Electronic Monitoring Documentation of Red Snapper (*Lutjanus campechanus*) Catches in the Eastern Gulf of Mexico Commercial Reef Fish Bottom Longline Fishery

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Overview of Electronic Monitoring Efforts

The Center for Fisheries Electronic Monitoring at Mote (CFEMM) has been pioneering electronic monitoring (EM) in the Gulf of Mexico (GoM) commercial reef fish fishery since 2016, utilizing Saltwater Inc. (SI) (Anchorage, AK) hardware and software. Industry volunteer participation has included collaborations with 22 commercial bottom longline (BLL) and vertical line vessels. Data reported below, including for red snapper (*Lutjanus campechanus*), was generated by 14 Eastern Gulf of Mexico (EGoM) BLL vessels fishing out of ports along Florida's west coast from Cortez, FL to Redington Shores, FL from July 2016 to December 2021.

- Red Snapper Recorded = 7,154
- Total Catch Events Recorded = 82,936
- Trips = 306
- Hauls Reviewed = 1,796 (Represents 25% of all potentially analyzable set-haul events)
- Sea Days = 2,822
- Unique species/species groupings annotated = 131

Video Review Protocol

Saltwater Inc. Electronic Monitoring Unit hard drives from participating vessels were collected during dockside visits or mailed by the respective captains or vessel owners. These hard drives were loaded to CFEMM workstations, where SI review software was used to annotate the collected video footage. Sets and hauls were marked along a timeline by reading associated sensor data (hydraulic pressure and rotation). A random subsample of 25% of the complete set/haul events from each trip were reviewed. Each recorded catch event was assigned characteristics based on a series of dropdown menus from which the reviewer would select the most accurate variable. These included:

- **Species**
- **Handling**
    - Brought onboard,
    - Not handled (dropped off),
    - Cutoff at rail (no entanglement),
    - Cutoff at rail (entanglement), or
    - Unknown handling.
- **Condition**
    - Live healthy,
    - Live stomach and/or eyes protruding,
    - Live damaged,
    - Dead on arrival damaged,
    - Dead on arrival undamaged, or
    - Unknown condition.
- **Fate**
    - Retained,
    - Retained as bait,
    - Discarded live healthy (vented),

    - Discarded live healthy (not vented),
    - Discarded live damaged (not vented),
    - Discarded live damaged (vented),
    - Discarded dead,
    - Discarded unknown, or
    - Unknown fate.
- **Shark Specific Attributes**
    - Sex - Male/Female
    - Maturity - Juvenile/Known Adult
    - Size Estimate - Small (>1m), Medium (1.1 to 2.9m), or Large (>3m)

Post-Review Processing

The resulting data navigated a CFEMM established QA/QC process where all annotated events and sensor data anomalies were reviewed by experienced staff to screen for identification errors or missing catch. Aggregated groupings of trips were further screened using "R", applying a series of over 50 error checks to flag any abnormalities. Once approved, final data was appended to the master CFEMM database in Access™. For reporting purposes, additional automatic calculations and environmental metadata were linked to the Access™ database through an export routine in "R", allowing for more than 200 key variables to be associated to catch events, such as depth, average temperature, and bottom type.

Overview of Red Snapper Occurrence in the EGoM BLL Fishery

The EGoM BLL fishery primarily targets red grouper (*Epinephelus morio*), red snapper, and yellowedge grouper (*Epinephelus flavolimbatus*) across the West Florida Shelf (WFS) from offshore Apalachicola, FL to the Dry Tortugas. The CFEMM documented 7,154 captures of red snapper on EGoM BLL gear targeting reef fish, from 1,796 reviewed hauls. Red snapper in the region were the second most frequently caught species on this gear type and were recorded on 61.3% of all BLL hauls.

Catch and Effort Distribution

Red snapper catches were recorded on BLL gear from 24.5° north latitude to 28.9° north latitude, and as far offshore as -84.3° west longitude, with the majority being recorded between 27.0° and 28.0° north latitude and -83.0° and -83.3° west longitude (Figure 1). These individuals were encountered in depths from 36.3 m to 168.4 m, with an average capture depth of 63.4 m. Catch per unit effort (CPUE) was calculated (*See Note*) based on hook-hours, using the regulated EGoM limit of 750 hooks. Red snapper CPUE indices for set-haul events from the WFS from 2016-2021 are presented in Figure 2.

