

Assessment of Fish Communities Associated with South Carolina Permitted Artificial Reef Sites with Comparable Natural Hard Bottom Sites by South Carolina Aquarium Volunteer Divers

Arnold Postell^{1*}, Raymond J. Rhodes², Dale Swing and Brian Kennedy

¹ South Carolina Aquarium, 100 Aquarium Wharf, Charleston, SC 29401
Apostell@scaquarium.org

² rhodesr@cofc.edu

* corresponding author

Abstract

The Marine Resources Division (MRD) of the South Carolina Department of Natural Resources currently manages a system of 45 permitted marine artificial reef (PAR) areas or sites off the South Carolina coast and within SC estuarine (internal) waters that generated an estimated economic impact of ~\$83 million during 2006. Given the environmental and economic importance of this system, MRD is faced with formulating management policies regarding the PAR system despite limited information on these systems. In 2007, MRD in conjunction with South Carolina Sea Grant Consortium funded the South Carolina Aquarium (SCA) to implement and conduct field research to assist MRD in improving the understanding of fish assemblages associated with selected PAR sites and comparable hard bottom areas off of South Carolina. Moreover, the SCA needed to use a cooperative fisheries research approach that involved trained volunteer divers participating in the collection of underwater observational data. Based upon recommendations by the MRD Artificial Reef Program staff, three different sites were selected for surveying per dive trip: one offshore man-made structure, i.e., Y-73, within a PAR area, one comparable offshore natural HB site, i.e., locally called 'The Gardens', and one near-shore PAR site, i.e., 'The Charleston 60'. For each survey site selected, two fish assessment trips per month to each of the three selected sites per trip (i.e., a total of three assessment dives per trip) have been attempted starting in July 2007 with plans of continuing these trips through April 2008. During each fish assessment survey at selected sites, advance trained SCA volunteer divers using the Roving Diver Technique have been recording species observed during the dive as well as other biotic (e.g., notes on fish feeding behavior, etc.) and selected abiotic information related to the survey site on a standardized diver fish assessment survey form. Site information is recorded by the surveying divers after each dive also includes assigning recorded species to specific abundance categories (i.e., four log₁₀ categories), survey depth ranges, temperatures and estimated visibility while surveying. By the end of February 2008, 110 dive surveys have been completed and 127 different fish species have been observed by SCA volunteer divers. In addition to enhancing the understanding of coastal temperate water fish assemblages, project results are also expected to assist MRD in evaluating the utility of cooperative fishery research projects involving trained volunteer recreational divers especially with regard to conducting future fish assessment surveys related to the SC artificial reef sites. Furthermore, the experience that the SCA staff has acquired conducting this study has increased the SCA capabilities to participate in applied cooperative research involving the recreational diving community, MRD and other stakeholder groups.

Keywords: fish communities, fish identification training, roving diver technique

Introduction

The Marine Resources Division (MRD) of the South Carolina Department of Natural Resources developed and currently manages a system of 45 permitted marine artificial reef (PAR) areas or sites off the South Carolina (SC) coast and within SC estuarine (internal) waters. This vast array or system of artificial reef sites enhances saltwater recreational fishing and diving opportunities while directly mitigating heavy utilization impacts on limited natural hard-bottom areas of SC (Robert Martore, MRD, personal communication). It is also apparent that the SC marine artificial reef system, as developed and managed by the MRD, is clearly a significant component of the entire SC coastal economy. For example, during 2006, aggregate expenditures by private boat anglers and charter divers making trips involving these AR sites generated an economic impact (i.e., economic importance) of approximately \$83 million in total sales (output) that directly and indirectly supported approximately 1,000 jobs (Rhodes and Pan, 2007).

Given the environmental and economic importance of this system, MRD like other marine resource management agencies is often faced with formulating policies and/or regulatory decisions regarding natural systems and related habitats like their PAR system despite limited information on these systems. Additionally, MRD is interested in evaluating the utility of cooperative fishery research approaches involving fishery stakeholders working in conjunction with professional scientists. In general, cooperative fishery research involves stakeholders such as marine biologists, user groups (e.g., commercial fishermen, recreational divers, etc.) and non-profit organizations "...in the design, conduct and communication of biophysical, gear design and engineering and social science research..." with the nature and degree of involvement varying with the partnership (Hartley and Robertson, 2006).

