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16. Abstract

This project was designed to document the effects of transplanting on seagrass re-vegetation rate at dredged material placement areas and to compare utilization of these sites by fishes and crustaceans with that in adjacent re-vegetated placement areas and in undisturbed seagrass beds. The objective of the project was to determine whether dredged material placement operations can be modified to increase the seagrass re-vegetation rate between dredging cycles and thus improve habitat value over a shorter time frame. Water quality, light transmittance, seagrass density, sediment characteristics, and densities of fishery species and other natant macrofauna were measured at, and adjacent to, two experimental re-vegetation sites in Lower Laguna Madre near South Padre Island. Dredge deposits at experimental sites were completed in November 1994, and *Halodule wrightii* (shoalgrass) was transplanted onto the sites in June and September 1995. Light transmittance was monitored during November 1995 - November 1996. Water, sediment, seagrass, and faunal data were collected in April and October 1996 and April and September 1997. Seagrasses neither survived transplanting nor colonized naturally at either site. The failure of transplants at the experimental sites was likely a combination of planting seagrasses adapted to high light and low nutrients into an environment characterized by low light, high sediment ammonium concentration, and unstable substrate. Water column and light environments at the experimental sites were generally amenable to seagrass growth, although they were near the lower limits of underwater irradiance for shoalgrass survival. Old, naturally re-vegetated deposits north and south of the experimental sites supported mixtures of several seagrass species with total shoot densities and above- and below ground biomass similar to those found in one or more of the undisturbed seagrass habitats to the east and west. Fish communities of vegetated and non-vegetated habitats were different, even though total densities often did not differ significantly. Total fish biomass was usually lower at the experimental sites than at any vegetated habitat, although not always significantly lower. Total decapod density and biomass were usually significantly higher in old re-vegetated habitats and undisturbed seagrass beds that at the newly deposited experimental sites. Potential methods for successful re-vegetation of dredged material deposits in this locale are outlined.

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Final Report to the U.S. Army Corps of Engineers Galveston District

Colonization of Dredged Material Placement Areas by Shoalgrass in Lower Laguna Madre, Texas, and the Habitat Value of these Sites for Fishery Species

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Introduction

Designated placement areas for maintenance dredged material along the Gulf Intracoastal Waterway in Laguna Madre of Texas often support seagrass habitats. Seagrasses recruit from surrounding areas to dredged material after sediments settle and water clarity improves. Four species of seagrasses grow in Laguna Madre (Onuf 1996), specifically shoalgrass (*Halodule wrightii*), manatee grass (*Syringodium filiforme*), turtle grass (*Thalassia testudinum*), and clovergrass (*Halophila engelmannii*), as does wigeongrass *(Ruppia maritima)* which is a salt-tolerant freshwater plant. Seagrass meadows are typically dominated by one species and are distributed according to water clarity, depth, and salinity preferences (Onuf 1996).

Periodic deposition of dredged material at placement areas covers seagrasses and reduces the value of the bottom for fishery species and other estuarine animals, because seagrass beds typically support significantly greater densities of organisms than unvegetated sand or mud (reviewed by Sheridan et al. 1998). These placement areas may become re-vegetated, but recovery time is not well studied and the conditions needed to maximize the rate of seagrass colonization are not understood. In addition, re-establishment of seagrass in an area does not assure re-establishment of fishery habitat value (Sheridan et al. 1998). This project was designed to document the effects of transplanting on seagrass re-vegetation rate at dredged material placement areas and to compare utilization of these sites by fishes and crustaceans with that in adjacent re-vegetated placement areas and in undisturbed seagrass beds. The project was sponsored by the U. S. Army Corps of Engineers (ACE) Section 1135 Program that addresses project modifications for improvement of the environment. Water quality, light transmittance, seagrass density, sediment characteristics, and densities of fishery species and other natant macrofauna were measured at, and adjacent to, two experimental re-vegetation sites. The objective of the project was to determine whether dredged material placement operations can be modified to increase the seagrass re-vegetation rate at these sites between dredging cycles and thus improve habitat value of the areas for fishery species and other fauna over a shorter time frame.

Methods

General Description of the Area

Laguna Madre is the southernmost estuary of the Texas coast, extending 200 km from Corpus Christi Bay to the Rio Grande delta. Lower Laguna Madre extends from the Land Cut, an area of wind-blown sand that is flooded only on extreme high tides, south about 90 km to Brazos-Santiago Pass near the mouth of the Rio Grande. Seagrasses are generally found in all but the deepest (2-3 m), most turbid waters (Onuf 1996). The Gulf Intracoastal Waterway (GIWW) was dredged by ACE in the late 1940's and bisects Lower Laguna Madre longitudinally, generally on the western side. Periodic dredging is needed to maintain navigation depths for barge traffic.

Seagrass species composition and changes in coverage in Lower Laguna Madre have been documented by Quammen and Onuf (1993) and Onuf (1996). Surveys conducted for ACE related to this project indicated the seagrass composition of re-vegetated placement areas in Lower Laguna Madre was a mosaic primarily of *Halodule*, *Syringodium*, and *Thalassia*, with lesser amounts of *Halophila* and *Ruppia* (G. Galbraith, Espey, Huston & Associates, Inc., Austin, Texas, July 1994, pers. comm.). All five seagrasses were found in surrounding undisturbed beds (M. Arhelger, Espey, Huston & Associates, Inc., Austin, Texas, October 1995, pers. comm.).

Dredging Operations

Dredged material was deposited on two open bay placement areas beside the GIWW approximately 18 km northwest of Brazos-Santiago Pass (Figure 1). The north experimental site was in Placement Area 233 (26° 11' 48.3" N, 97° 15' 41.2" W), and the south experimental site was in Placement Area 234 (26° 09' 45.0" N, 97° 14' 46.8" W). These placement areas were 1.5-2.0 m deep before dredging activities took place (Brown and Kraus 1996). At each placement area, new materials were added to a 60 m x 60 m section located approximately 300 m from the GIWW. Dredging was completed in November 1994. When finished, the deposits resembled flattened cones and the center of each experimental site had an emergent mound of dredged material. Poles extending two meters above the water line were placed at the corners and center of each site.

Seagrass Transplanting

Sediments at the experimental sites were allowed to consolidate until June 1995. Seagrass (primarily *Halodule wrightii*) was transplanted from donor beds on the eastern side of Lower Laguna Madre near South Padre Island into the southern half of each newly deposited section, making two 60 m x 30 m plots. Transplanting was conducted in June 1995 using the peat pot method (Fonseca 1993) and spacing on 1-m centers (M. Arhelger, June 1995, pers. comm.). Water depths were 0.9-1.1 m. A post-transplant survey in August 1995 found *Halodule*, *Thalassia*, and *Ruppia* growing on the experimental sites (M. Arhelger, September 1995, pers. comm.). However, survival was poor (7% at the north site, 44% at the south site) which necessitated replanting in September 1995. No further monitoring of seagrass survival and growth was conducted.

Monitoring Light Transmittance

Measurements of photosynthetically active radiation (PAR = ca. 400 to 700 nm wavelength) at the sea floor were collected at four locations (Figure 1): north and south experimental sites, an old re-vegetated deposit in Placement Area 235 about 1 km southeast of the south experimental site (26° 09' 08.3" N, 97° 14' 25.7" W), and in an undisturbed *Halodule* bed 4 km southeast of Placement Area 234 (26° 08' 03.7" N, 97° 12' 20.1" W) (K. Dunton, University of Texas at Austin, Marine Science Institute, Port Aransas, Texas, pers. comm.). Underwater data were collected with LI-193SA spherical (4π) quantum sensors providing input to an LI-1000 data logger (LI-COR Inc., Lincoln, Nebraska). The data logger was placed in a weighted clear polycarbonate housing (Ikelite Model 5910, Indianapolis, Indiana) and was wired to the sensor cables through molded underwater connectors (Crouse-Hinds Series 41 Penetrator, LaGrange, North Carolina). Sensors were mounted on PVC pipes at seagrass canopy level (15-20 cm above the bottom) to minimize fouling by drift algae and seagrass leaves. At the experimental sites, sensors were deployed in each treatment (transplanted and bare) to compare the effects of transplanting on light attenuation. Single underwater sensors were deployed elsewhere. At all sites, a clear polyethylene bag was placed over the sensor to minimize fouling and was replaced at one to three week intervals. The bags had negligible effects on sensor function (K. Dunton, pers. comm.).

Simultaneous measurements of surface PAR were collected at an instrument platform between the two experimental sites (Fix 1 in Figure 1; 26° 10' 45.2" N, 97° 15' 36.2" W). An LI-190SA flat quantum sensor and LI-1000 data logger were deployed at the platform, with the sensor mounted at the highest point to avoid shadows. The ratio of underwater irradiance to surface irradiance (% SI) at each site allowed comparison to the annual minimum light requirements for *Halodule* of 18-25% SI (Dunton 1994, Dunton and Tomasko 1994) and for *Thalassia* of > 14% SI (Lee and Dunton 1997). In addition, irradiance measurements were used to calculate an integrated diffuse light attenuation coefficient (k) which quantifies the amount of light absorbed in the water column and provides an index of water transparency. Light attenuation was calculated using the Beer-Lambert equation:

$$I_0 = I_z e^{-kz}$$

where I_0 is irradiance at the surface, I_z is irradiance at depth, and k is the attenuation coefficient.

Sensor data for the period November 1995 - November 1996 were analyzed. Instantaneous PAR was measured at 1 min intervals and integrated hourly. The sensors used in this study were calibrated to ± 5% (traceable to National Bureau of Standards); stability was ± 2% over any 1 year period, and data were recorded with a precision of ± 1 μmol photons m^{-2} s^{-1}.

Experimental Design

Sampling was designed to test whether the various habitats examined had comparable sediment characteristics or supported similar seagrass growth and fishery and forage organism densities. The six habitats include newly deposited dredged material with and without transplants, older dredged material that was not transplanted but had re-vegetated (at least 5 years post deposition, but actual age unknown), and undisturbed *Halodule*, *Syringodium*, and *Thalassia* beds east and west of the experimental sites. Sampling depths were generally standardized to those found at the experimental sites (0.8-1.5 m).

Since there were no *a priori* quantitative data with which to determine local sampling effort, sample size was derived from a power analysis (Sokal and Rohlf 1981) of seagrass community measurements along the upper Texas coast (Sheridan, unpublished data). With 10-12 samples per habitat, a 100% difference in transformed means could be detected with $\alpha = 0.05$ and $1-\beta$ = power = 0.95 for dominant fauna, seagrass, and sediment variables. Accordingly, a total of 12 replicates per habitat and 72 samples per period were planned for seagrass and faunal analyses (fewer for sediments, discussed below).

Sampling was randomized within grids specified for all habitats. At each experimental site, the two 60 m x 30 m sections (one transplanted, one bare) were partitioned into eighteen 10 m x 10 m grids, and six grids were sampled from each section. Old re-vegetated habitats were located at the northern end of Placement Area 233 (near 26° 12' 15.0" N, 97° 16' 0.0" W) and at the southern end of Placement Area 234 (near 26° 09' 0.0" N, 97° 14' 48.0" W; Figure 1). Because the old re-vegetated habitats are linear features with sloping sides, sampling was conducted along a 360 m transect divided into 10 m intervals, and six intervals within the appropriate depth range (0.8-1.5 m) were sampled from each old deposit. Seagrass species composition was not controlled in the old re-vegetated habitats. Undisturbed seagrass beds were located east and west of the experimental sites. The area bounded by 26° 09' 00" - 26° 13' 00" N and 97° 11' 30" - 97° 13' 00" W comprised the East seagrass area, and the area bounded by 26° 08' 00" - 26° 12' 00" N and 97° 16' 00" - 97° 17' 30" W comprised the West seagrass area (Figure 1). Each seagrass area was divided into 10 sec grids of latitude and longitude, and 18 of these grids in each area within the appropriate depth range of 0.8-1.5 m were sampled (six each of *Halodule*, *Syringodium*, and *Thalassia*). Target seagrass species were randomly assigned to each grid, and the center of each grid was located by GPS (Garmin International, Model 38, Olathe, Kansas; position accuracy 100 m). On arrival, the grid was searched for the appropriate seagrass species; if not found, an alternate grid was selected.

Sampling was conducted in April and October 1996 and in April and September 1997. These months were chosen because fish and decapod abundances, in particular spotted seatrout (*Cynoscion nebulosus*) and commercial penaeid shrimps (*Penaeus* spp.), were expected to be relatively high at these times of the year (Simmons 1957, Hellier 1962, Hoese and Jones 1963, Stokes 1974). September also represents the seasonal peak in aboveground biomass for seagrasses (Pulich 1985, Dunton 1990, 1994).

Macrofaunal Sampling

Fishes and decapods were sampled quantitatively with either drop trap or throw trap techniques, depending upon sediment characteristics and water depth. At all seagrass sites and re-vegetated placement areas, samples were collected with a 1.0 m^2 cylindrical drop trap made of fiberglass and deployed from the bow of a boat (Zimmerman et al. 1984). The edge of the drop trap was tall enough (1.7 m) to remain above water, enclosing the entire water column. Average water depth, salinity, temperature, dissolved oxygen, and turbidity were measured within the drop trap before any other activities. Salinity was measured with a temperature-compensated refractometer. Temperature and dissolved oxygen were measured with a YSI Model 55 meter (YSI Inc., Yellow Springs, Ohio). Water samples for turbidity analysis were collected in screw cap bottles and later tested in the laboratory with an HF Scientific Model DRT100B turbidimeter (HF Scientific, Ft. Myers, Florida). All water was then pumped out of the drop trap through a 1-mm mesh plankton net into a removable mesh bag. Any organisms remaining on the bottom were removed and added to the mesh bag. At the experimental placement areas, the combination of high tides and soft sediments occasionally forced use of a 1.0 m^2 throw trap (Kushlan 1981) in lieu of the drop trap. The throw trap, made of 3 mm mesh nylon net with an iron rebar bottom frame and a buoyant PVC plastic top frame, was also tall enough (1.5 m) to enclose the entire water column. The throw trap was deployed off the bow of a boat, then it was retrieved by pushing the leading edge of a 1.4 m^2 bag net (3 mm mesh net on a rebar frame) 5-10 cm into the mud under the throw trap and scooping the entire throw trap up out of the water. The throw trap was removed, sediments were washed out of the bag net, and the contents were collected in a mesh bag. Mesh bags were preserved in 10% buffered formalin-seawater until laboratory analysis.

