APPENDIX G – BROWARD COUNTY NEARSHORE HARDBOTTOM FISH STUDY - 2001

Broward County Proposed Beach Renourishment: Fishes

FINAL REPORT

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EXECUTIVE SUMMARY

This study was undertaken to examine the fish assemblages on the nearshore hardbottom area adjacent to a 30-km stretch of beach in Broward County, FL with an eye to the potential effects of a proposed beach renourishment. There were six objectives in this study:

1. Characterize the inshore fish assemblages along a 30-km stretch of Broward County shoreline potentially impacted by a proposed beach renourishment using nondestructive techniques, i.e. visual censusing.
2. Compare the results obtained with differing census methodologies.
3. Compare the fish assemblages on hardbottom areas adjacent to previously-renourished beach to hardbottom areas adjacent to never-renourished beach.
4. Compare the fish assemblages on hardbottom areas anticipated to be directly affected by the proposed renourishment beach to hardbottom areas not anticipated to be directly affected.
5. Compare the inshore fish assemblages to previously reported assemblages on the second and third reef tracts to gain insight into the possible unique aspects of nearshore hardbottom and the potential for mitigation.
6. Make recommendations to provide general guidance for beach renourishment relative to existing fish assemblages.

From June to August 2001, 298 fish counts were accomplished within the first 30 m of nearshore hardbottom. There was a transect-count and either a point-count or a rover-diver count completed every 152 m of shoreline.

A total of 72,723 fish of 47 families were recorded. Taking differences in census results into account, the nearshore, hardbottom fish assemblages consist of at least 169 species of which more than 85% of the total fish are juveniles. Most of these juveniles are grunts (family Haemulidae) which make up more than 90% of the juveniles and 80+% of the total fish assemblage. The remaining families are represented in decidedly lower numbers. The wrasses (Labridae) at 5.0% comprised the next largest portion of the population followed by Pomacentridae at approximately 2.0 %, Acanthuridae 1.0 %, Scaridae 0.8%, Gobiidae 0.5%; the rest of the 47 families contributed less than 0.5% each.

Comparisons of previously renourished to never renourished fish sites or of sites proposed to be buried by the equilibrium toe of fill to those not to be affected did not show clear site-dependant differences in fish assemblages. A comparison of the nearshore hardbottom assemblage with reports on the fishes of the middle and offshore reef indicated, for the most part, that the inshore reef had lower abundance and richness than the other reef tracts and that the majority of the nearshore species are also found at deeper hardbottom sites. Although hardbottom burial should be avoided, comparison of the inshore assemblage with fishes found on local artificial reefs indicates that loss of the hardbottom refuge of the predominant fish assemblage can be mitigated with artificial structure.

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1.0 INTRODUCTION

This study was undertaken to examine the fish assemblages on the nearshore hardbottom area adjacent to a 30-km stretch of beach in Broward County, FL with an eye to the potential effects of a proposed beach renourishment. There is substantial literature on the effects of filling and sedimentation, including beach renourishment projects, on invertebrate fauna; however, there is little literature available concerning the effects on fishes. Although there may be more gray literature, reports and other unpublished research, in existence, only one report and one relevant publication appear in standard data base searches. Fortuitously, both studies were done in southeast Florida (Courtenay et al., 1980; Lindeman and Snyder, 1999).

During a 7-month interval, Courtney at al. (1980) examined the fish assemblage in the nearshore reef area of Hallandale beach seven years after the beach was renourished. They completed 34, 50-min counts, including 12 on the nearshore hard bottom using a modified rover-diver technique (Jones and Thompson 1978). Lindeman and Snyder (1999), in a much more extensive study in Jupiter FL, counted fishes on 394, 15-m nearshore transects over a 27-month period. Their study included a 5 ha hardbottom area that was subjected to renourishment burial during the study period. In the body of the text below, the results of these earlier reports are compared to the results of this study

1.1 Objectives

There were six objectives in this study:

1. Characterize the inshore fish assemblages along a 30-km stretch of Broward County shoreline potentially impacted by a proposed beach renourishment using nondestructive techniques, i.e. visual censusing.

2. Compare the results obtained with differing census methodologies.

3. Compare the fish assemblages on hardbottom areas adjacent to previously-renourished beach to hardbottom areas adjacent to never-renourished beach.

4. Compare the fish assemblages on hardbottom areas anticipated to be directly affected by the proposed renourishment beach to hardbottom areas not anticipated to be directly affected.

5. Compare the inshore fish assemblages to previously reported assemblages on the second and third reef tracts to gain insight into the possible unique aspects of nearshore hardbottom and the potential for mitigation.

6. Make recommendations to provide general guidance for beach renourishment relative to existing fish assemblages.

1.2 Caveat

This report deals strictly with fish assemblages as determined by visual census. It does not deal with either trophic dynamics or cryptic species not observed with visual-census techniques. Both of these factors could potentially be impacted by beach renourishment and subsequently affect resident or transient fish assemblages. Further, the reader is cautioned that fishes are but one aspect of inshore reef ecology and, from a management perspective, this report should only be used in conjunction with the results of associated studies on substrate, invertebrates, and flora.

2.0 METHODS AND MATERIALS

2.1 Fish Census

During June 2001 100 transect-counts and 100 point-counts were done every 305 m (at Dade FDEP control monuments D1-D5, and Broward County FDEP control monuments, R31-R127, latitudes) for approximately 30 km of shoreline. During July and August 2001, 100 transect and 98 rover-diver counts were made every 152 m half way between the previous counts. Thus, there was a transect-count and either a point-count or rover-diver count completed every 152 m of shoreline. The SCUBA divers were placed in the water at the correct latitude (determined by differential global positioning system [DGPS]) at either the nearshore (western) edge of hardbottom or 50 m from shore (seaward edge of the swimming zone). In either case, the divers visually identified the nearshore edge before beginning the fish counts. The divers carried buoyed divers-flags, and on completion of the counts, the flags were left in place and their position recorded onboard by DGPS. Occasionally divers would have to swim the dive flags out of the swimming area. In these cases, the distance the diver had to swim the flag was estimated by fin kicks (2/m). The census takers consisted of two PhD ichthyologists and 7 graduate students. All graduate students had received both formal and informal training in fish identification and were extremely familiar with underwater fish identification from previous projects.

2.11 Transect-count

A 30 m line was stretched out West to East, by compass, beginning at the nearshore edge of hardbottom. The diver swam above the transect recording all fish within 1 m either side and 1 m above the line (an imaginary 60 cubic meter tunnel). Species were recorded as well as numbers and total length (by size class: <2, 2-5, 5-10, 10-20, 20-30, 30-50 and 50+ cm) as encountered. The diver carried a 1 m "T"-rod, with the size classes marked off, to aid in transect width and fish length estimation. Stretches of sand along the transect (absence of hard substrate) greater than 3 m were also recorded. The transect normally took approximately 10 min to complete but was not time delimited. On completion of the fish count the diver followed the line from beginning to end with a fiberglass surveyors tape closely following the contours of the substrate. Comparison of the tape distance to the 30-m line yielded an estimate of gross rugosity.

2.12 Point-count

The point-count was a modified Bohnsack and Bannerot (1986) method in which all the fish were counted in an imaginary cylinder, 15 m in diameter, from the substrate to the water surface. A 7.5-m line was laid out prior to the count as an aid in estimating the cylinder circumference. For the first 5 minutes, only the species were recorded. After the 5 minute species-count was completed, the number of fish per species and the minimum, maximum and mean total length of each species was recorded along with depth and bottom features. The diver carried a 1-m rod with a ruler attached at one end of the rod in a T-configuration to aid in length estimation. In the published methodology (Bohnsack and Bannerot, 1986) the diver accomplishes the count by staying in the center of the cylinder and rotating about to record species and length. We modified this to allow the diver to move around the cylinder because most of the fish were juveniles that often stayed in depressions close to the substrate and were therefore hidden from the counter. Point-counts were accomplished 20 m North of, and parallel to, the transect line at a point estimated by the diver to have maximum topographic relief; normally this was directly North of the East end of the transect. On completion of the fish count, the diver followed the 7.5-m radius line from beginning to end with a fiberglass surveyors tape closely following the contours of the substrate. Comparison of the tape distance to the radius line yielded an estimate of gross rugosity.