*Note***:** CPUE calculation: Hook hours were based on 750 hooks per set. Species specific CPUE was multiplied by the number of the species caught during a haul and multiplied by 1,000 to generate a whole number (Equation: [Indiv_CPU_Hook_Hours_BLL] x 1000. The average CPUE of catch within a 10 x 10 minute grid cell was applied in the presented maps.

Mean species-specific red snapper CPUE within 10 x 10 minute grid cells is depicted in Figure 3. Results showed high CPUE in the northwest quadrant of the overall fishing area, seaward of 60 m water depth. To generalize, the spatial distribution of CPUE, based on the NW-SE linear distance of the fishing area (~600 km) and the broadest E-W linear width of the fishing area (~160 km), various spatial analyses were conducted to understand spatial relationships of catch location and CPUE as a location attribute (mark).

Spatial concepts were investigated in a GIS environment (Geographic Coordinate System: GCS_WGS_1984; Projection: Mercator) first by catch location (integration of points > collection of events > nearest neighbor analysis > Global Moran's I > Incremental Global Moran's I) and then by attributes (CPUE). Conceptualization of spatial relationships of the attribute (mark) CPUE was facilitated by a preliminary incremental spatial autocorrelation analysis (ISAA) for red snapper (Figure 4). The ISAA revealed a peak distance where CPUE spatial processes were most prominent (76,480 meters; Z-score = 12.83) , as well as intense clustering of CPUE values across much of the entire fishing area (Figure 4). These data were used to execute several Getis-Ord GI*-based hotspot/coldspot analyses in ArcGIS Pro™. Ultimately, for the purposes of detecting a general CPUE trend across the entire fishing area, an Optimized Hot Spot Analysis was executed in ArcGIS Pro™, the results of which were spatially joined to 10 x 10 minute grid cells (merge rule = mean). The hotspot analysis supports the trend revealed in the CPUE grid map (Figure 5) that fishing efficiency generally increases above 27.2° north latitude and west of -83.5° west longitude. From these locations fishing efficiency decreases in a NW-SE direction across the fishing area north of 25.0 degrees. Higher fishing efficiency is predicted south of 25.0 degrees where hard coral habitat is likely. This trend was substantiated by species catch data when catch counts were aggregated to projected 10.0-minute grids. Furthermore, the trend was predicted using ordinary kriging of aggregated red snapper catch data and CPUE data.

Condition on Arrival, Discards, and Depredation

The overall at vessel mortality for this species was 7.84%, with 2.39% showing obvious physical indications of depredation (Table 1). Discard rates were over 25%, with more than twice as many red snapper discarded alive than dead, indicating other variables factoring into vessel specific reasons for discarding (Table 2).

Management Factors Influencing Catch

Based on CFEMM personal communications with EM project participating captains, the primary reason for discarding their red snapper catch was the unavailability or high cost to lease quota. Captains with quota limited vessels, stated that profit margins after lease for vessels who chose to do so were at roughly $1 per pound. In comparison, vessels who do not have to lease red snapper quota generate about $6 per pound. Commercial size limits had only a nominal effect on discarding, as the vast majority of the red snapper caught were well over the minimum size limit. Marketability was an additional cause for discarding; for example, one vessel with available quota discarded approximately 10% of their red snapper, which represented mainly individuals that came on board dead (usually from gut-hooking), resulting in discoloration that was deemed less favorable for sale. Collectively, these resulted in nearly one quarter of all red snapper to be discarded, which is of concern to management due to high discard mortality.

Anticipated changes in 2022, based on elevated lease costs and scarcity of quota (both for red grouper and red snapper) is expected to change effort, driving vessels to target non-IFQ species or avoid typical targets and focus more on deepwater species (e.g. yellowedge grouper, tilefish). Some vessels in late 2021 and in early 2022 had self-imposed trip limits for certain target species or split trips between shallow and deepwater to be able to fish throughout the year.

Tables and Figures

Table 1. Condition of red snapper on arrival on BLL gear in the EGoM.