All macrofaunal samples were collected during daylight hours. A recent study of fishes and decapods in seagrasses of Florida Bay, Florida, indicated no differences in community composition or density between daylight and nocturnal sampling (Sheridan et al. 1998).

Sediment Characteristics

In southern Texas estuaries, water column nutrient levels are low (typically < 5 µM; Dunton 1996) while sediment ammonium values range between 50 and 350 µM NH_4^+ (Pulich 1985, Czerny and Dunton 1995, Dunton 1996). Thus, sediment ammonium is generally considered the primary nutrient pool and could be a factor in determining the success and health of seagrass re-vegetation projects. Sediment pore water ammonium was measured in conjunction with faunal sampling (n = 6-12 for each habitat each month). Sediment samples were collected from within the empty drop trap or adjacent to the deployed throw trap in triplicate using a 60 ml plastic syringe. Samples were stored in plastic bags on ice during transport and were frozen prior to laboratory analysis. Pore water was extracted by centrifuging thawed sediments and analyzing the supernatant for NH_4^+ following the methods of Parsons et al. (1984). Data from the three replicates per site were averaged.

Sediment organic content and sand and silt+clay proportions were determined from single syringe samples (collected as above) during April 1996 and September 1997 (n = 8-12 per habitat each month). A subsample of sediment was dried to a constant weight, weighed, combusted at 500° C for 3 hr, then re-weighed to determine percent organic material lost (modified from Dean 1974). Rubble was removed from another subsample by washing through a 2 mm sieve, then sand and silt+clay proportions were determined following the methods of Folk (1980).

Seagrass Biological Characteristics

Seagrass coverage, shoot density, and above- and belowground biomass were measured either within the perimeter of the drop trap or adjacent to the deployed throw trap at each site. Seagrass coverage was estimated by haphazard placement of a single 0.25 m^2 quadrat divided into 100 grids on the bottom, then noting the presence of each species of seagrass within each grid. Shoot density and aboveground biomass were determined by placement of three 0.0625 m^2 quadrats on the bottom, counting the number of shoots enclosed, removing all aboveground material, washing sediments free, and drying the material to a constant weight. Results of the three subsamples were averaged per site. During April and September 1996, replicate cores (15 cm diameter, 20 cm deep; n = 10) were obtained for each seagrass species. These samples were separated into aboveground and belowground components, then washed, dried, and weighed as above. Thereafter, belowground biomass was estimated non-destructively for each aboveground subsample from regression equations derived from these cores (K. Dunton, unpublished data).

Data Analysis

Habitat-related differences in macrofaunal and seagrass densities and in sediment characteristics during each sampling period were examined by one-way analysis of variance (ANOVA). Differences in utilization of seagrass habitats by commercial and recreational fishery species was the primary focus of the analysis. Fishery species monitored by Texas Parks and Wildlife Department (Campbell et al. 1991, Robinson et al. 1997) that were captured in this study included brown shrimp (*Penaeus aztecus*), white shrimp (*P. setiferus*), pink shrimp (*P. duorarum*), blue crab (*Callinectes sapidus*), spotted seatrout (*Cynoscion nebulosus*), red drum (*Sciaenops ocellatus*), spot (*Leiostomus xanthurus*), Atlantic croaker (*Micropogonias undulatus*), sheepshead (*Archosargus probatocephalus*), southern flounder (*Paralichthys lethostigma*), and gulf menhaden (*Brevoortia patronus*). These species were combined into two groups (decapods and fishes) for analysis because of low densities. Other forage fishes and decapods were tested only if densities were $\geq 1\ m^{-2}$ in any habitat during a given month. Differences in water quality (depth, salinity, temperature, turbidity, dissolved oxygen), seagrass descriptors (total shoot density, above- and belowground biomass), and sediment characteristics (NH_4^+, % organic matter, and % sand) were also tested.

Examination of the distribution of error terms for the most abundant macrofauna and for the water, sediment, and seagrass characteristics indicated no gross violations of assumed normality (Shapiro-Wilk test statistic). Positive relationships between means and variances in density were detected for dominant macrofauna, and log(x+1)-transformation was used successfully to achieve homogeneity of variances for faunal data prior to ANOVA. Percentage data were arcsine-transformed prior to ANOVA. Tabular data are untransformed means, but ANOVA and multiple comparison results are from transformed data where applicable. Multiple comparison of treatment means employed Ryan's Q test for balanced designs or the GT2 test for unbalanced designs (Day & Quinn 1989). All analyses were conducted using SAS personal computer software (SAS Institute Inc. 1985).

Results

Seagrass biological characteristics. – Quantitative and qualitative measurements of seagrass coverage at both experimental sites indicated that no seagrasses survived the two planting efforts in 1995 and that none naturally colonized the dredged material (Tables 1-4). No transplants were ever found in drop traps or throw traps deployed on the deposits, and no live seagrass was noted by divers servicing underwater light meters during 1996 and 1997 (J. Kaldy, University of Texas at Austin, Marine Science Institute, Port Aransas, TX, pers. comm.).

Old, naturally re-vegetated deposits north and south of the experimental sites supported mixtures of *Halodule*, *Halophila*, *Syringodium*, and *Thalassia* with total shoot densities and above- and belowground biomasses similar to those found in one or more of the undisturbed seagrass habitat types to the east and west (Tables 1-4). The old north site supported a mixture of *Halodule*, *Halophila*, and *Syringodium* with little *Thalassia*, whereas the old south site was a mixture of *Syringodium* and *Thalassia*. *Ruppia* was not recorded at either old re-vegetated placement area.

Coverage in each of the three undisturbed seagrass habitats was dominated by one species but also supported an understory of one to three other species (Tables 1-4). Total shoot densities in *Halodule* habitats were usually significantly higher than those in *Thalassia* beds, while

Syringodium shoot densities were intermediate. Aboveground and belowground biomass were always highest in *Thalassia* and were often not significantly different between *Halodule* and *Syringodium* beds. There were no consistent differences within each habitat in terms of species coverage, shoot densities or biomasses between east and west beds, with one exception. *Thalassia* biomass was up to three times higher in western beds in three of four sampling periods; however, too few samples were collected to determine the significance of this trend. *Ruppia* was not recorded at any open bay sampling site.

Water column and sediment characteristics. – Water depth over the experimental deposits was observed to increase over time, from partially emergent in November 1994 to 1.0-1.5 m depths by September 1997. By October 1996, water depths at both experimental sites were not significantly different from the undisturbed seagrass beds to the east and west (Tables 1-4). Water depths at the old re-vegetated placement areas were significantly shallower than for other habitats in all sampling periods. This was due to restricted sampling depths caused by steeply sloping sides at the south site and by lack of seagrass growth in deeper waters at the north site. Although significant differences in salinity and temperature among habitats were occasionally observed, the magnitudes of difference were slight (e.g., 4 ‰ and 1-2° C) and were attributable to variations in cloud cover and rainfall among sampling days. In three of four months, turbidity values at one or more of the dredged material placement habitats were significantly higher than those observed over seagrass beds. Relatively high turbidities at the old re-vegetated placement areas were likely advected in from nearby open bay placement areas that were used at the same time this experiment started (Brown and Kraus 1996). Turbidities were generally higher in April than in September or October, due to higher wind speeds observed during sampling (averages of 24 and 33 km/h in April 1996 and 1997 versus 11 and 15 km/h in October 1996 and September 1997). A similar seasonal pattern in wind speed was recorded during year-long monitoring of the area by Brown and Kraus (1996). As the new deposits aged, seasonal average turbidity values at all three dredged material habitats decreased (April 1996, 59-83 NTU versus April 1997, 25-61 NTU; October 1996, 5-12 NTU versus September 1997, 3-5 NTU). Occasional differences in dissolved oxygen values were detected, but there were no indications of hypoxia (< 2 ppm) in any habitat.

The newly deposited dredged material compacted to some degree over time, but most likely the fine components were re-suspended and transported away by currents as observed at nearby open bay placement sites (Brown and Kraus 1996). This loss of fines was reflected in the increased percentages of sand and decreased percentages of silt and clay at the experimental sites between November 1995 and September 1997 (Tables 1 and 4). By the latter date, there were no significant differences among the six habitats in sand or silt+clay proportions. Organic matter contents of newly deposited material were usually lower than those found in seagrass habitats, though significant differences were only found in September 1997. Sediment NH_4^+ concentrations were significantly higher in pore waters of new deposits at experimental sites than in other habitats during all sampling periods, although levels decreased from >400 μM in April 1996 to <150 μM by September 1997. Observations made in November 1995, shortly after transplanting, indicated NH_4^+ concentrations exceeding 900 μM were common (K. Dunton, pers. comm.). The south experimental site exhibited NH_4^+ concentrations that were often 2 to 4 times higher than those observed at the north experimental site. The opposite trend was seen at the old re-vegetated deposits, although the NH_4^+ concentrations were much lower. No significant differences in NH_4^+ were detected among vegetated habitats, nor were any east-west differences noted; however, NH_4^+ concentrations were always lowest in *Thalassia* beds.

Light transmittance. – Surface irradiance followed a typical seasonal signature (Figure 2), with a minimum of 30 mol m^{-2} d^{-1} in December and a maximum of 60 mol m^{-2} d^{-1} in July. Spikes in the signature were caused by cloud cover (data gaps were due to equipment servicing). Underwater irradiance at all stations varied between 0 and 50 mol m^{-2} d^{-1} and between 0% and 100% of surface irradiance (SI; Figures 3-8). Underwater irradiance at the north experimental site ranged between 0.1% and 90% SI, with average winter values of 25% SI and average summer values of 15% SI (Figures 3-4). Underwater irradiance at the south experimental site ranged between 0% and 100% SI, with average winter values of 30% SI and average summer values of 20% SI (Figures 5-6). Irradiance levels were similar between new transplanted and new bare treatments at each experimental site. However, attenuation coefficients (k values) were up to 20% greater at the north experimental site than at the south experimental site, and k values at the experimental sites were 45% to 65% greater than those at the old re-vegetated site or the undisturbed *Halodule* bed. Underwater irradiance at the old re-vegetated placement area ranged between 0% and 100% SI, with average winter values of 40% SI and average summer values of 55% SI (Figure 7). Underwater irradiance at the undisturbed *Halodule* bed ranged between 0.1% and 100% SI, with average winter values of 35% SI and average summer values of 70% SI (Figure 8). Light transmittance below the minimum required for *Halodule* (18% SI) occurred on 45 to 60% of the days measured at the experimental sites but on less than 10% of the days measured at the re-vegetated placement area and the undisturbed *Halodule* site.

Macrofaunal communities. – Comparisons of dominant fish and decapod densities by sampling period are presented in Tables 5-8. Complete listings of all macrofauna captured in each habitat are included as Appendix 1. Fish communities of vegetated and non-vegetated habitats were different, even though total densities often did not differ significantly (Tables 5-8). When relatively large numbers of fishes were present at the non-vegetated experimental sites, they were always bay anchovy (*Anchoa mitchilli*) or striped anchovy (*Anchoa hepsetus*) which were not usually found in abundance over seagrasses. Anchovies are water column planktivores that are not closely linked to the substrate. The only other fish species approaching densities of 1 m^{-2} at the experimental sites was another planktivore, the scaled sardine (*Harengula jaguana*), in September 1997 (Appendix 1). In contrast, seagrass habitats and the old re-vegetated placement areas were characterized by relatively high densities of code goby (*Gobiosoma robustum*) and pinfish (*Lagodon rhomboides*) which were not found over mud substrates. Code goby and pinfish are epibenthic predators that are closely linked to the substrate. Other occasionally abundant fishes in vegetated habitats included gulf toadfish (*Opsanus beta*) and gulf pipefish (*Syngnathus scovelli*) (Appendix 1), which are also epibenthic predators. Total fish biomass was usually lower at the experimental sites than at any vegetated habitat, although not always significantly lower (Tables 5-8).

Total decapod densities were always higher in old re-vegetated habitats and seagrass beds that at the newly deposited experimental sites (Tables 5-8), with one exception. In April 1996, decapod densities were relatively high in the new transplanted habitat due to an abundance of small hermit crabs (*Pagurus criniticornis* and *Pagurus longicarpus)*. While hermit crabs were usually found in each of the six habitats each sampling period, densities were never as high as during that month. All of the dominant decapod species were found in all habitats during months they were collected, but most (9 of 12 taxa) were significantly more abundant in vegetated habitats than in mud habitats (Tables 5-8). The exception (aside from hermit crabs) was lesser blue crab (*Callinectes similis*) which frequently exhibited densities at the experimental sites that were not significantly different than those in one or more of the vegetated habitats. Decapods were split into shrimps and crabs to compare biomasses among habitats, due to anticipated effects of heavier-bodied crabs. In spite of that, shrimp and crab biomasses were usually significantly higher in vegetated habitats that in experimental habitats.

The numbers of fish species recorded in each habitat was almost always higher where seagrasses were growing (4-14 species) than over bare substrates at the experimental sites (1-8 species; Appendix 1) and were consistently highest in the old re-vegetated placement areas. Total recorded decapods were usually 10-14 species per sampling period in vegetated habitats, with *Halodule* tending to support fewer species (Appendix 1). The experimental sites harbored 4-13 decapod species in a given sampling period, again indicating the widespread distribution of the decapods. The total number of species recorded in each community was always higher (significantly so in three of four sampling periods) in vegetated habitats than at the experimental sites.

