

The determination of freshwater inflow rules for tidal river estuaries using a percent-of-flow approach



Southwest Florida
Water Management District



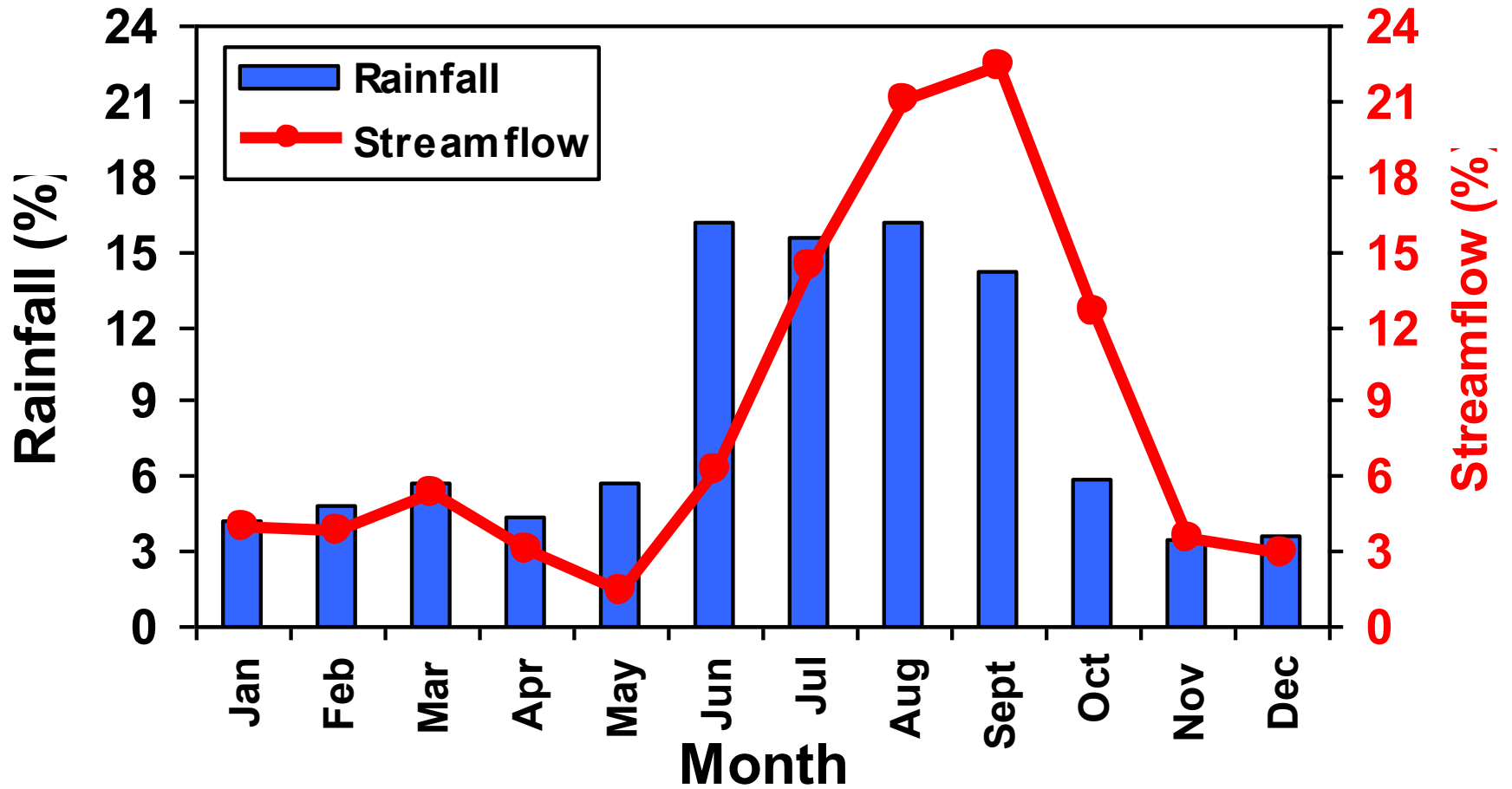
(F.S. 373.042)

