Detection of Mona Island and Abrir La Sierra, Puerto Rico Red Hind (*Epinephelus guttatus*) 1 m Off the Bottom with Hydroacoustic Techniques

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ABSTRACT

Quantifying fish abundance at spawning aggregation sites is critical for assessing stock status, but methods must overcome limitations posed by weather and labor-intensive diver-based surveys. This study attempts to quantify red hind (*Epinephelus guttatus*) utilizing hydroacoustic techniques. Here, we summarize the preliminary results for hydroacoustic surveys conducted at spawning aggregations at Mona Island (MI) and Abrir La Sierra (ALS), PR during January 7 and February 3 - 4, 2010, where we targeted fish within 1 m off the bottom only. A total of 14.519 km at MI and 3.465 km at ALS of hydroacoustic transects were collected. Fish in the 30 - 35 cm size class and larger were absent during January, but their abundance increased during February at both MI and ALS. This suggests the arrival of larger fish, which correlates with the data obtained by divers, except that the hydroacoustic data show an influx of fish sizes > 45 cm whereas divers observed an increase in fish below this size. The proportion of fish in the size classes 35 - 40 and 40 - 45 cm observed by divers seems to be skewed right when compared to the hydroacoustic data. The number of fish (n) per hydroacoustic survey is very similar for the month of February both for MI and ALS (n = 92, 114, 98, and 132, respectively). At ALS, fish target strengths (TS) values that coincide with calibration TS values for *E. guttatus* were detected within 1 m off the bottom, showing that the hydroacoustic system used can detect TS of fish close to the bottom. Fish density estimates of red hind at Mona Island were made for "IN" versus "OUT" the known spawning aggregation area. These data also show that spawning aggregation sites for red hind can be detected with active hydroacoustic methods within 1 m off the bottom.

KEY WORDS: Hydroacoustics, *Epinephelus guttatus*, SPAGS

Detección de Meros Cabrilla (*Epinephelus guttatus*) en Isla de Mona y Abrir La Sierra, Puerto Rico a 1m del Fondo con Técnicas de Hidroacústica

La abundancia de peces de arrecife en áreas de agregaciones reproductivas ó de desove es crítica para determinar el estado de su stock, pero los métodos deben superar limitaciones creadas por las condiciones del tiempo y el uso de buzos que requiere mucho esfuerzo para llevar a cabo censos visuales. Este estudio intenta cuantificar la densidad del mero cabrilla (*E. guttatus*) utilizando técnicas hidroacústicas. Aquí resumimos los resultados preliminares para censos hidroacústicos conducidos en las agregaciones reproductivas que desovan en Isla de Mona (MI) y Abrir La Sierra (ALS), PR durante el 7 de enero y el 3-4 de febrero de 2010, donde buscamos los peces a 1 m del fondo solamente. Un total de 14.519 kilómetros en MI y 3.465 kilómetros en ALS de transectos hidroacústicos fue coleccionado. Los peces en la talla de tamaño de 30-35 cm y más grande estuvieron ausentes en enero, pero su abundancia aumentó en febrero tanto en MI como en ALS. Esto sugiere la llegada de peces más grandes, que guarda correlación con los datos obtenidos por buzos, salvo que los datos hidroacústicos muestran un influjo de tamaños de peces > 45 cm mientras que los buzos observaron un aumento de los peces por debajo de este tamaño. La proporción de peces en las tallas de 35-40 y 40-45 cm observadas por los buzos parece estar desplazada hacia la derecha comparada con los datos hidroacústicos. El número de peces (n) por censos hidroacústicos es muy parecido para el mes de febrero para MI y ALS (n=92, 114, 98 y 132, respectivamente). En ALS, la intensidad de la onda acústica reflejada de los peces (TS) que coincide con los valores de calibración para *E. guttatus* se detectaron a 1 m del fondo, demostrando que el sistema de hidroacústica utilizado puede discriminar la presencia de peces cerca del fondo. Estimados de densidad de peces para el mero cabrilla en Isla de Mona fueron determinados para áreas "dentro" y ""fuera" del área de agregación reproductiva. Estos datos también demuestran que áreas de agregación reproductiva para el mero cabrilla pueden ser detectadas con métodos hidroacústicos activos a 1 m del fondo.

