

An Offshore Behavioral Contingent of an Estuarine Fish Population, Common Snook (*Centropomus undecimalis*)

Erick Ault, Derek Cox, Sarah Webb

Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute, Tequesta Field Laboratory, 19100 SE Federal Hwy, Tequesta, FL 33469



Background

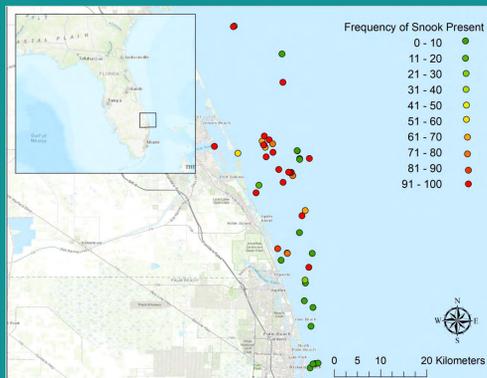
- Historically, snook are thought of as an inshore species, living mostly in the rivers and estuaries while spawning near inlets
- Divers observed seeing common snook up to 10 km offshore throughout the year in Southeast Florida, which support historical records of fish monitoring efforts dating back to 20 years
- The focus of this study was to investigate the possibility of a lesser known snook contingent residing in offshore coastal reef areas

Goals of this study

- Document the occurrence of offshore snook
- Quantify the spatial distribution of offshore snook along the coast of southeastern Florida
- Quantify group sizes and the age and size structure of snook present at these reef sites
- Determine whether the residency of this group is seasonal or year-round
- Determine if they engage in reproductive activity while offshore

Underwater Visual Observations

- Surveys followed a modified NOAA Reef Visual Census (RVC) protocol and were conducted in conjunction with various other field work
- During underwater observations, the min and max number of snook present were estimated, as well as min, max, and average total length (TL)
- Length and Abundance data were fit into 50cm size class bins by performing triangular distributions in R
- Size and abundance compared to distance from shore was also calculated



Left: Colored dots represent frequency of snook presence at surveyed sites
Bottom left: Percent presence of snook at artificial and natural reefs in various regions throughout surveys
Bottom right: Snook on artificial structure offshore

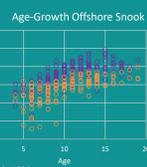
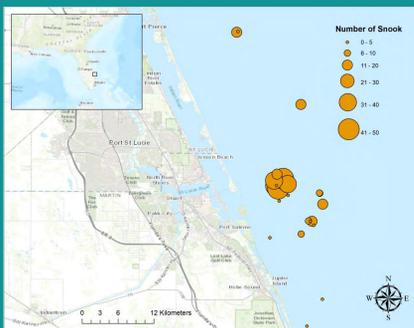
| Survey Location | Artificial | Natural | Total |
|-----------------|--------------------|--------------------|--------------------|
| Fort Pierce | 51 (70.6%) | 0 | 51 (70.6%) |
| St. Lucie | 292 (84.0%) | 24 (0%) | 316 (77.5%) |
| Jupiter | 10 (0%) | 155 (24.5%) | 165 (23.0%) |
| Palm Beach | 1 (0%) | 27 (0%) | 28 (0%) |
| Total | 354 (79.4%) | 206 (18.4%) | 560 (57.0%) |



- An estimated 9,769 snook were observed on 57.0% of 560 total underwater visual observation dives conducted offshore from 2009 - 2015
- The number of snook observed per dive averaged 15.0 snook per site overall and 26.8 Snook for those dives during which Snook were present, with a maximum of 225 snook estimated to be at a single location in the St. Lucie region
- The number of snook observed per dive did not differ by season ($p > 0.76$; emmeans pairwise comparisons); however, regional differences were observed with Jupiter having fewer snook than both Ft. Pierce and St. Lucie ($p < 0.001$; Ft. Pierce vs. St. Lucie $p = 0.08$; emmeans pairwise comparisons)
- Size estimates ranged from 350 - 1150 mm TL, with the majority (70.6%) between 750 - 949 mm TL size range. The size distributions did not differ by region or by season ($p > 0.79$; Kolmogorov-Smirnov test). Snook size relative to depth and distance from the inlet or shore were significant but did not explain a high percentage of variation ($p < 0.05$, $R^2 < 0.1$; linear regressions)

