

Monitoring the Response of Water Quality and Nekton in the Tidal Portion of the Brazos River, Texas to varying Freshwater Inflow

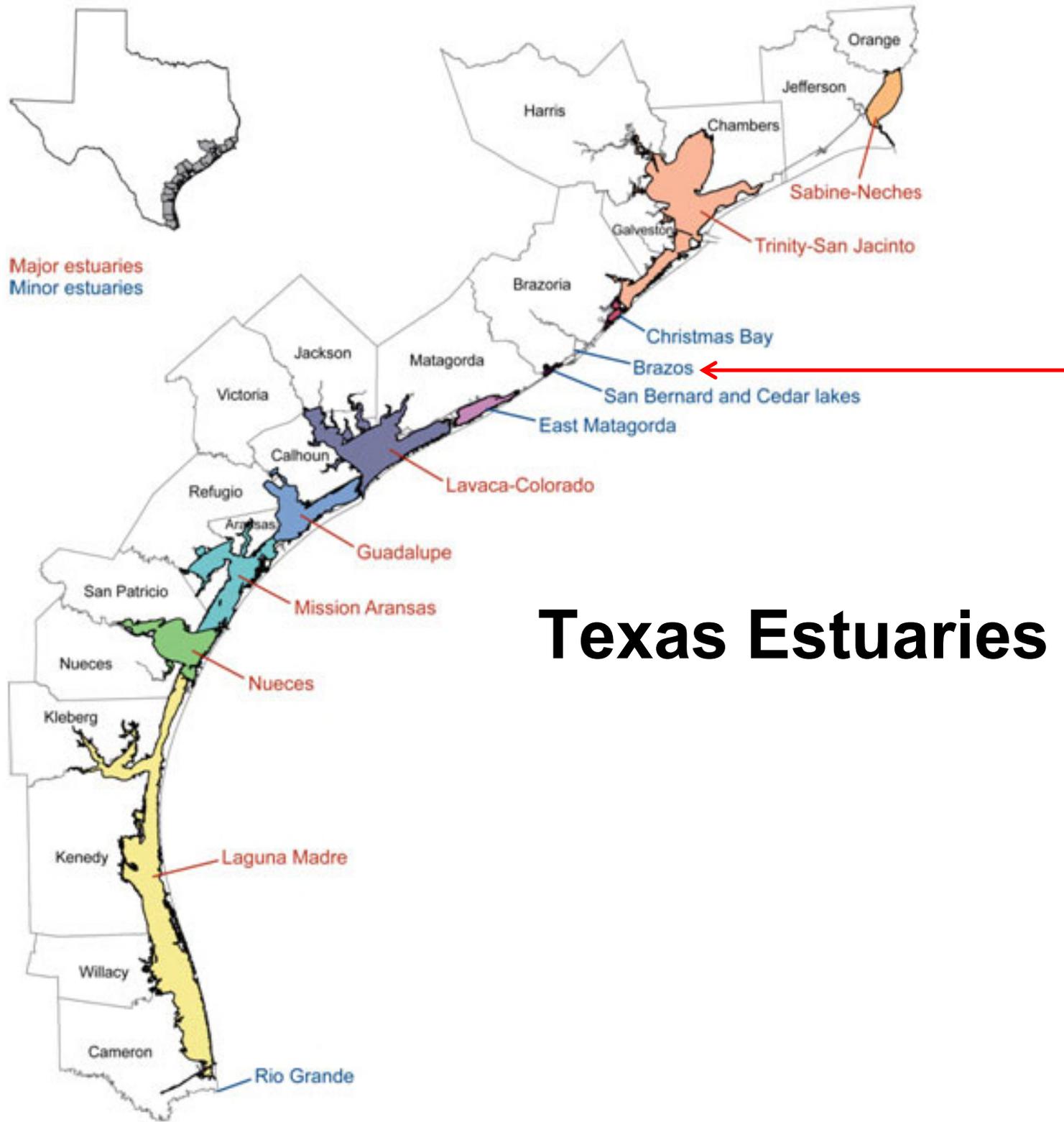
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Curtis