2.13 Rover-diver count

Rover-diver counts consisted of the diver recording the species encountered during a 20-minute interval. The diver was encouraged to look wherever he or she pleased in an attempt to record the maximum number of species. No abundance or size data was recorded. Rover-diver counts were accomplished in an area bounded by: the transect line of the transect-count, the western edge of hardbottom, and a 30-m line laid directly North of the eastern end of the transect line (essentially a 30-m square, but somewhat more or less depending on the hardbottom edge).

2.2 Site Comparisons

Specific site comparisons were made in order to gain some insight into the past and potential effects of renourishment as well as to possible unique habitat characteristics of the nearshore hardbottom.

2.21 Previously renourished versus never renourished sites

The beach areas between R-55 to R-85 and between R-94 to R-101 have never been directly renourished (Figure 1). The transects-counts, point-counts, and random-diver species lists from the hardbottom areas within these ranges were compared to the remaining sites which have been restored/renourished one or more times between 1970 and 1991. It is noteworthy however, that although the stretch of beach in Dania from R-94 to R-101 has never been directly nourished, it is sandwiched between two renourished beaches (John U. Lloyd and Hollywood/Hallandale).

2.22 Proposed hardbottom to-be-covered versus not-to-be-covered

The proposed equilibrium toe of fill line will impinge on some nearshore hardbottom. The transect-counts, point-counts, and random-diver species lists of this area (R-37 to R42.5; R-51.5 to R-55; R-65 to R67.5; R-70.5 to R-71; R-86.5 to R-91; R-99 to R-106; R-112 to R-116 and R-121.5 to R–123.5) were compared to the remaining areas not anticipated to be impacted by beach fill construction or fill equilibration.

2.23 Inshore hardbottom versus second and third reef tracts

The nearshore marine environment off the coast of Broward County, FL, USA, is characterized by three reef tracts that run parallel to the coast in a north-south direction, in sequentially deeper water (Goldberg, 1973). The inshore reef tract is generally in depths ranging from 3.1 m to 9.2 m; the middle reef from 7.4 m to 21.8 m and the offshore reef tract from about 14.2 m to below 30 m (Ettinger et al., 2001). In an ongoing study for NOAA/NMFS, point-counts have been made on the edges and crests of all three reef tracts at ¼ nm mile intervals. Approximately 550 counts have been made to date equally distributed amongst the three reef tracts (Spieler 2000, 2001; Ettinger, 2001). In addition, 40 concrete reefs, one m^3, placed between the inshore and middle reefs , and 20 placed between the middle and offshore reef were censused monthly for 18 months (877 counts)(Spieler, 1998). Comparison of the results from this study to these other databases will provide insight into possible unique characteristics of the nearshore hardbottom as well as the potential for effective mitigation.

2.3 Statistics

Data from all fish counts were tabulated into separate Excel files (see attached CD). Once in table format, the transect and point-count data for total fish abundance (of each size class and all size classes combined) and total fish species per count were entered into a statistical program (Statistical Analysis Systems Inc., Cary, NC, USA) for analysis. The data were not normally distributed and had high heteroscedasticity. Therefore a ranked (non-parametric) ANOVA (PROC RANK in SAS ≅ Kruskal-Wallis test) and a Student-Newman-Keuls (SNK) test between means were primarily used for analyses. In addition the Bray-Curtis dissimilarity index with multidimensional scaling (MDS) ordination was used (Field et al., 1982) to examine potential differences in fish-assemblage structure among sites. A p value <0.05 in both ANOVA and SNK was accepted as a significant difference.

3.0 RESULTS

3.1 Characterization of fish assemblage

Lists of all the species their numbers, locations, and sizes are contained in the raw data files (attached CD). Some summary statistics are noted below and in the Appendix (Tables 1-4).

3.11 Transect-count

The 200 transect-counts yielded a total 38,875 fishes of 118 species. Of these 88.3% were juveniles (less than 5 cm total length). Mean abundance ± standard error of the mean (SEM) was 3.24 ± 0.35 / m^2 and mean number of species (richness) was 0.19 ± 0.23 / $m^{2.}$ Of the total fishes counted 80.2% of the total were juvenile haemulids (90.9% of the total juveniles were haemulids). Other families contributed substantially lower numbers of individuals to the assemblage: Labridae 5.4%, Pomacentridae 2.4%, Scaridae 0.9%, Acanthuridae 0.8%, Gobiidae 0.7%. The remaining 37 families contributed less than 0.5% each.

3.12 Point-count

The 100 point-counts yielded a total 33,848 fishes of 109 species. Of these 84.8% were juveniles (less than 5 cm total length). Mean abundance was 1.88 ± 0.06 / m^2 and mean richness was 0.07 ± 0.003 / m^2. Of the total fishes counted, 79.6% of the total were juvenile haemulids (93.9% of the total juveniles were haemulids). Other families contributed substantially lower numbers of individuals to the assemblage: Labridae 5.0%, Pomacentridae 1.9%, Acanthuridae 1.9%, Scaridae 0.7%, remaining 31 families including Gobiidae (0.4%) contributed less than 0.5% each.

3.13 Rover-diver count

The 98 rover-diver counts yielded 145 species of 42 families.

3.2 Comparisons

3.21 Previously renourished versus never renourished sites

With the transect data, mean abundance was significantly greater on never-renourished than previously-renourished hardbottom (mean fish/transect: 278.84, 144.77; $p<0.05$). However, richness was greater on previously renourished sites (mean species/transect: 11.9, 10.5; $p<0.05$ with parametric, but not non-parametric analysis). Rugosity at the transect sites was the same, although the amount of sand was greater on previously-renourished transects (mean m/transect: 3.4, 1.61; $p<0.05$). In contrast, with point-count data, abundance and richness was the same between sites and the rugosity differed with previously-renourished sites having the higher rugosity. Although it is possible that the greater richness noted on the previously-renourished area is due to the additional sand offering more habitat for non-hardbottom species, the species list does not support such a hypothesis (Table 7). The higher previously-renourished rugosity noted in the point-counts may be due to loss of inshore hard bottom which would push the transects further east. Because, in general, the eastern portion of the nearshore hardbottom has the most rugosity, moving the point-counts eastward would increase rugosity. An MDS plot of Bray-Curtis dissimilarity indices did not show separated grouping of previously-renourished and never-renourished sites (Figure 2).

With the rover-diver counts, there were 27 species on the 64 sites previously-renourished that were not recorded on never-renourished (3 species noted at 2 sites, 3 species at 3 sites, and 1 species at 6 sites)(Table 7). The remaining 20 species were individuals seen at a single site. In contrast, on the 36 sites which were never-renourished, there were 10 species not observed on previously renourished sites (all 10 represented by a single site, and most likely single individuals). There were a total of 112 species at never-renourished sites and 124 species on the previously-renourished sites.

3.22 Proposed hardbottom to-be-covered versus not-to-be-covered

Abundance, richness, and rugosity did not differ significantly between sites where the equilibrium toe of fill is proposed to cover a portion of the hardbottom with either transect or point counts. With the rover-diver counts, there were 23 species on the 64 sites not-to-be covered that were not observed on proposed affected sites (3 species noted at 2 sites, and 2 species at 4 sites (Table 8). The remaining 18 species were individuals seen at a single site. In contrast, on the 36 sites which will be affected by fill equilibration there were 8 species not on unaffected sites (7 species represented by a single site and 1 species on 2 sites). There were a total of 105 species at the to-be-covered sites and 132 species on the not-to-be-covered sites. An MDS plot of Bray-Curtis dissimilarity indices did not show separated grouping of previously-renourished and never-renourished sites (Figure 3).

3.23 Inshore hardbottom versus second and third reef tracts

From previous studies, it is clear that the inshore reef has significantly lower richness and abundance than either the middle or second reef. (Spieler, 2000; 2001; Ettinger et al., 2001; Harttung et al., unpublished). Although juvenile grunts are not unique to the nearshore reef, they are more abundant there than on the other reef tracts. With rare exception, a single count of 2000, 3-cm grunts, juvenile grunts are not found on the offshore reef tract or the eastern edge of the middle reef in Broward County.

