Juvenile Goliath Grouper (*Epinephelus itajara*) habitat use and movement patterns in South Florida Estuaries

Uso del hábitat y patrones de movimiento del mero juvenil (*Epinephelus itajara*) en estuarios del sur de la Florida

Utilisation de l'habitat et modes de déplacement du mérou Goliath juvénile (*Epinephelus itajara*) dans estuaires du sud de la Floride

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EXTENDED ABSTRACT

The Atlantic Goliath Grouper (*Epinephelus itajara*) population in US waters has shown significant recovery following the closure of the fishery in 1990 but despite a relatively higher abundance of both adults and juveniles found in state and federal waters, the absolute extent of this recovery is largely unknown. To date, most research efforts have focused on adults and their associated spawning aggregations, revealing patterns of high residency and site fidelity but also long-distance movements related to spawning activities (Collins 2009; Ellis et al. 2014; Koenig et al. 2017).

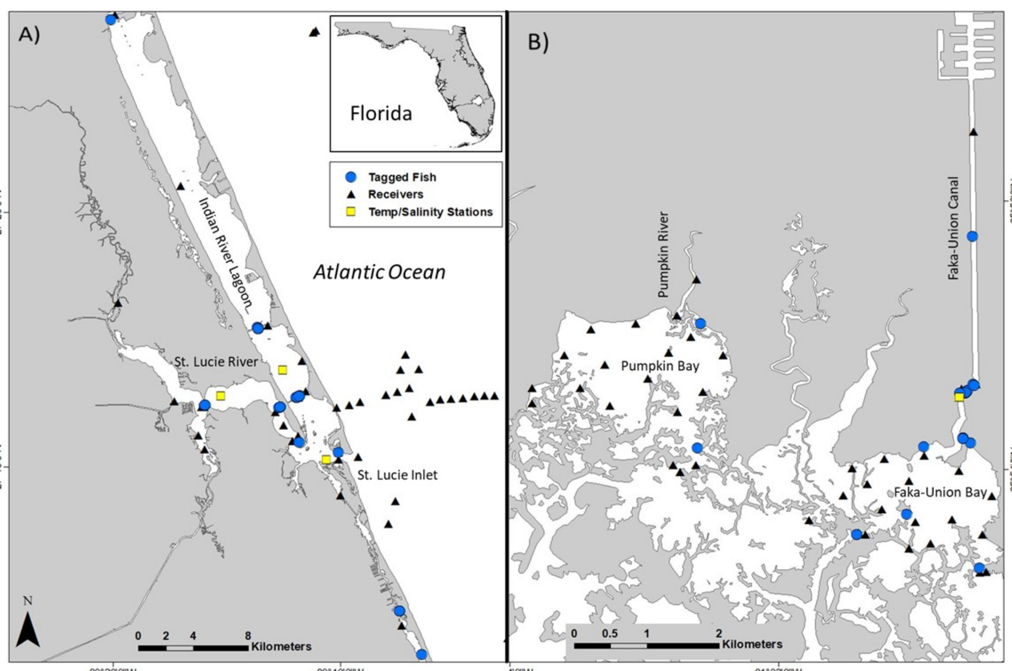

Figure 1. Tagging locations (blue dots) and receiver deployments (black triangles) within the two study systems: A) the St. Lucie River and southern Indian River Lagoon, and B) the Faka-Union and Pumpkin Bays. Locations of water quality stations are denoted by yellow boxes.

Relatively little information is available to describe the habitat associations and movement patterns of juvenile Goliath Grouper that typically utilize mangrove estuaries as nursery habitats (Schideler et al. 2015). Previous studies of juvenile Goliath Grouper have focused primarily on the Ten Thousand Islands region of southwest Florida, an area of extensive continuous mangrove habitat that hosts a high abundance of the species (Eklund and Schull 2001; Koenig et al. 2007). However, juvenile Goliath Grouper are also found in many other south Florida estuaries, including those experiencing extensive anthropogenic habitat alterations such as the Indian River Lagoon system located on the central Florida Atlantic coast. The use of human-altered habitats by estuarine and marine fishes can lead to detrimental impacts including the accumulation of harmful contaminants, reduced growth rates due to altered prey availability, or altered survival due to changes in predation exposure (Curtis et al. 2013).

