# HABITAT VALUE OF NATURAL VERSUS RECENTLY TRANSPLANTED EELGRASS, *ZOSTERA MARINA*, FOR THE BAY SCALLOP, *ARGOPECTEN IRRADIANS*

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## ABSTRACT

Bay scallops, *Argopecten irradians*, were used in a mark and recapture experiment to determine the habitat value of recently transplanted eelgrass, *Zostera marina*, meadows for fishery restoration and enhancement through stocking. The study site, adjacent to an island formed from dredge material, consisted of natural and transplanted eelgrass and of unplanted areas. Seventy-five marked bay scallops were placed in plots at a density of 2.2 scallops per $m^2$ on 20 February 1986. A month later, only 18 marked scallops were recovered; of these, 15 were found in the natural eelgrass beds. On the study site, 94% of 207 unmarked naturally occurring bay scallops were found in the natural eelgrass beds. Recovery of marked adult bay scallops was not affected by the distance from the dredge island; rather densities of natural scallop populations increased with distance from the island. A second, modified survey (30 March to 7 April 1986) was conducted specifically to examine the recovery of marked bay scallops; this survey again showed a high rate of loss both in the transplanted and unplanted areas.

The two surveys showed that recently transplanted eelgrass meadows do not provide the same habitat functions as natural meadows for bay scallops. Stocking of adult scallops in early stage eelgrass transplants to enhance or restore that fishery does not appear to be feasible. A protracted period of time may pass before habitat function is returned for the bay scallops in transplanted eelgrass meadows. Results from these surveys also illustrate the need for careful consideration in the placement of dredge material in the coastal environment.

Seagrass meadows form an essential habitat for a variety of marine organisms (Thayer et al. 1975, 1984; Kenworthy et al. 1988). These highly productive ecosystems provide refuge, food resources, and nursery grounds for a number of commercially and recreationally harvested species.

Recent concerns about loss of seagrass habitat in general (Thayer et al. 1984, 1985; Fonseca et al. 1985, 1987, 1988) have prompted research into ways in which that loss can be reduced. Since mitigation measures often require the creation of new seagrass meadows to replace damaged ones, it is critical that this trade-off provide a persistent habitat that is the functional equivalent of the one that is lost. Given our approach to creating seagrass beds by installing widely spaced planting units that coalesce in 1–2 years, it is possible that an artificially propagated bed will require a certain time interval before it will attain natural meadow functions. If these created beds do not provide similar functional values as natural ones or if they require a very long time to do so, then the entire concept of seagrass bed mitigation will have to be reexamined. These are critical questions, especially when seagrass restoration projects have not produced more acreage than was lost (Fonseca et al. 1988).

In the temperate zone, the dominant seagrass species is eelgrass, *Zostera marina*. Eelgrass has been utilized in many seagrass restorations (Fonseca et al. 1988). Recent losses of eelgrass and scallops in Long Island Sound due to a "brown tide" (Chris Smith pers. commun.[5]), and losses of scallops in Bogue and Back Sounds, Carteret County, NC, apparently due to a *Ptychodiscus* bloom, have prompted questions regarding seagrass and scallop restoration. Given the paucity of information on faunal recovery in restored or created seagrass beds,

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we sought to evaluate whether bay scallop, *Argopecten irradians*, stocking could be conducted simultaneously with eelgrass bed creation.

Under this approach, stocked adult bay scallops would be used as a source of spat settlement in the maturing eelgrass bed. Bay scallops often utilize eelgrass meadows throughout their life cycle (Gutsell 1930; Kirby-Smith 1970; Thayer and Stuart 1974). During the postveliger stage of development, a bay scallop attaches itself to submerged substrates such as vegetation (eelgrass blades), shells, rocks, animal tubes, or macroalgae. At approximately 10 mm in shell width, the scallop detaches and settles onto the bottom sediments to complete its life cycle; adult sizes range between 5 and 7 cm (Gutsell 1930; Kirby-Smith 1970; Thayer and Stuart 1974). During its lifespan (1.5–2 years), bay scallops feed upon phytoplankton (Peirson 1983) and detritus (Kirby-Smith and Barber 1974), which are plentiful in eelgrass systems (Thayer et al. 1975). If scallop stocking could not be done concomitantly with bed creation, natural recovery of the scallop population could be substantially delayed.

