represent recruitment events. Figure 5 depicts size distributions of crabs in November as further evidence of fall recruitment and the role of oligohaline grassbeds as settlement sites in Mobile Bay.

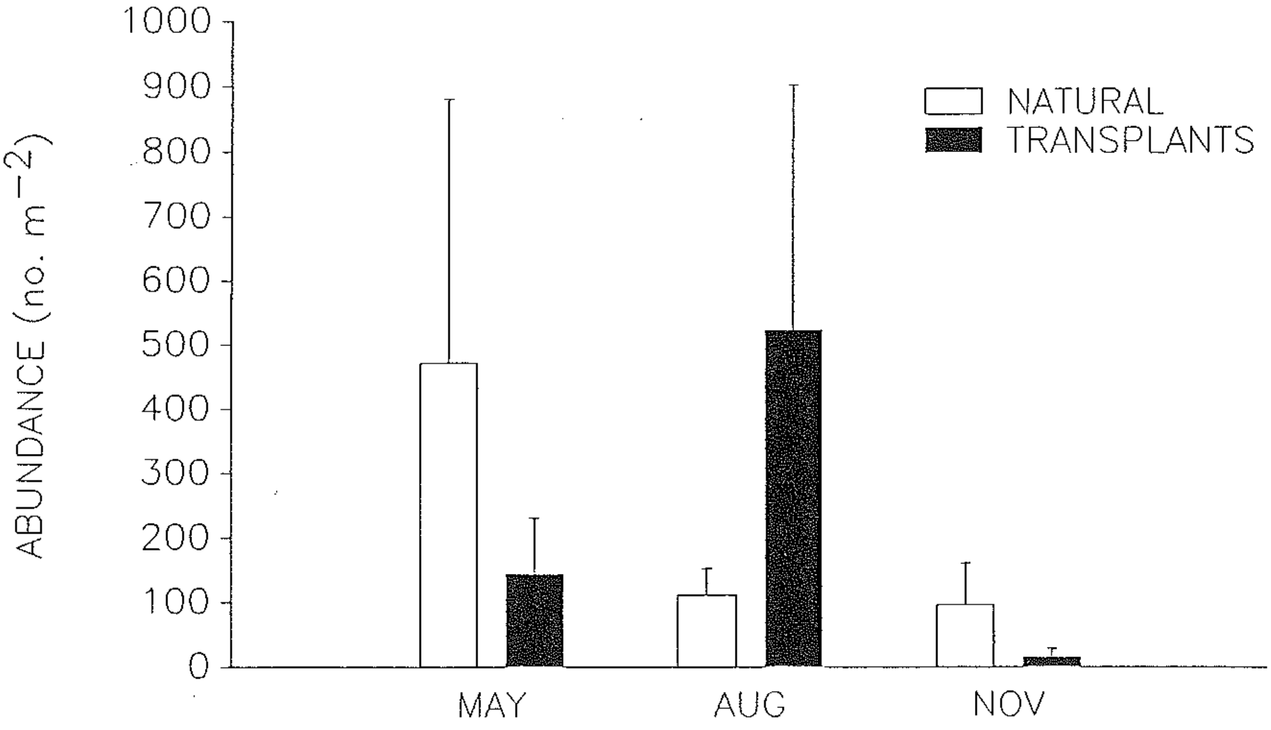

Figure 4. Monthly mean bivalve abundance in suction samples.

Table 4. Faunal abundance (no. m^{-2}) from suction samples by taxa, date and treatment. (N=natural, T=transplants)