Environmental Institute of Houston

University of Clear Lake

NWQMC Tampa, FL, May 3, 2016

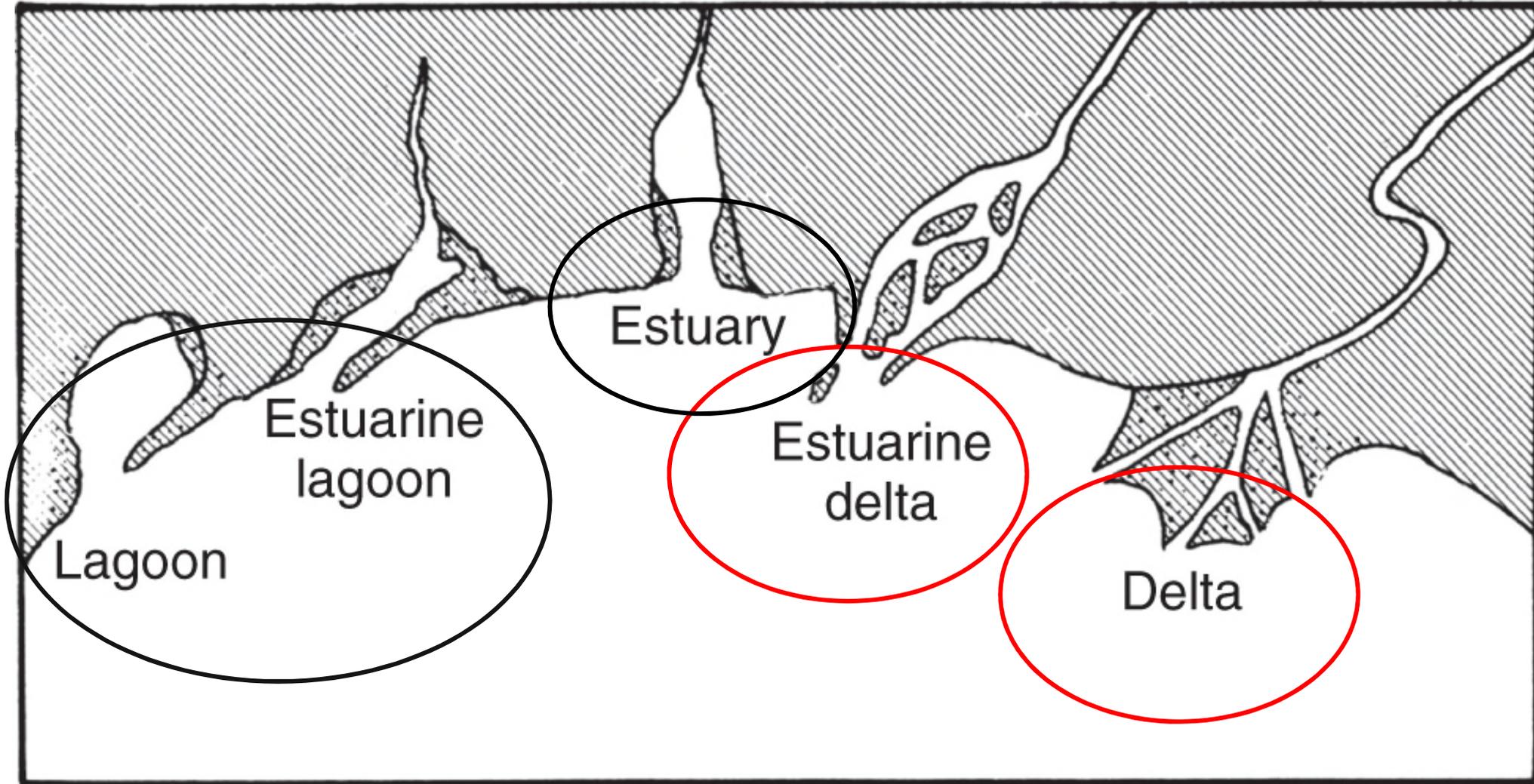




Texas Estuaries

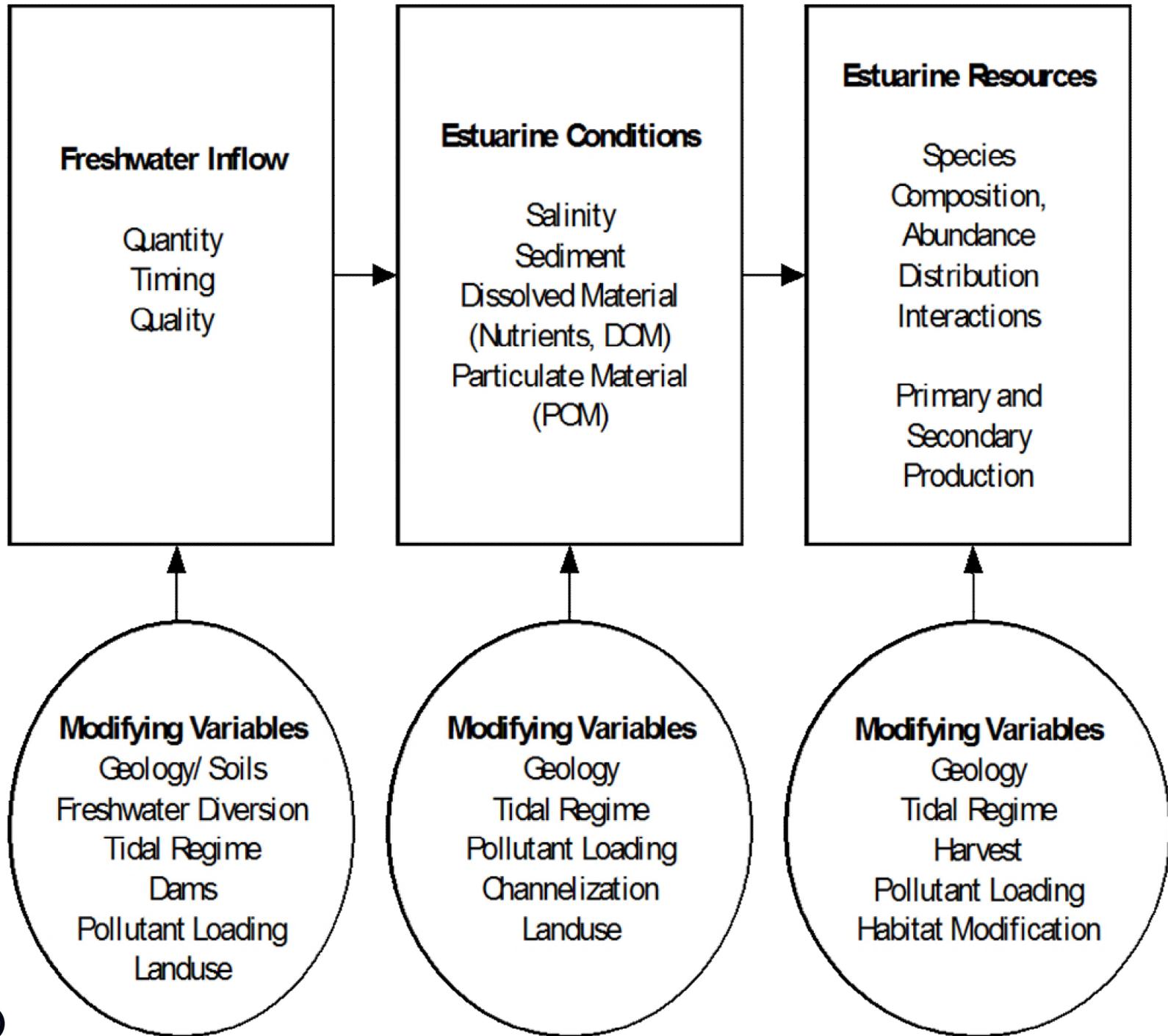
Most Texas Estuaries

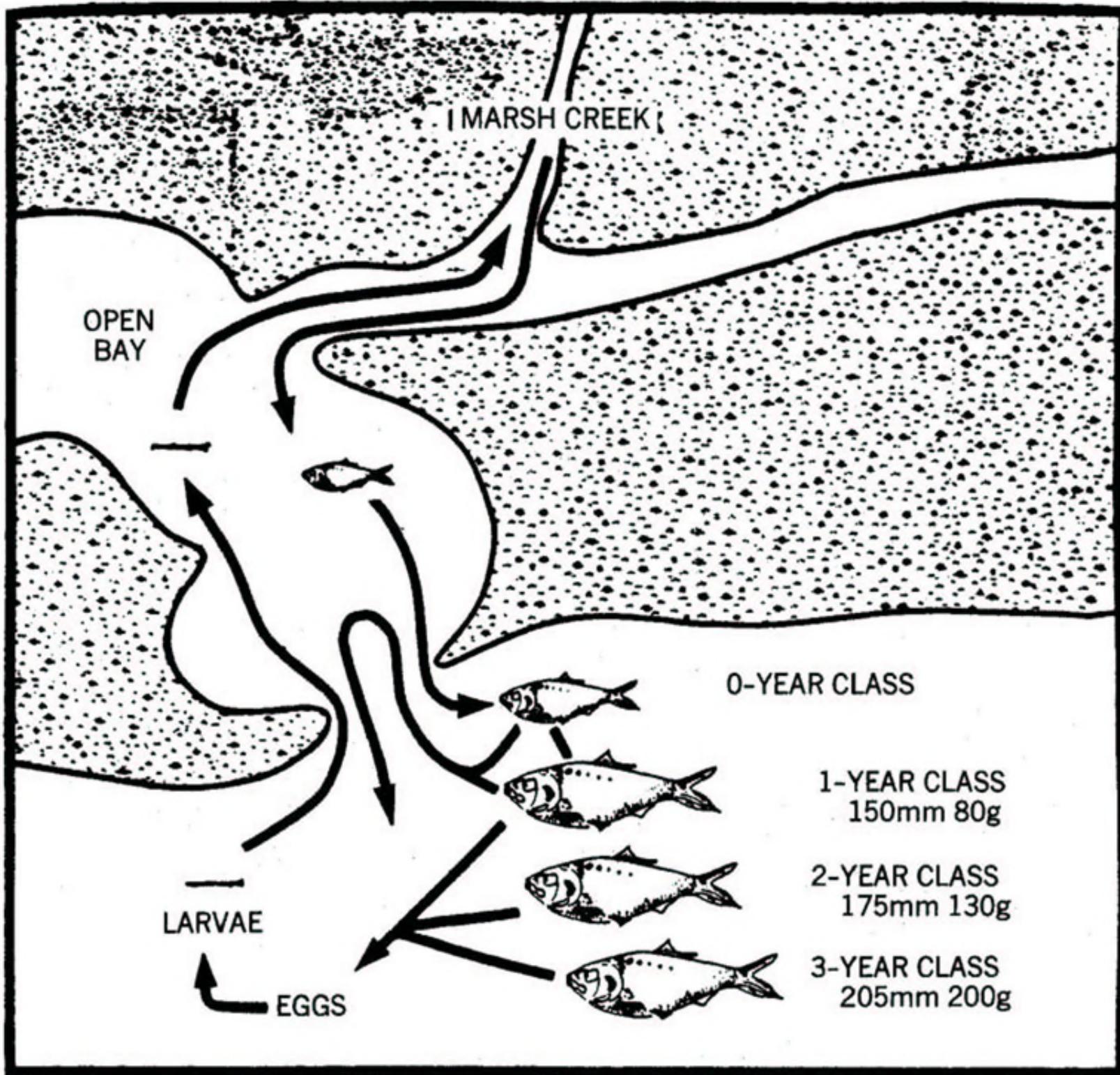
Brazos Riverine Estuary



Source: Modified from Davies, 1973; Bird 2000; Anderson 200

Freshwater Inflow Model

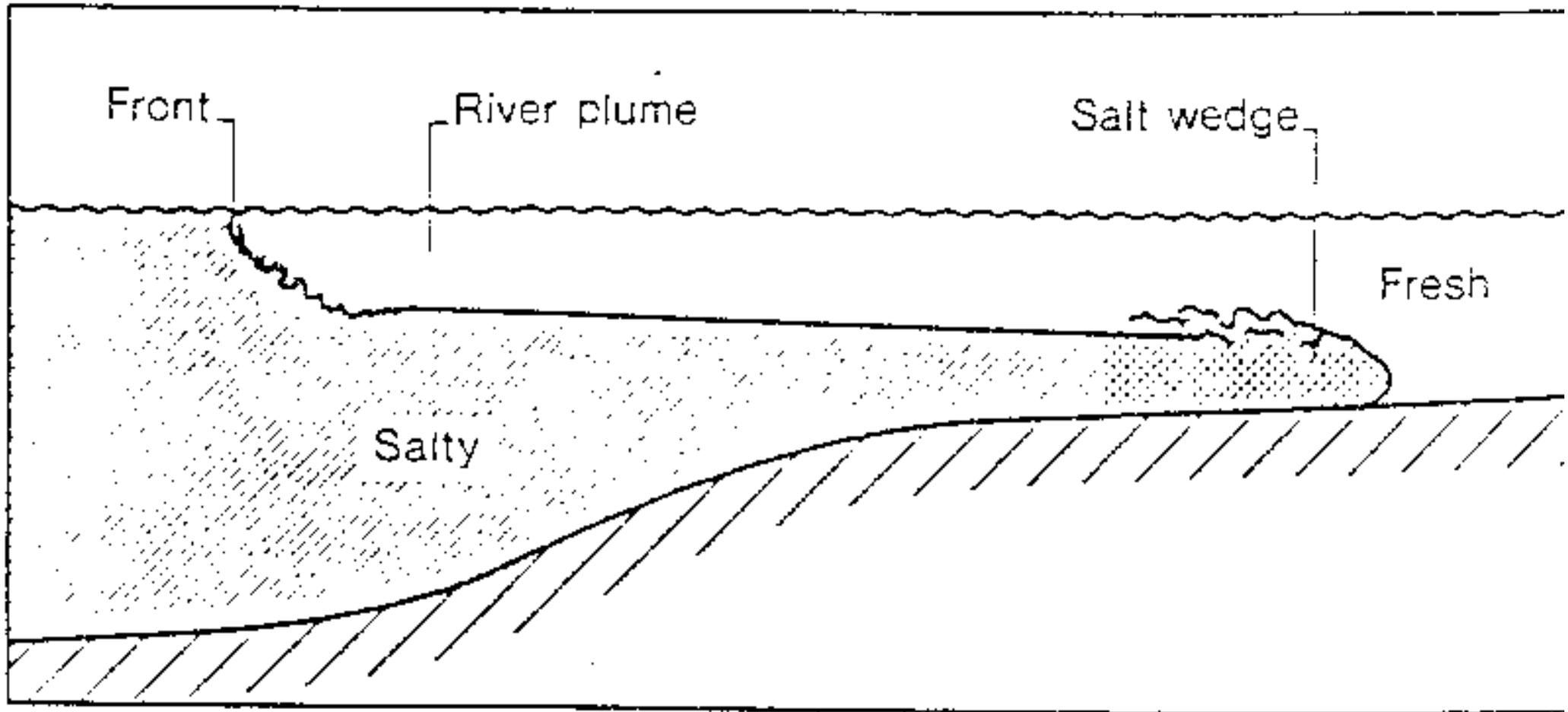




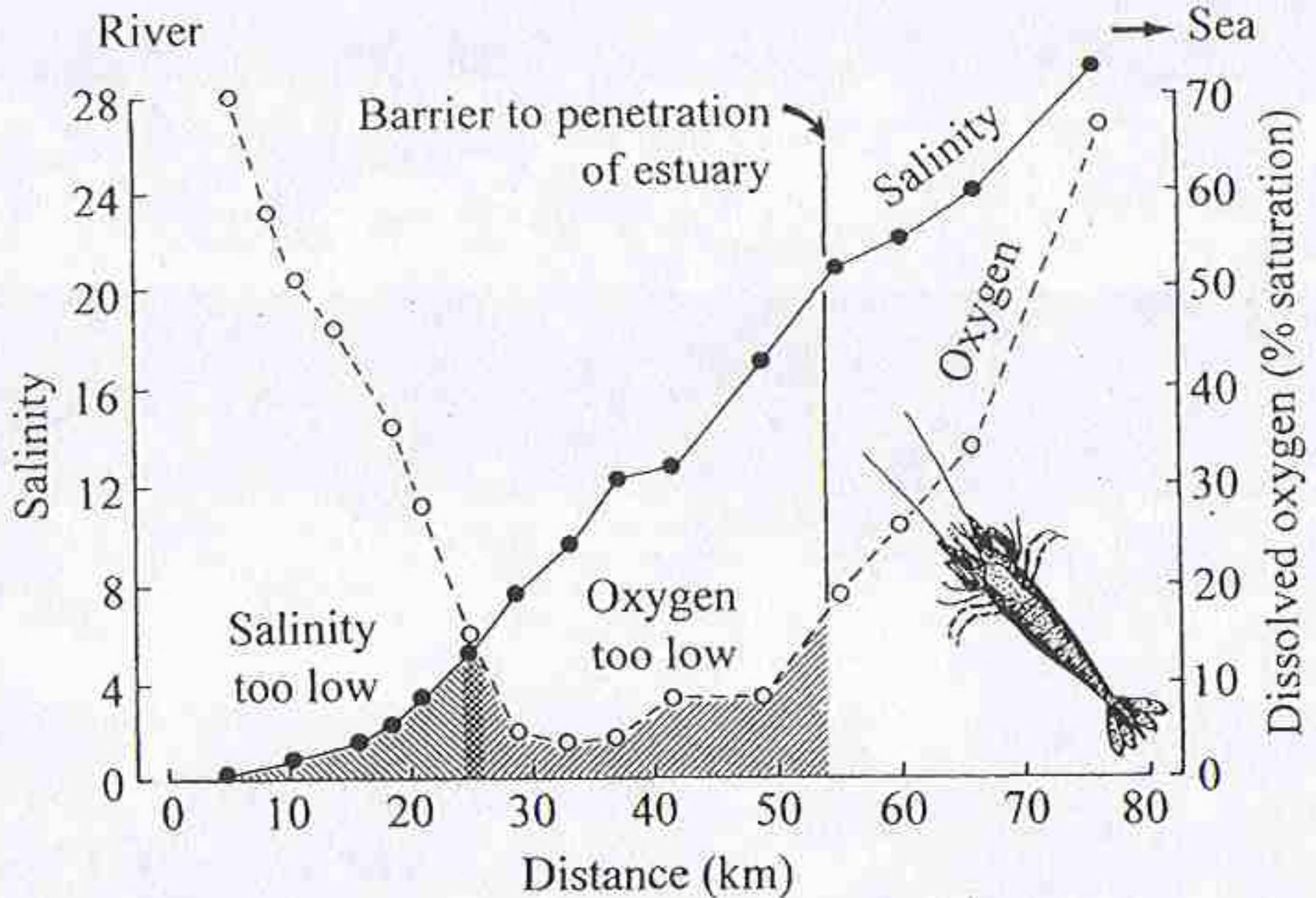
Positive Salt-wedge Estuary

Oceans

