Responses of Estuarine Benthic Macroinvertebrate Communities to Changing River Flows in the St. Johns River Estuary, Florida, USA

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Benthic Macroinvertebrates

- Invertebrate animals associated with bottom habitats; retained by 500 µm sieve mesh
- Major consumers of wetland plant production
- Key food base for higher trophic levels
- Indicators of ecological integrity:
  - sediments are “the memory” of the aquatic ecosystem; benthos integrates ephemeral events over longer time periods

Freshwater Inflow to Estuaries

- Affects water quality; salinity, dissolved O_2, nutrients, sediment supply
- Salinity a good surrogate for freshwater inflow
- Benthic macroinvertebrate communities strongly influenced by inflow/salinity

Estuarine Fishery Taxa: right salinity
right place
right time

Freshwater inflow

Dynamic Habitat

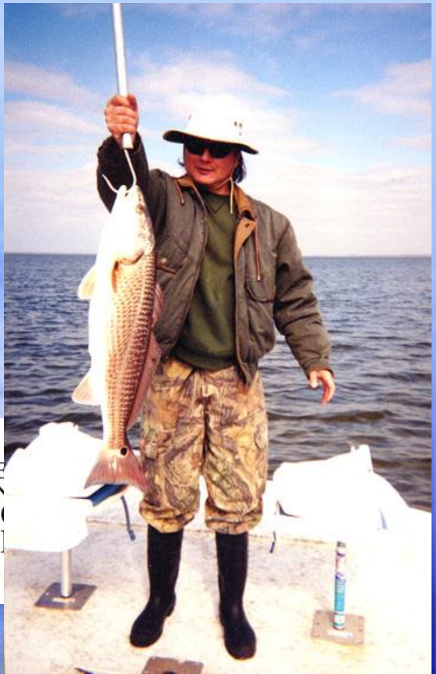
Static Habitat

Intertidal wetlands, tidal creeks
SAV beds, oyster reefs

Area of reduced, variable salinity

Browder and Moore 1981

Fish production



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Study Objectives

- Given an established link between inflow and salinity (via empirical data and modeling):
  - Identify specific macroinvertebrate indicators of salinity change (benthic infauna and epifauna/fishery taxa)
  - Develop empirical model(s) relating benthic invertebrate population and community characteristics to salinity variation
  - Assess effects of potential freshwater inflow reduction on salinity change and benthic macroinvertebrate communities

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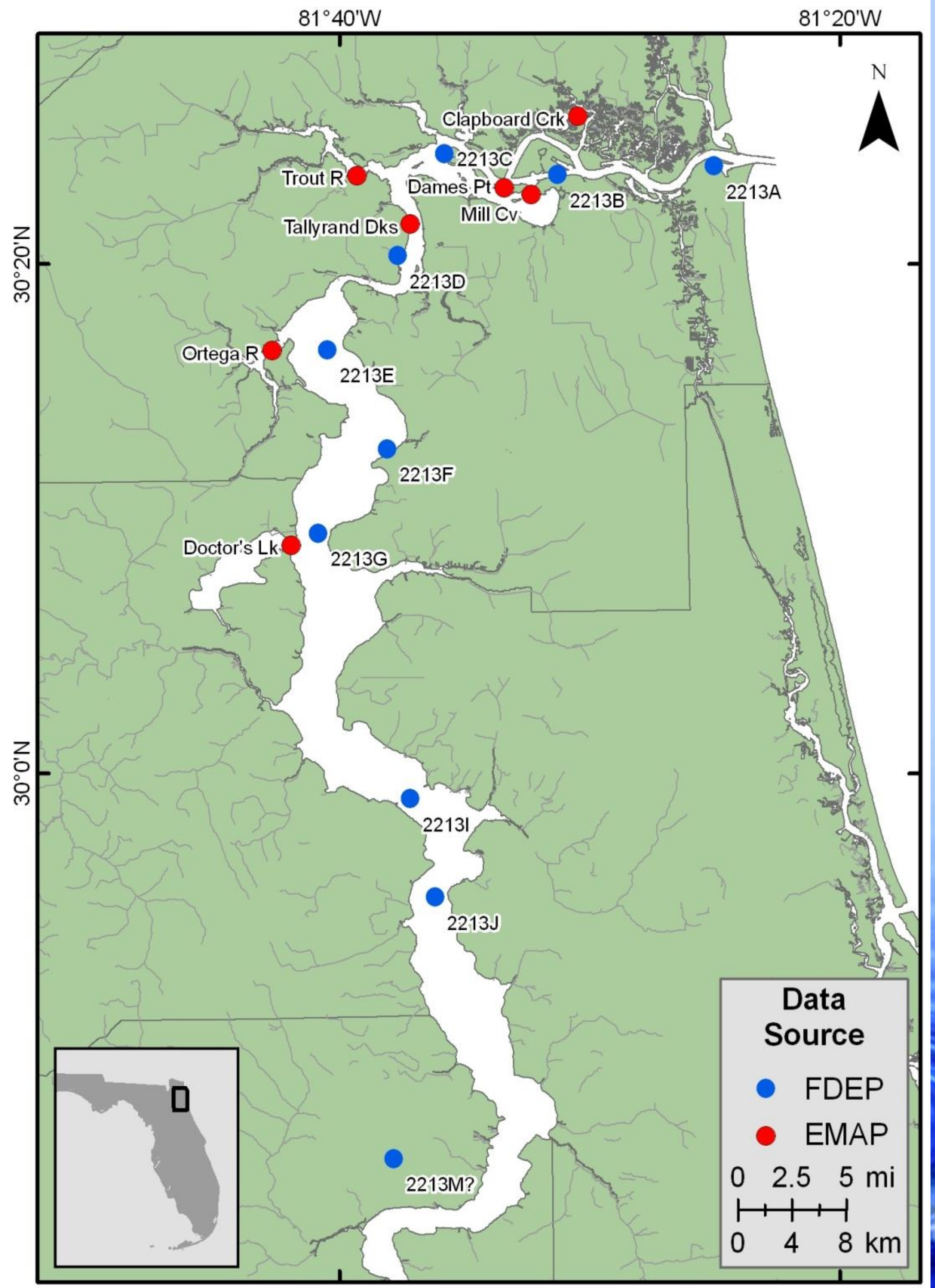

