

Five Years of Fish Assemblage Monitoring on Modified Reefs in the Florida Keys National Marine Sanctuary: The *Wellwood* Coral Restoration Site and the *Spiegel Grove* Artificial Reef

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ABSTRACT

Between 2002 and 2007, the Reef Environmental Education Foundation (REEF) conducted monitoring on the fish assemblages of two modified reef areas off Key Largo, Florida. The first project focused on the *Spiegel Grove*, a 510' Navy Landing Ship Dock that was intentionally sunk off Key Largo in 2002 to serve as a recreational diving and fishing artificial reef. Monitoring included the ship as well as seven nearby natural and artificial reef sites. For each monitoring project, a team of Advanced Assessment Team REEF Experts conducted Roving Diver Technique visual surveys. Belt transect surveys were also conducted as part of the *Wellwood* project in order to document size frequency shifts and more quantitative shifts in density of key taxa. The second project included an area damaged by the *M/V Wellwood*, a 122-meter freighter that ran aground in 1984 on Molasses Reef. The ship impacted the reef's upper forereef and remained aground for 12 days. The grounding destroyed 1,285 square meters of living corals and injured 644 square meters of coral reef framework. In 2002, limestone reef modules were placed in the injured area to provide substrate for new coral colonization. Monitoring included the restoration modules and contiguous low profile hardbottom areas adjacent to and in between the modules. Nearby reference sites were also surveyed to include areas that were closest in proximity to the grounding area while remaining undamaged and unrestored. Baseline surveys were conducted for both projects prior to the treatment (restoration and deployment).

KEY WORDS: Artificial reef, reef fish, Reef Environmental Education Foundation (REEF) Fish Survey Project, Florida Keys National Marine Sanctuary

Cinco Años de la Ensambladura de los Pescados Que Supervisan en los Filones Modificados en la Florida Afinan el Santuario Marina Nacional: El Sitio Coralino de la Restauración de Wellwood y el Filón Artificial de la Spiegel Grove

Entre 2002 y 2007, Reef Environmental Education Foundation (REEF) condujo la supervisión en las ensambladuras de los pescados de dos áreas modificadas del filón del Largo dominante, la Florida. El primer proyecto incluyó un área dañada por el m/v *Wellwood*, un carguero de 122 metros que funcionó encallado en 1984 en el filón de la melaza. La nave afectó el forereef superior del filón y seguía siendo encallada por 12 días. En 2002, los módulos del filón de la piedra caliza fueron colocados en el área dañada para proporcionar el substrato para la nueva colonización coralina. La supervisión incluyó los módulos de la restauración y las áreas contiguas del hardbottom del perfil bajo adyacente y entre a los módulos. Los sitios próximos de la referencia también fueron examinados. El segundo proyecto se centró en la Spiegel Grove, el muelle de la nave del aterrizaje de la marina de guerra 510 que fue hundido intencionalmente del Largo dominante en 2002 para servir como filón artificial recreacional del salto y de la pesca. La supervisión incluyó la nave tan bien como 7 sitios naturales y artificiales próximos del filón. Para cada proyecto de supervisión, un equipo de los expertos del REEF del equipo del gravamen avanzado condujo encuestas sobre visuales la técnica del zambullidor de la vagueación. Las encuestas sobre el transect de la correa también fueron conducidas como parte de los cambios de tamaño documento de la frecuencia del proyecto de *Wellwood* para y de cambios más cuantitativas en la densidad de los taxa dominantes. Los resultados de cada proyecto serán presentados.

PALABRAS CLAVES: El filón artificial, pescado del filón, examen visual, Reef Environmental Education Foundation, la Florida afina el santuario marina nac

BACKGROUND

In 2002, two events occurred off Key Largo, Florida, that resulted in modified reef structures – the deployment of a shipwreck artificial reef and the restoration of reef previously damaged by a ship grounding. In order to document potential changes in fish community structure as a result of these two management actions, the Reef Environmental Education Foundation (REEF) was contracted to conduct fish monitoring on both projects for a period of five years (REEF 2007, REEF 2008).

REEF is an international non-profit marine conservation organization that runs hands-on grassroots activities designed to educate and engage local communities in marine conservation-focused activities. REEF is based in Key Largo, Florida, with a Pacific office in Seattle, Washington. The mission of REEF is to conserve marine

ecosystems for their recreational, commercial, and intrinsic value by educating, enlisting and enabling SCUBA divers and other marine enthusiasts to become active stewards and citizen scientists. REEF links the diving community with scientists, resource managers and conservationists through marine-life data collection and related activities. REEF coordinates the Volunteer Survey Project, which has trained and involved over 10,000 divers and snorkelers in marine life identification and the collection of useful population and distribution data. This citizen science program has generated one of the largest marine life databases in the world, with over 120,000 surveys conducted to date. In addition to ongoing surveys, teams of Volunteer Survey Project volunteers are used in specific monitoring projects such as the *Spiegel Grove* and *Wellwood* Restoration.

