Sound drifters and the detection of grouper spawning aggregations

Boyas de sonido a la deriva y detección de agregaciones de desove de mero

Bouées sonores dérivantes et détection des agrégations de reproducteurs de les Concentrations de Mérous de Frai

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EXTENDED ABSTRACT

When groupers or other species gather at transient spawning aggregations (after Domeir and Colin 1997), fishery scientists can efficiently collect data, such as abundance, size, spawning frequency, harem size, sex ratio, fecundity, and site fidelity, needed for sustainable management. Frequently, these studies start with fishers' traditional ecological knowledge (TEK). Fishers, throughout their lives, collect data on the natural history of oceans and the distribution and behavior of the fishes upon which they depend for their livelihood. Fishers know much about where and when they have successfully caught fish, and current and historical fishing knowledge often becomes a fishing community resource (Valdés-Pizzini and García-Quijano 2009). TEK has been a valuable starting point in research of spawning dynamics and can be the foundation on which further research, monitoring, and management builds (Appeldoorn et al. 2014).

Scientific aggregation research has normally begun with SCUBA surveys of purported spawning aggregation sites to confirm the presence of spawning fish (Schärer et al. 2010). Active acoustic surveys have also been employed to confirm species aggregations (Rivera et al. 2011), although differentiating species or documenting fish that remain primarily near structure can be difficult (Reid and Simmonds 1993). Passive acoustic monitoring (PAM) devices that record species-specific, spawning-associated "fish calls," as indicators of the presence, behavior, and abundance of spawners at aggregation sites are widely used today (Rowell et al. 2012, Schärer et al. 2012). Passive acoustic techniques paired with supplemental diver assessments are currently employed to monitor spawning dynamics throughout the extended grouper spawning season, at several sites off the western coast of Puerto Rico (Rowell et al. 2012). Divers can document abundance and size, sex ratios for dimorphic species, and can collect some spatial and temporal data on courtship and spawning (CAS), and PAM is highly effective at documenting the full temporal extent of spawning of soniferous species. In combination, these approaches provide critical data to support effective management (Schärer et al. 2010). However, these approaches cannot always fully detect the extent of the spawning arena, and they are rarely effective at confirming rumored spawning sites without large expenditures of time and resources.

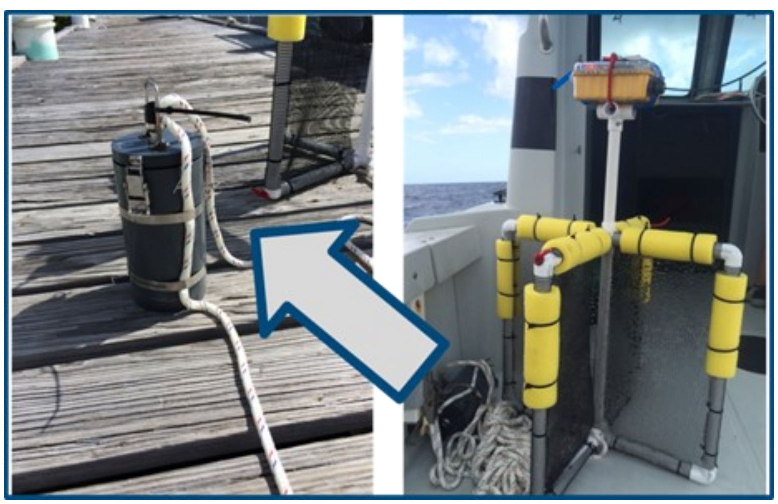

Figure 1. Sound drifters with waterproof electronics box on top (right picture), line and canister following deployment and retrieval at Abrir la Sierra. At left is a close-up of the canister, rigged for deployment. (Figure reproduced from Hill et al 2016)

To address these two needs, we developed a low-tech approach to map the extent of known spawning aggregations and to identify previously unknown spawning sites. From Hill et al. 2016: *We constructed "sound drifters," 0.5m in cross section that float with prevailing currents (Fig. 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* [weighted] *line from the center of the drifter. The recorders record all ambient sounds, including those associated with grouper courtship and spawning.* By matching GPS time signals with the time stamp from the sound recording, we can map the extent of grouper courtship activities or map locations where unproven aggregations may occur.