PALABRAS CLAVE: Hidroacústica, *Epinephelus guttatus*, SPAGS

Détection de Mérou Couronné (*Epinephelus guttatus*) À l'Île de Mona et Abrir La Sierra, Puerto Rico 1 M du Fond avec Hydroacoustique Techniques

Le fait de quantifier l'abondance de poisson aux sites d'agrégation frayants est critique pour évaluer le statut de stock, mais les méthodes doivent surmonter des restrictions posées par le temps et les enquêtes à base de plongeur qui nécessite l'emploi d'une forte main-d'oeuvre. Cette étude essaie de quantifier la mérou couronné (*E. guttatus*) le fait d'utiliser des techniques hydro-acoustiques. Ici nous résumons les résultats préliminaires pour les enquêtes hydro-acoustiques accomplies aux agrégations frayantes à Mona Island (MI) et Abrir La Sierra (ALS), PR pendant le 7 janvier et le 3-4 février 2010, où nous avons visé le poisson dans 1 m du fond seulement. Un total de 14.519 kms à MI et 3.465 kms à ALS d'hydro-acoustique transects a été recueilli. Le poisson dans la classe

de grandeur de 30-35 centimètres et plus grand était absent en janvier, mais leur abondance a augmenté en février tant à MI qu'à ALS. Cela suggère l'arrivée de plus grand poisson, qui est en corrélation avec les données obtenues par les plongeurs, sauf que les données hydro-acoustiques montrent un afflux de grandeurs de poisson> 45 centimètres alors que les plongeurs ont observé une augmentation dans le poisson au-dessous de cette grandeur la proportion de poisson dans les classes de grandeur 35-40 et 40-45 centimètres observés par les plongeurs semble être déformée le droit quand comparé aux données hydro-acoustiques. Le nombre de poisson (n) par enquête hydro-acoustique est très semblable pour le mois de février tant pour MI qu'ALS (n=92, 114, 98 et 132, respectivement). À ALS, le poisson vise des forces (TS) les valeurs qui coïncident avec l'étalonnage les valeurs de TS pour *E. guttatus* ont été découvertes dans 1 m du fond, en montrant que le système hydro-acoustique utilisé peut découvrir TS de poisson près du fond. Les estimations de densité de poisson de mérou couronné à Mona Island ont été faites pour "DANS" contre "SUR" de la région d'agrégation frayante connue. Ces données montrent aussi que le fait d'engendrer des sites d'agrégation pour la mérou couronné peut être découvert avec les méthodes hydro-acoustiques actives dans 1 m du fond.

MOTS CLÉS: Hydroacoustique, *Epinephelus guttatus*, SPAGS

INTRODUCTION

This work summarizes the operational accomplishment for the Hydroacoustic Survey (HAS) of fish at Mona Island, Puerto Rico during January 7 and February 3 - 4, 2010. The survey was conducted as part of the passive hydroacoustic study which is attempting to quantify red hind (*Epinephelus guttatus*) utilizing their spawning aggregation vocalizations as an index of population density.

This project is funded by the National Oceanic and Atmospheric Administration (NOAA) grant to the Caribbean Coral Reef Institute (CCRI) at the University of Puerto Rico at Mayagüez. The Institute is based at Magueyes Island, Lajas which is administered by the Department of Marine Science. This specific grant has been subcontracted to Polytechnic University of Puerto Rico located in Hato Rey. This study utilizes equipment provided by the NOAA Fisheries, Southeast Fisheries Science Center, Miami Laboratory, Biodiversity and Protected Resources Division.

