Innovative Use of Drifters and Sound Recording to Locate Grouper Spawning Aggregations

Innovando con el Uso de Boyas a la Deriva y Grabadores de Sonido para Localizar Agregaciones de Desove de Meros

Innover avec L'utilisation de Bouées Dérivantes et Enregistreurs Sonores pour Localiser les Concentrations de Mérous de Frai

RONALD L. HILL[1]*, JENNIFER C. DOERR[1], MICHELLE T. SCHÄRER[2], RICHARD S. APPELDOORN[3], and PHILLIP A. CALDWELL[1]
[1]*NOAA — NMFS, 4700 Avenue U, Galveston, Texas 77551 USA.*
*ron.hill@noaa.gov jennifer.doerr@noaa.gov phil.caldwell@noaa.gov
[2]*P.O. Box 1442, Boquerón, Puerto Rico 00622 USA.* michelle.scharer@upr.edu
[3]*Department of Marine Science, University of Puerto Rico, P.O. Box 9000, Mayagüez, Puerto Rico 00681 USA.* richard.appeldoorn@upr.edu

EXTENDED ABSTRACT

When fish, such as groupers, are gathered at transient spawning aggregations, they are more susceptible to overexploitation than when dispersed at their home reefs. The hyper-stability of annual aggregations tends to mask the loss of biomass at home reefs (Sadovy and Domeier 2005). Because historical fishing has depleted many grouper stocks throughout the Caribbean, conservation and management measures are needed that will ensure long-term sustainable management for productive fisheries and recovery of threatened populations. These measures may include area closures and seasonal closures of fishing and/or marketing. But, to be effective, management measures must match the temporal and spatial dynamics of the species in need of conservation.

Studies of many spawning aggregation sites have begun with the sharing of traditional ecological knowledge (TEK) by fishers. Fishers know much about where and when they have fished, and they learn of historical fishing locations and practices from other fishers (Valdés-Pizzini and García-Quijano 2009). TEK forms a valuable starting point in aggregation research, the foundation on which further research, monitoring, and management can build (Appeldoorn et al. 2014). That research has traditionally begun with SCUBA-based visual surveys of the purported spawning aggregation site (Schärer et al. 2010) and/or active acoustic surveys (Rivera et al. 2011). Recent projects have added passive acoustic techniques to record species-specific, spawning-associated "fish calls," as indicators of the presence, behavior, and abundance of spawners at aggregations (Rowell et al. 2012, Schärer et al. 2012). Several sites off the western coast of Puerto Rico, including Abrir la Sierra, are being monitored with passive acoustic techniques and supplemental diver assessments throughout the extended grouper spawning season (Rowell et al. 2012). With this approach, spatial and temporal data on courtship and spawning of several species are collected for analysis, providing the analytical results that underpin effective management (Schärer et al. 2010). While data are collected at sites identified through TEK and diver confirmations, the full spatial extent of the spawning arena is often difficult to discern. Diver explorations, active acoustic surveys, and drifting passive acoustic surveys have been used, but results have not always been as conclusive as desired (Rowell et al. 2011).

We have developed a novel approach, built on the drifting-boat passive acoustic survey idea (Rowell et al. 2011), to map the extent of spawning aggregations and to identify previously unknown spawning sites. We constructed "sound drifters," 0.5 m in cross section, that float with prevailing currents (Figure 1). Frames are built from PVC pipe with a mesh covering, and flotation is added to adjust height in the water. The body of the drifter is weighted so that the top cross bar floats at the surface of the water minimizing wind driven motion. Projecting from the top of the drifter is a waterproof electronics box; GPS locations are tracked throughout each drifter run. A canister (C. Koenig-design), containing a continuous recorder, is suspended on a line from the center of the drifter. The recorders record all ambient sounds, including those associated with grouper courtship and spawning. Matching GPS time signals with the time stamp from the sound recording allows us to map the extent of grouper courtship activity.