St. Johns River Estuary

Existing historical benthic data:

- Fla. Dept. of Environmental Protection
- USEPA EMAP-E Program

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Existing benthic data sets

- Florida Dept. of Environmental Protection
  - Collected w/ petite ponar dredge (1973-1996)
  - US std #30 mesh (595 µm)
  - In-situ water quality data
- US Env. Protection Agency EMAP-E Program
  - Young modified Van Veen grab (2000)
  - 500 µm mesh sieve
  - In-situ & laboratory water quality and sediment data

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Benthic Data Analysis

- Nonmetric multidimensional scaling to compare community structure
- Nonlinear regression (log-normal model) to compare mean macroinvertebrate abundance and water quality
- BIO-ENV to correlate benthic community structure and water quality (with RELATE)

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Fisheries Independent Monitoring Program
Florida Fish and Wildlife Conservation Commission

- Stratified random sampling with multiple gear types to monitor juvenile finfish and crustacean populations in SJR estuary
  - Blue crab (*Callinectes sapidus*) – SJR landings $1.2 million US in 2009 (hard- and softshell crab)
  - Penaeid shrimp (primarily White shrimp, *Litopenaeus setiferus*) – SJR landings $4.9 million US in 2009 (food and bait shrimp)

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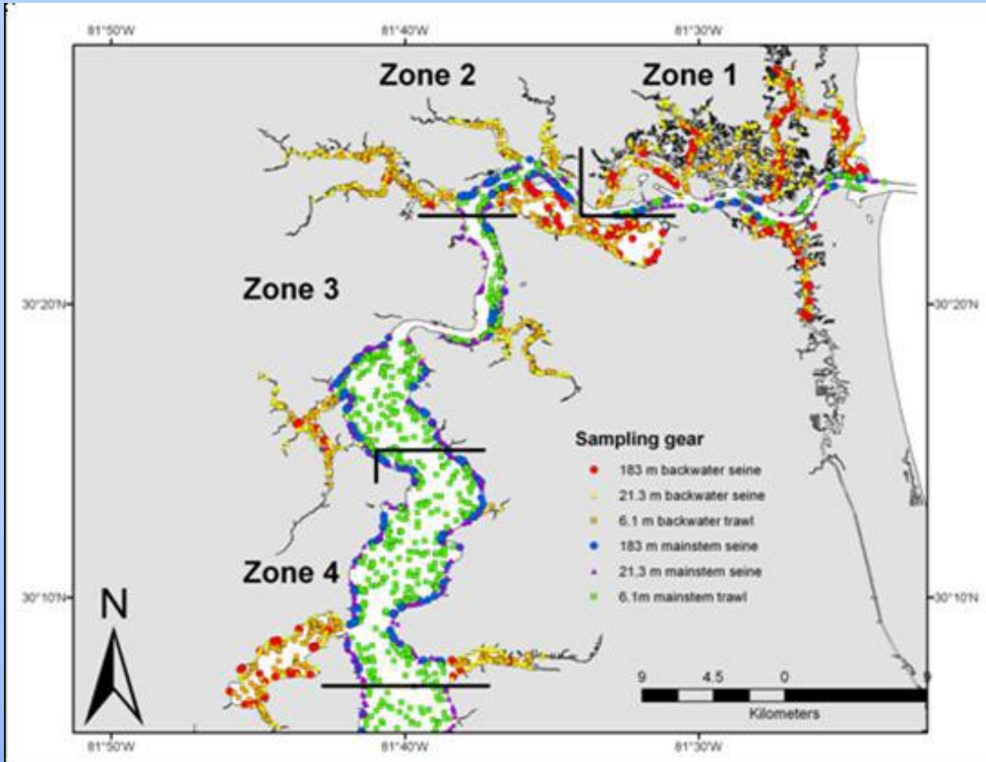
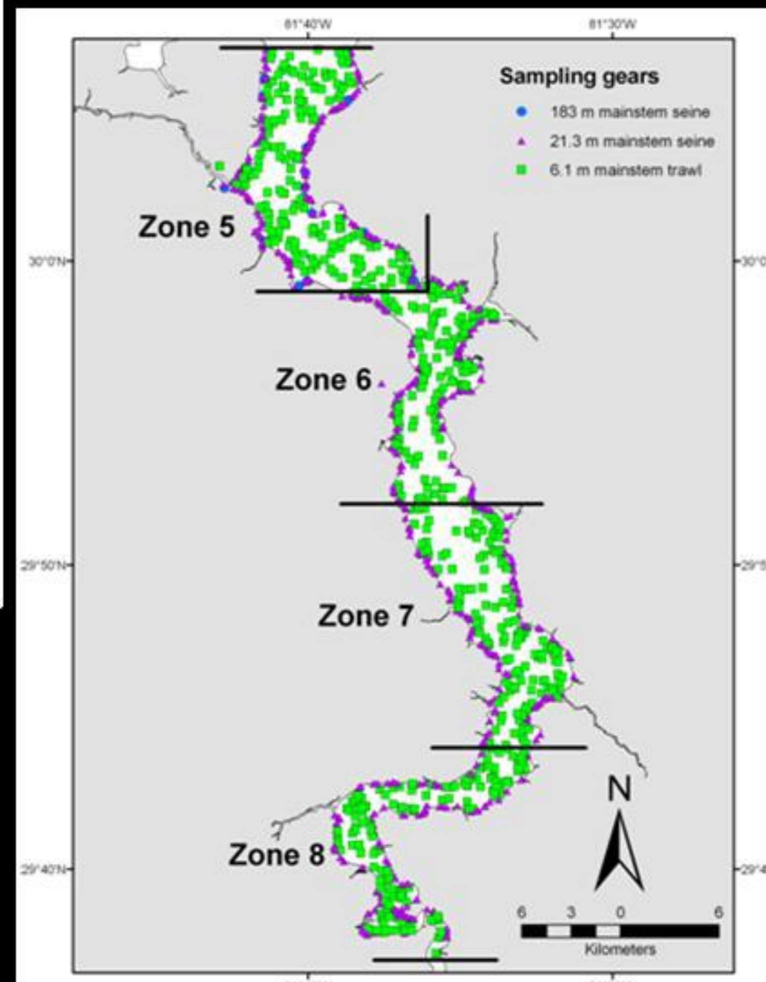
FIM Sites