Minimum flows are “the limit at which further withdrawals would be significantly harmful to the water resources or ecology of the area”

Translated

How much water can be removed for water supply without damaging the ecology of a river or its receiving estuary

Percentage of yearly rainfall and streamflow by month



Freshwater and Estuarine Minimum Flow Studies

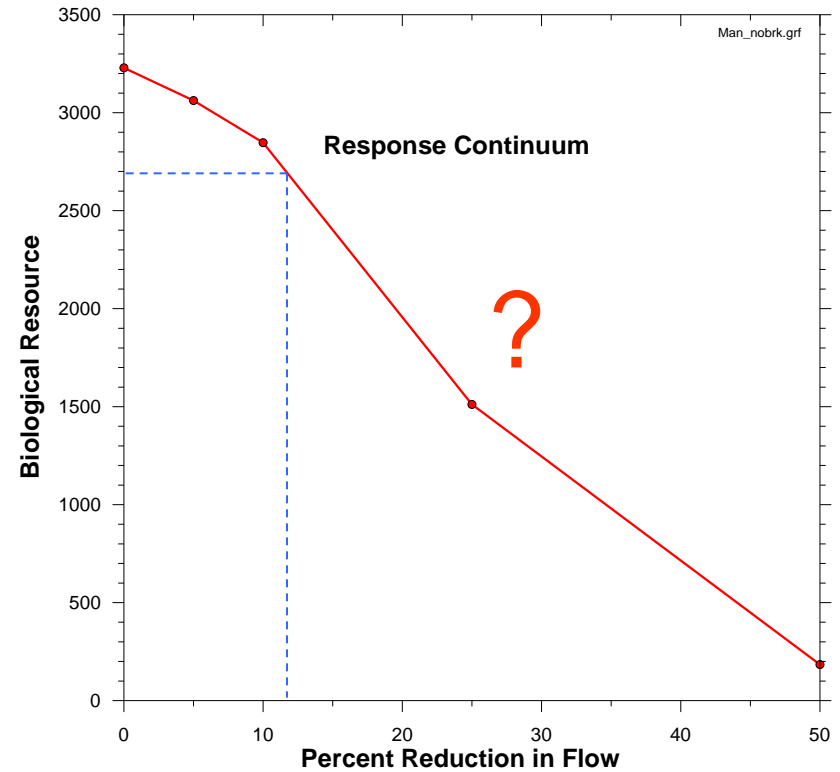
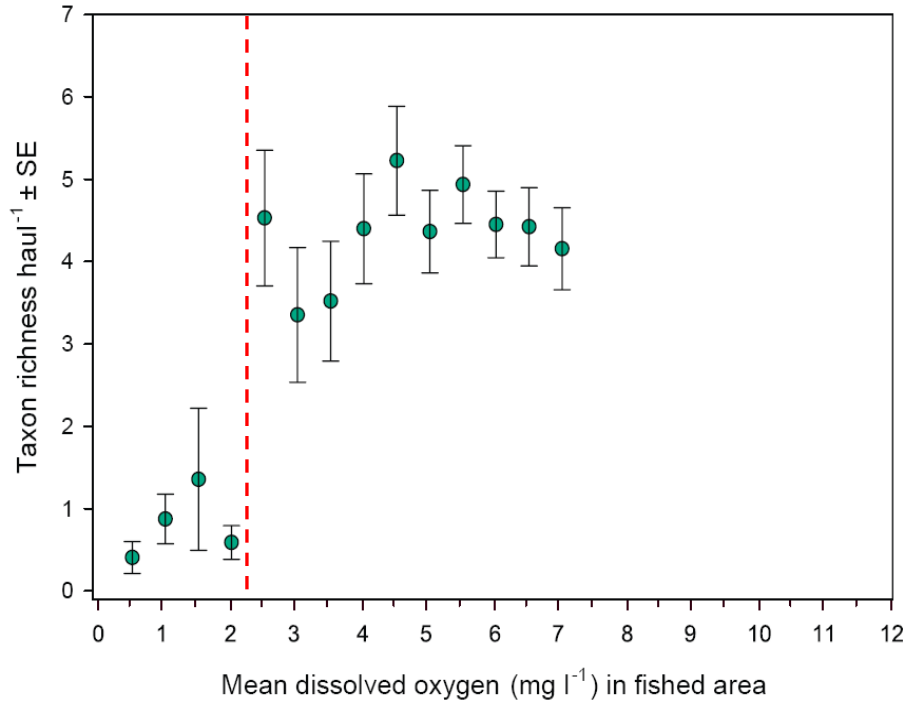
Fresh Water