Condition On Arrival	% of Red Snapper
Dead on Arrival - Damaged	2.21
Dead on Arrival - Undamaged	5.63
Live - Damaged	0.18
Live - Healthy	71.27
Live - Stomach and/or Eyes Protruding	20.59
Unknown Condition	0.11

Table 2. Fate of red snapper on BLL gear in the EGoM.

Catch Fate	% of Red Snapper
Discarded - Dead	6.44
Discarded - Live and Damaged (Not Vented)	0.22
Discarded - Live and Damaged (Vented)	0.08
Discarded - Live and Healthy (Not Vented)	8.28
Discarded - Live and Healthy (Vented)	8.09
Discarded - Unknown	0.08
Retained	76.68
Retained as Bait	0.01
Unknown Fate	0.10

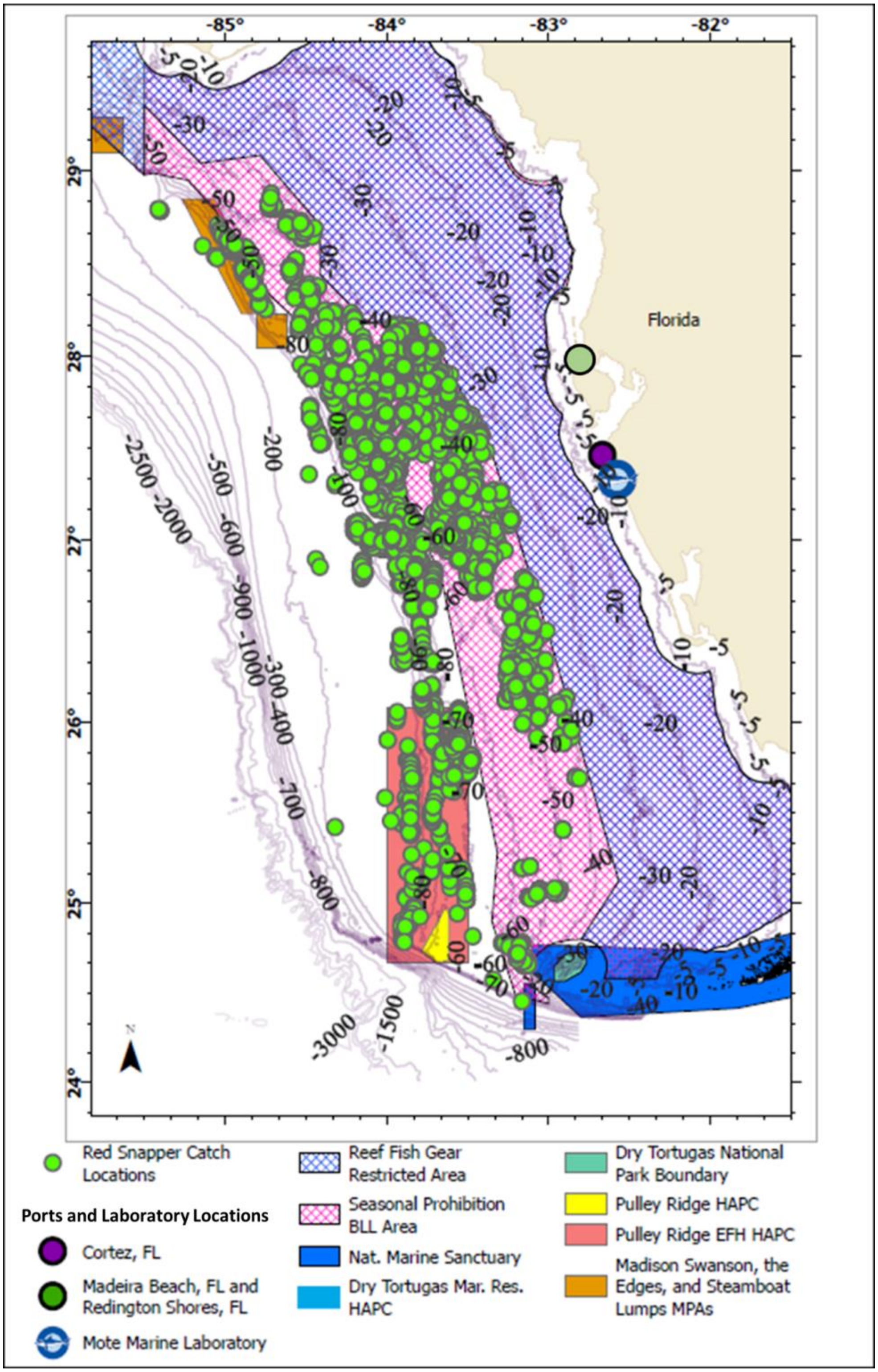

Figure 1. Individual red snapper (n=7154) annotated catch locations, depth contour isobaths (meters), and catch proximity to regulated regions of the GoM as denoted in the map legend, for BLL vessels fishing the WFS from July 2016 to December 2021.

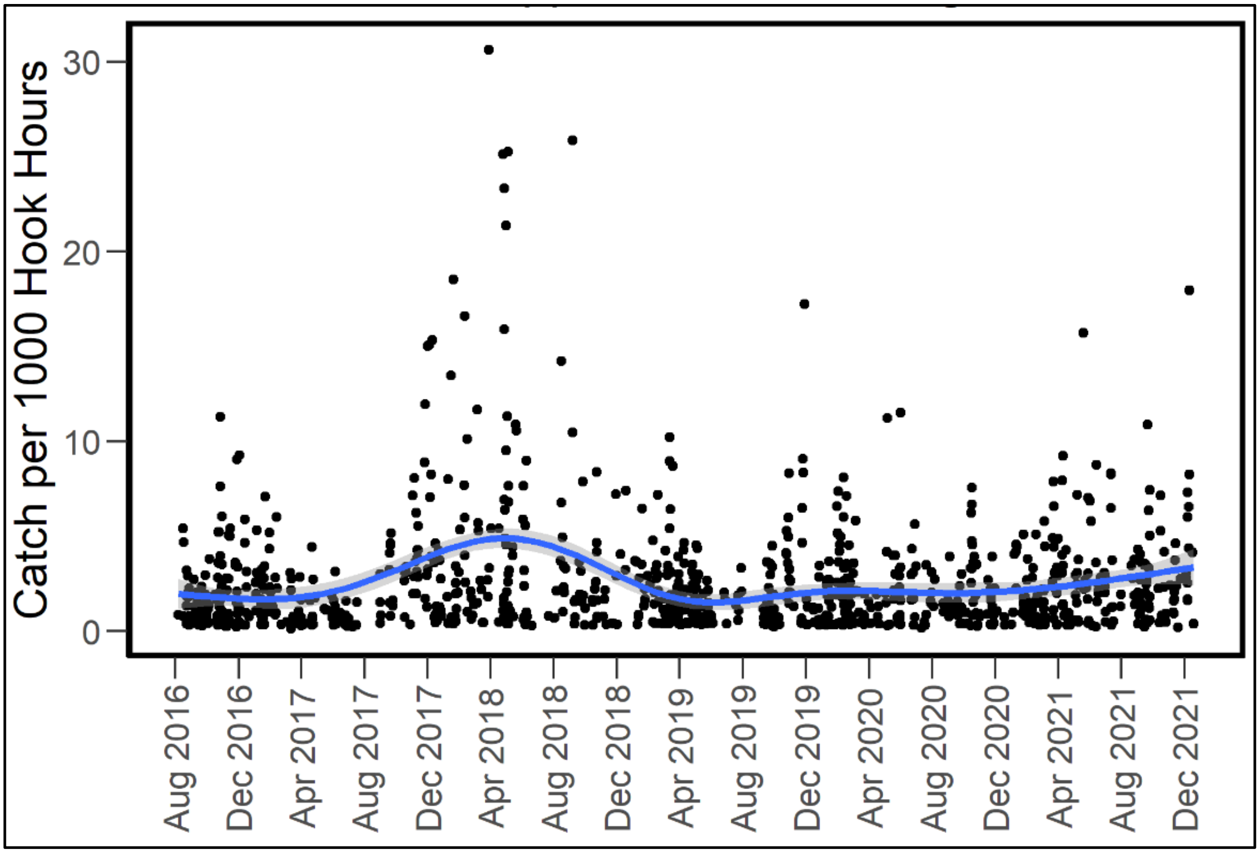

Figure 2. Red snapper CPUE indices for BLL set-haul events from the WFS from 2016-2021. The blue line indicates a general additive model smoother with a 95% confidence interval in gray shading.

