EFFECTS OF MODULE SPACING ON THE FORMATION AND MAINTENANCE OF FISH ASSEMBLAGES ON ARTIFICIAL REEFS

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INTRODUCTION

This is an annual interim report of a two-year study initiated May 1998.

There is an obvious need for experimental studies examining optimal configuration and spacing of artificial reef modules. The rational for such studies is, in part, to determine optimal placement of artificial reef material in order to obtain the maximum density of fishes, or selected species, for a given amount of reef material. We are, however, only aware of a single published study which has examined the role of spacing of artificial reefs on associated fish assemblages (Frazer and Lindberg 1994).

In a thorough study, Frazer and Lindberg (1994) off the northwest coast of Florida placed an equal number of small concrete modules (0.77 x 0.58 x 0.30 m) in differing configurations within equally sized plots. Censusing the modules, they found an increase in fish density, as well as selected invertebrates, with increased spacing between modules. The authors concluded that widely spaced reefs offer increased forage areas to animals utilizing soft-bottom prey.

In contrast, in an unpublished study, also off northwest Florida, Bortone (Pers. communication) was unable to see spacing-dependant differences in fish numbers or biomass for a unit of area (e.g. 100 m^2) regardless of the distance among modules (car bodies). However, the differences between Bortone's and the Frazer and Lindberg (1994) studies may due to how they determined density (numbers/unit area versus numbers/module) rather than a real difference in results.

Regardless, we concur with Frazer and Lindberg (1994) that it is not clear that the results of the previous studies can be extrapolated to other environs without further inquiry. Both the studies above were done off the northwest coast of Florida in areas of extensive sand bottom with limited hard-bottom substrate or vertical profile. In contrast, the inshore areas of Broward County consist of sequential hard and sand bottom strips 100-200m wide running parallel along the coast. Results from our previous studies (e.g. the wide variation in fish numbers on identical modules) indicate that, unlike the northwest coast, substrate is not a major limiting factor to fish density in our area. On the other hand, refuge from predation, and possibly current, apparently is (Spieler 1998). Further, the predominant fishes on our artificial reefs are either planktivores, herbivores or piscivores and not dependent on soft-bottom forage (i.e. juvenile grunts, cardinals, surgeons, snappers) like the animals in the Frazer and Lindberg (1994) study. In addition, in one study (Spieler 1998), by accident, three of our modules were dragged by anchor from 35m to 1-5m separation. These modules were removed from study and thus not censused. Nevertheless, the three were seen monthly over a period of 18 months during routine censuses of other modules. There is a large shoal of mixed fishes that moves among the three closely spaced modules at the approach of a diver and we suspect that the total fishes associated with the three outnumber the total of any three widely spaced modules. Therefore, we believe a study examining the potential role of spacing of artificial reefs on the formation and maintenance of fish assemblages needs to be performed in the Broward County offshore environment. The results of this study will directly impact how we deploy future reef material and will yield insight into the interrelated functions of natural and artificial patch reefs.

In this study we are examining the role of module spacing on reef fish assemblages. Specifically we are testing the null hypothesis that: spacing among artificial reefs does not affect associated fish assemblages.

METHODS AND MATERIALS

Experimental Design

We are experimentally testing the null hypothesis (above) by examining fish assemblages on reefs of similar configuration but differing spacing. Reef modules are configured into equilateral triangles, with a module at each apex . There are four different sized triangles, with two replicates of each size. The smallest triangle has zero space (<.33m) between the modules, that is the sides of the three modules are nearly touching; the second has 5 m sides; the third 15 m and the fourth 25 m sides (Fig. 1). In addition there are replicates of single- and double-module configurations. Weather permitting, the modules are censused monthly.

Modules and Reconfiguration

This study uses the Rinker modules (aka Layer-cake or Spieler-Gilliam modules) used in previously completed studies (Spieler 1998). The Rinker modules have proven themselves to be extremely effective small stand-alone reefs. The associated fish assemblages on these modules are larger and more diverse than what we have seen, to date, on other stand-alone reefs in our area (e.g. ReefBalls TM or Swiss-Cheese modules). The modules were on site in a permitted, ground-truthed area in approximately 7 m water. The exact location for each reef module was buoyed (using D-GPS), then modules were individually picked off the bottom using air-bags and towed to a new site. Configuration of the Rinker modules to the specific spacing of this study (Figure 1, Appendix 1) was accomplished by DNRP and NOVA personnel in 1998 during the period 1 May to mid-August. This effort required extensive coordination between the two institutions and ideal weather to effectively tow the reefs, using lift bags, into position. Towing the modules took place May 1, 14, 15, and June 19 at that time the modules were roughly in the correct position. After placement the exact spacing among modules was measured underwater and those reefs out of position were again moved by lift bag. Underwater measurements and fine tuning the placement to specific sites occurred August 3, 14, 17. The reefs were cleaned of fishes with a piscicide September 9 and 10. The first census was taken October 1 and a second on October 30, 1998.

