Will Watershed Restoration in South Florida Impair or Improve Juvenile Fish Communities in Downstream Estuaries?

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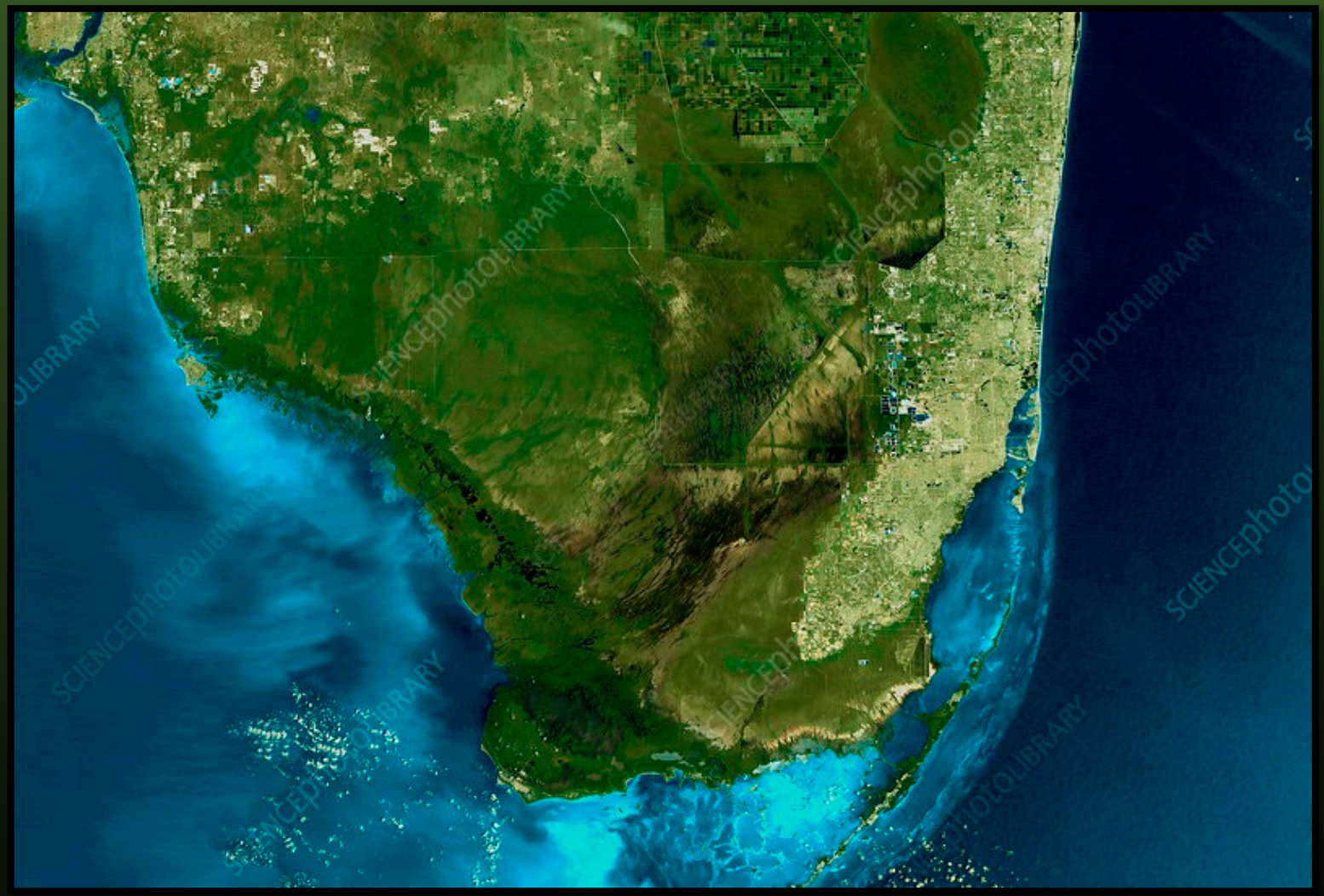
Topics

- Past, present, and future of freshwater flow over the SW Florida landscape
- 3 study bays in the Ten Thousand Islands
- Trawl and water quality monitoring programs
- How do fish communities differ among the 3 bays?
- What environmental variables relate to fish communities and fish movements?
- What does it mean for the Picayune Strand Restoration Project?



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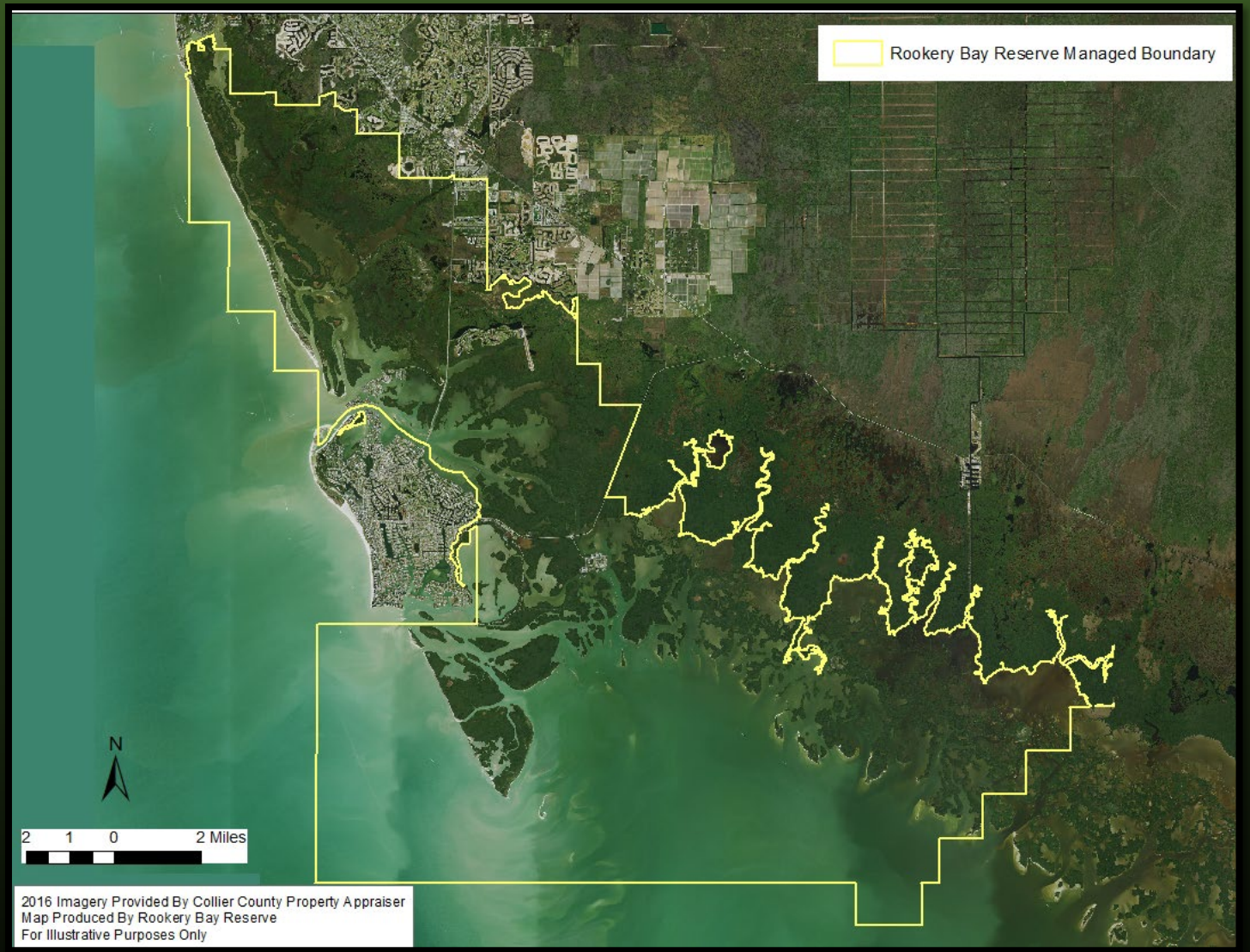
Rookery Bay NERR

