Corroborating Fishermen's Knowledge of Red Hind Spawning Aggregation Sites Using Passive Acoustic Mapping Techniques

Corroboración del Conocimiento de Pescadores sobre Lugares de Agregaciones de Desove del Mero Cabrilla Usando Técnicas Acústicas Pasivas de Mapeo

Corroboration de la Connaissance des Pêcheurs au Sujet de Places des Frai Agrégations de Mérou Couronné en Utilisant des Techniques de Cartographie Acoustiques Passives

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ABSTRACT

The red hind, *Epinephelus guttatus,* is one of the most important commercial reef fishes in Puerto Rico. Red hind form spawning aggregations at predictable sites and times, and this behavior has led to marked declines in its abundance as a consequence of directed fishing on spawning aggregations. However, this trend can be reversed by targeting management and assessments toward these aggregations. This is facilitated if the exact time and location of spawning aggregations are known. In this study we followed-up a previous survey of patriarchal fishermen who identified past and present suspected spawning aggregations sites, with field surveys to confirm their exact location and status. Passive acoustic monitoring of red hind courtship sounds was made using a boat-based hydrophone and GPS. Plotting of transect positions with the number and strength of red hind calls allowed the extent of aggregations to be mapped. This study extended the known area of spawning for one west coast aggregation, confirmed the presence of another west coast site, tentatively confirmed the predicted absence of aggregations off of Guanica, and confirmed a new aggregation site (identified by a separate fisherman) off of Mayaguez. The newly confirmed site off the west coast was subsequently monitored using passive hydroacoustics and visited by divers. These baseline data will facilitate future surveys to assess spawning stocks with minimal effort and track their recovery following the establishment of area and seasonal closures.

KEY WORDS: Red hind, spawning aggregation, passive acoustics, traditional ecological knowledge

INTRODUCTION

The red hind, *Epinephelus guttatus,* is one of the most important commercial species in the shallow reef fisheries in Puerto Rico. Red hind, like most groupers, form spawning aggregations at predictable sites and times. In Puerto Rico, aggregations form primarily in the months of January and February, although they may arrive at the aggregation site in December and stay into March. Spawning occurs in the days after full moons, but the exact time is site specific. Males tend to arrive earlier than females, set up territories and stay on site throughout the spawning season. In contrast, females tend to arrive only as the time of spawning approaches and will leave the site between spawning events in those years for which more than one aggregation occurs. The formation of spawning aggregations at predictable sites and times facilitates targeted fishing, and this has led to marked declines in red hind abundance. However, this trend can be reversed by targeting management and assessments toward these aggregations, assuming the locations of spawning aggregations are known.

At present, the number of confirmed spawning aggregation site locations for red hind around Puerto Rico is limited. Ojeda et al. (2007a) listed just four sites, and to that can be added a fifth at Mona Island (Mann et al. 2010). However, in a comprehensive interview study with patriarchal fishermen, Ojeda et al. (2007 a,b) identified a total of 39 potential extant red hind aggregations and an additional 10 sites where aggregations use to occur in the past. To date, there has been no effort to confirm these locations. Part of the problem is that, unless accompanied to the exact location by someone who knows, red hind aggregations may be difficult to locate without extensive searching in the general indicated area. Additionally, there is only a narrow time window wherein the fish are aggregated, and with this time being site specific it is easy to miss the peak days of highest abundance and reproductive behaviors while searching. The use of passive acoustic technology offers a potential way to survey large areas for the presence of aggregating fish. Male red hind make courtship associated calls (Mann et al. 2010) that are used to both defend territories and attract females. Rowell et al. (2011) demonstrated the use of passive acoustics for mapping a red hind aggregation at Abrir la Sierra, off the west coast of Puerto Rico. In this study, we adopt the approach of Rowel et al. (2011) for the following goals:

i) Map the full southern extent of the Abrir la Sierra aggregation site, and
ii) Confirm the validity of information provided by fishermen relative to other aggregation sites.

METHODS

Four locations were studied. In addition to the Abrir la Sierra site (Rowel et al. 2011), we attempted to map three sites identified by fishermen. Two of these, Buoy 4 on the southern edge of the western platform off of Cabo Rojo and Guanica on the southern coast, were identified in the study by Ojeda et al. (2007b), with the latter suspected as being depleted. The third site was not identified by Ojeda et al. (2007b), but was reported separately by an additional fisherman. This was Manchas Exteriores, an elevated ridge located just outside Mayaguez Bay on the west coast.

Acoustic mapping followed the methods of Rowell et al. (2011). Drift transects (engines off to reduce surface and flow noise) were conducted over suspected locations from a small boat equipped with a fathometer and map GPS to locate depth and position. Surveys were done 5 to 10 days after the full moons of January and February in the late afternoon – early evening, when red hind are known to increase their rate of calling (Mann et al. 2010). During each transect, a hydrophone connected to digital audio recorder ((M-Audio MicroTrack II) was lowered over the side to a depth of 1 - 2 m off the bottom. A handheld GPS was used to simultaneously record the geographic coordinates of the drift track. A head set connected to the audio recorder allowed for real-time monitoring of red hind calls. A single transect continued until no more calls were heard. To identify the spatial limits of the aggregations, the occurrences and intensities of individual red hind calls were subsequently charted with their GPS locations in a geographic information system.

