Functional Migration Areas of Dog Snapper *Lutjanus jocu* and Cubera Snapper *Lutjanus cyanopterus* Spawning Aggregations in the U.S. Virgin Islands

Áreas Funcionales de Migración de Perro *Lutjanus jocu* y Cubera Snapper *Lutjanus cyanopterus* Agregaciones Reproductivas en las Islas Vírgenes de EE.UU.

Zones de Migration Fonctionnels de Chien *Lutjanus jocu* et Cubera Snapper *Lutjanus cyanopterus* Frayères dans les Îles Vierges Américaines

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KEY WORDS: Acoustic telemetry, reproduction, catchment

EXTENDED ABSTRACT

Functional migration areas describe movements of reef fish to and from spawning aggregations as well as the spatial distribution of fish within spawning areas and can offer insight to the ecological connectivity of habitats, distribution of resources, population dynamics, and management opportunities within a system. Nemeth (2009) has described a model of the Functional Migration Area (FMA) for aggregating reef fish. The FMA delineates zones of decreasing size based on function and behavior, which range from the catchment area (~1000 km^2), staging area (100 km^2), courtship arena (< 10 km^2) down to the spawning site (1 km^2) and include migration pathways and daily movements. Although many characteristics of spawning aggregations are similar among species, they also display spatial, temporal, and geographic variability (Domeier and Colin 1997). Much of the work describing FMAs has been based on grouper species, while snapper aggregations and FMAs have not been well documented.

Dog snapper *Lutjanus jocu* and Cubera snapper *Lutjanus cyanopterus* form spawning aggregations throughout the Caribbean (Carter and Perrine1994, Domeier et al. 1996, Lindeman et al. 2000, Claro and Lindeman 2003, Whaylen et al. 2004, Heyman et al. 2005) including at the Grammanik Bank, St. Thomas, USVI (Kadison et al. 2006). We used passive acoustic telemetry to track the movement of *L. jocu* and *L. cyanopterus* to and from the spawning aggregation at Grammanik Bank in an effort to describe the FMA for both snapper species.

The Grammanik Bank is located on the Puerto Rican shelf edge, 15 km south of St. Thomas. We used an acoustic receiver array distributed among three sites along the shelf, which included the Grammanik Bank, Tampo, a site 25 km to the east and El Seco, a site 28 km to the southwest. Twenty-two *L. cyanopterus* and 29 *L. jocu* were caught and implanted with acoustic tags at the Grammanik Bank aggregation site in June, July, August, and September 2014. Detections were downloaded from the receivers in December 2014 and again in September 2015. Total detections within the array at the Grammanik Bank were tallied to determine the spawning season for each species. Residence time at receivers within the Grammanik Bank were analyzed using Hot Spot Analysis (Getis and Ord 1992) to determine the extent of the courtship arena and spawning area. A map of movements between receivers was created using ArcGIS. Lines were drawn based on consecutive detections for each fish and a line density raster was created to illustrate the common movement pathways for each species (Hooge et al. 2000). The catchment area was determined by creating a minimum convex hull encapsulating all of the receivers with a successful detection and extending it northward along the shelf to the shoreline, a distance of ~15 km.

Based on detections at the Grammanik Bank, the spawning season for *L. cyanopterus* began in May, peaked in August and concluded in November, while *L. jocu* aggregations formed in every month (Figure 1). Both aggregations showed tight site fidelity within the aggregation area at the Grammanik Bank. Both species were found to reside within a 1.4 - 1.5 km^2 area up to 89% of the time they were within the 15 km^2 array at the Grammanik Bank (Figure 2). This area likely encompasses the courtship arena and spawning site based on detections, observed behavior and prior visual surveys. Individuals of both species (2 *L. jocu*, 2 *L. cyanopterus*) repeatedly moved 28 km southwest to the array at El Seco and 4 different *L. cyanopterus* and 4 *L. jocu* were detected 25 km to the east at the Tampo receiver. There were multiple detections of two *L. jocu* at the El Seco array. The two *L. jocu* travelled between the Grammanik Bank and El Seco a total of six times over the course of three months. Conservative estimates of the catchment area, based on the detections that were the furthest from the aggregation site, were 787 km^2 for both *L. cyanopterus* and *L. jocu* (Figure 2). These estimates of catchment area for *L. jocu* and *L. cyanopterus* indicate that management of the fishery may be uniquely difficult as these fish may be crossing jurisdictions from the U.S. Virgin Islands to Puerto Rico and the British Virgin islands. However, protection of the spawning site may be highly effective given the tight site fidelity of both species.

