Effects of Habitat Complexity on Reef Fish Assemblages Associated with Northwest Gulf of Mexico Banks

Efectos de Hábitat Complejidad de Comunidades de Peces de Arrecife Asociados con el Noroeste del Golfo de México Bancos

Les Effets de la Complexité de l'Habitat sur l'Assemblage de Poissons de Récif Tropicaux Associés avec les Rives du Nord-Ouest du Golfe du Mexique

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EXTENDED ABSTRACT

The northwest Gulf of Mexico (Gulf) shelf-edge reefs and banks support a wide variety of reef-dependent and reef-associated fish species, many of which are important to commercial and recreation fisheries in the Gulf region. Effective fishery management is necessary to protect these resources and ensure long-term productivity. A paradigm shift in recent years has seen management procedures transition from single-species based approaches to ecosystem-based fisheries management (EBFM), essentially reversing the order of traditional management priorities to focus on the ecosystem rather than the target species (Pikitch et al. 2004).

The biological communities associated with the northwest Gulf banks were classified by Rezak et al. (1985) based on the degree of reef building and primary productivity. More recently, Flower Garden Banks National Marine Sanctuary (FGBNMS) scientists have modified and reorganized the zonation classification of Rezak et al. (1985) into a similar, but more generalized, habitat classification scheme based solely on five broad biological zones (Schmahl et al. 2008). Relationships between benthic habitat characteristics and fish assemblages, diversity, and abundance have been well documented, though the specific mechanisms behind these relationships are highly dependent on the system in question (Gratwicke and Speight 2005). Examining how specific habitat characteristics are associated with the delineation of reef fish assemblages is important for understanding how these hard-bottom habitats are used by various reef fishes and could inform future management decisions about the protection of reef habitats. This is especially important in the northwest Gulf where these high relief banks provide a unique source of natural, hard-bottom habitat that supports large numbers of reef-associated fish in an otherwise soft-bottom, low relief environment.

We examined the fish assemblages and habitat characteristics associated with three shelf-edge banks and one artificial reef in the northwest Gulf. The three banks (Bright, McGrail, and Jakkula) are located on the Louisiana-Texas (LATEX) shelf edge, while the artificial reef is closer to shore on the LATEX shelf in the East Cameron Artificial Reef Planning Area (Figure 1). The relative abundances of reef fish species were estimated from video surveys conducted from December 2012 to October 2013. A six-camera array consisted of a circular, baited cage, within which two stereo pairs and two single cameras were mounted orthogonal to one another at a height of 0.5 m affording a near 360° view.

Videos were reviewed in EventMeasure software (SeaGIS Pty. Ltd.) to identify and enumerate all species for the duration of the recording. Identifications were made to the lowest taxonomic level possible and enumerations were calculated in the form of MaxN. In addition to characterizing reef fish assemblages, the environment in which fish were observed was also characterized, including depth, temperature, salinity, maximum relief, percent cover of substrate type (rock, sand, mud, and rubble) and percent of live cover. The importance of environmental variables and habitat characteristics in defining habitat zones and influencing assemblage structure was investigated with a multivariate permutational analysis (PERMANOVA), principal components analysis (PCA), and distance-based linear models (DISTLM) in Plymouth Routines in Multivariate Ecological Research, Version Six (PRIMER 6). This suite of routines was chosen as a natural progression of specificity; a global PERMANOVA to test whether environmental variables and habitat characteristics differed significantly between habitat zones, a PCA to determine which environmental or habitat variables were driving potential differences between zones, and DISTLM to model how environmental variables and habitat characteristics influenced observed fish assemblages.

The PERMANOVA indicated that habitat zone was a significant factor ($F_{pseudo} = 7.5$, $p = 0.001$) in defining differences of environmental and habitat characteristic variables, however the Site*Habitat interaction was not significant ($F_{pseudo} = 1.1$, $p = 0.37$), an indication that environmental and habitat characteristic variables were consistent within a given habitat zone across sites. While not based on the specific characteristics defined in this study, the habitat classification schemes developed by both Rezak et al. (1985) and the FGBNMS (Schmahl et al. 2008) were defined due to dramatic differences in habitat characteristics and were observed at multiple banks. Thus neither the significant differences in fundamental habitat complexity characteristics between zones, nor the consistency among sites, are surprising.