Densities of commercially and recreationally important fishes were low (< 1 fish m^{-2}) in all habitats and study periods, with the exception of April 1997 when gulf menhaden and Atlantic croaker raised the mean density to 2.1 fish m^{-2} in *Syringodium* habitat (Tables 5-8). Fewer than 10 specimens each of sheepshead, spotted seatrout, spot, southern flounder, and red drum were found in 288 samples (Appendix 1). Total catches of commercial and recreational fishes were highest in the old re-vegetated and *Syringodium* habitats. Considered as a group, densities of commercially and recreationally valued decapods were always higher in most or all vegetated habitats than in newly deposited dredged materials (Tables 5-8). Mean densities ranged up to 10.8 decapods m^{-2} in old re-vegetated habitat in April 1997. This group of decapods was dominated by brown shrimp, which comprised 87% of all specimens captured. Blue crab was the second most abundant species (8.5% of the commercial and recreational decapods). Total captures of these two species over all 288 samples were highest in old re-vegetated, *Halodule*, and *Syringodium* habitats (Appendix 1).

Discussion

Water column and light environments at the experimental sites were generally adequate to support survival and growth of transplanted seagrasses. Temperature, salinity, and dissolved oxygen measurements indicated well-mixed waters throughout the sampling area. Turbidity was higher at the experimental sites than elsewhere, which led to increased light attenuation and thus decreased light transmittance to the bottom. However, the underwater light regime at the experimental transplant sites was 15-20% SI during the summer. These values exceeded the 14% SI minimum light requirements for *Thalassia* (Lee and Dunton 1997) but were near the 18-25% SI minimum required for *Halodule* (Dunton 1994, Dunton and Tomasko 1994). Plants at the old re-vegetated and undisturbed *Halodule* sites received 3 to 4 times their estimated minimum light requirements. Plants acclimated to relatively low light conditions should have been able to survive and grow after transplanting to the experimental sites. However, the transplant materials were collected from a high light environment near South Padre Island. *Halodule* is not known to photoadapt to reduced light (Dunton and Tomasko 1994), thus the plants likely were stressed by the low light conditions.

Sediment ammonium concentrations at the experimental sites were an order of magnitude higher than elsewhere at the start of this study (18 months after deposition) and remained elevated for another 18 months. Sediment ammonium concentrations from the old re-vegetated sites and from natural seagrass beds were significantly lower than the experimental sites. However, only those ammonium concentrations observed in November 1995 (two months after planting; K. Dunton, pers. comm.) and in April 1996 (this study) were above published maxima for Laguna Madre seagrasses (Pulich 1985, Czerny and Dunton 1995, Dunton 1996, Lee and Dunton 1997). Recent observations indicate that ammonium concentrations exceeding 400 μM occasionally are detected in Laguna Madre *Halodule* beds (J. Morse, Texas A&M University, College Station, Texas, pers. comm.). Although sediment ammonium is an important nutrient, extreme levels may be stressful or toxic to plants (Vines and Wedding 1960, Warren 1962, Santamaria et al. 1994). Plants acclimated to relatively high sediment ammonium concentrations should have been able to survive and grow after transplanting to the experimental sites. However, the transplants used in this experiment likely were adapted to the low sediment ammonium environment typical of *Halodule* beds east and west of the experimental sites. The high ammonium concentrations, in combination with other stresses, may have inhibited growth of the transplants.

The experimental sites were initially characterized by lower sediment organic content and lower sand / higher silt+clay contents than re-vegetated or undisturbed seagrass habitats. Sediment organic content in Lower Laguna Madre has been reported to range from 0.1% to 2.8% (White et al. 1986). No habitat was below that range during the study, and seagrass habitats always exceeded it, so organic matter was not a limiting factor to seagrass growth. While some compaction likely occurred, the larger amount of fine material in the dredged sediments was probably winnowed out and transported away from experimental sites. Three years after dredging, there were no differences in sand or silt+clay proportions among any habitats. The experimental sites were located in a reach of Lower Laguna Madre where there is a strong cross-channel flow (southwest to northeast across the GIWW) resulting from a circulation gyre (Militello and Kraus 1994). Deposits of fine materials in this area would have been subjected to strong erosion and transport processes. Bathymetric mapping of open bay deposits in Placement Areas 233 and 234 before and after dredging indicated that deposits were flattened out by this circulation feature in as little as 13 months (Brown and Kraus 1996). Transplants in this unstable sediment would have had to grow rapidly, in spite of other stresses, to offset erosion.

Although the time between last use and present study measurements on the old re-vegetated deposits was unknown, this study indicated that eventually seagrasses can colonize from neighboring beds and stabilize dredged material deposits if sediments are not subjected to rapid erosion and if water column and light conditions permit. The old re-vegetated deposits appeared to be outside the influence of the erosional forces affecting the experimental sites. Seagrass shoot density, biomass, light transmittance, and sediment ammonium at old deposits were often similar to conditions in one or more of the undisturbed seagrass habitats. Underwater irradiance reached the minimum *Halodule* support level within 18 months of dredging in the present study. These water transparency conditions were also met in the same time frame at adjacent open bay placement areas (Brown and Kraus 1996) as well as at sites farther north (Onuf 1994). However, more than three years would be necessary for sediment ammonium levels of fresh deposits to decline to levels associated with adjacent undisturbed seagrass communities in this area of Lower Laguna Madre. The failure of all transplants prevented projection of re-vegetation rates in this study. Natural re-vegetation of dredged material deposits in Upper Laguna Madre was considered slow by Rickner (1979), who found that seagrass was relatively sparse at sites < 10 years old and approached natural conditions only after > 20 years. However, recent observations at placement areas north of the experimental sites in both Lower Laguna Madre and Upper Laguna Madre indicate unassisted *Halodule*, *Halophila*, and *Ruppia* colonization and dense above-ground biomass within two years is possible at physically stable sites (Sheridan, unpublished data).

This study provides the first quantitative estimates of fish and decapod densities for the southern half of Lower Laguna Madre. Faunal densities and biomasses at the muddy experimental sites were generally lower than those of seagrass habitats, less so for fishes than for decapods. Species compositions were also affected by lack of vegetation, in that water column fishes were more numerous at non-vegetated habitats and epibenthic fishes dominated seagrass habitats. Non-vegetated mud or sand habitats typically exhibit significantly lower faunal densities than do adjacent seagrasses (Summerson and Peterson 1984, Fonseca et al. 1990, Sogard and Able 1991, Humphries et al. 1992, Connolly 1994, Sheridan et al., 1998; but see Sheridan et al. 1992 for exceptions). This suggests seagrasses provide a general refuge function for mobile fishes and invertebrates, but there are species that are adapted to life in vegetated habitats and are not found in mud or sand habitats (Sheridan 1992). Once the dredged material deposits re-vegetate, they support high densities and diversities of fishes and decapods typical of undisturbed seagrasses in Laguna Madre. How long it takes Laguna Madre deposits to re-vegetate and to attract similar faunal densities and diversities remains unknown. In the Indian River Lagoon of Florida, undisturbed seagrass beds and well-established recolonized dredged deposits with similar macrofaunal densities exhibited differences in species composition and community indices even after 31 years (Brown-Peterson et al. 1993).

Spring and fall densities of fishes and decapods in seagrass habitats examined in this study were generally lower than those in seagrass beds sampled with quantitative gear elsewhere in Texas. Fish densities ranged from 2 to 12 m^{-2} in this study. Farther north, the range in fish densities in seagrass habitats of Lower and Upper Laguna Madre was 8-17 m^{-2}, those in extreme Upper Laguna Madre and Corpus Christi Bay were 8-14 m^{-2}, and those in Christmas Bay were 15-98 m^{-2} (Sheridan, unpublished data). In Florida, fish densities were 5-13 m^{-2} in Rookery Bay (Sheridan 1992), 55-75 m^{-2} in Florida Bay (Sheridan et al. 1998), and up to 66 m^{-2} in Indian River Lagoon (Snodgrass 1992). Similar trends were noted for decapods, which in this study ranged from 10 to 73 m^{-2}. The range in decapod densities in seagrass habitats in the Lower and Upper Laguna Madre north of the present study area was 20-90 m^{-2}, those in extreme Upper Laguna Madre and Corpus Christi Bay were 24-133 m^{-2}, and those in Christmas Bay were 40-120 m^{-2} (Sheridan, unpublished data). In Florida, decapod densities were 28-145 m^{-2} in Rookery Bay (Sheridan 1992), 160-450 m^{-2} in Florida Bay (Sheridan et al. 1998), and 90 m^{-2} in Indian River Lagoon (Gore et al. 1981).

Even though fish and decapod densities were relatively low, fisheries productivity of Lower Laguna Madre is high. Texas Parks and Wildlife Department monitors nine bay systems and four offshore statistical subareas. Inshore finfish production in 1996 was second only to Upper Laguna Madre, while offshore finfish landings (statistical subarea 21) ranked second behind the Upper Texas coast (statistical subarea 18; Robinson et al. 1997). Party boat fishing pressure and landings in Lower Laguna Madre are the highest of any Texas bay system (Campbell et al. 1991). Offshore shrimp landings often rank second behind the upper-middle Texas coast (statistical subarea 19; Nance 1993). The mechanism for maintaining system productivity resides in the 480 km^2 of seagrasses in Lower Laguna Madre (Quammen and Onuf 1993), the third largest expanse of seagrasses in the U. S. Gulf of Mexico behind the Florida Bay - Florida Keys complex and the Florida Big Bend region (6475 km^2 and 3350 km^2, respectively, Sargent et al. 1995). Seagrasses provide refuge and food for juvenile fishery and forage organisms, and this study has indicated that re-vegetated placement areas can be as productive as adjacent natural seagrass beds.

Conclusions and Recommendations

The failure of transplants at the experimental sites was likely a combination of planting seagrasses adapted to high light and low nutrients into an environment characterized by low light, high sediment ammonium concentration, and unstable substrate. Water column and light environments at the experimental sites were generally amenable to seagrass growth although near the lower limits in underwater irradiance. Sediment ammonium concentrations were initially high but declined throughout the study. The sediments themselves were unstable and rapidly dispersed by currents. The project would have been more informative had the experimental sites been more stable and had the donor plants come from light and sediment environments more like the experimental area. However, this study provided the first quantitative estimates of fish and decapod densities for the southern half of Lower Laguna Madre and indicated that re-vegetated placement areas can be as productive as adjacent natural seagrasses.

Methods for conserving present seagrass habitats and enhancing recovery of seagrasses to dredged material placement areas while keeping commercial waterways open still need to be included in dredging management plans. It is unlikely that material dredged from the GIWW and deposited in open bay Placement Areas 233 and 234 would ever remain in place long enough for seagrasses to colonize. Circulation patterns cause rapid erosion of these deposits. However, depositing material at the extreme northern or southern ends of this pair of sites (or in Placement Areas 232 or 235) should remove it from erosional currents since these locations are now characterized by emergent islands or shallow seagrass-covered banks. Another option for Placement Areas 233 and 234 would be to use submerged or emergent levees to confine dredged material and protect it from currents. A submerged levee was built in Placement Area 234 and an emergent levee was built in Placement Area 233, and both were filled at the same time as the Section 1135 sites (T. Roberts, ACE, pers. comm.). The top 1 m of the emergent levee was visible when it was built in 1994, but it was no longer visible after about two years. The success or failure of these confinement techniques is unknown and should be examined. If unsuccessful, it likely would have been caused by the same erosional forces breaching the levee material. To be successful, these levees could be reinforced or armored until dredged materials have settled and seagrasses (transplanted or recruited naturally) were able to receive sufficient light in calmer waters. Ideally, the top of such a levee would be 0.5-1.0 m below mean low water to insure water flow and access by fishery and forage organisms.

In the case of Lower Laguna Madre, it remains to be seen whether transplanting onto fresh dredged material deposits will accelerate re-vegetation and enhance fishery productivity. The Section 1135 project, while an apparent failure to speed up seagrass coverage of fresh dredged material deposits, has supplied information on the siting of open bay placement areas, on seagrass transplanting, and on the value of seagrass habitats to fishery and forage organisms.

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Table 1. Seagrass, water column and sediment characteristics in dredged material placement sites and adjacent seagrass habitats in Lower Laguna Madre, April 1996. N = 12 replicates per habitat for seagrass and water column data and n = 8 - 12 for sediment data. Sand and silt/clay data for New sites from November 1995. Organics data for New sites from February 1996. * = tested by ANOVA. Means indicated with differing letters were significantly different (ANOVA and Ryan's Q or GT2 test).

		Dredged Material Habitats						Seagrass Habitats								
		New, Transplanted		New, Bare		Old, Revegetated		Halodule		Syringodium		Thalassia		ANOVA		
		Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	df	F	P
Seagrass coverage (%)	*Halodule*	0.0	0.0	0.0	0.0	6.5	4.3	78.5	9.5	0.0	0.0	8.3	8.3			
	Halophila	0.0	0.0	0.0	0.0	41.9	13.2	11.1	7.5	0.0	0.0	0.0	0.0			
	Syringodium	0.0	0.0	0.0	0.0	11.1	5.4	18.2	9.1	94.2	4.1	11.4	4.9			
	Thalassia	0.0	0.0	0.0	0.0	50.0	15.1	3.8	3.3	6.4	4.5	84.3	8.8			
Shoot density (per m2)	*Halodule*	0	0	0	0	41	21	647	155	56	38	68	34			
	Halophila	0	0	0	0	109	41	20	20	0	0	4	4			
	Syringodium	0	0	0	0	67	27	57	28	859	181	79	29			
	Thalassia	0	0	0	0	364	115	35	27	63	37	463	79			
	Total *	0 b	0	0 b	0	580 a	93	758 a	144	977 a	173	614 a	61	5, 66	15.40	<0.001
Seagrass biomass (dry g / m2)	Aboveground *	0.0 c	0.0	0.0 c	0.0	30.7 b	7.8	8.2 bc	2.3	33.0 b	4.5	86.7 a	14.6	5, 66	21.82	<0.001
	Belowground *	0.0 c	0.0	0.0 c	0.0	182.7 b	55.5	32.8 bc	7.6	93.8 bc	16.0	532.1 a	89.4	5, 66	21.95	<0.001
	Total	0.0	0.0	0.0	0.0	213.4	63.2	40.9	9.6	126.8	19.9	554.8	94.5			
Water column	Depth (cm) *	95.5 b	2.4	109.3 a	4.8	82.1 c	1.7	119.9 a	4.6	112.8 a	4.0	118.3 a	3.7	5, 66	15.68	<0.001
	Salinity *	32.6	0.5	33.9	0.5	33.6	0.6	34.0	0.6	32.2	0.6	32.1	0.4	5, 66	2.65	0.030
	Temperature (C) *	21.6	0.1	21.3	0.1	21.6	0.3	22.0	0.5	22.3	0.3	22.3	0.4	5, 66	1.72	0.143
	Turbidity (NTU) *	83.3 a	15.3	80.5 a	14.9	58.6 a	16.6	10.8 b	3.8	6.8 b	1.6	8.7 b	2.8	5, 66	10.76	<0.001
	Oxygen (ppm) *	5.8 b	0.6	6.4 ab	0.2	7.4 a	0.6	7.3 ab	0.2	7.2 ab	0.3	7.2 ab	0.2	5, 66	2.68	0.029
Sediment	NH4 (uM) *	429.4 a	78.7	462.4 a	91.7	56.8 b	8.8	45.3 b	5.7	52.4 b	5.0	36.9 b	6.3	5, 62	15.77	<0.001
	% Organics *	1.8	0.1	1.7	0.2	2.1	0.3	3.3	0.2	3.5	0.3	3.6	0.3	5, 66	1.69	0.150
	% Sand *	53.4 bc	4.0	41.4 c	6.7	80.5 a	3.9	71.9 ab	2.2	64.2 ab	5.4	72.8 a	2.7	5, 56	10.09	<0.001
	% Silt/Clay	46.8	4.0	58.6	6.7	19.5	3.9	28.1	2.2	35.8	5.4	27.3	2.7			

Table 2. Seagrass, water column and sediment characteristics in dredged material placement sites and adjacent seagrass habitats in Lower Laguna Madre, October 1996. N = 12 replicates per habitat for seagrass data and n = 6 - 12 for sediment and water column data. * = tested by ANOVA. Means indicated with differing letters were significantly different (ANOVA and Ryan's Q or GT2 test).