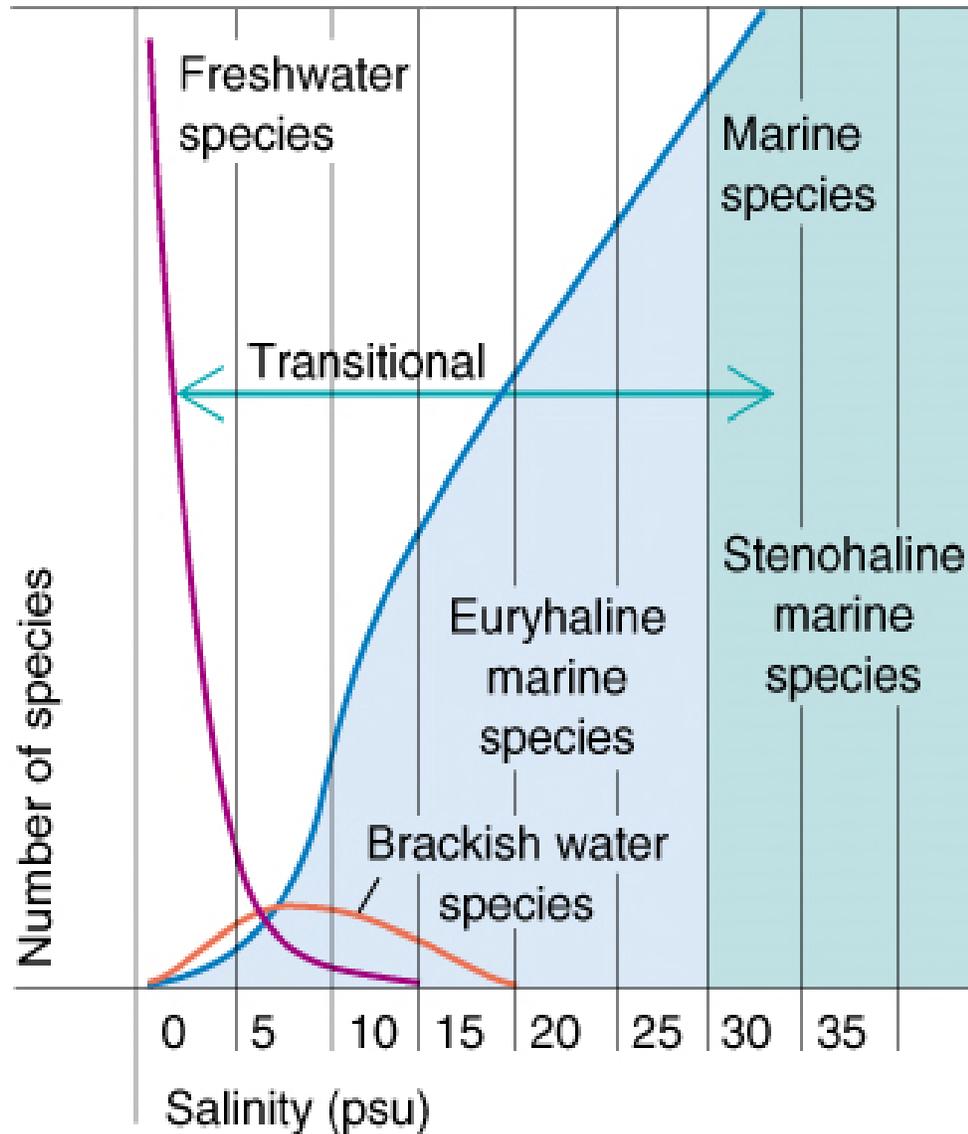
Land



Dynamics of flow, salinity and dissolved oxygen on organisms



Dynamic: freshwater inflow creates a mosaic of habitat for both freshwater and marine organisms



TX SB3 Environmental Flow Process 2007

Establishing Environmental Flow Standards



Science-based
Environmental Flow
Analyses and
Environmental Flow
Regime developed by
Science Experts (BBEST)

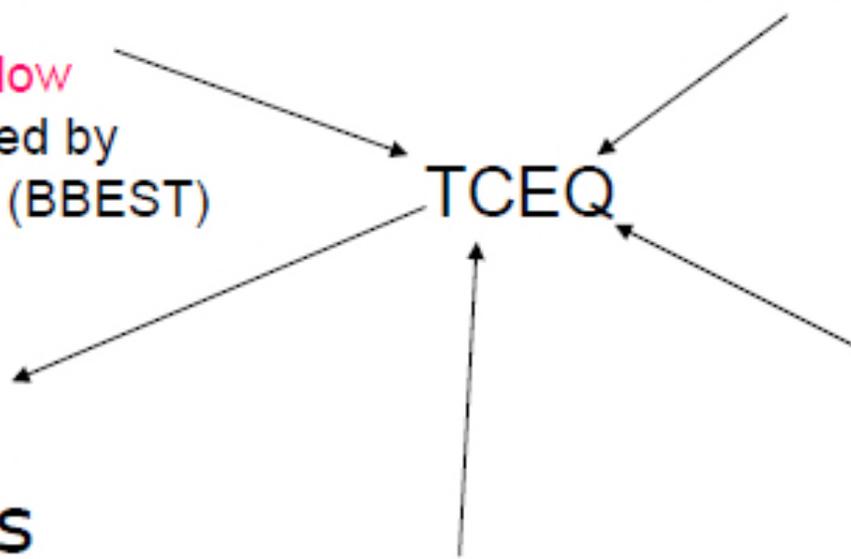
Recommended Standards
and Strategies by
Stakeholders (BBASC)