Twenty-three species from this study are unique to the fish counts of the nearshore hardbottom, that is they have not been previously recorded on natural or artificial substrate in Broward County (Spieler, 1999; 2000; 2001; Ettinger et al., 2001)(Table 9). However, 18 of these were only noted at one site and therefore may be due simply to chance occurrence or differences in methodology; the rover-diver counts have not been done on either the middle or offshore reef tract. The remaining five species (molly miller, rosy razorfish, tiger goby, banded blenny, and sea bream) are neither rare nor endangered in Florida and, with the exception of the banded blenny, have a published depth distribution exceeding that of the nearshore hardbottom. Thus, it appears that although the Broward County nearshore hardbottom is an important habitat for juvenile fishes, especially grunts, the species makeup of the fish assemblage is not unique to this reef tract.

3.24 Inshore hardbottom versus artificial reef structure

In a previous study, concrete reefs, $1m^3$, were placed on sandy substrate between the nearshore and middle reef (7 m depth) and between the middle and offshore reef (21 m depth) (Spieler, 1999). The shallow reefs consisted of 40 reefs divided into four treatments, involving increasing refuge with caging, and the fish were counted monthly. During the period of June-August, the same months of this study, the juvenile grunts made up 72-85% of the fish assemblage, depending on treatment. At the offshore site of 20 reefs, the juvenile grunts ranged from 49-58%. In addition, at the shallow site fish abundance ranged from 69-249 fish/ m^3 and richness from 6.4-7.2 species/ m^3. At the offshore site for the same period, the numbers were: 59-114 fish/ m^3 and 11-13 species/ m^3. The potential for mitigation becomes clear when these numbers are compared with the mean abundance and richness from either this study or that of Lindeman and Snyder (1999) both of which found less than 4 fish and less than 1 species/m^3 or m^2 of natural substrate. In addition, the species makeup of the artificial reef assemblages resembled the natural nearshore hardbottom. As mentioned, juvenile grunts predominated, but labrids, scarrids, acathurids, and gobies made up the next most represented families. In contrast to the natural hardbottom, the damsel fish (Pomacentridae) were rare on the artificial reefs.

4.0 DISCUSSION

4.1 Census methodologies

There is an extensive literature on visual fish-counting methodology including a number of studies that compare counting methodologies (for references see Bortone and Kimmel, 1991). Currently, the transect-count and point-count are the most popular. Both of these methods are quantitative and thus amenable to rigorous statistical analysis and both are less sensitive to experience level differences amongst counters than are rover-diver counts. Because the rover-diver method is in large measure dependant on diver experience and water clarity, and determining the area covered during a random swim is difficult, it is less appropriate for quantitative comparisons. Rover-diver counts, however, are more likely to provide a more complete species list than other methods because the counter is only restricted by time in his or her search and can more readily move among differing habitats.

As anticipated, the 98 rover-diver counts recorded the highest numbers of species (145). The 100 point-counts recorded only 109 species and, with almost twice the counts, the 200 transects only had 118 species. The point and transect-counts had a similar percentage of juvenile fish (<5 cm) (84.8 and 88.3% and respectively). However, there was a highly-significant greater abundance (3.24 versus 1.88; $p<0.001$) and richness (0.19 versus 0.07; $p<0.001$) on the transects than the point-counts per m^2. This is especially curious in light of the fact that the rugosity was significantly higher on the point-counts than the associated transects (1.12 versus 1.08; $p<0.05$). That rugosity would be higher on the point-counts was anticipated because the counter selected the area of highest diversity 20m north of the transect to perform the count. This was normally due north of the east edge of the transect. It appears the point-count is less than optimal census methodology in the nearshore environment as, in this area, juvenile fishes predominate and they remain close to the substrate, often in shallow depressions. This characteristic may have made them more difficult to see in the greater area covered by the point-count (176.7 m^2) than the transect (60 m^2).

4.2 The inshore fish assemblages

Taking the differences in census results into account, the nearshore, hardbottom fish assemblages consist of at least 169 species (Table 10) of which more than 85% of the total fish are juveniles. Most of these juveniles are grunts (family Haemulidae) which make up more than 90% of the juveniles and 80+% of the total fish assemblage. The remaining families are represented in decidedly lower numbers. The wrasses (Labridae) at 5.0% comprised the next largest portion of the population followed by Pomacentridae at approximately 2.0 %, Acanthuridae 1.0 %, Scaridae 0.8%, Gobiidae 0.5%; the rest of the 47 families contributed less than 0.5% each.

Courtney at al. (1980) recorded 67 species of 26 families on the nearshore hardbottom (first reef) off Hallandale. All but four of these species were recorded in this study (polka-dot batfish, *Ogcocephalus radiatus*; freckled cardinalfish, *Phaeoptyx conklini*; spotfin mojarra, *Eucinostomus argenteus*; and ocean triggerfish, *Canthidermis sufflamen*) and were recorded only as rare or occasional at Hallandale.

Lindeman and Snyder (1999) reported 86 species with juveniles representing 80+%. Likewise, they also found haemulids made up the largest percentage of fishes with 6 of the 11 most abundant species. The remaining of the most abundant species, a porgy (*Diplodus argenteus*,) two damsels (*Stegastes variabilis*, *Abudefduf saxatilis*) a wrasse (*Halichoeres bivittatus*) and a blenny (*Labrisomus nuchipinnis*), differ from this study in that the porgies and blennies were not major components. In addition two of the most abundant species in Jupiter, sailors choice and silver porgy, (13% and 11%, respectively, of the total fish counts) were not abundant in Broward. Both of these species are present in Broward, but seldom in great abundance.

4.3 Previously- renourished versus never-renourished beach.

The data for transect-counts and point-counts provide conflicting interpretations of the fish assemblages on the nearshore hardbottom areas adjacent to previously-renourished or never-renourished beaches. Whereas the transect data indicates greater abundance but perhaps lower richness on the never-renourished sites; there is no difference between these variables at the two sites in the point-counts. There were some differences in the species noted between the two areas with the rover-diver counts, but for the most part (81%), these were single sightings. Finally no difference was noted between the two areas in an MDS plot of the Bray-Curtis dissimilarity indices. Taken as a whole, these data indicate no readily discernible difference among the fish assemblages between the previously renourished and never renourished areas.

Courtenay et al. (1980) reported an absence of previously recorded, dusky jawfish (*Opistognathus whitehursti)* along the first reef platform seven years after renourishment of Hallandale beach. They attributed this absence to the incursion of finer materials, possibly eroded beach fill. A similar extirpation of dusky jawfish was not noted in this study: 13 were recorded in the 64 random-diver counts on the nearshore hardbottom adjacent to previously renourished beach; and 8 were recorded in the 36 counts on hardbottom adjacent to never renourished beach.

Lindeman and Snyder (1999) reported a dramatic decrease in both species abundance and richness within a year of hardbottom burial at Carlin Park, Jupiter. Because the time intervals between renourishment and counts differ substantially between the Lindeman and Snyder (1999) study (<1yr) and this one (>10 yr) a direct comparison is not possible. Without knowing either the short-term effects (within a year of previous renourishment on Broward County hardbottom) or the original nearshore edge of hardbottom, it would be premature to conclude that the Broward hardbottom had essentially returned to a pre-renourishment fish assemblage from the conditions noted in Carlin Park.

4.4 Proposed renourishment

The hardbottom area proposed to be affected by renourishment does not statistically differ from hardbottom that should not be affected. Although there may be unique sites or species lost in the summary statistics, the simplest conclusion is the area to be affected likely does not provide unique habitat or fish assemblages different from other sections of nearshore hardbottom.