TAXON	MONTH TREATMENT	ABUNDANCE (no.m^{-2}) 5 N	 5 T	 8 N	 8 T	 11 N	 11 T
AMPHIPODS		232.07	25.72	950.65	936.05	524.17	201.23
CADDIS FLY LARVAE		0.00	0.00	0.00	0.00	4.60	2.83
CALLINECTES SAPIDUS		10.08	0.00	1.13	1.12	28.90	14.73
CERATOPOGONIDS		309.33	397.71	0.00	0.00	22.09	0.00
CHIRONOMIDS		15.10	326.58	157.70	819.73	1.13	1.13
EPHEMEROPTERA		0.00	0.00	9.50	59.83	0.00	0.00
GOBIONELLUS BOLEOSOMA		0.00	0.00	0.00	0.00	0.00	3.97
LUCANIA PARVA		0.00	0.00	7.85	57.58	2.83	0.57
MENIDIA BERYLLINA		0.00	0.00	0.57	0.00	4.53	0.00
MYSIDS		2.25	3.92	27.40	45.30	18.13	29.47
MYTILOPSIS LEUCOPHAETA		0.00	0.00	77.75	511.07	5.10	3.97
NERITINA RECLIVATA		107.93	5.05	49.22	11.20	226.10	131.47
ODONATA		0.00	0.00	8.40	48.65	0.57	1.70
PALAEMONETES PUGIO						2.83	0.00
PENAEUS AZTECUS		0.00	0.00	0.57	0.00	0.00	0.00
PHYSA SP.		0.00	0.00	0.00	1.68	0.00	0.00
POLYCHAETES		0.00	11.18	8.97	5.03	48.73	26.07
POLYMESODA CAROLINIANA		0.00	0.00	4.48	0.57	0.00	0.00
RANGIA CUNEATA		472.52	144.28	30.20	13.43	92.93	11.33
RHITHROPANOPEUS HARRISII		1.12	2.82	0.00	0.00	10.20	6.80
SAYELLA FUSCA		103.48	50.88	144.27	518.93	0.00	2.83
SYMPHURUS PLAGIUSA		0.00	0.00	0.00	0.00	0.57	0.00
SYNGNATHUS SCOVELLI		0.57	0.00	7.30	1.13	2.83	2.27
TELLINA ALTERNATA		0.00	0.57	0.00	0.00	0.00	0.00
UNIDENTIFIED JUVENILE FISH		0.57	0.57	2.23	20.13	1.13	1.70
XENANTHURA BREVITELSON		0.00	0.00	0.00	0.00	10.77	0.00

