Do Artificial Reefs Sustain Communities Similar to Nearby Natural Reefs? A Seasonal Study in the Northeastern Gulf of Mexico

Sustentan Los Arrecifes Artificiales Comunidades Similares a las de Arrecifes Naturales Cercanos? Un Estudio Estacional en el Noreste del Golfo de Mexico

Est-ce que les Récifs Artificiels Abritent les Mêmes Communautés que les Récifs Naturels Alentours? Une Étude Saisonniére dans le Nord-Est du Golfe du Mexique

KELLY C. KINGON[1,2]*, CHRISTOPHER C. KOENIG[1], SANDRA BROOKE[1], CHRISTOPHER D. STALLINGS[3], KARA WALL[3], and CATHERINE SANDON[4]

[1]*Florida State University Coastal and Marine Laboratory, 3618 Highway 98, St. Teresa, Florida 32358 USA.*
[2]*University of Trinidad and Tobago, Marine Sciences Programme, 2nd Avenue N, Western Main Road., Chaguaramas, Trinidad and Tobago.*
[3]*University of South Florida, College of Marine Science, 140 7th Ave S, St. Petersburg, Florida 33701 USA.*
[4]*Birmingham-Southern College, 900 Arkadelphia Rd., Birmingham, Alabama 35254 USA. *kelly.kingon@utt.edu.tt.*

EXTENDED ABSTRACT

It is well known that nearshore reefs provide habitat for a diverse array of fishes and macro-invertebrates, but there are few studies that compare nearshore artificial and natural reefs and explore the temporal variations in their communities. The primary objective of this study was to quantify seasonal patterns of fish and macro-invertebrate associations with several natural and artificial reef types in the northeastern Gulf of Mexico. The study area off the coast of northwest Florida was divided into 4 blocks, each containing both natural and artificial reefs (Figure 1). Natural reefs were composed of two types: (1) exposed rocks covered with macro-invertebrates, "rocky reefs", and (2) macro-invertebrates without exposed rock, "invertebrate only reefs". Artificial reefs consisted of several types of materials: concrete debris, concrete culverts, reef-balls, concrete beams, and a steel-hull shipwreck (Table 1). The exact position of reef types was determined by mapping a 1 -km x 1-km area around known reef structures (Figure 1) using a Humminbird side-imaging sonar system and methodology described in Kingon (2013). Within each block, five sampling stations were randomly selected from the maps to represent each of the three reef types. Thus, there were 15 sampling stations per block, except in blocks 2 and 4 where additional stations were added to include the different artificial reef structures present (Table 1). Stations were surveyed seasonally using **S**ubmersible Rotating Video systems (SRVs, Koenig and Stallings 2015) to assess fish diversity and abundance as well as habitat characteristics. Coverage of sessile macro-invertebrates and algae was quantified seasonally from down-looking quadrat photos taken along three random 30-m transects within each reef type of each block. The study was run for two years, from summer 2012 to summer 2014.

The SRV cameras provided quick and efficient underwater estimates of fish density even during conditions that would be unsafe (e.g., stormy weather, high seas) or stressful for divers (e.g., cold water, deep depths). Using SRV cameras, we were able to survey all 66 stations in just a few days with as few as 2 people on board the research vessel. Large numbers of samples were required for the necessary statistical power to discern the ecological patterns in highly variable reef systems such as the ones in our study area. The SRVs provided an efficient means to collect those data rapidly.

From the SRV data we found that reef fish assemblages, at both natural and artificial reefs, were seasonally dynamic with some species observed more commonly on artificial reefs and others more commonly, or exclusively, on natural reefs. greater amberjack (*Seriola dumerili*), tomtate (*Haemulon aurolineatum*), Atlantic spadefish (*Chaetodipterus faber*), black drum (*Pogonias cromis*), and red drum (*Sciaenops ocellatus*) were observed primarily on artificial reefs, whereas white grunt (*Haemulon plumierii*) and hogfish (*Lachnolaimus maximus*) were seen more often on natural reefs. Black sea bass (*Centropristis striata*) were observed exclusively on natural reefs. The reasons for these habitat preferences are not well understood and warrant further study.

Densities of fishes were often much higher on artificial reefs relative to natural reefs and this may be a result of the differences in habitat area and connectivity of the two reef types. Natural reefs within the study area were 25 times more extensive than artificial reefs, and artificial reefs were often surrounded by large expanses of sand habitat. The limited spatial extent and the lack of nearby habitats other than sand may explain the higher fish densities frequently observed on artificial reefs.