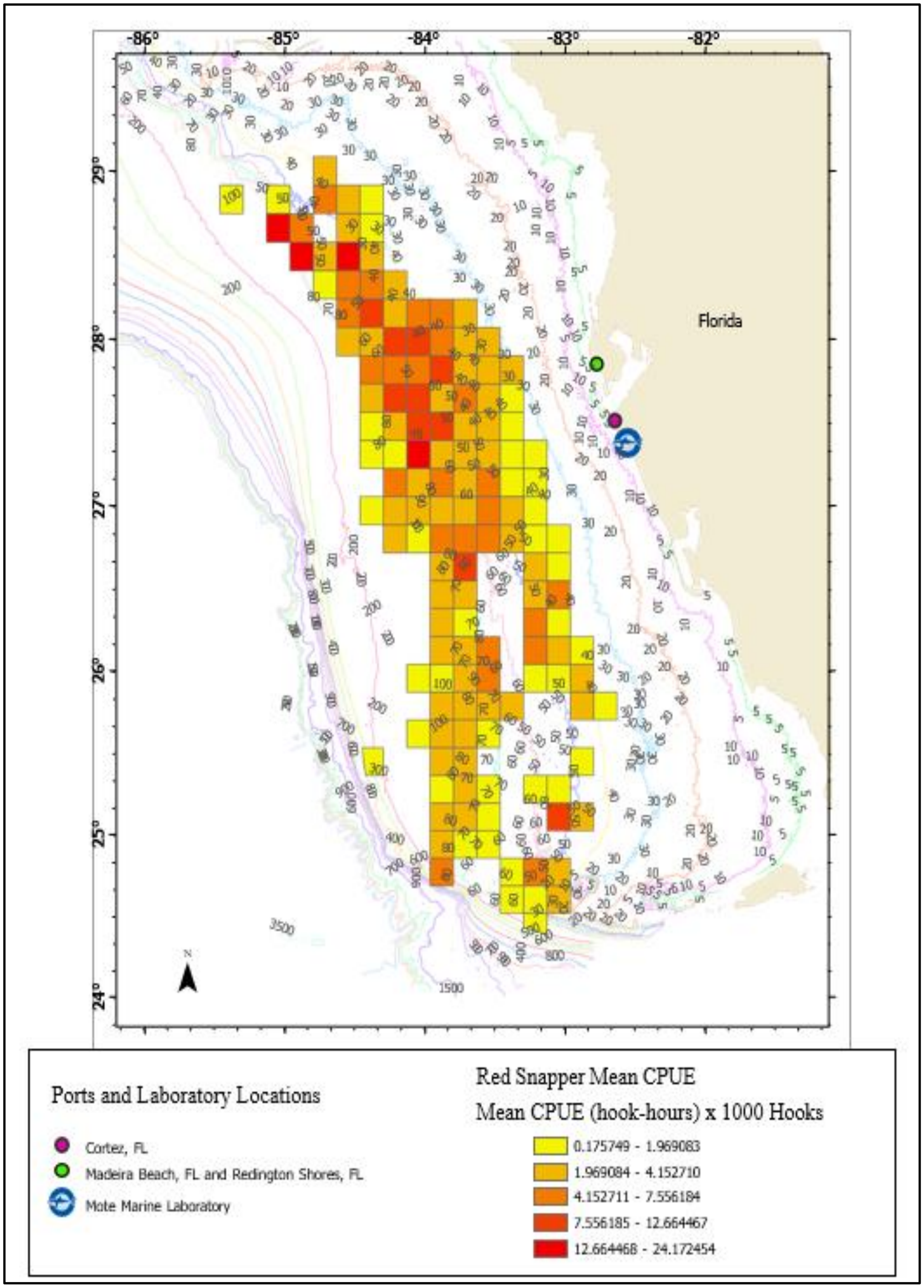

Figure 3. Red snapper mean CPUE (set-haul hook-hours x 1000) by species, spatially joined to a 10.0-minute grid for BLL vessels fishing the WFS with depth contour isobaths (meters) from July 2016 to December 2021.