Using a National Oceanic and Atmospheric Administration (NOAA) grant, MRD in conjunction with South Carolina Sea Grant Consortium funded the South Carolina Aquarium (SCA) starting in 2007 to implement and conduct field research to assist MRD in improving the understanding of fish assemblages associated with selected PAR sites and comparable hard bottom areas off of South Carolina using a core of volunteer divers trained by the SCA. Specifically, this cooperative fisheries research (MRD-SCSGC, 2007) needed to involve trained volunteer divers participating in the collection of observational data "...to examine the importance of variables such as: depth, location, construction materials, age, or productivity on an artificial reef versus comparable natural hard bottom areas." According to Van Dolah et al., 2008, natural 'hard bottom' (HB) areas off of South Carolina's coast are characterized as "...broad expanses of smooth sand bottom interspersed with areas of low relief hard ground and rocky outcrops. These habitats provide hard substrate for a diverse assemblage of sessile invertebrates which, in turn, attract a variety of motile species including many demersal fishes."

In this study, this need or objective was addressed by implementing a cooperative fisheries research project involving volunteer divers trained by the SCA with these divers routinely collecting field observations on fish species associated with selected man-made structures within PAR areas and a comparable HB area starting in 2007.

Since the South Carolina Aquarium (SCA) opened in 2000, the community of SC recreational scuba divers have routinely volunteered to perform various diving tasks essential to the cost-effective operation of the SCA as a private not-for-profit organization. For the safety of these divers, these volunteer SC divers are required to operate under the auspices and specific diving guidelines of the SCA. The SCA currently supports a group of over 90 volunteer divers that start with a minimum training level of advanced certification in recreational SCUBA diving. These divers then progress to acquiring Scientific Diving Standards of the American Academy of Underwater Sciences (AAUS) or

equivalent standards with cooperating partners (NOAA) to do open-water diving activities under the auspices of the SCA.

Although SCA volunteer divers were critical to this cooperative fisheries research project, the SCA also has a variety of physical resources to support open-water diving activities. The SCA owns a 28-foot Scout -Abaco Series vessel, 'On the Clock/RV,' with two 225-HP Yamaha outboards that was donated by Scouts Boats, Incorporated, in November 2006. This vessel includes electronics and other equipment critical to offshore activities such as the collection of live specimens. This vessel can comfortably carry up to four SCA volunteer divers and the required two SCA crewmembers for offshore dive trips involving trained volunteer divers. SCA staff and volunteers are CPR and Oxygen Provider certified with full emergency equipment in place on the vessel. Additionally, the SCA has a full collection of scuba diving gear and safety equipment used for SCA's daily educational dive programs as well as open-water diving activities. The SCA also has a nitrox blending station as enriched air-nitrox is needed for open-water diving activities.

Methods

The sites selected for observational dives during this project were limited to areas generally considered accessible by private boat recreational anglers and divers departing from boat ramps (e.g., Wappoo Cut Boat Ramp), marinas, private docks and other boating access points in the greater Charleston areas and within about two hours or less of boat traveling time when departing from these points. This accessibility to the general study area, mainly via the Charleston Harbor, is important when considering the potential impacts of fishing and diving on artificial reef sites and HB areas stemming from the apparently large number of both user groups (i.e., divers and anglers), especially recreational saltwater anglers, in the greater Charleston area.

Based upon recommendations by the MRD Artificial Reef Program staff and results of two pretest trips, three different sites were selected for surveying per dive trip: one offshore man-made structure, i.e., 'Y-73,' within a PAR area, one comparable offshore natural HB site, i.e., locally called 'The Gardens', and one nearshore PAR site, i.e., 'The Charleston 60.' Selection of these survey sites was based upon several criteria including their accessibility from Charleston Harbor, a rough proxy for fishing pressure; location-depth characteristics, i.e., 'offshore' (~80-100 ft) site vs. 'near-shore' (~40-60 ft) site and the need to have one HB site comparable to a selected PAR site. The 'Y-73' is approximately 30 miles offshore from the mouth of the Charleston Jetties. It is a 180-ft steel hull tanker ship sitting straight up in sand at 100 ft and it has a 40-foot relief to the wheelhouse. 'The Gardens,' the project's selected HB area, is a limestone out-cropping about 28 miles offshore that has a maximum depth of approximately 85 ft with the ledge relief averaging about 12 ft. 'The Charleston 60', a PAR site, is a 240-ft broken up barge resting in about 60 ft of water about 18 miles offshore. It was hypothesized that 'The Gardens' HB site was generally comparable with the 'Y-73' PAR site based on comparable depth and a proximity of two miles from each other. No comparable HB was chosen to compare with 'The Charleston 60' due to limitations of three dives per day and the desire for consistency during each trip to aid with the seasonality component.

