# Preliminary Report on Artificial and Natural Reef Communities in the NE Gulf of Mexico, Similar or Not?

# Reporte Preliminar sobre las Comunidades de Arrecifes Artificiales y Naturales del Noreste del Golfo de México. Son Similares o No?

# Rapport Préliminaire sur les Communautés des Récifs Artificiels et Naturels du NE du Golfe du Mexique Sont-elles Similaires?

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## ABSTRACT

The importance of near-shore reefs in providing habitat for adult and juvenile fishes and macro-invertebrates has been well established, but the differences between natural and artificial reefs in providing this habitat function is poorly understood. The overall objective of this study was to determine seasonal fish and macro-invertebrate assemblage differences between shallow (6-12 m deep), near-shore natural and artificial reefs in an effort to gain insight into how the functions of these reef types differ. This report describes preliminary data on the seasonal distribution and abundance of fishes among 3 reef types (high-relief natural (>0.5 m), low-relief natural (< 0.5 m), and artificial reefs) in four blocks, in addition to the living and structural habitat characteristics of those sites. The location of the study was off the eastern end of St. George Sound, Florida (SW of Florida State University Coastal and Marine Laboratory (FSUCML)) just offshore of extensive seagrass habitat. Around each reef site a 1-km x 1-km area was mapped with sidescan sonar which provided the exact positions of habitat structures within the sites. Five sampling stations were randomly selected within each of the three reef types in each zone (= 15 sampling stations within each zone). Stations were surveyed seasonally using the point-count method of Bohnsack-Bannerot (1989) plus drop cameras to assess fish diversity and abundance. Sessile macro-invertebrates, also surveyed seasonally, were quantified from quadrat photos taken along three randomly chosen 30-m transects in each of the three habitat types of each zone. Preliminary results suggest differences in fish communities between natural and artificial reefs as well as among different types of artificial and natural reef structures. The temporal relationships between habitat type and community composition are complex, but we expect that our approach to this problem will reveal community patterns and lead to hypotheses on the processes driving those patterns.

KEY WORDS: Artificial reefs, hard bottom habitat, reef fish, sidescan sonar, Gulf of Mexico

## INTRODUCTION

Artificial reef fish communities have been studied and compared to natural reef fish communities for a variety of reasons, including mitigation, fishing enhancement, and suitability as juvenile habitat. Coral reefs damaged by dredging, trawling, etc., have been mitigated by deploying artificial reefs leading to studies evaluating the appropriateness of artificial reefs for this purpose (e.g., Carr and Hixon 1998, Rilov and Benayahu 2000). Deployment of artificial reefs for enhancement of recreational fishing opportunities led to concerns about attraction of fishes from neighboring natural reefs (Arena et al. 2007). Connectivity between inshore nurseries such as seagrass, saltmarsh and mangroves and offshore juvenile and adult habitat (reviewed in Gillanders et al. 2003, Kimirei et al. 2011) remains an important research topic. Evidence for ontogenetic habitat shifts is clear but details of critical links in these habitat shifts are missing. Seagrass and other inshore nursery habitats provide shelter and food for a variety of species, including the economically important Black Sea Bass (*Centropristis striata*), Gag (*Mycteroperca microlepis*), and Hogfish (*Lachnolaimus maximus*). But little is known about survival of early juveniles during their migration to and sojourn in post-nursery offshore habitats. Although habitat suitability may play a critical role in survival, habitat-mediated predation may also be important (Connell 1997).

This paper presents a preliminary report of our ongoing studies of patterns of shallow, near-shore reef habitat use by fishes, including those egressing from primary seagrass nurseries. Our data are derived from the analysis of videos from summer 2012 and diver survey data from summer 2012, fall 2012, spring 2013, and summer 2013. This two-year project extends from summer 2012 to summer 2014 and upon completion will include both video and diver survey data for all seasons during that time period. Our objectives are to:

i) Identify seasonal patterns of fish species and abundance associated with 3 reef types, natural (high and low relief) and artificial,
ii) Relate fish community patterns with the characteristics of the reef habitat (e.g. depth, relief, structure type, proximity to nursery habitat, surrounding seascape, invertebrate composition, prey availability, predator avoidance),
iii) Determine how similar communities of both fishes and macro-invertebrates are at nearby artificial and natural reefs, and
iv) Evaluate the effects of divers on fish surveys and the effectiveness of our drop camera video analysis techniques.