Data collected 2001-2010





FIM Data Analysis

- Abundance vs. freshwater inflow (from two upstream USGS gauges) analyzed empirically
  - Data screened (Spearman's rho); only significant relationships between abundance & inflow were analyzed
  - Data transformed appropriately (varied); standard regression used to relate abundance & inflow (lagged 30 d, 60 d, 90 d, etc.)
  - Only regressions w/ $r^2>0.25$ retained; SAS program built to relate abundance changes to inflow change

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Benthic Data Analysis

Results

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SJR Estuary Benthic Communities

- 545 species collected in the FDEP and EMAP studies
- 30 species/taxa accounted for 80% of the total abundance
- Top 10 dominant taxa (abundance): amphipods (2), mollusks (2), polychaetes (2), aquatic insects (2), barnacle (1) and oligochaete (1)
- Four of these top 10 taxa are indicative of water quality degradation/impairment (e.g., *Limnodrilus hoffmeisteri* and *Streblospio benedicti*)

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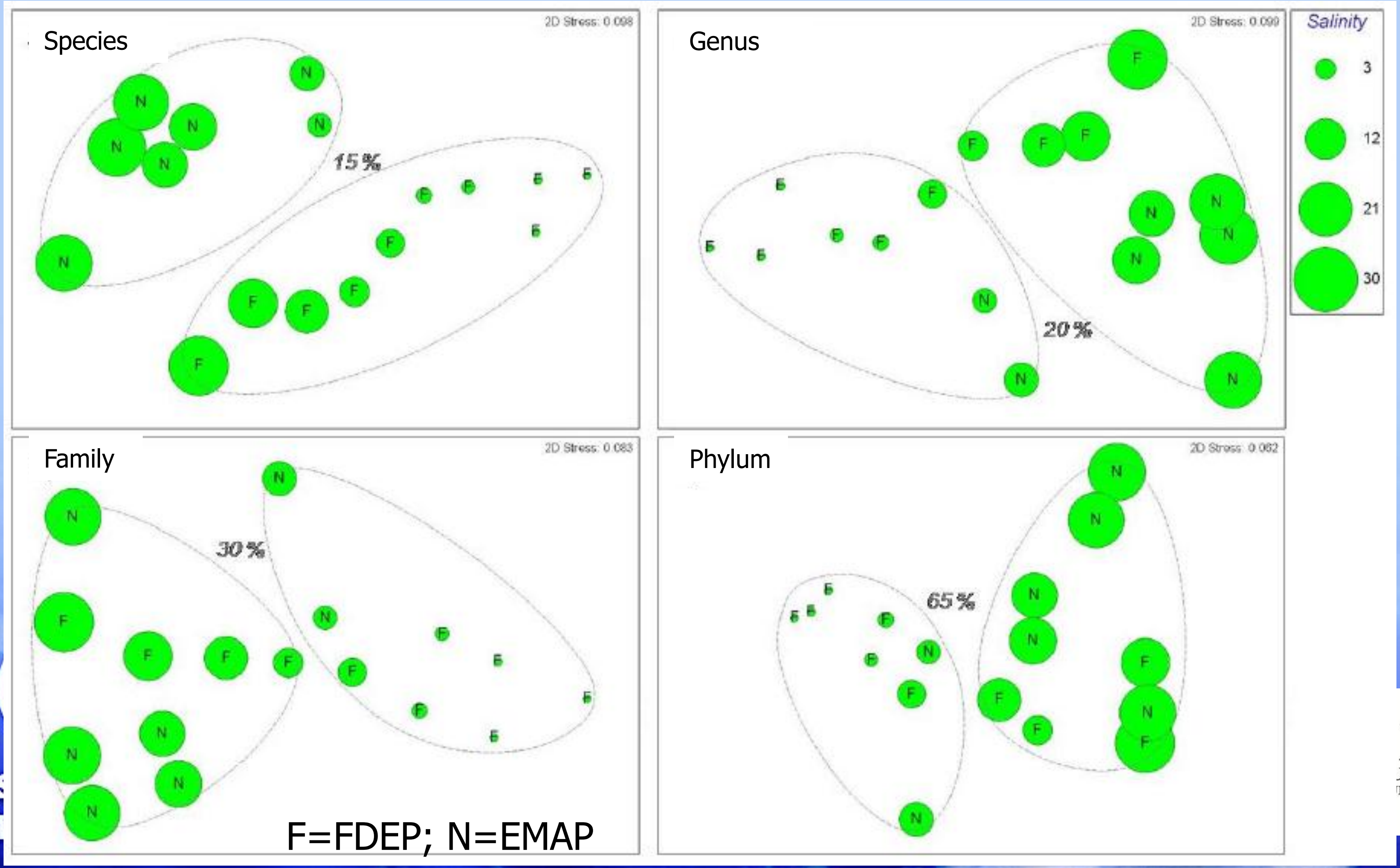
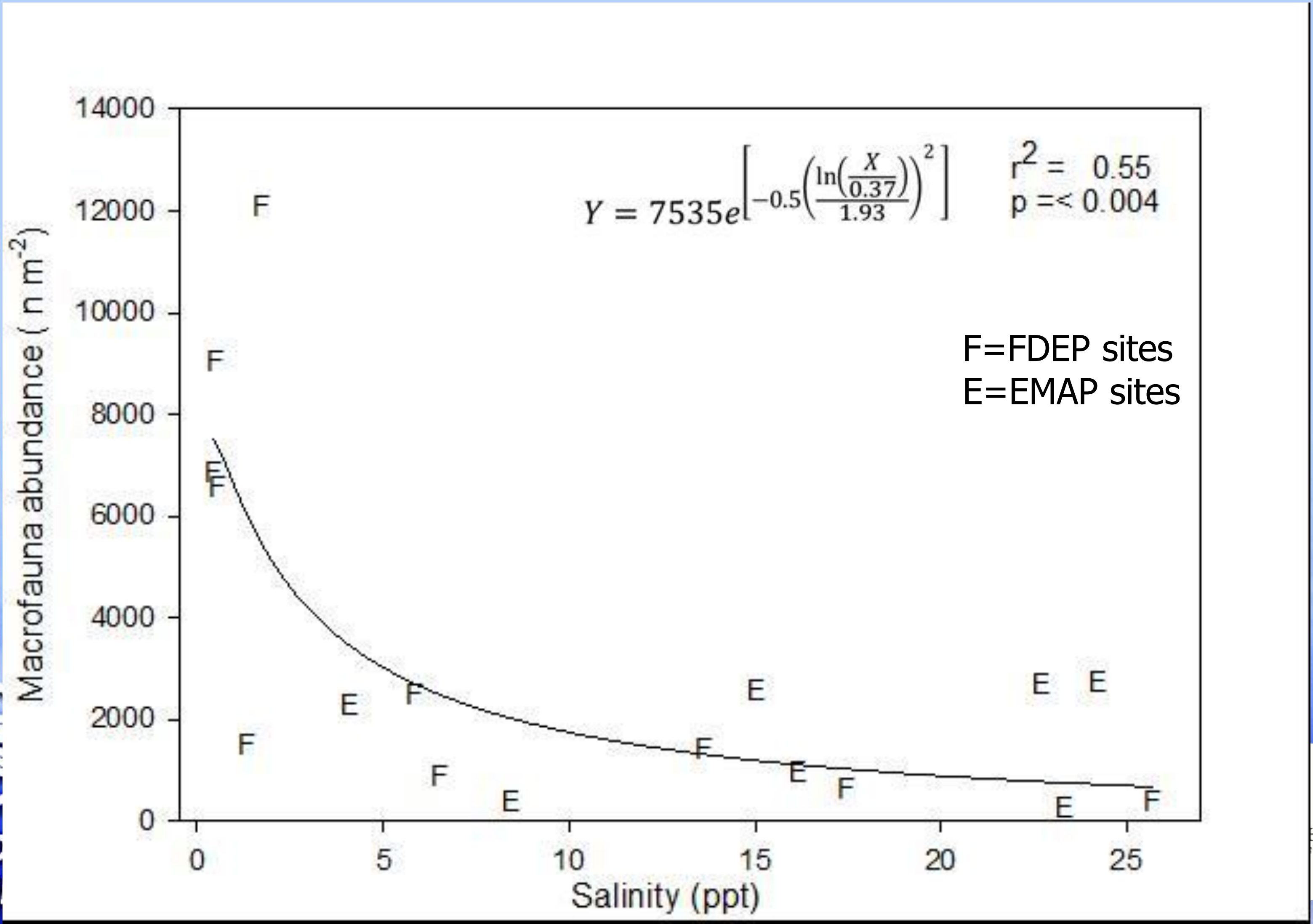
Benthic community structure was related most strongly to salinity (vs. DO, pH or water temperature)