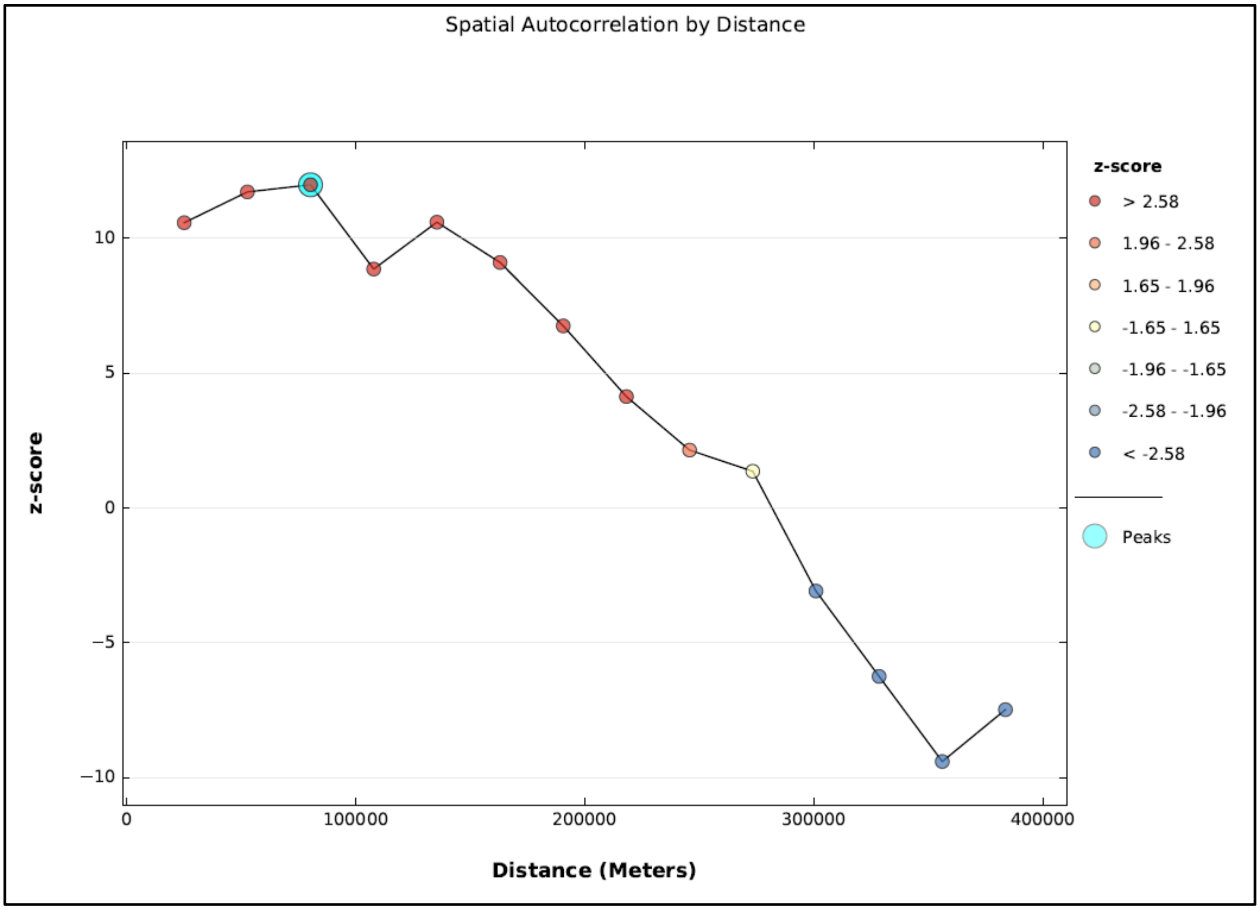

Figure 4. Results of incremental spatial autocorrelation analysis across the entire red snapper fishing area to detect isotropic distances where spatial processes were most prominent. This data was used to facilitate a Getis-Ord GI* hotspot/coldspot analysis (Figure 5).