OBJECTIVES

The main objectives of this project are to obtain fish size and density information for the submerged shelf at the Mona Island red hind spawning aggregation site using active and passive hydroacoustic techniques. This specific study covers the active hydroacoustic preliminary findings. The goal is to combine passive and active hydroacoustic survey methods of reef fish and diver surveys at the same locations to provide validation of red hind size and density. If hydroacoustic survey methods proof accurate, then these methods can be used to survey large submerged shelf areas to help locate other red hind spawning aggregations quickly and remotely.

The data collected will be made available to fisheries and MPA managers for elaboration or modification of fisheries regulations, protection of stocks and status of fisheries resources.

METHODS

Data Collection

The survey tracks obtained during February 3 - 4, 2010 can be seen in Figure 1. The route surveyed followed the shelf and crisscrossed it in the search for fish echoes.

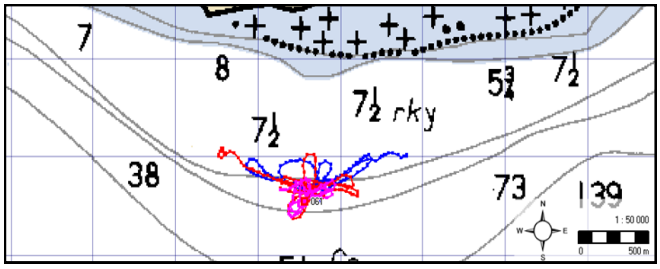

Figure 1. Mona Island survey site. Survey track color indicates date and time. The blue color was collected on February 3 at 10:32 am, the red color at 5:06 pm and the purple color was collected on February 4 at 8:57 am. Depth values are in fathoms.

All hydroacustic data position information was obtained utilizing a ComNav Marine Ltd. Navigator G4 GPS with WAAS enabled. An additional Garmin 76 portable GPS was used to collect and provide navigation data for boat maneuvering. The vessel Cove Island was used as the survey platform. Transects were traversed at a boat speed of approximately 4 - 5 knots. The planned survey was structured to follow up to approximately 1 km, East and West of the station site which was marked by a surface float.

Echo integration sampling sequence intervals were used to define the minimum spatial areas of resolution over which to estimate fish density during field data collection. A five minute sequence duration was used to collect the data. The overall acoustic repetition (ping) rate of the hydroacoustic system was 5 pings per second. This results in sampling strata or cells of approximately 5 m in depth all the way to the sea bottom. The configuration file used was PR_2010_Rivera_6EeePC.cfg. The bottom line of reference was manually traced using the BotEdit tool in HTI EchoScape processing software. Data selection was accomplished importing the DEP .raw file into the Excel spreadsheet program available in Windows Office 2007. Data was parsed to select for TS values of -42 to -30 dB which convert to a fish size range of 16.5 to 59.5 cm (this is the size range for red hind obtained by diver visual surveys). The TS values were converted to size (cm) using the following equation; *fish size (cm) = (2165)*exp (.12* (TS))* (Figure 2). In addition, only TS values within 1m off the bottom were used for this analysis since red hind usually seeks bottom instead of the water column for abode.

This behavior was confirmed by diver observation at the study site.

Hydroacoustic Equipment

Split-beam hydroacoustic systems (Model 244, Hydroacoustic Technology Incorporated, Seattle, WA) operating at 120 kHz (Transducer Model 541S) with a 6° circular beam were used for the HAS. Data were recorded to computer and DAT tape during field collection utilizing the program DEP, and later analyzed using EchoScape, both programs are an HTI data entry and analysis program.

The transducer was oriented straight down in the water column and mounted on a 1 m long aluminum dead-weight towing vehicle. The transducer depth was approximately 1 – 1.5m when towed. The maximum sample depth was approximately 60 m.

The survey system collected the hydroacoustic data files directly to a notebook computer. All data were also concurrently recorded to DAT tape, providing an ultimate data backup of the unfiltered digital samples for later reprocessing as digital samples. Differential or WAAS enabled (Wide Area Augmentation System) Global Positioning System (GPS) receiver (ComNav G4) were interfaced with all hydroacoustic and navigation systems to provide position to within approximately 3 m. The GPS receiver was connected to an external antenna which was positioned amidship.