4.5 Essential fish habitat (EFH).

The South Atlantic Fishery Management Council (SAFMC) has identified nearshore hard-bottom areas as essential fish habitat (EFH) and a habitat area of particular concern (HAPC) for the snapper/grouper management unit. EFH "is defined as those waters and substrate necessary to fish for spawning, breeding, or growth to maturity" and HAPC is based on three criteria: the importance of ecological function provided by the habitat; the sensitivity to human-induced degradation; and if, and to what extent, developmental activities are, or will, be stressing the habitat (SAFMC, 1998). Thirty-three species of the snapper/grouper management unit and one coastal migratory pelagic species were recorded in this study (Table 10). It is also noteworthy that essentially all the species recorded in this study are designated restricted species and regulated by Florida law (68B-42.001F.A.C.) and two species are prohibited from harvest (manta and eagle rays 68B-44.008, F.A.C.). Currently, there are no marine fish species listed as endangered or threatened by the State of Florida (FFWCC 1977). SAFMC also provides permitting agencies with recommended guidelines for habitat mitigation (SAFMC, 1998). Specifically: 1) The created habitat should be functionally and ecologically comparable to what is being replaced. 2) The created habitat should be sited as close as possible to the eliminated habitat. 3) The habitat size should be at least twice the areal size (footprint) of that destroyed. 4) The configuration of replacement habitats should be determined by ecological setting and physical factors.

4.6 Mitigation potential

It appears from the perspectives of either: richness, abundance, or predominant species commonality, that hardbottom loss can be mitigated by artificial structure (see Section 3.24). It is noteworthy, however, that at present optimal methods for reef restoration with artificial substrate is poorly understood (Spieler et al., 2001). For example, a study comparing fish assemblages throughout the year, on different, un-caged, artificial reef designs, found abundance of 25 to 75 fish /m^3 and richness from 6-12 species/m^3 depending on reef design (Sherman, 2000). Increasing refuge by caging reefs can increase abundance to in excess of 100 fish /m^3 (Spieler, 1998). Boulder reefs, which are commonly used in mitigation projects, yielded abundance of only 14/m^3 and richness of less than one species/m^3 (Walker et al., submitted). Likewise, few studies have examined how effective mitigation structures are in restoring fish assemblages to near pre-disturbance states. Typically, mitigation structures are placed and simply forgotten; in a few cases, the artificial structure is monitored for several years.

However, without comparing the assemblages on the artificial structure with those on the natural area prior to the disturbance (e.g. hardbottom burial) and undisturbed natural areas around the mitigation site, little knowledge is gained on the effectiveness of any specific mitigation. Further, since there is little current knowledge on effective reef mitigation technology, mitigation projects should incorporate hypothesis based scientific studies to examine multiple mitigation designs.

5.0 CONCLUSIONS and RECOMMENDATIONS

Previous studies clearly show there will be significant short-term effects of beach renourishment and habitat burial on associated fish assemblages. It is not so clear if these effects are, for the most part, transient or permanent. By far, the major component of the inshore fish assemblages is juvenile grunts, both in species numbers as well as individuals, and these fish appear to quickly recruit to newly uncovered hardbottom (Lindeman and Snyder 1999). In addition, the Broward nearshore hardbottom does not appear to provide a unique habitat for some fish species that is unavailable at other hardbottom sites. The major discernable impact of any hardbottom burial will be on the loss of juvenile grunt habitat, primarily refuge.

Thus it appears that the proposed beach renourishment will have minimal qualitative impact on the nearshore fish assemblages and that quantitative impacts can be mitigated with artificial refuge. However, to return to the introductory caveat (section 1.2), this study does not provide an in-depth examination of trophic dynamics. Such a study would require, as a minimum, understanding the feeding habits of each fish species and the potential impact of beach renourishment on each food resource; a Herculean task requiring years. Further, the visual techniques used in this study do not census all species; to do so would require destructive methodology using extensive applications of a piscecide. And finally, although the statistical methodology offers some assurance that gross qualitative and quantitative affects of the proposed beach renourishment can be mitigated, small populations of individual species may not be amenable to rigorous analysis. Therefore, because it is not possible to proceed with absolute certainty, we concur with the advice of others that a “risk-averse approach should be taken to hardbottom burial” (Lindeman and Snyder, 1999).

In addition to limiting hardbottom burial, we concur with the recommendations of the SAFMC regarding mitigation relative to habitat type and location (see Section 4.5) with the addition that any mitigation should include a rigorous pre- and post-renourishment study to determine optimal mitigation methodologies. We do not agree with the SAFMC recommendation of replacing twice the area destroyed for mitigation. Although well meaning, and presumably erring on the side of habitat, the scientific basis for such a recommendation is questionable. For example, depending on the design of the artificial reefs used at the mitigation site, one could achieve a 10 to more than 100-fold increase in fish/m^2. The effects of such a population increase on the surrounding ecology is not known and could be detrimental. Rather than arbitrary replacement value in terms of area we suggest a goal of faunal restoration. Ideally, artificial reefs should be constructed that will provide a similar assemblage of fishes, in kind and number, to that anticipated to be lost to renourishment. This mitigation should then be monitored at least 3 years and adjusted through addition, deletion, or design modification to achieve the desired faunal mitigation goals. Simply placing some artificial reefs out for mitigation without attempting to determine their effectiveness relative to natural habitat, as well as to other artificial reef designs, should be discouraged.