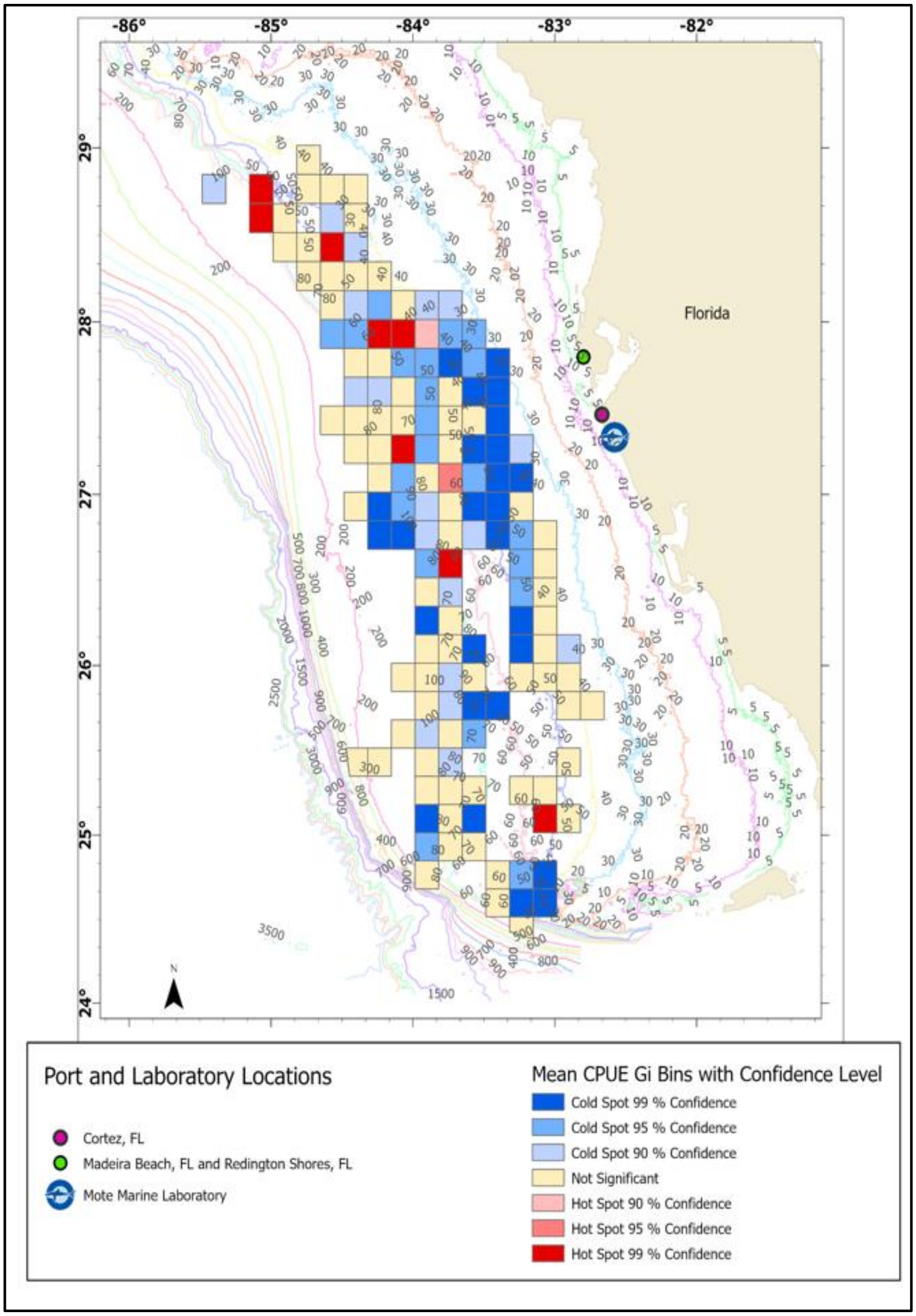

Figure 5. Statistically significant spatial clusters (Getis-Ord GI* spatial statistic) of high value (hotspot), low value (coldspot), random distributions (yellow markers) of species specific CPUE (set-haul hook-hours x 1000) spatially joined to 10.0-minute grids (merge rule = mean) , and depth contour isobaths (meters), for red snapper catch of BLL vessels fishing the WFS from July 2016 to December 2021.

Literature Cited

R Core Team (2019). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/