Linking Hydroacoustics with Simple Optical Groundtruthing for the Assessment of Spawning Aggregations: A Case Study with Nassau Grouper (*Epinephelus striatus*)

Vinculación de la Hidroacústica con una Simple Operación de Campo Óptica para la Evaluación de Agregaciones de Desove: Un Estudio de Caso con Nassau Grouper (*Epinephelus striatus*)

Relier L'hydroacoustique à une Simple Surveillance Optique du Sol pour L'évaluation des Concentrations de Géniteurs: Une Étude de Cas avec Nassau Grouper (*Epinephelus striatus*)

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EXTENDED ABSTRACT

Nassau grouper are known to migrate to specific sites, often at the tips of islands, during periods of winter full moons to reproduce in Fish spawning Aggregations (FSAs) (Sala et al. 2001, Whaylen et al. 2004, Starr et al. 2007). When and where these will occur is therefore predictable and as a result many of these FSAs have been eradicated or reduced to negligible numbers through overfishing (Sadovy de Micheson et al. 2008). The predictability however also gives the opportunity to monitor FSAs and as FSAs are vital life-history events this monitoring is necessary to determine the health of aggregating populations (Sadovy and Colin 2012, Sadovy de Mitcheson 2016), this is especially true of the endangered Nassau grouper (*Epinephelus striatus*). As FSAs often occur at the limits of safe diving operations and can be constrained by strong currents and poor underwater visibility, the aim of these surveys was to determine if hydroacoustic surveys could provide an alternative method to find, assess and therefore inform future management of aggregating fish species. Further, there has been minimal research comparing Underwater Visual Census (UVC) data and the data resultant from hydroacoustics (Zenone et al. 2017).

Data were collected with a Biosonics DTX echosounder with a 200kHz transducer, pole mounted over the side of the survey vessel. The system was calibrated as per the standard methods before the start of the surveys (Foote et al. 1987). The hydroacoustic system was paired with an inexpensive towed Sony CCTV camera with a live wired feed into a laptop computer, used to provide essential groundtruthing of the hydroacoustic data. FSAs were therefore located through analysis of the hydroacoustic data in conjunction with the towed camera (Figure 1). This optic – acoustic system was used to locate Nassau grouper FSAs at sites on the West end of Little Cayman (LCW), and East ends of Grand Cayman (GCE) and Cayman Brac (CBE). At the sites of GCE and CBE, the current status of these historic FSAs was unknown (Bush et al. 2007). Fish abundance at each FSA was gained through echo integration, to determine fish density, and then these densities were multiplied by FSA extent. Concurrent SCUBA UVC surveys occurred on the LCW FSA and these numbers were compared with hydroacoustic estimates. The SCUBA surveys run by the REEF Grouper Moon Project also provided measures of fish total length (TL) by the use of laser callipers. These lengths were scaled by hydroacoustic Target Strengths (TSs) extracted from "tracked fish" on the periphery of the LCW FSA allowing an *in situ* TS to TL formula to be suggested for Nassau grouper (TS = 27.6log10(TL) -147.32).

Acoustic mean fish abundance estimates on the FSA at LCW (893 ± 459SE) did not differ significantly to concurrent SCUBA estimates (1150 ± 75SE). Mean fish densities (fish number per 1,000m^3) were significantly higher at LCW (33.13 ± 5.62SE) than at the other sites (GCE 7.01 ± 2.1SE, CBE 4.61 ± 1.16SE). Application of the TS to TL formula revealed mean fish TL was significantly higher at LCW (65.4 cm ± 0.7SE) than GCE (60.7 cm±0.4SE), but not CBE (61.1 cm ± 2.5SE) (Figure 2). Use of other empirical TS to TL formula resulted in underestimation of fish length in comparison to diver measurements, highlighting the benefits of secondary length data and deriving specific TS to TL formula for the population to be surveyed. The location of the FSAs was examined with reference to seasonal marine protected areas (Designated Grouper Spawning Areas) and this showed FSAs were partially outside these areas at GCE and very close to the boundary at CBE. With all these results, it should be noted that the LCW FSA was surveyed closest to the full moon (2 days after), whereas the CBE FSA was surveyed 4 days after the full moon and the FSA at GCE surveyed 5 and 6 days after the full