RESULTS

Figure 1 shows the results of the mapping surveys to determine the southern boundary of the aggregation at Abrir la Sierra. The previously mapped area of aggregating red hind spanned a distance of 400 m along the shelf. New surveys found the southern margin to extend another 1.8 km along the shelf edge. However, only a few red hind were heard further than 1.2 km to the south. Even within the area wherein red hind calls were heard consistently, there were variations in the frequency and intensity of calls, indicating that red hind were not uniformly distributed within this range. Despite this greater extent, all of the mapped areas are within the boundaries of the seasonal closure area managed by the Caribbean Fisheries Management Council.

Passive acoustic mapping confirmed the presence of aggregating red hind at Manchas Exteriores (Figure 2). Two additional drift transects, not shown in Figure 2, were conducted further south, but no red hind calls were detected. No diver surveys were conducted to further confirm this site due to its proximity to a sewage outfall.

Figure 3 shows the results of the passive acoustic surveys at Buoy 4. Again, the presence of aggregating red hind was detected. The initial part of this survey was conducted during the period of strong north to south tidal currents. These strong currents coupled with moderate wave and wind motion resulted in differing velocities between the drifting hydrophone and vessel and the flowing water mass, as well as swell-generated vertical motion. During such conditions, unwanted flow noise and cable strumming were dominant in the recordings, possibly masking red hind calls. Transects during this time did not record red hind calls, even where fish were later heard (Figure 3). However, strong currents are also thought to inhibit territorial and courtship behavior and thus reduce calling activity (unpublished observations). At slack tide, currents were greatly reduced and had a more westerly component. During this time red hind calls were frequently heard along multiple transects (Figure 3).

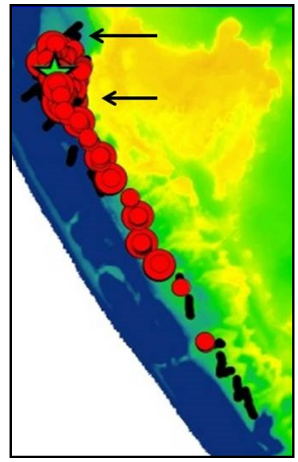

Figure 1. Passive acoustic mapping of red hind calls at Abrir la Sierra off the west coast of Puerto Rico. Red dots indicate locations where red hind calls were heard, with the size of the dot indicating number of calls. Small black dots indicate drift tracks where no calls were heard. Arrows indicate the boundaries of the previous mapped extent reported by Rowell et al. 2011.

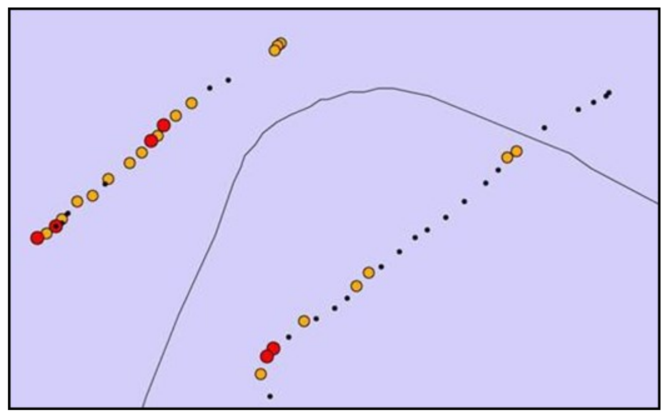

Figure 2. Passive acoustic mapping of red hind calls at Machas Exteriores west of Mayaguez, Puerto Rico. Colored dots indicate locations where red hind calls were heard, with the intensity of red indicating increasing number of calls. Small black dots indicate drift tracks where no calls were heard.

Divers subsequently visited this site for visual confirmation and to place a long-term passive acoustic recorder to monitor the dynamics of the aggregation over the course of the spawning season.