Spiegel Grove

The *Spiegel Grove* is a 510' Navy Landing Ship Dock that was intentionally sunk off Key Largo, Florida, on June 10, 2002, to serve as a recreational diving and fishing artificial reef. The ship lies in 130' of water; at its broadest point the deck is 84' wide, creating a wall-like habitat from 45' to the sandy bottom. Since the *Spiegel Grove* was righted by Hurricane Dennis (2005), the top deck now lies in approximately 85' depth. At the time of its sinking, the *Spiegel Grove* was the largest vessel intentionally sunk. Monroe County, the Upper Keys Artificial Reef Foundation (UKARF) and the Florida Keys National Marine Sanctuary (FKNMS) worked closely to obtain, clean, scuttle and sink the vessel, as well as raise funds for the effort.

REEF was contracted by Monroe County to conduct a study with pre- and post-deployment monitoring on the fish assemblages of the *Spiegel Grove* and adjacent reef areas. REEF implemented a 5-year monitoring plan to document fish species presence/absence, sighting frequency and estimated abundance over time at the *Spiegel Grove* site and at seven nearby natural and artificial reef sites. The primary goal of the monitoring was to document fish recruitment to the *Spiegel Grove* site, detect changes over time in the assemblage and compare patterns between sites. A separate study was conducted by NOAA to assess the relative socioeconomic benefits of the *Spiegel Grove* (Leeworthy *et al.* 2006).

Wellwood Restoration

The *M/V Wellwood*, a 122-meter Cypriot-registered freighter, ran aground on August 4, 1984, on Molasses Reef off Key Largo. The ship impacted the reef's upper forereef and subsequently remained aground for 12 days. The grounding destroyed 1,285 square meters of living corals and injured 644 square meters of coral reef framework. Prior to the grounding, the area was a transition zone with high relief coral formations. The grounding transformed the area into a flattened, barren pavement covered with coral rubble. Between 1986 and 2002, several assessment efforts were conducted to document the recovery and status of the impacted area. While most of the monitoring focused on the benthic condition, two studies included the fish assemblage (Dennis and Bright 1990, NURC 1997).

Eighteen years after the grounding, the area resembled nearby hard ground habitat with little structure and the benthic community was dominated by gorgonians (Gittings 2002). Storms in the late 1990s had disrupted and/or removed significant portions of destabilized reef framework in the area (Hudson *et al.* 2007). Natural recovery to a state similar to the pre-grounding condition failed to occur within a reasonable time frame and therefore, habitat restoration was initiated. The National Marine Sanctuary Program published an environmental assessment to systematically evaluate the short- and long-term environ-

mental and socioeconomic effects related to the restoration of the grounding site (NOAA 2002).

The restoration effort, designed by Dr. Harold Hudson (Florida Keys National Marine Sanctuary Reef Restoration Biologist), included 14 repair sites within the affected area. Nine limestone reef modules and five limestone boulder/concrete structures were installed between June 2 and July 22, 2002, which affected a total of 185 m² of damaged reef area. A more thorough description of the restoration effort and the affected area can be found in CPE 2001 and Hudson *et al.* 2007. The primary objectives of the restoration were to 1) stabilize damaged reef framework, 2) infill hurricane-excavated craters, and 3) rebuild reef topography (Hudson *et al.* 2007).

REEF was contracted by the National Marine Sanctuary Program to begin a five-year monitoring project on the fish assemblages at the *Wellwood* grounding site and two nearby reference areas. The primary goals of the monitoring data collected during this project were to aid in the assessment of restoration efforts and provide a benchmark for long-term evaluation of the fish communities at the grounding site. A benthic monitoring program conducted by National Marine Sanctuary scientists includes periodic assessments of the structural stability of installed restoration modules and coral recruitment patterns (Hudson *et al.* 2007).

METHODS

For each project, a team of Advanced Assessment Team REEF Experts conducted Roving Diver Technique surveys (RDT; Schmitt and Sullivan 1996) at each project site. In addition, belt transect surveys were conducted as part of the *Wellwood* project. Teams surveyed once prior to the management action (sinking, restoration) and 10 times following the *Spiegel Grove* deployment and 13 times following installation of restoration modules at the *Wellwood* site. Following deployment/restoration, surveys were conducted monthly for the first three months, quarterly for the following year, and then annually on the *Spiegel Grove* project and semi-annually on the *Wellwood* project.

The RDT is a non-point visual survey method specifically designed to generate a comprehensive species list and sighting frequency and relative abundance estimates. During RDT surveys, divers swim freely throughout a dive site and record every observed fish species. During each survey, divers assign each recorded species one of four log₁₀ abundance categories [single (1); few (2 - 10), many (11 - 100), and abundant (> 100)]. Each RDT survey is approximately 60 minutes, depending on safe diving limits. Following the dive, each surveyor records the species data along with survey time, depth, temperature, and other environmental information on a REEF scansheet. The scansheets are returned to REEF and are manually reviewed for completeness and any obvious errors. The scansheets are then scanned and digitized, and

the resulting data file is error-checked using quality control data management programs. Data are then uploaded into the REEF SQL database.