For each survey site selected, two fish assessment trips per month to each of the three selected sites per trip (i.e., a total of three assessment dives per trip) have been attempted starting in July 2007 with plans of continuing these trips through April 2008. During each fish assessment survey at selected sites, the advance trained cooperating volunteer divers have been using the Roving Diver Technique (RDT) (e.g., Schmitt and Sullivan, 1996). RDT is considered a viable fish assessment technique and has been effectively used with trained volunteer divers to collect scientific observations on marine fish communities and assemblages. This methodology has been utilized by NOAA to help with the

management of National Marine Sanctuaries (e.g., Pattengill-Semmens and Semmens, 1998) including Gray's Reef, Flower Gardens, Florida Keys, and others. The RDT is a non-stationary *in situ* survey technique used by individual divers to record fish species observed while freely swimming or 'roving' throughout a designed dive site such as an artificial reef. Besides the simplicity of using RDT with a new project involving volunteer divers, it was also selected because of the SC offshore diving environment, especially dive safety issues associated with strong currents and potential poor visibility (e.g., less than five feet). The RDT is compatible with maintaining a close 'buddy team' as required by the SCA as well as mitigating 'task loading' risks for volunteer divers compared to using transect and fixed station type techniques. RDT also allows divers the flexibility to observe and record a broad spectrum of species during each dive, an approach congruent with the qualitative nature of this cooperative research.

Immediately following each survey dive (i.e., during surface intervals), each survey diver records species observed during the dive as well as other biotic (e.g., notes on fish feeding behavior, etc.) and selected abiotic information related to the survey site on a standardized diver fish assessment survey form. Site information is recorded by the surveying diver after each dive also includes assigning recorded species to specific abundance categories (i.e., four \log_{10} categories), survey depth ranges, temperatures and estimated visibility while surveying. The data recorded on the fish assessment survey form were designed to be comparable to the MRD's survey diver assessment form and the data elements in the Reef Environmental Education Foundation (REEF) database. After each survey trip, a SCA Survey Coordinator is responsible for the timely (e.g., within five days) review of observations recorded on each diver's survey form and subsequent entry into a SCA-designed database.

All divers participating in field survey activities were required to receive training on identification of fish species that might be observed during a survey dive. Moreover, given the importance of open-water diving skills, only divers with AAUS or equivalent certification were given extensive advanced fish identification training including testing at the end of the training sessions and then evaluated under field (open-water) conditions before being allowed to participate in an assessment survey. Training materials such as an underwater photo books were also created to aid the volunteers in learning to accurately differentiate between the 256 potential fish species that might be observed at a given survey site. Lecture seminars were given to give more hands-on learning options, and finally practice and testing was used to confirm accuracy of the knowledge of fish identification. Candidate divers also had the opportunity to hone their fish identification skills while diving in our Great Ocean Exhibit, the deepest marine exhibit in North America at 42 ft. This 385,000 gallon tank holds about 45 different marine fish species with many species representing pelagic to demersal species commonly found off of SC.

Results

By the end of February 2008, 110 dive surveys have been completed and 127 different fish species have been observed by SCA volunteer divers. There have been multiple challenges and some incredible sightings during this project. The challenges started with the survey abilities of the volunteers. We started with a small pool of eight divers that were ready to go offshore with a tested quality of fish identification knowledge from the beginning. During the first eight months of this study that number has grown to 24 qualified divers. This larger group to choose from has helped with scheduling due to limited ability to accurately predict weather conditions more than 48 hours before a planned trip. The weather conditions off the coast of SC are variable and severe. Winds, waves, and visibility change rapidly to create potential dangerous dive conditions. The offshore weather buoys that normally can give a fairly reliable five day forecast were broken for the majority of 2007. Several trips were canceled with short notice and one trip had to return to port due to unpredicted seas. Cold

water did lessen the number of qualified divers that wear thermally protected in the 55°F water temperatures in the winter. Survey trips were not possible for two months because the SCA boat trailer was stolen and required boat maintenance for offshore trips was not possible.