No red hind calls were heard during the survey conducted off of Guanica (Figure 4). However, transects

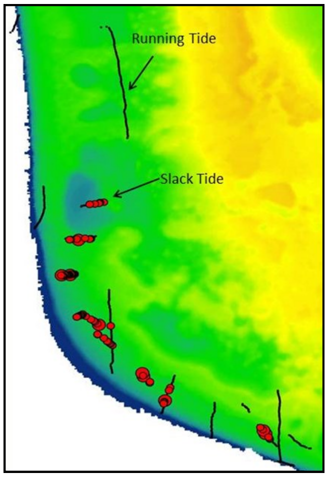

Figure 3. Passive acoustic mapping of red hind calls at Buoy 4 off the west coast of Puerto Rico. Red dots indicate locations where red hind calls were heard, with the size of the dot indicating number of calls. Small black dots indicate drift tracks where no calls were heard. North-south (vertical) tracks occurred during a strong running tide; others were done during slack tide (see arrows).

were made during a period of strong wind and high waves, which resulted in substantial flow and cable strumming noise that may have interfered with detection of red hind calls. Thus, while the results were consistent with reports of the aggregation(s) off Guanica being depleted, the absence of any calls detected could alternatively be related to noise interference or to the aggregations occurring in a slightly different location than for those areas surveyed. Sea conditions limited the time in which transects could be conducted and prevented returning to the site during aggregation time.

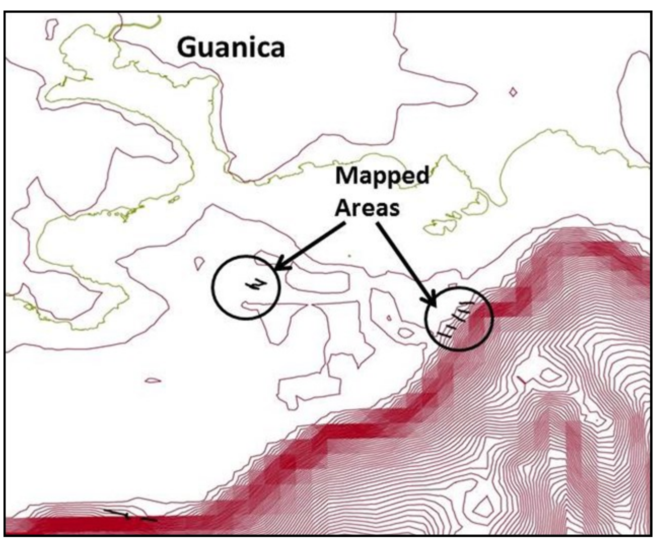

Figure 4. Location of passive acoustic drift surveys (short black lines within circles) for red hind along the shelf off Guancia, Puerto Rico. No red hind calls were detected.

DISCUSSION

In this study, passive acoustic mapping was successfully used to detect/confirm the presence of aggregating red hind and to define the extent of known aggregation sites. Determining the exact location of spawning aggregations allows for targeted management actions related to both enforcement activities and the assessment of spawning stock size and condition. In particular, the newly confirmed site off Buoy 4 was subsequently monitored using a long term passive hydroacoustic recorder and visited by divers. These baseline data will facilitate future surveys to assess spawning stocks efficiently.

This study also confirmed the value of using fishermen's traditional knowledge, both in its efficacy and veracity, for locating spawning aggregation sites. Such information has been critical in other studies mapping the location of spawning aggregations within the region (e.g., Claro and Lindeman 2003, Cowie-Haskell and Delaney 2003), which supports continued and enhanced collaboration between scientists, managers and fishers for the protection of these critical life-stage events. In particular, it suggests that more effort is warranted toward documenting the aggregation sites identified by Ojeda et al. (2007b), with priority given to those species currently threatened or which have high overall value in the present fishery, such as red hind. The application of the ecosystem approach towards management is slowly but steadily gaining credence within the region (Mahon et al. 2011) and must be incorporated into future efforts toward coastal and marine spatial planning. Spatial and temporal information on fish spawning aggregations will be critical inputs if these approaches are to be successful.

The use of passive acoustic methods could be expanded to locate aggregations of other soniferous fishes. However, this approach depends on documenting species specific sounds associated with spawning activity (courtship associated sounds). To date, most activity has focused on groupers, with species specific calls now documented for the red hind (Mann et al. 2010), and the goliath (Mann et al. 2009), yellowfin (Schärer et al. 2012a), Nassau (Schärer et al. 2012b) and black (Schärer et al. 2014) groupers. Additionally, this approach is limited to the peak days of calling activity as spawning approaches and the peak hours of the day, which may be species specific. These limitations are similar to those faced by divers. The advantage of passive acoustic surveys is that a greater area or various sites can be assessed simultaneously within a given amount of time.

Tidal currents and wave and wind action were found to have a significant impact on the ability to detect red hind calls, primarily cable strumming. Technological improvements that dampen vibrations could eliminate strumming, such as cable fairing, oil filled enclosures, and spar buoy systems. This may not only increase the range of conditions under which surveys can be conducted, but eventually may allow for active towing surveys as previously utilized in marine cetacean studies (Yack et al. 2013). The latter would greatly increase the area that could be covered per time and would be particularly valuable in areas of high current, which characterize most known aggregation sites around Puerto Rico. Hydrophones have previously been deployed on autonomous underwater gliders, which have no motor noise, to map the distribution of fish sounds over long distances (Wall et al. 2012), but this technology is not practical for use in areas of strong current or where fish may be located along a specific depth range along the insular shelf edge.

ACKNOWLEDGEMENTS

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