Characterizing the Spatio-temporal Distributions of a Red Hind, *Epinephelus guttatus*, Fish Spawning Aggregation in St. Croix, U.S. Virgin Islands: Using Acoustic Telemetry for Conservation and Management

Caractérisation des Distributions Spatio-temporelles d'un Hérisson Rouge, *Epinephelus guttatus*, Agrégation de Frai de Poissons à Sainte-Croix, Îles Vierges Américaines: Utilisation de la Télémétrie Acoustique pour la Conservation et la Gestion

Caracterización de las Distribuciones Espacio-temporales de un Híbrido Rojo, *Epinephelus guttatus*, Agregación de Desove de Peces en St. Croix, Islas Vírgenes de los EE.UU: Utilización de la Telemetría Acústica para su Conservación y Manejo

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EXTENDED ABSTRACT

Over 200 species of coral reef fishes form fish spawning aggregations (FSA) (Russell et al. 2014) at specific locations and times (Domeier 2012). Red Hind, *Epinephelus guttatus*, form seasonal (Munro et al. 1973, Burnett-Herkes 1975, Shapiro et al. 1993), transient FSAs (Colin et al. 1987), whereby they exhibit high site fidelity with limited migration of 5 - 20 km between their home range and spawning ground (Sadovy et al. 1994, Luckhurst 1998, Nemeth et al. 2007). As a major commercial fishery species in the Caribbean (CFMC 1985; 50 FR 34850) fishing has attributed to its vulnerable status by the International Union for Conservation of Nature, Red List Unit, and risk of extinction if uncontrolled fishing continues (Sadovy de Mitcheson et al. 2012). As a protogynous hermaphrodite (female to male) at about 280-320 mm TL (Sadovy et al. 1992; Shapiro et al. 1993), fishing on FSAs also greatly contributes to its decline causing skewed sex ratios (Whaylen et al. 2004), sperm limitation (Bannerot et al. 1987), hyperstability, and FSA disappearance (Olsen and LaPlace 1978). Additional threats to Red Hind include coastal development which negatively impacts nursery habitats of seagrass meadows and mangrove forests by their removal, increases in non-point source pollution and sedimentation, and climate change, as sea surface temperatures continue to increase, current direction and speed is likely to change, thereby affecting larval disbursement and local recruitment.

The Lang Bank Red Hind Spawning Aggregation Area (LBFSA) is located 16 km east of St. Croix, U.S. Virgin Islands, along a spur and groove scleractinian and octocoral reef formation with a mean depth of 30 m. This marine protected area (MPA) is geographically isolated from its nearest neighboring islands of St. Thomas and Tortola located 60 and 65 km to its north-northeast, and by a deep oceanic trench of 4,200 m. The LBFSA is closed seasonally during known peak spawning months of Red Hind from December to February (Colin et al. 1987, Shapiro et al. 1993, Nemeth et al. 2006). The identification of its fish spawning aggregation (FSA) site by Nemeth et al. (2006) lead to a scientific hypothesis that fish repeatedly cross the nearest (western) MPA boundary during its seasonal closed period. The aim of this study is to test this hypothesis by recording spatio-temporal distributions of Red Hind within the LBFSA between two consecutive spawning seasons, 2014 and 2015, with the use of passive acoustic telemetry.

Range testing was performed by *in-situ* drifts aboard a research vessel before establishing an array comprised of 17 acoustic receivers (VR2W-69 kHz) (Vemco Division, AMIRIX Systems, Halifax, Nova Scotia). Acoustic receivers were spaced 600 m apart with a 400 m radius detection range. During the 2014 the acoustic array was comprised of ten acoustic receivers (500 - 509), with six placed at the FSA site, and four along the expected migratory pathway of Red Hind (Nemeth et al. 2006) along the western MPA boundary (506 - 509) forming an acoustic curtain (Pecl et al. 2006) in testing the null hypothesis (Figure 1). Fish were collected during the week of spawning at the FSA site by fish traps. An effort was made to tag fish of various lengths and of identified sex by performing a gentle fish squeeze along its ventral side to expel gametes (Table 1). Fish tagged (n = 19) had a coded acoustic transmitter (V13-1H or V13-1x, 69 kHz, 180 s delay) (Vemco Division, AMIRIX Systems, Halifax, Nova Scotia) surgically implanted into its body cavity before being released by divers at the FSA site to safeguard against predation, and to observe for post surgical mortality. The 514-day battery life of acoustic transmitters allowed for the transmission of pings from tagged fish to last the entire study period.

Study results revealed almost no detections recorded along the western MPA boundary, with only five detections recorded between two acoustic receivers. Numerous sequential detections recorded along the northwestern MPA boundary identified the presence of a migratory corridor (Figure 1). Although, a detection gap occurred by the flooding of acoustic receiver 520 which resulted in no data being recovered. Peak detections between seasons generally concur with primary spawning months for the U.S. Virgin Islands (Colin et al. 1987, Shapiro et al. 1993, Beets and Friedlander 1999), with peaks in January and February of 2014, composed of 8 (100%) and 5 (62%) tagged fish, respectively, and February and March in 2015, composed of 9 (47%) and 3 (15%) tagged fish, respectively. However, numerous detections were recorded in April 2015, drawing to question the temporal variability of Red Hind that aggregate to spawn within the LBFSA. Lastly,

one tagged fish was detected 17 km from the FSA by an acoustic array in Buck Island Reef National Monument, and one tagged fish was recaptured by a commercial fisher 13 km from the FSA. Both distances traveled concur with migrations between home range and spawning ground for this species (Sadovy et al. 1994, Luckhurst 1998, Nemeth et al. 2007).