## METHODS

### Study Area

Surveys occurred within four blocks, numbered 1 to 4, east to west, located in the northeastern Gulf of Mexico south and south east of Dog Island, Florida (Figure 1). Inshore of these reefs is extensive seagrass habitat identified as important nursery habitat for Gag, *Mycteroperca microlepis*, (Koenig and Coleman 1998). Each block contains natural reefs, high (> 0.5 m) and low (< 0.5 m) relief, and one or more artificial reefs, mostly high relief. The artificial reefs, deployed from 1992 to 2000, comprise 15 artificial reef deployments arranged in 4 clusters off Dog Island in depths from 6.5 - 12 m (Table 1). In Block 1 "Gas Transmission" artificial reef, composed of concrete debris, is the shallowest reef at 6.5 m and closest to shore. In Block 2, "Two Dogs" artificial reef is composed of two areas of concrete materials—culverts in one and reefballs (see www.reefball.org/whatsaball/whatsaball.htm) in the other—in depths of 10 - 11 m. In Block 3, "Carrabelle Three Mile" artificial reef, composed of concrete culverts as well, is also 11 m deep. In Block 4, "One More Time" is a steel-hull shrimp boat with concrete beams strewn around the wreck. The wreck is 12 m deep and largely intact. Natural reefs in Block 1 are: "Alledgedly H" (high relief; 10.5 m deep) and "Alledgedly L" (low relief; 10 m deep). Natural reefs in Zone 2 are "Sargassum H" (high relief; 14 m deep) and "Sargassum L" (low relief; 12.5 m deep). Natural reefs in Block 3 are "CR77/78" which includes high and low natural reefs (13 m deep). Natural reefs in Block 4 are "CR65" (high relief; 15.5 m deep) and "CR71" (low relief; 14.5 m deep). All reef sites, natural (high and low relief) and artificial, within each block contained 5 stations, except "One More Time" which had 6 stations, 3 on the wreck and 3 on the surrounding concrete beams. The extra station was added to the shrimp boat wreck because of differences in relief and structural properties of the wreck and the surrounding beams.

### Sidescan Sonar Mapping

A 1-km x 1-km area was mapped around each site in all 4 blocks using a Humminbird 997c SI sidescan sonar unit operating at 455 kHz. Some sites (Alledgedly H and L, Sargassum H and L, and Two Dogs Culverts and Reefballs) were within the same 1-km x 1-km area which resulted in a total of 10 mapped areas instead of thirteen. Each area was mapped by following parallel tracks, 75 m apart and 1-km long, with sidescan sonar data recorded at a swath width of 100 m. This process resulted in 14 north-south tracks with an overlap of 50% allowing the track data to be mosaicked. Sidescan data were processed, georeferenced, and mosaicked following the methods described in Kingon (2013). The resulting imagery was then manually classified into three habitat classes: artificial reef, natural reef/hardbottom, and unconsolidated sediment (primarily sand) within the study area using ESRI ArcGIS software.

Using these habitat maps we developed a stratified random sampling design to survey a subset of the structures in each block. Sampling stations were randomly selected from within the artificial and natural reef habitat boundaries. The data collection at the stations included visual fish surveys by divers, underwater video to quantify the fish community, and quadrat photographs to determine invertebrate densities and diversity.

### Fish Census

Quantitative fish surveys were performed using two methods: (1) by divers using the method of Bohnsack and Bannerot (1989; BB survey), and (2) using drop cameras (first 2 seasons using four GoPro cameras with 360$^o$ coverage, and thereafter a single GoPro camera rotating 360$^o$, both without the presence of a diver (Figure 3)). This paper only documents the video results from the first season using the 4-camera array. Data on habitat, fish species and abundances were recorded at the randomly-selected sampling stations. A minimum visibility of 3 m was necessary to run the census for both the BB survey and the drop cameras. The BB survey was slightly modified when fish diversity and abundances were low by shortening the initial survey period when compilation of species list occurs. While conducting the visual surveys divers were outfitted with a GoPro HD video camera mounted on their forehead or chest. The camera recorded the diver's visual field while the diver performed the BB survey. The camera provided video records of each dive and allowed confirmation of fish identification if the diver was uncertain at the time of the BB survey. BB surveys were done seasonally (every three months) for two years beginning in the summer of 2012 at one station per site (13 surveys total).

The drop cameras used to census fish populations were four GoPro cameras covering 360$^o$ mounted on a PVC pyramid mount about 1 m above the bottom. This was our first attempt at documenting the fish community using a drop camera system and it was used throughout the summer and fall of 2012. The second camera system we used was that built by Koenig and composed of a 2 RPM gear motor, a 12 VDC sealed lead-acid rechargeable battery, a magnetic switch and a PVC housing (Figure 3). A GoPro HD camera was mounted on a platform attached to the shaft of the gear motor so that the camera rotated at 2 RPM, surveying the area around the camera, but without a diver being present. (Data from these rotating cameras are not presented here). A horizontal 3-m PVC pole with a float on the far end was attached to the drop camera device to determine visibility of the non-diver survey. The drop camera surveys occurred prior to the diver BB surveys and recorded for a minimum of 10 minutes. The 4-camera data were analyzed by picking the camera with the best view of the artificial or natural reef habitat (following DeVries et al. 2013). If more than one camera showed the reef, then a camera was randomly picked from those with good habitat views (DeVries et al. 2013). Then the first five minutes of that camera's video data were read once it reached the seafloor. The fishes seen in the video were identified and enumerated. A minimum number of each species was determined by counting the number of individuals of each fish species that seen on the screen at one time. As fish moved in and out of the frame new minimum counts were made. The counts used in the figures were the highest minimum count observed during the first 5 minutes of video and then averaged across habitat type, artificial and natural. The remainder of the video recordings were analyzed for occurrences of additional species.