		Dredged Material Habitats						Seagrass Habitats								
		New, Transplanted		New, Bare		Old, Revegetated		Halodule		Syringodium		Thalassia		ANOVA		
		Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	df	F	P
Seagrass coverage (%)	*Halodule*	0.0	0.0	0.0	0.0	41.0	14.4	96.2	2.2	0.8	0.8	0.0	0.0			
	Halophila	0.0	0.0	0.0	0.0	23.6	9.7	0.0	0.0	0.0	0.0	0.0	0.0			
	Syringodium	0.0	0.0	0.0	0.0	26.5	11.5	14.5	8.9	96.5	2.6	8.4	8.3			
	Thalassia	0.0	0.0	0.0	0.0	52.1	14.6	0.0	0.0	24.8	13.0	99.5	0.4			
Shoot density (per m2)	*Halodule*	0	0	0	0	782	310	4742	527	114	63	0	0			
	Halophila	0	0	0	0	0	0	0	0	0	0	0	0			
	Syringodium	0	0	0	0	741	159	178	98	2237	377	28	27			
	Thalassia	0	0	0	0	723	238	2	2	161	82	1168	118			
	Total *	0 d	0	0 d	0	2246 b	274	4921 a	497	2512 b	359	1196 c	102	5, 66	45.04	<0.001
Seagrass biomass (dry g / m2)	Aboveground *	0.0 b	0.0	0.0 b	0.0	105.3 a	21.4	60.7 a	8.6	73.7 a	12.9	97.4 a	10.1	5, 66	16.12	<0.001
	Belowground *	0.0 c	0.0	0.0 c	0.0	654.1 a	100.0	248.7 b	25.7	340.3 b	32.9	654.7 a	142.4	5, 66	16.26	<0.001
	Total	0.0	0.0	0.0	0.0	759.5	121.0	309.3	25.3	414.0	40.3	752.2	146.0			
Water column	Depth (cm) *	112.4 a	1.9	114.5 a	2.0	95.9 b	4.2	117.3 a	5.3	124.4 a	5.0	122.9 a	3.8	5, 62	6.56	<0.001
	Salinity *	29.8	0.6	32.0	1.0	33.9	0.5	32.3	1.2	32.9	1.2	32.5	1.3	5, 62	1.5	0.202
	Temperature (C) *	25.6 a	0.3	25.8 a	0.2	24.4 b	0.1	25.5 ab	0.3	25.5 ab	0.4	25.4 ab	0.3	5, 62	2.97	0.018
	Turbidity (NTU) *	6.3 b	2.0	11.6 a	2.2	5.4 b	0.9	3.8 b	1.1	2.4 b	0.4	2.8 b	0.3	5, 42	10.36	<0.001
	Oxygen (ppm) *	7.8	0.0	6.9	0.3	6.7	0.2	6.4	0.3	6.3	0.3	6.4	0.3	5, 42	0.34	0.848
Sediment	NH4 (uM) *	303.8 a	65.9	274.6 a	103.5	30.9 b	7.4	27.8 b	5.1	36.1 b	8.4	27.1 b	3.9	5, 38	7.58	<0.001

Table 3. Seagrass, water column and sediment characteristics in dredged material placement sites and adjacent seagrass habitats in Lower Laguna Madre, April 1997. N = 12 replicates per habitat for seagrass data and n = 7 - 12 for sediment and water column data. * = tested by ANOVA. Means indicated with differing letters were significantly different (ANOVA and Ryan's Q or GT2 test).

		Dredged Material Habitats						Seagrass Habitats								
		New, Transplanted		New, Bare		Old, Revegetated		Halodule		Syringodium		Thalassia		ANOVA		
		Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	df	F	P
Seagrass coverage (%)	*Halodule*	0.0	0.0	0.0	0.0	17.3	11.2	68.3	12.5	0.0	0.0	0.0	0.0			
	Halophila	0.0	0.0	0.0	0.0	1.3	0.7	1.7	1.7	0.0	0.0	0.0	0.0			
	Syringodium	0.0	0.0	0.0	0.0	50.8	13.3	3.7	2.5	83.1	8.9	4.8	2.9			
	Thalassia	0.0	0.0	0.0	0.0	0.4	0.4	8.8	8.3	18.3	11.1	97.3	2.5			
Shoot density (per m2)	*Halodule*	0	0	0	0	542	279	2822	367	155	155	0	0			
	Halophila	0	0	0	0	60	33	54	41	0	0	0	0			
	Syringodium	0	0	0	0	870	234	210	128	1815	319	241	161			
	Thalassia	0	0	0	0	0	0	0	0	161	102	1268	131			
	Total *	0 c	0	0 c	0	1471 b	222	3086 a	397	2131 b	246	1509 b	163	5, 66	29.79	<0.001
Seagrass biomass (dry g / m2)	Aboveground *	0.0 c	0.0	0.0 c	0.0	30.0 b	7.8	19.1 b	3.1	37.8 b	3.9	79.6 a	9.2	5, 66	31.03	<0.001
	Belowground *	0.0 c	0.0	0.0 c	0.0	76.4 b	13.1	69.5 b	11.0	113.0 b	19.7	538.2 a	81.5	5, 66	33.95	<0.001
	Total	0.0	0.0	0.0	0.0	106.4	20.6	88.5	14.0	150.9	21.9	614.7	91.1			
Water column	Depth (cm) *	113.2 a	2.8	123.0 a	5.0	82.4 b	2.3	117.2 a	3.2	116.7 a	2.1	113.7 a	2.3	5, 66	21.02	<0.001
	Salinity *	25.1	0.6	25.3	0.5	24.6	0.1	26.4	0.7	26.3	0.7	25.9	0.6	5, 66	1.51	0.199
	Temperature (C) *	25.6	0.6	24.9	0.5	24.8	0.4	25.9	0.2	25.4	0.4	25.2	0.6	5, 66	0.82	0.541
	Turbidity (NTU) *	25.3 b	2.3	27.3 b	1.8	61.0 a	6.6	11.1 c	1.5	10.7 c	2.1	11.9 c	2.6	5, 66	31.07	<0.001
	Oxygen (ppm) *	8.6	0.6	9.0	0.6	8.1	0.3	8.3	0.3	7.7	0.3	7.8	0.4	5, 66	1.25	0.298
Sediment	NH4 (uM) *	60.2 ab	14.8	113.2 a	24.6	19.0 b	1.6	16.6 b	2.7	16.6 b	2.9	10.5 b	1.9	5, 41	11.24	<0.001

Table 4. Seagrass, water column and sediment characteristics in dredged material placement sites and adjacent seagrass habitats in Lower Laguna Madre, September 1997. N = 12 replicates per habitat for seagrass data except n = 8 for New, Transplanted and New, Bare and n = 10 for Old, Revegetated. N = 12 for sediment and water column data. * = tested by ANOVA. Means indicated with differing letters were significantly different (ANOVA and Ryan's Q or GT2 test).

		Dredged Material Habitats						Seagrass Habitats								
		New, Transplanted		New, Bare		Old, Revegetated		Halodule		Syringodium		Thalassia		ANOVA		
		Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	df	F	P
Seagrass coverage (%)	*Halodule*	0.0	0.0	0.0	0.0	26.0	12.9	92.3	5.2	0.0	0.0	0.2	0.2			
	Halophila	0.0	0.0	0.0	0.0	4.9	2.1	7.2	6.8	0.0	0.0	0.0	0.0			
	Syringodium	0.0	0.0	0.0	0.0	15.0	10.7	4.7	4.2	88.3	8.4	7.6	7.1			
	Thalassia	0.0	0.0	0.0	0.0	15.4	10.7	0.9	0.9	17.5	9.3	100.0	0.0			
Shoot density (per m2)	*Halodule*	0	0	0	0	2075	661	4842	782	40	33	12	8			
	Halophila	0	0	0	0	341	157	245	195	0	0	0	0			
	Syringodium	0	0	0	0	826	407	218	111	3617	638	65	47			
	Thalassia	0	0	0	0	221	147	0	0	183	126	1449	158			
	Total *	0 c	0	0 c	0	3463 ab	930	5305 a	700	3839 a	599	1526 b	130	5, 56	13.74	<0.001
Seagrass biomass (dry g / m2)	Aboveground *	0.0 c	0.0	0.0 c	0.0	76.1 b	12.3	71.0 b	12.0	85.4 ab	11.4	128.7 a	12.8	5, 56	19.13	<0.001
	Belowground *	0.0 c	0.0	0.0 c	0.0	297.2 b	57.9	247.8 b	41.9	214.4 b	49.7	1017.5 a	119.3	5, 56	31.34	<0.001
	Total	0.0	0.0	0.0	0.0	373.3	67.4	319.9	53.9	299.8	56.3	1150.7	132.0			
Water column	Depth (cm) *	120.4 a	5.8	111.6 a	3.8	92.0 b	2.2	117.8 a	3.7	112.1 a	4.5	112.8 a	3.2	5, 66	6.23	<0.001
	Salinity *	30.7 ab	0.5	33.5 a	0.2	32.3 ab	0.5	29.3 b	1.1	31.4 ab	0.7	30.6 ab	1.1	5, 66	3.5	0.007
	Temperature (C) *	27.4 c	0.1	27.3 c	0.0	29.5 a	0.2	28.2 b	0.2	28.4 b	0.2	28.1 b	0.3	5, 66	19.51	<0.001
	Turbidity (NTU) *	2.8 ab	0.6	4.8 a	0.8	4.4 a	1.1	1.6 b	0.3	1.8 b	0.3	1.8 b	0.3	5, 66	4.91	<0.001
	Oxygen (ppm) *	6.0 b	0.0	7.5 b	0.1	9.5 a	0.9	6.9 b	0.5	7.4 b	0.5	6.9 b	0.2	5, 66	6.03	<0.001
Sediment	NH4 (uM) *	108.8 a	17.0	140.7 a	16.7	34.2 b	2.6	39.6 b	7.0	34.9 b	5.9	18.4 b	2.3	5, 66	22.08	<0.001
	% Organics *	2.8 c	0.4	3.0 c	0.4	2.6 c	0.2	3.4 c	0.2	4.9 b	0.3	6.1 a	0.4	5, 66	17.96	<0.001
	% Sand *	65.2	5.8	68.6	6.7	72.4	5.3	69.1	2.2	64.0	3.2	64.1	5.4	5, 66	1.05	0.395
	% Silt/Clay	34.8	5.8	31.4	6.7	27.6	5.3	30.9	2.2	36.0	3.2	35.9	5.4			

Table 5. Faunal densities (mean per sq. m) in dredged material placement sites and adjacent seagrass habitats in Lower Laguna Madre, April 1996. N = 12 replicates per habitat. Only fish and decapod species exhibiting densities > 1 per sq. m in any habitat are listed. * = includes one large fish. Comm. / rec. = commercial and recreational. Means indicated with differing letters were significantly different (ANOVA df = 5, 66; Ryan's Q test).