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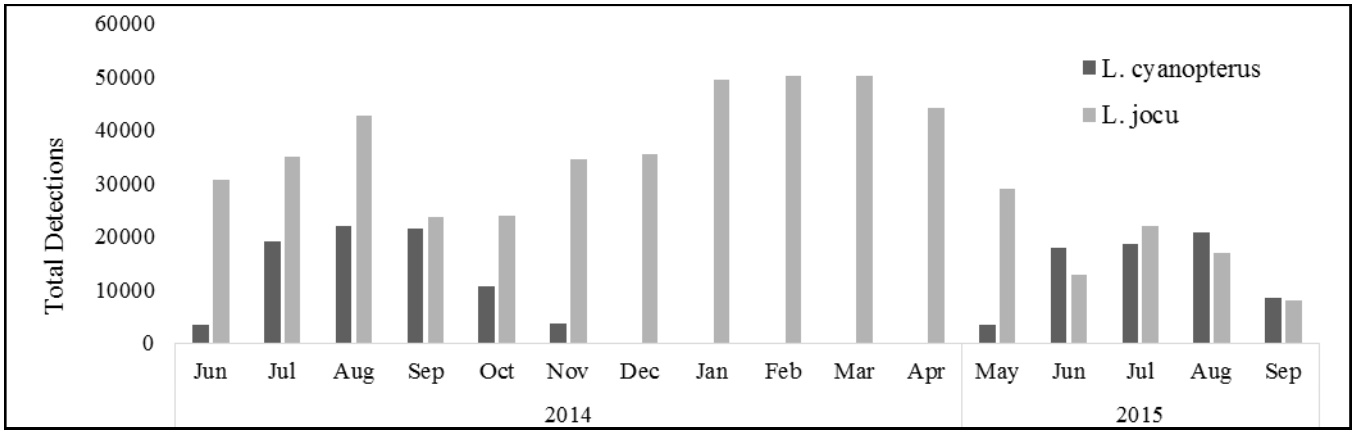

Figure 1. Total detections within the spawning site at the Grammanik Bank receiver array for *L. cyanopterus* and *L. jocu* between June 2014 and September 2015.

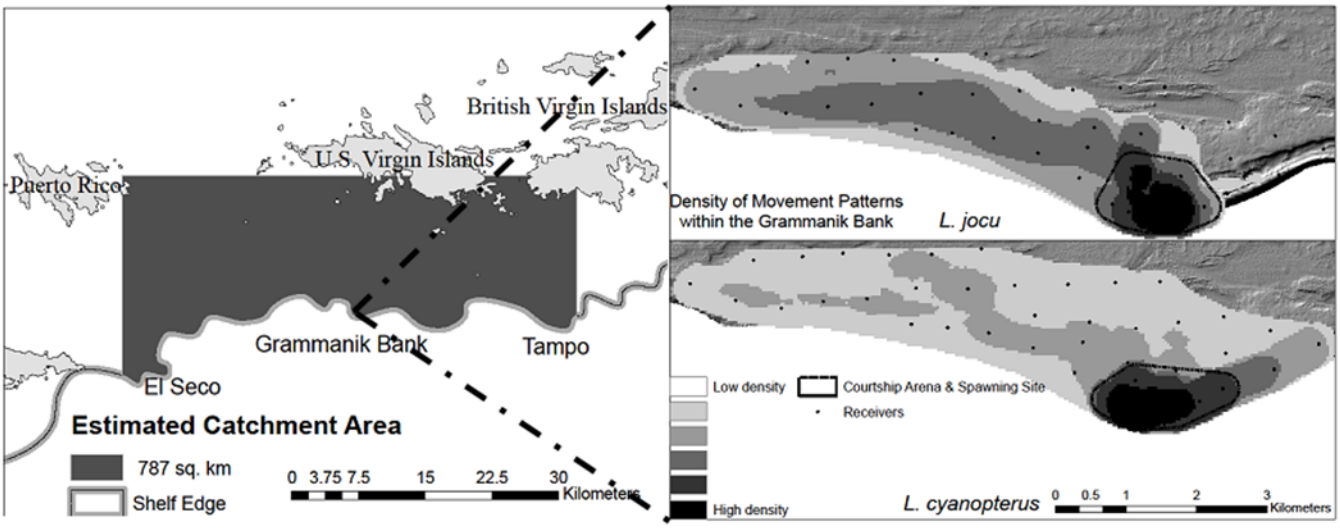

Figure 2. (Left) Estimated catchment area for *L. jocu* and *L. cyanopterus* (787 km^2), based on detections and the associated shelf area to shore. (Right) Density of movement patterns within the Grammanik Bank per tagged fish and the boundaries of the courtship arena (which includes the spawning site) for *L. jocu* 1.4 km^2 and *L. cyanopterus* 1.5 km^2.