To better understand the behaviors of juvenile Goliath Grouper within estuaries across a range of environmental conditions and levels of anthropogenic-alteration, we are presently conducting an acoustic telemetry study in three South Florida estuaries: the St. Lucie River and southern Indian River Lagoon (St. Lucie) on the Florida Atlantic coast, and on the southwest Gulf coast in the Caloosahatchee River and Charlotte Harbor (Charlotte Harbor), and in the Faka-Union and Pumpkin Bays (Faka-Union) located in the Ten Thousand Islands region. Our objectives for this study are to: 1) describe habitat use by juvenile Goliath Grouper in estuaries with different environmental conditions; and 2) compare habitat use and movement patterns across time as environmental conditions change within estuaries.

Starting in early 2017, we tagged a total of 60 juvenile Goliath Grouper with Innovasea acoustic telemetry tags (V9 and V16; 440 days and 6.5 years battery life). A total of 30 juveniles (size range = 502 – 1132 mm TL) were tagged in the St. Lucie system between February 2017 and November 2018; 8 juveniles (216 – 1130 mm TL) were tagged in the Charlotte Harbor system between June 2017 and May 2019; and 22 juveniles (255 – 846 mm TL) were tagged in the Faka-Union system between October 2018 and April 2019 (Figure 1). Juveniles were caught via hook-and-line, set lines, and chevron or crab traps, then measured, tagged with an external identification tag, sampled for genetics via fin clip, and had an acoustic tag surgically implanted in the peritoneal cavity before release at the capture site. Tagged fish were tracked through arrays of acoustic telemetry