	Dredged Material Placement Sites						Seagrass Habitats							
	New, Transplanted		New, Bare		Old, Revegetated		Halodule		Syringodium		Thalassia		ANOVA	
Species or Group	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	F	P
Fishes	1.0 c	0.4	0.8 c	0.3	4.3 ab	1.0	2.4 bc	1.0	2.3 bc	0.8	5.8 a	1.1	5.58	<0.001
Gobiosoma robustum	0.0 b	-	0.0 b	-	0.1 b	0.0	0.5 ab	0.1	0.5 ab	0.1	1.1 a	0.1	4.47	0.001
Lagodon rhomboides	0.0 c	-	0.0 c	-	3.2 ab	0.3	1.5 bc	0.2	1.7 abc	0.2	3.9 a	0.3	7.48	<0.001
Decapods	18.2 a	6.2	3.9 b	1.0	28.0 a	5.7	9.8 a	1.6	16.1 a	5.3	15.8 a	3.3	6.39	<0.001
Alpheus heterochaelis	0.2 b	0.1	0.1 b	0.1	1.8 a	0.2	0.2 ab	0.1	0.7 ab	0.1	1.0 ab	0.1	3.14	0.013
Callinectes similis	0.5 ab	0.1	0.3 ab	0.1	1.6 a	0.2	1.1 ab	0.1	0.3 b	0.1	0.2 b	0.1	3.19	0.012
Dyspanopeus texana	0.0 c	-	0.0 c	-	6.0 a	0.4	1.0 bc	0.1	1.8 bc	0.2	2.3 b	0.2	12.60	<0.001
Hippolyte zostericola	0.3 bc	0.1	0.1 c	0.1	8.5 a	0.7	1.7 abc	0.2	4.0 ab	0.6	4.8 a	0.3	7.02	<0.001
Pagurus criniticornis	10.6 a	1.8	0.1 b	0.1	1.8 ab	0.3	0.0 b	-	0.0 b	-	0.0 b	-	7.45	<0.001
Pagurus longicarpus	4.7 a	0.5	2.4 a	0.2	0.0 b	-	0.3 b	0.1	0.5 b	0.1	0.3 b	0.1	7.94	<0.001
Palaemonetes vulgaris	0.0	-	0.0	-	0.5	0.1	0.1	0.1	1.1	0.3	0.1	0.1	1.00	0.426
Penaeus aztecus	0.8 bc	0.1	0.2 c	0.1	2.8 ab	0.2	4.6 a	0.2	4.1 a	0.3	2.7 ab	0.2	8.29	<0.001
Tozeuma carolinense	0.1 bc	0.1	0.0 c	-	3.8 a	0.4	0.3 bc	0.1	2.6 ab	0.3	3.2 ab	0.5	4.93	<0.001
Number of species	3.8 c	0.3	2.8 c	0.4	7.6 a	0.7	4.6 bc	0.8	4.6 bc	0.6	6.5 ab	0.6	8.62	<0.001
Comm. / rec. fishes	0.2	0.1	0.1	0.1	0.1	0.1	0.0	-	0.0	-	0.1	0.1	0.71	0.621
Comm. / rec. decapods	1.1 bc	0.3	0.6 c	0.3	3.4 ab	0.8	5.0 a	1.0	4.3 ab	1.2	2.8 ab	0.6	5.95	<0.001
Fish biomass (g, wet)	1.02 b	0.58	0.31 b	0.17	24.75* a	22.93	0.99 b	0.43	0.87 b	0.34	2.95 ab	0.87	2.96	0.018
Shrimp biomass (g, wet)	2.04 bc	1.70	0.17 c	0.17	3.81 a	1.15	0.74 bc	0.19	2.22 ab	0.85	2.15 ab	0.67	4.61	0.001
Crab biomass (g, wet)	1.41 ab	0.57	1.88 ab	0.99	4.70 a	1.19	0.74 b	0.29	3.21 a	2.73	1.87 ab	0.78	2.91	0.020

Table 6. Faunal densities (number per sq. m) in dredged material placement sites and adjacent seagrass habitats in Lower Laguna Madre, October 1996. N = 12 replicates per habitat except n = 9 in New, Transplanted and n = 11 in New, Bare. Only fish and decapod species exhibiting densities > 1 per sq. m in any habitat are listed. Comm. / rec. = commercial and recreational. Means indicated with differing letters were significantly different (ANOVA df = 5, 62; GT2 test).

	Dredged Material Placement Sites						Seagrass Habitats							
	New, Transplanted		New, Bare		Old, Revegetated		Halodule		Syringodium		Thalassia		ANOVA	
Species or Group	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	F	P
Fishes	3.1 b	2.0	11.5 a	6.7	7.8 ab	2.5	4.8 ab	0.9	6.3 ab	1.2	5.3 ab	0.7	2.77	0.025
Anchoa mitchilli	3.0 b	1.9	11.5 a	6.7	2.8 b	2.1	0.0 b	-	0.0 b	-	0.2 b	0.1	2.38	0.049
Gobiosoma robustum	0.1 b	0.1	0.0 b	-	1.8 a	0.4	3.0 a	0.8	2.3 a	0.5	2.8 a	0.6	8.21	<0.001
Lagodon rhomboides	0.0 b	-	0.0 b	-	1.1 ab	0.3	0.9 ab	0.4	2.6 a	0.7	1.4 ab	0.6	5.09	<0.001
Decapods	2.7 b	0.8	4.0 b	0.9	72.7 a	20.6	42.0 a	9.4	42.7 a	11.6	42.3 a	5.4	19.90	<0.001
Alpheus heterochaelis	0.0 c	-	0.0 c	-	8.9 ab	3.5	1.6 bc	0.8	2.7 abc	1.0	8.3 a	2.2	8.86	<0.001
Dyspanopeus texana	0.0 b	-	0.1 b	0.1	20.6 a	8.4	6.0 a	1.6	13.2 a	3.7	11.8 a	2.2	13.88	<0.001
Hippolyte zostericola	0.0 b	-	0.0 b	-	29.1 a	10.7	14.4 a	3.9	14.4 a	5.0	13.6 a	2.9	17.82	<0.001
Pagurus criniticornis	1.7 ab	0.7	2.6 a	0.8	1.4 ab	0.7	0.1 b	0.1	0.7 ab	0.4	0.9 ab	0.5	2.40	0.047
Palaemonetes intermedius	0.0	-	0.0	-	0.2	0.1	0.2	0.1	0.8	0.6	1.1	0.6	1.39	0.241
Panopeus herbstii	0.0 b	-	0.0 b	-	1.1 ab	0.6	0.0 b	-	2.2 a	1.1	1.3 ab	0.6	2.91	0.020
Penaeus aztecus	0.2 b	0.2	0.3 b	0.2	5.0 a	1.2	5.3 a	1.1	4.7 a	1.1	3.4 a	0.7	11.18	<0.001
Tozeuma carolinense	0.0 c	-	0.0 c	-	3.5 b	1.4	13.3 a	4.6	2.4 bc	1.4	0.3 c	0.1	13.26	<0.001
Number of species	1.5 b	0.5	1.7 b	0.5	9.8 a	0.8	7.0 a	0.5	8.0 a	1.1	8.7 a	0.7	29.42	<0.001
Comm. / rec. fishes	0.0	-	0.0	-	0.3	0.2	0.0	-	0.0	-	0.1	0.1	0.77	0.576
Comm. / rec. decapods	0.2 b	0.2	0.3 b	0.2	5.8 a	1.4	6.3 a	1.2	5.4 a	1.2	3.6 a	0.7	12.31	<0.001
Fish biomass (g, wet)	0.26 b	0.18	0.86 b	0.50	12.73 a	4.26	3.48 ab	1.36	10.01 a	2.64	5.00 a	1.96	8.71	<0.001
Shrimp biomass (g, wet)	0.04 b	0.02	0.06 b	0.04	5.62 a	1.77	2.57 a	0.53	4.41 a	1.05	4.84 a	0.95	14.87	<0.001
Crab biomass (g, wet)	0.03 b	0.01	0.21 b	0.09	7.18 a	4.12	1.46 ab	0.45	11.47 a	7.36	3.12 a	0.60	7.78	<0.001

Table 7. Faunal densities (mean per sq. m) in dredged material placement sites and adjacent seagrass habitats in Lower Laguna Madre, April 1997. N = 12 replicates per habitat. Only fish and decapod species exhibiting densities > 1 per sq. m in any habitat are listed. Comm. / rec. = commercial and recreational. Means indicated with differing letters were significantly different (ANOVA df = 5, 66; Ryan's Q test).

	Dredged Material Placement Sites						Seagrass Habitats							
	New, Transplanted		New, Bare		Old, Revegetated		Halodule		Syringodium		Thalassia		ANOVA	
Species or Group	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	F	P
Fishes	2.5 b	0.6	2.7 ab	0.4	4.5 ab	0.8	2.7 ab	0.7	5.5 ab	1.5	7.7 a	1.0	3.18	0.012
Anchoa hepsetus	1.5 ab	0.5	1.4 abc	0.4	0.7 abc	0.2	0.0 c	-	0.2 bc	0.4	2.5 a	0.9	4.40	0.002
Gobiosoma robustum	0.0 b	-	0.1 b	0.2	0.7 ab	0.2	0.2 b	0.1	0.8 ab	0.6	1.7 a	0.5	3.80	0.044
Lagodon rhomboides	0.0 b	-	0.0 b	-	0.1 b	0.2	1.3 a	0.4	1.5 a	0.5	2.3 a	0.4	9.84	<0.001
Decapods	3.5 b	1.2	8.0 b	3.5	33.0 a	6.7	16.1 a	2.2	19.9 a	4.0	27.3 a	4.8	11.38	<0.001
Alpheus heterochaelis	0.0 b	-	0.3 b	0.7	0.9 b	0.6	0.0 b	-	0.3 b	0.3	3.0 a	1.1	5.94	<0.001
Callinectes similis	0.3 c	0.1	1.0 bc	0.3	3.5 a	0.5	1.9 b	0.6	0.4 c	0.3	0.0 c	-	13.94	<0.001
Dyspanopeus texana	0.1 c	0.2	0.3 c	0.6	6.0 a	3.2	0.6 bc	0.1	2.1 ab	0.6	2.9 a	0.5	7.12	<0.001
Hippolyte zostericola	0.1 c	0.2	1.0 c	1.7	5.8 b	2.0	3.6 b	1.1	5.3 b	2.2	13.0 a	2.2	11.83	<0.001
Pagurus criniticornis	0.3	0.1	1.3	1.7	0.3	0.2	0.3	0.3	0.1	0.2	0.2	0.4	0.62	0.686
Palaemonetes intermedius	0.0	-	0.1	0.2	0.3	0.6	0.7	0.6	1.7	0.6	0.3	0.4	2.08	0.079
Penaeus aztecus	0.8 d	0.2	1.3 cd	0.5	10.3 a	1.4	7.7 a	1.2	6.4 ab	1.7	3.1 bc	0.7	13.98	<0.001
Tozeuma carolinense	1.9	1.1	2.3	1.6	4.1	0.8	1.2	0.6	2.8	1.1	3.8	2.2	1.08	0.381
Number of species	3.1 c	0.6	4.2 bc	0.9	9.4 a	1.1	5.7 ab	0.6	6.9 a	0.8	7.3 a	0.6	8.29	<0.001
Comm. / rec. fishes	0.3	0.1	0.5	0.2	1.2	0.4	0.7	0.3	2.1	1.5	0.4	0.3	0.92	0.474
Comm. / rec. decapods	0.9 d	0.3	1.5 cd	0.5	10.8 a	1.7	7.8 a	1.2	6.9 ab	1.9	3.3 bc	0.7	13.25	<0.001
Fish biomass (g, wet)	0.66 b	0.23	1.26 ab	0.47	3.07 ab	1.08	1.58 ab	0.53	1.88 ab	0.41	5.47 a	2.46	3.00	0.017
Shrimp biomass (g, wet)	1.30 b	0.48	1.59 b	0.69	4.36 a	0.92	2.27 ab	0.55	2.98 ab	0.83	3.95 a	0.59	4.24	0.002
Crab biomass (g, wet)	0.90	0.75	2.06	1.44	1.86	0.34	0.38	0.16	1.23	0.42	2.79	1.84	1.91	0.104

Table 8. Faunal densities (mean per sq. m) in dredged material placement sites and adjacent seagrass habitats in Lower Laguna Madre, September 1997. N = 12 replicates per habitat. Only fish and decapod species exhibiting densities > 1 per sq. m in any habitat are listed. Comm. / rec. = commercial and recreational. Means indicated with differing letters were significantly different (ANOVA df = 5, 66; Ryan's Q test).

	Dredged Material Placement Sites						Seagrass Habitats							
	New, Transplanted		New, Bare		Old, Revegetated		Halodule		Syringodium		Thalassia		ANOVA	
Species or Group	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	F	P
Fishes	7.4 a	4.7	0.1 b	0.1	4.6 ab	0.9	5.4 a	0.8	11.4 a	2.3	6.9 a	0.8	15.36	<0.001
Anchoa mitchilli	6.3 a	4.4	0.0 b	-	0.0 b	-	0.0 b	-	0.0 b	-	0.0 b	-	3.33	0.001
Gobiosoma robustum	0.0 d	-	0.0 d	-	1.7 c	0.4	3.8 b	0.8	8.3 a	1.9	4.8 ab	1.1	29.29	<0.001
Lagodon rhomboides	0.0 b	-	0.0 b	-	0.6 ab	0.3	0.3 ab	0.1	2.1 b	0.8	1.7 b	0.7	4.88	<0.001
Decapods	4.8 b	1.1	2.9 b	1.3	49.0 a	9.2	47.9 a	9.2	38.9 a	7.0	64.2 a	13.9	21.66	<0.001
Alpheus heterochaelis	0.0 b	-	0.0 b	-	1.7 b	0.9	0.7 b	0.3	1.6 b	0.6	6.2 a	2.0	7.06	<0.001
Callinectes sapidus	0.2 b	0.1	0.0 b	-	1.3 a	0.4	0.8 ab	0.3	0.3 b	0.1	0.3 b	0.3	4.95	<0.001
Callinectes similis	0.5 ab	0.3	0.4 ab	0.1	1.1 a	0.3	0.3 ab	0.1	0.1 b	0.1	0.0 b	-	3.71	0.005
Dyspanopeus texana	0.1 c	0.1	0.0 c	-	12.8 b	4.2	13.8 ab	6.6	15.4 ab	4.2	29.8 a	8.6	17.74	<0.001
Hippolyte zostericola	0.0 b	-	0.0 b	-	18.0 a	4.7	12.1 a	2.5	13.6 a	2.4	21.4 a	5.2	21.60	<0.001
Pagurus criniticornis	2.8	0.7	1.9	1.1	1.3	0.7	0.8	0.5	0.9	0.4	0.8	0.4	2.30	0.055
Penaeus aztecus	0.4 c	0.3	0.4 c	0.2	6.2 a	1.4	4.0 ab	1.9	4.9 ab	1.1	2.1 b	0.5	11.35	<0.001
Penaeus sp.	0.1 b	0.1	0.0 b	-	1.3 a	0.5	0.1 b	0.1	0.3 b	0.2	0.1 b	0.1	4.76	<0.001
Tozeuma carolinense	0.0 c	-	0.0 c	-	3.5 b	1.2	15.0 a	5.9	1.4 bc	0.9	2.6 bc	1.7	11.61	<0.001
Number of species	2.8 b	0.5	1.8 b	0.3	9.2 a	1.1	7.3 a	0.8	8.0 a	0.5	7.2 a	0.6	24.19	<0.001
Comm. / rec. fishes	0.1	0.1	0.0	-	0.2	0.1	0.0	-	0.0	-	0.0	-	1.49	0.205
Comm. / rec. decapods	0.7 c	0.3	0.4 c	0.2	9.1 a	1.7	4.9 b	2.0	5.6 ab	1.1	2.6 b	0.7	16.23	<0.001
Fish biomass (g, wet)	1.88 ab	1.02	0.26 b	0.26	11.16 a	4.51	2.01 ab	0.72	6.21 a	2.30	5.63 a	2.02	3.71	0.005
Shrimp biomass (g, wet)	0.10 b	0.10	0.10 b	0.10	2.79 a	1.00	1.58 a	0.52	1.83 a	0.46	4.33 a	1.25	9.71	<0.001
Crab biomass (g, wet)	0.12 b	0.10	0.05 b	0.03	1.92 a	0.52	4.19 a	1.83	2.18 a	0.55	6.29 a	2.18	10.58	<0.001