Prior to the survey period, the hydroacoustic system used in this study was calibrated relative to a US Naval standard transducer of known sensitivity.

Vessel Navigation

All fish density data were successfully collected during January 7 and February 3 - 4, 2010 aboard the vessel Cove Island. Navigation was accomplished utilizing a Garmin 76 portable GPS which displayed distance and bearing from the site location which was also marked by buoy as a visual reference. In addition, the ship's 200 kHz fathometer displaying depth in meters would also provide confirmation in better detail of the bathymetry than the nautical chart to ensure staying within the shelf limits. In

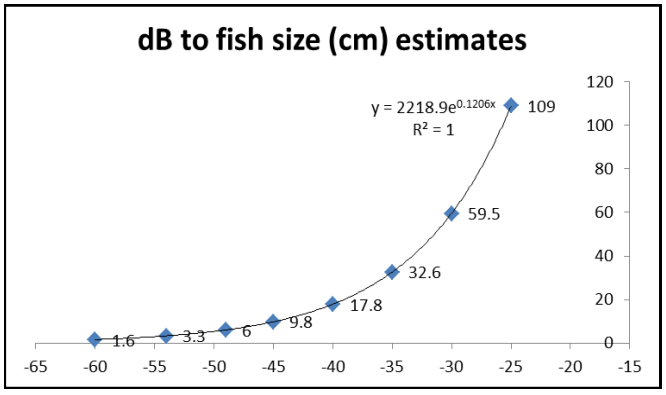

Figure 2. Fish size in cm estimates from target strength (TS) values in dB.

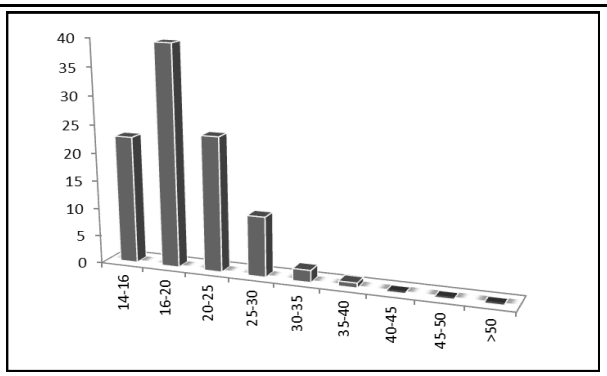

Figure 3. Size frequency bins in cm as percent of fish size within 1m off the ocean bottom. Data collected on January 7, 2010 at 1300 hours at Mona Island. n = 233.

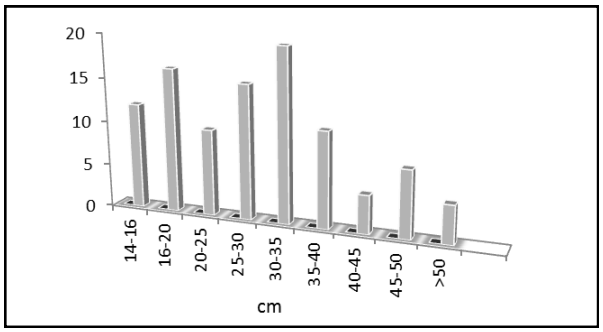

Figure 4. Size frequency bins in cm as percent of fish size within 1m off the ocean bottom. Data collected on February 3, 2010 at 1032 hours at Mona Island. n = 92.

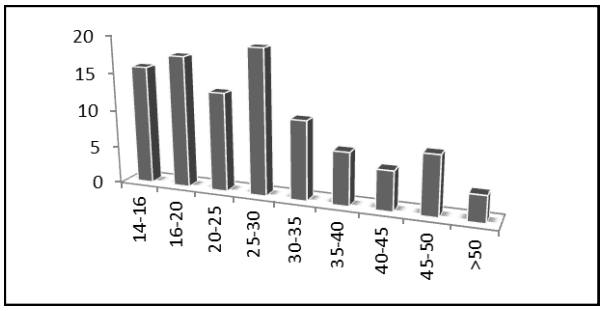

Figure 5. Size frequency bins in cm as percent of fish size within 1m off the ocean bottom. Data collected on February 3, 2010 at 1706 hours at Mona Island. n = 114.