The modules were censused monthly, weather permitting, by divers using SCUBA and recording data underwater on plastic slates. Species, numbers of fish per species, and total length were recorded. Because the modules are small (1 m^3) we are able to record all fishes and no census transects or data extrapolation was required. The resulting data were analyzed by nonparametric analysis of variance (ANOVA) techniques (SAS: Proc GLM of ranked data).

RESULTS

Total Fish:

There was a significant difference among the configuration treatments in the total number of fishes ($p<0.001$, ANOVA). As would be expected the single module had the lowest number of fish per module (mean 36) followed by two modules together (56), these two groups differed significantly from the configuration of three modules touching (125, $p<0.05$, SNK). The three modules that were touching also differed from any of the other 3-module configurations, which did not differ from each other ($p<0.05$, SNK). There were also significant differences amongst the configuration for all size classes. With the exception of 5-10 cm fish there were significant differences amongst months for each size class as well as total fishes ($p<0.05$, ANOVA)(Figures 2). In general, the greatest numbers of fish were found in April through July.

Species:

There was also a difference amongst treatments in the number of species ($p<0.001$, ANOVA). The three modules touching had more species than any other configuration (mean =18, $p<0.05$ SNK). The lowest diversity was found on the single- and double-module configurations (Figure 3).

Biomass:

There was a significant difference amongst treatments in biomass as well ($p<0.001$, ANOVA). Biomass was highest on the three modules touching, and differed significantly in this configuration from single and double modules ($p<0.05$, SNK) but not from other three-module configurations (Figure 4).

LITERATURE CITED

Frazer, T.K. and W.J. Lindberg. 1994. Refuge spacing similarly affects reef-associated species from three phyla. Bull. Mar. Sci. 55: 388-400.

Spieler, Richard E. 1998. Recruitment of juvenile reef fishes to inshore and offshore artificial reefs: final report. Contract completion report to Broward County Office of Natural Resource Protection.