Fish species richness was also variable among reef types and seasons, but was typically greatest on natural rocky reefs. Seasonally, fish species richness was highest during the warmer months and declined during winter (Figure 2). This pattern does not reflect the additional species that are likely moving onto the reefs from inshore habitats during fall and winter when shallow water temperatures drop and the seagrasses die back (Zieman and Zieman 1989). However, different fish species tended to utilize these nearshore reefs at different times of year, so it may be that some species leave the nearshore reefs in the cooler months and other species from inshore come in and fill those empty niches.

The patterns seen in gag (*Mycteroperca microlepis*) provide an example of the dynamic seasonality exhibited by many of the fish species found within the study area. Juvenile Gag egress from inshore seagrass nurseries in this region of the Gulf of Mexico during late summer-early fall (Koenig and Coleman 1998, Stallings et al. 2010). This pattern coincides with

observations of juvenile gag starting to appear on the study reefs in late summer. During thst period, Gag were most abundant on artificial reefs in blocks 1 and 2; those nearest inshore seagrass habitat. However, by late fall Gag densities on artificial reefs declined, but increased on rocky reefs in the area suggesting that they moved to other more extensive habitat for the next phase of their juvenile stage. These seasonal habitat associations of juvenile Gag illustrate the ecological importance of nearshore reefs in the study area. Further research is required to determine movement patterns and survival of these juveniles. The juvenile phase of the gag life cycle is poorly understood yet fundamental to understanding recruitment in this economically important species.

In addition to the patterns identified in the fish communities of artificial and natural reefs, macro-invertebrate assemblages differed among reef types as well. The percent cover of stony corals was low (< 3%) on all reef types, but was significantly higher on both types of natural reefs ($p < 0.01$ by ANOVA) than on artificial reefs (Figure 3). However, species composition of stony corals was similar across reef types indicating artificial reefs provide suitable hard substrate for their colonization. The lower percent cover of stony corals on artificial reefs may be due to the relatively short soak time of the artificial reefs (15 - 23 years) as coral growth and recruitment are slow processes (Moulding et al. 2011). The reef area not covered by stony corals was dominated by sponges at all the reef types, but there was significantly higher sponge coverage on artificial reefs than on invertebrate only natural reefs ($p < 0.05$ by ANOVA). Species of sponges differed between artificial and natural reef types with encrusting and boring sponges occurring more regularly on artificial reefs and higher profile vase, tube and branching species dominating natural reefs. The percent cover of octocorals, algae and ascidians did not differ significantly between artificial and natural reef types (all ANOVA tests, $p > 0.05$). Seasonal differences in macro-invertebrate coverage were rare, but differences in algal coverage did occur. Sessile fauna generally grow slowly and can persist over many years (Moulding et al. 2011, Storr 1964) whereas algal growth can increase quickly in response to seasonal nutrient influx and die back when the nutrients are depleted (Cheney and Dyer 1974). It was unclear whether

Table 1. Artificial reef sites surveyed in this study and information on their composition, depth, and deployment dates.

Block	Site Name	Materials	Deployment Date	Depth (m)
1	Florida Gas Transmission	concrete debris	2000	6.5
2	Two Dogs Reefballs	130 pallet balls	1999	10
	Two Dogs Culverts	130 culverts 8'x18"	1999	11
3	Carrabelle Three Mile	969 concrete culverts	1992-1993	11
4	One More Time	75' steel shrimp boat	1992	12
		75 concrete L beams 20-25'x3.5'x2'	2000	12

