Hurricane-Driven Movements of Common Snook in the Shark River: An Examination of Fish Redistribution and Environmental Drivers

Jordan A. Massie¹, Bradley A. Strickland², Rolando O. Santos¹, Javiera Hernandez¹, Natasha Viadero¹, Ross E. Boucek³, Hugh Willoughby¹, Michael R. Heithaus², and Jennifer S. Rehage¹

¹Florida International University, Department of Earth & Environment, Miami, FL 33199
²Florida International University, Department of Biological Sciences, North Miami, FL 33181
³Bonefish & Tarpon Trust, Florida Keys Initiative, Marathon, FL 33146

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Why Study Animal Movement?

- Can provide valuable information on how animals experience their environment, often driven by physiological needs and predictable cues
  - Seasonal migrations for reproduction
  - Shifts in food/resource availability

- Rapid shifts in distribution also caused by abrupt environmental change, can carry consequences
  - Stressful conditions
  - Mismatch in resources
  - Timing of life-history events

- Behavioral responses occur quickly, can provide insight into how animal populations might respond to future climatic changes
Introduction

What can we learn from changes in fish behavior that occurred in response to the passing of Hurricane Irma on September 10th, 2017?
Research Questions:

- To what extent did the disturbance associated with Hurricane Irma influence fish populations in ENP?
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- To what extent did the disturbance associated with Hurricane Irma influence fish populations in ENP?
- What were the environmental cues that may have elicited behavioral responses and prompted fish movements?
- What are the potential consequences of movements in response to extreme climate events?
Hypotheses:

1. Fish responded to cues directly related to hurricane conditions, particularly drops in barometric pressure.
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2. Movements were driven by changes in riverine conditions:
   - Storm surge
   - Increased precipitation, rising water levels
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2. Movements were driven by changes in riverine conditions
   - Storm surge
   - Increased precipitation, rising water levels

3. Movements best explained by combination of both hurricane and riverine conditions
Focal Species: Common Snook (*Centropomus undecimalis*)

- Tropical euryhaline species
- Recreationally/economically important fishery
- Marine obligate spawners, juveniles rear in small creeks and freshwater marshes
- Adults utilize habitat across salinity gradients, seasonally tracking abundant food sources
- Captured in the Shark River, ENP throughout year using boat-based electrofishing
Shark River, Everglades National Park
• Main conduit of water through western Everglades
• Ecologically distinct habitat zones
**Shark River, ENP**

**Upper River:**
- Bordered by mangroves and sawgrass marshes
- Very low salinities, limited tidal influence
- Predominantly freshwater community
Tarpon Bay:

- Wide, shallow, mangrove lined habitats
- Seasonal variation in salinity (3 – 25 ppt)
- Community consisting of estuarine species
Shark River, ENP

Lower River:
- Deep river channels, higher mangrove height/biomass
- Highest degree of tidal fluctuation
- Most marine influenced community
Tracking Movement: Acoustic Telemetry
Snook tagging began in 2012, ongoing

37 receivers spanning headwaters to GOM

When fish swims within 500 m, records unique tag number

Detections associated with time/location, used to characterize movement patterns
Hurricane Irma – September 10\textsuperscript{th}, 2017

- Passed within 60 km of the Shark River
- Heavy rain, high winds, large drop in atmospheric pressure
- Storm surge > 2 meters in the lower river
Hurricane Irma – Snook Response?

- “Hurricane Window” defined based on rapidly changing conditions between Sept. 9 and Sept. 12, 2017
- 22 Snook recorded on array during this window
  - 73% moved to different habitat zone
  - First fish moved 7 hours before storm conditions
  - 50% of fish had moved within 8 hours of eyewall passage
Hurricane Irma – Snook Response?

All fish located in the upper river before storm
Hurricane Irma – Snook Response?

As the hurricane passed, fish rapidly spread throughout the system.
3 predominant movement strategies detected

- Upper river to bay zone (67%)
- Upper river to lower river (22%)
- No movement among zones (11%)
Hurricane Irma – Snook Response?

A few fish left entirely
Hurricane Irma – Snook Response?

A few fish left entirely, detected on receivers 70 km north at Faka Union on the Gulf Coast
Hurricane Irma – Snook Response?

6 Month Window Following the Storm

- 6% fish remained in Tarpon Bay
- 25% returned to upper river
- 19% continued moving among river zones
- 19% redetected at coast between Oct-April
- 31% not re-detected
What could have driven these movements?

- Low barometric pressure?
- Increasing water level from rainfall in the upper river?
- Storm surge/anti-surge?
- Change in dissolved oxygen?
- Changes in water temperature?
Hurricane and Riverine Conditions

- Selected variables reported to drive movement in other species
- **Hurricane Conditions**: Rapid drop in barometric pressure associated with the hurricane
- **Riverine Conditions**: Changes in water level spatially dependent, caused by different factors
  - Storm surge in lower river
  - Rainfall in upper river
What could have driven these movements?

Analysis

Logistic regression models used to investigate drivers, response variable is cumulative proportion of fish moving among zones over time

- Hurricane Effects: Barometric pressure
- Riverine Effects: Independently considered lower river stage (storm surge) and upper river stage (increased rainfall)
- Combined Effects: Considers both pressure and stage

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<th>df</th>
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Best fitting model was a combination of upper river stage and barometric pressure

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What could this mean for the population?

• Lower prey availability in new location (**bad for fitness**)

• Relocating to the coast could lead to increased predation by sharks (**risky behavior**)

• Lower densities, Snook more spread out, could reduce fishing success (**unhappy anglers**)

What could this mean for the population?

But...

Fish sampling in December, 2017 produced the highest catch of juvenile Snook on record!

Back calculations of hatch date indicated spawning shortly after Hurricane Irma.
What could this mean for the population?

But...

Fish sampling in December, 2017 produced the highest catch of juvenile Snook on record!
Could hurricanes also have positive impacts on the Snook reproduction?

Research in the coming years on population size, fish distribution, and angler success could answer this question.
Summary:

- Hurricane Irma resulted in large-scale movement of Snook in ENP
- Fish redistributed throughout the system, with some fish moving into coastal waters
- Movement corresponded to high water levels in the headwaters, and low barometric pressure
- Future work will focus on long-term population trends, and if hurricane behaviors might be predicted by pre-storm movements
Acknowledgements:

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- Florida Coastal Everglades Long Term Ecological Research Program (FCE LTER)
- National Park Service
- Pat O’Donnell, Rookery Bay National Estuarine Research Reserve

[Logos and icons representing various organizations]
Questions?

Jordan Massie
PhD Student, Rehage Lab
Department of Earth & Environment
jmassie@fiu.edu

Shark River at dusk. Image by Jordan Massie