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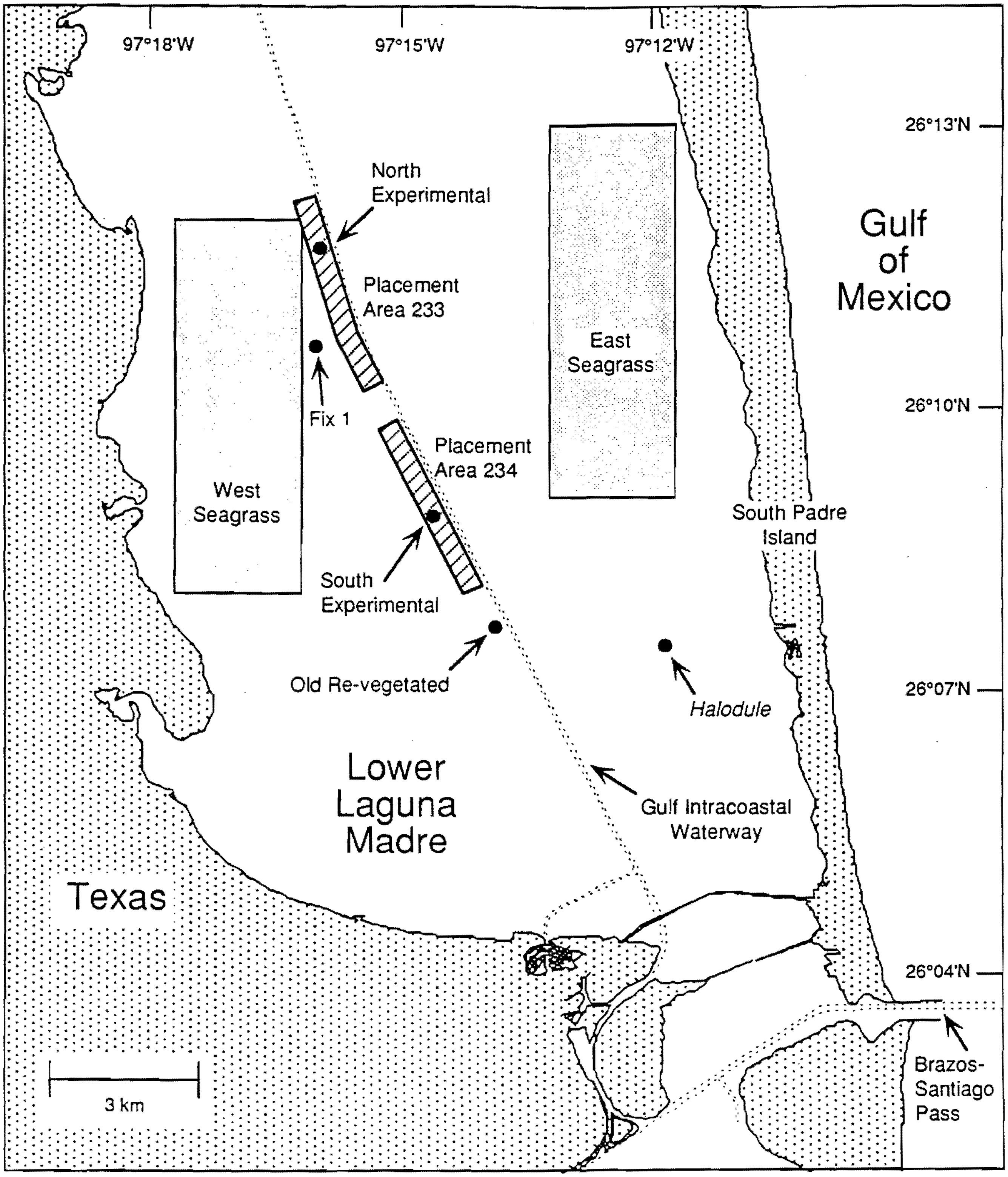

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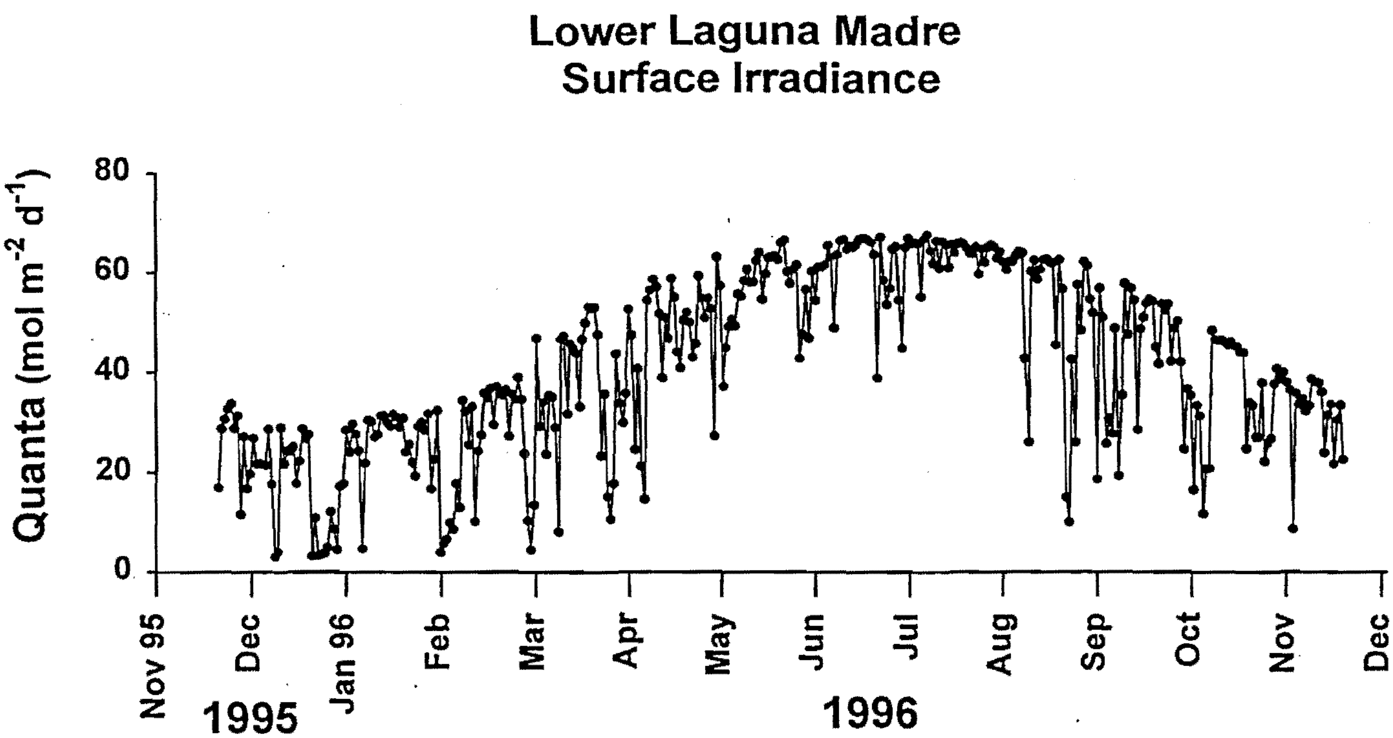

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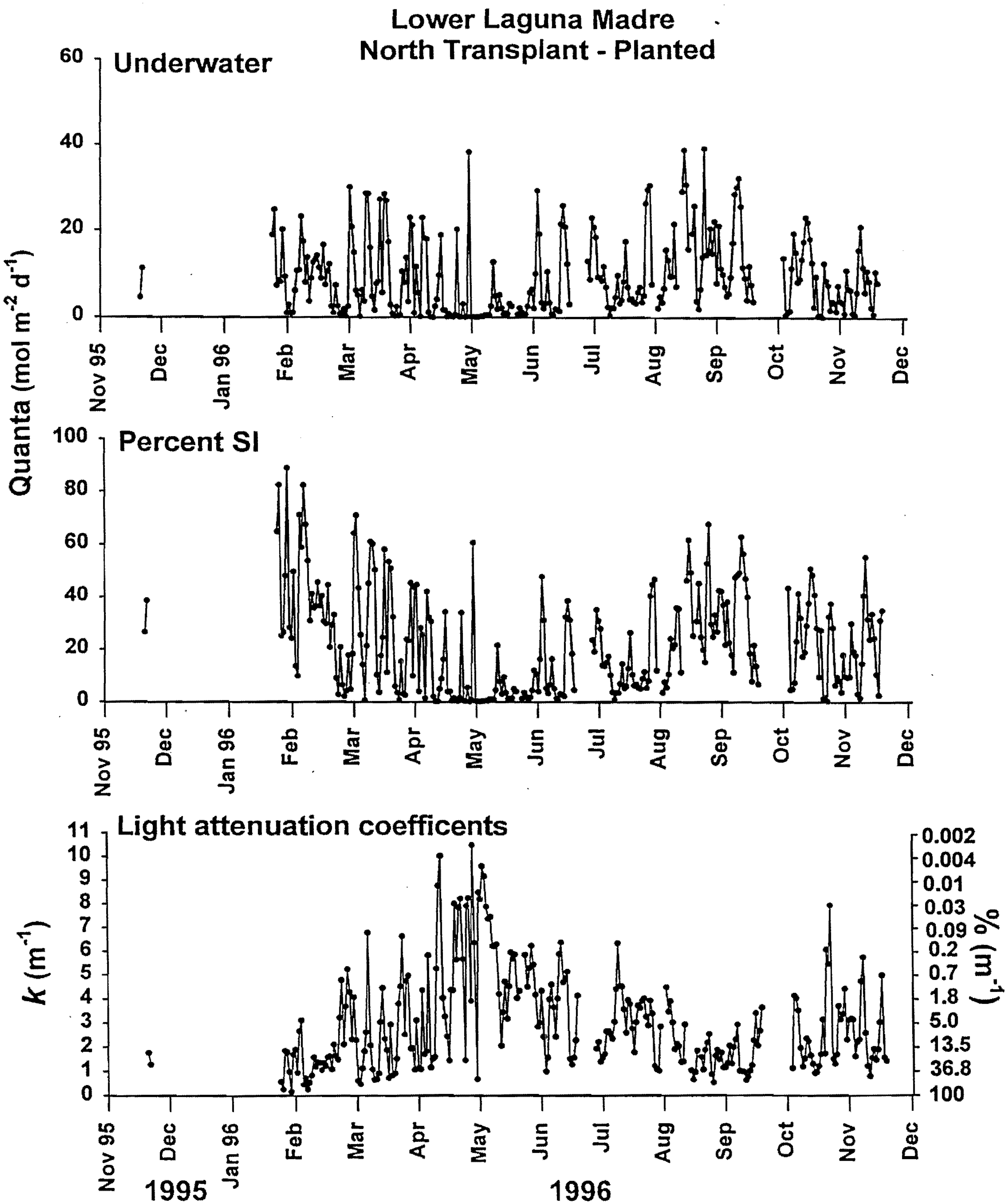

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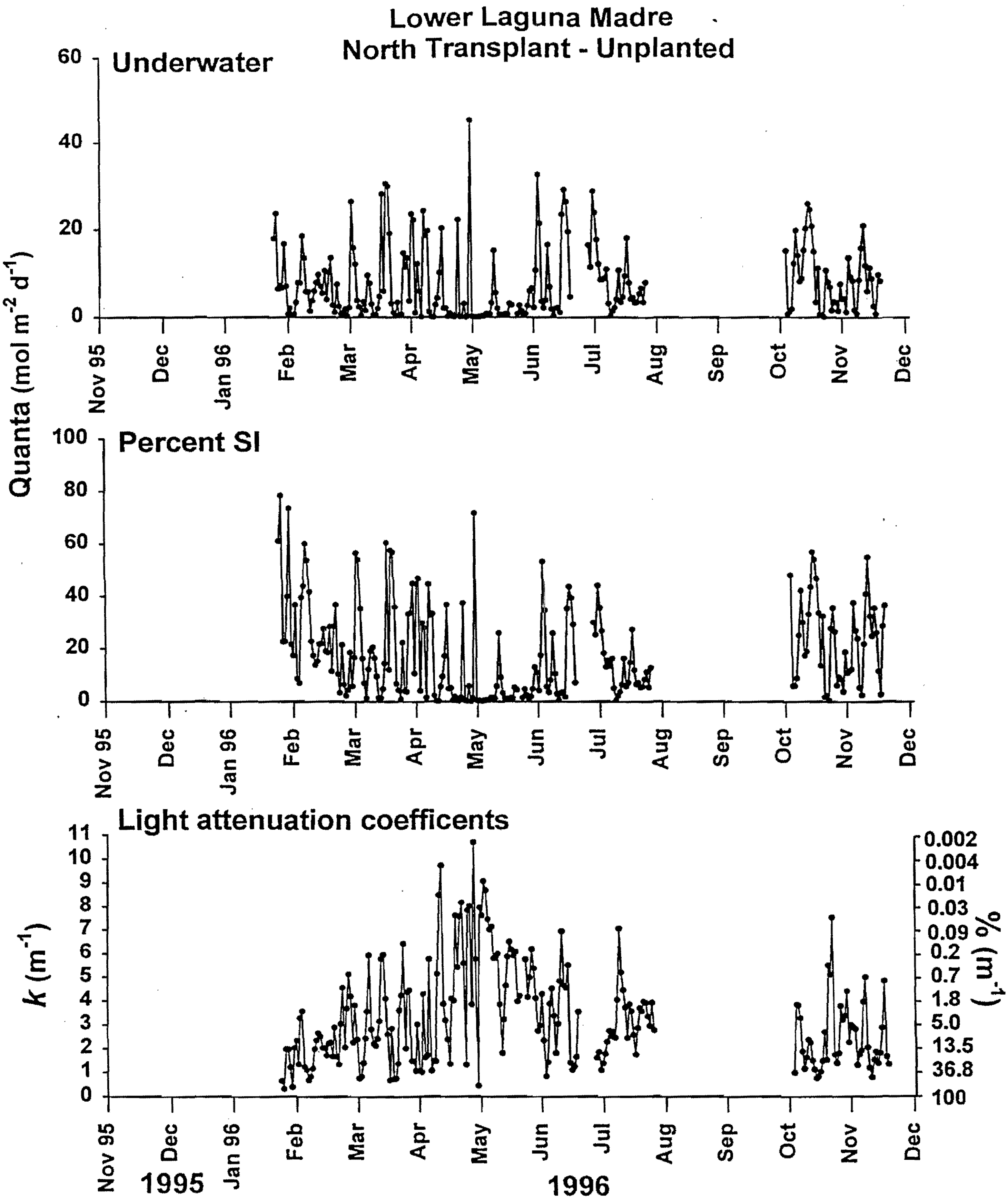

