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

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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?

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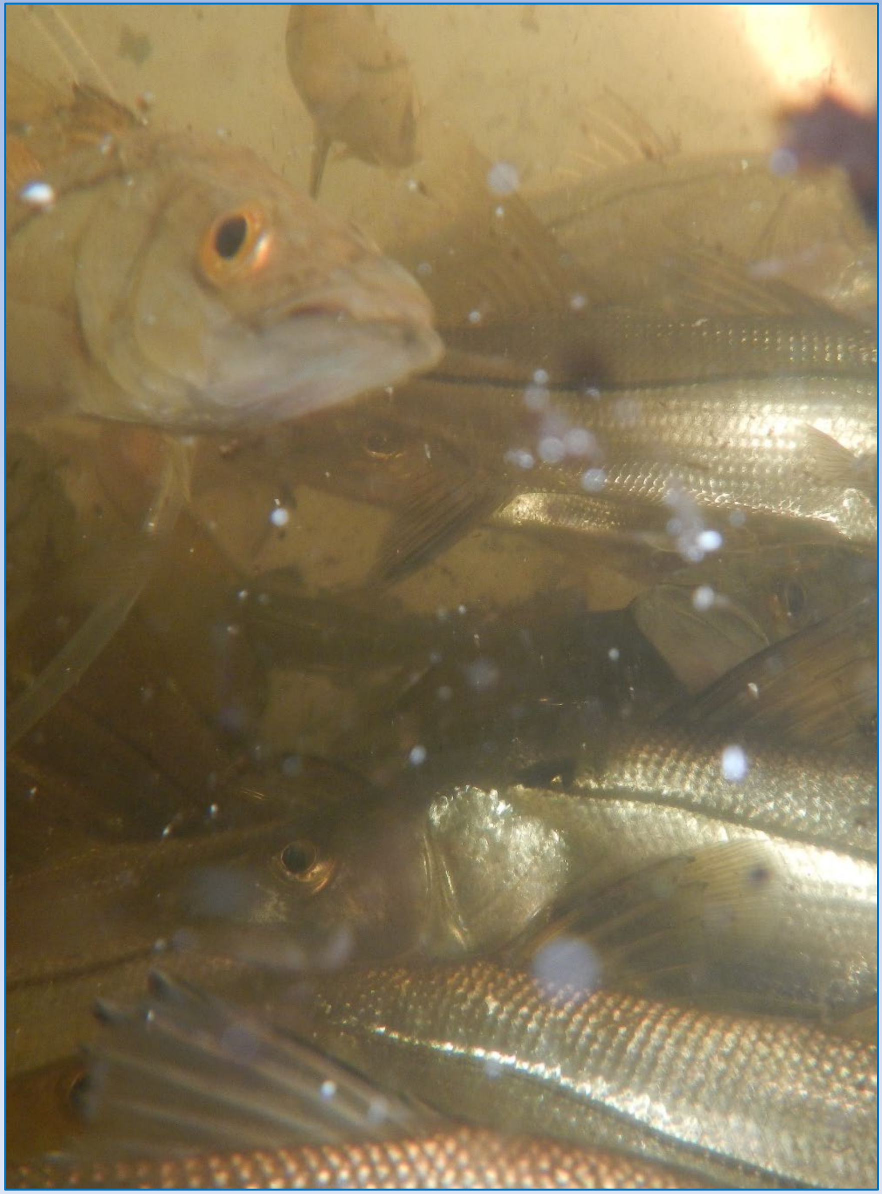
Research Questions:

- To what extent did the disturbance associated with Hurricane Irma influence fish populations in ENP?



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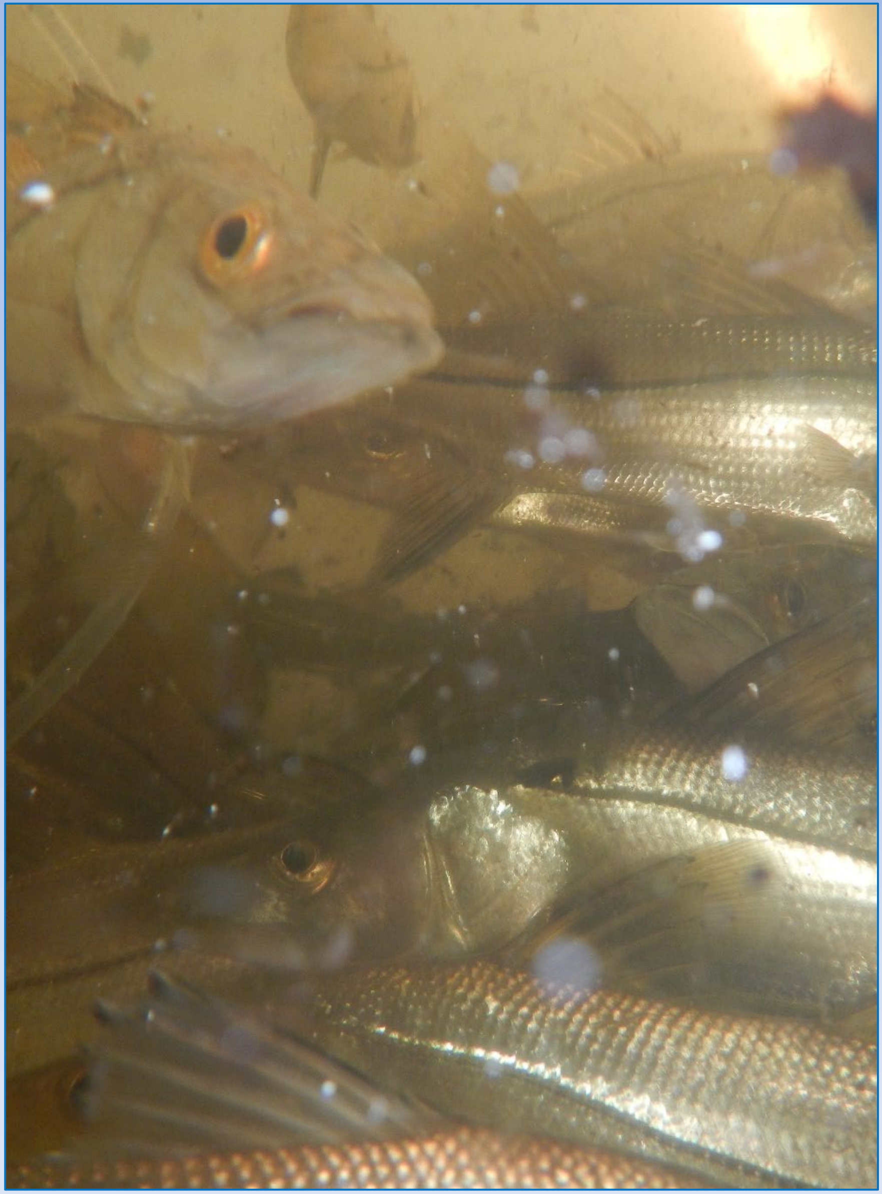
- ❖ **What are the potential consequences of movements in response to extreme climate events?**