- Fish Passage
- Floodplain Inundation
- Wetted Perimeter
- Woody Snags
- Fish / Invertebrate habitat modeling

Estuarine

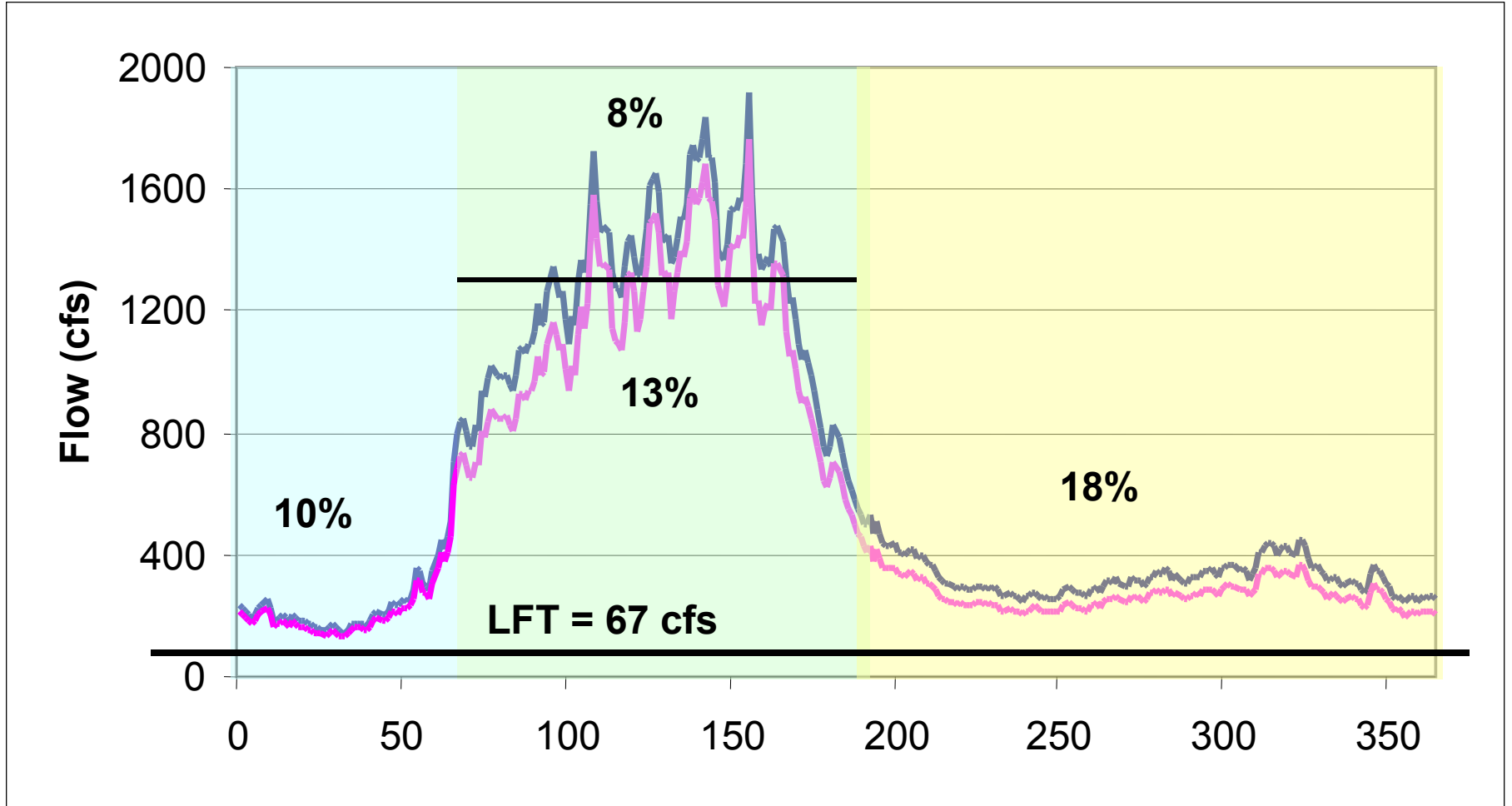
- Fish and invertebrate distribution & abundance
- Salinity zone modeling
- Benthic invertebrates
- Oyster zones
- Manatee Use
- Tidal Wetlands
- Water Quality (DO)
- Phytoplankton