- One of 29 National Estuarine Research Reserves in the US
- NOAA/FL DEP/FIU partnership established in 1978
- 110,000 Acres
- Committed to preservation through research, education, and land protection
- > 37,000 kids on field trips
- > 8,700 professional scientists/researchers trained
- Excellent opportunity to study landscape-scale processes



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Under Natural Conditions

- Seasonal wet/dry cycles
- Gradual sheet flow
- Collects into tidal creeks
- Flows into estuaries in a prolonged pulse
- Dries out beginning around Oct

Benefits

- Aquifer recharge
- Fire suppression
- Healthy swamp ecosystems
- Natural estuarine salinity patterns

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Plumbing Problems

- 1920's Tamiami Trail mostly blocked southward sheet flow

"… giant machinery is carving a 'Dream City' out of raw virgin acreage…"

- 1960's South Golden Gates Estates drained Picayune Strand through Faka Union River/Canal

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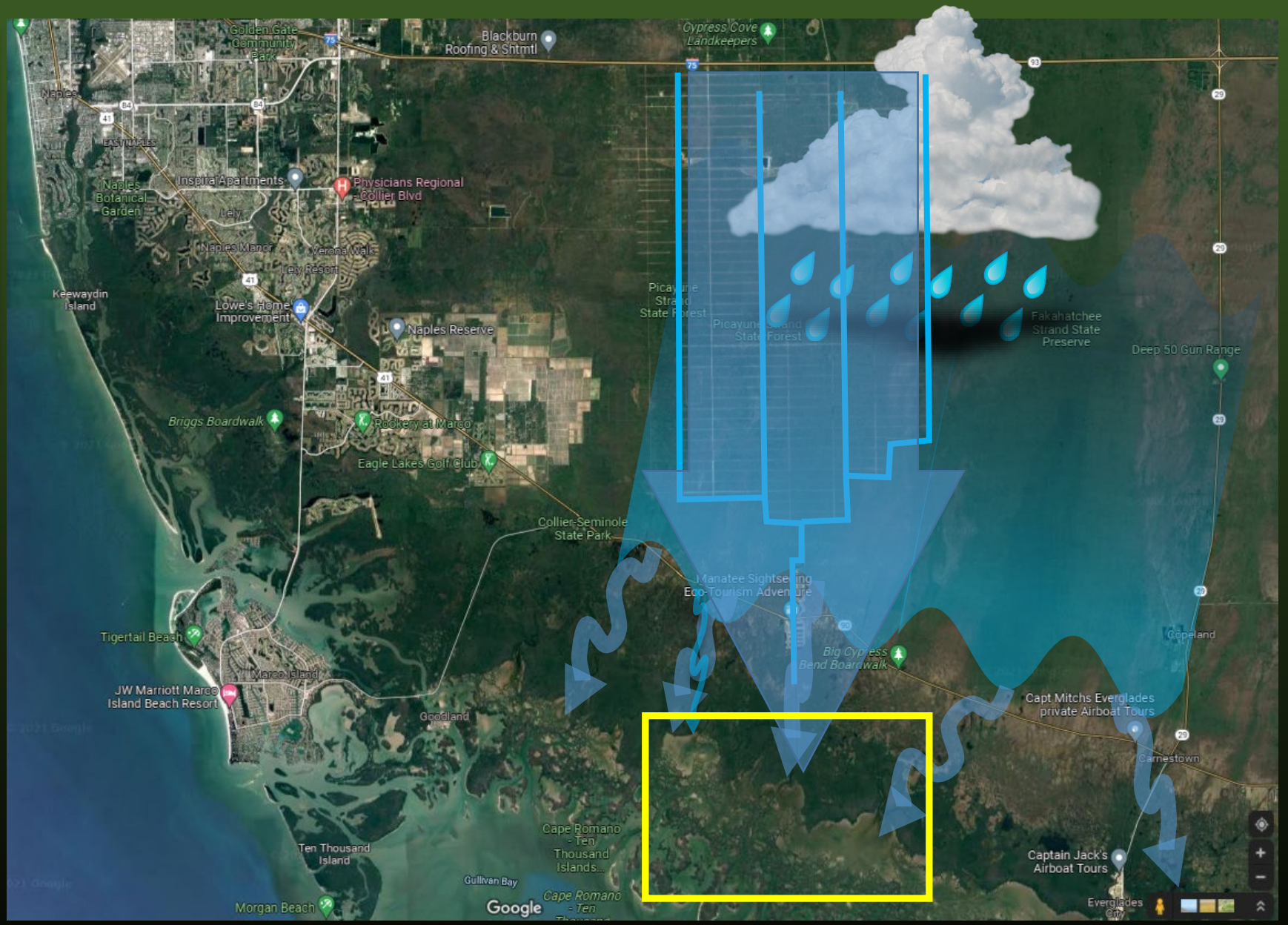
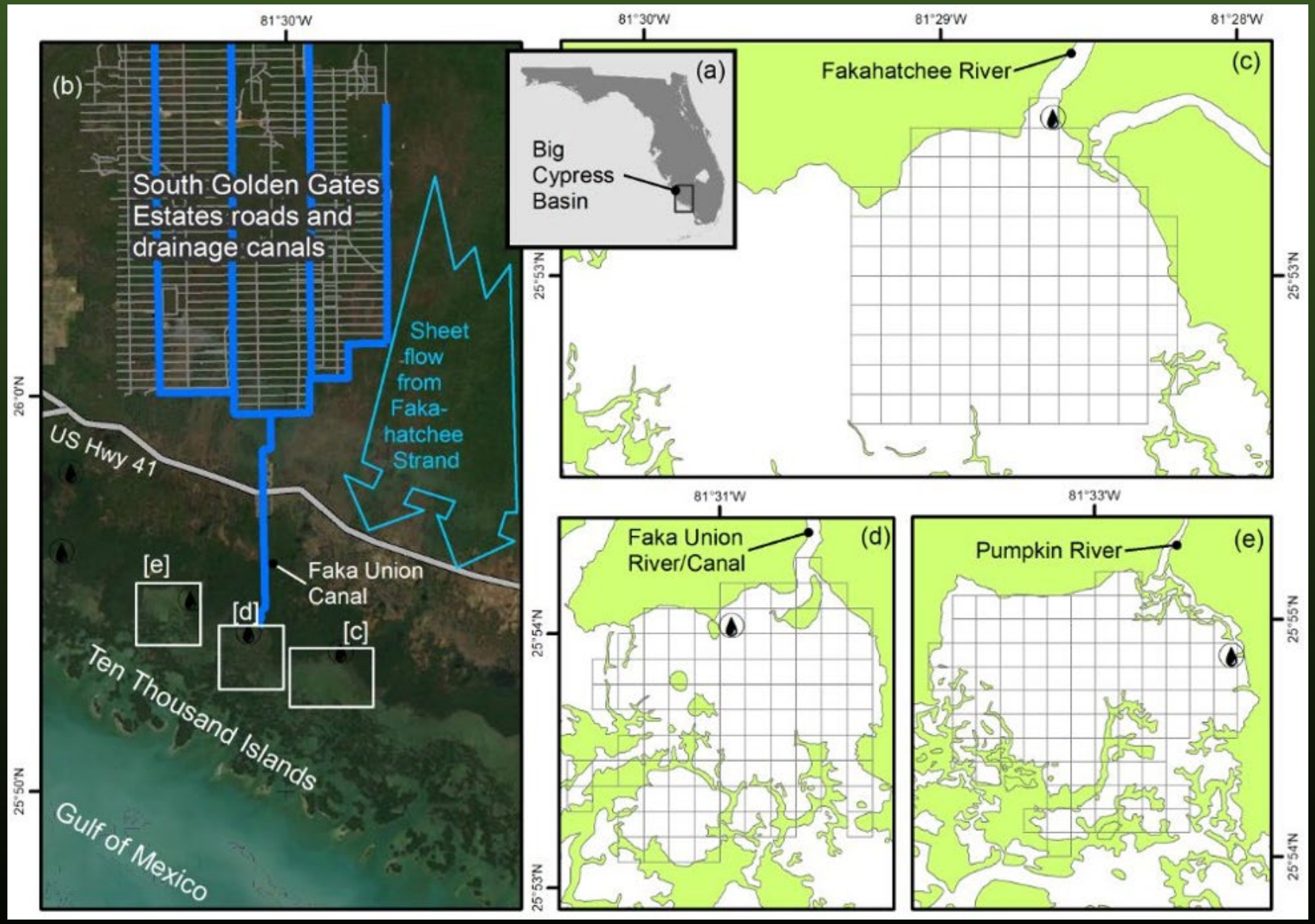
Under Drained Conditions