### Macro-invertebrate Survey

Three 30-m transects were run from a randomly selected point on a reef in each habitat type (artificial, high and low relief natural) within each block. Randomly selected compass headings were used to determine the heading of each transect. If a transect led off the reef and over sand, then the next random heading was used. Down-looking photographic quadrats (0.25 $m^2$) were randomly placed along each transect at the natural reefs (6 random photo starting points per transect and 4 consecutive photos taken at each starting point) and quadrat photographs were taken at the artificial reefs where the transect crossed artificial reef material at consecutive 0.5 m intervals to capture all intersected materials. A pyramid frame (Figure 4) and a Canon S90 digital camera in a Canon waterproof housing captured the high quality standardized images, similar to the approach of Edmunds et al. (1998). Invertebrate species were identified from the photos using a catalog of sessile invertebrates found on reefs in Apalachee Bay, Florida (Schellinger 2013) and other invertebrate identification guides. The quadrat photos allowed us to estimate the density of dominant species. Coral Point Count (CPCe; Kohler and Gill 2006) was employed to determine percent cover of these species. The method involved using 30 randomly spaced points over each quadrat photograph (similar to methods used in Koenig et al. 2000 and Aronson et al. 1994). Points that landed on macro-invertebrates were identified to the lowest taxa practicable and those landing on the substrate were assigned to a substrate type and size class. Using these data, percent cover of the dominant macro-invertebrate species and substrate types were calculated.

## RESULTS

### Sidescan Sonar Mapping

The Humminbird 997c sidescan imaging system was used to map approximately 12 $km^2$ of seafloor. Artificial reefs covered 29,082 $m^2$ or 0.25% of the mapped area, while the coverage of natural reefs was nearly 25 times greater at 720,994 $m^2$ amounting to 6.14% of the mapped area. The remaining area (10,990,000 $m^2$, 93.61%) was unconsolidated sediment, primarily sand. The low-cost Humminbird system worked well for mapping these relatively shallow-water areas.

### Fish Census

The data presented in this preliminary report resulted from 66 drop camera videos from summer 2012 and 95 diver BB surveys (including video attachment) from summer 2012, fall 2012, spring 2013, and summer 2013. Since summer 2012 a total of 45 fish species were observed during the BB surveys. Thirty-seven of those species were recorded on natural reefs and 34 species on artificial reefs. Eleven species were observed only on natural reefs and eight were observed only on artificial reefs (Table 2). Twenty-six species were observed on both reef types in the diver BB surveys (Table 3). More pelagic and schooling species were encountered at the artificial reefs while demersal species were more common on natural reefs. Using the drop camera video data from summer 2012, ten additional species were only encountered when a diver was not present including a Kemp's Ridley sea turtle (Table 4). A single Lionfish (*Pterois* spp.) first appeared on one of our sites ("Carrabelle Three Mile" artificial reef) during a fall 2013 diver BB survey.

Fish species richness, as observed from diver BB surveys, varied among sites from a low of two species at the "Gas Transmission" artificial reef to a high of 23 species at the "One More Time" wreck (Figure 5). Fish species richness on natural reefs ranged from 9 to 18 species. Abundances for most fish species were higher on artificial reefs than on natural reefs during the summer of 2012 videos, especially for pelagic species (Figures 5 and 6); the Blue Runner (*Caranx crysos*) was an exception.

Two economically important fishery species in this region are Gag, *Mycteroperca microlepis*, and Black Sea Bass, *Centropristis striata*. Diver BB surveys for these two species indicate that Gag numbers, very low in summer

**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 |
| 2 | Two Dogs Culverts | - 130 culverts 8'x18" | 1999 | 11 |
| 3 | Carrabelle 3 Mile | - 969 concrete culverts | 1992-1993 | 11 |
| 4 | One More Time | - 75' steel shrimp boat<br>- 75 concrete L beams 20-25'x3.5'x2' | 1992<br>2000 | 12 |

2012, increased dramatically in fall 2012 suggesting that 2012 had good recruitment of young-of-year in neighboring seagrass (Table 5). No diver BB surveys were completed during winter 2013 due to poor weather conditions and

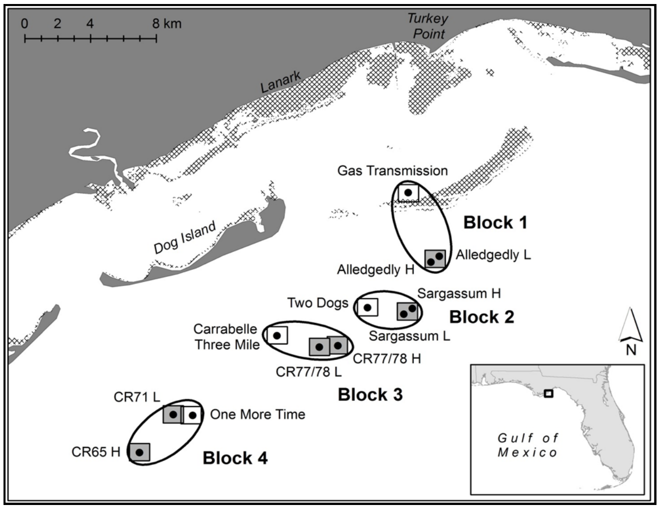


**Figure 1.** Map of the study area showing the four blocks. The squares denote the 1-km x 1-km sidescan-mapped areas. Gray shaded squares are natural reefs and white squares are artificial reefs. Each block has one artificial reef and two natural reefs, one high relief and one low relief. The crosshatched areas are seagrass beds. H – High relief natural reef, L – Low relief natural reef