Significantly Harmful ?



Flow prescription for freshwater river

Peace River at Arcadia



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Subtitled

Assessing Shifts in Fish Nursery Zones to Determine Allowable Reductions of Freshwater Inflow

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Value of Estuarine Dependent Fisheries In Florida

Commercial fisheries

- Shrimp
- Blue Crabs
- Mullet
- Oysters

Dockside value

\$37,224,699
\$10,394,829
\$ 6,915,987
\$ 5,474,876

Sport Fisheries

- Snook
- Tarpon
- Red Drum
- Spotted Seatrout

Economic value

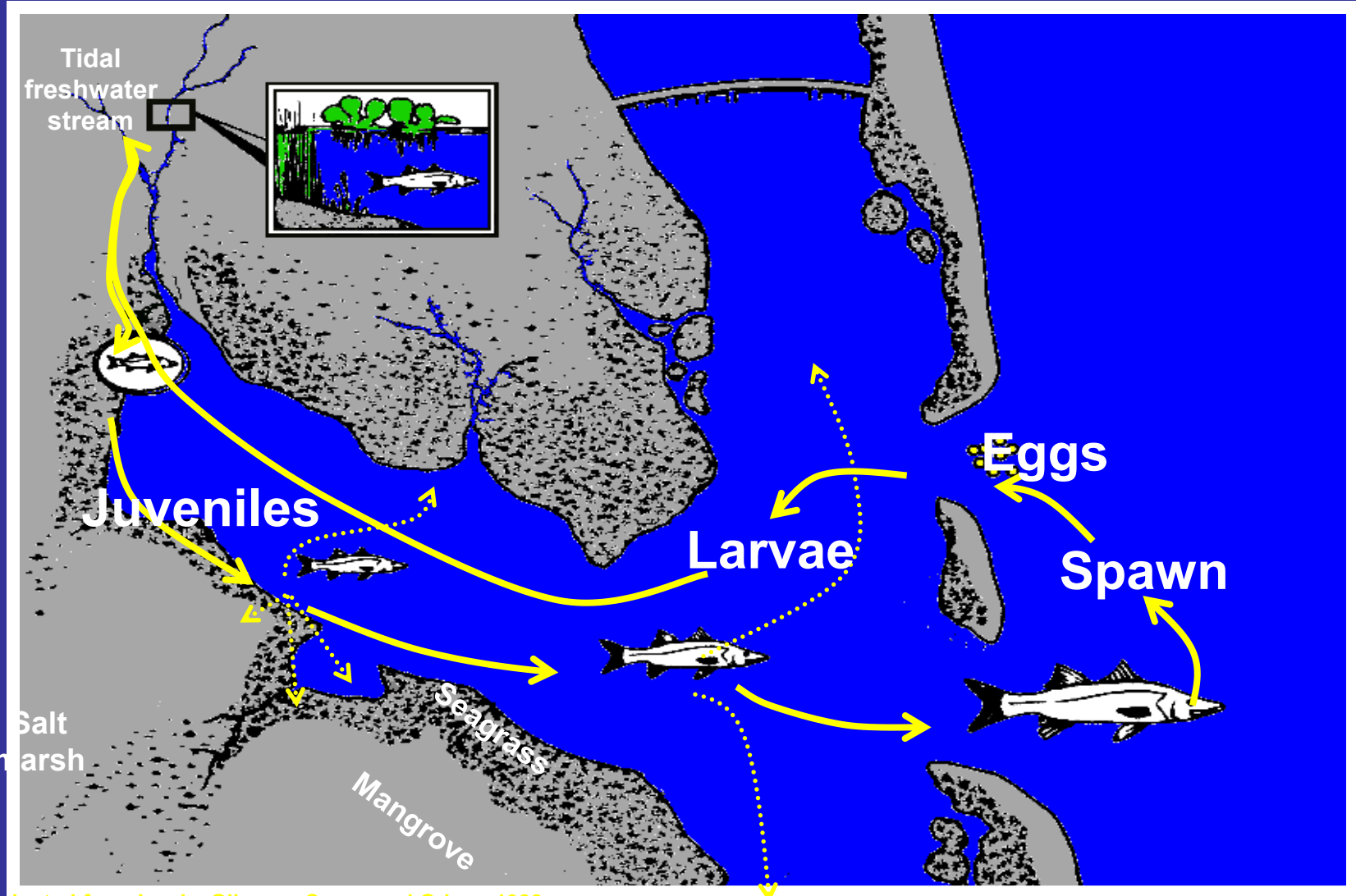
Saltwater sport fishing
5 to 6 billion \$ per year

Positive relationships between fish or shellfish abundance or harvest with freshwater inflow

- **Texas** - blue crab, shrimps, red drum (Longley 1994)
- **Australia** - mullet, barramundi (Meynecke et. 2006)
- **Africa** - shrimp (Gammelsrod 1992)
- **Cuba** - shrimps, mullet, oysters (Baisre and Arboleya, 2006)
- **California** - striped bass, smelt (Jassby et al. 1995, Kimmerer 2002)