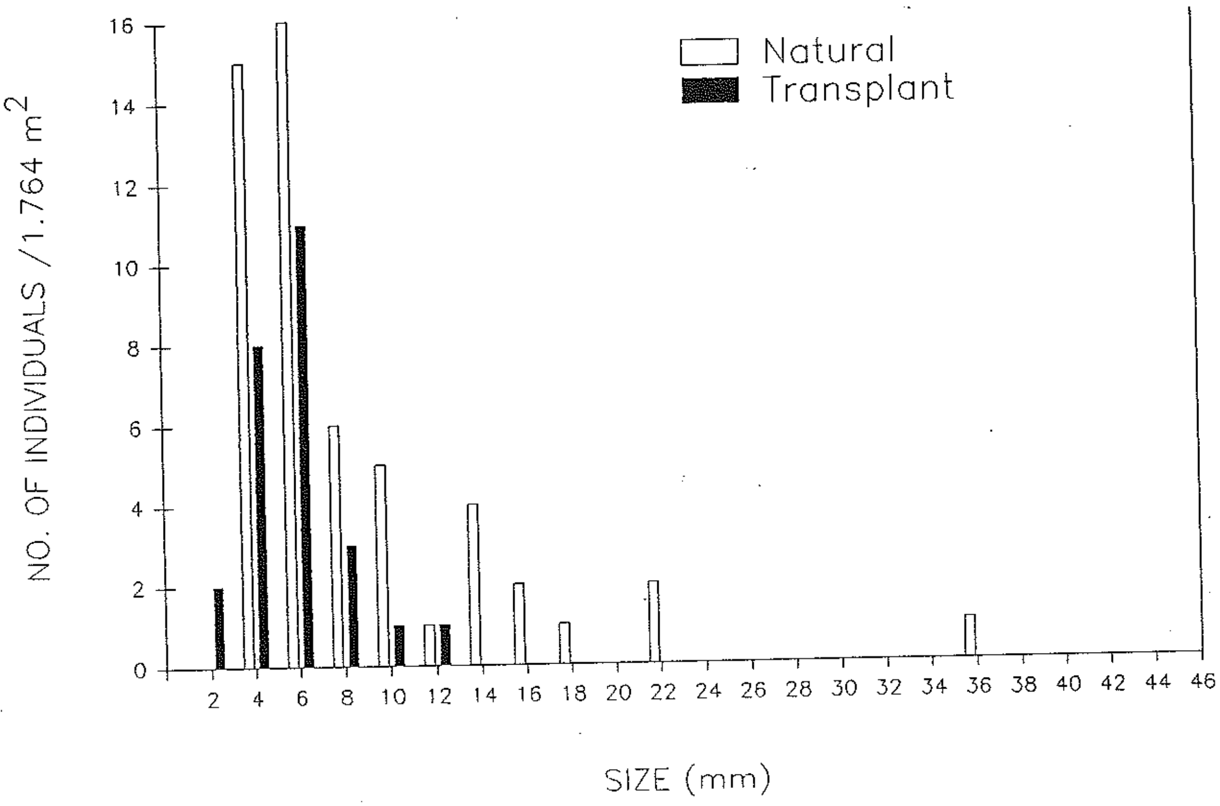

Figure 5. Size frequency distribution of blue crabs, Callinectes sapidus, in November suction samples.

CORE SAMPLES

Infaunal taxa taken by coring (Table 5) were a subset of those taken in the suction sampling. These samples were taken to collect small infauna and did not sample large animals effectively. In May, 9 taxa were taken in the naturally vegetated areas but only 4 were found in the transplant areas. All of these four were also taken in the naturally vegetated sites, but the two most abundant taxa there (coot clams and amphipods) were not found in the transplant areas. Abundances were nearly three times as great at the naturally vegetated sites, with the major part of this difference due to the large numbers of coot clams and amphipods found there.

Only four species were collected at the naturally vegetated sites in August and only two species were found at the transplant sites (Table 5). Both collections were dominated by polychaetes, but total abundances were much less than in May, and the difference between sites was greatly reduced (Figure 6).

As was seen in suction samples, a significant increase in infaunal polychaete abundance in natural beds contributed to totals more than twice the density of infauna in November in transplanted beds (Figure 7). The three most abundant taxa were the same in both treatments: polychaetes, amphipods and Nertina (Table 5). Three taxa identified from natural beds were not found in November cores from transplant plots.

Twelve infaunal taxa were identified from cores, 5 in only one sample. Infaunal communities were less diverse and of lower density than epibenthic and natant forms.

Table 5. Infaunal abundance (no.m^{-2}) from core samples by taxa, date and treatment. (N=natural, T=transplants)

		ABUNDANCE (no.m^{-2})					
	MONTH	5		9		11	
TAXON	TREATMENT	N	T	N	T	N	T
AMPHIPODS		596.56	0.00	66.28	44.19	331.42	110.47
CERATOPOGONIDS		309.33	397.71	0.00	0.00	22.09	0.00
CHIRONOMIDS		375.62	176.76	0.00	0.00	0.00	0.00
NERITINA RECLIVATA		22.09	0.00	88.38	0.00	176.76	44.19
ODONATA		22.09	22.09	0.00	0.00	0.00	0.00
POLYCHAETES		110.47	397.71	353.52	309.33	729.13	375.61
POLYMESODA CAROLINIANA		0.00	0.00	22.09	0.00	0.00	0.00
RANGIA CUNEATA		1148.94	0.00	0.00	0.00	110.47	0.00
RHITHROPANOPEUS HARRISII				0.00	0.00	44.19	0.00
SAYELLA FUSCA		154.66	0.00	0.00	0.00	0.00	0.00
UNIDENTIFIED JUVENILE FISH		22.09	0.00	0.00	0.00	0.00	0.00
XENANTHURA BREVITELSON				0.00	0.00	22.09	44.19