Our study was embedded in a larger, long-term study of eelgrass restoration and faunal recovery. In that study, eelgrass was transplanted onto subtidal dredge material and monitored to determine the rate at which these propagated areas attain functional characteristics of adjacent, natural meadows.

In preparing for the bay scallop stocking study, we observed in an independent scallop dredging survey that scallop densities near the study site declined from 2.0 to nearly 0/m$^2$ between November and January 1985. During this period, laughing gulls, *Larus atricilla*, were seen dropping live scallops, a common feeding activity for these birds (Pearson et al. 1959), onto a dredge material island adjacent to our study area. This suggests that the gulls were at least partially responsible for the observed decline in scallop densities. Because this portion of the study was designed to include an evaluation of developing eelgrass meadows as scallop habitat, the close proximity of the dredge island and the increased likelihood of high predation on the scallops by gulls had to be considered in the assessment. Given the decline in the natural scallop population, possibly exacerbated by gull predation, we utilized a mark and recapture technique to assess stocking feasibility.

The general objectives of the study were to compare the capabilities of natural eelgrass, transplanted eelgrass, and unplanted areas in supporting a stocked adult bay scallop population as a means of enhancing recovery of a local fishery. Specifically, we sought to 1) examine the feasibility of seeding adult scallops in newly transplanted eelgrass beds; 2) relate scallop density in experimental plots to a) the proximity of these plots to the dredge island and b) any preferential migration from the transplanted or unplanted areas to the adjacent, natural eelgrass beds; and 3) control for adult scallop recruitment by comparing the densities of naturally occurring scallops in natural and transplanted eelgrass beds of two spatial arrangements, as well as in unplanted plots within the study site.

## METHODS

The study site (long. 76°32′W, lat. 34°40′N, Fig. 1) was located at the southern end of Core Sound and northwest of Cape Lookout, NC. Specifically, the experiment was conducted off the southwest side of a dredge material island in relatively shallow waters (0.15 m at low tide and 1.0 m at high tide). The island was originally created 10 years before the study with maintenance dredging deposits added every 2–3 years. The overall study site covered 4,556 m$^2$, which was divided into five separate blocks extending out from the island (Fig. 2). For this study on the scallops, only blocks 1, 3, and 5 were utilized. Each block contained five different experimental units which were 7.5 m on a side (56.25 m$^2$). An experimental unit was separated from adjacent units by a 7.5 m corridor. The five treatments for each experimental unit were as follows: 1) natural interior eelgrass (NI, ≥15 from unvegetated substrate), 2) natural eelgrass bordering unvegetated substrate (NE), 3) low perimeter to area (LPA) eelgrass transplant arrangement (see below), 4) high perimeter to area (HPA) eelgrass transplant arrangement (see below), and 5) bare (B), unplanted dredge material. Although positioning of the two natural treatments were fixed, the other three treatments were randomly assigned to the remaining three experimental units within each block.

Each experimental unit contained eight plots (2.25 m$^2$), which were consecutively located around the perimeter of the experimental unit (Fig. 2). These eight plots were designated to accommodate eight faunal sampling periods for the parallel study of fishery habitat establishment. The two transplant arrangements had different perimeter to area ratios in order to examine the refuge value of large, unbroken seagrass cover versus patchy cover. The LPA treatments had eelgrass planting units throughout the 7.5 m × 7.5 m area, whereas HPA