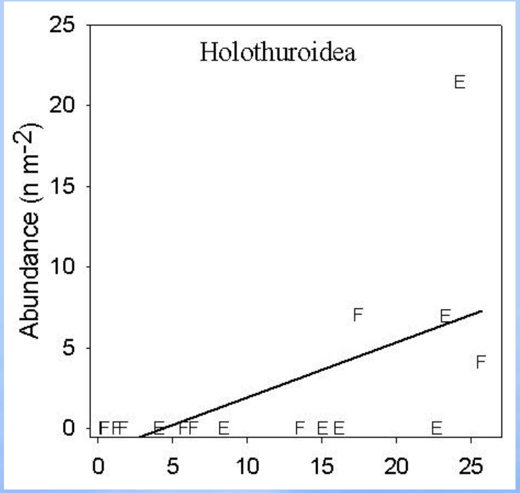


Mean overall benthic abundance was significantly related to mean salinity

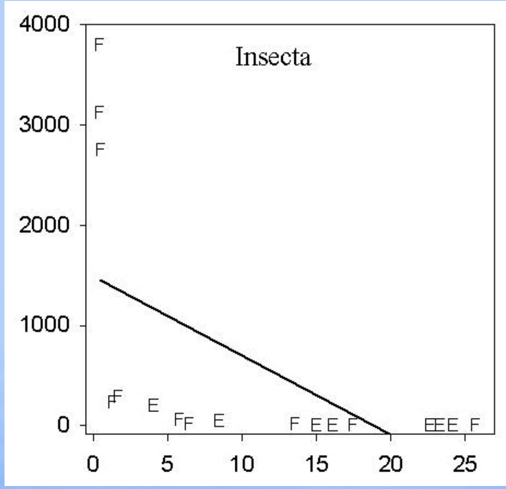


Different benthic taxa responded to salinity variation differently

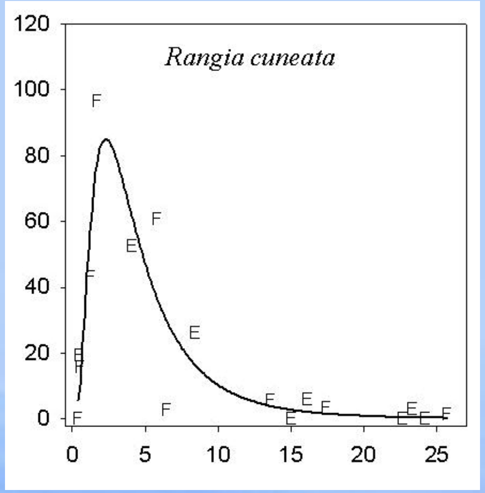
Increase



Decrease



"Optimum"



Salinity (ppt)

F=FDEP sites
E=EMAP sites

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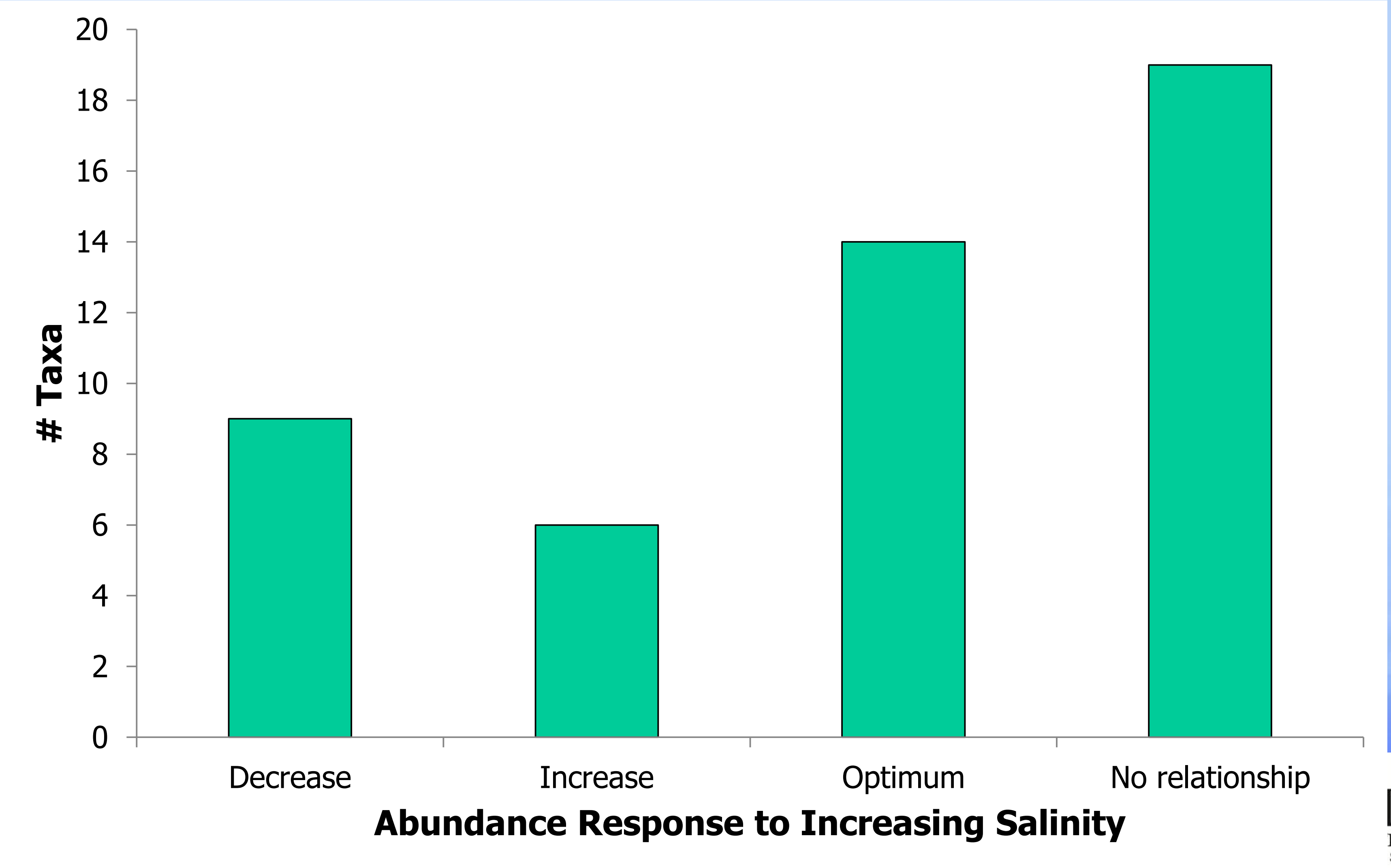
Response to increasing salinity