- No sheet flow down Picayune strand
- Partial sheet flow down Fakahatchee strand
- Flow greatly reduced to Pumpkin Bay
- Flow rapidly channeled through Faka Union Canal





Watershed-scale "Goldilocks" experiment

- Faka Union Bay *(too wet)*
- Pumpkin Bay *(too dry)*
- Fakahatchee Bay *(just right)*

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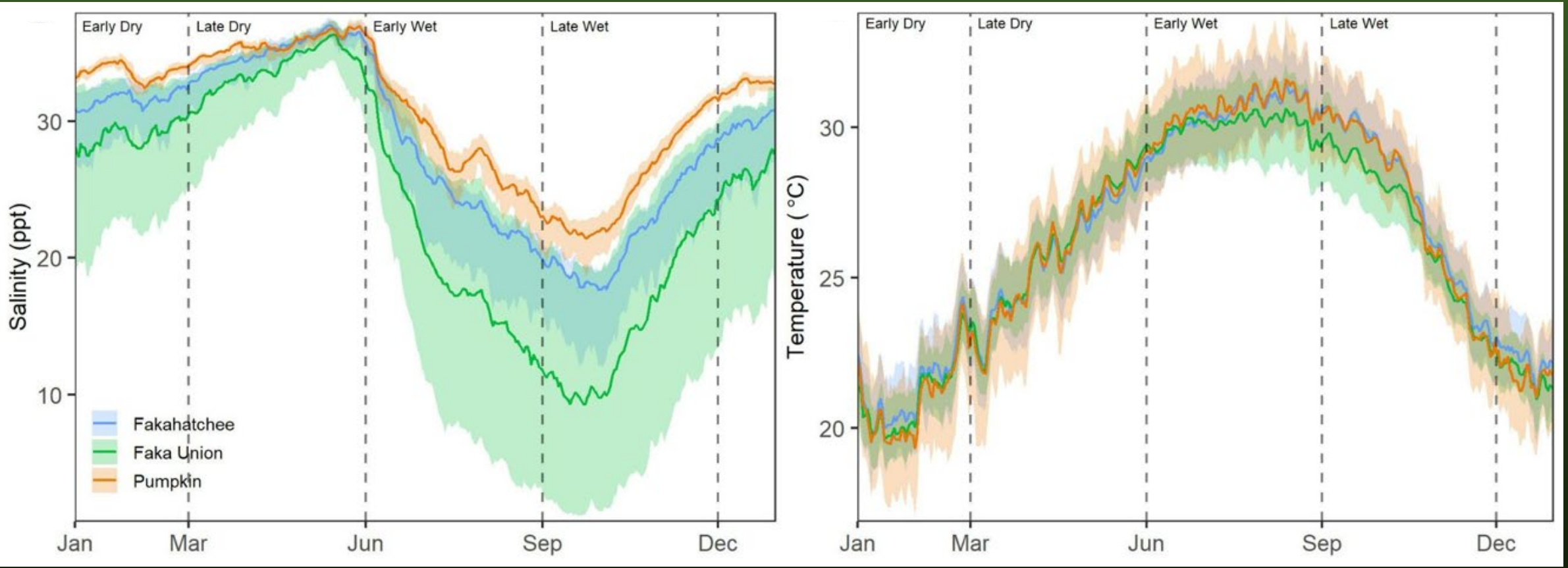

Drainage effects on the environment of these bays

- Salinity is much lower and more variable in Faka Union during the wet season
- Salinity is higher and less variable in Pumpkin Bay
- Salinity is high in all three bays at the end of the dry season
- Seasonal temperature broadly consistent among bays

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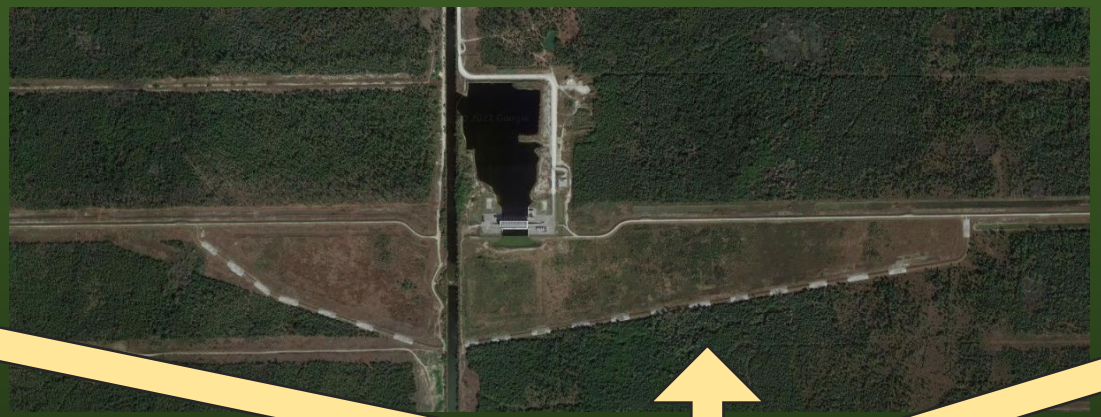