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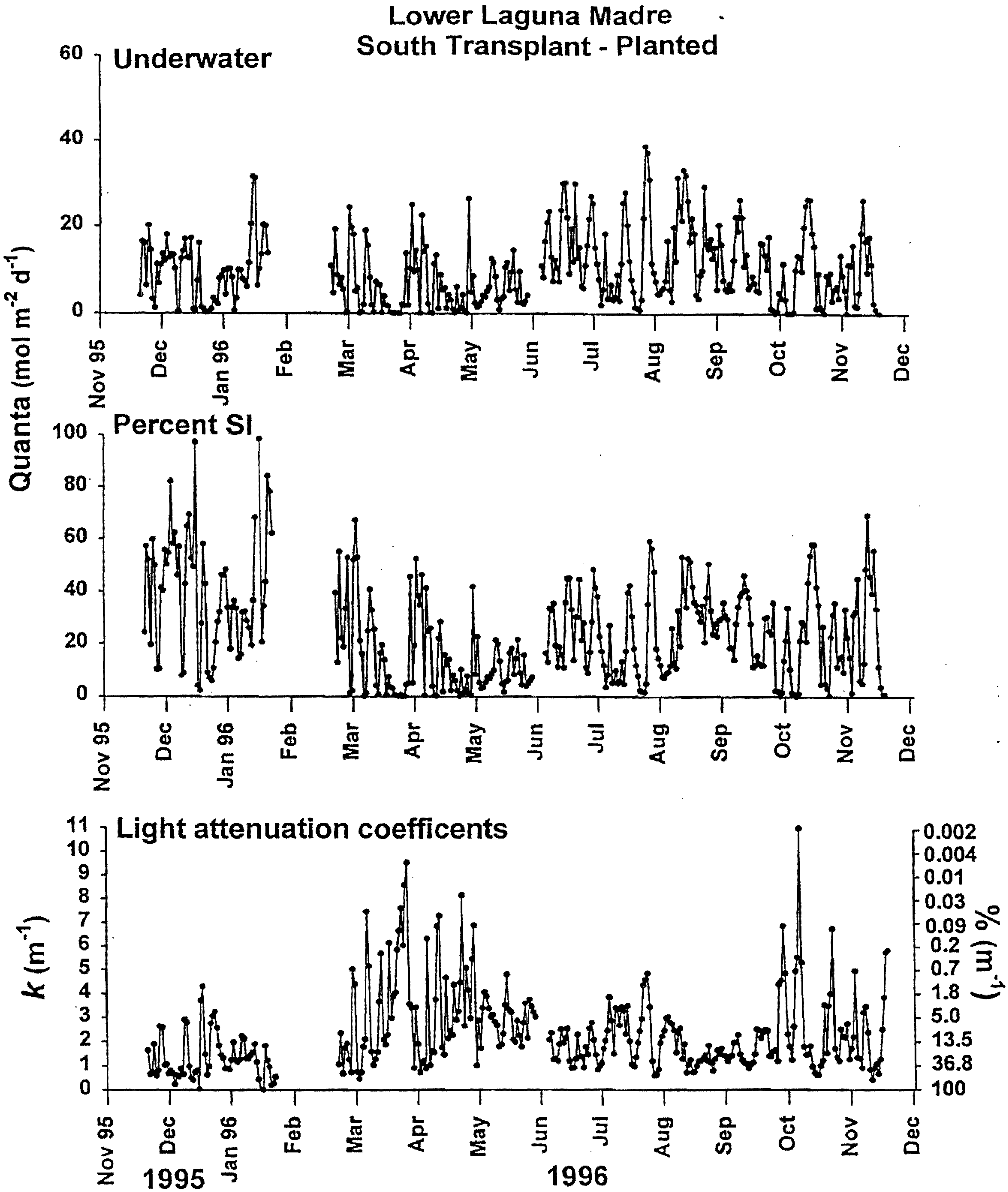

Figure 5. Underwater irradiance, percent surface irradiance (SI) and diffuse attenuation coefficient (k) at the South New Transplant site.

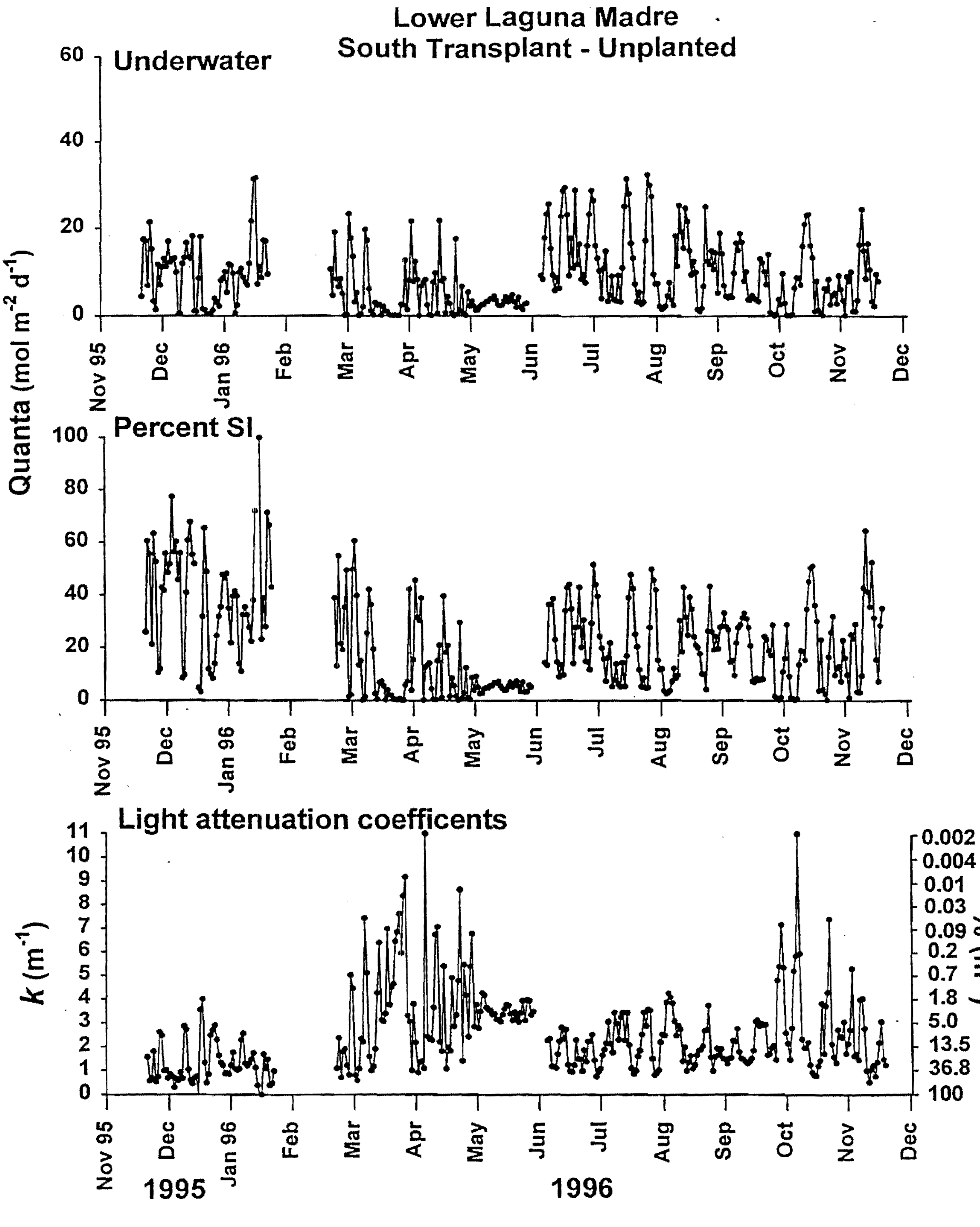

Figure 6. Underwater irradiance, percent surface irradiance (SI) and diffuse attenuation coefficient (k) at the South New Bare site.

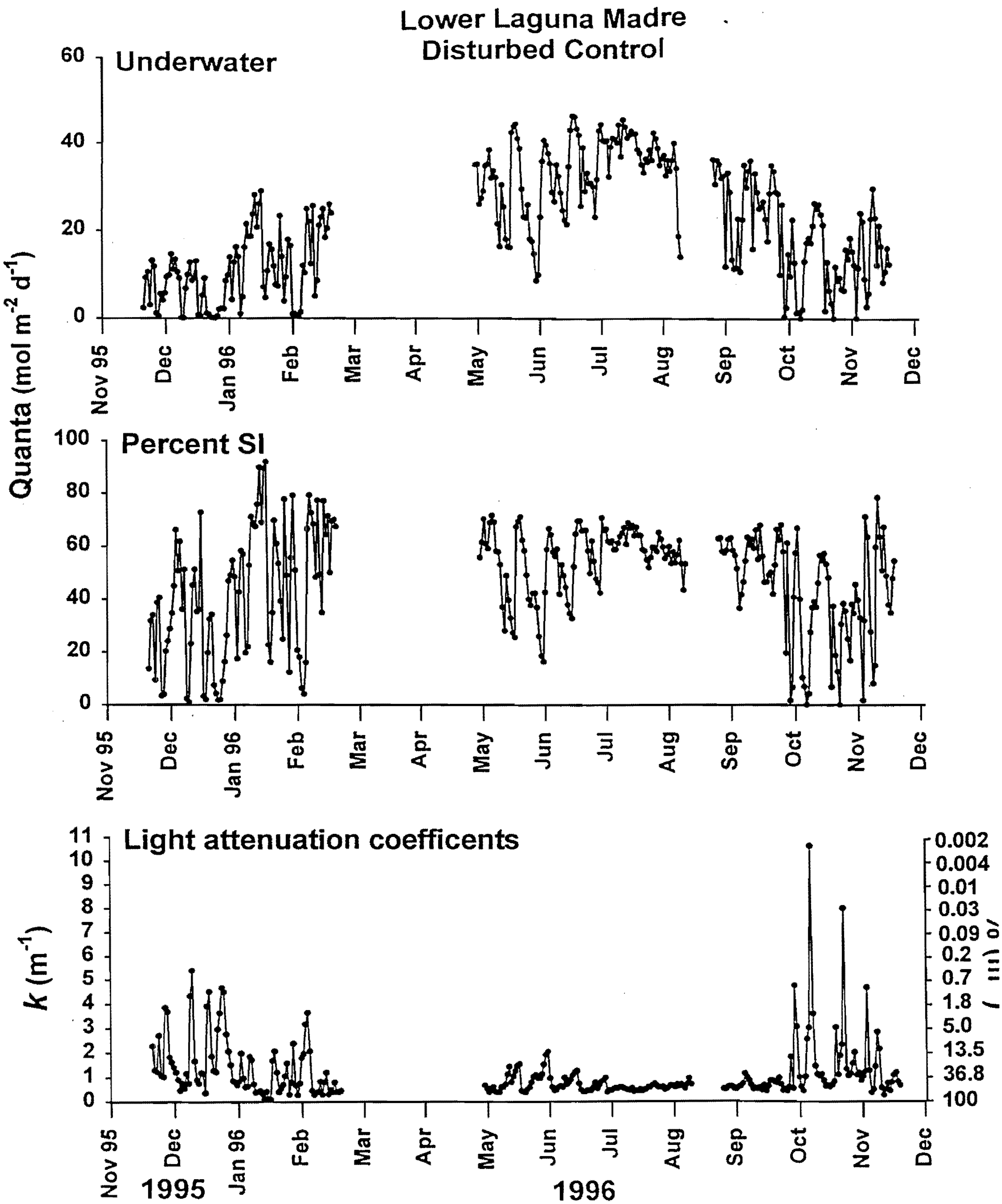

Figure 7. Underwater irradiance, percent surface irradiance (SI) and diffuse attenuation coefficient (k) at the South Old Re-vegetated site.