high sea state. Gag numbers declined by spring 2013 except at the "Two Dogs Culverts" artificial reef where abundances were high. By summer 2013, Gag were more abundant at "Two Dogs Reefballs" and "One More Time" artificial reef sites. Once established on shallow reefs offshore of their seagrass nursery habitat, late juvenile Gag appear to have seasonal reef habitat associations, although differential mortality on reef sites cannot be ruled out. However, egressing juvenile Gag appear to accumulate on reefs closer to the seagrass habitat (Blocks 1 and 2) in the fall, showing relatively high abundances on both the artificial and natural reef sites in those blocks. Egressing Black Sea Bass show distinctly different behavior than Gag in that they were never seen on artificial reefs, but were abundant on natural reefs in fall 2012 and spring 2013 (Table 6).

### Macro-invertebrate Survey

We've archived over 3,000 quadrat photos of the seafloor for the macro-invertebrate survey (corals, sponges, ascidians, etc.) in all 4 blocks through summer 2013. These photographs will provide quantitative estimates of macro-invertebrate species richness and abundance, habitat associations, spatial distribution, and seasonal variation. This analysis is currently underway; results are not presented in this paper.

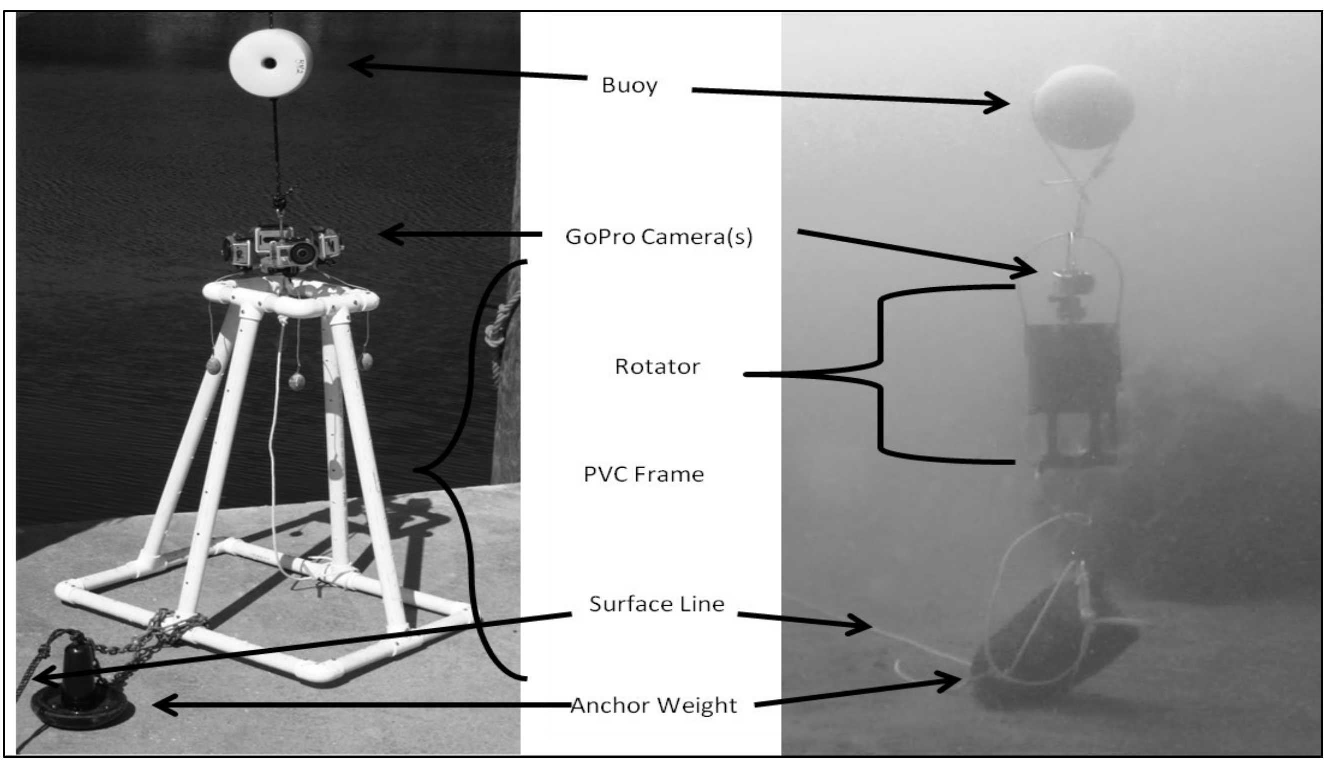


**Figure 2.** Images of the 4-camera array (left) used in this preliminary analysis (first 2 seasons) and the rotating drop camera underwater (right) used for subsequent surveys. A buoy holds the camera(s) upright and level

## DISCUSSION

Detailed mapping of the study sites was mostly lacking prior to this study. Only two of our artificial reef were accurately mapped over a decade prior to this study. The "Carrabelle Three Mile" site was mapped in 1998 using a Marine Sonic Sea Scan sidescan system operating at 600 kHz and with 150 m swath width (Meide and Faught 1998). They mapped a 610 x 600 m area around "Carrabelle Three Mile". Subsequently in 2000, the "One More Time" wreck site was mapped using the same sidescan system (PUA 2000). Our study provides current sidescan maps of five artificial reef sites including the two previously mapped, six natural reef sites and their surroundings. This work lays the groundwork for future studies on the natural and artificial reef habitats and their associated communities off the FSUCML and provides artificial reef managers with data on structural and position changes in the previously mapped artificial reefs.