The drifters were deployed 30-31 January 2016 during preliminary field trials over the known red hind aggregation site at Abrir la Sierra. Diver surveys and passive acoustic monitoring confirmed that deployments occurred during the time of maximum density and sound production for the sampled month (Figure 2). The drifters were deployed by hand from a small boat (25 feet). The boat maintained a constant heading, and the set of five drifters were deployed, spaced a consistent distance apart, (100 - 250 m for the three runs). During each 1- to 1.5-hr run the drifters traveled approximately 1 km, depending on the strength and direction of the current at that time. As displayed in Figure 3, there is some evidence of current variation over space and time, affecting overall coverage and distance traveled. In spite of the variation, the area of interest was efficiently covered in about 3 - 4 hours. The drifters successfully recorded courtship/spawning sounds from red hind. Plotting of the GPS time signals over benthic maps, e.g., bathymetric maps (Figure 3.), allows us to visualize the tracks of the drifters. By matching the time-referenced sounds from the recorders, we can identify the areas with the most sound activity and also estimate the spatial extent of the entire red hind courting arena. Analysis of the digital sound files is currently ongoing, but preliminary results confirm the successful recording of red hind and other grouper sounds. For example, one of the last recordings to the west (orange line, Figure 3) identified a previously unknown black grouper site

that will be added to the locations being monitored in 2016 - 2017. Future trials will expand the extent covered by the drifters and achieve complete sound mapping of the area. The sound drifter technique will also be used in other parts of Puerto Rico, where we are less certain of the exact locations of spawning aggregations.

In spite of the success with the sound drifters, there are some caveats. Drifter direction depends on the direction of the currents, which are not always predictable on a fine scale. We also see evidence of effects of benthic topography that cause unpredictable differences in the tracks of adjacent drifters, e.g., convergence seen on southerly set in Figure 3. This inability to predict fine scale current patterns can affect the spatial distribution of data collection, although the method is simple enough that missed areas can be covered with subsequent runs, if time and weather conditions allow. So far, we have benefitted from extensive collaboration, which is critical to developing a full understanding of the complexities of spawning grouper. Future runs will build on this promising approach to search for and map additional grouper spawning sites.

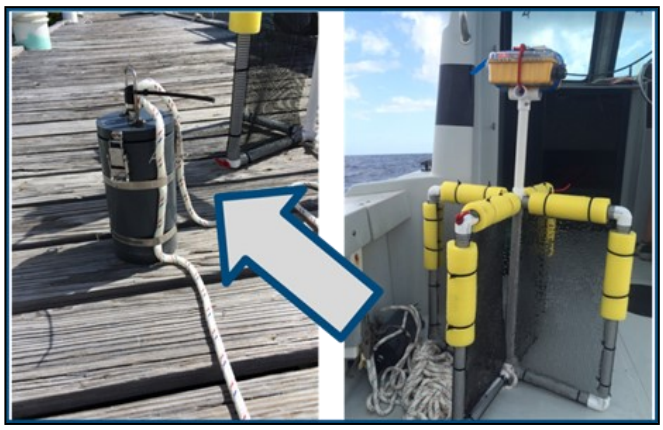

Figure 1. Sound drifters with waterproof electronics box on top (right picture), line and canister following deployment and retrieval at Abrir la Sierra. At left is a close-up of the canister, rigged for deployment.

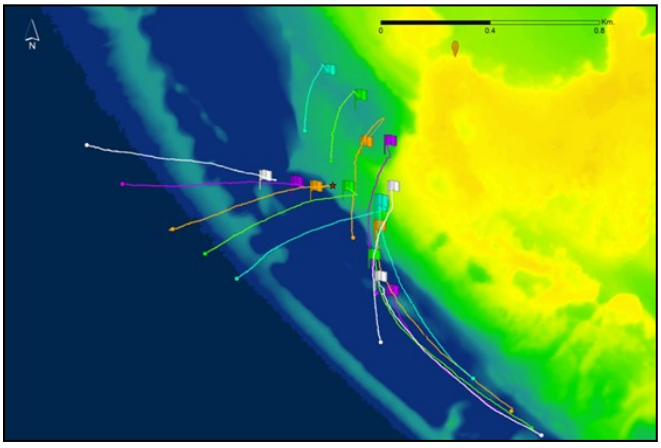

Figure 3. Sound-drifter tracks overlaid on bathymetric chart of Abrir la Sierra. Start of each track is marked with colored flag. Three sets of 5 drifters were deployed 30-31 January 2106. Navigational buoy, Buoy 6, is marked with red (teardrop) shape northeast of drifter deployments.