TCEQ

Input from
Public & Other
Stakeholders

Guidance/Input from
EFAG and SAC

Environmental
Flow Standards



United States Geological Survey Gage 08116650, Brazos River near Rosharon

| Season | Subsistence | Hydrologic Condition | Base | Dry Condition Seasonal Pulse | Average Condition Seasonal Pulse | Wet Condition Seasonal Pulse |
|--------|-------------|----------------------|-----------|---|---|---|
| Winter | 430 cfs | Dry | 1,140 cfs | 1 per season Trigger: 9,090 cfs Volume: 94,700 af Duration: 12 days | 3 per season Trigger: 9,090 cfs Volume: 94,700 af Duration: 12 days | 2 per season Trigger: 13,600 cfs Volume: 168,000 af Duration: 16 days |
| | | Average | 2,090 cfs | | | |
| | | Wet | 4,700 cfs | | | |
| Spring | 430 cfs | Dry | 1,250 cfs | 1 per season Trigger: 6,580 cfs Volume: 58,500 af Duration: 10 days | 3 per season Trigger: 6,580 cfs Volume: 58,500 af Duration: 10 days | 2 per season Trigger: 14,200 cfs Volume: 184,000 af Duration: 18 days |
| | | Average | 2,570 cfs | | | |
| | | Wet | 4,740 cfs | | | |
| Summer | 430 cfs | Dry | 930 cfs | 1 per season Trigger: 2,490 cfs Volume: 14,900 af Duration: 6 days | 3 per season Trigger: 2,490 cfs Volume: 14,900 af Duration: 6 days | 2 per season Trigger: 4,980 cfs Volume: 39,100 af Duration: 9 days |
| | | Average | 1,420 cfs | | | |
| | | Wet | 2,630 cfs | | | |

cfs = cubic feet per second
af = acre-feet
N/A = not applicable

**Freshwater instream and estuarine inflow standards
and flow tiers for Brazos River**

Influence of freshwater inflow on Nekton

- Response of nekton to salinity fluctuation influenced by frequency, rate, magnitude, and duration freshwater inflow¹.
- *Freshwater inflow → salinity, sediment, dissolved oxygen → biotic community*
- *Our ability to detect change based on monitoring design and effort*
- *Past efforts to detect effects on nekton in other estuaries have had mixed results.*

¹. Tolan 2013; McFarlane et al. 2015.

Historical Data – Brazos River

- Routine fisheries monitoring lacking
- Johnson (1977) - 2 year study 1975-76; lower 40.2 km at 5 sites. Monthly sampling for temperature, salinity and oxygen profiles and nekton surveys using trawls. Very limited spatial information provided.
- Miller (2014) – monthly replicate trawl and seine survey 2012, 4 in lower 42 rkm. Vertical profiles of temperature, salinity and oxygen including replicate trawls.

Study Objectives

- 1. Evaluate environmental flow recommendations in the tidal portion of the Brazos River using *historical* AND *recent* data.**
- 2. Characterize the flow regime, and select water quality variables**
- 3. Quantify response of nekton community (species composition, distribution and density of juvenile and adult nekton), and**

Methodology

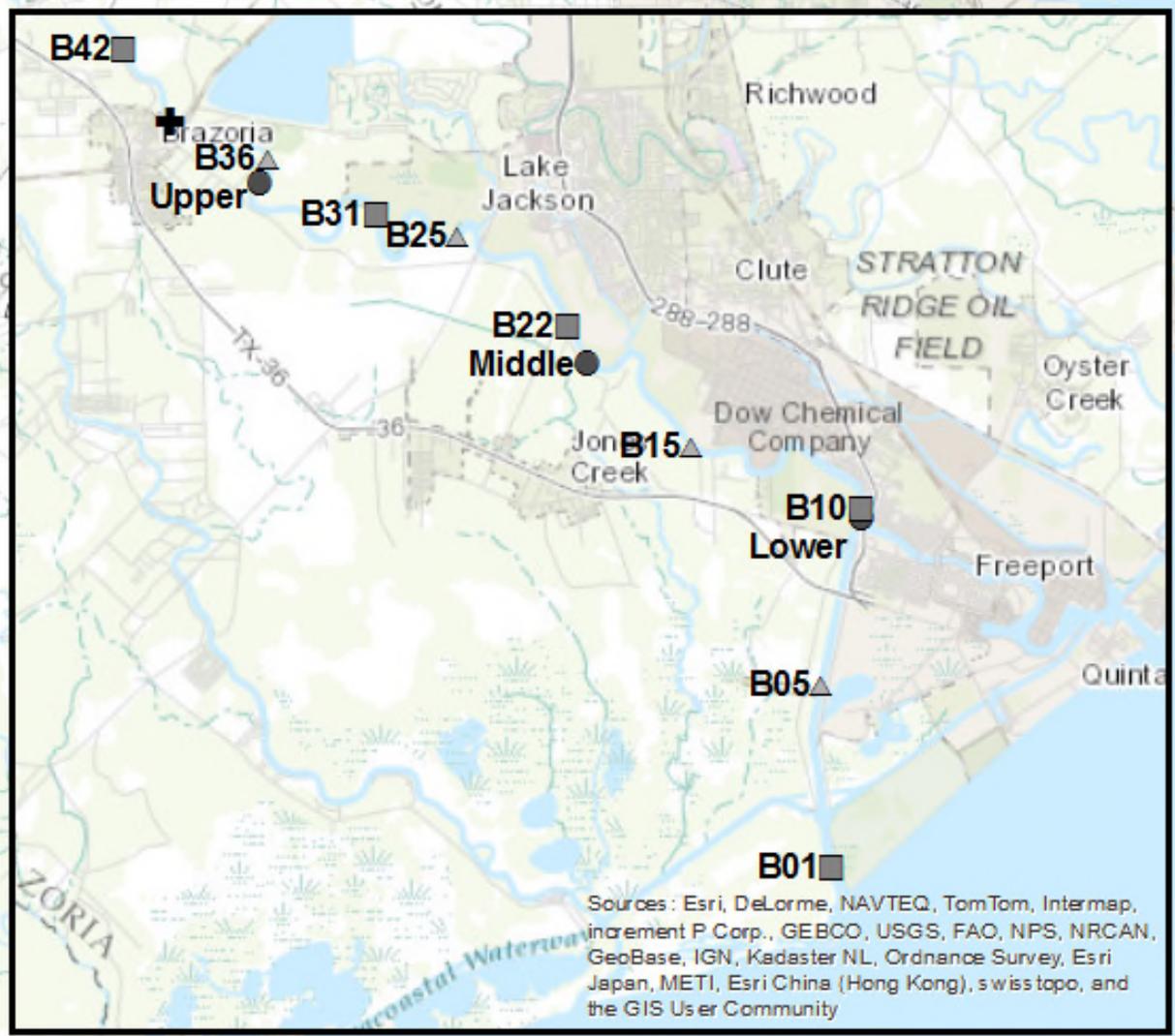
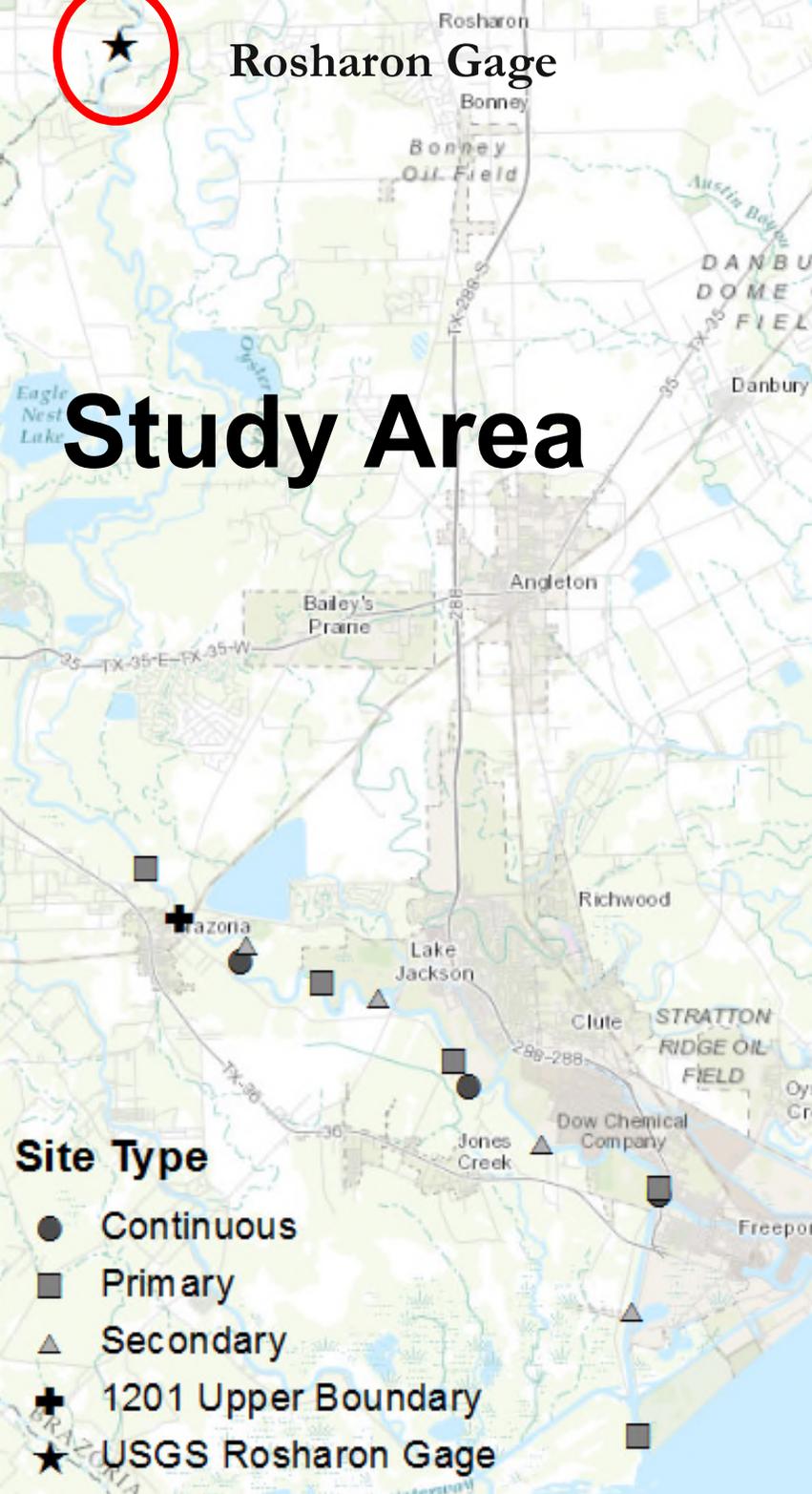
Current Study – Nov 2014 – May 2015