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APPENDIX

Figure 1

PREVIOUS BEACH NOURISHMENT PROJECTS

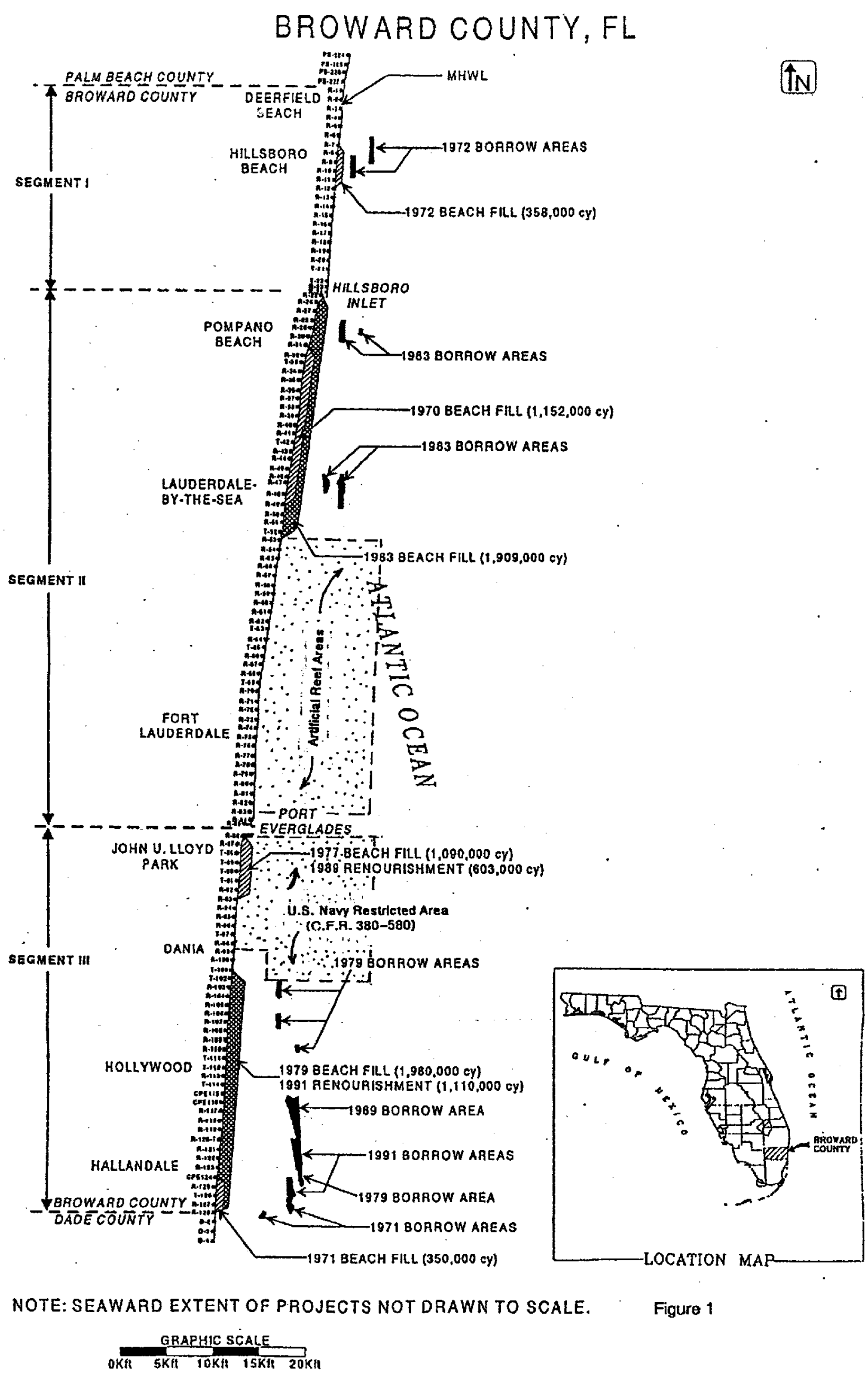

Figure 1

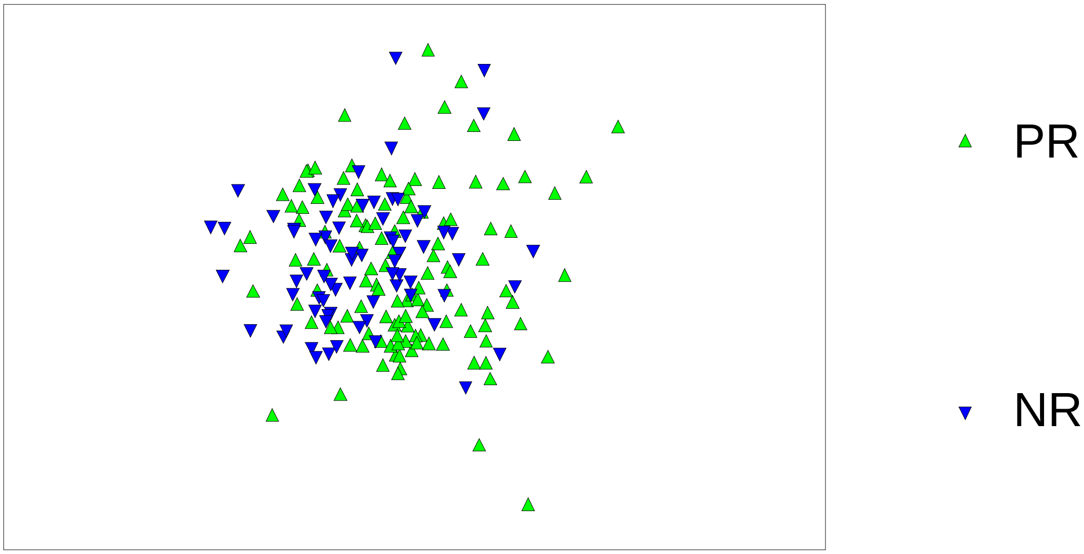

Figure 2. MDS –plots of Bray-Curtis dissimilarity indices of previously-renourished (PR) and never-renourished sites (NR).

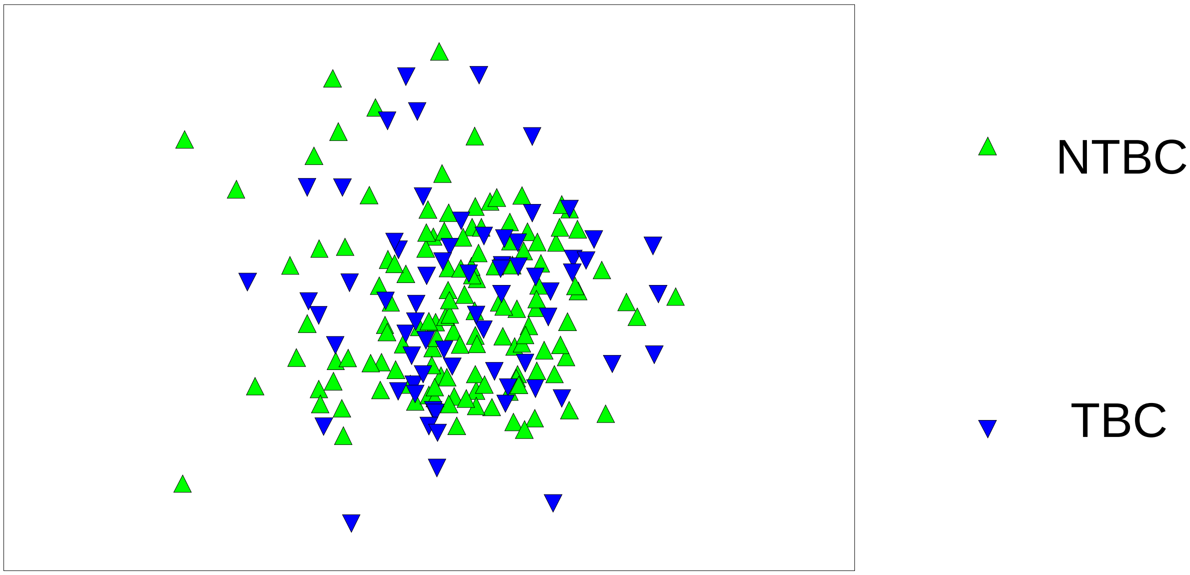

Figure 3. MDS plots of Bray-Curtis dissimilarity indices of sites proposed to be covered in renourishment (TBC) and not to be covered (NTBC).

Table: 1

Summary Statistics for Transect-Count Fish Abundance

Transect Total Abundance	
Mean	194.375
Standard Error	20.78858215
Median	96
Mode	52
Standard Deviation	293.9949481
Sample Variance	86433.02952
Kurtosis	13.84305237
Skewness	3.306187214
Range	2195
Minimum	4
Maximum	2199
Sum	38875
Count	200
Confidence Level (95.0%)	40.99419668

Transect	**To-Be-Covered Sites**		**Not To-Be-Covered**
Mean	172.641791	Mean	205.3233083
Standard Error	30.21557329	Standard Error	27.332396
Median	93	Median	97
Mode	13	Mode	52
Standard Deviation	247.3251266	Standard Deviation	315.2125677
Sample Variance	61169.71823	Sample Variance	99358.96286
Kurtosis	12.35493052	Kurtosis	13.42437694
Skewness	3.22844223	Skewness	3.255677529
Range	1441	Range	2195
Minimum	6	Minimum	4
Maximum	1447	Maximum	2199
Sum	11567	Sum	27308
Count	67	Count	133
Confidence Level (95.0%)	60.3273167	Confidence Level (95.0%)	54.06611431

Transect	**Never Renourished Sites**		**Renourished**
Mean	278.8378378	Mean	144.7698413
Standard Error	45.20736306	Standard Error	18.38238689
Median	107.5	Median	88
Mode	110	Mode	52
Standard Deviation	388.8884415	Standard Deviation	206.341781
Sample Variance	151234.2199	Sample Variance	42576.9306
Kurtosis	7.622356636	Kurtosis	18.1684673
Skewness	2.485294113	Skewness	3.825976328
Range	2190	Range	1443
Minimum	9	Minimum	4
Maximum	2199	Maximum	1447
Sum	20634	Sum	18241
Count	74	Count	126
Confidence Level (95.0%)	90.09820574	Confidence Level (95.0%)	36.38102556

Table: 2

Summary Statistics for Transect-Count Species Richness

Transect Total Species Richness	
Mean	11.38
Standard Error	0.350703528
Median	11
Mode	8
Standard Deviation	4.959696862
Sample Variance	24.59859296
Kurtosis	-0.14506571
Skewness	0.585075089
Range	24
Minimum	1
Maximum	25
Sum	2276
Count	200
Confidence Level (95.0%)	0.691572389

Transect	To-Be-Covered Sites		Not To-Be-Covered
Mean	10.91044776	Mean	11.61654135
Standard Error	0.671083742	Standard Error	0.405128015
Median	9	Median	11
Mode	8	Mode	8
Standard Deviation	5.49305717	Standard Deviation	4.672164193
Sample Variance	30.17367707	Sample Variance	21.82911825
Kurtosis	0.112924845	Kurtosis	-0.220567995
Skewness	0.951039052	Skewness	0.357103697
Range	22	Range	23
Minimum	3	Minimum	1
Maximum	25	Maximum	24
Sum	731	Sum	1545
Count	67	Count	133
Confidence Level (95.0%)	1.339861437	Confidence Level (95.0%)	0.801382271