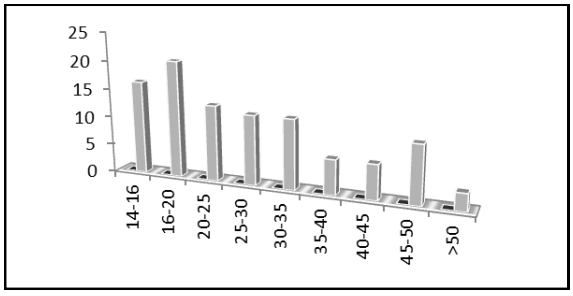

Figure 6. Size frequency bins in cm as percent of fish size within 1mof the ocean bottom. Data collected on February 4, 2010 at 0857 hours at Mona Island. n = 98.

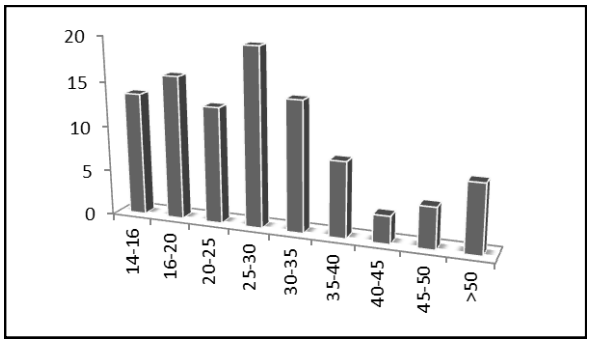

Figure 7. Size frequency bins in cm as percent of fish size within 1mof the ocean bottom. Data collected on February 4, 2010 at 1805 hours at ALS.. n = 132.

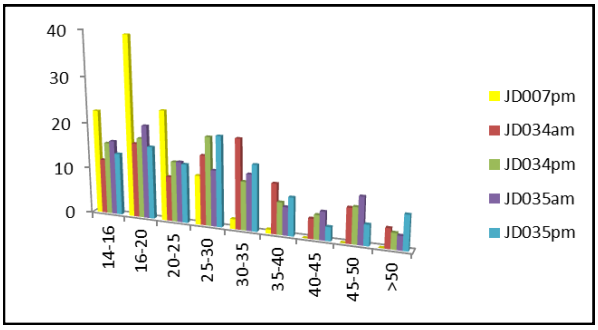

Figure 8. Size frequency bins in cm as percent of fish size within 1m off the ocean bottom. Data collected on January 7 (JD007pm), February 3 (JD034am & pm) and February 4, 2010 (JD035am &pm). Survey accomplished with an HTI model 244, 120 kHz hydroacoustic system. Survey conducted to quantify red hind (*Epinephelus guttatus*) spawning aggregation at Mona Island and Abrir La Sierra (ALS; JD035pm).

Table 1. Data collection files summary statistics.

File Name	GPS Points	Transect length in km	Sequence number	Location
S0071318	na	~3.000	5	Mona
S0341032	177	4.065	7	Mona
S0341706	154	4.436	7	Mona
S0350857	112	3.018	5	Mona
S0351805	118	3.465	6	ALS

this area the shelf edge is very narrow and deep. Surveys consisted of transects intersecting the surface buoy mostly parallel to the shelf edge. Survey transects depth range was generally between 20 - 40 m although turns along the edge of the continental shelf reached approximately 60 m.

Data Analysis

Data files S0071300, S0341032, S0341706, S0350857 and S0351805 were collected and analyzed for this study (Table 1). Number of fish per size class estimates for each data file summarized in Table 2 and in Figures 2 - 8.