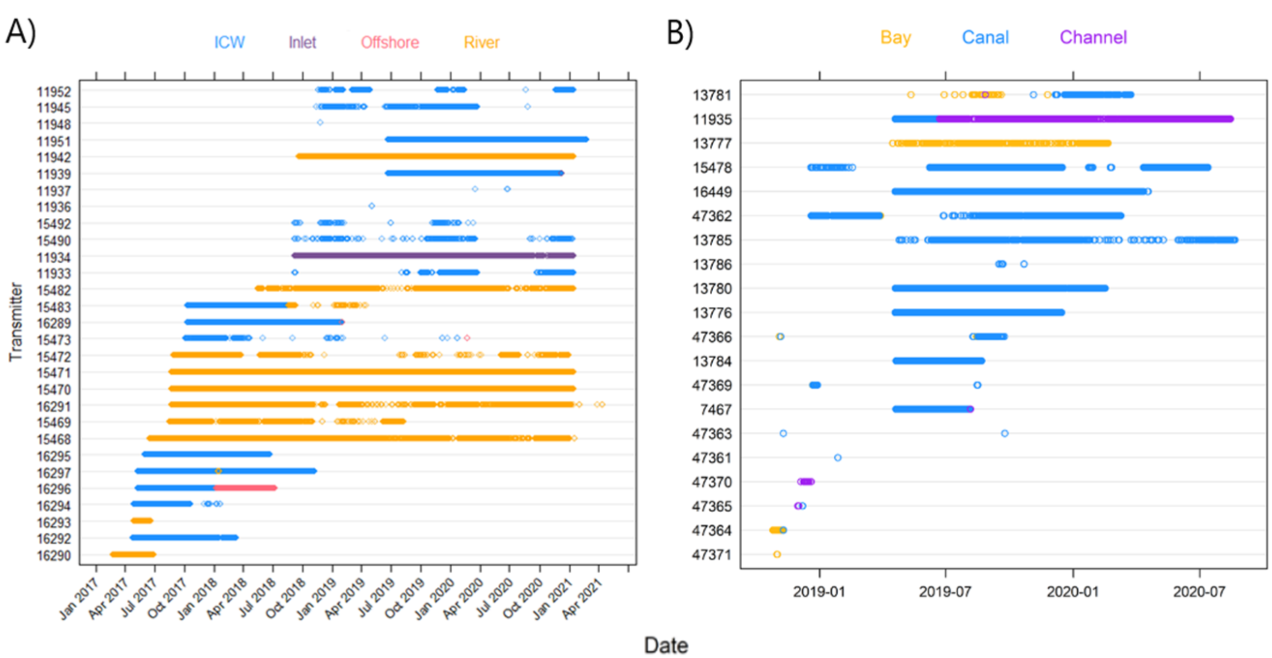

Figure 2. Detections over time of acoustically tagged juvenile Goliath Grouper in A) the St. Lucie River and southern Indian River Lagoon, and B) the Faka-Union Canal and Bay system. Colors denote the habitat type of receivers where fish were detected.

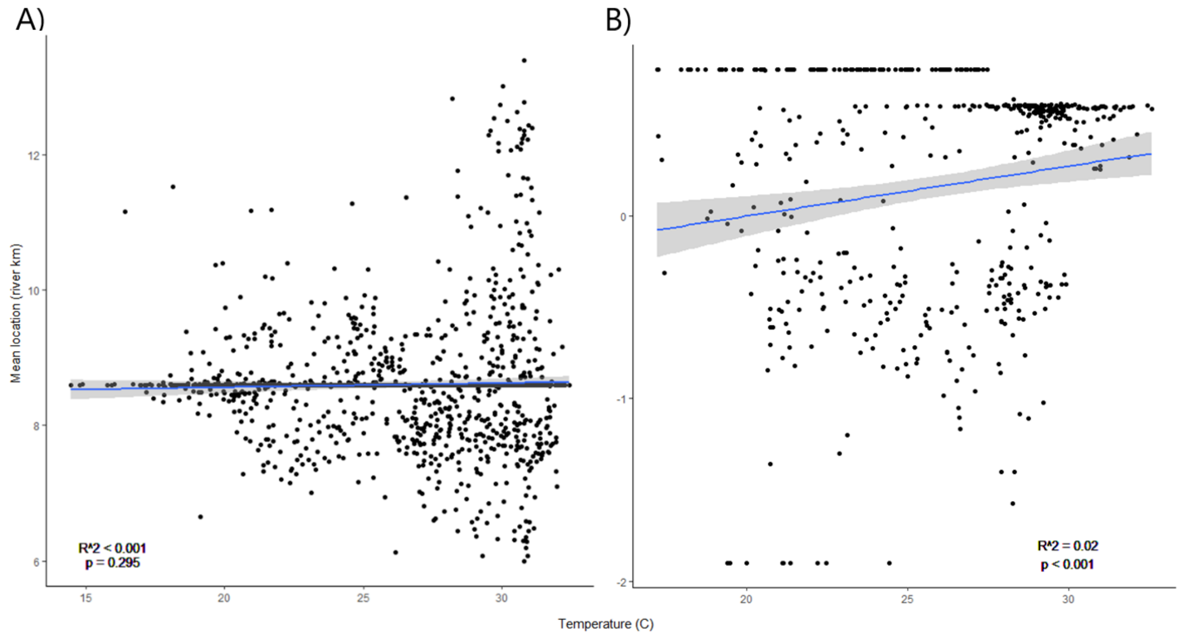

Figure 3. Mean daily location (river km = distance from mouth of the river) for each acoustically tagged juvenile Goliath Grouper in A) the St. Lucie River, and B) the Faka-Union Canal and Bay system, plotted against daily mean surface water temperature. In the St. Lucie River, the water temperature gauge is located approximately 6 km upriver; in the Faka-Union Canal, the water temperature gauge is located approximately 0.5 km upriver.

receivers (Innovasea VR2W and VR2Tx) deployed throughout each estuary and, in the case of the St. Lucie system, extending through the inlet onto nearshore reef habitats. Here we report only on those fish tagged and detected within the St. Lucie (n = 30) and Faka-Union (n = 20) systems.