Once entered into the REEF database, summary data are displayed on the Internet at the REEF Website (<http://www.REEF.org>) by geographic location, including a complete species list, sighting frequency of each species, and density score for each species, where

Sighting Frequency (%SF) = number of surveys reporting species / total number of surveys at that site, and

Density Score (DEN) = $[(n_S \times 1) + (n_F \times 2) + (n_M \times 3) + (n_A \times 4)] / (n_S + n_F + n_M + n_A)$, where n is the number of times each abundance category was assigned).

Using these two metrics, a weighted measure of abundance, Abundance Score, can be calculated as %SF * DEN.

In order to document size frequency shifts and more quantitative shifts in density of key taxa, belt transects were conducted during the *Wellwood* project. The AGRRA protocol for fish transects was followed (AGRRA 2001). The transect locations were randomly selected. The diver swam the length of the belt transects (2 m x 30 m) and recorded all species of the following groups: grouper (Serranidae), snapper (Lutjanidae), grunt (Haemulidae), parrotfish (Scaridae), surgeonfish (Acanthuridae), leatherjacket (Balistidae), angelfish (Pomacanthidae), butterflyfish (Chaetodontidae), and five additional species: yellowtail damselfish (*Microspathodon chrysurus*), hogfish (*Lacholaimus maximus*), Spanish hogfish (*Bodianus rufus*), barracuda (*Sphyraena barracuda*) and bar jack (*Caranx ruber*). The size of each fish was estimated and assigned to a size category (< 5 cm, 5 - 10, 10 - 20, 20 - 30, 30 - 40, > 40 cm) using a 50 cm bar with 5 and 10 cm increments for scale. Grunts and parrotfishes less than 5 cm in length were not recorded.

STUDY AREA

The location of the *Spiegel Grove* is a barren, level sand bottom with a depth of approximately 40 m. The 7 comparison sites were selected by FKNMS staff and represent a broad range of nearby natural and artificial structure. The closest structure to the wreck site is a small patch of hard coral substrate (~9 m²) located approximately 0.3 km from the sinking location in a depth of approximately 38 m (called "Rocks next to *Spiegel Grove*"). The nearest substantial reef structures are the natural reef edges at Dixie Ledge and the Red Can Ledges, approximately 0.6 km shoreward of the sinking site. These reefs are sloping drop-offs and feature low profile hardbottom with sparse coverings of small hard corals, soft corals such as gorgonians, and sponges. Located approximately 1.1 km inshore from the sinking site are Dixie Shoals and the Red Can

Shallows. These two hardbottom areas are of moderate rugosity with low profile structure and moderate hard and soft coral cover. Dixie Shoals Shallows and the Red Can Shallows represent the nearest shallow water coral reef communities to the sinking site. More than one mile to the south is the wreck of the Norwegian freighter, the *Benwood*, which was sunk in 1942. This is the closest artificial reef to the *Spiegel Grove* sinking site and harbors a large diversity and abundance of fishes. Benwood Ledge is the deep reef area adjacent to the *Benwood* site and is similar in structure to the two Ledge sites.

The *Wellwood* study area included a portion of the grounding area that is being restored and two adjacent reference sites. The Restoration site surveyed included restoration modules and contiguous low profile hardbottom areas adjacent to and in between the restoration modules. The reference sites were chosen to include areas that were closest in proximity to the grounding area while remaining undamaged and unrestored. The reference areas were within nominal distance (25 - 75 m) from the restoration area and all three sites could be visited during a normal recreational dive.

Additional details and images of the study areas for both projects can be found on the REEF website (<http://www.reef.org/programs/monitoring>).

KEY FINDINGS

Spiegel Grove

- i) Fish species rapidly colonized the *Spiegel Grove* following deployment. Forty-six species were documented on the wreck less than a month after it was deployed. By August 2002, the average richness per monitoring was 66. Toward the end of the monitoring effort, average species richness increased to 76 per monitoring event.
- ii) 191 fish species have been documented on the wreck, including species rarely found elsewhere in the Florida Keys, such as blackcap basslet and blackfin snapper. Goliath and Nassau grouper, both protected species, were also documented on the wreck.
- iii) The persistence in species present at the *Spiegel Grove* (e.g. which species were seen during each monitoring event) as measured by the Jaccard Coefficient (J'), gradually increased through time.
- iv) The species composition of the *Spiegel Grove* was least similar to the shallow reference sites, including the Dixie Shoals, Red Can Shallows, and the well-established *Benwood* artificial reef. This is likely due to the fact that these sites support a high number of species and are in shallow water surrounded by productive reef and seagrass habitat. The species composition of the *Spiegel Grove* is approaching that of the deeper, natural reefs such as Dixie Ledge, Benwood

Ledge and Red Can Ledges.

Wellwood Restoration

- i) After initial colonization, Restoration site fish assemblage diversity, density and biomass have leveled off and remained lower than that at nearby reference areas. A total of 165 fish species were recorded at the Restoration Site during the 5-year project. In comparison, 189 were documented at the North Reference site and 207 were documented at the South Reference Site.
- ii) Parrotfish and surgeonfish appear to be responding quickest to the restoration efforts, with densities and biomass values similar to that of the reference sites. Grunt and snapper species are primarily absent from the Restoration Site.

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