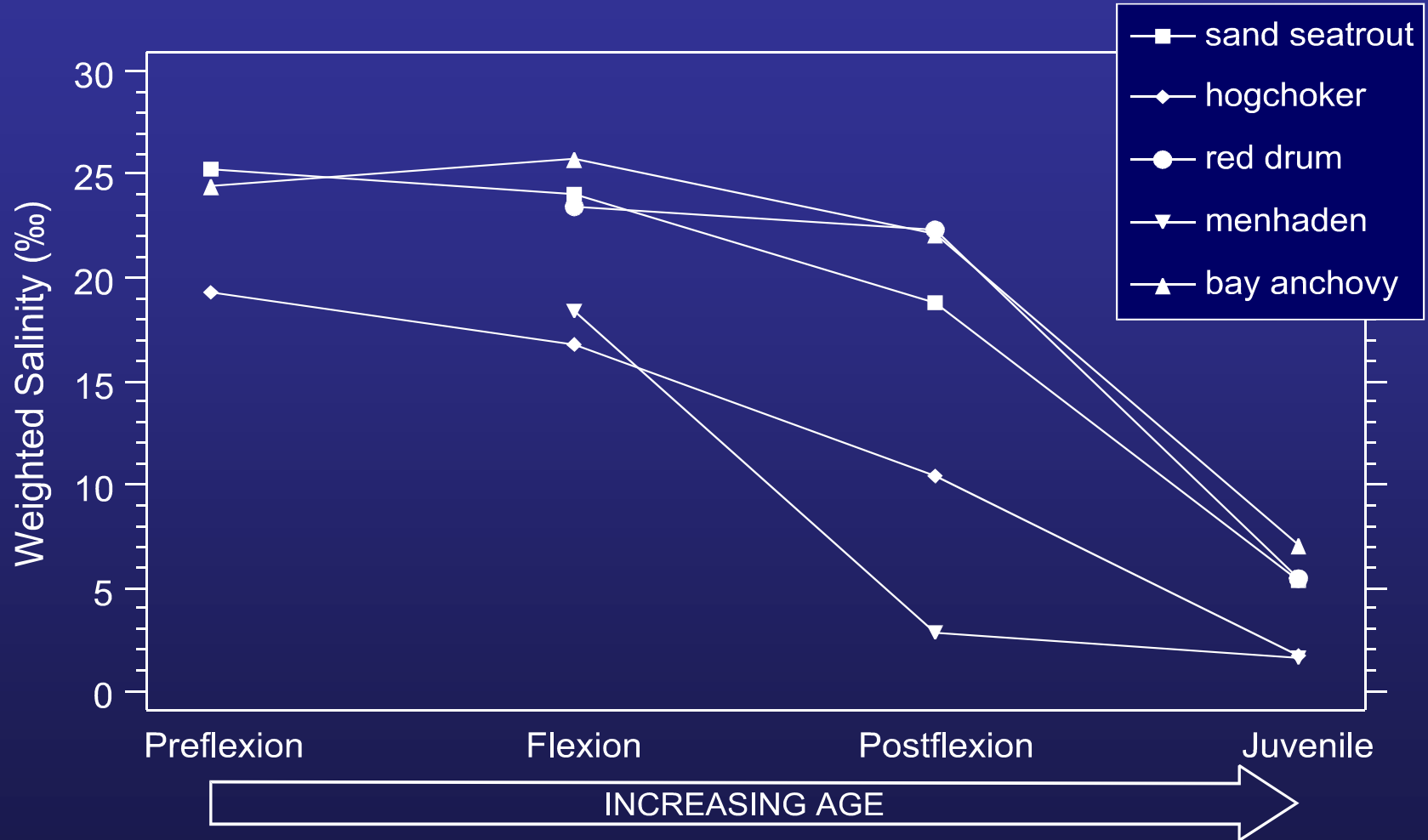
- **Florida**
 - **Appalachicola** - oysters, blue crab (Wilber, 1992, 1994)
 - **Everglades** - pink shrimp (Browder 1985)
 - **Little Manatee** - snook, blue crab, mullet (FWRI 2007)
 - **Alafia River** - red drum, mysids, moharra (FRWI, 2005, Peebles 2005)
 - **Peace River** - mysids, sn. seatrout, pink shrimp (USF 2002, FWRI 2004)
 - **Myakka River** - anchovy, spot, pink shrimp (FWRI and USF, 2006)