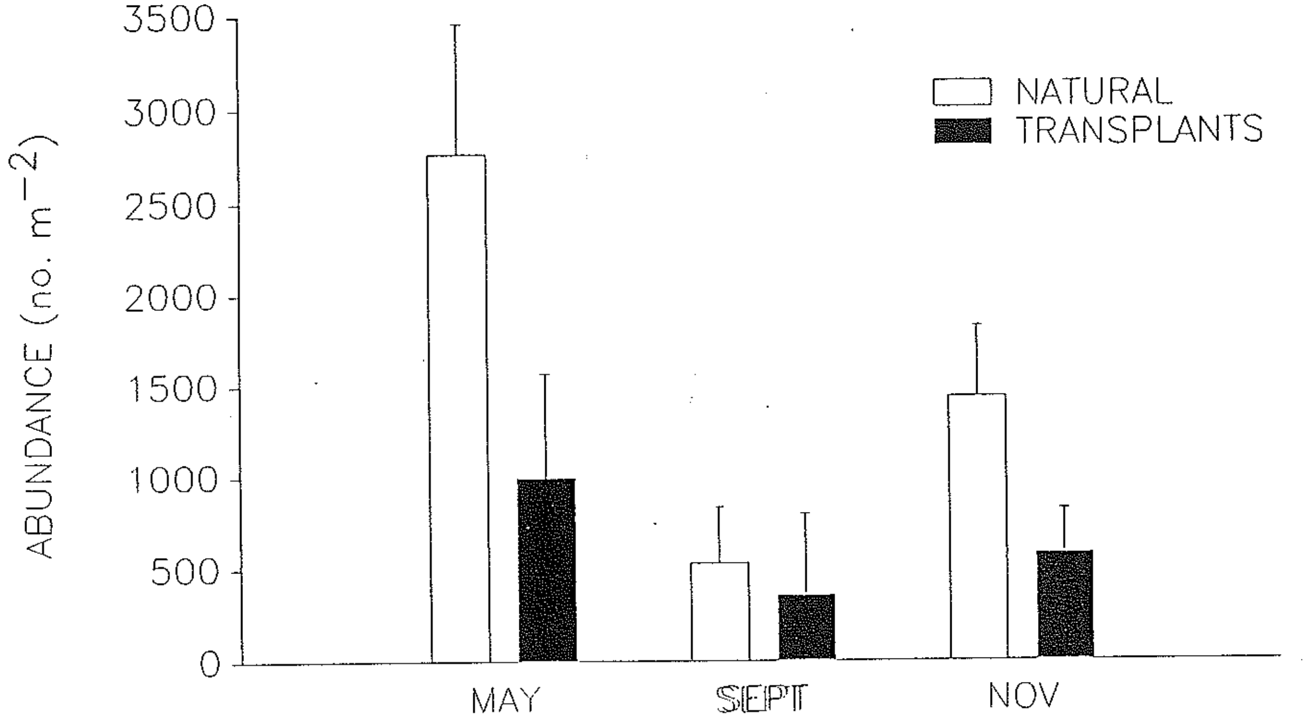

Figure 6. Monthly mean infaunal abundance (core samples).