The drifters are deployed by hand from a small boat, generally deployed as an array of 5-6 devices (Hill et al. 2016). After the sound drifters are recovered and sound files are downloaded, an analysis of sound pressure levels and species-specific courtship calls can provide indications of aggregations.

Following trials at the proven red hind spawning aggregation at Abrir La Sierra off western Puerto Rico where we discovered a previously undocumented black grouper spawning site, we deployed the drifters in both summer and winter around Culebra off northeastern PR. Based on loose descriptions from fishers, we deployed drifters in the summer of 2016, in areas where goliath grouper were reported to spawn in past years. The surveys of the area, displayed as multiple tracks to the southeast of Culebra (Fig. 2), recorded sounds of grunts (Haemulidae) in a pattern known as "fish chorusing," but no grouper sounds were detected. In deployments in the winter of 2017, red hind CAS sounds were detected at three different

Figure 2. Sound-drifter tracks overlaid on map of Culebra. Black circles represent low sound pressure levels, white circles represent high sound pressure levels, and grouper shadow icons represent distinct grouper calls. Yellow ovals highlight drifter deployments where red hind CAS sounds were detected in winter 2017. Tracks to the SE represent summer 2016 deployment when Haemulid fish chorusing was recorded.

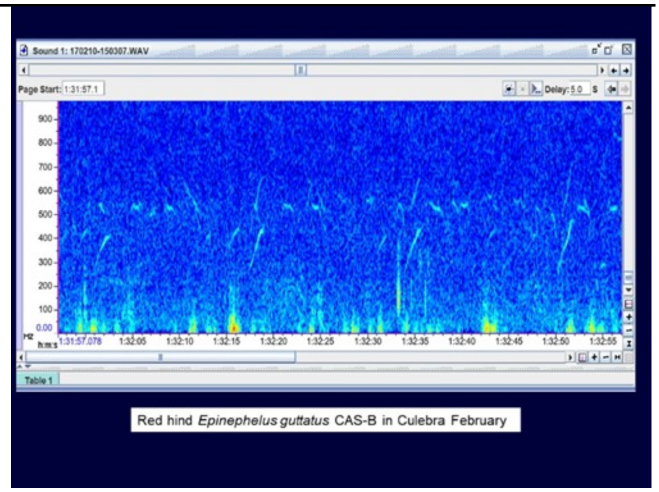

Figure 3. Spectrogram of Red hind (*E. guttatus*) calls detected northwest of Culebra. Red color represents high sound level.

locations (yellow ovals, Fig. 2): northwest of Culebra near the shelf edge, west of Luis Peña reserve near Cayo Lobo, and east of Culebra and the reef line extending south from Culebrita. Grouper shadow icons represent distinct grouper calls typical of CAS, as displayed in the spectrogram (Fig. 3).

In spite of the success with the sound drifters in detecting spawning red hinds, there are some caveats. Drifter direction depends on the direction of the currents, which are not always predictable (Hill et al. 2016). The inability to predict fine scale current patterns prior to deployment can affect the spatial distribution of data collection, although the method is simple and rapid enough that missed areas can be covered with subsequent runs, if time and weather conditions allow. As with other PAM devices, the post-processing of the sound recordings can be somewhat labor intensive. Also, the distance over which spawning sounds can be detected has not been determined. This critical piece of information will improve our understanding of detections from both stationary and drifting spawning monitoring.

In general, sound drifter are effective ways to document spawning locations and delineate spawning arena boundaries. By locating these previously undocumented fish spawning aggregation sites on the shelf near ALS and the shelf around Culebra we have added to the information needed to effectively manage these important fish stocks. Additional monitoring of these newly identified aggregations will provide greater understanding of the distribution of spawning sites and provide and avenue to manage these valuable natural resources more effectively.

KEYWORDS: spawning aggregations, soniferous fish, sound drifters, biophony, soundscape

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