Estimations of fish sizes are based on the equation of Love, 1971 defined as:

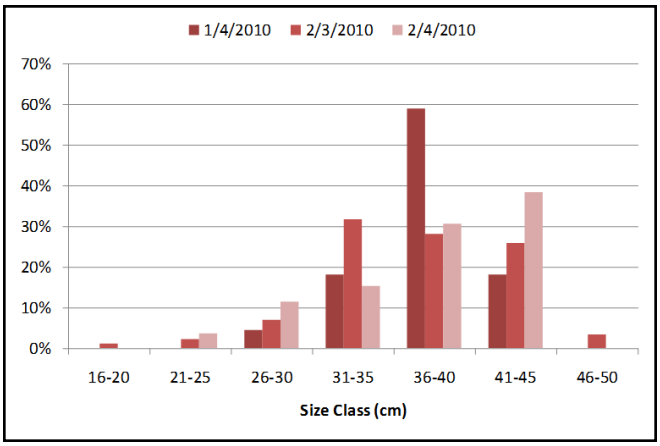

Figure 9. Diver visual survey data for red hind. Length frequency distribution for three survey dates. Proportion based on the totals for each day. Data from Dr. Michelle Scharer.

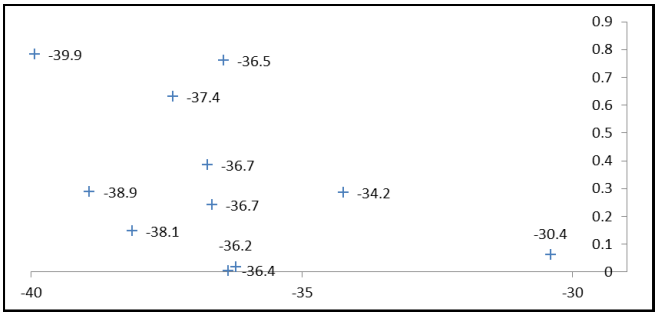

Figure 10. Abrir la Sierra site target strength (TS in -dB) versus distance off the bottom (m, vertical axis) for echoes which TS are inferred to be red hind based on the similarity of the TS to the calibration TS value for red hind. A TS of -40 dB is equivalent to a 17.8 cm size fish, a -30 dB is equivalent to a 59.5 cm size fish based on a conversion of TS to size using Love, 1971 formula.

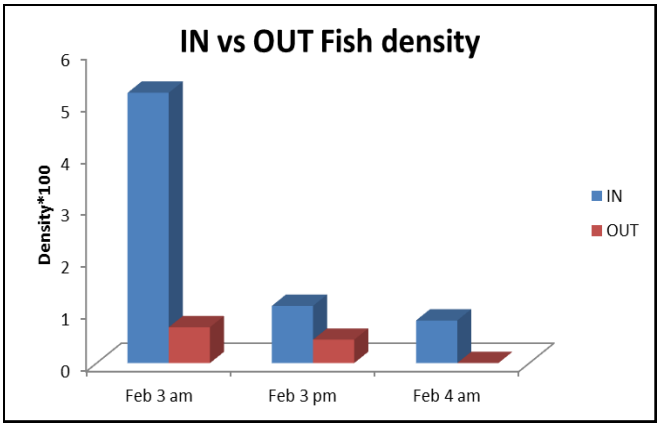

Figure 11. Fish density (*100) within (IN) and outside (OUT) of red hind spawning aggregation site at Mona Island during February 3-4, 2010. Density estimates are based on a hydroacoustic survey data analysis.

Table 2. Size frequency bins in cm as percent of fish size within 1m of the ocean bottom for Mona Island hydroacoustic survey. Survey conducted on January 7 (JD007)and February 3-4, 2010 (JD034 & JD035).