**Table 2.** Species observed only on natural reefs (left) and artificial reefs (right) during diver BB surveys.

| NATURAL REEF | | ARTIFICIAL REEF | |
|---|---|---|---|
| **Species** | **Common Name** | **Species** | **Common Name** |
| *Centropristis striata* | Black Sea Bass | *Chloroscombrus chrysurus* | Atlantic Bumper |
| *Lutjanus campechanus* | Red Snapper | *Selene vomer* | Lookdown |
| *Ioglossus calliurus* | Blue Goby | *Caranx hippos* | Crevalle Jack |
| *Microgobius carri* | Seminole Goby | *Bairdiella chrysoura* | Silver Perch |
| *Synodus intermedius* | Sand Diver | *Paralichthys albigutta* | Gulf Flounder |
| *Gymnothorax sp* | Moray Eel | *Epinephelus itajara* | Goliath Grouper |
| *Ginglymostoma cirratum* | Nurse Shark | *Sphyraena barracuda* | Great Barracuda |
| *Coryphopterus dicrus* | Colon Goby | *Mycteroperca phenax* | Scamp |
| *Scorpaena brasiliensis* | Barbfish | | |
| *Calamus proridens* | Littlehead Porgy | | |
| *Serraniculus pumilio* | Pygmy Sea Bass | | |

**Table 3.** Species observed at both the natural and artificial reef sites during diver BB surveys.

| **Species** | **Common Name** |
|---|---|
| *Centropristis ocyurus* | Bank Sea Bass |
| *Serranus subligarius* | Belted Sandfish |
| *Caranx crysos* | Blue Runner |
| *Stegastes variabilis* | Cocoa Damselfish |
| *Pareques umbrosus* | Cubbyu |
| *Mycteroperca microlepis* | Gag |
| *Lutjanus synagris* | Lane Snapper |
| *Balistes capriscus* | Gray Triggerfish |
| *Seriola dumerili* | Greater Amberjack |
| *Clupeidae* | Herring |
| *Lachnolaimus maximus* | Hogfish |
| *Lutjanus griseus* | Gray Snapper |
| *Opsanus pardus* | Leopard Toadfish |
| *Stephanolepis hispidis* | Planehead Filefish |
| *Diplectrum formosum* | Sand Perch |
| *Calamus calamus* | Saucereye Porgy |
| *Decapturus sp* | Scad |
| *Parablennius marmoreus* | Seaweed Blenny |
| *Echeneis neucratoides* | Sharksucker |
| *Archosargus probatocephalus* | Sheepshead |
| *Halichoerus bivattatus* | Slippery Dick |
| *Chaetodipterus faber* | Atlantic Spadefish |
| *Scomberomorus maculatus* | Spanish Mackerel |
| *Haemulon aurolineatum* | Tomtate |
| *Haemulon plumierii* | White Grunt |
| *Rypticus maculatus* | Whitespotted Soapfish Soapfish |

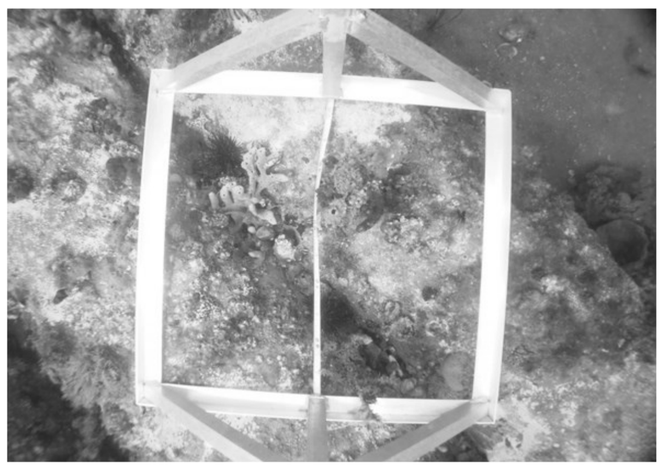

**Figure 3.** An example of the down-looking camera frame (0.25 $m^2$) over two culverts.

Our research compliments and augments prior research conducted on artificial reefs off the Suwannee River, Florida including that done by Lindberg and Loftin (1998, 1999) and Lindberg et al. (2006). In addition, our study will provide detailed data on macro-invertebrate communities, which are rarely considered in artificial reef studies. Such work is potentially important to fish communities because the composition of macro-invertebrates may vary among types of artificial and natural reefs, thereby changing the biological composition and three-dimensional aspects of the habitat and associated fish community (Perkol-Finkel and Benayahu 2007). Sessile macro-invertebrates may offer suitable habitat characteristics for reef fish by providing shelter or increased prey availability.