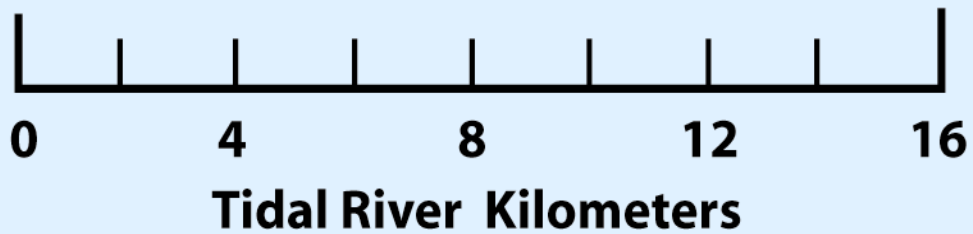
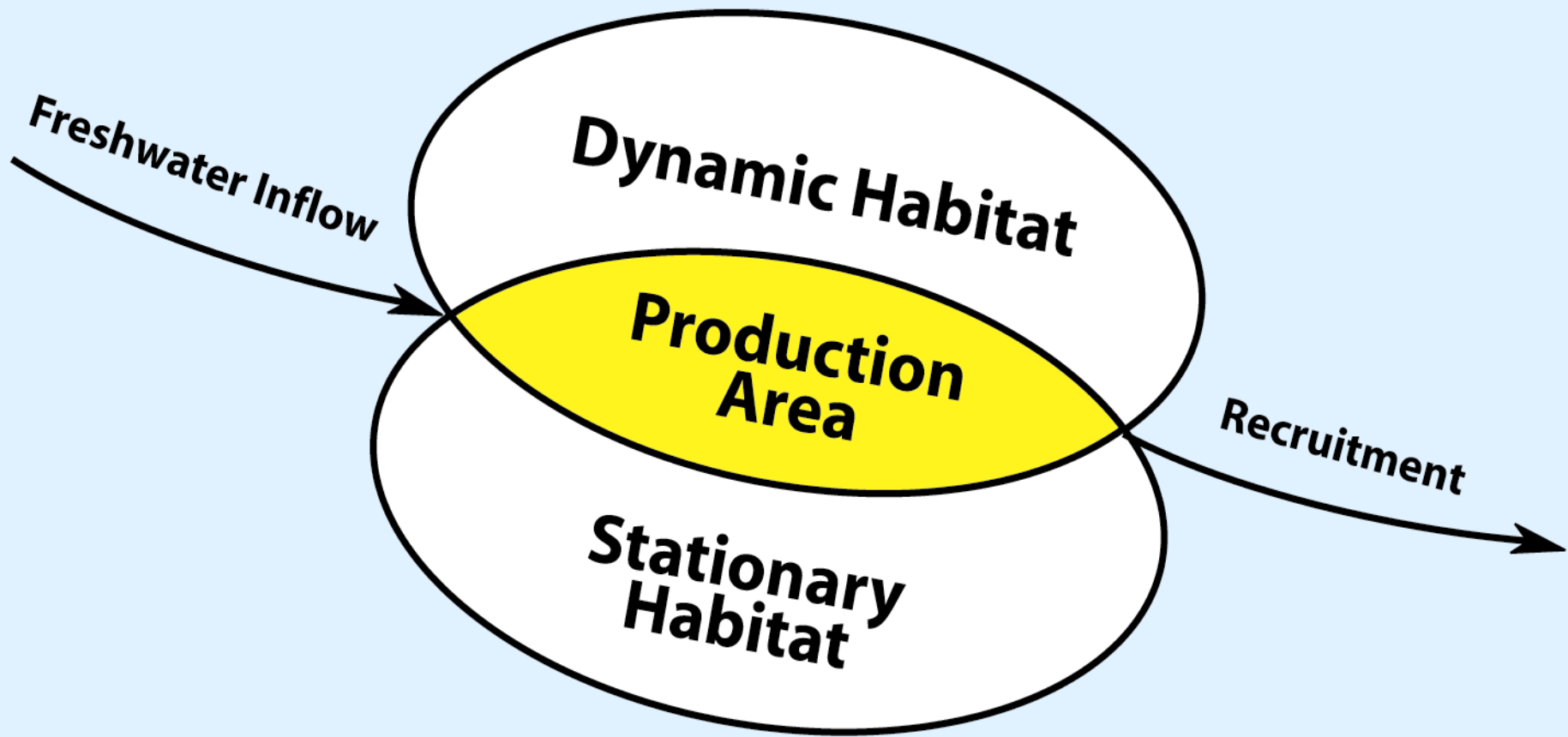
Typical life cycle of an estuarine dependent species (snook)