In conclusion, we reject the null hypothesis. Fish are not repeatedly crossing the closest (western) MPA boundary during the seasonal closed period, and are exhibiting high site fidelity within the MPA during primary spawning months, and beyond. A migratory corridor was located, but its spatial extent beyond the MPA remains unknown and should be further investigated. Due to numerous detections recorded beyond peak spawning months during the 2015 season, the temporal variability of Red Hind that form the LBFSA remains uncertain and should also be further studied. Therefore, we recommend this study be continued to better understand the spatio-temporal distributions among Red Hind that form the LBFSA by keeping the acoustic array in place for the duration of one calendar year, and by expanding it beyond the MPA's northwestern boundary for determining the

Table 1. Fish tagged with a coded acoustic transmitter in 2014 and 2015 spawning seasons.

Tagged Date	Gender	TL (mm)	Tag Dead Date
2015 Jan 30	Male	456	2016 Jun 27
2015 Jan 30	Female	382	2016 Jun 27
2015 Jan 30	Female	319	2016 Jun 27
2015 Jan 30	Male	355	2016 Jun 27
2015 Jan 30	Female	406	2016 Jun 27
2015 Feb 06	Female	330	2016 Jul 04
2015 Feb 06	Female	268	2016 Jul 04
2015 Feb 06	Female	298	2016 Jul 04
2015 Jan 08	Male	454	2016 Jun 05
2015 Jan 08	Unknown	404	2016 Jun 05
2015 Jan 08	Male	434	2016 Jun 05
2014 Jan 15	Male	390	2015 Jun 13
2014 Jan 16	Unknown	422	2015 Jun 14
2014 Jan 18	Female	310	2015 Jun 16
2014 Jan 18	Female	345	2015 Jun 16
2014 Jan 19	Male	365	2015 Jun 17
2014 Jan 19	Female	365	2015 Jun 17
2014 Jan 19	Female	329	2015 Jun 17
2014 Jan 19	Unknown	342	2015 Jun 17

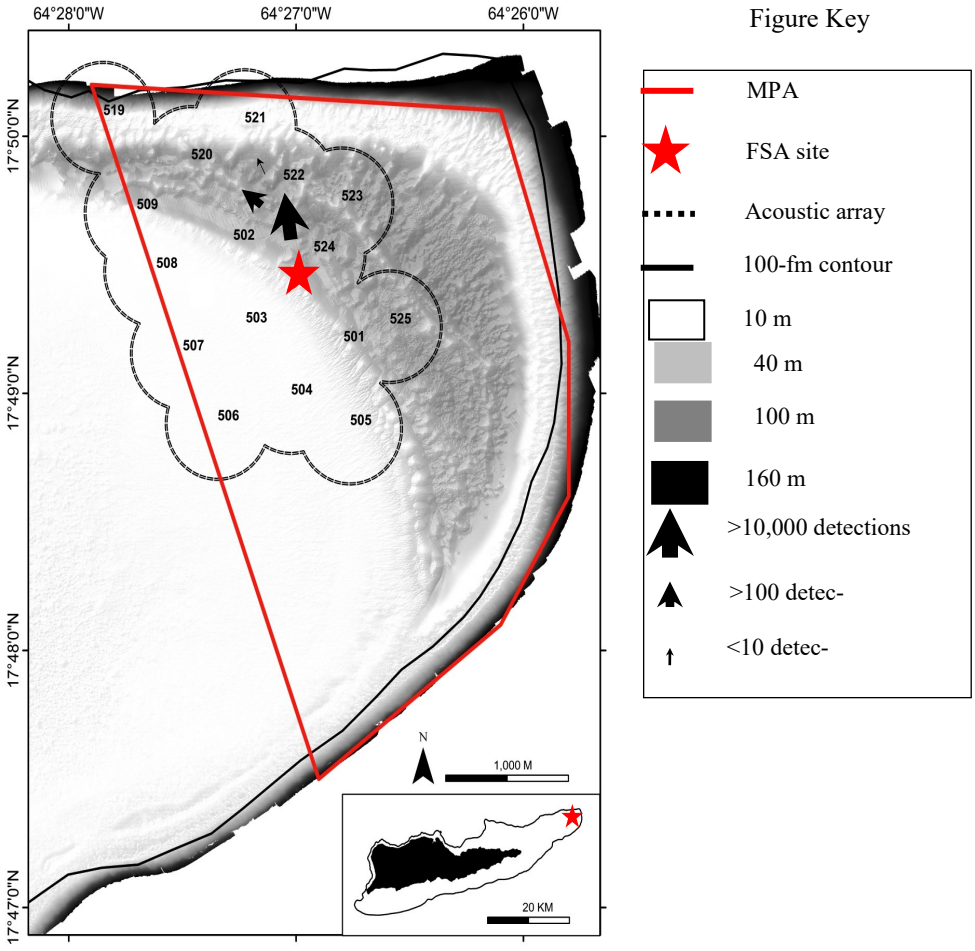

Figure 1. Site map of the Lang Bank Red Hind Spawning Aggregation Area with its acoustic array and migratory corridor displayed.

spatial extent of the migratory corridor. The continuation of this study is critical to safeguard this FSA due to known genetic isolation of Red Hind in St. Croix among its neighboring islands (Portnoy et al. 2013), and in supporting management measures needed for protecting its spawning stock.

KEYWORDS: *Epinephelus guttatus*, fish spawning aggregations, acoustic telemetry, marine protected areas

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