Surveys during this study were conducted at artificial reef structures that are commonly deployed throughout the Gulf of Mexico and western Atlantic (e.g., vessels, concrete culverts, beams, slabs, reefballs) resulting in data on the differences in the functional roles of these habitat types in supporting faunal communities. In addition, the paired design of this study involves artificial reef sites with adjacent low and high relief natural sites, thus allowing direct comparison among these different habitat types. Also being assessed are the effects of seascape characteristics such as variation in depth and distances from shore, seagrass nursery habitat, freshwater sources, and offshore spawning sites on reef fish distributions. In combination, the approach of this study enhances our understanding of region-wide patterns and processes of juvenile reef fish dynamics within the context of both artificial and natural reefs in the Gulf of Mexico.

At artificial reefs, fish density was generally very high but reef area is typically low so their contribution to fish populations is likely minimal unless we can show better fitness at those sites. Natural reefs are much more abundant than artificial reefs (almost 25x greater in area) and if you extrapolate fish densities to total hardbottom area abundances are generally higher than those seen on artificial reefs. We also need to consider connectivity when assessing artificial reef populations as many circumstances drive fishes to relocate (e.g. reduced prey availability,

**Table 4.** Species observed only in drop camera videos taken without divers present in summer 2012.

| Species | Common Name | Site |
|---|---|---|
| *Epinephelus morio* | Red Grouper | natural reef only |
| *Diplodus holbrookii* | Spottail Pinfish | natural reef only |
| *Acanthostracion quadricornis* | Scrawled Cowfish | natural reef only |
| *Carcharhinus sp.* | Bull or Sandbar Shark | natural reef only |
| *Aluterus schoepfi* | Orange Filefish | natural reef only |
| *Sphoeroides spengleri* | Bandtail Puffer | natural reef only |
| *Ogcocephalus radiatus* | Polka-dot Batfish | natural reef only |
| *Rachycentron canadum* | Cobia | artificial reef only |
| *Lepidochelys kempii* | Kemp's Ridley sea turtle | artificial reef only |
| *Sciaenops ocellatus* | Red Drum | both natural and artificial |

**Table 5.** The total number of Gag (*Mycteroperca microlepis*) encountered seasonally during diver BB surveys at a single station at each site. Due to poor weather conditions no diver BB surveys were completed during winter 2013 and visibility was < 3 m at Gas Transmission in spring and summer 2013 inhibiting the completion of surveys at that site for those 2 seasons.

| Block | Site | Summer 2012 | Fall 2012 | Spring 2013 | Summer 2013 |
|---|---|---|---|---|---|
| 1 | Gas Transmission | | 19 | - | - |
| | Alledgedly High | 1 | 7 | | 3 |
| | Alledgedly Low | 1 | 28 | 3 | 2 |
| 2 | 2 Dogs Culverts | | 14 | 27 | 6 |
| | 2 Dogs Reefballs | 1 | 23 | 1 | 37 |
| | Sargassum High | | 14 | 1 | 2 |
| | Sargassum Low | | | 2 | 4 |
| 3 | 3 Mile | | 5 | 2 | |
| | CR78/77 High | | | 3 | |
| | CR78/77 Low | | | | |
| 4 | One More Time | | 1 | 3 | 14 |
| | CR65 High | | | 3 | |
| | CR71 Low | | | | |

increased predator abundance, spawning). Attempts are made to deploy artificial reef materials on sand habitats, however, this makes moving off of artificial reefs extremely dangerous as there is little protection from predators when over sand. Natural reef patches are often close to each other allowing fish to move quickly and with much less risk from one hardbottom patch to another. The relationship between proximity to surrounding habitats and fish abundance and diversity will be evaluated. If there is a strong positive relationship, then it may be beneficial to place artificial reefs near natural reefs so fish can move between the two habitat types with less risk of predation. Presently that is not considered when deploying artificial reefs despite the importance of the surrounding seascape (Nagelkerken et al. 2000). Artificial reefs may be oases in a seascape of sand but many species may be stranded there so if in fact production does occur it will be difficult for it to lead to spillover and enhancement of populations elsewhere.

With the exception of a single study (Lindberg et al. 2006) previous efforts to examine populations of juvenile reef fish on artificial reefs were restricted to the summer. The temporal component of this study reveals how seasonal recruitment and emigration patterns of inshore species affect their densities and distributions on artificial and surrounding natural reefs. The dynamics of juvenile reef fish populations post-egress from seagrass and other inshore habitats is poorly understood. But it is important to understand these dynamics during early life stages because survival rates in this stage define recruitment rates to the fishery. Thus, it is essential to know the role of various habitats in providing protection to reef fish fishery species.