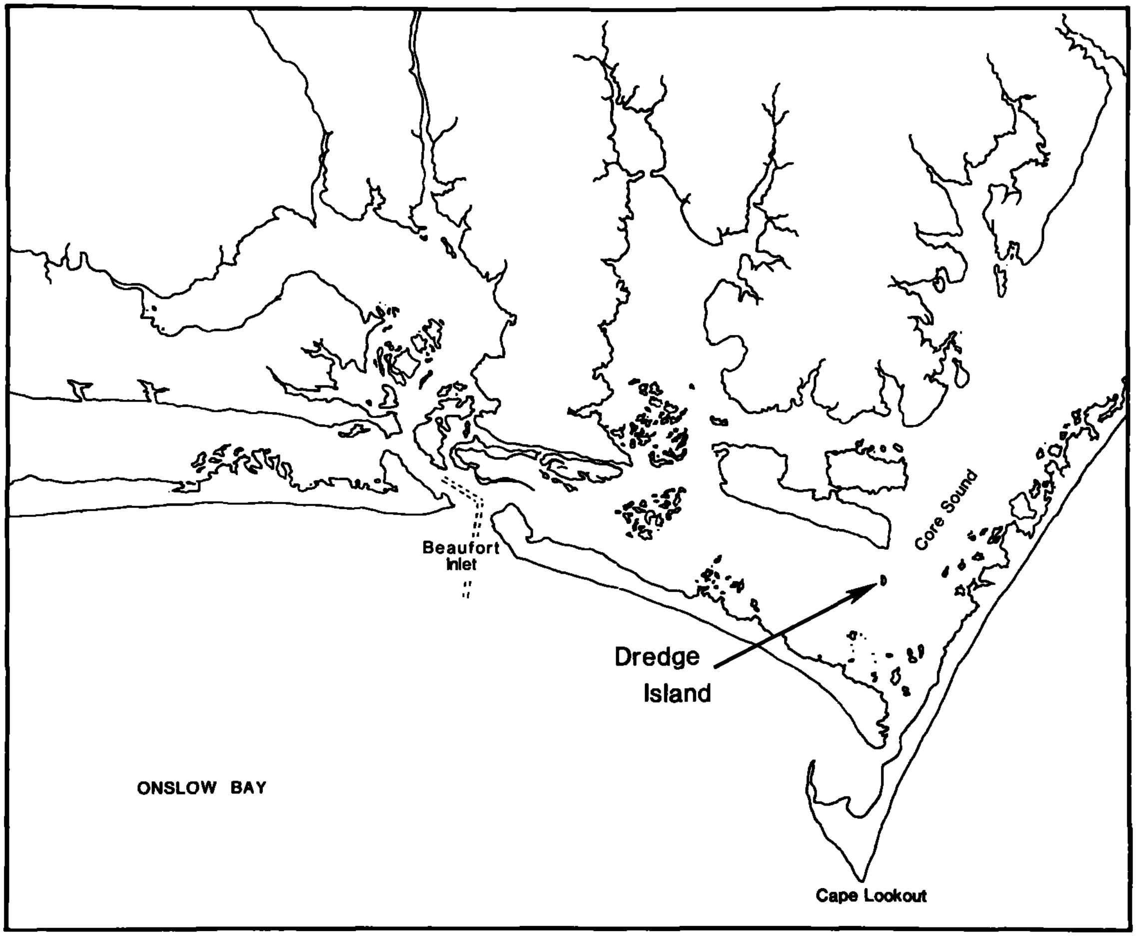



FIGURE 1.—An aerial view of Back Sound, North Carolina. Location of the study site and dredge island is long. 76°32′W, lat. 34°40′N.

treatments had 16 planting units on 0.5 m centers only within the eight 2.25 $m^2$ sampling plots. A planting unit consisted of 15 shoots of eelgrass tied together and anchored in the substrate with metal pins (Fonseca et al. 1985).

Eelgrass transplantation was performed in September 1985. Eelgrass cover, shoot addition, and seedling recruitment were monitored periodically in the transplanted treatments. Shoot density and cover in the natural meadow were monitored simultaneously with eelgrass seedling recruitment into unplanted areas by surveying randomly chosen plots within each treatment type. A 1.5 m × 1.5 m frame subdivided with cords into 36, 0.25 × 0.25 m (0.063 $m^2$) sections was laid down, marking the perimeter of the plots. In the natural meadow and unplanted areas, three randomly selected 0.063 $m^2$ sections were surveyed within each plot for the number of eelgrass shoots and seedlings. In transplanted plots, the intersections of alternate cords fell on the 16 eelgrass planting units per plot. Three of these were randomly chosen and the number of shoots and area of bottom covered were recorded for each planting unit. To obtain the coverage estimate, a smaller grid with cords on 5 cm intervals was placed over the planting, and the number of squares (0.0025 $m^2$) and half squares with eelgrass shoots were summed as area covered by the planting unit.