- 5 primary sites: (1, 10, 22, 31, 42 rkm) + additional 4 secondary sites (5, 15, 25, 36 rkm)
- Main channel 10 ft trawling – (3 rep) - @ 5 primary sites + shoreline Renfro Beam trawls (3 reps) – @ 5 primary sites
- Water quality profiles (temp, pH, sal, DO, turbidity) at all 9 sites
- Automated surface monitoring sondes @ rkm 10, 22, 36 - SCT & dissolved oxygen
- Study limited to periods < 10,000 cfs due to safety



Rosharon Gage

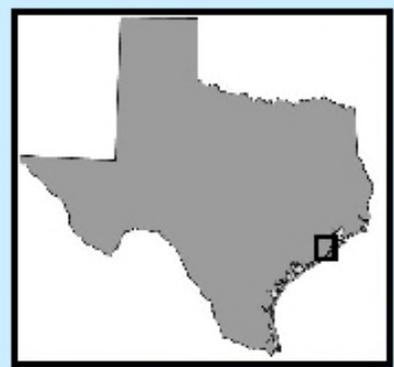
Study Area



Sources : Esri, DeLorme, NAVTEQ, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, and the GIS User Community

Site Type

- Continuous
- Primary
- ▲ Secondary
- ✚ 1201 Upper Boundary
- ★ USGS Rosharon Gage



Sources : Esri, DeLorme, NAVTEQ, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, and the GIS User Community

Methods

- Compared data from current study (Oct 2014 - May 2015) to Miller (2014) – 2012 (monthly - 12 months)
- Information on date of collection not provided for Johnson 1977. Limited ability of using that data set.
- Evaluated surface and bottom water temperature, salinity, and dissolved oxygen vs. season and flow
- Nekton community composition and estuarine species proportion (Miller and current study only)

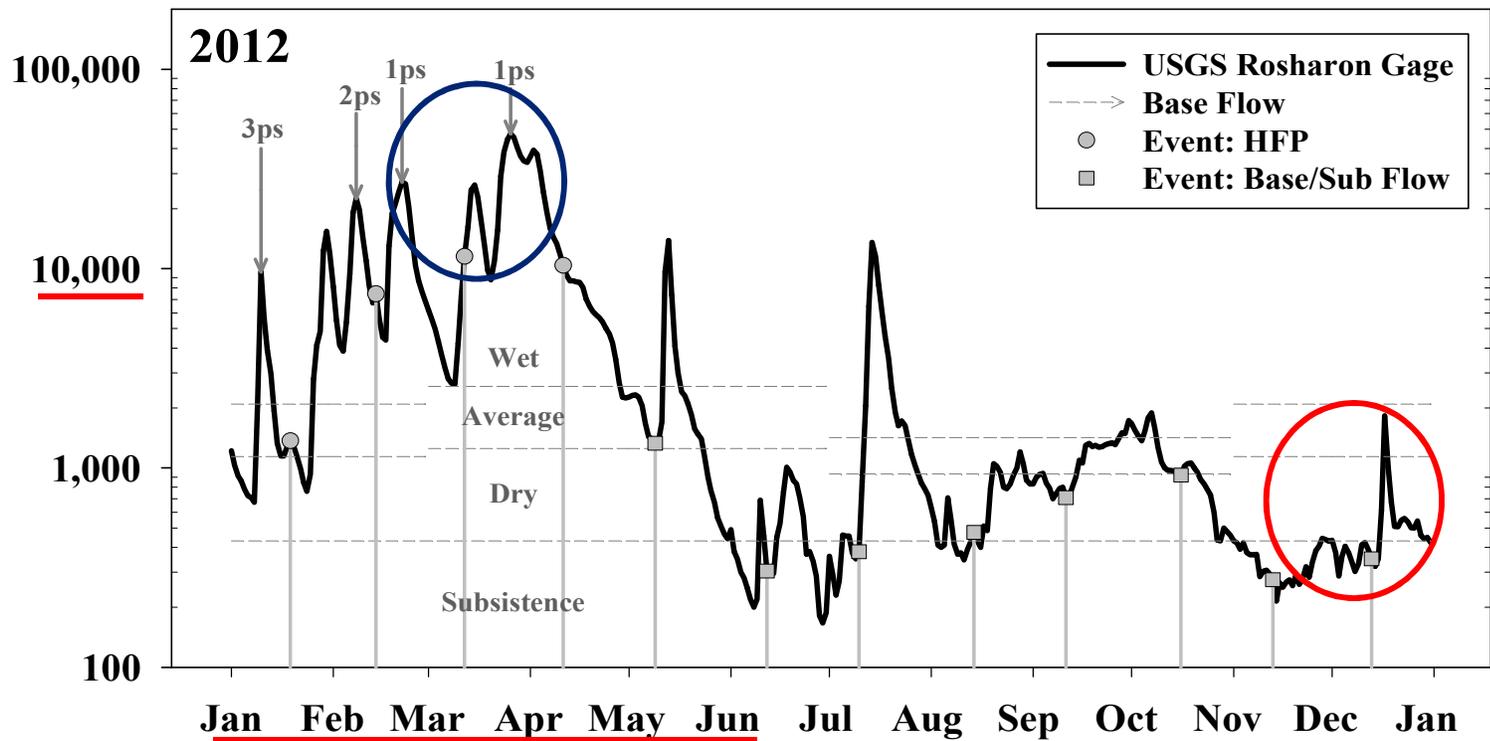
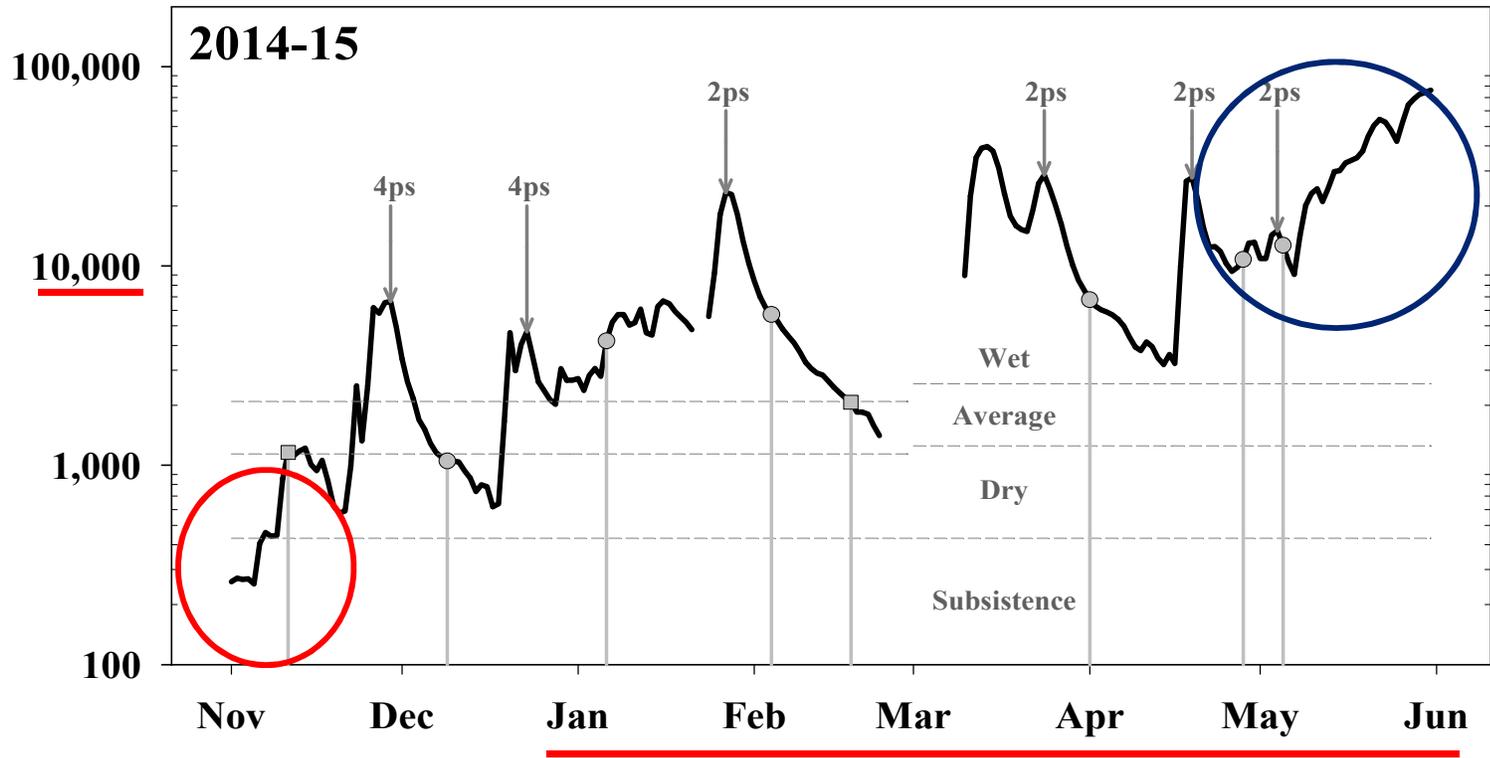
Data Analysis

- PRIMER - cluster analysis, NMDS, ANOSIM.
- Linear models fitted to select variables vs. flow
- ANOVA – water quality variable, flow tier, rkm