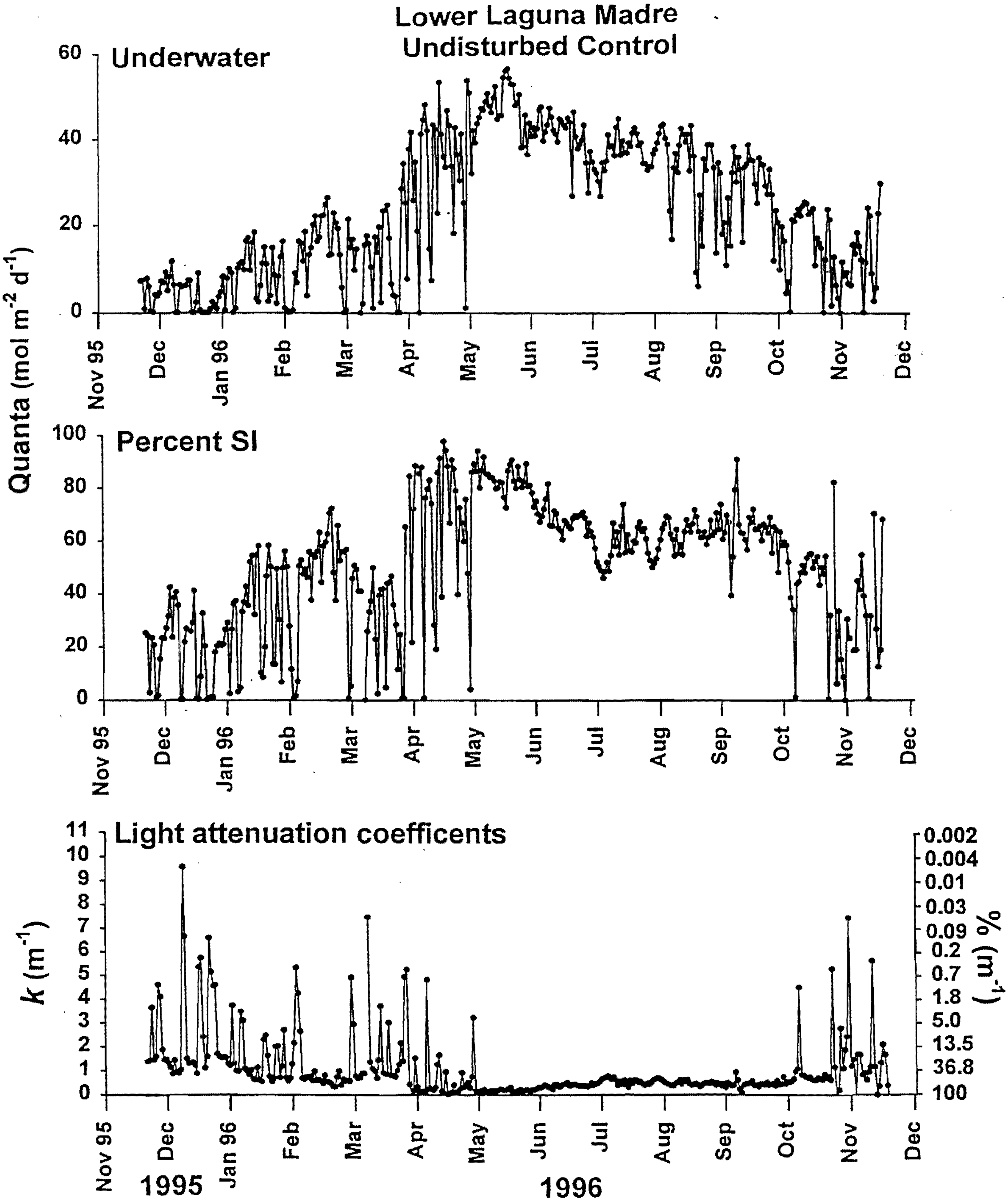

Figure 8. Underwater irradiance, percent surface irradiance (SI) and diffuse attenuation coefficient (k) at the Undisturbed *Halodule* site.

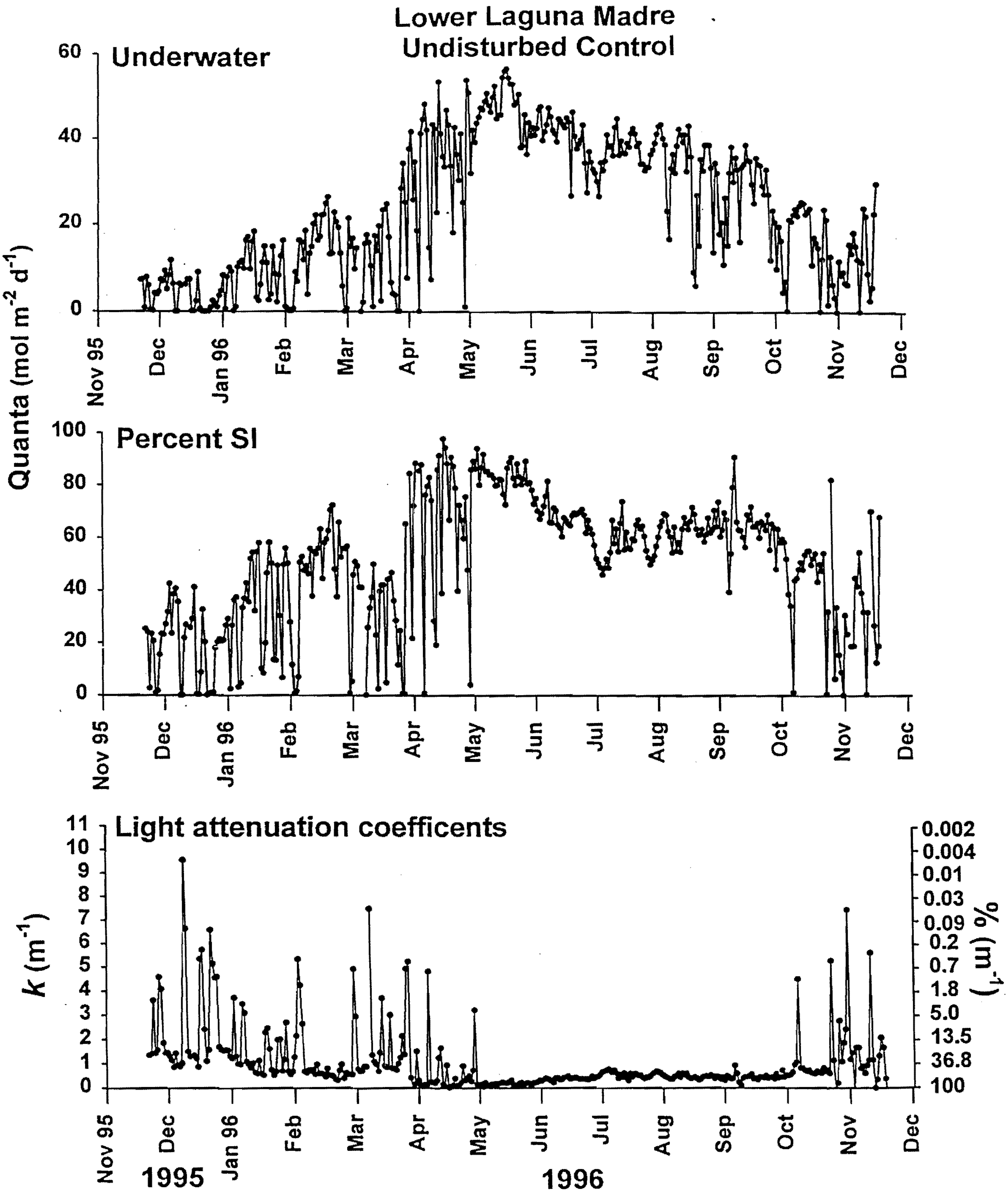

Figure 8. Underwater irradiance, percent surface irradiance (SI) and diffuse attenuation coefficient (k) at the Undisturbed *Halodule* site.

Appendix 1. Densities of fishes and decapods (number per sq. m) in dredged material placement sites and adjacent seagrass habitats in Lower Laguna Madre.

A. April 1996. N = 12 replicates per habitat.

	Dredged Material Habitats						Seagrass Habitats					
	New, Transplanted		New, Bare		Old, Revegetated		Halodule		Syringodium		Thalassia	
Species	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Fishes	1.0	0.4	0.8	0.3	4.3	1.0	2.4	1.0	2.3	0.8	5.8	1.1
Anchoa mitchilli	0.4	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Archosargus probatocephalus	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Bairdiella chrysoura	0.0	0.0	0.2	0.1	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Clupeidae (unknown)	0.1	0.1	0.3	0.1	0.3	0.1	0.1	0.1	0.0	0.0	0.3	0.2
Gobionellus boleosoma	0.1	0.1	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Gobiosoma bosc	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0
Gobiosoma robustum	0.0	0.0	0.0	0.0	0.1	0.1	0.5	0.3	0.5	0.3	1.1	0.4
Hippocampus zosterae	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.1	0.1
Lagodon rhomboides	0.0	0.0	0.0	0.0	3.2	1.1	1.5	0.8	1.7	0.8	3.9	1.0
Micropogonias undulatus	0.2	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Myrophis punctatus	0.3	0.1	0.3	0.2	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0
Opsanus beta	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Sciaenidae (unknown)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
Symphurus plagiusa	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0
Syngnathus scovelli	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.1	0.1	0.2	0.1
Decapods	18.2	6.2	3.9	1.0	28.0	5.7	9.8	1.6	16.1	5.3	15.8	3.3
Alpheus heterochaelis	0.2	0.2	0.1	0.1	1.8	0.7	0.2	0.1	0.7	0.5	1.0	0.3
Callinectes sapidus	0.3	0.2	0.4	0.3	0.7	0.2	0.4	0.2	0.2	0.2	0.2	0.2
Callinectes similis	0.5	0.2	0.3	0.2	1.6	0.6	1.1	0.3	0.3	0.2	0.2	0.2
Clibanarius vittatus	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Dyspanopeus texanus	0.0	0.0	0.0	0.0	6.0	1.4	1.0	0.4	1.8	0.7	2.3	0.6
Hippolyte zostericola	0.3	0.2	0.1	0.1	8.5	2.6	1.7	0.6	4.0	2.2	4.8	1.1
Isocheles wurdemanni	0.6	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Libinia dubia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
Pagurus annulipes	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.0	0.0
Pagurus criniticornis	10.6	6.3	0.1	0.1	1.8	1.0	0.0	0.0	0.0	0.0	0.0	0.0
Pagurus longicarpus	4.7	1.6	2.4	0.8	0.0	0.0	0.3	0.2	0.5	0.5	0.3	0.2

A. April 1996 Continued

Pagurus pollicaris	0.2	0.1	0.3	0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0
Palaemonetes intermedius	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.2	0.7	0.6
Palaemonetes pugio	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2
Palaemonetes vulgaris	0.0	0.0	0.0	0.0	0.5	0.4	0.1	0.1	1.1	1.0	0.1	0.1
Panopeus herbstii	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.2
Panopeus turgidus	0.0	0.0	0.0	0.0	0.5	0.3	0.2	0.1	0.5	0.5	0.0	0.0
Penaeus aztecus	0.8	0.3	0.2	0.1	2.8	0.7	4.6	0.8	4.1	1.2	2.7	0.7
Tozeuma carolinense	0.1	0.1	0.0	0.0	3.8	1.3	0.3	0.2	2.6	1.1	3.2	1.8
Mean number of individuals	19.2	6.2	4.8	1.1	32.3	6.6	12.2	1.8	18.4	5.3	21.6	3.3
Total species recorded	15		13		22		17		17		20	

B. October 1996. N = 12 replicates per habitat except n = 9 in New, Transplanted and n = 11 in New, Bare.

	Dredged Material Habitats						Seagrass Habitats					
	New, Transplanted		New, Bare		Old, Revegetated		Halodule		Syringodium		Thalassia	
Species	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Fishes	3.1	2.3	11.5	6.7	7.8	2.5	4.8	0.9	6.3	1.2	5.3	0.7
Anchoa mitchilli	3.0	2.2	11.5	6.7	2.8	2.1	0.0	0.0	0.0	0.0	0.2	0.1
Archosargus probatocephalus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
Bairdiella chrysoura	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.1	0.0	0.0	0.1	0.1
Eucinostomus argenteus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.2	0.1	0.1
Gobiosoma bosc	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0
Gobiosoma robustum	0.1	0.1	0.0	0.0	1.8	0.4	3.0	0.8	2.3	0.5	2.8	0.6
Gobiesox strumosus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
Hippocampus zosterae	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.3	0.2	0.2	0.1
Lagodon rhomboides	0.0	0.0	0.0	0.0	1.1	0.3	0.9	0.4	2.6	0.7	1.4	0.6
Microgobius thalassinus	0.0	0.0	0.0	0.0	0.3	0.2	0.0	0.0	0.0	0.0	0.0	0.0
Myrophis punctatus	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.0	0.0
Opsanus beta	0.0	0.0	0.0	0.0	0.5	0.3	0.3	0.2	0.3	0.1	0.2	0.1
Sciaenops ocellatus	0.0	0.0	0.0	0.0	0.3	0.2	0.0	0.0	0.0	0.0	0.0	0.0
Symphurus plagiusa	0.0	0.0	0.0	0.0	0.3	0.1	0.0	0.0	0.1	0.1	0.0	0.0
Syngnathus louisianae	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Syngnathus scovelli	0.0	0.0	0.0	0.0	0.5	0.2	0.3	0.1	0.2	0.2	0.3	0.1
Decapods	2.7	0.9	4.0	0.9	72.7	20.6	42.0	9.4	42.7	11.6	42.3	5.4
Alpheus heterochaelis	0.0	0.0	0.0	0.0	8.9	3.5	1.6	0.8	2.7	1.0	8.3	2.2
Callinectes sapidus	0.0	0.0	0.0	0.0	0.5	0.4	0.7	0.4	0.3	0.3	0.0	0.0
Callinectes similis	0.3	0.2	0.2	0.1	0.8	0.3	0.1	0.1	0.2	0.2	0.1	0.1
Clibanarius vittatus	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.2	0.1
Dyspanopeus texanus	0.0	0.0	0.1	0.1	20.6	8.4	6.0	1.6	13.2	3.7	11.8	2.2
Hippolyte zostericola	0.0	0.0	0.0	0.0	29.1	10.7	14.4	3.9	14.4	5.0	13.6	2.9
Libinia dubia	0.0	0.0	0.0	0.0	0.3	0.1	0.1	0.1	0.3	0.2	0.4	0.2
Pagurus criniticornis	1.7	0.8	2.6	0.8	1.4	0.7	0.1	0.1	0.7	0.4	0.9	0.5
Pagurus longicarpus	0.0	0.0	0.6	0.5	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0
Pagurus pollicaris	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0