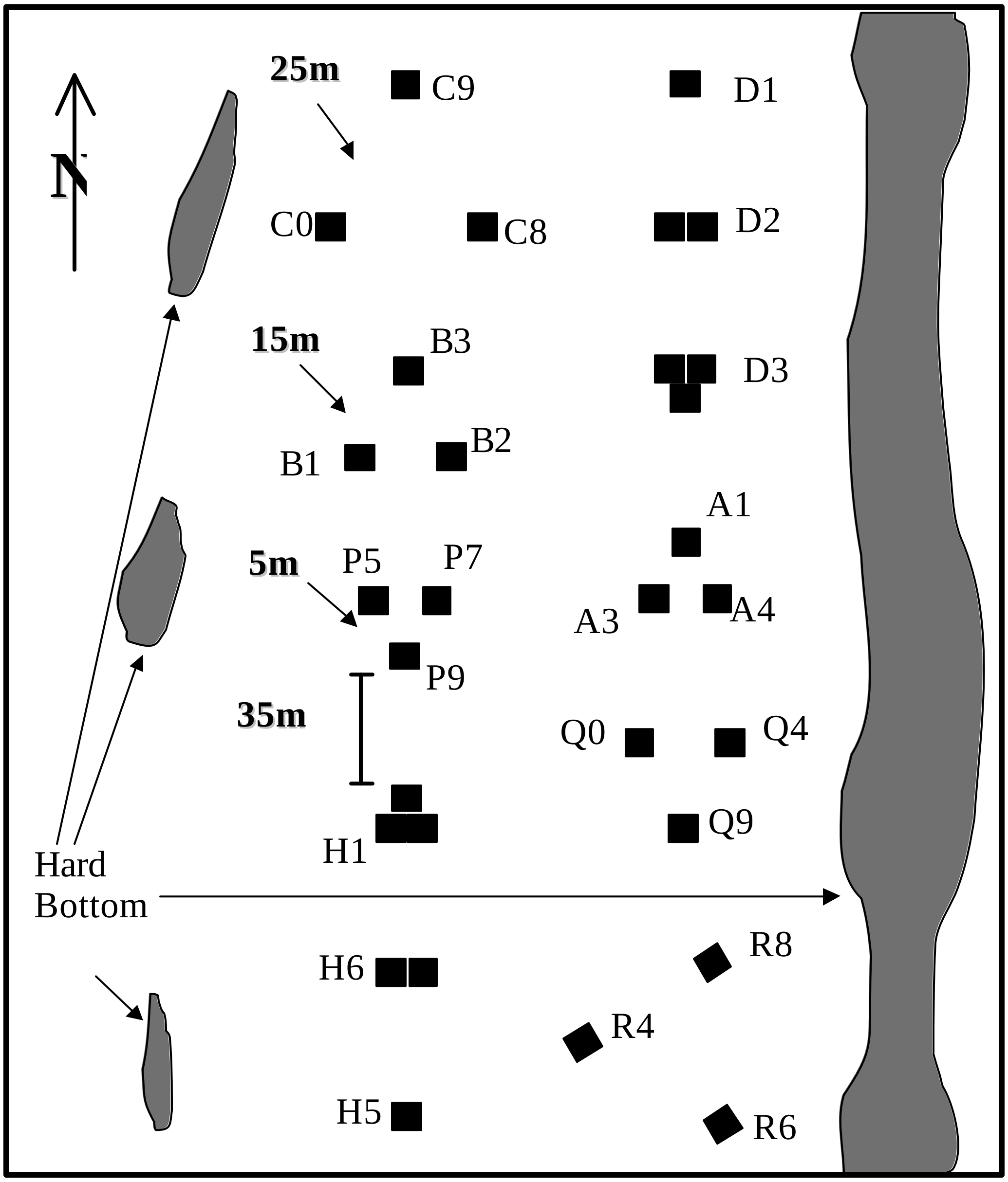


Figure 1. Study site. Not drawn to scale.

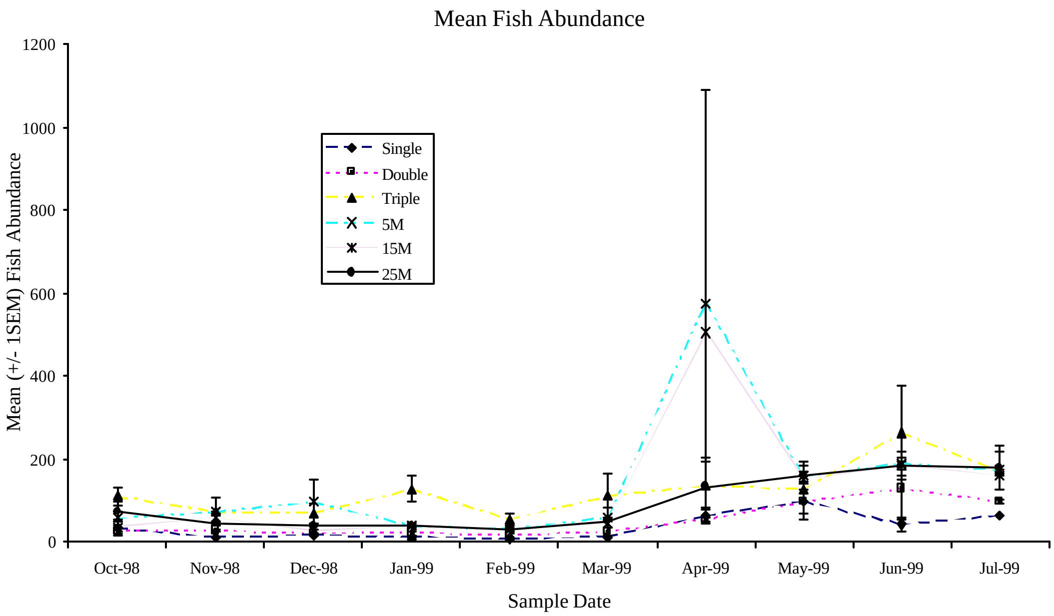
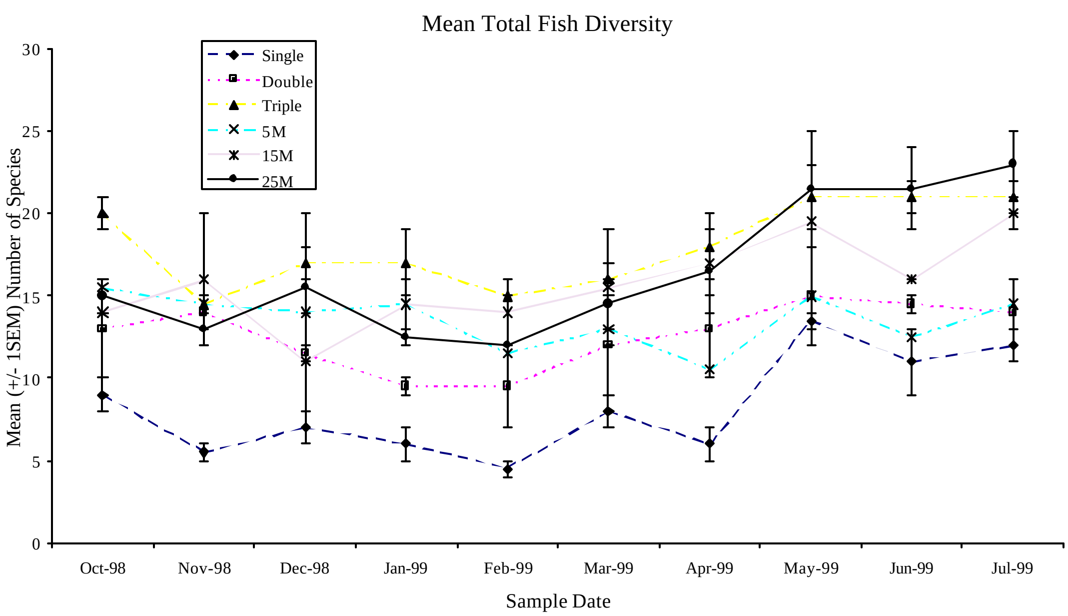