Transect	Never Renourished Sites		Renourished
Mean	10.48648649	Mean	11.9047619
Standard Error	0.439717877	Standard Error	0.488395958
Median	10	Median	11
Mode	8	Mode	8
Standard Deviation	3.782596207	Standard Deviation	5.482231037
Sample Variance	14.30803406	Sample Variance	30.05485714
Kurtosis	0.675890679	Kurtosis	-0.651950728
Skewness	0.383210097	Skewness	0.469163667
Range	21	Range	22
Minimum	1	Minimum	3
Maximum	22	Maximum	25
Sum	776	Sum	1500
Count	74	Count	126
Confidence Level (95.0%)	0.87635706	Confidence Level (95.0%)	0.966596229

Table: 3

Summary Statistics for Transect-Count Rugosity Index

Transect Total Rugosity Index	
Mean	1.081643333
Standard Error	0.003908735
Median	1.066666667
Mode	1.066666667
Standard Deviation	0.055277863
Sample Variance	0.003055642
Kurtosis	7.210118308
Skewness	2.02907541
Range	0.41
Minimum	1.003333333
Maximum	1.413333333
Sum	216.3286667
Count	200
Confidence Level (95.0%)	0.007707859

Transect	To-Be-Covered Sites		Not-To-Be-Covered
Mean	1.080721393	Mean	1.082107769
Standard Error	0.00735175	Standard Error	0.004584501
Median	1.066666667	Median	1.07
Mode	1.066666667	Mode	1.056666667
Standard Deviation	0.060176665	Standard Deviation	0.052871048
Sample Variance	0.003621231	Sample Variance	0.002795348
Kurtosis	13.31356076	Kurtosis	2.597748366
Skewness	2.927942278	Skewness	1.395484383
Range	0.4	Range	0.296666667
Minimum	1.013333333	Minimum	1.003333333
Maximum	1.413333333	Maximum	1.3
Sum	72.40833333	Sum	143.9203333
Count	67	Count	133
Confidence Level (95.0%)	0.014678237	Confidence Level (95.0%)	0.009068586

Transect	Never Renourished Sites		Renourished
Mean	1.075837838	Mean	1.08505291
Standard Error	0.004218586	Standard Error	0.005679132
Median	1.07	Median	1.066666667
Mode	1.073333333	Mode	1.066666667
Standard Deviation	0.036289645	Standard Deviation	0.063748093
Sample Variance	0.001316938	Sample Variance	0.004063819
Kurtosis	0.800951656	Kurtosis	5.668375458
Skewness	0.768097537	Skewness	1.92671899
Range	0.183333333	Range	0.41
Minimum	1.01	Minimum	1.003333333
Maximum	1.193333333	Maximum	1.413333333
Sum	79.612	Sum	136.7166667
Count	74	Count	126
Confidence Level (95.0%)	0.008407635	Confidence Level (95.0%)	0.011239706

Table: 4

Summary Statistics for Point-Count Fish Abundance

Point-Count Total Abundance	
Mean	331.8431373
Standard Error	40.08690265
Median	203
Mode	471
Standard Deviation	404.8578713
Sample Variance	163909.8959
Kurtosis	14.91167477
Skewness	3.468174142
Range	2623
Minimum	8
Maximum	2631
Sum	33848
Count	102
Confidence Level (95.0%)	79.52162051

Point-count	**To-Be-Covered Sites**		**Not To-Be-Covered**
Mean	317.6744186	Mean	342.1694915
Standard Error	54.39794025	Standard Error	57.1988245
Median	194	Median	213
Mode	103	Mode	167
Standard Deviation	356.711149	Standard Deviation	439.3525076
Sample Variance	127242.8439	Sample Variance	193030.6259
Kurtosis	11.5421198	Kurtosis	15.77879265
Skewness	2.981254061	Skewness	3.630081462
Range	1982	Range	2623
Minimum	22	Minimum	8
Maximum	2004	Maximum	2631
Sum	13660	Sum	20188
Count	43	Count	59
Confidence Level (95.0%)	109.7795226	Confidence Level (95.0%)	114.4958013

Point-count	**Never Renourished Sites**		**Renourished**
Mean	383.1052632	Mean	301.40625
Standard Error	72.64190301	Standard Error	47.18385665
Median	235	Median	196.5
Mode		Mode	471
Standard Deviation	447.7947641	Standard Deviation	377.4708532
Sample Variance	200520.1508	Sample Variance	142484.245
Kurtosis	8.918042263	Kurtosis	22.84400429
Skewness	2.891903215	Skewness	4.070851559
Range	2048	Range	2623
Minimum	29	Minimum	8
Maximum	2077	Maximum	2631
Sum	14558	Sum	19290
Count	38	Count	64
Confidence Level (95.0%)	147.1863328	Confidence Level (95.0%)	94.28947109

Table: 5

Summary Statistics for Point-Count Species Richness

Point-Count Total Species Richness	
Mean	12.45098039
Standard Error	0.509971897
Median	12
Mode	9
Standard Deviation	5.150463693
Sample Variance	26.52727626
Kurtosis	0.234230356
Skewness	0.486499631
Range	25
Minimum	2
Maximum	27
Sum	1270
Count	102
Confidence Level (95.0%)	1.011646922

Point-Count	**To-Be-Covered Sites**		**Not To-Be-Covered**
Mean	12.14634146	Mean	12.6557377
Standard Error	0.777394786	Standard Error	0.677864392
Median	12	Median	12
Mode	9	Mode	8
Standard Deviation	4.977755396	Standard Deviation	5.29429015
Sample Variance	24.77804878	Sample Variance	28.0295082
Kurtosis	0.359609779	Kurtosis	0.229842503
Skewness	0.419941689	Skewness	0.520724052
Range	23	Range	25
Minimum	3	Minimum	2
Maximum	26	Maximum	27
Sum	498	Sum	772
Count	41	Count	61
Confidence Level (95.0%)	1.57117284	Confidence Level (95.0%)	1.355930227

Point Count	**Never Renourished Sites**		**Renourished**
Mean	11.47368421	Mean	13.03125
Standard Error	0.707344967	Standard Error	0.689694819
Median	11	Median	13
Mode	13	Mode	15
Standard Deviation	4.360367218	Standard Deviation	5.517558553
Sample Variance	19.01280228	Sample Variance	30.44345238
Kurtosis	-0.238558157	Kurtosis	0.020044876
Skewness	0.007669782	Skewness	0.51759467
Range	17	Range	25
Minimum	3	Minimum	2
Maximum	20	Maximum	27
Sum	436	Sum	834
Count	38	Count	64
Confidence Level (95.0%)	1.433215642	Confidence Level (95.0%)	1.378245958

Table: 6
Summary Statistics for Point-Count Rugosity Index

Point-Count Total Rugosity Index	
Mean	1.124550725
Standard Error	0.012396832
Median	1.093333333
Mode	1.053333333
Standard Deviation	0.118906233
Sample Variance	0.014138692
Kurtosis	9.267675365
Skewness	2.429095855
Range	0.773333333
Minimum	1
Maximum	1.773333333
Sum	103.4586667
Count	92
Confidence Level (95.0%)	0.024624786

Point-Count	To-Be-Covered Sites		Not To-Be-Covered
Mean	1.129904762	Mean	1.121263158
Standard Error	0.023658592	Standard Error	0.013924746
Median	1.08	Median	1.1
Mode	1.053333333	Mode	1.053333333
Standard Deviation	0.139966116	Standard Deviation	0.105129526
Sample Variance	0.019590514	Sample Variance	0.011052217
Kurtosis	12.7119921	Kurtosis	1.871566884
Skewness	3.065097172	Skewness	1.425827559
Range	0.773333333	Range	0.453333333
Minimum	1	Minimum	1
Maximum	1.773333333	Maximum	1.453333333
Sum	39.54666667	Sum	63.912
Count	35	Count	57
Confidence Level (95.0%)	0.048080011	Confidence Level (95.0%)	0.027894599