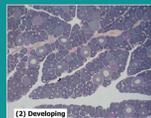
Specimen Collection and Histology

- Targeted sampling of female snook took place during crepuscular period of spawning season by rod and reel or spearing from Jupiter to Fort Pierce
- Length, total weight, and gonad weight of each snook were recorded and otoliths were aged
- Histological samples were preserved and classified using modified standards proposed by Brown-Peterson et al. 2011 and included: (1) Immature, (2) developing, (3) spawning capable, (4) regression, and (5) regeneration



Above Left: Map of locations of snook collected and number from each site; Top upper right: photo of an otolith used for determining fish age; Top bottom right: age and length for collected specimens

Below left: Histological sample results from females showing proportion in each stage or reproductive cycle; Below right: microscope shot of prepared oocyte squash used to identify reproductive stage (showing the "developing" stage)



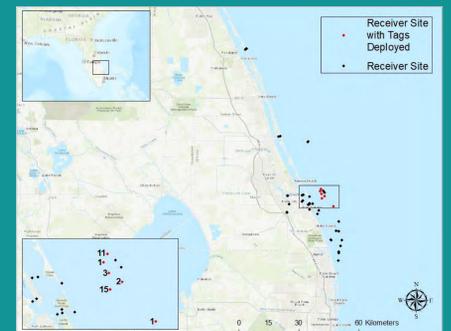
- 341 Snook were collected offshore from 2009-2015 by spearing or rod and reel averaging 918 mm in length, 7.4 kg in weight, and 10.4 years old
- The majority (314 samples, 87.5%) were collected from 16 sites in the St. Lucie Inlet region
- 204 females with an average Gonadosomatic Index (GSI) of 3.65 (range 0.3-13.8)
- Females sampled at these offshore sites were mature (99.5%)
- 26 females collected from June - September were classified as "actively spawning" while offshore

Acoustic Telemetry

- Snook were tagged either internally via surgical implantation using Vemco V-16 acoustic transmitters with a battery life of ~7 years or externally using Vemco V-9 tags via speargun with a battery life of ~1 year
- An array of 53 acoustic receivers were placed inshore, at the mouths of inlets, and in strategic offshore locations and downloaded every 4 - 6 months
- False detections were removed and the number of detection days for each fish at offshore receivers was calculated
- Fish with ≥ 20 detections, ≥ 10 detection days, and ≥ 2 stations were included in final analysis including offshore residency and percent of detection days offshore
- Snook that were not tagged offshore, but moved into the offshore array and met requirements above were included as well



Right: Map of acoustic receiver locations with red dots indicating a receiver that tagged fish were released on and black representing locations of additional receivers; Inset map shows the number of internally tagged fish at each receiver location



| Tag Type Location | Average Size (mm TL) | Average Total Days Detected | Days Detected Offshore | % Days Detected Offshore | Residency Index Offshore |
|-----------------------|----------------------|-----------------------------|------------------------|--------------------------|--------------------------|
| Internal Offshore | 848.6 | 484.9 | 472.1 | 97.2 | 49.9 |
| External Offshore | 800.8 | 141.7 | 141.7 | 95.1 | 73.3 |
| Internal Not Offshore | 881.4 | 554.5 | 306.7 | 54.8 | 37.0 |
| Total | 844.1 | 396.4 | 318.9 | 84.1 | 53.9 |

Residency Index Offshore = days detected in offshore array / days tag was active $\times 100$

% Detection Days Offshore = days detected in offshore array / total days tag was detected $\times 100$

- 83 tagged snook were detected at offshore receivers
- 41 snook ($n = 29$ tagged offshore, $n = 12$ tagged elsewhere) met the criteria for analysis (≥ 20 detections offshore, ≥ 10 detection days offshore, and ≥ 2 stations offshore)
- Over 95% of days detected for offshore snook were at offshore locations
- Snook were detected offshore year-round
- Only two snook tagged offshore were ever detected at an inlet

Conclusions and Future Work

- A contingent population of snook reside offshore from Fort Pierce to Jupiter year-round as mature adults, occasionally in large schools, and predominately inhabiting artificial reefs
- The lack of juveniles indicates the offshore contingent likely relies on immigration from inshore populations, although the transition to becoming an offshore resident is not yet clear
- A large portion of these fish are spawning capable or actively spawning and could be contributing to the overall population via larval transport into estuaries throughout southeast Florida and the southeast Atlantic
- Additional research exploring habitat connectivity, population dynamics, and stable isotope and microchemistry analysis of otoliths could be useful for identifying the role and importance of this contingent population as well as identifying if others exists throughout their range

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