Results

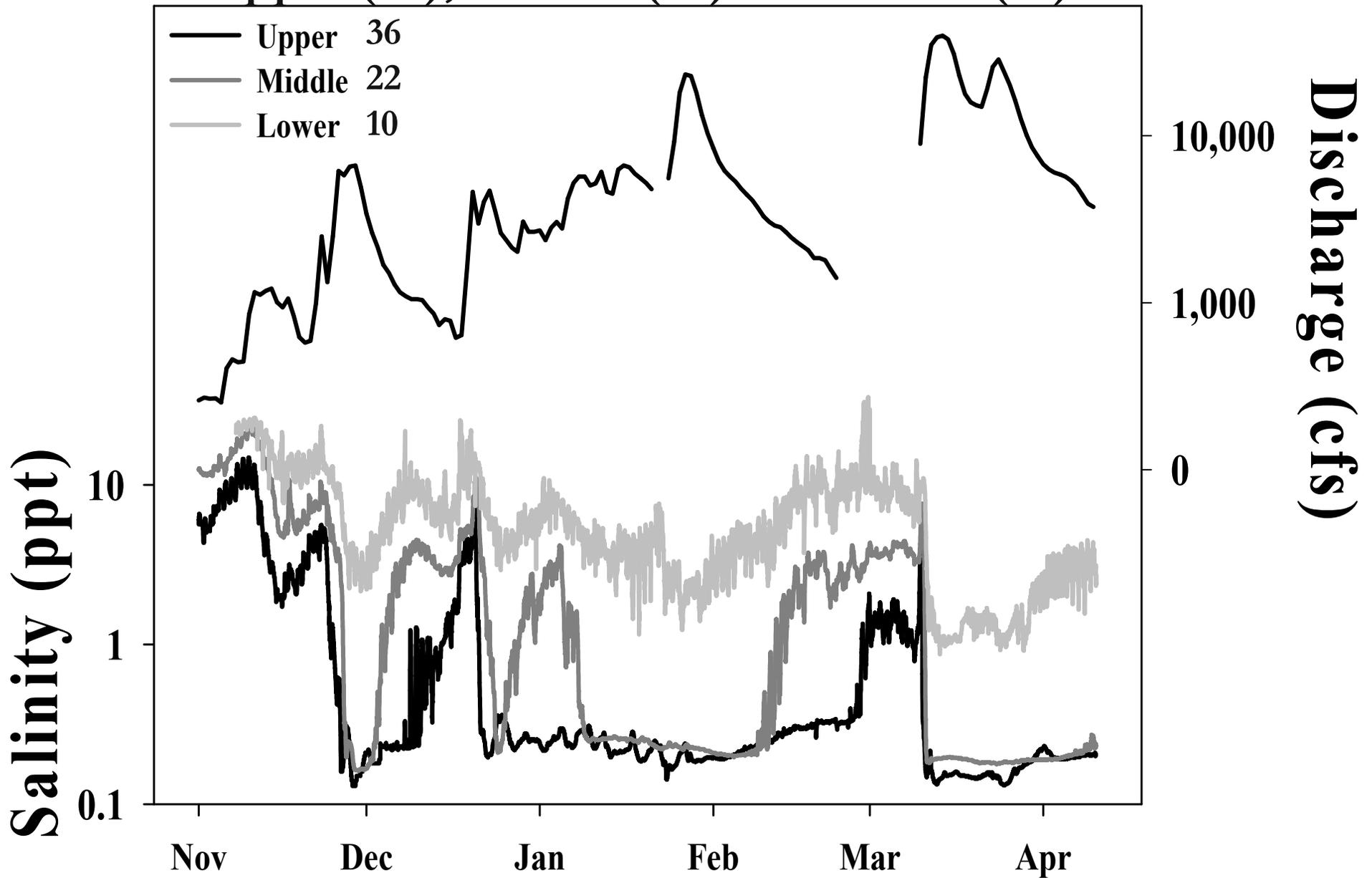
Hydrology and Water Quality

Mean Daily Discharge (cfs)



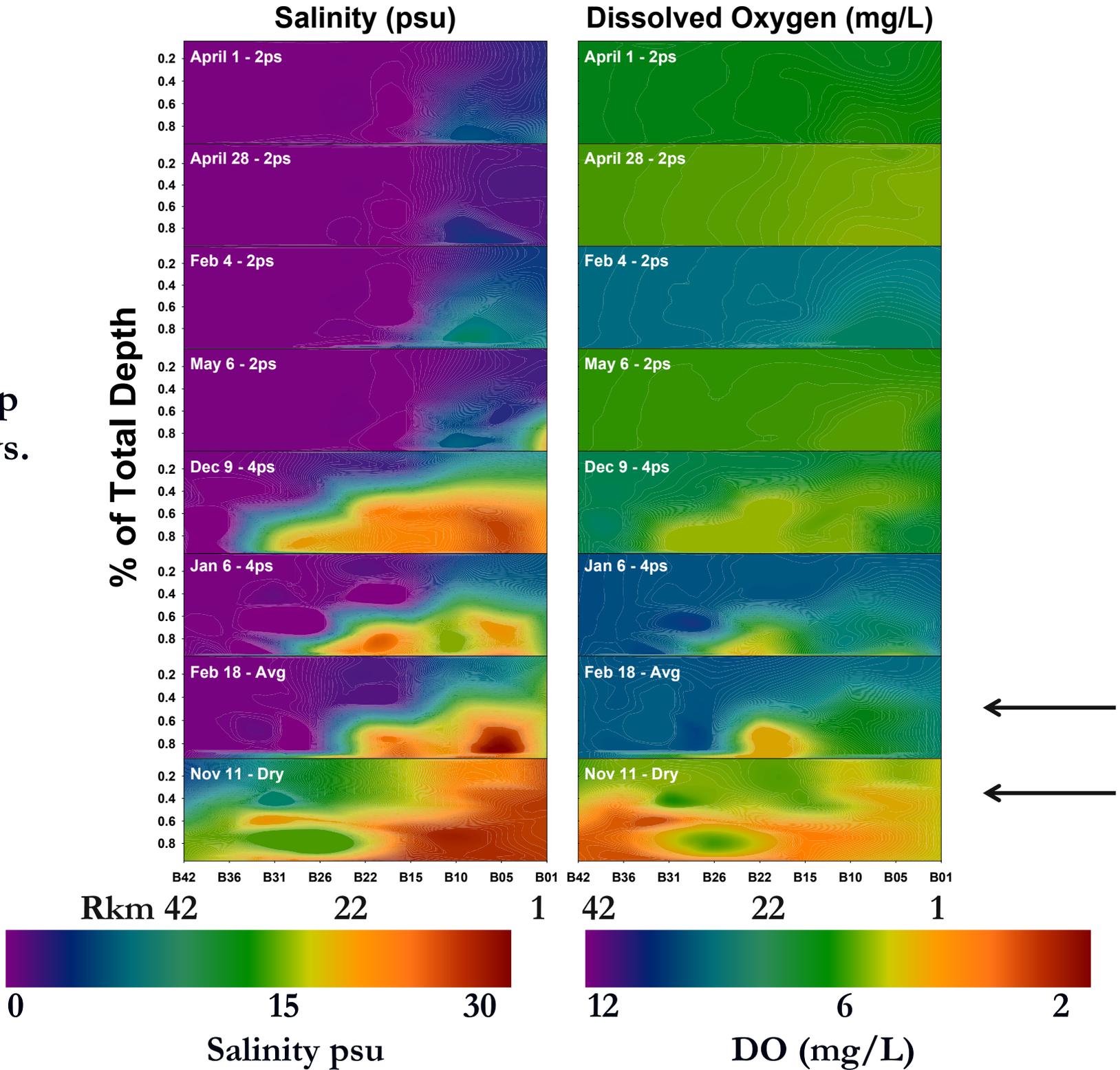
Automated Salinity Readings vs. Discharge – 2014-15 Study

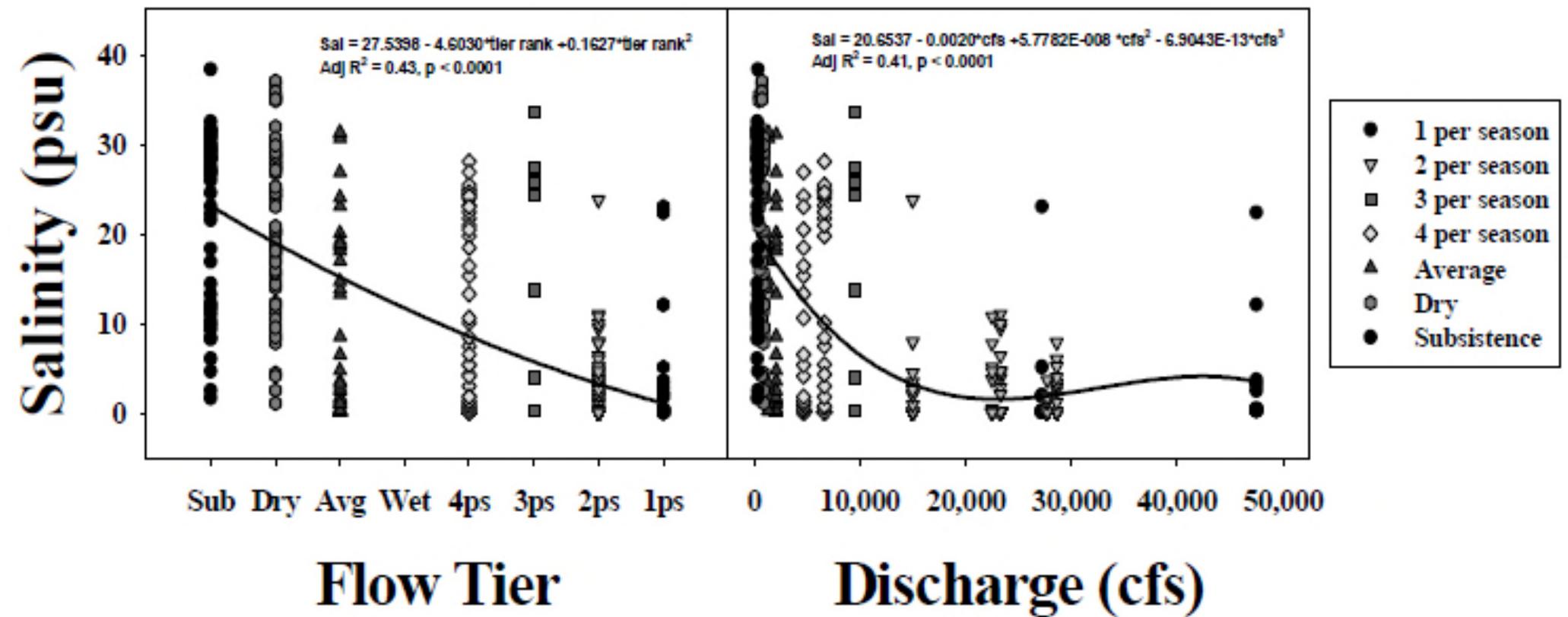
Upper (36), Middle (22) and Lower (10) rkm



2014-15
Data

Relationship
of salinity vs.
D.O.