Bay scallops were collected from eelgrass beds to the southwest of the study site using a commercial scallop dredge and were held in tanks supplied with continuously flowing seawater. Seventy-five scallops (size range from umbo to lip, 6.0–7.5 cm) were marked with waterproof pens to denote the number of the individual and its block assignment. Additionally, we cut small notches in the shell ridges with

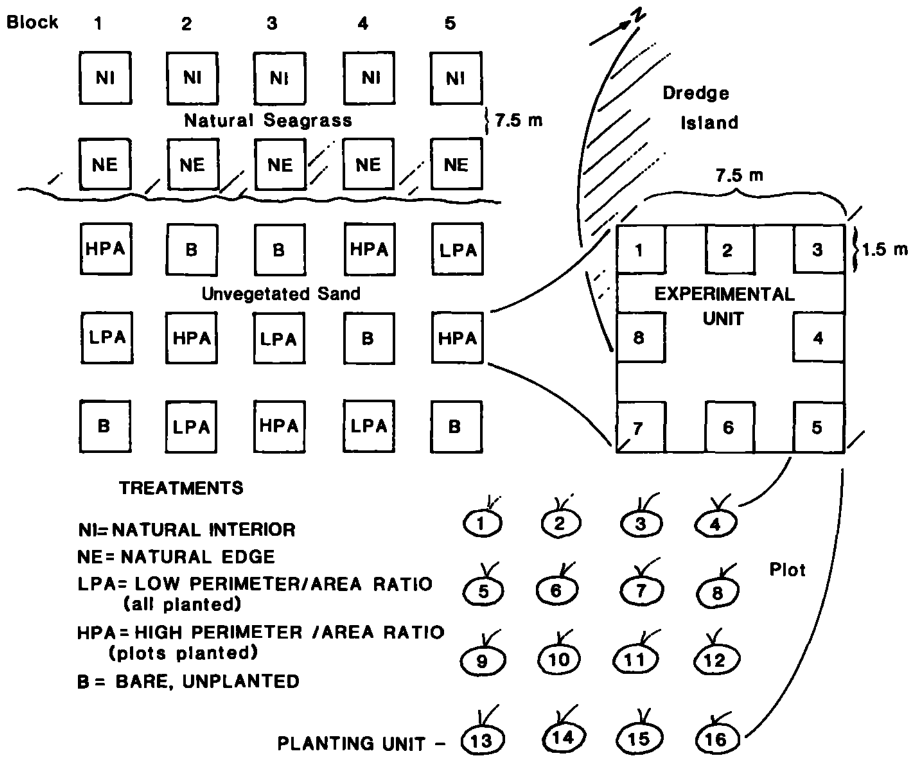



FIGURE 2.—Map view of the study site with the dredge island to the northeast. Each treatment is 7.5 m on a side and each plot is 1.5 m on a side.

a fine-tooth hacksaw blade to indicate the type of treatment.

The first placement of bay scallops was done during high tide on 20 February 1986. Based on natural scallop density surveys conducted in November 1985 showing densities of ~2.0 scallops/m$^2$, we stocked 5 bay scallops/2.25 m$^2$ plot. The 5 scallops were individually placed next to 5 randomly selected planting units out of the 16 in the plot. Thirty-four days after deployment, scallop surveys were conducted over four days from 26 to 30 March 1986 (survey I). The survey was conducted by placing a 7.5 m × 7.5 m grid made of ⅛″ nylon line, subdivided into 25 sections (2.25 m$^2$ each) over an experimental unit. Bay scallops were located by systematically searching the substrate and grasses by sight and touch while snorkeling. Within each 2.25 m$^2$ section, the efficiency of this method in recovering bay scallops <15 mm was untested, but recovery of bay scallops in the size range that was marked was 100% in three separate field trials. All unmarked bay scallops were measured to the nearest 0.1 cm on site, recorded by the section in which they were found, and replaced after measuring. Marked bay scallops were identified and recorded in the same manner.