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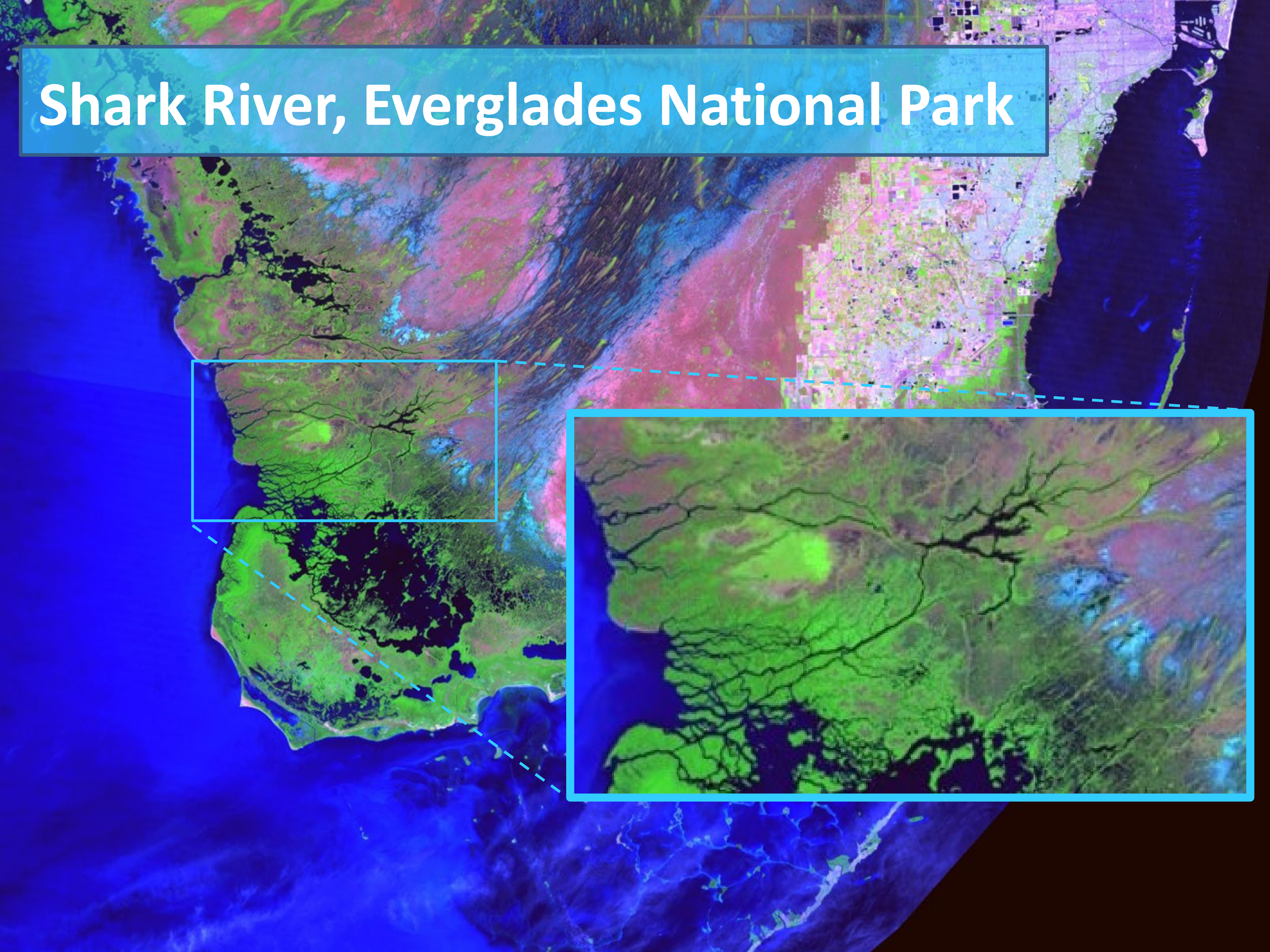
3. **Movements best explained by combination of both hurricane and riverine conditions**

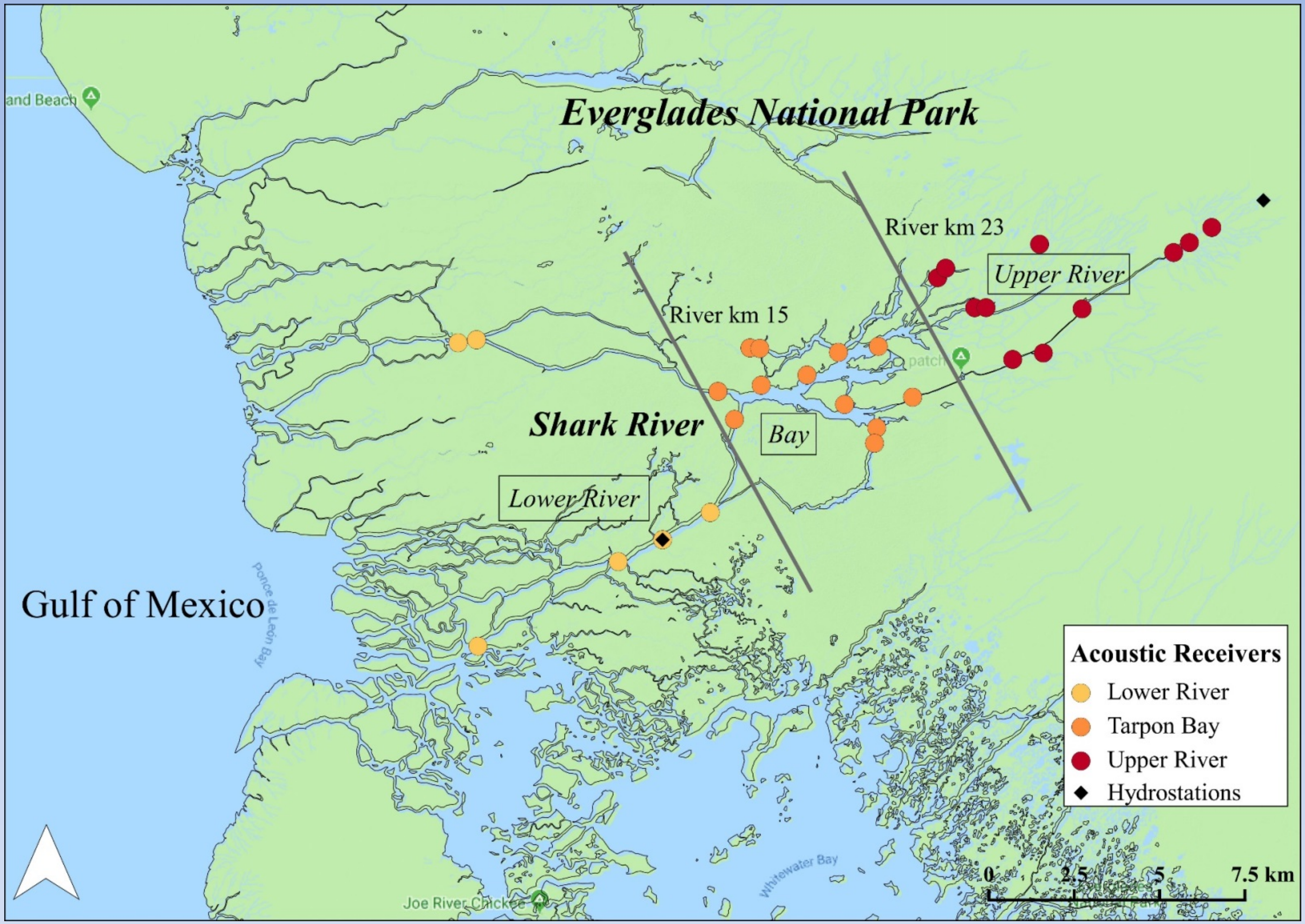
Focal Species: Common Snook (*Centropomus undecimalis*)

- Tropical euryhaline species
- Recreationally/economically importance 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

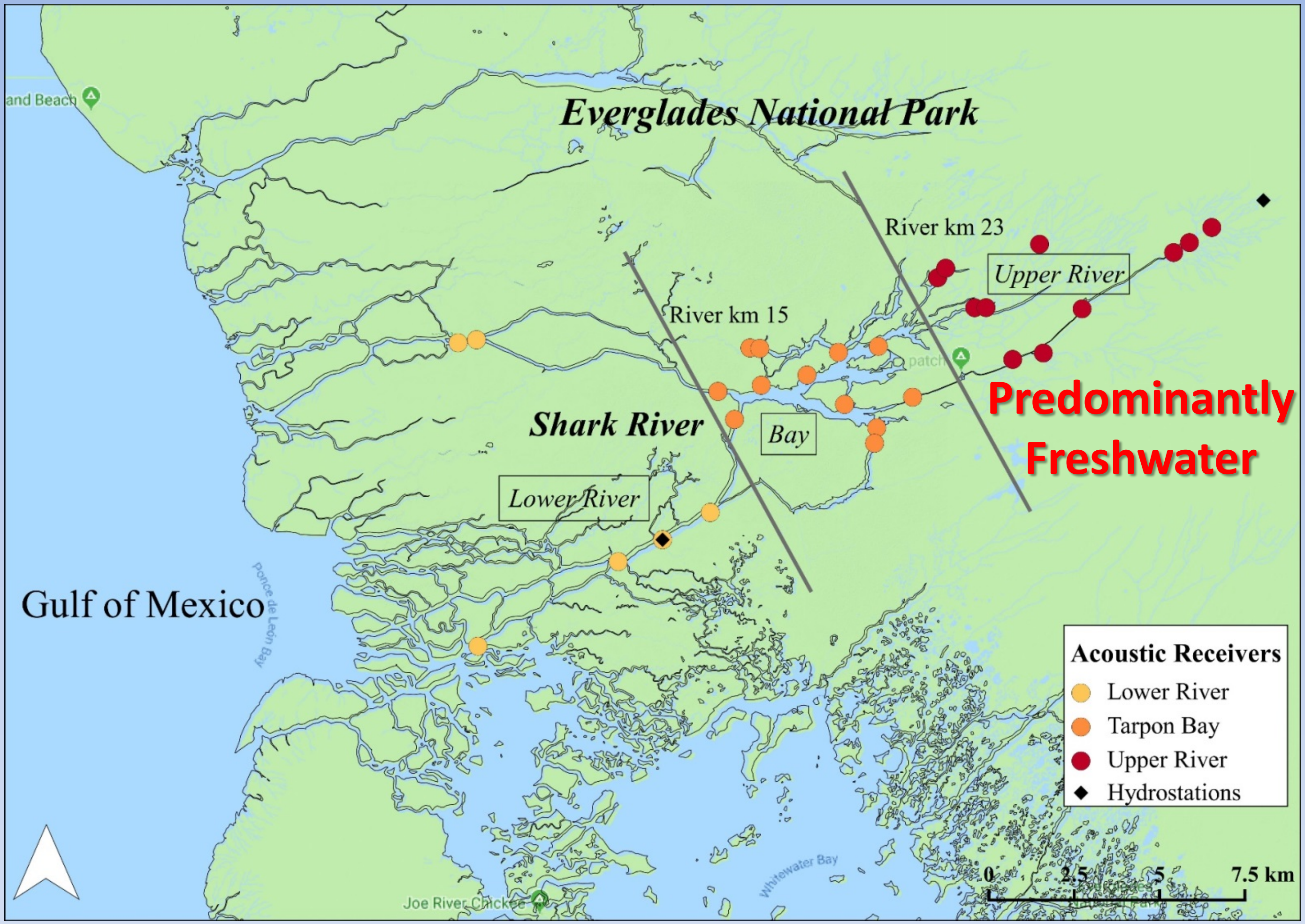


Shark River, ENP



- Main conduit of water through western Everglades
- Ecologically distinct habitat zones