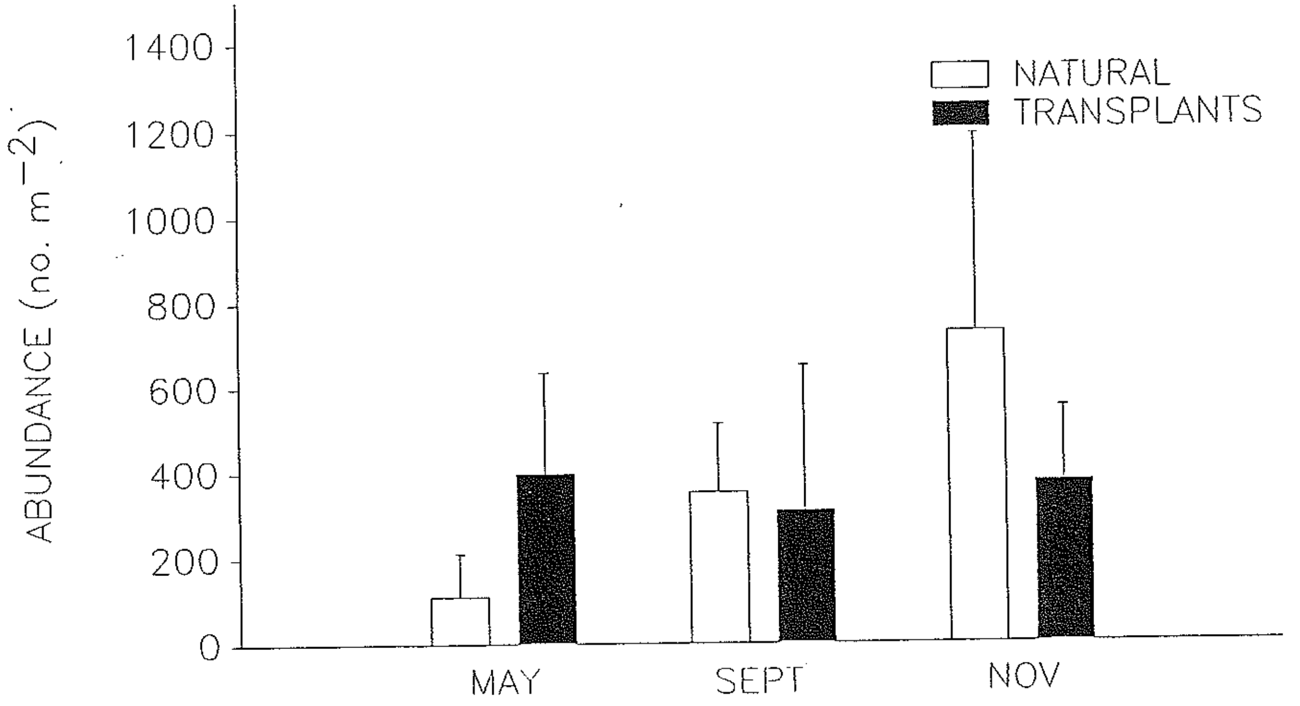

Figure 7. Mean monthly polychaete abundance in core samples.

CONCLUSIONS

PLANTS

The rate of survival and continued growth of transplanted tapegrass for the growing season of transplanting, indicates that this methodology may have potential for restoration in the low salinity, protected areas of Upper Mobile Bay. However, performance in the first and second year, especially in terms of areal coverage and root biomass formation will need to be assessed before final evaluations can be made. Seasonal increases in salinity and perhaps wave energy along the Montrose to Fairhope reach of the northeastern shores may produce conditions not favorable to transplant success. These areas will receive further investigation.

FAUNA

Between-site comparisons.

Faunal species composition was generally quite similar between habitats regardless of the sampling method used, and there was from 60% to 100% overlap in the five numerically dominant taxa between sites. However, the rank order of these five most abundant taxa was identical in only one of the six possible comparisons. Animal abundance between sites was greater at the naturally vegetated area in May and November for all types of collections, while in August abundances were greater at the transplant site in the suction collections (Figure 3) as were September and November infaunal samples (Figure 6). These differences in seasonal abundance seem to reflect the recruitment of young individuals of amphipod, chironomid, polychaete and bivalve species. Seasonal changes in abundance were also demonstrated for infauna. However, natural beds supported larger infaunal communities for all months sampled.

Within-site comparisons

Although there is much overlap in the most abundant faunal taxa between sampling dates, there were several examples of shifts in the rank order of the most abundant taxa. As discussed in the preceding paragraph, this apparently reflects the effects of recruitment events among amphipods, chironomids, polychaetes and bivalves. Similarly, seasonal changes in abundance, whether increases or decreases, seem to be tied to recruitment events. In the core samples, which showed decreases at both sites from May to August and a subsequent increase in November, the loss of young coot clams, ceratopogonids and chironomids (presumably due to predation in the case of coot clams, and either to maturation or the effects of increased salinity in the case of the insects) accounts for the great majority of these declines. Similarly increases in polychaetes in the November transplant infauna may represent a recruitment event.

ACKNOWLEDGEMENTS

The research reported in this paper was supported in part by the Alabama Marine Environmental Sciences Consortium, the Gulf Coast Conservation Association and NOAA Office of Coastal Resource Management through contract ADECA-MESC-CZM-88-002 with the Alabama Department of Economic and Community Affairs. MESC Contribution No. 165.

LITERATURE CITED

Allen, H.H., J.W. Webb and S.O. Shirley 1984. Wetlands development in moderate wave-energy climates. pp. 943-955 IN, Proc. Conf. Dredging '84, Waterway, Port, Coastal and Ocean Division ASCE/Nov. 14-16, 1984, Clearwater Beach, FL.

Beno, M. 1986. They're doing the tuber toss in LaCrosse. Ducks Unlim. May/June, 1986, pp. 51-52.

Bourne, W.S. 1932. Ecological and physiological studies on certain aquatic angiosperms. Contrib. Boyce Thompson Inst. Plant Res., Inc. 4:425-496.