Due to low recovery of marked bay scallops from the transplant and bare areas over the 34–38 d period, a second survey (survey II) was initiated which excluded the natural seagrass beds. This second set of scallops was identified with waterproof pens and notching, but both shells were notched in the event the shells became separated after death. Forty-five bay scallops, five in each of nine plots, were released in LPA, HPA, and B treatments in blocks 1, 3, and 5, but not in any natural treatments, on 30 March 1986 and surveyed 8 days later.

## RESULTS

General observations during February through April revealed a variety of shorebirds, especially laughing gulls, brown pelicans (*Pelecanus occidentalis*), and cormorants (*Phalacrocorax olivaceus*), frequenting the dredge island. Seagulls dropped mollusc shells onto the island repeatedly to fracture the shell and feed on the contents. A marked shell from the HPA treatment (survey II, block 1) was found in the intertidal zone of the island, and one from a natural edge plot in survey I was found at a high, central point on the island during a randomized search of the island. Other potential predators, blue crabs (*Callinectes* sp., $N = 3$) and whelks (*Busycon* sp., $N = 12$), also were observed in the grassbeds during the surveys.

Eelgrass cover and density in the natural meadow remained relatively constant throughout the study period. Natural bed experimental units had a consistent 77% cover, while shoot densities ranged between 441 and 1,148 shoots/m$^2$, with an average of 635 shoots/m$^2$ over the time between 20 February and 7 June 1986. Seedlings of eelgrass were observed among the natural and transplanted eelgrass in late March and early April. No eelgrass seedlings were recorded in the randomly chosen unplanted plots, although some were observed nearby. Throughout this time, transplanted treatments generally increased in number of shoots and area covered. By early June 1986, planting units averaged 0.02 m$^2$, or approximately 15 cm in diameter with an average of 25 shoots/planting unit.

After 34–38 days (survey I), 18 of 75 marked bay scallops (24%) were recovered (Fig. 3) and all were located in the plot in which they had been deployed. Fifteen of these 18 bay scallops were recovered in the natural grassbeds, with 9 located in the natural interior (NI) treatments and 6 in the natural edge (NE) treatments. Of the three remaining scallops, two were found in HPA treatments and one in a B, unplanted treatment. Three scallops were recovered from block 1 (farthest from the dredge island), 8 from block 3 (intermediate), and 7 from block 5 (closest).

A total of 207 unmarked, naturally occurring bay scallops were counted and measured during survey I (Fig. 4). There were 77 from the natural interior, 119 from the natural edge, 3 from LPA, 6 from HPA, and 2 from B, unplanted area treatments. One hundred and twenty-five bay scallops were found in block 1 (farthest from land), 50 in block 3, and 32 in block 5.

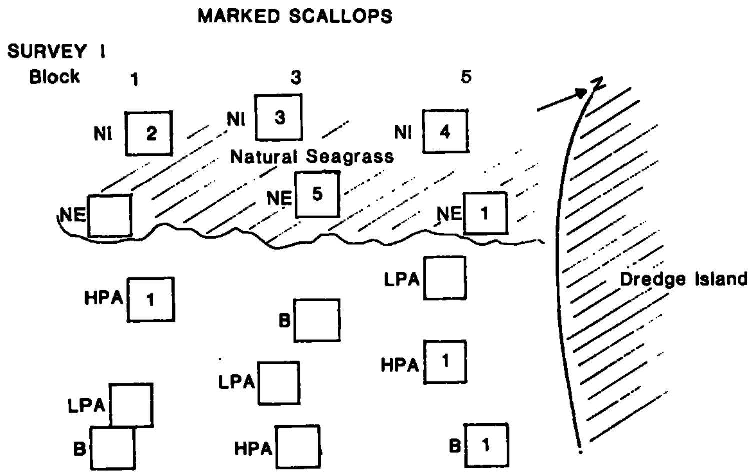
Our second, shorter survey recovered 10 out of the 45 (22%) bay scallops deployed in the transplanted grassbeds and B, unplanted areas (Fig. 3). Five of those recovered were located in LPA areas, 4 in HPA, and 1 in a B treatment. Five scallops were found in block 1, 2 in block 3, and 3 in block 5.