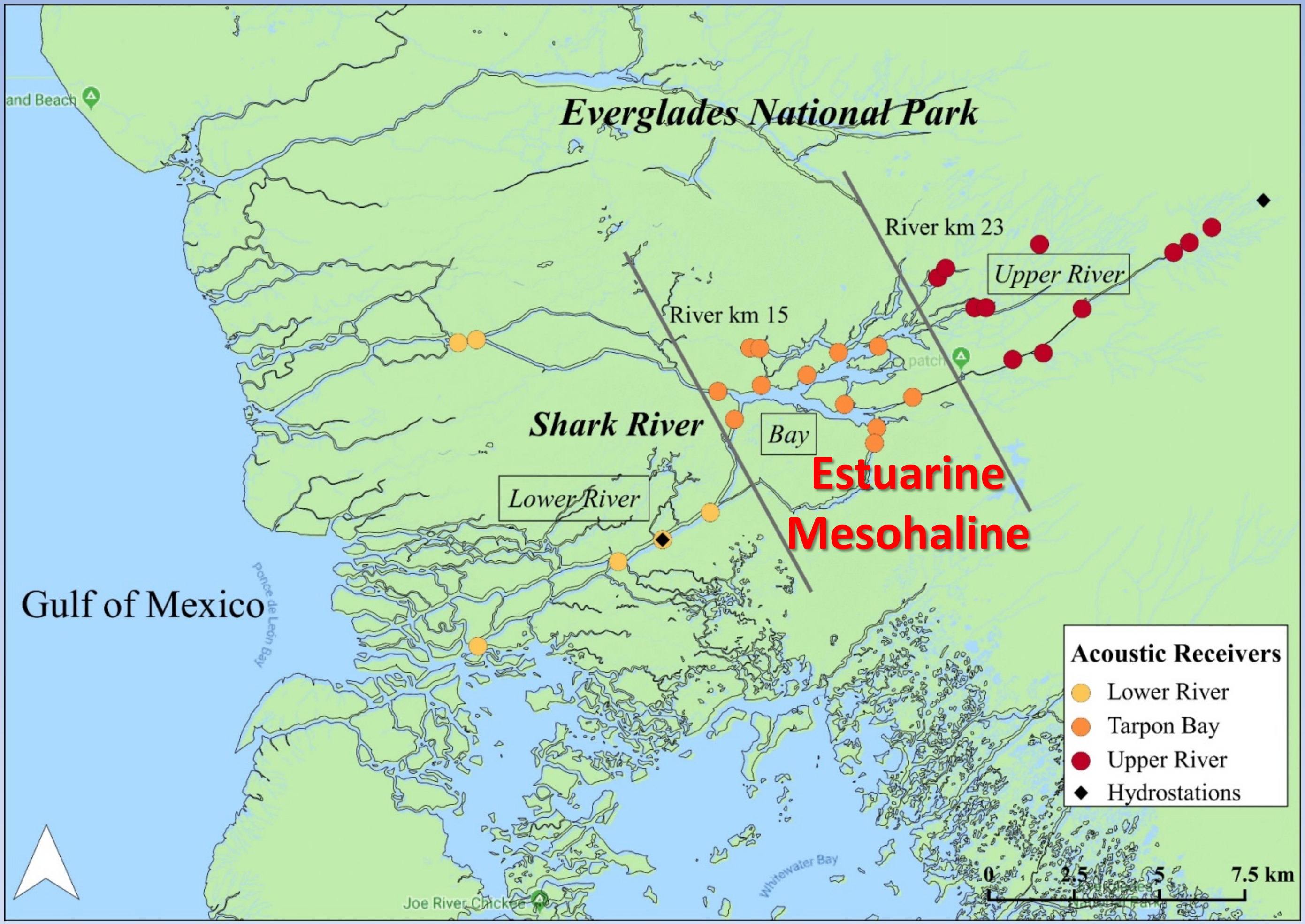
Shark River, ENP



Upper River:

- Bordered by mangroves and sawgrass marshes
- Very low salinities, limited tidal influence
- Predominantly freshwater community

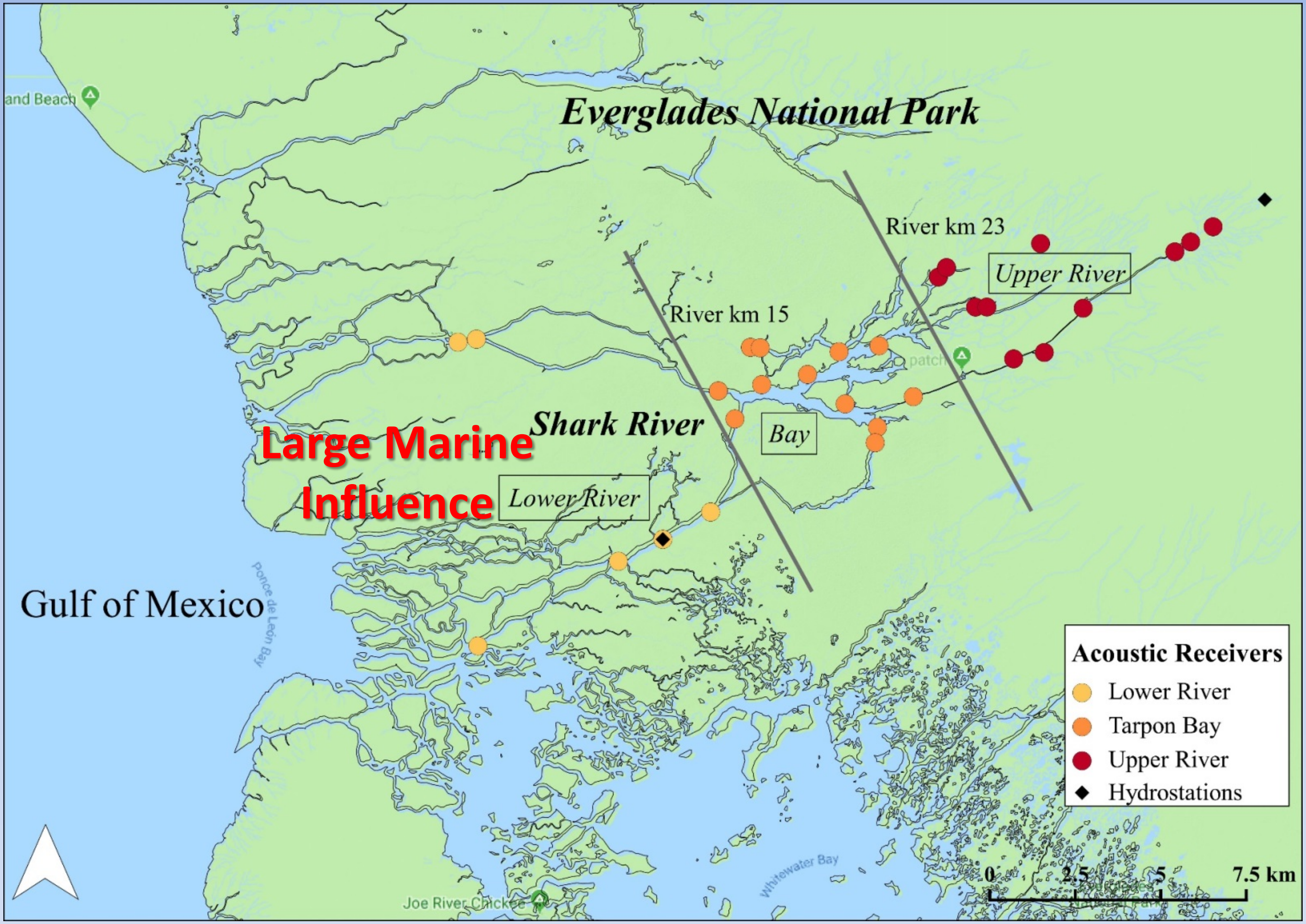
Shark River, ENP



Tarpon Bay:

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

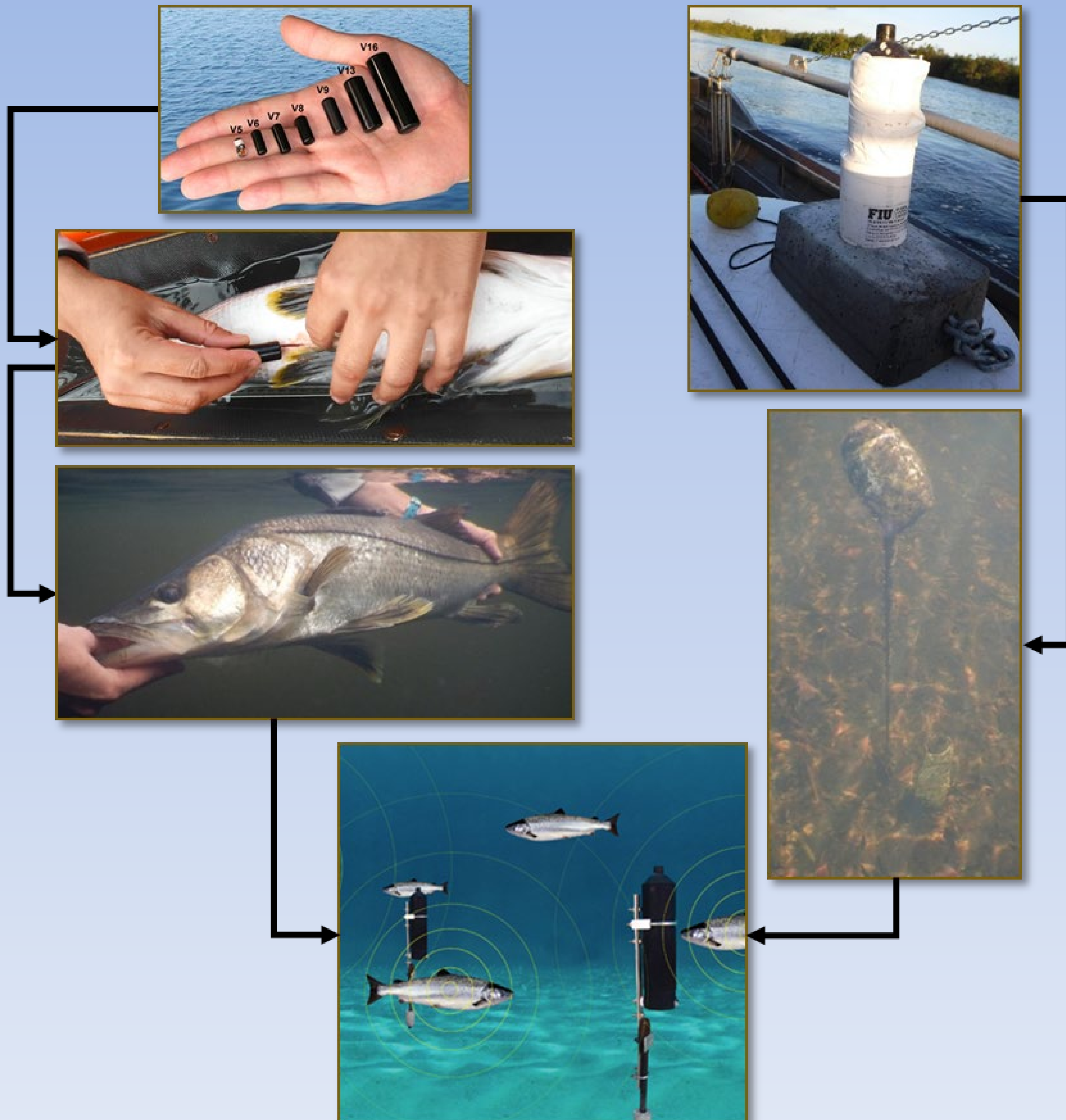
Shark River, ENP



Lower River:

- Deep river channels, higher mangrove height/biomass
- Highest degree of tidal fluctuation
- Most marine influenced community

Tracking Movement: Acoustic Telemetry



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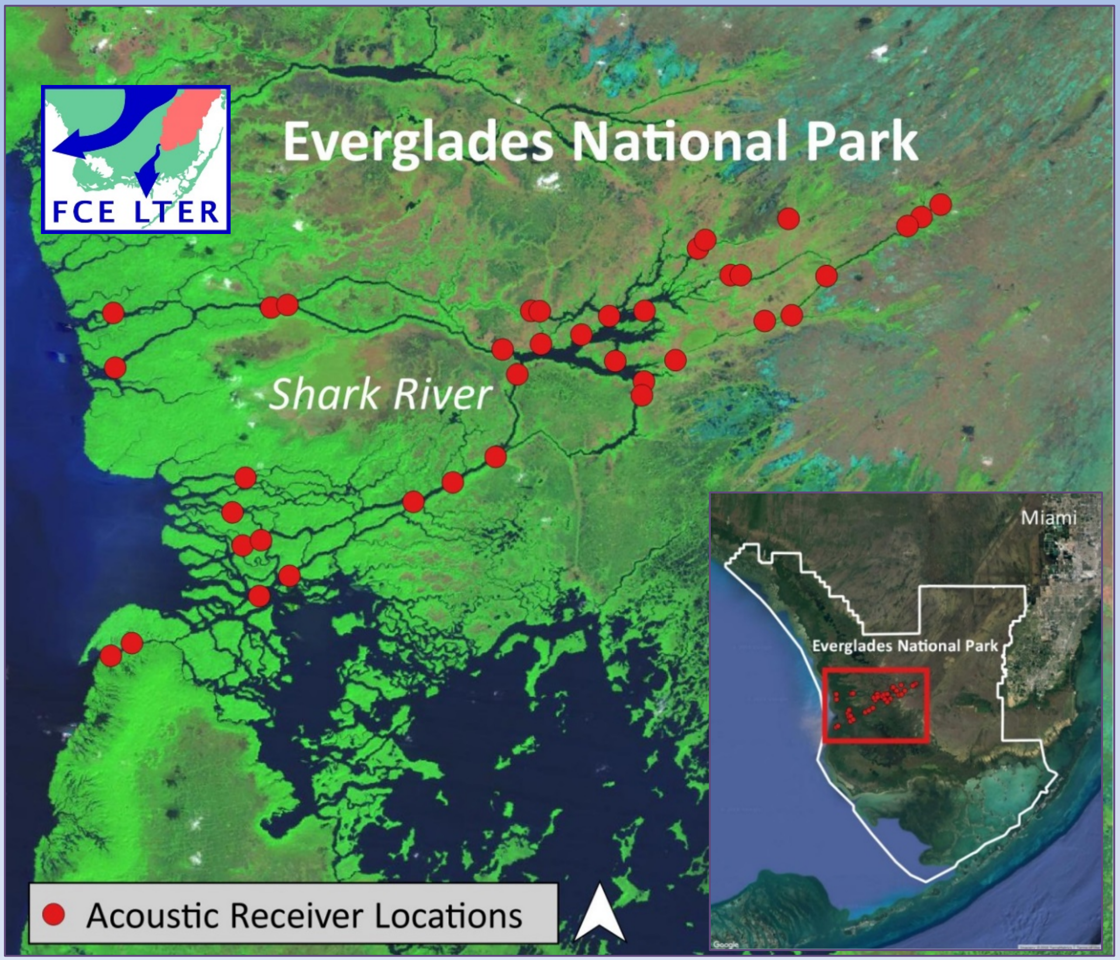
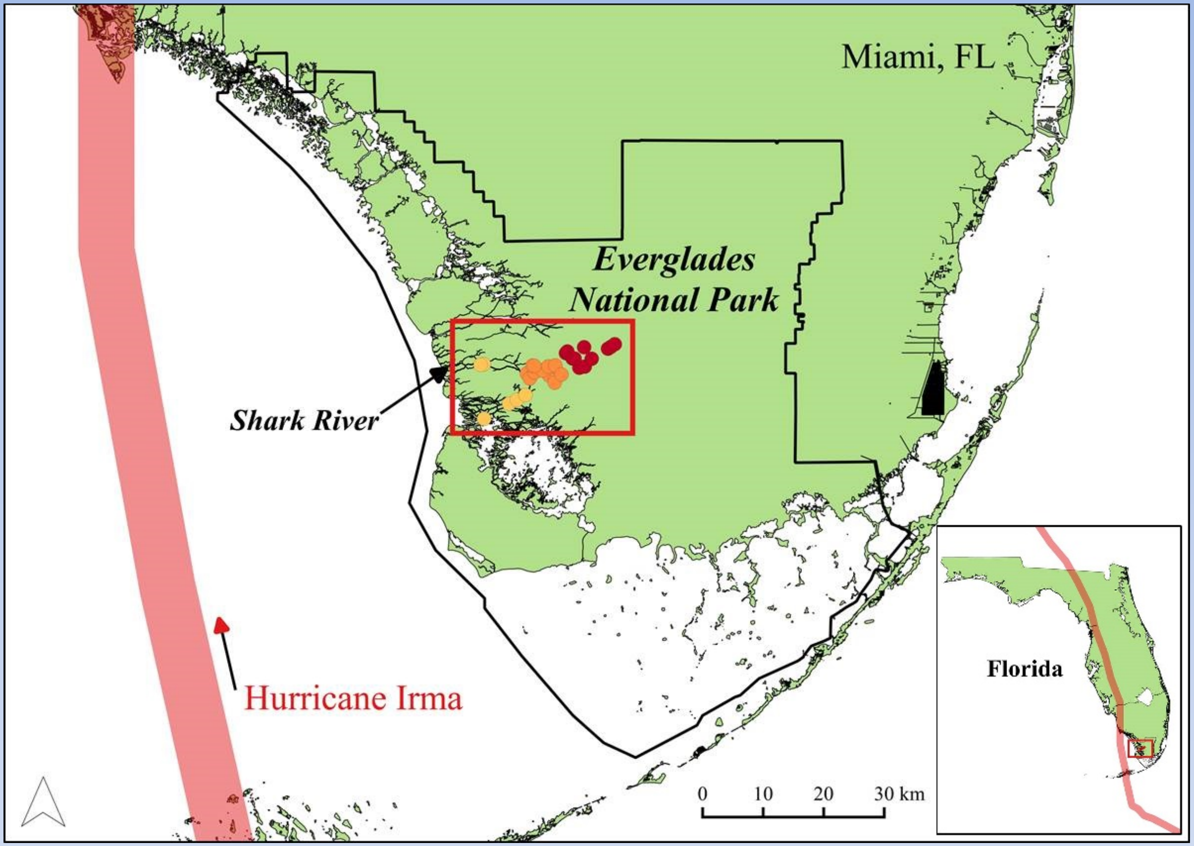