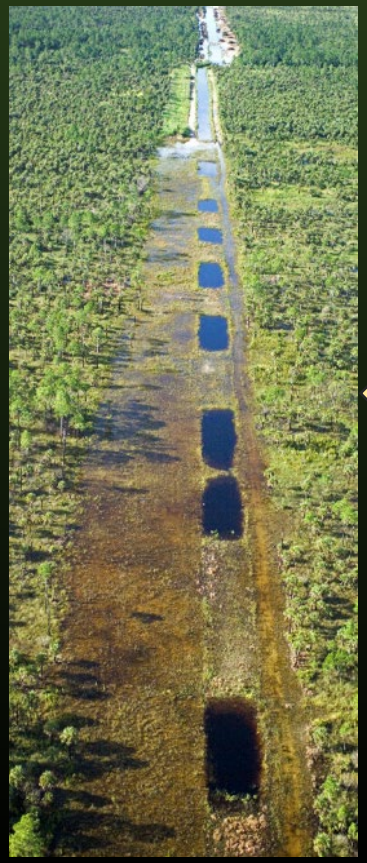

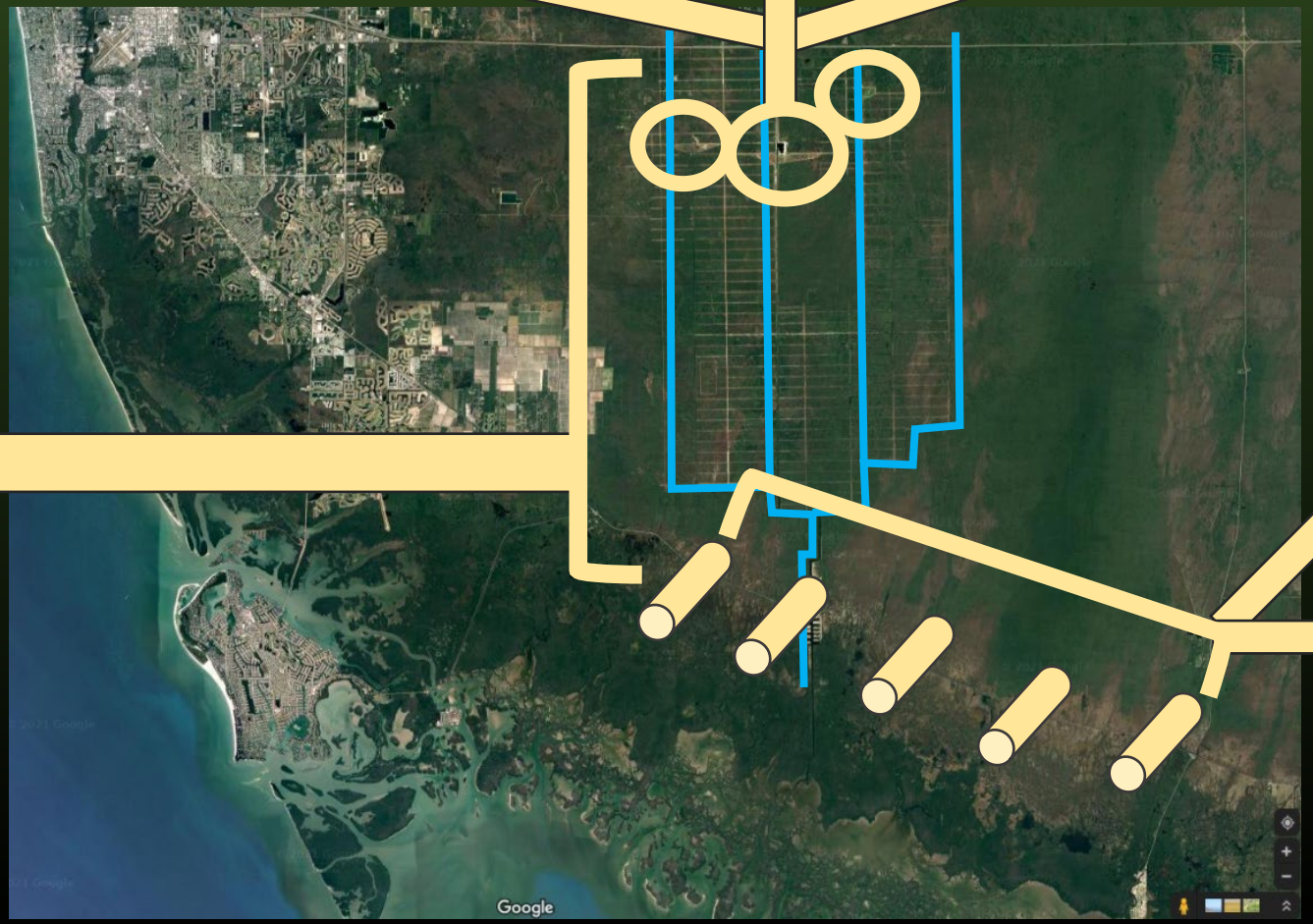

Lars Soderqvist, USGS

Study Objectives

- How might watershed restoration affect juvenile estuarine fish?

- How do fish communities and abundances of key species differ among the 3 bays?
- How do temperature and salinity relate to fish communities, abundances, and movements?

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The data

- Since 2000, 4 replicate trawls monthly per bay
- Fish are identified, counted, and measured
- Bycatch of macroalgae, sponges, etc. recorded
- Continuous water quality data in each bay at fixed stations (e.g., S, T, DO, turbidity)
- Fish tracking

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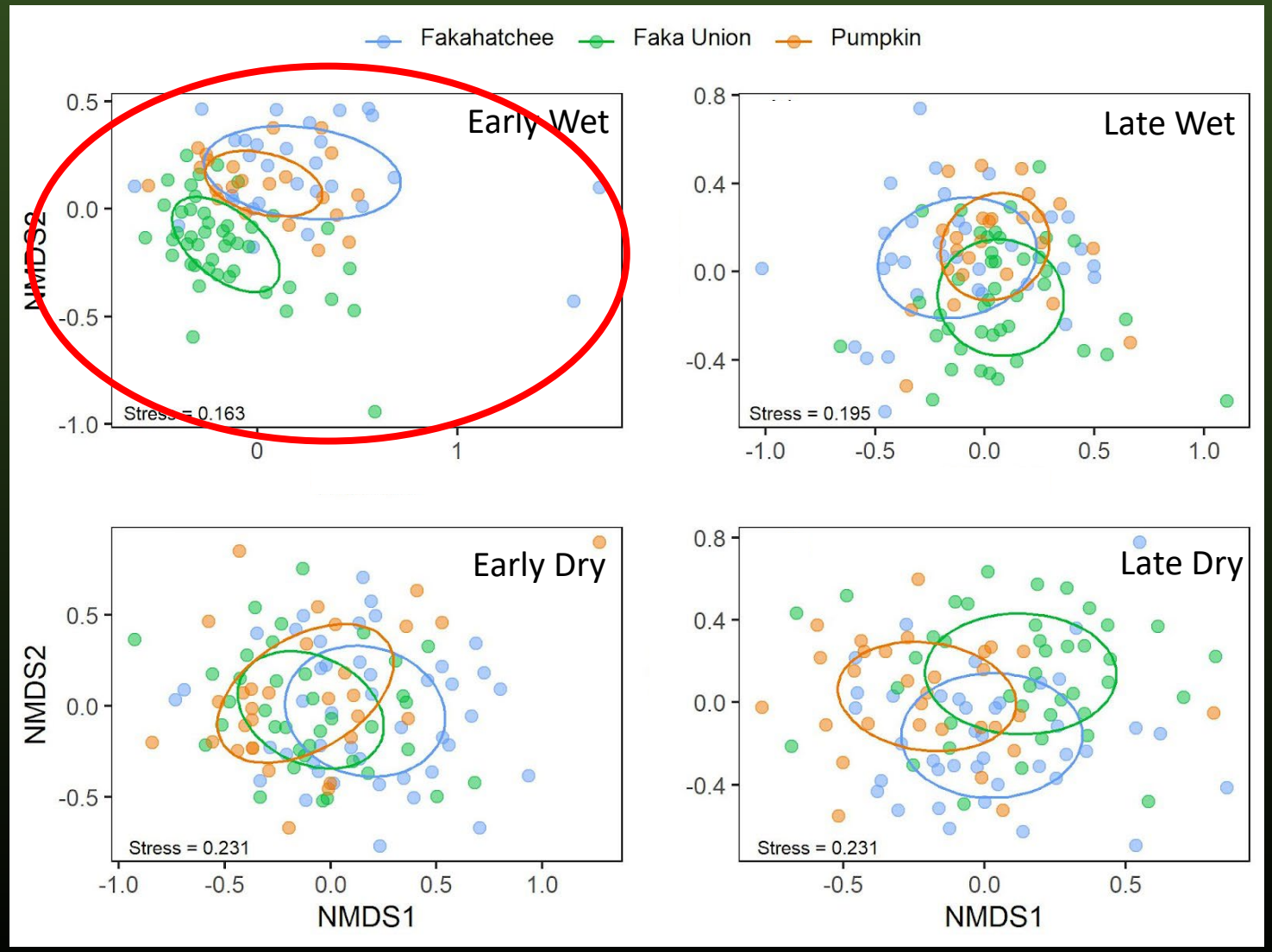
How do fish communities differ among bays by season?

nMDS, ANOSIM, SIMPER



- It depends on the season!
- Significant difference in the Early Wet season between Faka Union and Fakahatchee
- But not a big difference (R=0.38)
  - FH has more pinfish, silver perch, hardhead catfish, pigfish, code goby, and gulf pipefish
  - FU has more mojarra, anchovy, blackcheek tonguefish, and sand weakfish
- The rest of the year, lots of similarity among bays

How do temperature and salinity relate to fish communities?