Data from Current 2014-15 Study and Miller (2014) (2012 data)

Salinity: significant interactions between flow tiers and river kilometer

ANOVA and multiple comparison test results.

| Dep. Var | p-value | Interaction | Variables | p-value | Contrasts |
|------------------|---------|-------------|-----------|---------|--|
| Salinity | 0.002 | S | 2sps-site | <0.001 | (B1-B10)(B15-B42) |
| | | | 4ps-site | 0.002 | (B1-B26)(B15-B31)(B26-B42) |
| | | | Avg-site | 0.016 | (B1-B10)(B15-B42) |
| | | | Dry-site | 0.002 | (B1-B22)(B15,B22, B31)(B22-B36)(B26-B42) |
| Dissolved oxygen | 0.732 | NS | Tier | <0.001 | All tiers different |

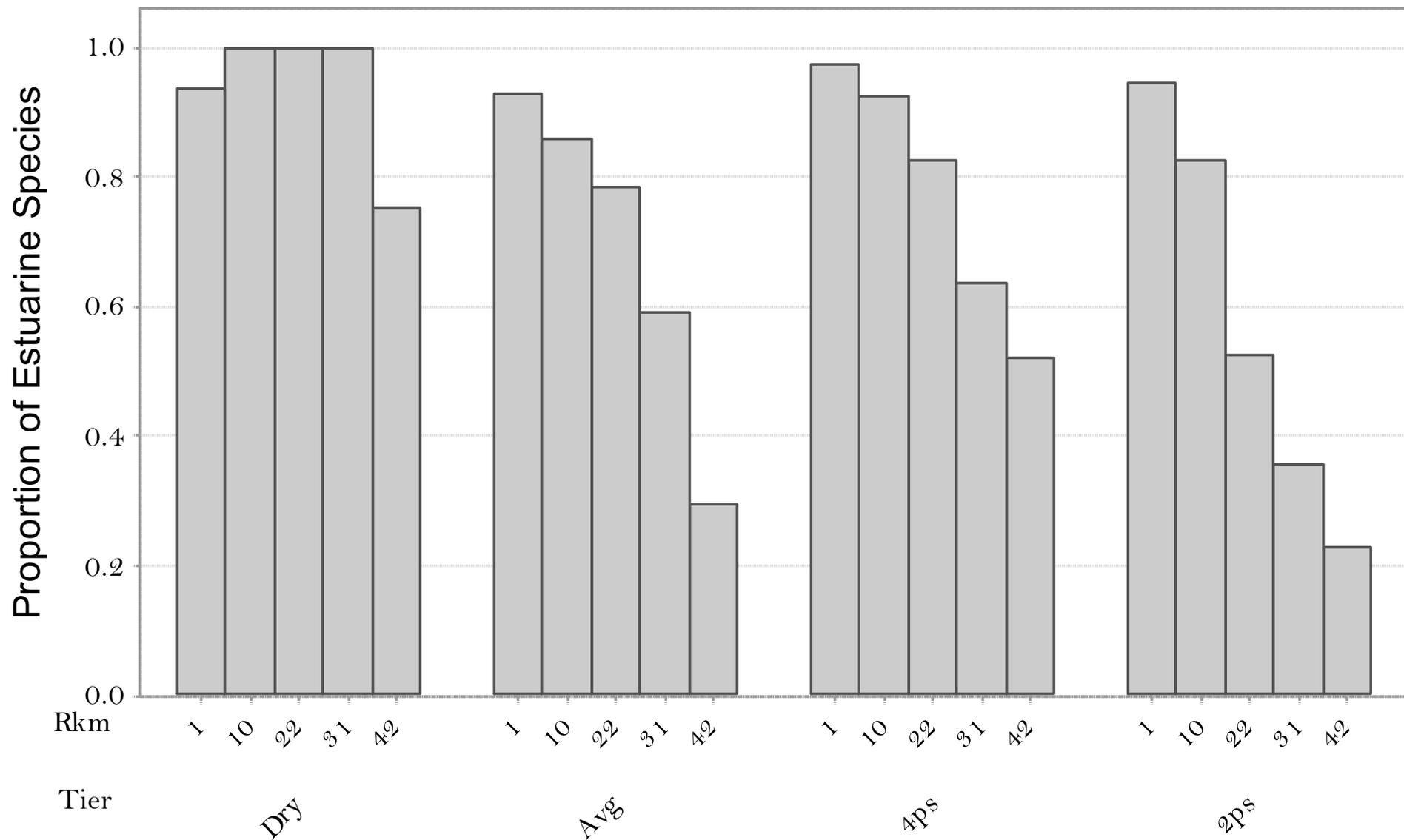
Dissolved oxygen: no significant interaction between flow tiers and river kilometer. All flow tiers different.