- Snook tagging began in 2012, ongoing
- 37 receivers spanning headwaters to GOM
- When fish swims within 500 m, records unique tag number
- Detections associated with time/location, used to characterize movement patterns

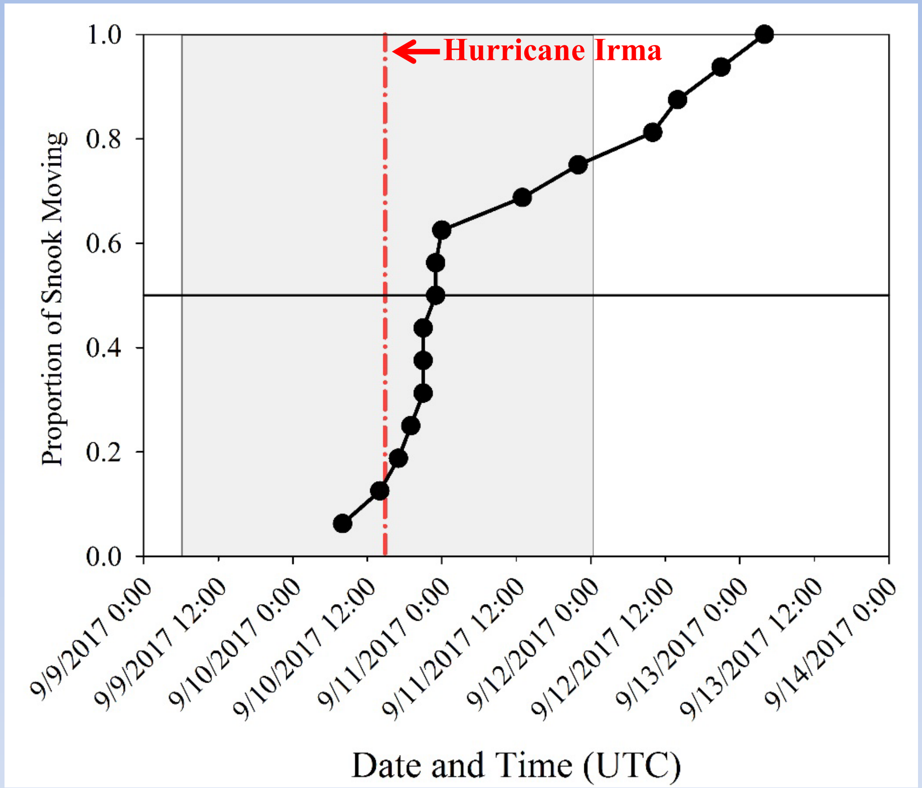
Hurricane Irma – September 10th, 2017



- 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



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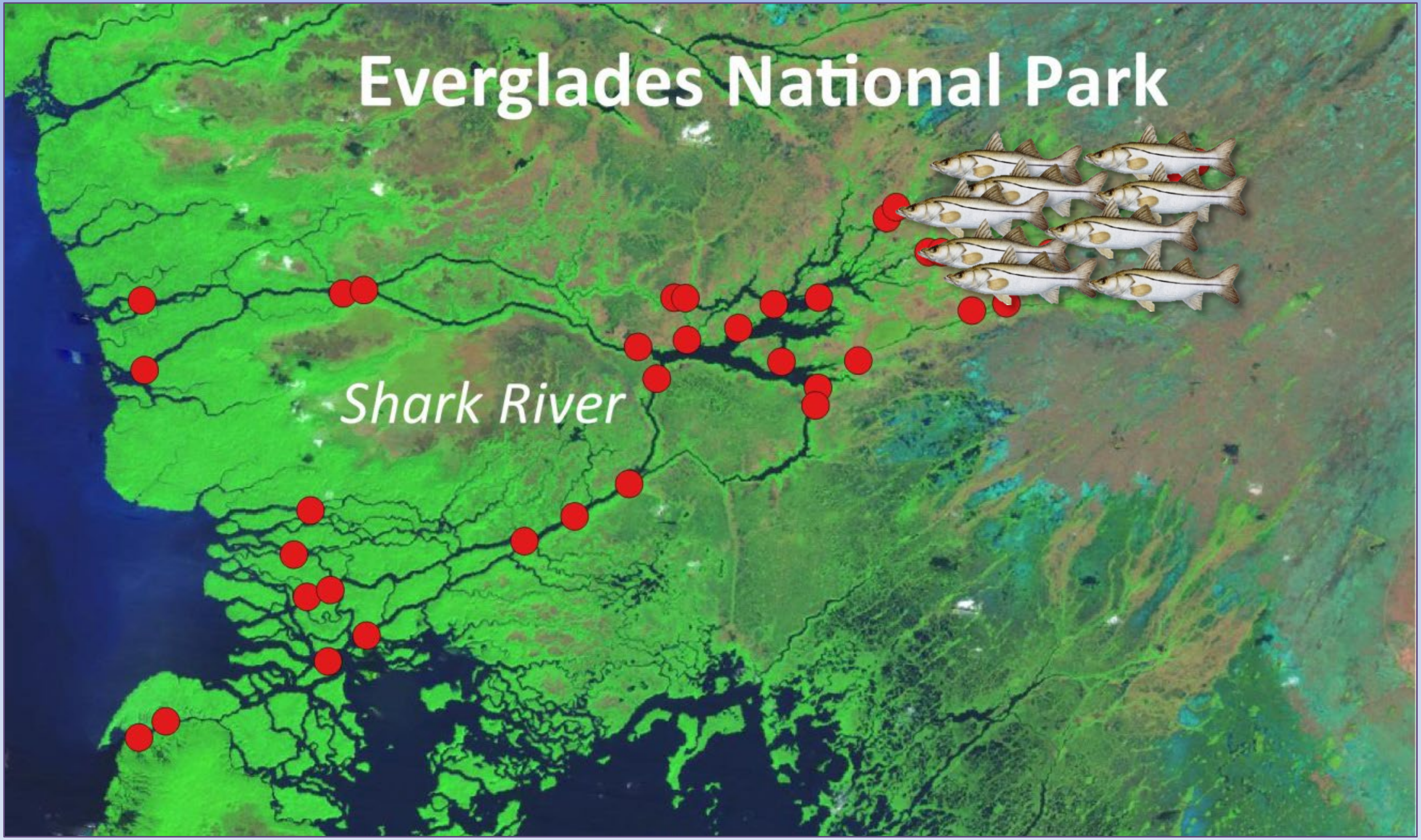
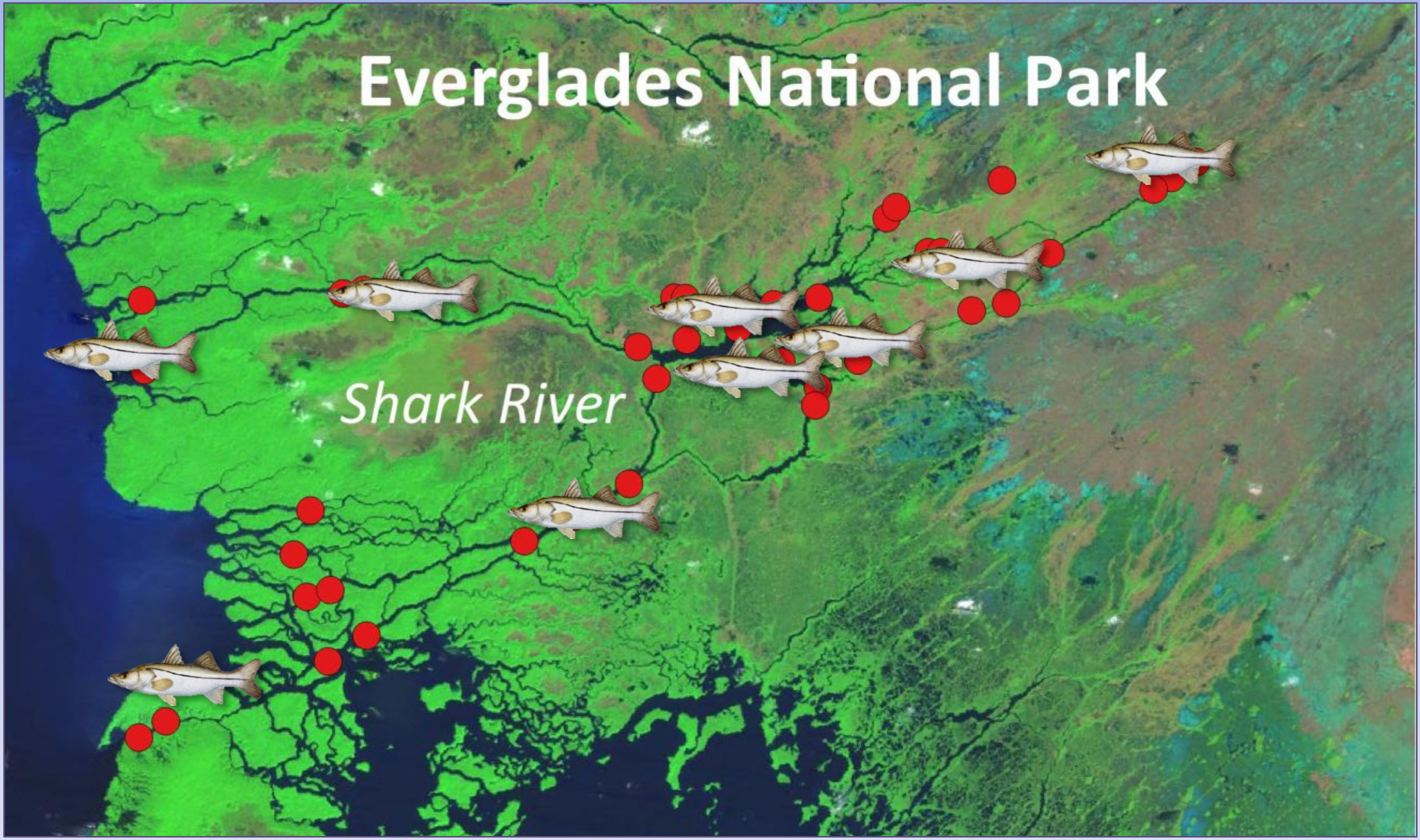