The distribution and densities of fishes was strongly influenced by season—this was obvious for Gag and Black

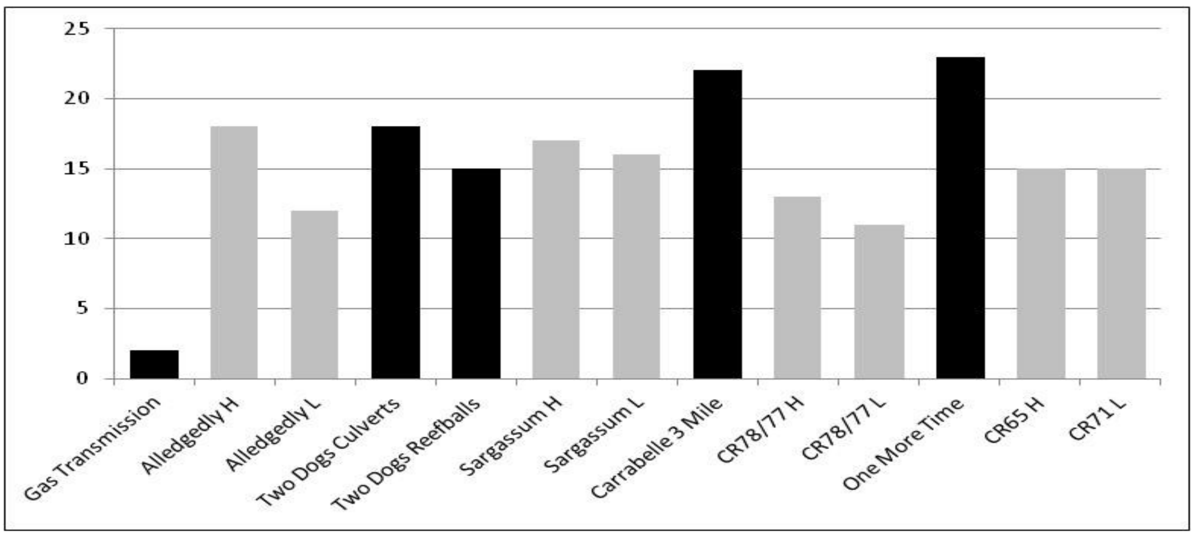


**Figure 4.** The cumulative fish species diversity on artificial (black bars) and natural (gray bars) reefs; data from diver BB surveys in summer 2012, fall 2012, spring 2013, and summer 2013. Numbers at the top represent the blocks

**Table 6.** The total number of Black Sea Bass (*Centropristis striata*) encountered seasonally during diver BB surveys at a single station at each site. Black Sea Bass were only seen on natural reef sites so the artificial reefs are not included here. Due to poor weather conditions no diver BB surveys were completed during winter 2013.

| Block | Site | Summer 2012 | Fall 2012 | Spring 2013 | Summer 2013 |
|---|---|---|---|---|---|
| 1 | Alledgedly High | | 16 | 1 | 1 |
| | Alledgedly Low | 3 | 55 | 4 | 1 |
| 2 | Sargassum High | | 26 | 1 | 3 |
| | Sargassum Low | | 10 | 1 | |
| 3 | CR78/77 High | | 5 | 6 | |
| | CR78/77 Low | | 2 | 5 | |
| 4 | CR65 High | | 12 | 9 | |
| | CR71 Low | | 12 | 35 | 1 |

Sea Bass. Although both species egress from juvenile seagrass habitat, they show very different distributions. However, it is not known whether these patterns arise from habitat preference or from differential survival. There is also a spatial pattern related to distance from seagrass habitat, that of Turkey Point Shoal and Lanark Reef. Blocks 1 and 2 are closest to these seagrass systems of eastern St. George Sound whereas Blocks 3 and 4 are more distant and blocked by Dog Island. The observed patterns suggest that juveniles egressing from seagrass find their first refuge in nearby Blocks 1 and 2 in the fall, but then disperse to other more distant reefs, such as those in Blocks 3 and 4.

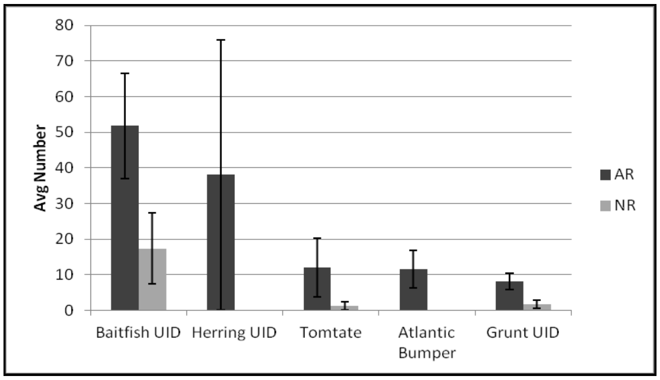


**Figure 5.** Mean abundance of dominant fish species on artificial (AR) and natural (NR) reefs during summer 2012 drop-camera surveys. Error bars represent standard error. Several fishes could not be identified to species from the video analysis but were assigned to the lowest taxonomic level possible followed by UID (unidentified). Baitfish were likely schools of scad (*Decapterus* spp.) and/or herring (*Clupeidae* spp.).

It is likely that near-shore reefs, such as those studied in this work, are of high importance to juvenile Gag. This species spends the first five months of benthic life in seagrass (Koenig and Coleman 1998), then egresses to offshore reefs in the fall (Stallings et al. 2010), but does not mature until at least 3 years of age. So, natural and artificial reefs off seagrass habitat seem to be a very important habitat for this reef fish. Detailed studies of survival and trophic patterns among reef types during this late juvenile stage would likely elucidate the most important reef types that support growth and survival.