	JD007pm		JD034am		JD034pm		JD035am		JD035pm	
bin (cm)	freq	%	freq	%	freq	%	freq	%	freq	%
14-16	53	22.75	11	11.96	18	15.79	16	16.33	18	13.64
16-20	92	39.48	15	16.30	20	17.54	20	20.41	21	15.91
20-25	56	24.03	9	9.78	15	13.16	13	13.27	17	12.88
25-30	25	10.73	14	15.22	22	19.30	12	12.24	26	19.70
30-35	5	2.15	18	19.57	12	10.53	12	12.24	19	14.39
35-40	2	0.86	10	10.87	8	7.02	6	6.12	11	8.33
40-45	0	0.00	4	4.35	6	5.26	6	6.12	4	3.03
45-50	0	0.00	7	7.61	9	7.89	10	10.20	6	4.55
>50	0	0.00	4	4.35	4	3.51	3	3.06	10	7.58
n	**233**		**92**		**114**		**98**		**132**	

Table 3. Estimates of fish density based on hydroacoustic survey transects at Mona Island. Data collected on February 3-4, 2010. Data is presented as IN and OUT of the main red hind aggregation site area. All February 4 data was collected only IN site area. The value "n" is based on TS values which are inferred to

	n		density				Total transect length (km)	OUT transect length (km)
Date	IN	OUT	IN		OUT			
			m^2	*100m	m^2	*100m		
Feb 3 am	194	33	.052	5.2	.0069	.69	4.065	2.275
Feb 3 pm	61	16	.01	1.1	.0045	.45	4.436	1.660
Feb 4 am	52	na	.0082	.82	na	na	3.018	na

TS=19.1*log (L) -.0.9*log (f) -62.0, where,
TS = target strength (dB)
L = length of the fish (cm)
f = frequency of transmitted sound (kHz)

Spawning Aggregation Site Fish Density Calculation

The length of survey transect inside (IN) and outside (OUT) of the red hind spawning aggregation site were calculated utilizing a scaled plot of the survey track utilizing the string method. The hydroacoustic transducer (6^o) beam diameter was calculated as the average for a depth range of 15 to 25 m. This resulted in an average beam diameter of 2.1 m. This beam diameter was then multiplied times the the transect length for each location studied (IN and OUT). The value ¨n¨ for each location and each survey date was then divided by the respective area (m^2) to obtain a density/m^2. This value was then multiplied times 100 to obtain a density/100 m value. These data are summarized in Table 3 and Figure 11.

RESULTS AND DISCUSSION

A total of 17.984 km (14.519 km at Mona Island and 3.465 km at ALS) of hydroacoustic transects were collected. Fish abundance in the 30-35 cm size class and larger is absent during the month of January, 2010. The abundance increases for the February, 2010 surveys at both Mona Island and ALS sites. This suggests the arrival of fish class sizes which correlate with the data obtained by divers (see Figure 9) although the hydroacoustic data shows an influx of fish sizes > 45 cm which the diver survey does not show. The proportion of frequency for the size classes 35 - 40 and 40 - 45 cm by divers seems to be skewed right when compared to the hydroacoustic data. The same data is underestimated by 66% in the hydroacoustic data set when compared to the diver data. Amazingly, the number of fish (n) per hydroacoustic survey is very similar for the month of February, 2010, both for Mona Island and ALS (n = 92, 114, 98 and 132). At ALS, fish target strengths (TS) values that coincide with calibration TS values for *E. guttatus* were detected within 1 m off the bottom, showing that the hydroacoustic system used can detect TS of fish close to the bottom (see Figure 10). Fish density estimates of red hind at Mona Island were made for "IN" versus

"OUT" the known spawning aggregation area (see Table 3 and Figure 11). These data show that spawning aggregation sites for red hind can be detected with active hydroacoustic methods within 1m off the bottom. This study continues refining the data collection and analysis techniques and final conclusions have not been reached.

LITERATURE CITED

Johnston, S.V., J.A. Rivera, A. Rosario, M.A. Timko, P.A. Nealson, and K.K. Kumagai. 2006. Hydroacoustic evaluation of spawning red hind (*Epinephelus guttatus*) aggregations along the coast of Puerto Rico in 2002 and 2003. *NOAA, National Marine Fisheries Service Professional Paper* **5**:10-17.

Love, R.H. 1971. Dorsal-aspect target strength of an individual fish. *Journal of the Acoustical Society of America* **49**:816-823.