Point-count	Never Renourished Sites		Renourished
Mean	1.109777778	Mean	1.134047619
Standard Error	0.013749074	Standard Error	0.018336032
Median	1.096666667	Median	1.08
Mode	1.04	Mode	1.053333333
Standard Deviation	0.082494444	Standard Deviation	0.137214297
Sample Variance	0.006805333	Sample Variance	0.018827763
Kurtosis	1.721614407	Kurtosis	7.817826777
Skewness	1.239665946	Skewness	2.347622588
Range	0.36	Range	0.773333333
Minimum	1	Minimum	1
Maximum	1.36	Maximum	1.773333333
Sum	39.952	Sum	63.50666667
Count	36	Count	56
Confidence Level (95.0%)	0.027912138	Confidence Level (95.0%)	0.03674622

Table: 7
Species Recorded Unique To Sites Previously Renourished or Never Renourished

Species list (renourished sites) 64 sites	**Species list(never renourished sites) 36 sites**
Spotted eagle Ray	Spotted Moray
Flying Gurnard	Leopard Searobin
Blackbar soldierfish	Whitenose Pipefish
Greater Soapfish	Shortfin pipefish
Harlequin Bass	Belted Cardinalfish
Lookdown	Rainbow Runner
Round Scad (2)*	Rainbow Parrotfish
Dog Snapper	Spinyhead Blenny
Schoolmaster	Marbled Blenny
Slender Mojarra	Striped Burrfish
Mottled Mojarra (3)	
Cottonwick	
Spanish Grunt	
Smallmouth Grunt (2)	
Yellow Goatfish (3)	
Bermuda Chub	
Spadefish	
Spotfin Butterflyfish	
Blue Angelfish	
Redfin Parrot (6)	
Hairy Blenny	
Banded Blenny (3)	
Masked Goby	
Cero	
Scrawled Filefish (2)	
Queen Trigger	
Honeycomb Cowfish	

* Number in parenthesis indicates number of sites where species was recorded (lack of a number indicates individual was seen on a single site).

Table: 8
Species Recorded Unique to Sites To-Be-Covered or Not To-Be-Covered

Species List (non fill-effected sites) 64 sites	**Species List (effected by fill) 36 sites**
Spotted Moray	Flying Gurnard
Whitenose Pipefish	Leopard Searobin
Shortfin pipefish	Lookdown
Harlequin Bass	Schoolmaster
Belted Cardinalfish	Reef Croaker
Sharksucker (2)*	Hairy Blenny
Rainbow Runner	Scrawled Filefish (2)
Round Scad (2)	Queen Trigger
Dog Snapper	
Slender Mojarra (4)	
Cottonwick (2)	
Sea Bream	
Spotfin Butterflyfish	
Blue Angelfish	
Rainbow Parrotfish	
Spinyhead Blenny	
Marbled Blenny	
Barred Blenny	
Colon Goby	
Trunkfish	
Striped Burrfish	
Downy Blenny	
Planehead Filefish (4)	

* Number in parenthesis indicates number of sites where species was recorded (lack of a number indicates individual was seen on a single site).

Table: 9

Fish Unique to The Inshore Reef

Blackfin Cardinalfish (1)*
Colon Goby (1)
Downy Blenny (1)
Molly Miller (4)
Mottled Mojarra (1)
Rosy Razorfish (4)
Slender Mojarra (1)
Tarpon (3)
Tiger Goby (3)
Banded Blenny (2)
Belted Cardinalfish (1)
Flying Gurnard (1)
Hairy Blenny (1)
Marbled Blenny (1)
Rockcut Goby (1)
Sea Bream (2)
Shortfin Pipefish (1)
Trunkfish (1)
Whitenose Pipefish (1)
Conchfish (1)
Goldentail Moray (1)
Rusty Goby (1)
Sharptail Eel (1)

* Indicates number of times observed.

Table: 10

South Atlantic Florida Management Council List of Managed Species Recorded on the Nearshore Reef

South Atlantic Snapper-Grouper Complex

Gray Triggerfish
Queen Triggerfish
Yellow Jack
Blue Runner
Bar Jack
Spadefish
Black Margate
Porkfish
Margate
Tomtate
Smallmouth Grunt
French Grunt
Spanish Grunt
Cottonwick
Sailors Choice
White Grunt
Bluestripe Grunt
Mutton Snapper
Schoolmaster
Gray Snapper
Mahogany Snapper
Dog Snapper
Lane Snapper
Yellowtail Snapper
Rock Hind
Grasby
Red hind
Red Grouper
Scamp
Sheepshead
Saucereye Porgy
Hogfish
Puddingwife

Coastal Migratory Pelagics

Cero

Table: 11

Inshore Species List (Summer 2001) Transect, Point Count, Rover Diver

Common Name	Scientific Name
NURSE SHARKS	**ORECTOLOBIDAE**
Nurse Shark	*Ginglymostoma cirratum*
STINGRAY	**DASYATIDAE**
Southern stingray	*Dasyatis americana*
ROUND STINGRAYS	**UROLOPHIDAE**
Yellow Stingray	*Urobatis jamaicensis*
EAGLE RAY	**MYLIOBATIDAE**
Spotted Eagle Ray	*Aetobatus narinari*
MANTA	**MOBULIDAE**
Manta	*Manta birostris*
TARPONS	**MEGALOPIDAE**
Tarpon	*Megalops atlanticus*
MORAY EELS	**MURAENIDAE**
Spotted Moray	*Gymnothorax moringa*
Green Moray	*Gymnothorax funebris*
Goldentail Moray	*Muraena miliaris*
Purplemouth Moray	*Gymnothorax vicinus*
SNAKE EELS	**OPHICHTHIDAE**
Sharptail Eel	*Myrichthys breviceps*
LIZARDFISHES	**SYNODONTIDAE**
Sand Diver	*Synodus intermedius*
Inshore Lizardfish	*Synodus foetens*
SQUIRRELFISH	**HOLOCENTRIDAE**
Squirrelfish	*Holocentrus adscensionis*
Blackbar Soldierfish	*Myripristis jacobus*
PIPEFISH AND SEAHORSE	**SYNGNATHIDAE**
Shortfin pipefish	*Cosmocampus elucens*
Whitenose pipefish	*Cosmocampus albirostris*
CORNETFISH	**FISTULARIIDAE**
Bluespotted Cornetfish	*Fistularia tabacaria*
FLYING GURNARD	**DACTYLOPTERIDAE**
Flying Gurnard	*Dactylopterus volitans*
SCORPIONFISH	**SCORPAENIDAE**
Spotted Scorpionfish	*Scorpaena plumieri*
SEAROBINS	**TRIGLIDAE**
Leopard searobin	*Prionotus scitulus*
SEA BASSES	**SERRANIDAE**
Scamp	*Mycteroperca phenax*
Red Hind	*Epinephelus guttatus*
Rock Hind	*Epinephelus adscensionis*

Red Grouper	*Epinephelus morio*
Graysby	*Epinephelus cruentatus*
Sand Perch	*Diplectum formosum*
Barred Hamlet	*Hypoplectrus puella*
Blue Hamlet	*Hypoplectrus gemma*
Butter Hamlet	*Hypoplectrus unicolor*
Lantern Bass	*Serranus baldwini*
Harlequin Bass	*Serranus tigrinus*
SOAPFISHES	**GRAMMISTIDAE**
Greater Soapfish	*Rypticus saponaceus*
JAWFISH	**OPISTOGNATHIDAE**
Banded Jawfish	*Opistognathus macrognathus*
Dusky Jawfish	*Opistognathus whitehursti*
CARDINALFISHES	**APOGONIDAE**
Twospot Cardinalfish	*Apogon pseudomaculatus*
Belted Cardinalfish	*Apogon townsendi*
Blackfin Cardinalfish	*Astrapogon puncticulatus*
Conchfish	*Astrapogon stellatus*
Barred Cardinal Fish	*Apogon binotatus*
Flamefish	*Apogon maculatus*
TILEFISHES	**MALACANTHIDAE**
Sand Tilefish	*Malacanthus plumieri*
REMORAS	**ECHENEIDIDAE**
Sharksucker	*Echeneis naucrates*
JACKS	**CARANGIDAE**
Greater Amberjack	*Seriola dumerili*
Round Scad	*Decapterus punctatus*
Rainbow Runner	*Elagatis bipinnulata*
Yellow Jack	*Caranx bartholomaei*
Blue Runner	*Caranx crysos*
Bar Jack	*Caranx ruber*
Lookdown	*Selene vomer*
SNAPPERS	**LUTJANIDAE**
Gray Snapper	*Lutjanus griseus*
Lane Snapper	*Lutjanus synagris*
Mutton Snapper	*Lutjanus analis*
Mahogany Snapper	*Lutjanus mahogoni*
Dog Snapper	*Lutjanus jocu*
Yellowtail Snapper	*Ocyurus chrysurus*
Schoolmaster	*Lutjanus apodus*
MOJARRAS	**GERREIDAE**
Yellowfin Mojarra	*Gerres cinereus*
Slender Mojarra	*Eucinostomus jonesi*
Mottled Mojarra	*Eucinostomus lefroyi*
GRUNTS	**HAEMULIDAE**
Porkfish	*Anisotremus virginicus*