## DISCUSSION

The greater recovery of marked as well as unmarked, naturally occurring bay scallops from the natural beds as compared to the transplanted and bare areas (Figs. 3, 4) indicated that natural bed treatments provided a more suitable habitat for adult bay scallops. Bay scallops in the transplanted areas apparently suffered a higher mortality than occurred in denser, natural vegetation as suggested by the low recovery of marked scallops and our observations of seabird predation. None of the bay scallops deployed in the transplants or bare areas were found in the natural beds, although in some instances the natural bed was only a few meters distant. The few scallops recovered from these transplant and bare treatments were found in the plot of their deployment. Either there was little movement of the deployed bay scallops, and they were preyed upon, or the ones that moved were preyed upon. Whichever the mechanism of loss, it was apparent that few survived the 34 d deployment in these treatments.

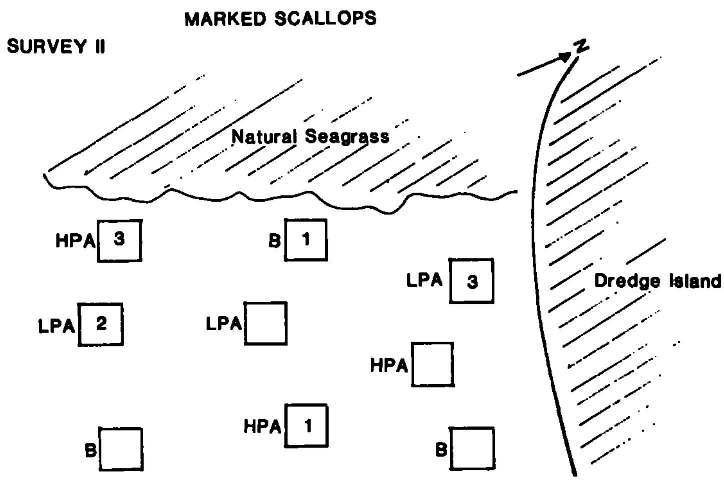
Neither treatment (LPA, HPA) of 5–6 mo old transplanted areas or bare areas provided the same habitat resource as adjacent, natural grassbeds (survey I); transplants did, however, provide a slightly better habitat for adult bay scallops than bare, unplanted areas over a short time (results from survey II). Twenty-two percent of the marked bay scallops were recovered from the transplant and bare treatments in survey II (8 day) deployment as opposed to 7% over the same area in survey I (34 days), suggesting a steady decline in numbers as a function of time. The extensive dense vegetation of the natural beds likely provides better refuge from predators such as gulls or blue crabs, along with increased protection from physically disruptive factors such as wave action.

Recovery of marked bay scallops from the treatment areas could not be attributed to the distance from the dredge island (Fig. 3). In survey I, the number of marked bay scallops recovered decreased with distance from the island, while in survey II, the opposite was observed. Distances from the island may not have been great enough to record a noticable difference in seabird predation upon adult bay scallops as a function of distance. The natural scallop population, however, did demonstrate a fivefold increase in numbers with increasing distance from the dredge island (Fig. 4). There is no bottom elevation gradient across this distance. Tidal flow and wave energy patterns around dredge island conceivably could interfere with recruitment of water-borne




SURVEY I

| | % Recovered Block 1 | 3 | 5 |
|---|---|---|---|
| NI | 40 | 60 | 80 |
| NE | | 100 | 20 |
| LPA | | | |
| HPA | 20 | | 20 |
| B | | | 20 |