Results

Hydrology, Salinity vs. Nekton

Current Study

Proportion of Estuarine Taxa



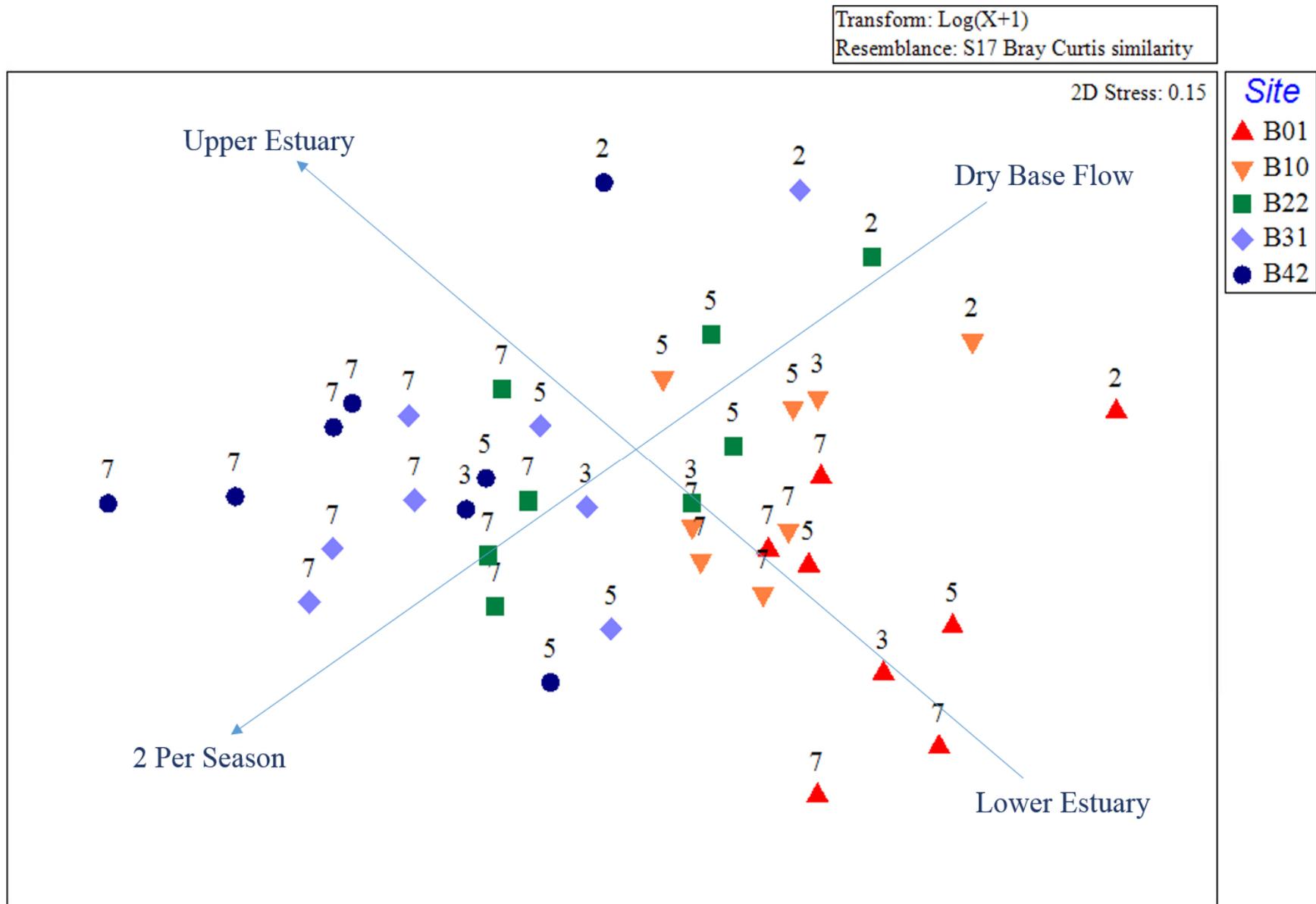
N = 1

1

2

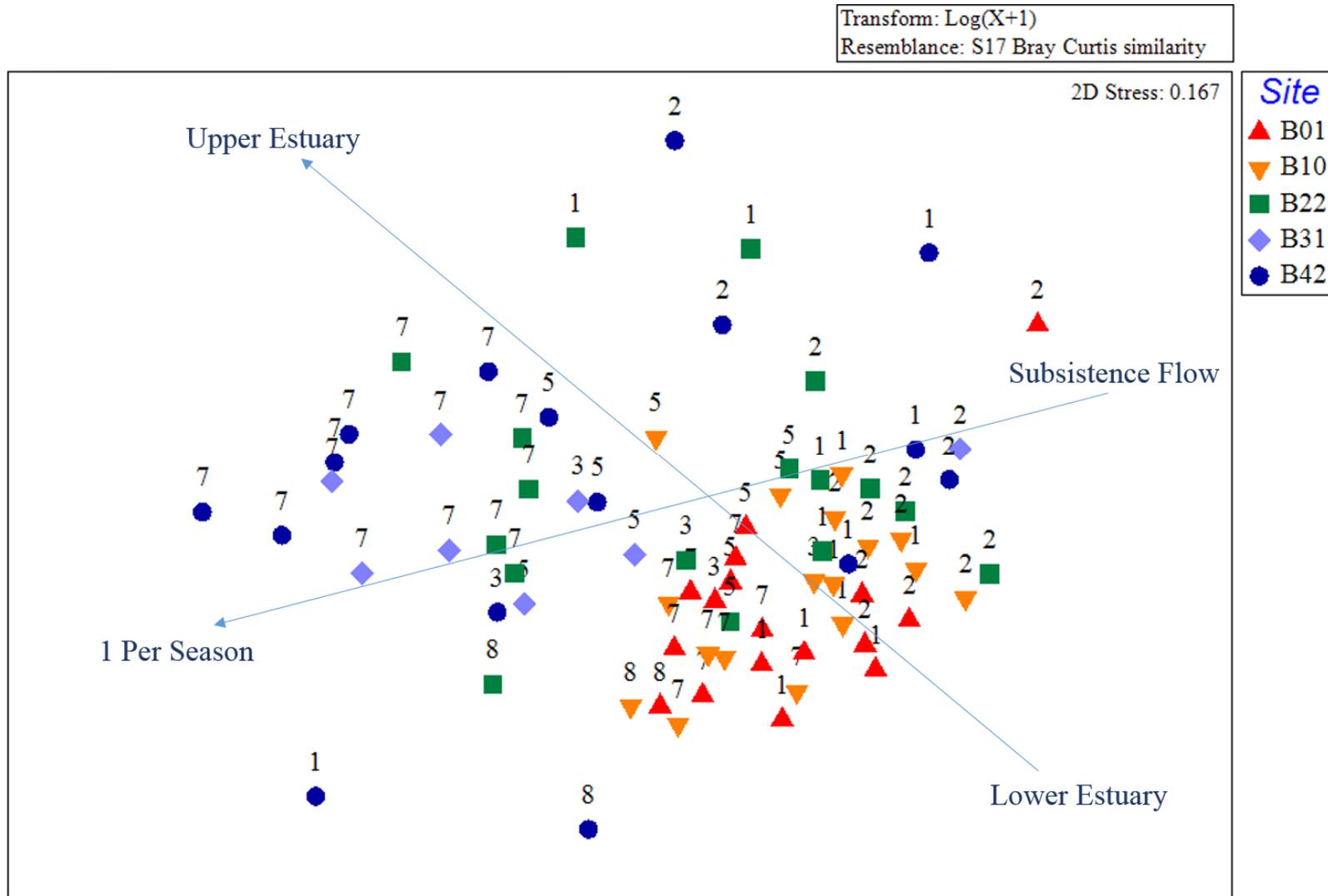
4

2014-2015 Study : Nekton Community nMDS Ordination



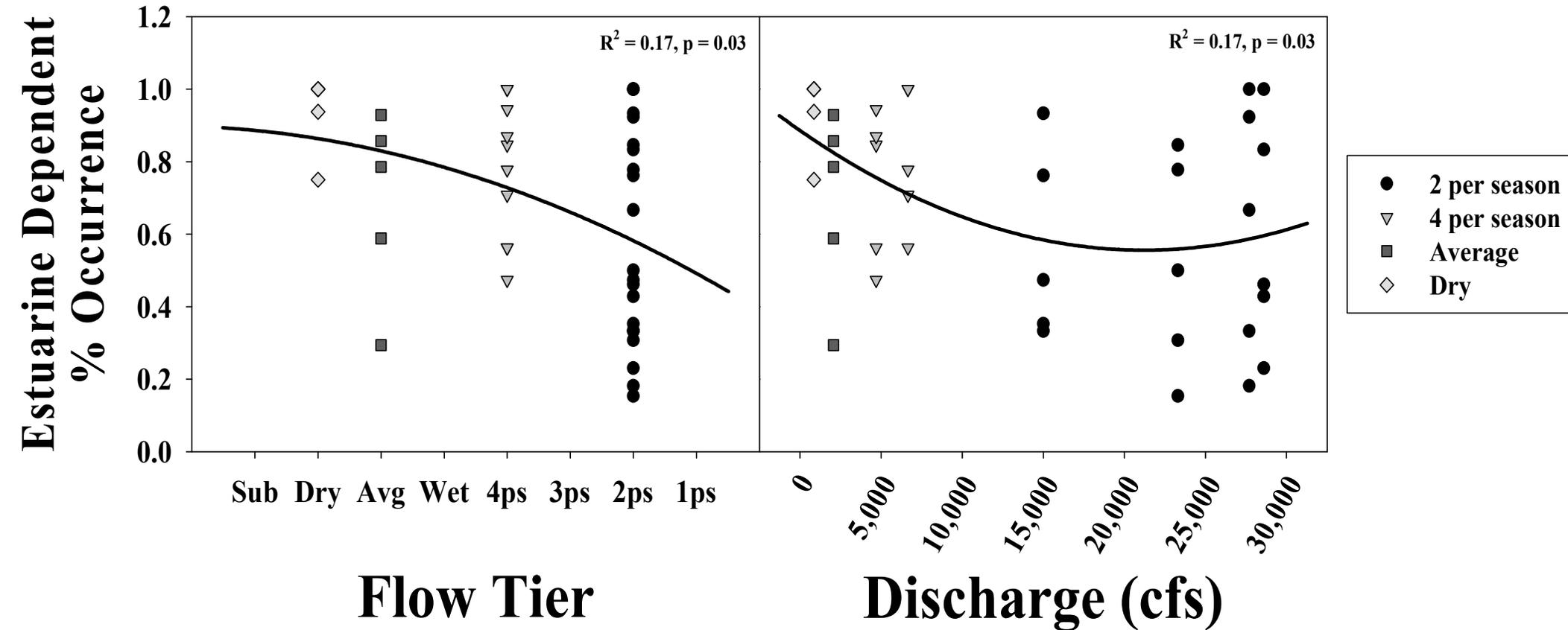
NMDS plot for nekton abundance (log+1 transformed with Bray-Curtis resemblance) data from 2014-15, all sampling methods combined. Points are labeled by Flow Tier Category (2=dry base flow, 3=average wet flow, 5=four per season, and 7=two per season events). Relationships by Flow Tier) and Site location (are shown with general trend lines.

2014-15 & 2012 (Miller 2014) : nMDS Ordination



NMDS plot for nekton abundance (log+1 transformed with Bray-Curtis resemblance) from 2012 and 2014-15 using combined otter trawl and beam trawl data. Relationships by Flow Tier (from top right to bottom left) and Site location (from bottom right to top left) are shown with general trend lines. Points are labeled by Flow Tier Category (1=Subsistence flow 2=dry base flow, 3=average wet flow, 5=four per season, 7=two per season events, and 8=one per season).

Current Study



Weak but significant relationship between estuarine species and flow tiers and discharges

* As new data compiled and sample size increases this will be repeated for each river kilometer sampled = more statistical power

Conclusions

- Salinity and dissolved oxygen responded rapidly to changes in freshwater inflow.
- Critical to evaluate vertical stratification – influences bottom fish communities
- Prob. of hypoxia lower when flow was high and salt wedge was reduced or pushed further downstream
- Nekton species composition sensitive to salinity but some species exhibit strong seasonal response, i.e. overall proportion of each species may be less sensitive = broad tolerance to salinity changes?
- Latitudinal gradients related to salinity and dissolved oxygen likely interacting with strong seasonal pulses of juvenile fish .

Pending Analyses

- Examining additional data from Johnson 1977
- Stable isotope analysis – contribution of upstream nutrients to estuarine juvenile fauna
- Response of larval fish and zooplankton communities to flow regime
- Evaluation of patterns in main channel vs. shoreline distribution of juvenile nekton
- Evaluation of shoreline adult nekton communities – electroshocking data

Future Proposed Work

- Further investigation of other flow tiers
- Use of mark/recapture and lfda, otolith aging to evaluate growth of immigrating YOY fish in response to flow regime
- Telemetry of larger fauna (gar, bull shark)?

Acknowledgments

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- Field Assistance: Kristi Fazioli, Bryan Alleman, Michael Lane, Natasha Zarnstorff, Sherah Loe, Rachel Byrne, James Yokely, Josi Robertson, Nicole Morris & Raphaelita Bishara



Questions?



Citations

- Alber, 2002. A conceptual model of estuarine freshwater inflow management. *Estuaries* 25(68): 1246-1261.
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