Figure 2. Mean (+/- 1SEM) number of total fishes (all size classes and species combined) for all reef treaments. Differences among treaments: P<0.01, ANOVA, Triple> 5m, 15m, 25m> Double, Single, P<0.05, SNK, underlined groups are not significantly different.



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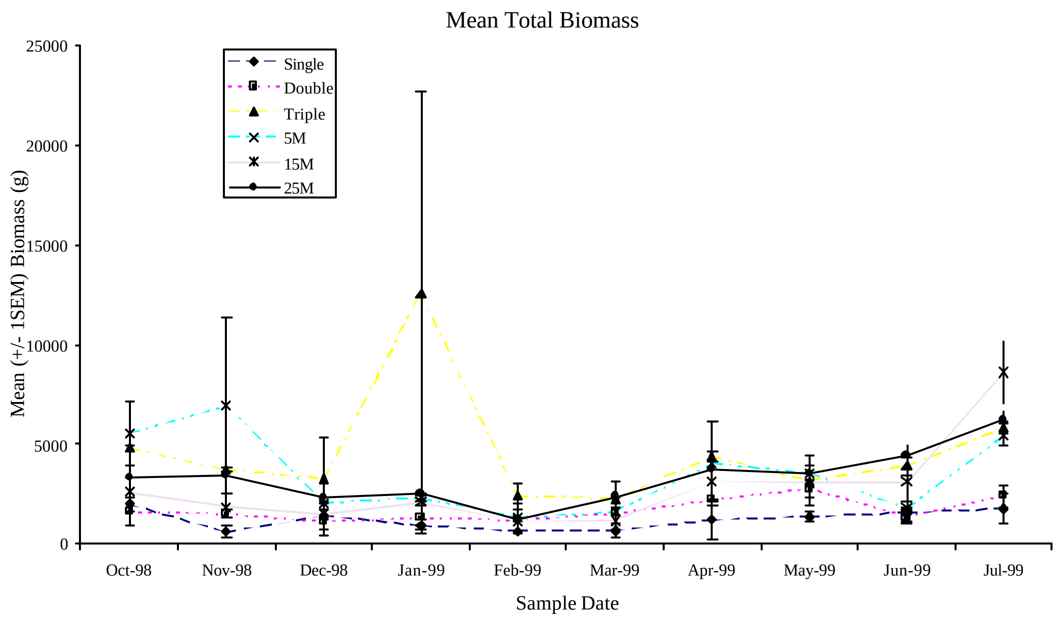

Figure 4. Mean (+/- 1SEM) biomass (g) of total fishes (all size classes and species combined) for all reef treaments. Differences among treaments: P<0.01, ANOVA, Triple> 5m, 15m, 25m> Double, Single, P<0.05, SNK, underlined groups are not significantly different.