Qualitatively, PCA ordination grouped habitat zones very consistently and discretely (Figure 2). The first three principle components (PCs) cumulatively accounted for 75.8% of the total variation, a good representation of the original data. All environmental and habitat variables, except salinity, accounted for a large portion (eigenvector > 0.4) of the variation of one of the three important (eigenvalue > 1) PCs.

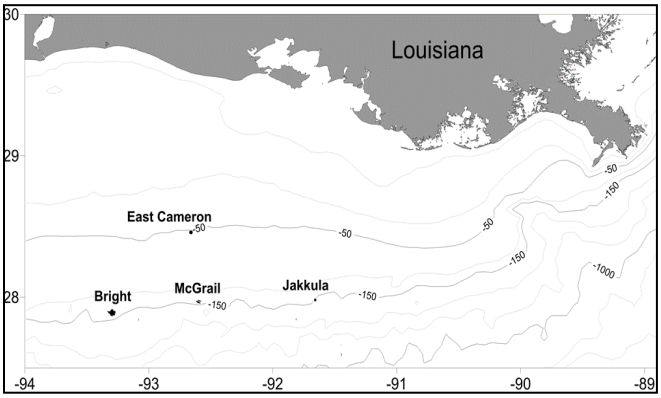

Figure 1. Sampling locations for video survey collection at one artificial reef (East Cameron) and three shelf-edge reefs (Bright McGrail, Jakkula) in the northwestern Gulf of Mexico off Louisiana (LA).

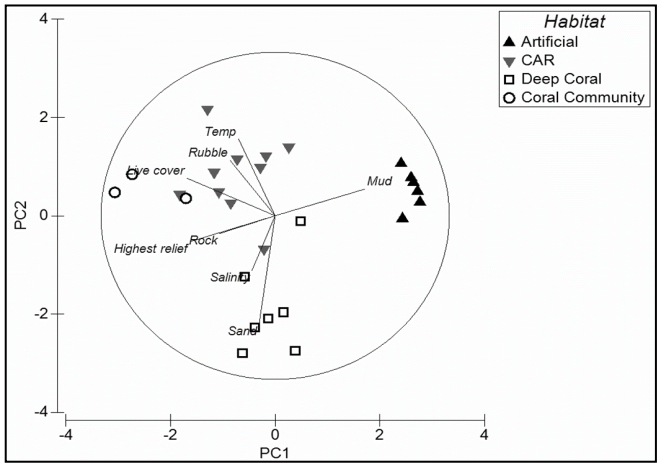

Figure 2. Two-dimensional principle components analysis of individual video surveys based on environmental and habitat characteristics. Symbols represent the habitat zone within which a survey was conducted. Vectors indicate the contribution of each variable to the two principle component axes.

The DISTLM showed that all nine environmental and habitat variables together explained 49% of the total variation in the multivariate species data cloud. Mutual AICc and BIC model selection suggested a two-variable model, percent mud substrate and percent live cover ($R^2 = 0.27$), represented the ideal tradeoff between parsimony and model fit. This model fit well because these two variables effectively delineated habitat zones, a factor shown to significantly discriminate species assemblages in a concurrent study. Percent mud substrate provided information about whether the habitat was artificial or natural because the natural habitats displayed minimal, if any, mud substrate. Percent live cover then differentiated between natural habitat zones because the three natural habitat zones were characterized by varying amounts of benthic epifauna.

This study furthered our understanding of how reef fish assemblages are defined and distributed at these sites, as well as what underlying environmental or habitat characteristics may be most important in driving the assemblage patterns observed. This information could be useful for decision-making, such as the proposal to extend the FGBNMS to new bank sites (USDOC 2012), by providing information about the reef fish species and distributions in these new areas based on known habitat zone distribution or specific environmental and habitat characteristics.

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