All fish located in the upper river before storm

Hurricane Irma – Snook Response?



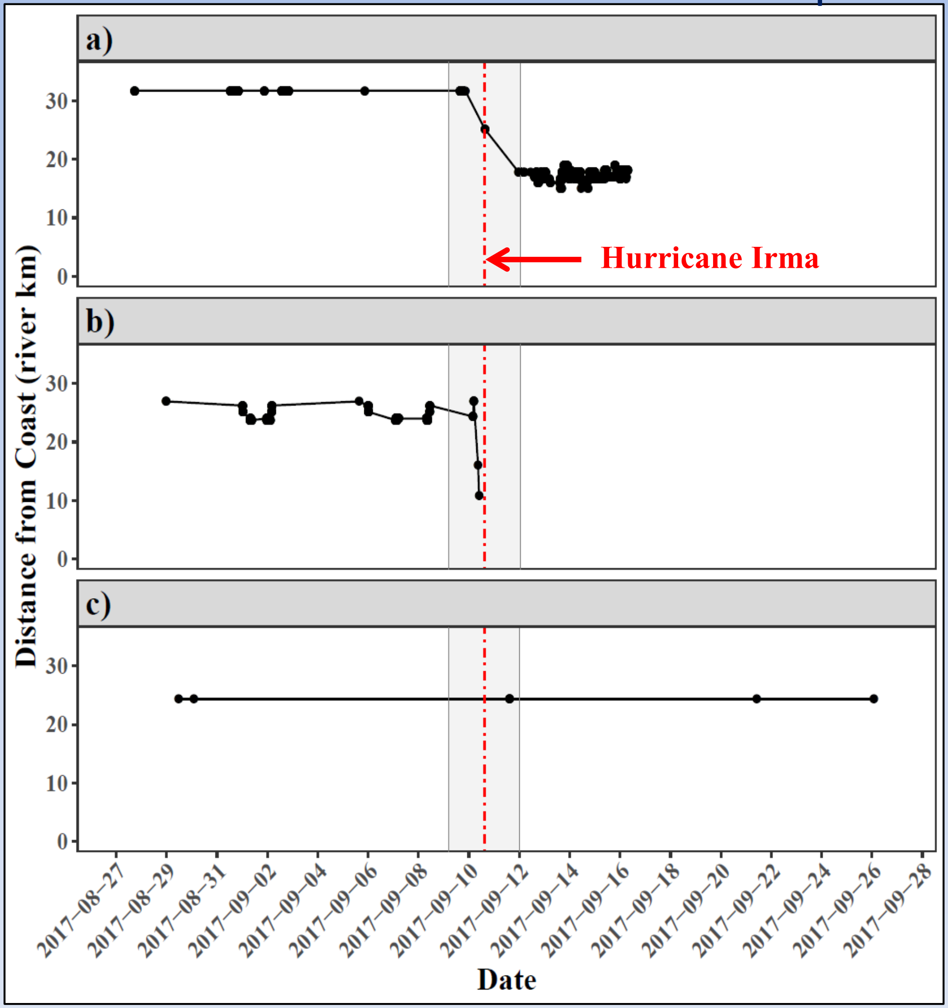
As the hurricane passed, fish rapidly spread throughout the system

Hurricane Irma – Snook Response?

3 predominant movement strategies detected

- Upper river to bay zone (67%)
- Upper river to lower river (22%)
- No movement among zones (11%)