- Must consider not only temperature and salinity at the time of the trawl…
- … but also in the days and months prior to each sample.
- Which environmental variables, or combinations of them are best correlated with the fish community from each monthly sample? Relate, BioEnv

Tested Variables: Salinity and Temperature

- Mean
- Standard Deviation
- Range
- Minimum
- Maximum

Tested time intervals before each trawl

- 1 day
- 3 days
- 1 week
- 2 weeks
- 1 month
- 2 months
- 3 months

These may all be seasonal scale effects, possibly not temperature or salinity per se.

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What is the relationship between salinity/temperature and abundance of key species?

GAMs, tested all combinations of T, S, bay, month, year

Key Species	Rationale	% Deviance Explained	
Lined sole	prey	44	
Anchovy spp.	prey	19	←
Sheepshead	game fish	33	
Hardhead catfish	predator	45	
Gafftopsail sea catfish	predator	76	→
Silver perch	prey	41	
Sand weakfish	prey	59	
Spotted weakfish	game fish	61	→
Fringed flounder	prey	21	←
Mojarra spp.	prey	61	→
Code goby	prey	33	
Pinfish	prey	56	
Gray snapper	game fish	19	←
Lane snapper	game fish	40	
Whiting spp.	abundant	40	
Clown goby	abundant	44	
Green goby	abundant	34	
Pigfish	abundant	61	→
Gulf flounder	game fish	63	→
Bighead searobin	abundant	57	
Blackcheek tonguefish	abundant	39	
Gulf pipefish	abundant	33	
Inshore lizardfish	predator	23	←

Longer term, seasonal scale variables were most important, possibly not temperature or salinity per se.

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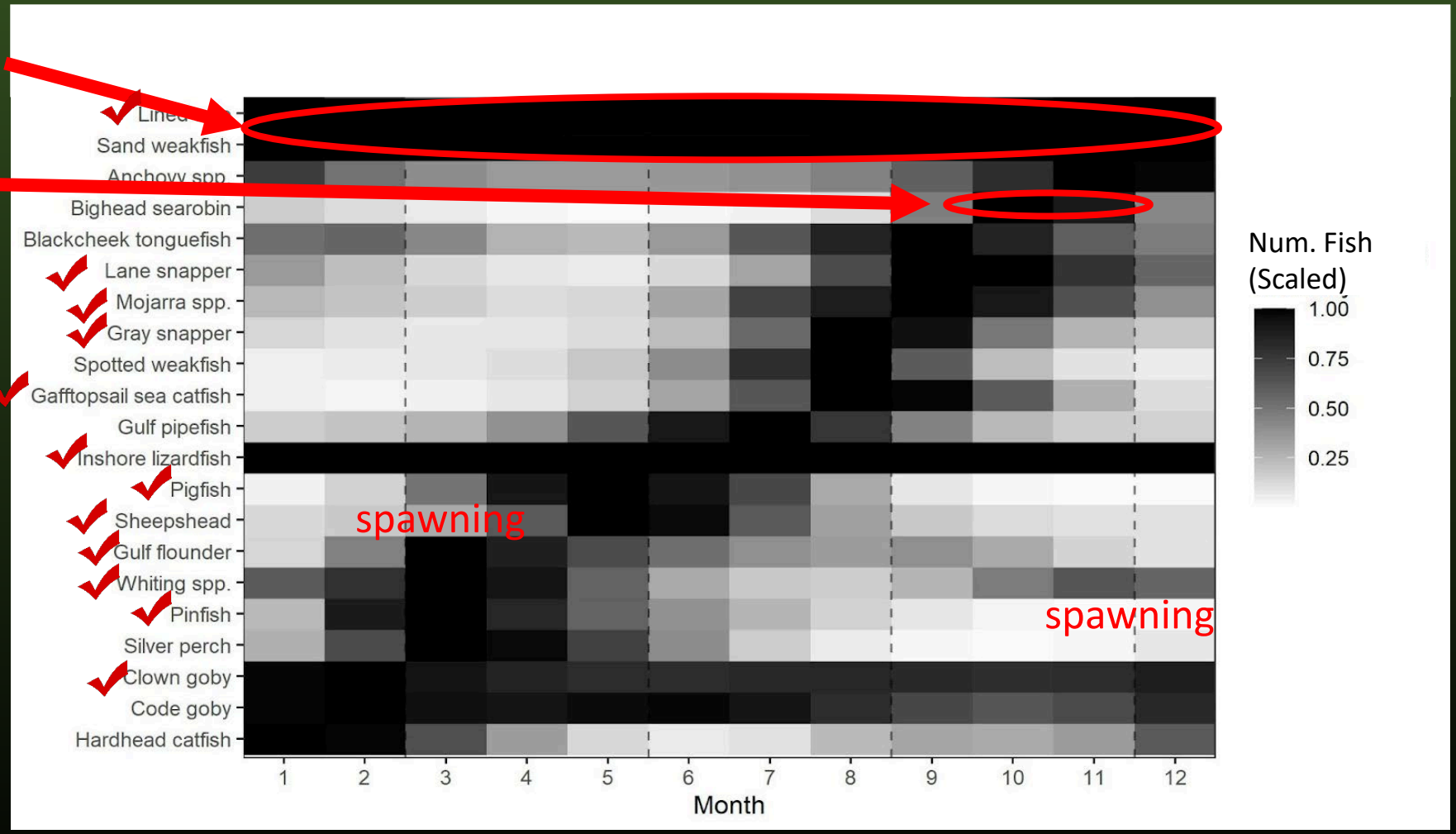
Are there seasonal differences in abundance for key species?

Notable patterns

- Some had consistent monthly abundance
- Most had seasonal peaks
- Known spawning period + larval development lag matched expected timing