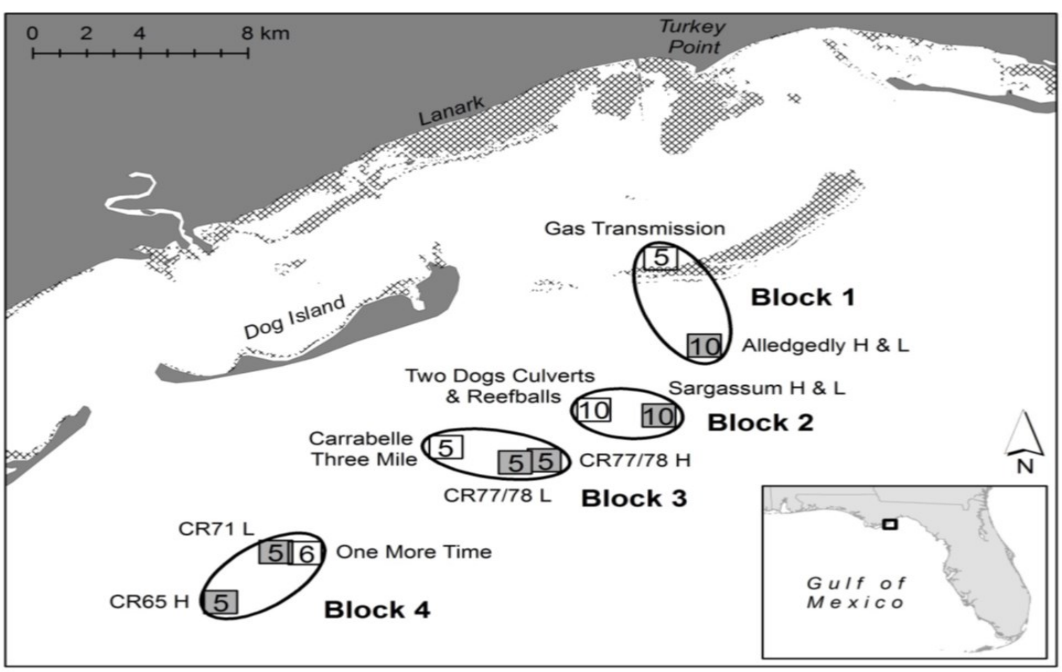

Figure 1. Map of the study area south-southeast of Dog Island, FL showing four blocks (ellipses) containing natural and artificial reefs. The squares denote the 1-km x 1-km sidescan-sonar-mapped areas. Each block contains artificial reef materials and natural reefs consisting of high relief/invert + rock (H) and low relief/invert only (L). Gray shaded squares encompass natural reefs; white squares surround artificial reefs. The number within each square indicates the number of stations sampled seasonally within each reef type. The crosshatched areas are seagrass beds.

the differences in benthic flora and fauna influenced the patterns we observed in the fish communities, but further analysis may reveal linkages.

The dynamic temporal and spatial nature of reef fish assemblages on natural and artificial reefs in the northeastern Gulf of Mexico is clearly demonstrated in this study. Our data suggest the reefs we surveyed provide essential habitat for a variety of fish species; functioning as nurseries, spawning grounds or feeding areas depending on the species and time of year. We also observed a diverse assemblage of macro-invertebrates and algae on all reef types, with sponges being the dominant forms and corals able to colonize the artificial structures. Natural reefs are extensive in area in this region, but in other regions where natural reef habitat is limiting or has been destroyed by activities such as trawling, artificial reefs may play a more crucial role. The species that appeared to prefer artificial reefs may benefit greatly if additional artificial reefs are deployed, especially along movement corridors (e.g. the juvenile gag that seem to use them as temporary refuges in their offshore egress). Considering seascape composition and taking a more species specific approach prior to artificial reef deployment may provide greater ecological and economic benefits from them.

KEY WORDS: Hardbottom habitat, reef fish, sidescan sonar, ahermatypic corals, sponges

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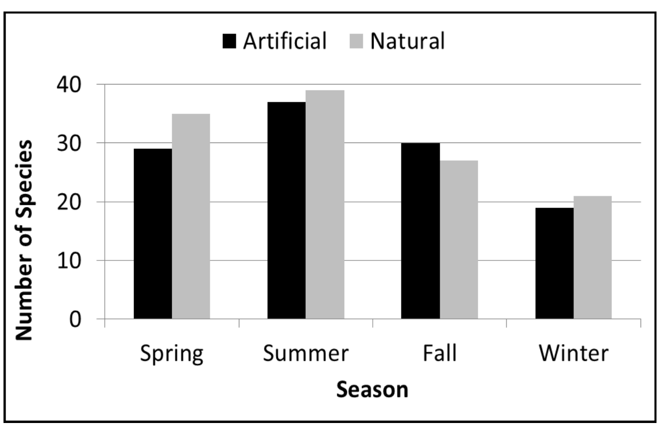

Figure 2. Number of fish species seen at artificial and natural reefs by season on nearshore artificial and natural reefs of the northeastern Gulf of Mexico.

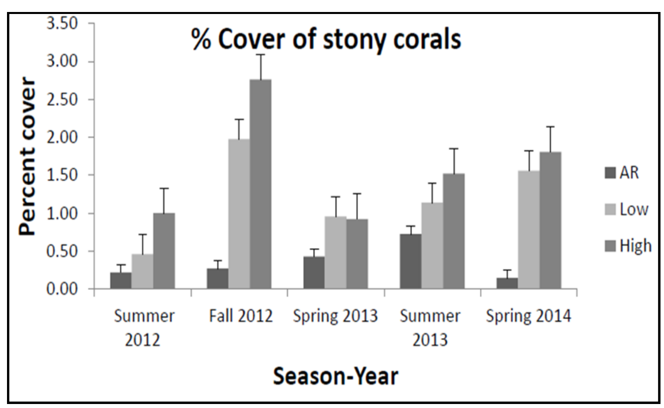

Figure 3. Percent cover of stony corals on artificial reefs (AR), natural low-relief/invertebrate only reefs (Low) and high-relief/rocky reefs (High) during spring, summer, and fall seasons. Error bars indicate standard errors.