Acoustic detections and movement paths



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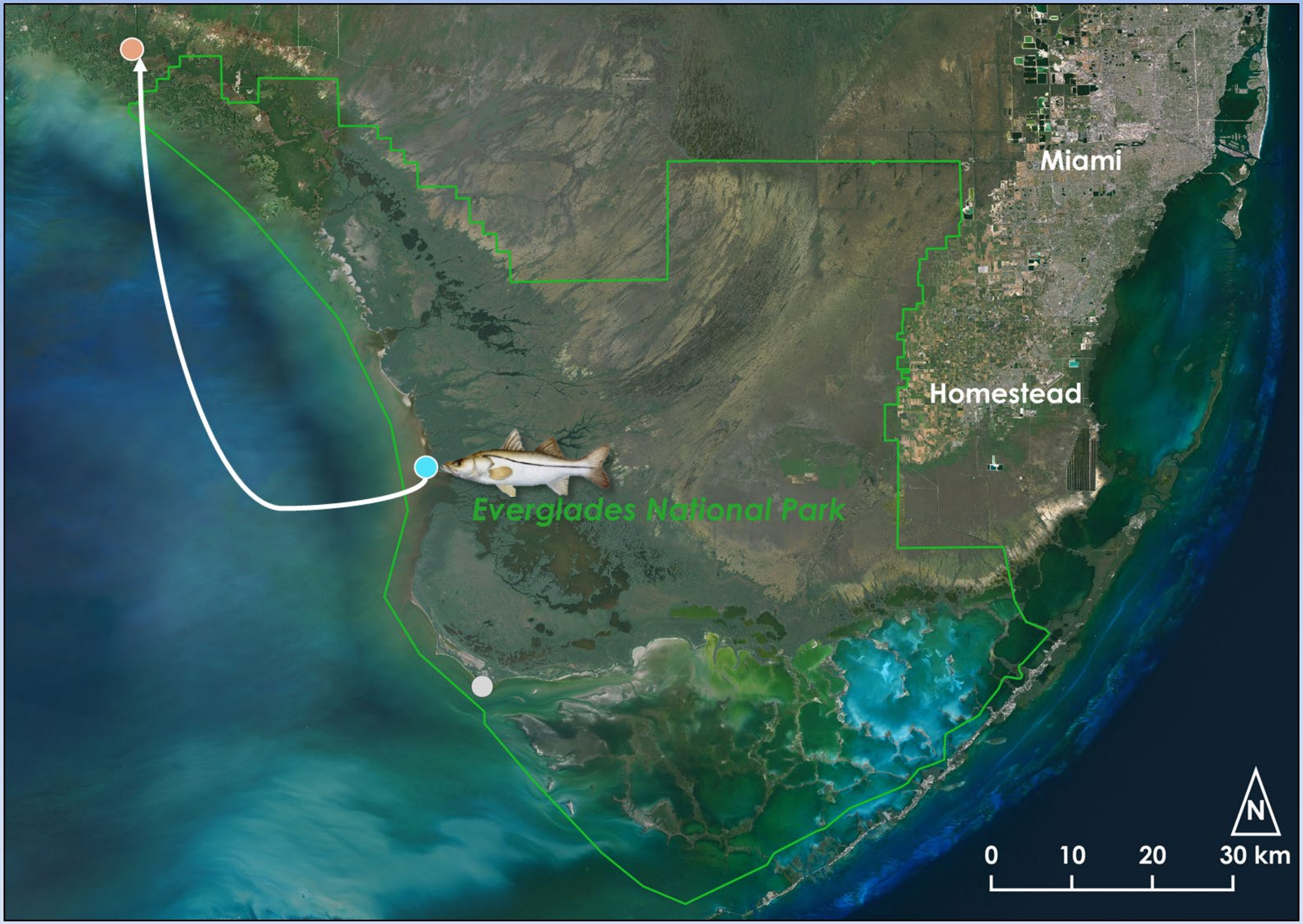
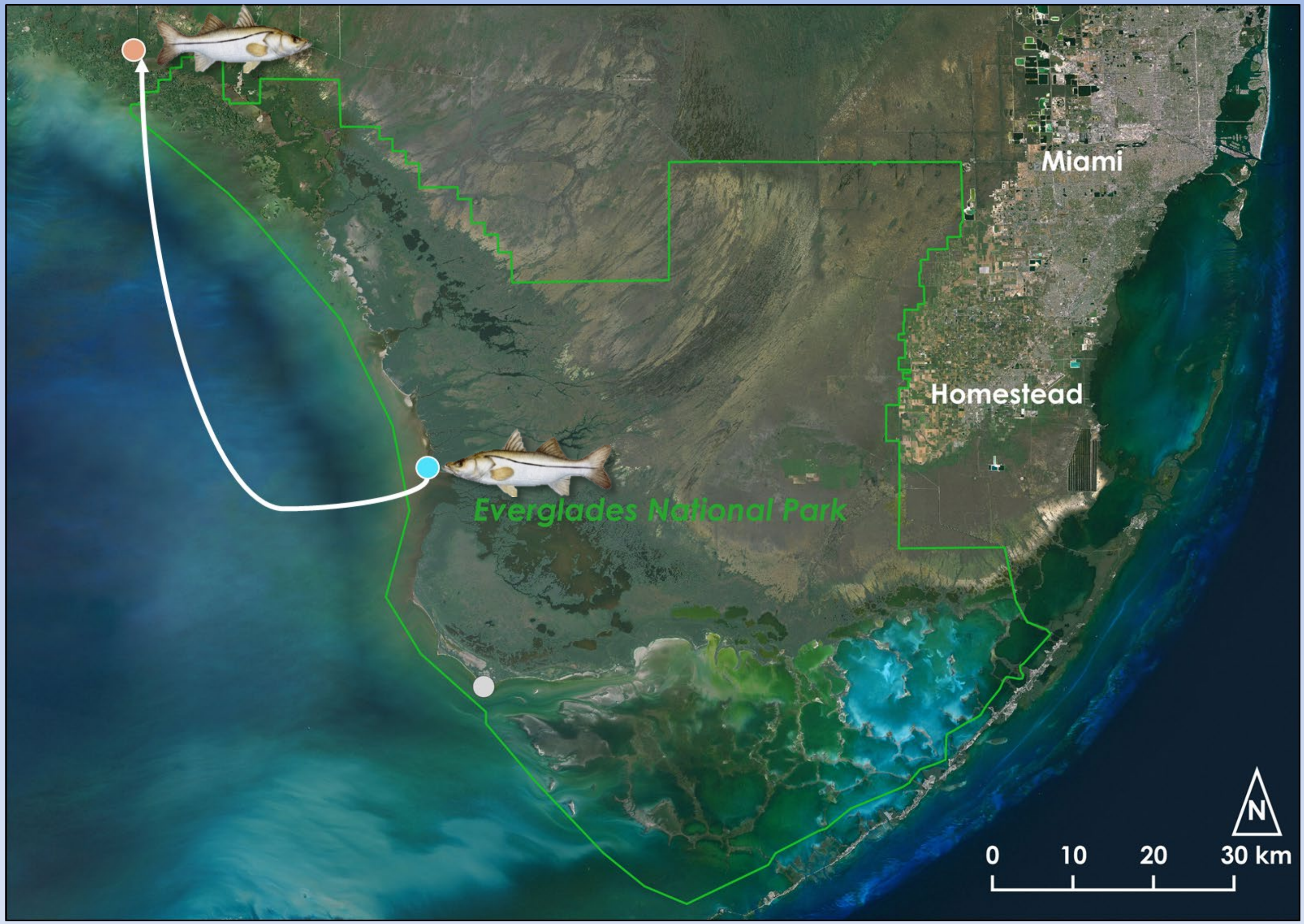


A few fish left entirely

Hurricane Irma – Snook Response?

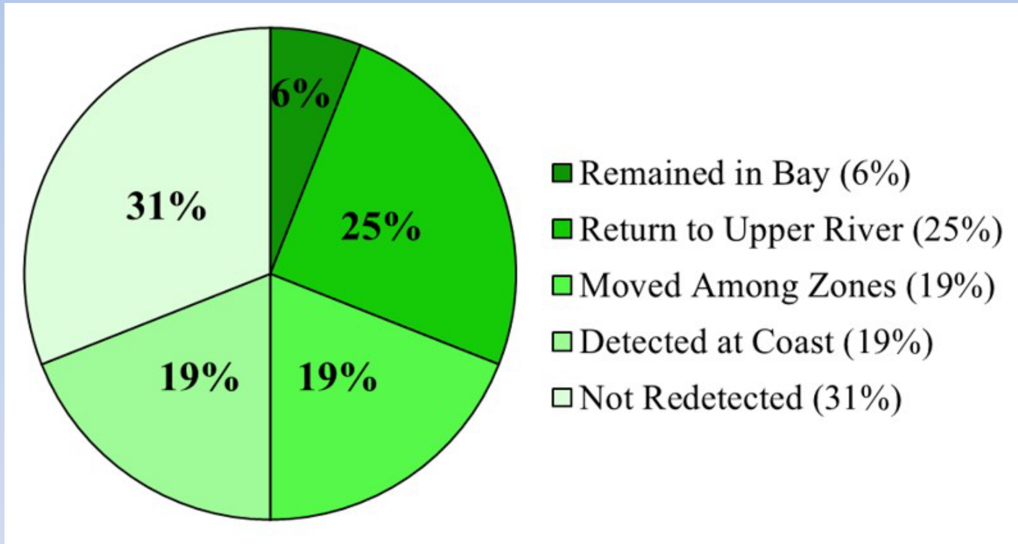


A few fish left entirely, detected on receivers 70 km north at Faka Union on the Gulf Coast

Hurricane Irma – Snook Response?