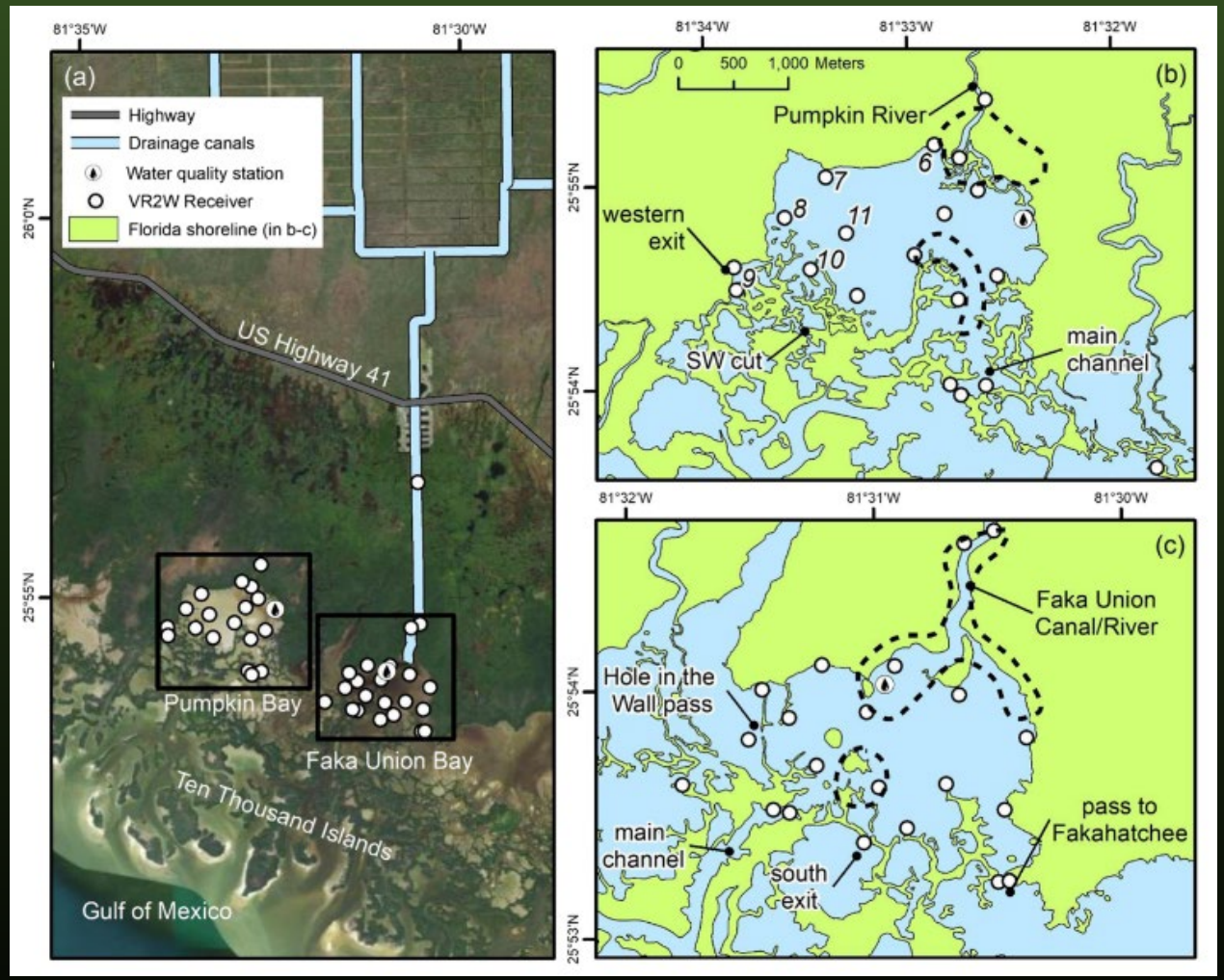
- Apparent mismatch for others due to:
  - Ontogenetic habitat shifts?
  - Regional variation in spawning seasons?



But wait there is more! … Fish tracking

Methods

- Tagged larger juvenile gray snapper, red drum, and goliath grouper in Pumpkin and Faka Union
- Are there differences in site fidelity and movement distance for fish in the two bays?
- Is timing of movements related to Salinity and Temperature?
- T-tests, chi-square, GAM, and a quasi-random movement simulation removing any influence of S and T



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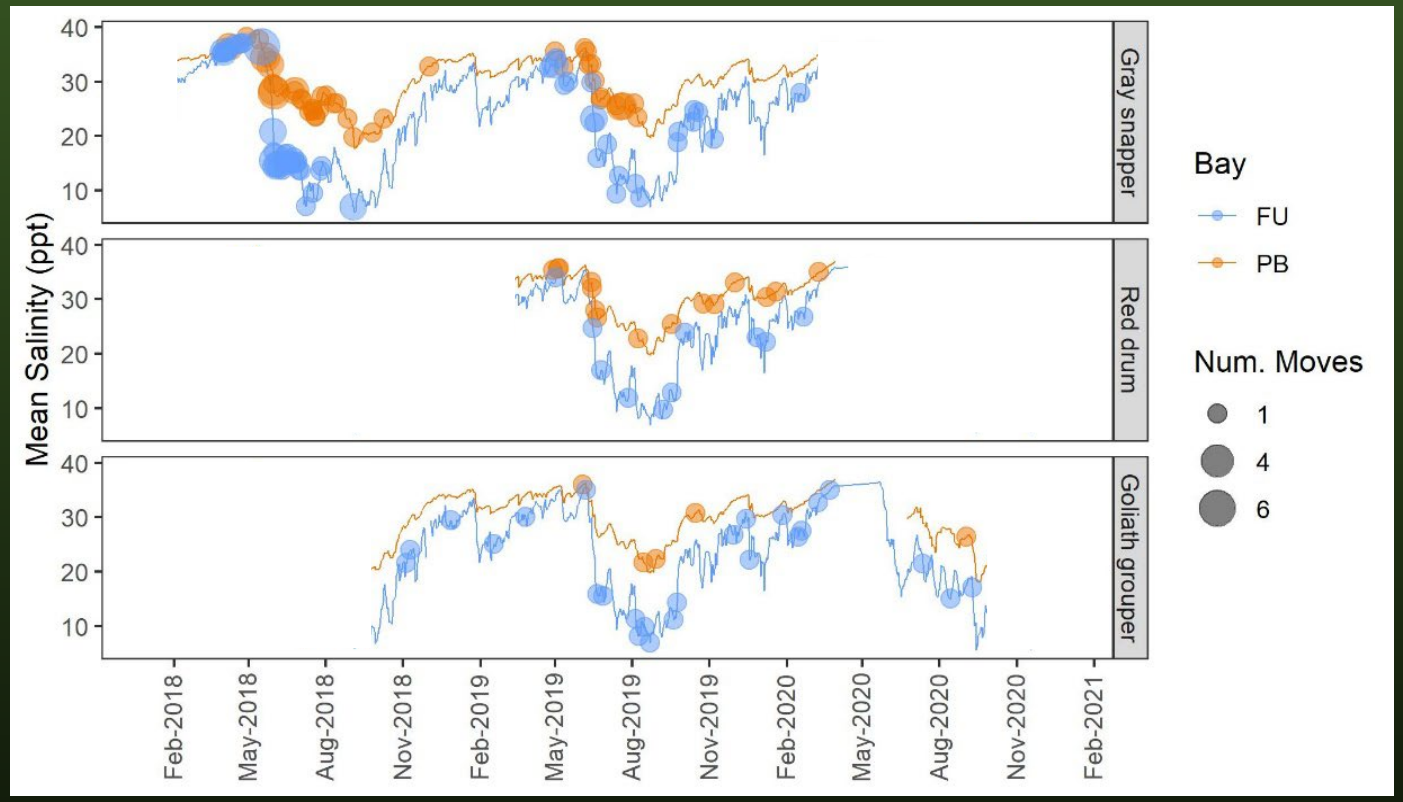
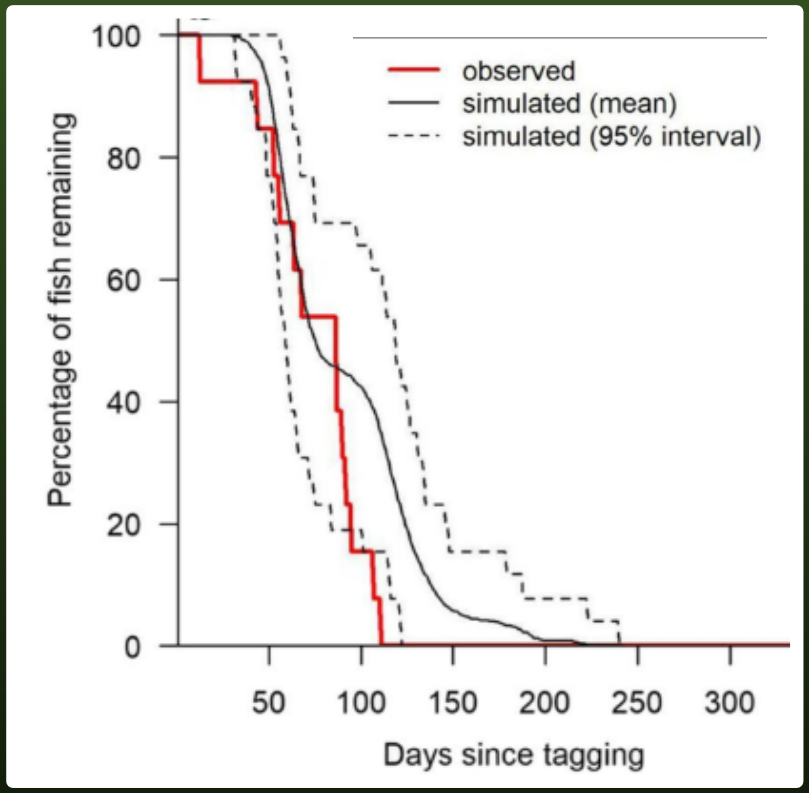
But wait there is more! … Fish tracking





