Primed and Cued: Linking Interannual and Seasonal Variations in Freshwater Flows to the Spawning Migrations of Common Snook in the Florida Coastal Everglades

J.A. Massie[1] (*jmass041@fiu.edu*), R.O. Santos[2], R.J. Rezek[3] , W.R. James[2], N. Viadero[1], R.E. Boucek[4], D.A. Blewett[5], A.A. Trotter[5] , P.W. Stevens[5], and J.S. Rehage[1]

1. Dept. of Earth & Environment, Florida International University; 2. Dept. of Biological Sciences, Florida International University; 3. Dept. of Marine Sciences, Coastal Carolina University; 4. Bonefish & Tarpon Trust, Florida Keys Initiative; 5. Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute

1) Common Snook Migration

Migration often occurs in response to environmental **cues** prompting movement into habitats favorable to reproduction. However, some individuals may choose not to migrate, and conditions preceding the reproductive season (**primers**) may influence this decision. Common Snook (*Centropomus undecimalis*) are a tropical euryhaline fish species well-suited to studies of migration. Snook are marine obligate spawners and migrate from rivers and estuaries to coastal spawning sites to reproduce. In Florida, research has described variation in both the proportion of the population that migrates annually and the specific timing of migration, but the environmental factors shaping these behaviors remain unknown. Here, we use long-term telemetry data from Snook in the Everglades to investigate the role of freshwater flows in migratory patterns. Alterations to the timing/magnitude of flow pulses may affect Snook spawning behaviors in the future and understanding how fish might respond to environmental change can help inform conservation and management for this ecologically and economically important species.

Jordan Massie with Common Snook captured and tagged in the Shark River

2) Tracking Migratory Movements

- Snook tracked using passive acoustic telemetry in the Shark River, Everglades National Park (**Fig. 1, Fig. 2**)
- 207 Snook tagged between 2012 and 2019 (total length 42 - 101 cm)
- Implanted with VEMCO V13/V16 acoustic transmitters
- Monitored by array of 37 VEMCO VR2W receivers (ongoing)

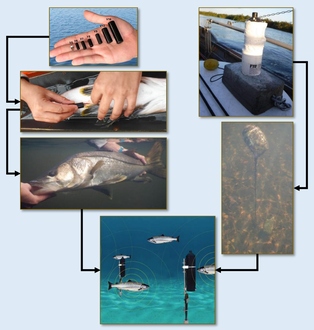


Figure 1: *Illustration of acoustic telemetry methods. Images on left show tagging/release, images on right show receiver pre/post-deployment.*

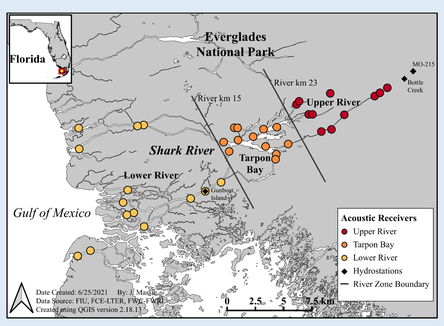
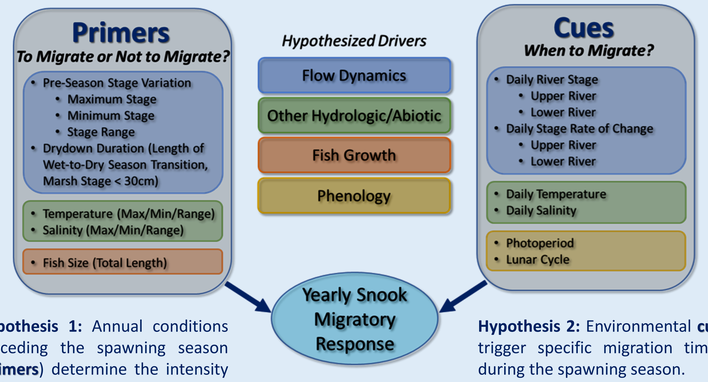


Figure 2: *Acoustic monitoring stations in the Shark River array. Map shows delineation of river zones used to assess migratory movements and hydrostations used to source environmental data.*

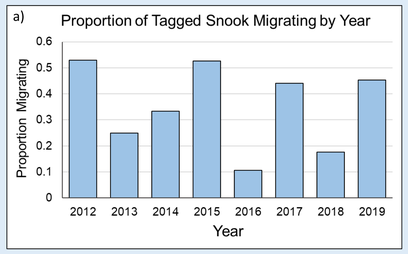
3) Conceptual Framework and Migratory Patterns



Hypothesis 1: Annual conditions preceding the spawning season (**primers**) determine the intensity of the migratory response.

Hypothesis 2: Environmental **cues** trigger specific migration timing during the spawning season.