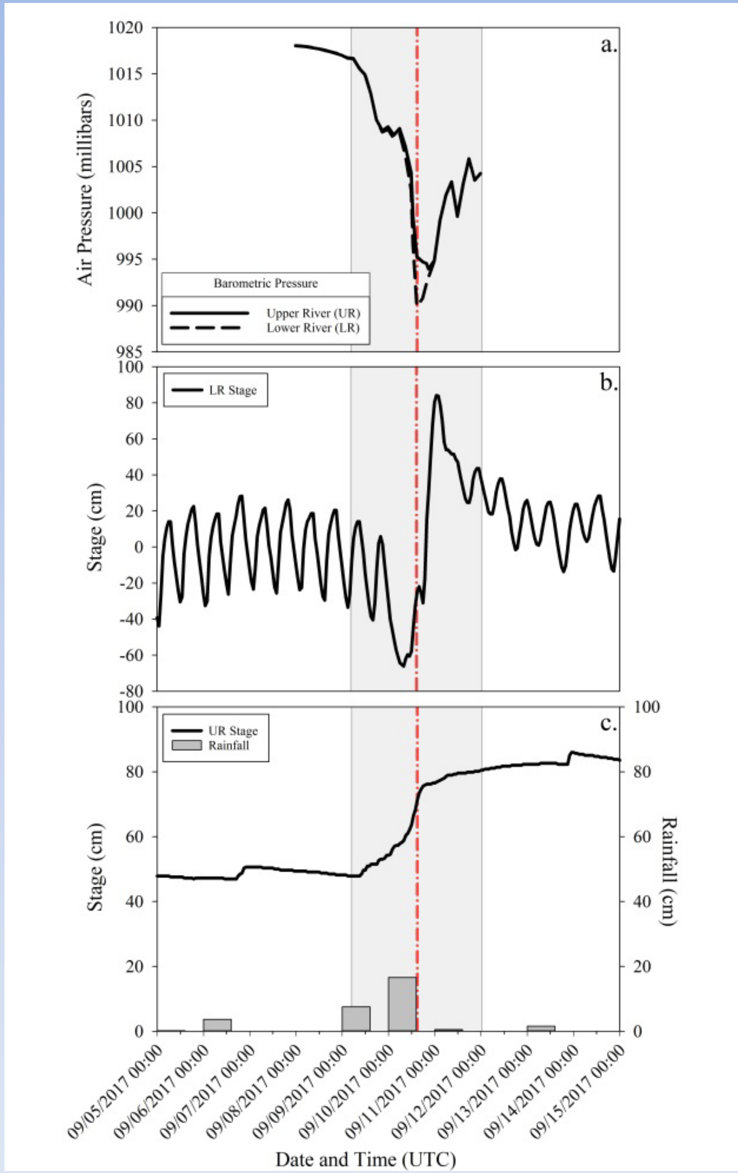
6 Month Window Following the Storm

- 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?



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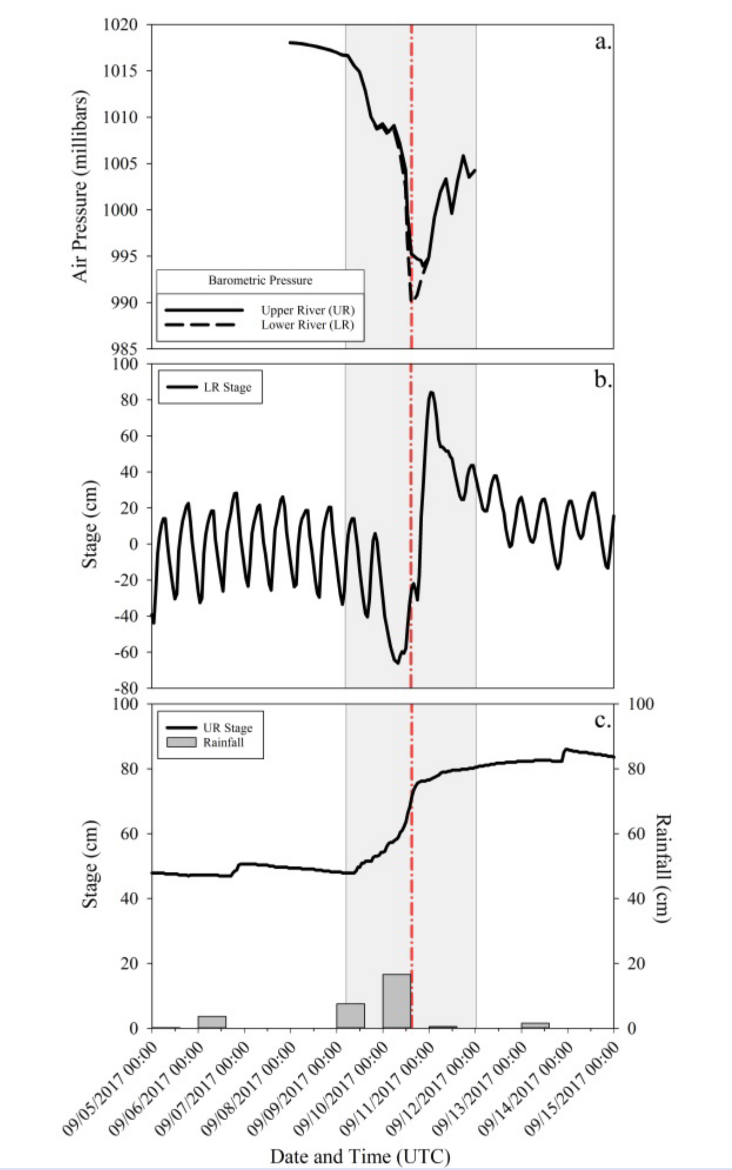
Hurricane and Riverine Conditions

- 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

Model		Variable(s)	k	df	ΔAIC	*w* AIC	Resid Dev	LL	D^2
Hurricane Effects	a.	Barometric Pressure	1	2	72.3	<0.001	102.1	-51.03	0.43
Riverine Effects	b.	Lower River Stage (LR Stage)	1	2	64.1	<0.001	93.9	-46.94	0.47
	c.	Upper River Stage (UR Stage)	1	2	9.5	0.006	39.3	-19.64	0.78
	d.	UR Stage + LR Stage	2	3	7.6	0.016	35.3	-17.67	0.80
Combined Effects	e.	Pressure + UR Stage + LR Stage	3	4	2	0.264	27.8	-13.88	0.84
	f.	Pressure + UR Stage	2	3	0	0.714	27.8	-13.88	0.84

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- Hurricane Effects: Barometric pressure
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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…

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

Back calculations of hatch date indicated spawning shortly after Hurricane Irma.

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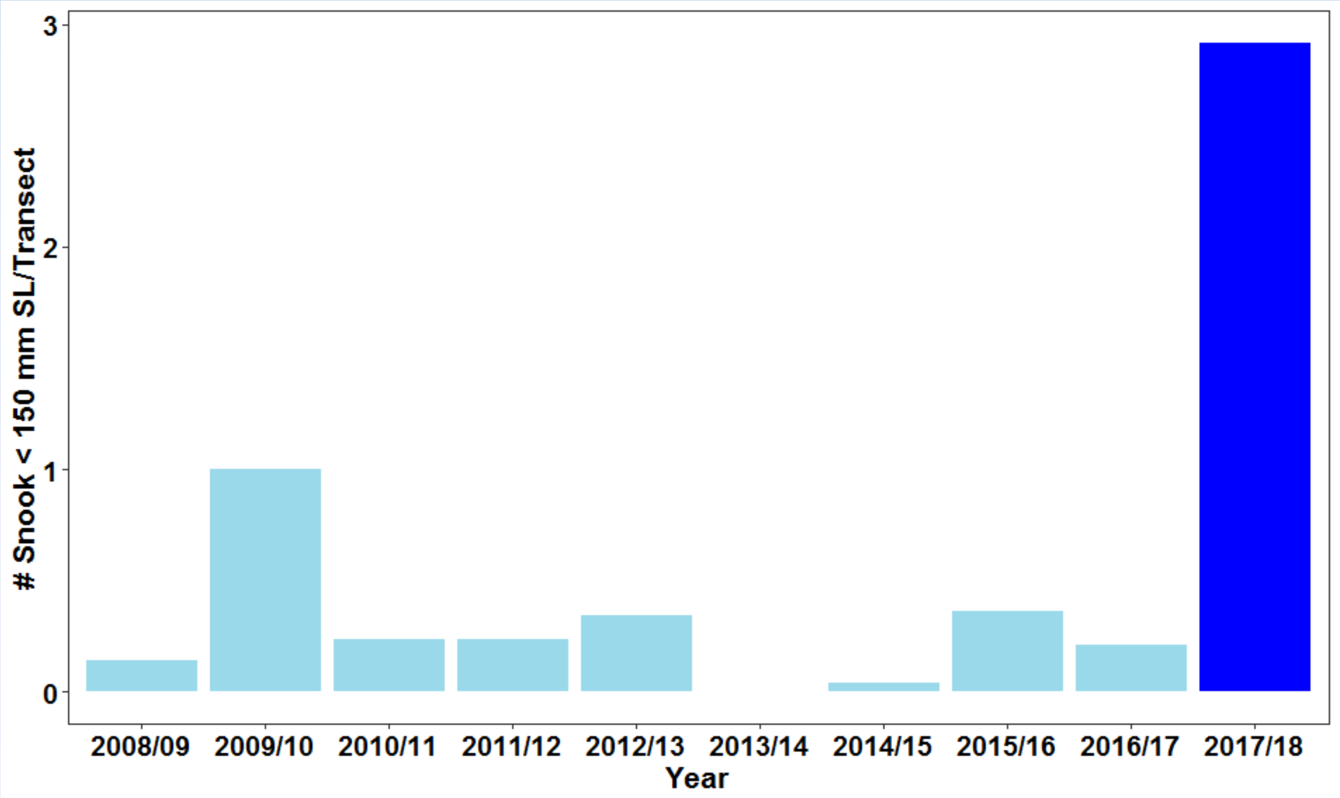

Could hurricanes also have positive impacts on the Snook reproduction?

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

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- National Park Service
- Pat O'Donnell, Rookery Bay National Estuarine Research Reserve

Questions?

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Shark River at dusk. Image by Jordan Massie