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Salinity appeared to be a major factor affecting benthic communities in the SJR estuary

- Influenced total abundance
- Influenced abundance of individual taxa (phylum, family, genus and species)
- Influenced overall community structure

Supporting evidence:

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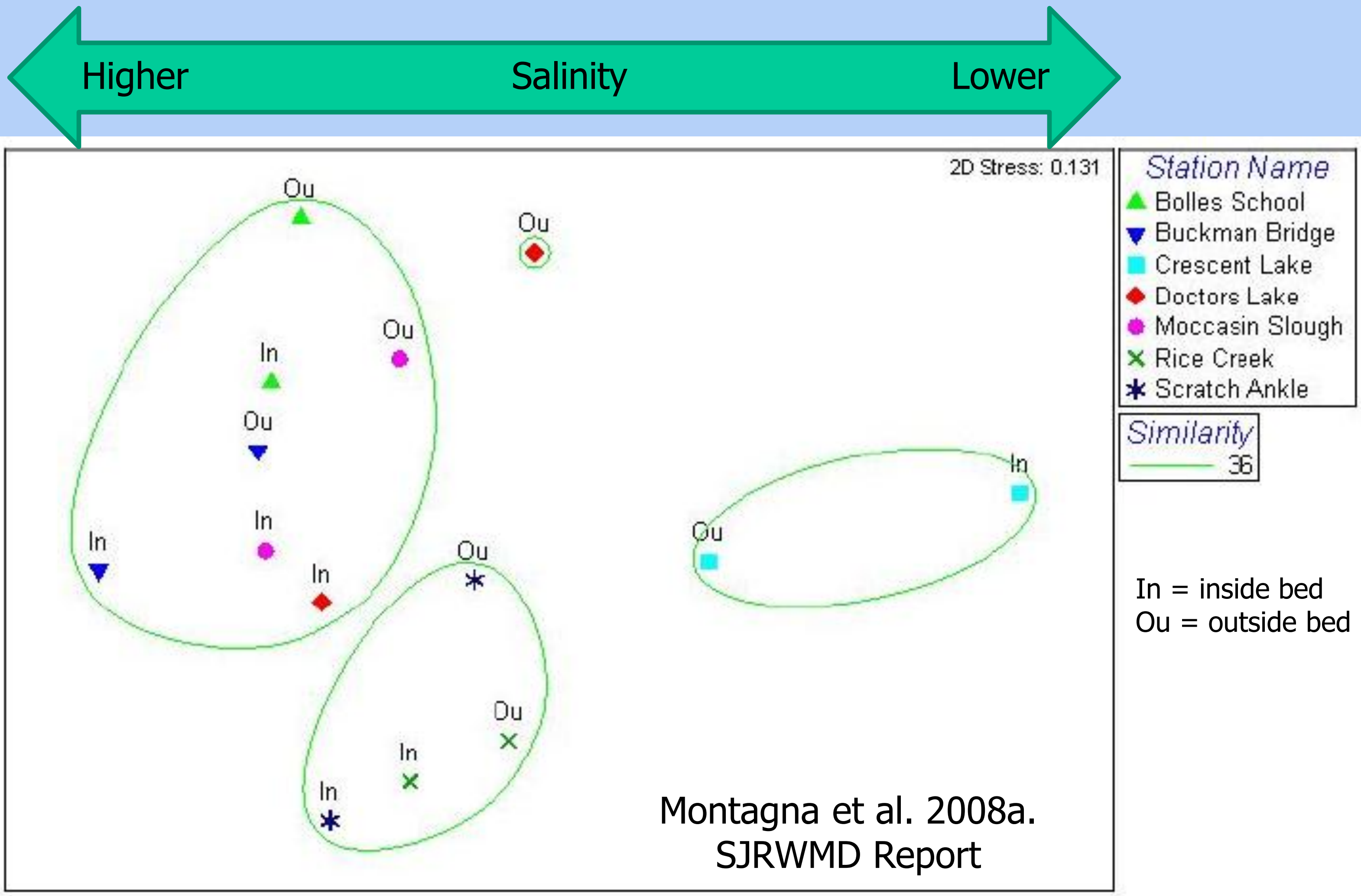
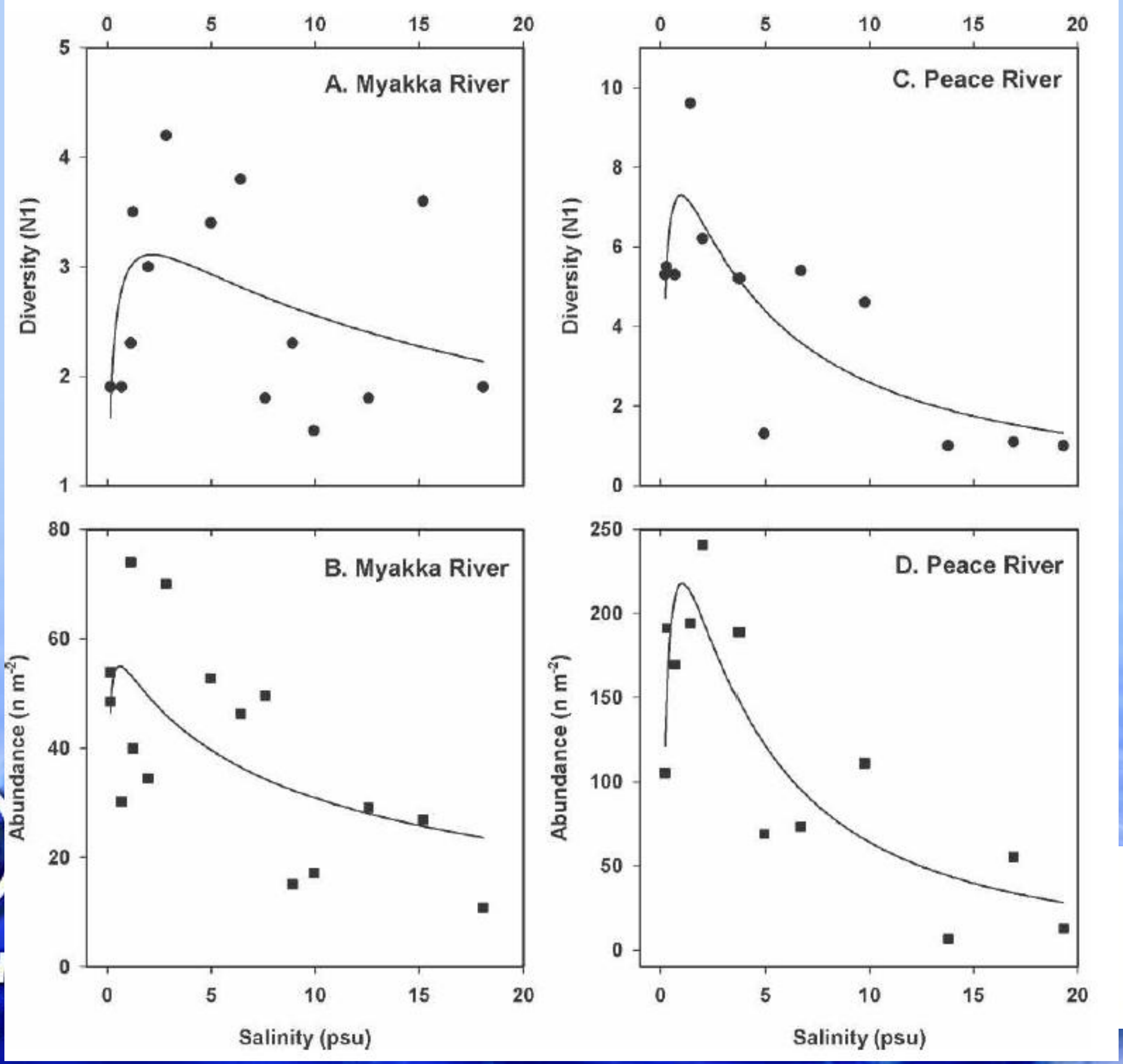
Community structure of benthic infauna in lower SJR SAV beds best explained by salinity