Our study of the shallow marine reefs, artificial and natural, off the eastern end of St. George Sound is ongoing. We present here a preliminary report of some of our data showing patterns that are emerging from our approach to the evaluation of spatial, temporal, and habitat type investigations. With the large variety and number of artificial reefs being deployed throughout the state, it is important to understand how these reefs influence growth and survival of reef fish relative to natural reefs. Reef fish evolved in association with natural reefs—artificial reefs are new on the evolutionary scene. However, many natural reefs have been altered or destroyed by bottom gear such as trawls and dredges. The questions is, can artificial reefs mimic natural reefs in function and provide similar benefits to the associated fish populations?

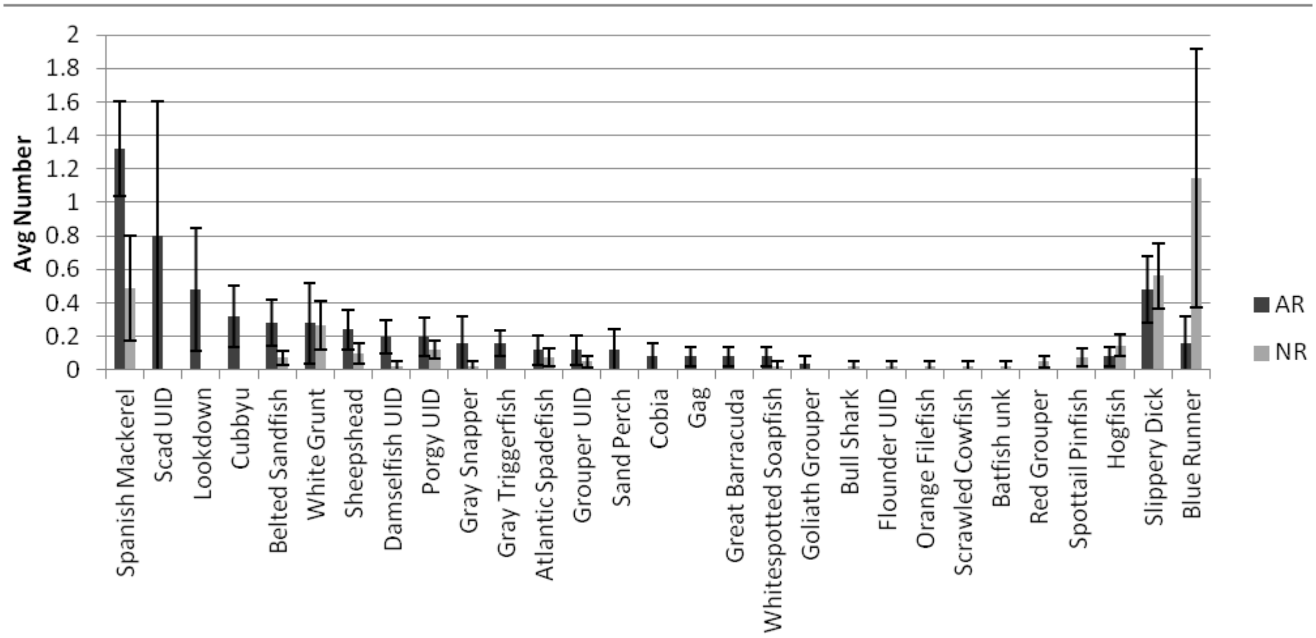


**Figure 6.** Mean abundance of sub-dominant fishes on artificial (AR) and natural (NR) reefs during summer 2012 drop-camera surveys. Error bars represent standard error. Several fishes could not be identified to species from the video analysis but were assigned to the lowest taxonomic level possible followed by UID (unidentified).

## ACKNOWLEDGMENTS

This study was funded by the Florida Fish and Wildlife Conservation Commission's Artificial Reef Program. Keith Mille, Jon Dondrill, and Bill Horn with the Artificial Reef Program in Tallahassee, Florida provided assistance with both administrative tasks and diver surveys. They also provided the use of their research vessel for all field activities. The faculty and staff at the FSUCML have been instrumental in the completion of this work. Special thanks to Felicia Coleman, FSUCML director, Maranda Marxsen for managing the finances, and Bobby Henderson, Mark Daniels and Dan Oberlin for boat, vehicle and construction assistance. The project could not have been completed without the support of the Academic Dive Program at the FSUCML and the following scientific divers and volunteers: Sonja Bridges, Tyler Schenck, Bob Ellis, Chris Malinowski, Leco Bueno, Sandra Brooke, Steve Morey, Dmitry Dukhovskoy, Donnie McClain, Austin Heil, Jennifer Schellinger, Alex Chequer, Brendan Mulholland, Alicia Brown, Chelsie Counsell, Jess Cusick, Dale Kingon, Pascal Brignole, Daniel Kuncicky, Natalie Byars, Travis Richards, Nicole Martin, Caitlyn Buerk, Ryland Taylor, and Hanna Garland.

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