SURVEY II

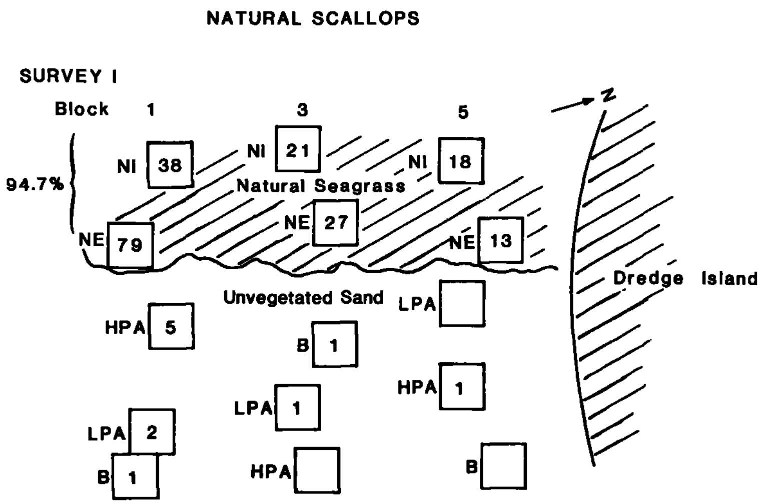
| | % Recovered Block 1 | 3 | 5 |
|---|---|---|---|
| LPA | 40 | | 60 |
| HPA | 60 | 20 | |
| B | | 20 | |

FIGURE 3.—Distribution of recovered scallops as numbers per experimental unit (survey 56.25 m$^2$). Survey I deployed 20 February 1986, and surveyed 30 March 1986. Survey II deployed 30 March 1986 and surveyed 7 April 1986. Five scallops were originally deployed in each plot. Treatment types: NI = Natural Interior, NE = Natural Edge, HPA = High Perimeter to Area, LPA = Low Perimeter to Area, B = Bare.

scallop larvae or diminish food sources closer to the island, making recruitment and feeding, not predation, a more likely factor influencing the existing natural scallop distribution.

Natural seeding of the eelgrass, together with the transplanted treatments, should gradually provide more protection for adult bay scallops and greater amounts of vegetative cover for postveliger scallop attachment, but this coverage will not occur within the first year using transplanted eelgrass (Fonseca et al. 1985). Since eelgrass must be transplanted in the fall in North Carolina (Fonseca et al. 1985), the eelgrass transplants during the first year, will not be of a size to provide habitat functions equivalent to natural beds when bay scallop larvae settle in the late winter. There is, therefore, a substantial time interval in which eelgrass transplants in this area do not have scallop habitat value equivalent to natural beds.

The creation of islands with dredge material in coastal waters may result in a reduction of bay scallop recruitment or survival within the area, as well as increasing bird predation by providing them with a substrate for dropping and opening scallops.




Natural Abundance

| Treatment | # of Scallops |
|---|---|
| NI | 77 |
| NE | 119 |
| LPA | 3 |
| HPA | 6 |
| B | 2 |

| Block | # of Scallops |
|---|---|
| 1 | 125 |
| 3 | 50 |
| 5 | 32 |

FIGURE 4.—Distribution of natural scallops as number per experimental unit survey (56.25 $m^2$) on 30 March 1986 (survey I). Treatment types: NI = Natural Interior: NE = Natural Edge, HPA = High Perimeter to Area, LPA = Low Perimeter to Area, B. = Bare.

Due to enhanced seabird predation, restoring eelgrass beds adjacent to these islands will likely not provide a suitable area for bay scallop stocking until the bed matures and coalesces. These results may not be widely applicable because our study focused on a single eelgrass-dredge island system over one scallop settlement season. However, it is apparent that the location and manner of dredge material disposal should be examined closely. Although shorebird and seabird habitat was certainly enhanced by the creation of the dredge material island, there may be local environmental and economic impacts on the scallop population and its fishery, as well as other existing, soft bottom communities, even without direct destruction of the adjoining seagrass bed itself as evidenced by the gradient of scallop abundance away from the island.

There are two major conclusions to be drawn from this study. First, if natural eelgrass meadows are destroyed and transplants are used as replacements for the lost habitat, it is essential to recognize that the transplants will not immediately function as the natural bed it replaced. The delay or lack of habitat replacement could permanently reduce the production of economically valuable fauna in the area if proper measures are not taken to insure that any removed or destroyed eelgrass is properly balanced with a functionally equivalent habitat replacement. Second, this study has shown that natural eelgrass beds at this site provided a substantially more suitable habitat for scallops than the transplanted treatments, within the first 5–6 months after planting. Stocking of recently transplanted eelgrass beds with scallops as a means of restoring or enhancing that fishery cannot be supported by these data.

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