LITERATURE CITED

Appeldoorn, R.S., T.J. Rowell, M. Schärer-Umpierre, and M. Nemeth. 2014. Corroborating fishermen's knowledge of Red Hind spawning aggregation sites using passive acoustic mapping techniques. *Proceedings of the Gulf and Caribbean Fisheries Institute* **66**:375-378.

Locascio, J.V. and M.L. Burton. 2016. A passive acoustic survey of fish sound production at Riley's Hump within Tortugas South Ecological Reserve: implications regarding spawning and habitat use. *Fishery Bulletin* **114**(1):103-116.

Rivera, J., T. Kellison, R.S. Appeldoorn, M. Schärer, M. Nemeth, T. Rowell, D. Mateos, and P. Nealson. 2011. Detection of Mona Island and Abrir La Sierra, Puerto Rico Red Hind (*Epinephelus guttatus*) 1 m off the bottom with hydroacoustic techniques *Proceedings of the Gulf and Caribbean Fisheries Institute* **63**:143-148.

Rowell, T.J., R.S. Appeldoorn, J.A. Rivera, D.A. Mann, T. Kellison, M. Nemeth, and M. Schärer-Umpierre. 2011. Use of passive acoustics to map grouper spawning aggregations, with emphasis on Red Hind, *Epinephelus guttatus*, off western Puerto Rico, *Proceedings of the Gulf and Caribbean Fisheries Institute* **63**:139-142.

Rowell, T.J., M.T. Schärer, R.S. Appeldoorn, M.I. Nemeth, D.A. Mann, and J.A. Rivera. 2012. Sound production as an indicator of Red Hind density at a spawning aggregation. *Marine Ecology Progress Series* **462**:241-250.

Sadovy, Y., and M. Domeier. 2005. Are aggregation-fisheries sustainable? Reef fish fisheries as a case study. Coral Reefs **24(2)**:254-262.

Schärer, M.T., M.I. Nemeth, and R.S. Appeldoorn. 2010. Protecting a multi-species spawning aggregation at Mona Island, Puerto Rico. *Proceedings of the Gulf and Caribbean Fisheries Institute* **62**:252-259.

Schärer, M.T., M.I. Nemeth, D. Mann, J. Locascio, R.S. Appeldoorn, and T.J. Rowell. 2012. Sound production and reproductive behavior of Yellowfin Grouper, *Mycteroperca venenosa* (Serranidae) at a spawning aggregation. *Copeia* **2012(1)**:135-144.

Valdés-Pizzini, M., and C. García-Quijano. 2009. Coupling of humans, habitats and other species: a study of the fishers' traditional ecological knowledge (TEK) in La Parguera. *Caribbean Journal of Science* **45**(2-3):363-371.

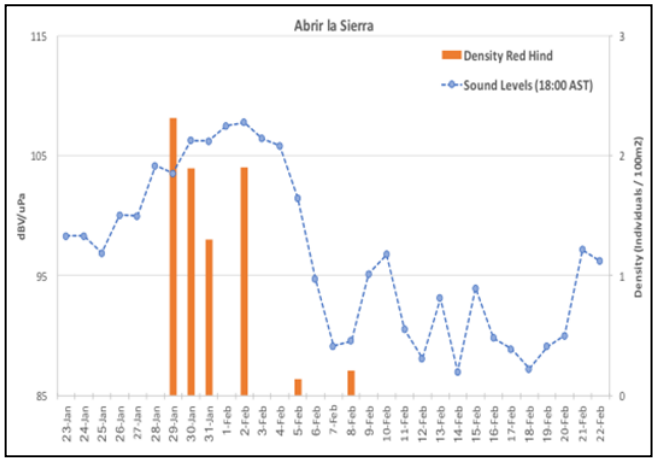

Figure 2. Red hind (*E. guttatus*) densities derived from diver surveys (bars) and sound level of red hind courtship and spawning calls as recorded by passive acoustic monitoring devices. Data/graph provided by M. Schärer.