Carter, V. and N.B. Rybicki 1985. The effects of grazers and light penetration on the survival of transplants of Vallisneria americana Michx. in the tidal Potomac River, Maryland. Aquat. Bot. 23:197-213.

Folk, R.L. 1980. Collection and preparation of samples for analysis. Petrology of Sedimentary Rocks. Hemphill Publ. Co., Austin, TX 182 p.

Fonseca, M.S. and W.J. Kenworthy 1979. Transplanting of eelgrass and shoalgrass as a potential means of economically mitigating a recent loss of habitat. pp. 279-326. IN: D.P. Cole (ed.). Proc. 6th Ann. Conf. on Wetlands Restoration and Creation, May 19, 1979. Hillsborough Comm. Coll., Tampa, FL 357 p.

Fonseca, M.S., W.J. Kenworthy, F.M. Cheap, C.A. Currin and G.W. Thayer 1984. A low-cost transplanting technique for shoalgrass (Halodule wrightii) and manatee grass (Syringodium filiforme). U.S. Army COE, Waterways Exp. Sta., Vicksburg, MS, Environ. Impact Progr. Instruction Rept. EL-84-1.

Fonseca, M.S., W.J. Kenworthy, G.W. Thayer, D.Y. Heller and K.M. Cheap 1985. Transplanting of the seagrasses Zostera marina and Halodule wrightii for sediment stabilization and habitat development on the east coast of the United States. U.S. Army COE, Environ. Impact Res. Progr. Tech. Rept. EL-85-9. Waterways Exp. Sta., Vicksburg, Miss. 63 p.

Godcharles, M.F. 1971. A study of the effects of a commercial hydraulic clam dredge on benthic communities in the estuarine areas. Fla. Dept. Nat. Resour. Div., Mar. Resour. Tech. Ser. No. 64.

Haramis, G.M. and V. Carter 1983. Distribution of submerged aquatic macrophytes in the tidal Potomac River. Aquat. Bot. 15:65-79.

Heck, K.L., Jr. and R.J. Orth 1980. Seagrass habitats: The roles of habitat complexity and predation in structuring associated fish and motile macroinvertebrate assemblages. pp. 449-464, IN V. Kennedy (ed.). Estuarine Perspective. Academic Press, N.Y.

Heck, K.L., Jr. and T.A. Thoman 1984. The nursery role of seagrass meadows in the upper and lower reaches of the Chesapeake Bay. Estuaries 7(1): 70-92.

Heck, K.L., Jr. and K.A. Wilson 1987. Predation rates on decapod crustaceans in latitudinally separated seagrass communities: a study of spatial and temporal variation using tethering techniques. J. Exp. Mar. Biol. Ecol. 107:87-100.

Kikuchi, T. 1974. Japanese contribution on consumer ecology in eelgrass (Zostera marina L.) beds with special reference to trophic relationships and resources in inshore fisheries. Aquaculture 4:145-160.

Korschgen, C.E. and W.L. Green 1985. American wild celery (Vallisneria americana): A literature review. Northern Prairie Wildl. Res. Cent., La Crosse, WI. 50 p. manuscript.

Lewis, D.W. 1984. Texture of detrital sediments. IN Practical Sedimentology. Hutchinson Ross Publ. Co., Stroudsburg, PA. 229 p.

Livingston, R.J. 1984. The ecology of the Apalachicola Bay system: an estuarine profile. US FWS/OBS - 82/05. 148 p.

Mann, K.H. 1972. Macrophyte production and detritus food chains in coastal waters. Mem. Ist. Ital. Idrobiol. 29: 353.

Nelson, W.G. 1981. Experimental studies of decapod and fish predation on seagrass macrobenthos. Mar. Ecol. Prog. Ser. 5:141-149.

Orth, R.J. 1976. The demise and recovery of eelgrass, Zostera marina, in the Chesapeake Bay, Virginia. Aquat. Bot. 2:141-159.

Orth, R.J. and K.A. Moore 1981. Submerged aquatic vegetation of the Chesapeake Bay: Past, present and future. Trans. N. Amer. Wildl. Nat. Res. 46:271-283.