Results

- Few differences in fish home range parameters between bays
- Only 10-11% PDE in the GAMS
- Similar emigration rates could arise independent of S and T

Movements are likely related simply to age, size, and ontogenetic shifts

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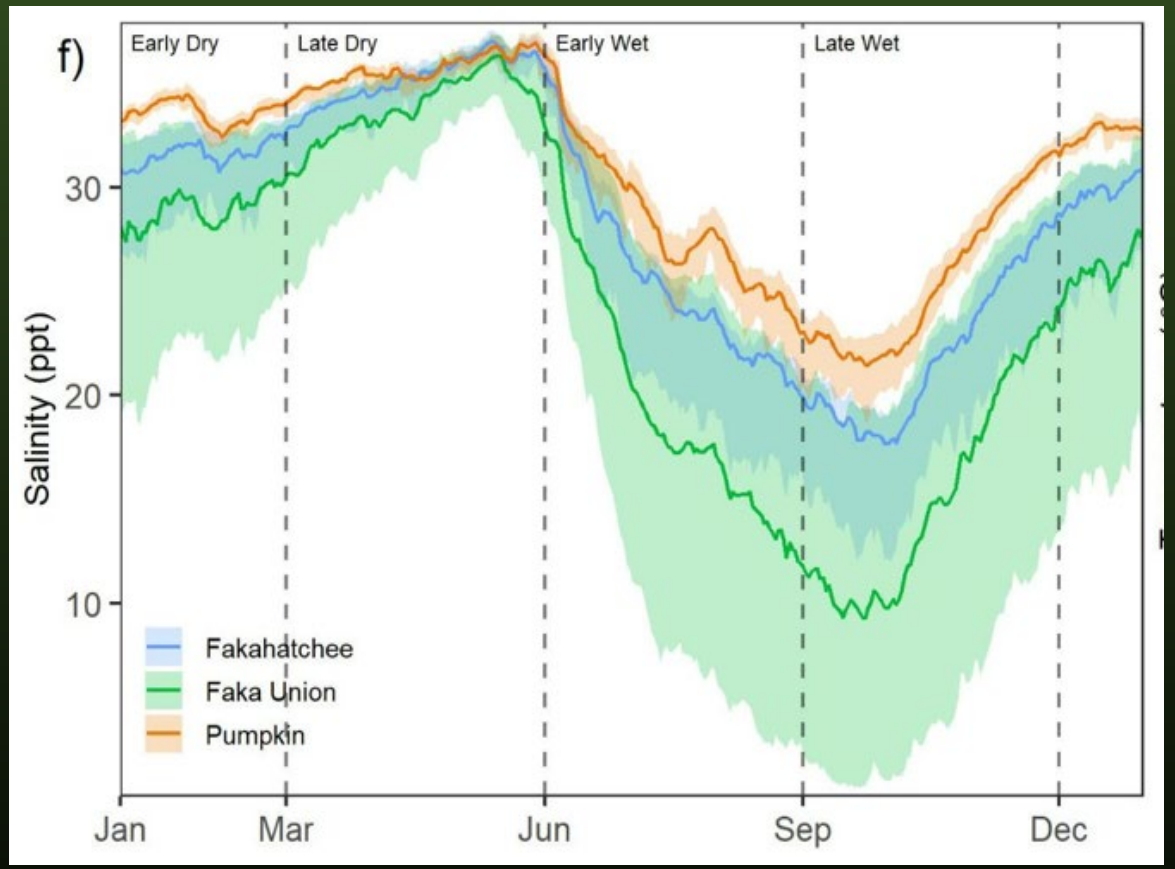
Conclusions: How might watershed restoration affect these estuarine fish?

- These are euryhaline/estuarine species and can tolerate the anticipated range of restored salinities
- Species membership not expected to change, but relative proportions may
- High salinity in all three bays at the end of the dry season "resets" the entire system
- Main influence may simply be seasonal, and not due to flow per se. (e.g., spawning, recruitment, habitat shifts)



- Proceed with the restoration!

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Conclusions: How might watershed restoration affect these estuarine fish?

In Faka Union:

- Fewer fish (e.g., mojarra, anchovy, sand weakfish) and therefore fewer in the ecosystem overall
- More algae and sponges which may also translate into more pinfish, gulf pipefish, and code goby
- Likely increase in fish diversity

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Caveats

- Analysis is based on conditions several decades after the plumbing was changed
- Results are for “flats” fish
- Results are for smaller/slower species susceptible to the trawl

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Future Directions

Analyses

- Biomass, body condition, growth rate, cohorts
- Spatial patterns within bays (edge, inlet/outlet)
- Juvenile shark data!

Monitoring

- Don’t change a thing for the next 5-10 years
- Longer term to evaluate climate change effects

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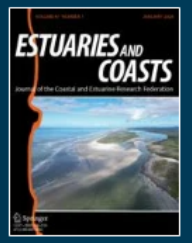
Too Much Freshwater, Not Enough, or Just Right? Long-Term Trawl Monitoring Demonstrates the Impact of Canals that Altered Freshwater Flow to Three Bays in SW Florida



Estuaries and Coasts

Aims and scope →

Submit manuscript →

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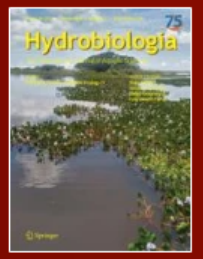
What controls home range relocations by estuarine fishes downstream from watersheds with altered freshwater flow?



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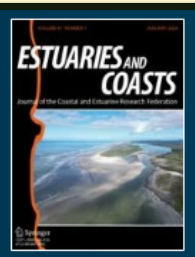
How Are Man-Made Changes in Freshwater Flow Related to the Abundance of Juvenile Estuarine Fishes?



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Volume 46, pages 1632–1651, (2023) Cite this article

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Thank you!