Figure 3: *Conceptual diagram showing the two-pronged modeling approach used to investigate the environmental drivers of Snook migration at multiple temporal scales.*



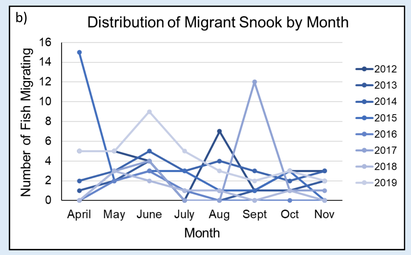


Figure 4: *Panel a) illustrates the high degree of interannual variability in the proportion of tagged snook migrating each year, and panel b) illustrates variation in migration timing within the spawning season .*

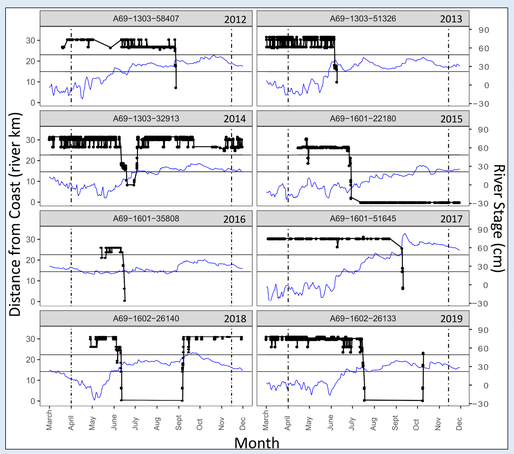


Figure 5: *Movement tracks for individual acoustically tagged Snook showing downstream migrations. Blue lines indicate river stage at Bottle Creek in the upper river. Horizontal black lines delineate boundaries between the upper river (> 23 river km), Tarpon Bay (15-23 river km), and lower river (< 15 river km), and vertical hashed lines mark the beginning and end of the spawning season (April 1-Nov 15).*

Snook Migratory Patterns

- Wide variation in proportion of Snook migrating each year (11-53%, **Fig. 4a**)
- Migration observed in all months of spawning season (April 1-Nov 15, **Fig. 4b**)
- Two migration tactics (**Fig. 5**)
  - Direct movement to coast
  - Stopover in Tarpon Bay

4) Identifying Primers and Cues

GLMMs used to evaluate the environmental conditions influencing annual migration probability (**primers**) and migration timing (**cues**) for Snook (**Fig. 3**).

- Response variable a binary indicator of:
  - Annual **Primers**: Whether each fish migrates in a year
  - Seasonal **Cues**: Downstream migration timing for each individual/day
- Evaluated using AIC; best fitting variables selected for global model
- Backward selection to identify top model

Best-Fit Models

- Annual **Primers**
  - **Marsh Drydown Duration + Fish Size** (R^2 = 0.28)
- Seasonal **Cues**
  - **Stage + Daily Stage Change + Temperature + Salinity + Year** (R^2 = 0.32)

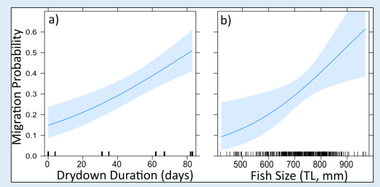


Figure 6 (above): *Isolated variable effects from best-fitting GLMM explaining annual migration probability (**primers**).*

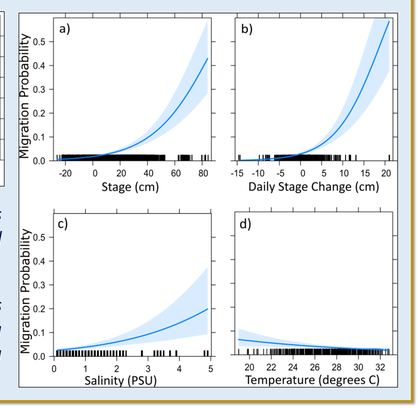
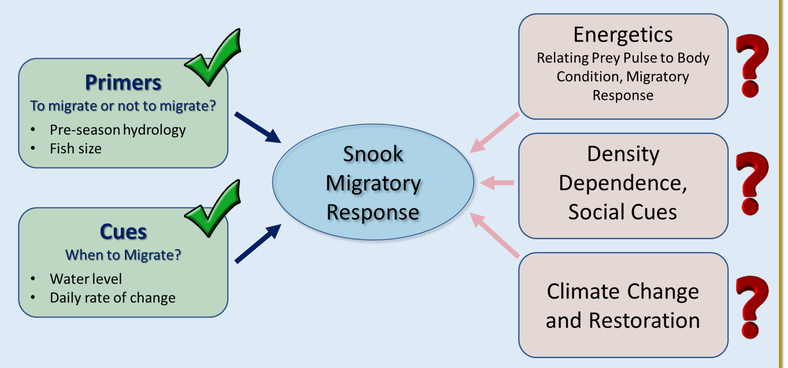


Figure 7 (right): *Isolated variable effects from best-fitting GLMM explaining migration timing within the spawning season (**cues**).*

5) Future Research Directions



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