moon. It is likely therefore that the acoustics results presented underestimate the total abundances of individuals in these FSAs as they do not account for the most active times i.e. closer to the full moon. Therefore, we recommend that in order to fully evaluate a given FSA, hydroacoustic surveys should be conducted both across days and at multiple times per day in order to increase the probability of capturing peak abundance at any given FSA.

Hydroacoustics has proven to be capable of locating FSAs in historic areas where it was unknown whether fish were still aggregating. This also means that acoustics can be used to search for aggregations in new locations and used in situations when diving surveys are impractical or hazardous. We have shown that surveying FSAs with hydroacoustics produces fish count information comparable to that from diver estimates and can provide additional information e.g. fish size, when groundtruthing is also provided. Further, we demonstrate how a simple and inexpensive camera system can provide this essential groundtruthing. Repeat annual hydroacoustic surveys over the same sites could yield much information on how exploited FSAs are recovering and could assist with the vital monitoring of endangered aggregating populations.

KEYWORDS: Hydroacoustics, Nassau Grouper (*Epinephelus striatus*), fish spawning aggregations (FSAs), echo integration.

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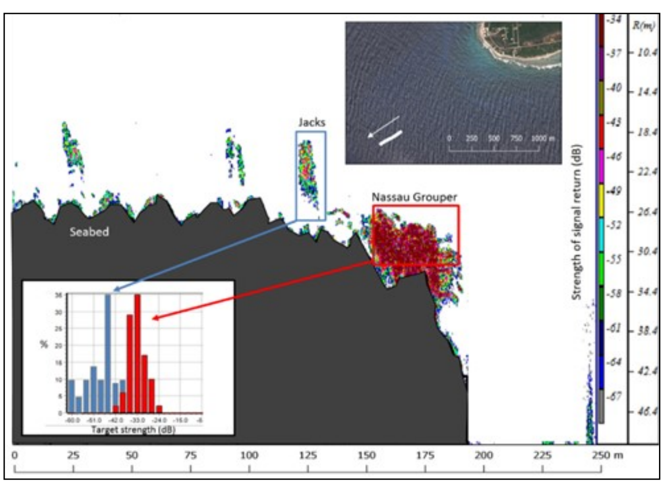

Figure 1. How fish Target Strengths vary with different species.

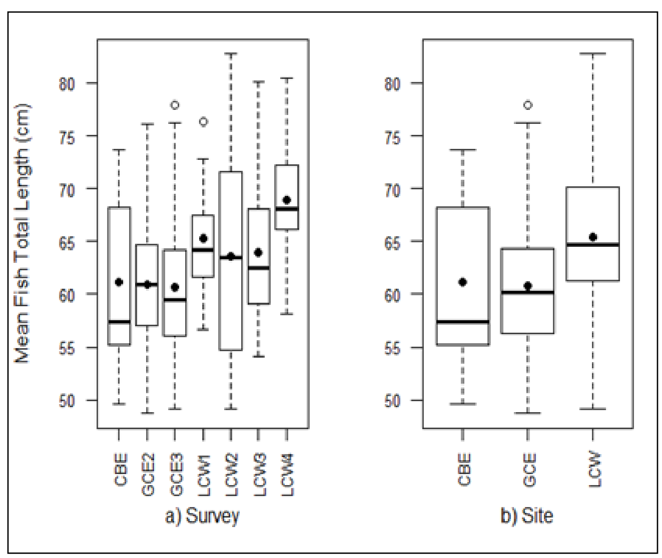

Figure 2. Resultant Nassau grouper lengths at the FSAs surveyed.