Juvenile Grunts	*Haemulon sp.*
Spanish Grunt	*Haemulon macrostomum*
Caesar Grunt	*Haemulon carbonarium*
Striped Grunt	*Haemulon striatum*
Smallmouth Grunt	*Haemulon chrysargyreum*
Cottonwick	*Haemulon melanurum*
White Grunt	*Haemulon plumieri*
Margate	*Haemulon album*
Black Margate	*Anisotremus surinamensis*
Tomtates	*Haemulon aurolineatum*
French Grunt	*Haemulon flavolineatum*
Bluestripe Grunt	*Haemulon sciurus*
Sailors Choice	*Haemulon parrai*
PORGIES	**SPARIDAE**
Jolthead Porgy	*Calamus bajonado*
Spottail Pinfish	*Diplodus holbrooki*
Sheepshead Porgy	*Calamus penna*
Silver Porgy	*Diplodus argenteus*
Saucereye Porgy	*Calamus calamus*
Sea Bream	*Archosargus rhomboidalis*
DRUMS	**SCIAENIDAE**
Highhat	*Equetus acuminatus*
Reef Croaker	*Odontoscion dentex*
Spotted Drum	*Equetus punctatus*
GOATFISHES	**MULLIDAE**
Yellow Goatfish	*Mulloidichthys martinicus*
Spotted Goatfish	*Pseudupeneus maculatus*
SWEEPERS	**PEMPHERIDAE**
Glassy Sweeper	*Pempheris schomburgki*
BUTTERFLYFISHES	**CHAETODONTIDAE**
Spotfin Butterflyfish	*Chaetodon ocellatus*
Reef Butterflyfish	*Chaetodon sedentarius*
ANGELFISHES	**POMACANTHIDAE**
Queen Angelfish	*Holocanthus ciliaris*
Blue Angelfish	*Holocanthus bermudensis*
French Angelfish	*Pomacanthus paru*
Gray Angelfish	*Pomacanthus arcuatus*
SEA CHUBS	**KYPHOSIDAE**
Bermuda Chub	*Kyphosus sectatrix*
DAMSELFISHES	**POMACENTRIDAE**
Beaugregory	*Stegastes leucostictus*
Longfin Damselfish	*Stegastes diencaeus*
Dusky Damselfish	*Stegastes fuscus*
Threespot Damselfish	*Stegastes planifrons*
Bicolor Damselfish	*Stegastes partitus*
Cocoa Damslefish	*Stegastes variabilis*

Yellowtail Damselfish	*Microspathadon chrysurus*
Sergeant Major	*Abudefduf saxatilis*
WRASSES	**LABRIDAE**
Hogfish	*Lachnolaimus maximus*
Spanish Hogfish	*Bodianus rufus*
Clown Wrasse	*Halichoeres maculipinna*
Slippery Dick	*Halichoeres bivittatus*
Puddingwife	*Halichoeres radiatus*
Yellowcheek Wrasse	*Halichoeres cyanocephalus*
Blackear Wrasse	*Halichoeres poeyi*
Yellowhead Wrasse	*Halichoeres garnoti*
Green Razorfish	*Xyrichtys splendens*
Rosy Razorfish	*Xyrichtys martinicensis*
Bluehead Wrasse	*Thalassoma bifasciatum*
PARROTFISHES	**SCARIDAE**
Striped Parrot	*Scarus croicensis*
Princess Parrot	*Scarus taeniopterus*
Blue Parrot	*Scarus coeruleus*
Bucktooth Parrot	*Sparisoma radians*
Rainbow Parrot	*Scarus guacamaia*
Redtail Parrot	*Sparisoma chrysopterum*
Redfin Parrot	*Sparisoma rubripinne*
Redband Parrot	*Sparisoma aurofrenatum*
Stoplight Parrot	*Sparisoma virride*
Greenblotch Parrot	*Sparisoma atomarium*
Bluelip Parrot	*Cryptotomus roseus*
CLINIDS	**CLINIDAE**
Rosy Blenny	*Malacoctenus macropus*
Saddled Blenny	*Malacoctenus triangulatus*
Banded Blenny	*Paraclinus fasciatus*
Downy Blenny	*Labrisomus kalisherae*
Hairy Blenny	*Labrisomus nuchipinnis*
Marbled Blenny	*Paraclinus marmoratus*
Sailfin Blenny	*Emblemaria pandionis*
Roughhead Blenny	*Acanthemblemaria aspera*
Spinyhead Blenny	*Acanthemblemaria spinosa*
COMBTOOTH BLENNIES	**BLENNIDAE**
Barred Blenny	*Hypleurochilus bermudensis*
Seaweed Blenny	*Parablennius marmoreus*
Redlip Blenny	*Ophioblennius atlanticus*
Molly Miller	*Scartella cristata*
GOBIES	**GOBIIDAE**
Seminole Goby	*Microgobius carri*
Dash Goby	*Gobiosoma saepepallens*
Neon Goby	*Gobiosoma oceanops*
Bridled Goby	*Coryphopterus glaucofraenum*

Blue Goby	*Ioglossus calliurus*
Hovering Goby	*Ioglossus helenae*
Masked/Glass Goby	*Coryphopterus hyalinus/personatus*
Goldspot Goby	*Gnatholepis thompsoni*
Colon Goby	*Coryphopterus dircus*
Rusty Goby	*Quisquilius hipoliti*
Rockcut Goby	*Gobiosoma grosvenori*
Tiger Goby	*Gobiosoma macrodon*
SPADEFISHES	**EPHIPPIDAE**
Spadefish	*Chaetodipterus faber*
SURGEONFISHES	**ACANTHURIDAE**
Ocean Surgeon	*Acanthurus bahianus*
Doctorfish	*Acanthurus chirurgus*
Blue tang	*Acanthurus coeruleus*
BARRACUDAS	**SPHYRAENIDAE**
Great Barracuda	*Sphyraena barracuda*
MACKERELS	**SCOMBRIDAE**
Cero	*Scomberomorous regalis*
LEATHERJACKETS	**BALISTIDAE**
Queen Trigger	*Balistes vetula*
Gray Trigger	*Balistes capriscus*
FILEFISHES	**MONACANTHIDAE**
Scrawled Filefish	*Aluterus scriptus*
Orange Filefish	*Aluterus schoepfi*
Orangespotted Filefish	*Cantherhines pullus*
Planehead Filefish	*Monocanthus hispidus*
BOXFISHES	**OSTRACIIDAE**
Scrawled cowfish	*Lactophrys quadricornis*
Spotted Trunkfish	*Lactophrys bicaudalis*
Trunkfish	*Lactophrys trigonus*
Honeycomb cowfish	*Lactophrys polygonia*
Smooth trunkfish	*Lactrophrys triqueter*
PUFFERS	**TETRAODONTIDAE**
Sharpnose Puffer	*Canthigaster rostrata*
Bandtail Puffer	*Sphoeroides spengleri*
SPINY PUFFERS	**DIODONTIDAE**
PorcupineFish	*Diodon hystrix*
Striped Burrfish	*Chilomycterus schoepfi*
Balloonfish	*Diodon holocanthus*