Orth, R.J. and J. van Montfrans 1987. Utilization of a seagrass meadow and tidal marsh creek by blue crabs, Callinectes sapidus. I Seasonal and annual variations in abundance with emphasis on post-settlement juveniles. Mar. Ecol. Prog. Ser. 41:283-294.

Peterson, G.H. 1982. Clam predation by whelks (Busycon spp.): Experimental tests of the importance of prey size, prey density, and seagrass cover. Mar. Biol. 66:159-170.

Phillips, R.C. 1980. Creation of seagrass beds. pp. 91-104. IN: J.C. Lewis and E.W. Bunce (eds.). Rehabilitation and creation of selected coastal habitats: Proc. of a Workshop. U.S. Fish and Wildl. Serv. FWS/OBS-80/27. 162 pp.

Phillips, R.C. 1982. Seagrass meadows. pp. 173-201. IN: R.R. Lewis, III (ed.) Creation and restoration of coastal plant communities. CRC Press, Boca Raton, FL, 219 p.

Purcell, B.H. 1977. The ecology of the epibenthic fauna associated with Vallisneria americana beds in a north Florida estuary. M.S. Thesis, Florida State University. 111 p.

Rasmussen, E. 1977. The wasting disease of eelgrass (Zostera marina) and its effect on environmental factors and fauna. pp. IN C.P. McRoy and C. Helfferich (eds.). Seagrass ecosystems: A scientific perspective. Marcel Dekker, N.Y.

Renfro, W.C. 1963. Small beam net for sampling postlarval shrimp. pp. 86-87, IN U.S. Fish Wildl. Circ. 161.

Rybicki, N.B. and V. Carter 1986. Effect of sediment depth and sediment type on the survival of Vallisneria americana Michx grown from tubers. Aquat. Bot. 24:233-240.

Stout, J.P. and M.J. Lelong 1981. Wetland habitats of the Alabama coastal area. Part II. An Inventory of wetland habitats south of the Battleship Parkway. Ala. Coastal Area Board, Tech. Publ. CAB-81-01. 24 Atlas pages.

Stout, J.P. M.J. Lelong, H.M. Dowling, and M.T. Powers 1982. Wetland habitats of the Alabama Coastal Zone. Part III. An inventory of wetland habitats of the Mobile-Tensaw River Delta. Ala. Coast. Area Bd., CAB Tech. Rept. 81-49A. 25 p. + 9 maps.

Summerson, H.C. and C.H. Peterson 1984. Role of predation in organizing benthic communities of a temperate-zone seagrass bed. Mar. Ecol. Progr. Ser. 15:63-77.

Taylor, J.L. and C.H. Saloman 1968. Some effects of hydraulic dredging and coastal development in Boca Ciega Bay, Florida. Fish. Bull. 67:213.

Thayer, G., D. Wolfe and R.W. Williams 1975. Man's impact on seagrass ecosystems. Am. Sci. 63(3):288-296.

Thayer, G.W., M.S. Fonseca, and W.J. Kenworthy 1985. Restoration of seagrass meadows for enhancement of nearshore productivity. pp. 259-278. IN N.L. Chao and W. Kirby-Smith (eds.) Proc. Intntl. Symp. on Utilization of Coast. Ecosys.: Planning, pollution and productivity, 21-27 Nov. 1982, Rio Grande, Brazil.

Thorhaug, A. 1974. Transplantation of the seagrass Thalassia testudinum Konig. Aquaculture 4:177-183.

Thorhaug, A. 1980. Techniques for creating seagrass meadows in damaged areas along the east coast of the U.S.A. pp. 105-116. IN: J.C. Lewis and E.W. Bunce (eds.). FWS/OBS-80/27. 162 pp.

Vittor, B.A., J.R. Stewart, Jr. and A.L. Middleton 1987. Creation of a brackish tidal marsh at West Fowl River, Alabama, pp. 120-129, IN T.A. Lowery (ed.). Symp. on the Nat. Res. of the Mobile Bay Estuary, Feb., 1977. Miss-Ala Sea Grant Publ. No. MASGP-87-007.

Zolczynski, J. 1987. Changes in submerged grassbeds of the Mobile delta 1979-1986. p. 104 IN: T. Lowery (ed.) Symposium on the natural resources of the Mobile Bay Estuary, Feb. 1987. MASGP-87-007. 208 p.