In both the St. Lucie and Faka-Union we consistently captured juvenile Goliath Groupers under structures, though structure type differed slightly between the two estuaries. In the St. Lucie, which is highly urbanized relative to the Faka-Union, fish were mainly caught under dock and bridge pilings, while in the Faka-Union fish were caught primarily along undercut mangroves. Tagged fish in both estuaries have exhibited high site fidelity, with most detections coming from the same sub-habitat where the fish were tagged (Figure 2). In the St. Lucie system, fish were tagged either in the St. Lucie River or the adjacent Intercoastal Waterway. Of the 30 total Goliath Groupers tagged in the St. Lucie system, we detected 27 of those for more than two weeks, but only two fish were detected moving between the river and ICW (Figure 2a). In the Faka-Union, fish were tagged in the Faka-Union Canal, Faka-Union Bay, or the main channel leading out of the system. Of the 20 total fish tagged in the Faka-Union, we detected 14 for more than two weeks, but we only detected four fish moving between habitats (Figure 2b).

Environmental conditions – here we focus on water temperature and salinity – varied seasonally but to different amounts in the two focal estuaries. Generally, while the maximum and minimum temperatures recorded were similar between the St. Lucie and Faka-Union, the St. Lucie River experienced lower salinity minima and much greater variability in salinity compared to the Faka-Union. Water temperature and salinity were inversely correlated in both focal estuaries, where the highest recorded water temperatures coincided with the lowest salinities. This observation is consistent with the sub-tropical South Florida climate, where most rainfall occurs during the summer and early fall. To evaluate how detections of tagged fish differed across the range of observed environmental conditions, we conducted simple linear regressions to determine if salinity or water temperature predicted the daily location of individual fish. Daily location was calculated as the mean location, measured in terms of the distance of each receiver location from the river mouth (river km), of all receivers with detections on a given day. This was regressed against the daily mean salinity or surface water temperature within each river. Fish responses to fluctuating environmental conditions differed between the two estuaries. In the St. Lucie, the extent of the river with detections increased with increasing temperature, while in the Faka-Union the opposite pattern was observed (Figure 3). Though the correlation between location and temperature was not significant for tagged fish in the St. Lucie River ($R^2 < 0.001$; $p = 0.295$), examination of the correlation plot shows that fish were detected across as greater span of the river as temperatures increased (Figure 3a). However, in the Faka-Union there was a significant positive correlation between mean daily location and temperature ($R^2 = 0.02$; $p < 0.001$), and examination of the correlation plot indicates that tagged fish were more likely to be detected in the Canal (river km > 0), than in the Bay as water temperature increased, though the correlation was weak (Figure 3b). We observed lagged responses to declining salinity in both estuaries, where detections increased downstream following rapid drops in salinity. However, regressions for both estuaries were non-significant with weak correlations. Disentangling how residency patterns influence these results will require additional analysis.

While the results reported here are still preliminary, they offer novel insight into the habitat use pattens of juvenile Goliath Grouper. Similarities in catch location were expected based on the known affinities of adult Goliath Grouper to high relief structures (Collins et al. 2015). We hypothesized that fish would move in response to changing salinity and though this was the general pattern we observed, it was not to the extent expected. The different correlations between temperature and location observed in the two estuaries are interesting but will require additional analyses to disentangle how high site fidelity of these fish – their propensity to remain in one location – interacts with rapidly changing environmental conditions. Tracking will continue through the duration of tag life as these fish continue to undergo ontogenetic shifts in habitat utilization, and we hope the results will continue to illuminate the ecology and life history of this iconic species.

KEYWORDS: Movement, Habitat, Mangrove, Estuary

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