There were some interesting sightings during the completed surveys. Schools of adult red drum (*Sciaenops ocellatus*) were observed aggregating during fall of 2007 at the near-shore PAR, 'The Charleston 60.' Red drum is a very important inshore recreational fishing species in SC. Rarely seen goliath grouper (*Epinephelus itajara*) were observed in summer 2007 at the deep water PAR survey site. Red lionfish (*Pterois volitans*) were seen at both deep water sites multiple times. These are an invasive species that are spreading rapidly through the western Atlantic. Fish in the batfish family (Ogcocephalidae) that appear to be palefin batfish (*Ogcocephalus rostellum*) were observed during a fall 2007 survey dive at the deepwater PAR site. Survey divers were not able to verify the species on first sighting because the palefin batfish is similar in appearance to the polka-dot batfish (*Ogcocephalus cubifrons*). *O. rostellum* was reported by Bradbury (1980) in deep water trawl samples collected off of the western Atlantic coast. On a subsequent dive trip, SCA also collected a single specimen for identification purposes.

Discussion

Once the field phase of this study is completed, a final report will be prepared that will include: a) a comprehensive list of observed fish species with frequency, abundance and size group estimates; b) comparison of permitted artificial reef vs. natural hard bottom; and, c) comparison of depth-location and seasonality. In addition to the benefits derived from the technical analysis of the survey data being collected, the active involvement of the MRD staff in this project will allow them to better evaluate the utility of a cooperative fishery research project involving trained volunteer SC recreational divers especially with regard to conducting future fish assessment surveys related to the SC artificial reef sites. Furthermore, the experience that the SCA staff has acquired implementing and conducting this study is increasing SCA capabilities to cost-effectively participate in applied cooperative research with the recreational diving community, MRD and other stakeholder groups. Moreover, given the environmental education mission of the SCA, we now have trained more local divers to better understand the habitats and fish species off of the SC coast. Several of volunteer survey divers are knowledgeable about REEF so we believe that their involvement in this project will help motivate them to continue doing REEF surveys when participating in local recreational diving activities and/or when diving out of state. We also believe volunteer divers that participating in this project can also better communicate with our guests at SCA during educational presentations about what they see offshore.

Acknowledgments

The authors would like to thank the National Oceanic and Atmospheric Administration, the South Carolina Department of Natural Resources' Marine Research Division in conjunction with South Carolina Sea Grant Consortium for financial and administrative support. We also thank South Carolina Aquarium staff and volunteer divers as well as others at the SCA for their support and encouragement. The authors are especially thankful for technical support provided by Reef Environmental Education Foundation including Lad Akins and Leda Cunningham and the South Carolina Department of Natural Resources' Artificial Reef Program (i.e., Bob Martore and staff).

The views expressed herein are those of the authors and do not necessarily represent the views of the South Carolina Aquarium, South Carolina Sea Grant Consortium, South Carolina Department of Natural Resources, NOAA, or any of their sub-agencies. Further, use of trade names does not imply endorsement by the authors or their funding agencies and organizations.

References

Bradbury MG. A revision of the fish genus *Ogcocephalus* with descriptions of new species from the western Atlantic Ocean (*Ogcocephalidae*; *Lophiiformes*). Proc Calif Acad Sci. 1980; 42: 229-285.

Hartley TW, Robertson RA. Stakeholder engagement, cooperative fisheries research and democratic science: The case of the Northeast Consortium. Human Ecol Rev. 2006; 13(2): 161-171.

Marine Resources Division – South Carolina Sea Grant Consortium . Fishing for funding: A request of cooperative fisheries research grants. Charleston, SC: S.C. Sea Grant Consortium, 2007; 8 pp.

Pattengill-Semmens CV, Semmens BX. An analysis of fish survey data generated by non expert volunteers in the Flower Garden Banks National Marine Sanctuary. J Gulf Mexico Sci. 1998; (2): 196-207.

Reef Environmental Education Foundation. Database. www.reef.org/category/site/database

Rhodes RJ, Pan B. Economic Impact and Use Survey of South Carolina Artificial Reef Users: Private Boat Anglers and Charter Divers, 2006. Final Report. Prepared for the SC Dept. of Natural Resources, Marine Resources Division, Charleston, SC: 2007; 73 pp.

Schmitt EF, Sullivan KM. Analysis of a volunteer method for collecting fish presence and abundance data in the Florida Keys. Bull Mar Sci. 1996; 59(2): 404-416.

Van Dolah RF, Hinde P, Nicholson N. Effects on Roller Trawling on a Hard Bottom Sponge and Coral Community. Savannah, Georgia: Gray's Reef National Marine Sanctuary, 2008. graysreef.noaa.gov/trawls.html