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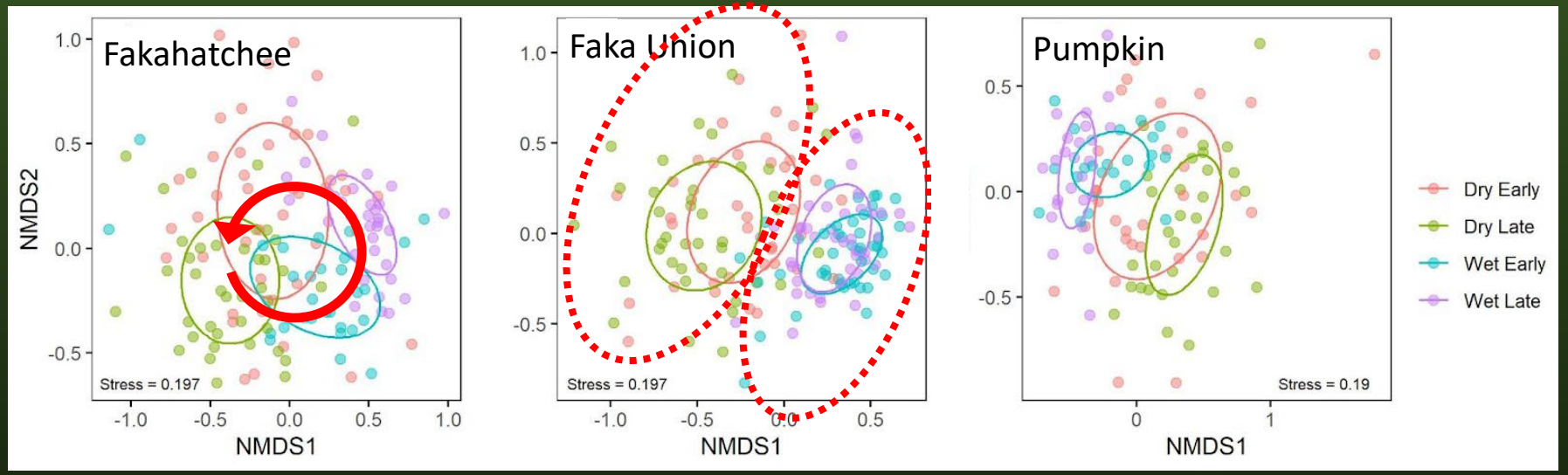
Hundreds of volunteers contributed over 25,000 hours assisting with data collections and quality assurance. Notably, the late Jean Barden single handedly QAQCed over a decade of the trawl data. The education and outreach provided to the local community in exchange for their assistance in economically and effectively gathering this long term dataset has been invaluable. This analysis was funded by NCCOS Project 848. Arliss Winship, Laughlin Siceloff, Jeffrey Schmid, and Keith Laakkonen provided constructive review comments. The trawl program was funded by the Florida Department of Environmental Protection. Water quality data was provided by multiple Rookery Bay personnel including Julie Drevenkar, Heather Stoffel, Vickie McGee, and Christina Panko-Graff and is funded by a site operations, management, education, and monitoring grant to RBNERR from NOAA/Office for Coastal Management. GIS base layers were provided by Jill Schmid. Joanna Weaver provided context on the PSRP restoration. Field sampling was conducted under FWC permit SAL-20-0059-SRP.

How do fish communities differ among seasons by bay?

nMDS, ANOSIM, SIMPER

- It depends on the bay!
- Largest differences between Dry Late and Wet Late seasons in all three bays
- Just 2 seasons in Faka Union (Wet or Dry)
- Similar to Pumpkin!
- 4 season cycle observed in Fakahatchee



Comparison (R values)	Faka-hatchee	Faka Union	Pumpkin
Dry Late vs. Wet Early	0.37	0.63	0.42
Dry Late vs. Wet Late	0.72	0.62	0.73
Dry Late vs. Dry Early	0.21	0.14	0.13
Wet Early vs. Wet Late	0.32	0.14	0.34
Wet Early vs. Dry Early	0.30	0.49	0.24
Wet Late vs. Dry Early	0.30	0.34	0.27

- In Fakahatchee and Pumpkin, the late wet season had more mojarras, anchovies, blackcheek tonguefish, lane snapper, lined sole, and catfishes than the late dry season
- In Faka Union, late wet had more mojarras, sand weakfish, and clown and green gobies than late dry

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Are there interannual differences in abundance?

Some notable variations (Faka Union shown)

- "wetter" dry seasons
- "drier" wet seasons
- Longer dry seasons
- Later wet seasons
- Very "wet" wet seasons
- Anomalous events

Demonstrates the importance of long-term data!

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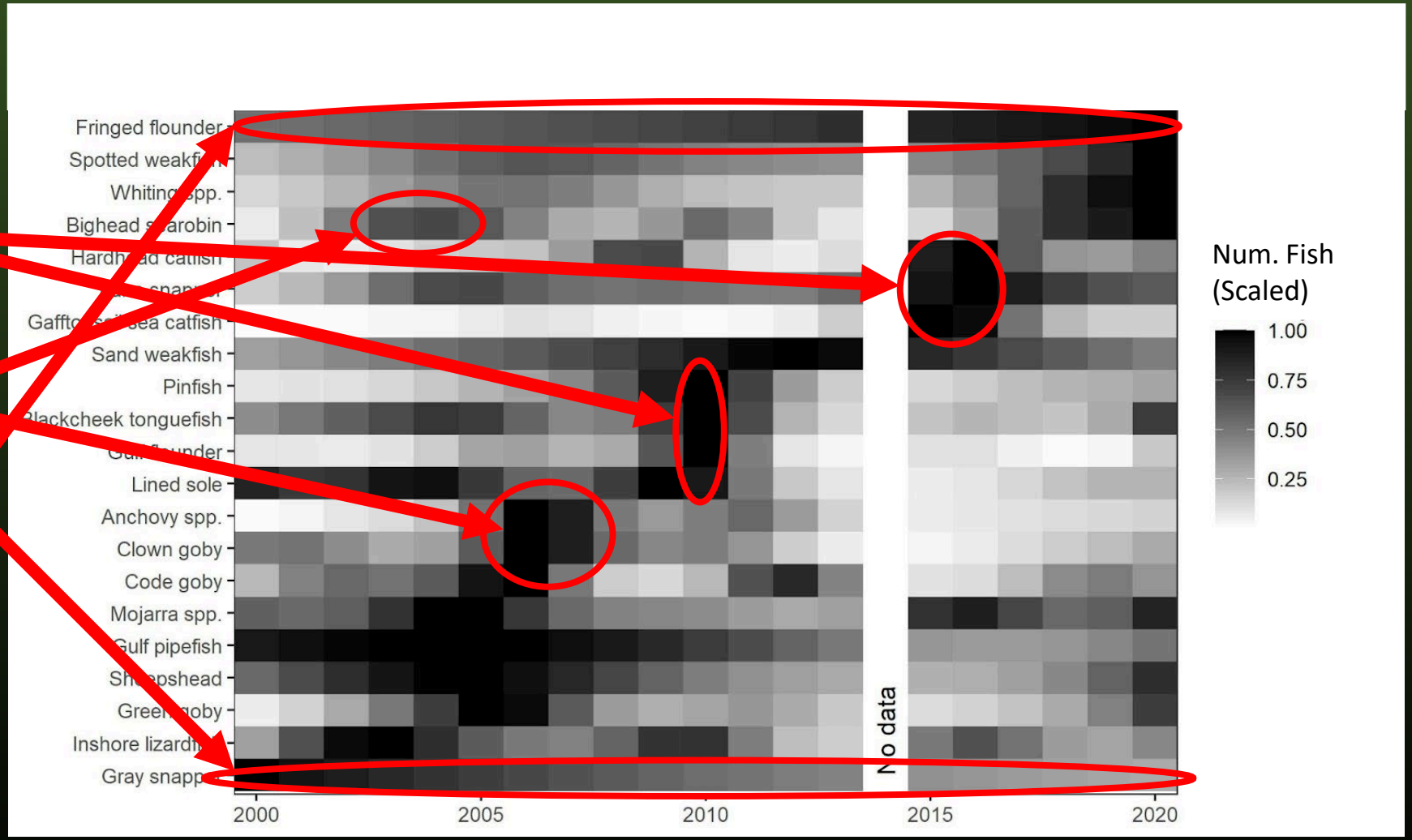
Are there interannual differences in abundance?

Notable patterns

- Years of peak abundance differed among species
- Many showed 2-3 consecutive years of higher/lower abundance
- Gradual increase (48 x more)
- Gradual decrease (0.29 x less)



Value of long-term data!