Montagna et al. 2008a.
SJRWMD Report

Salinity, more than sediment type or other water quality variable, explained most variation in mollusk communities in Florida Gulf Coast estuaries



Montagna et al. 2008b. Am. Malacol. Bull.

Salinity Indicator Taxa

- Freshwater/low salinities (< 2 ppt)
  - Aquatic insects; oligochaetes; *Mytilopsis leucophaeata*; *Rangia cuneata*; (*Corbicula fluminea**)
- Intermediate salinities (5-15 ppt)
  - Corophiid amphipods; Hydrobiid snails (*Littoridinops* sp.); Spionid polychaetes
- Higher salinities (> 15 ppt)
  - Echinoderms (Holothuroidea; Ophiuroida); selected polychaetes (*Mediomastus* sp.; Capitellidae); *Mulinia lateralis*

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* - not collected this study

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Effects of Salinity Alteration

- Developed spreadsheet model based on salinity/total abundance regression

$$Y = 7535e^{\left[-0.5\left(\frac{\ln\left(\frac{X}{0.37}\right)}{1.93}\right)^2\right]}$$

- Scaled abundance based on major salinity zones (modified Venice system)
- Applied modeled flow reduction scenarios

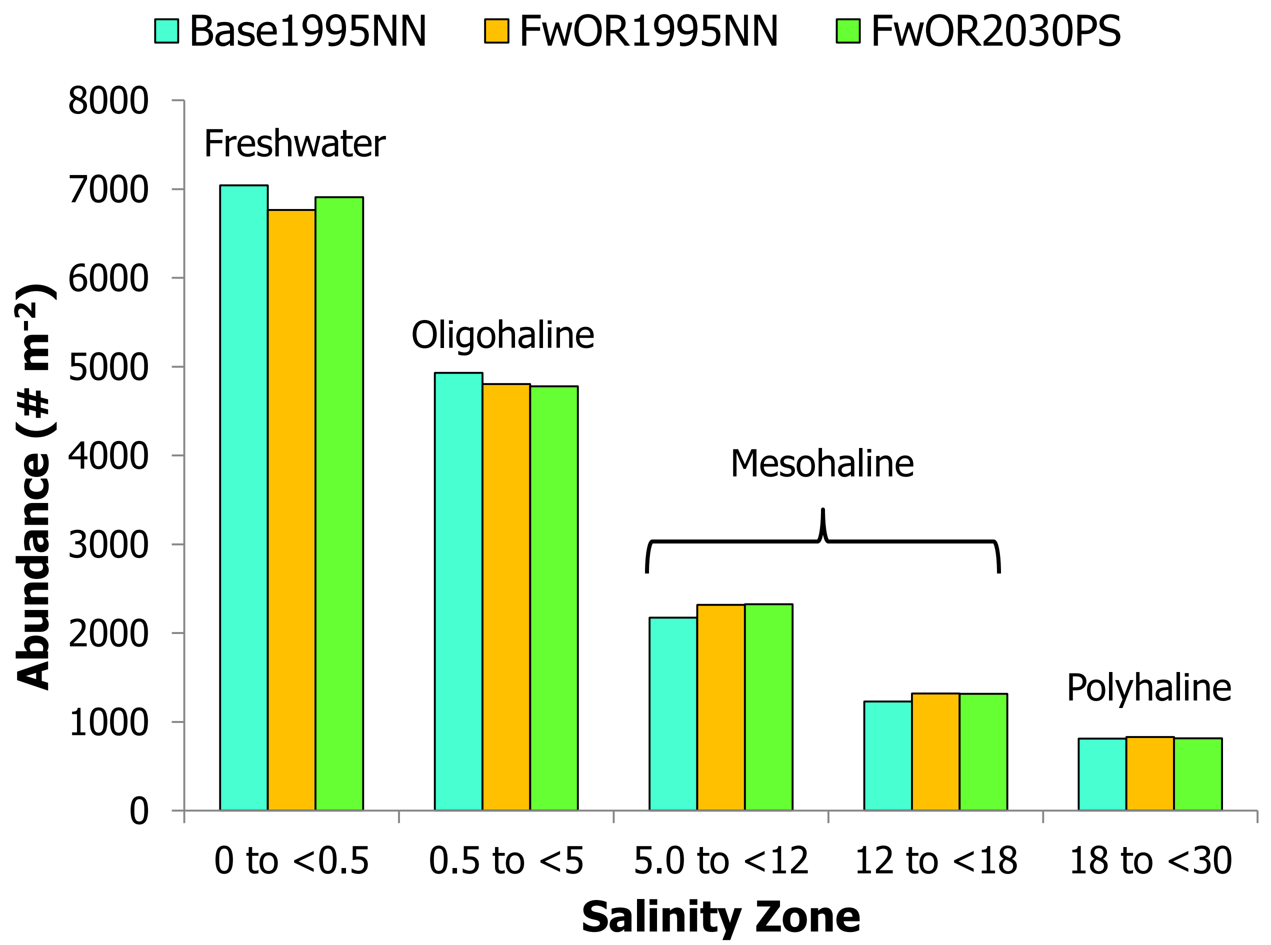
Change in mean abundance

Base1995NN – Existing

FwOR1995NN –
262 mgd (992 mL/d)
withdrawal

FwOR2030PS –
262 mgd withdrawal
2030 land use
USJRB Restoration
Sea level rise accounted for

(Salinity scenarios based on model output from EFDC)



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FIM Data Analysis

Results

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Blue Crab

Response Type	Gear	Lag (days)	r2	FwOR1995NN (% Δ from Base)	FwOR2030PS (% Δ from Base)
Monthly (trip) abundance	183 m seine (Apr-Oct)	180	0.256	+24.92	+9.20
Monthly (trip) abundance	6.1 m trawl (Jun-Dec)	180	0.469	+15.11	+2.60

- Not adversely affected by flow reductions
- Abundance increased under reduction scenarios

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White Shrimp

Response Type	Gear	Lag (days)	r2	Median COA at Base1995NN (km)	FwOR1995NN (Δ km)	FwOR2030PS (Δ km)
Center of abundance	21.3 m seine (Aug-Nov)	30	0.481	34.92	+1.25	-0.26
Center of abundance	21.3 m seine (Jun-Jul)	90	0.657	32.59	+3.75	+1.64
Center of abundance	6.1 m trawl (Jun-Sep)	30	0.417	57.96	+3.24	+0.49

- No relationships between abundance and inflow
- Center of abundance generally moves upstream with declining inflow

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Summary

- Salinity was a major driver influencing benthic macroinvertebrate communities and populations in the SJR estuary
- Benthic abundance decreased in response to upstream withdrawals in lower-salinity reaches; increased in higher-salinity reaches
- Blue crab and white shrimp populations generally not affected adversely by flow reductions

Reports and Contacts

- Montagna, P. A., T. A Palmer, and J. B. Pollack. 2011. St. Johns Estuary: Estuarine Benthic Macroinvertebrates. Phase 2 Final Report. SJRWMD Special Publication SJ2012-SP4. http://www.floridaswater.com/technicalreports/pdfs/SP/SJ2012-SP4.pdf
- Fisheries work: SJRWMD Water Supply Impact Study Final Report. SJRWMD Technical Publication SJ2012-1. Chapter 12; Appendix 12-F. http://www.floridaswater.com/technicalreports/tpubs1.html
- Contacts:
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