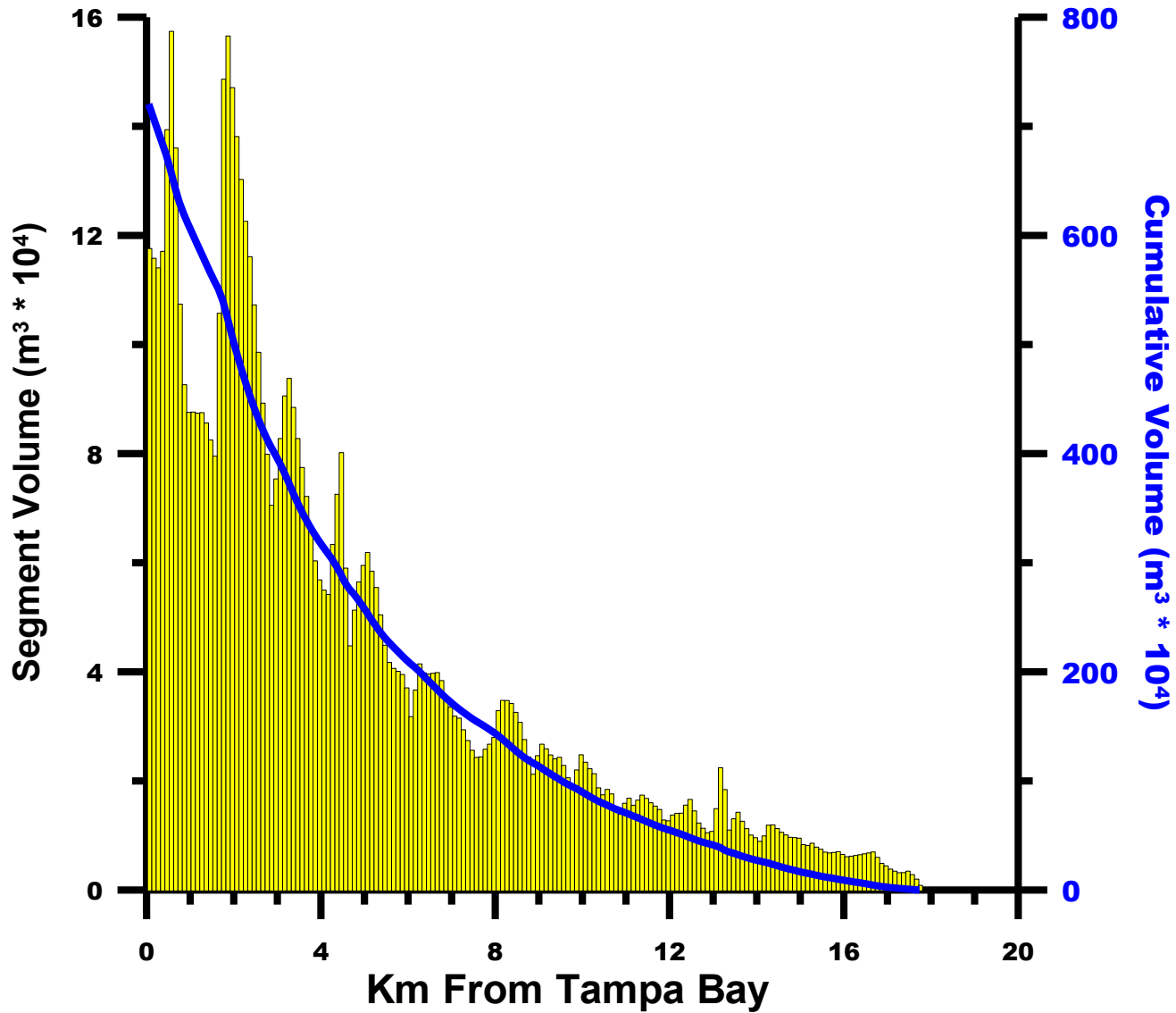
Adapted from Lewis, Gilmore, Crewz and Odum, 1988

Fish life stages vs. mean salinity at capture



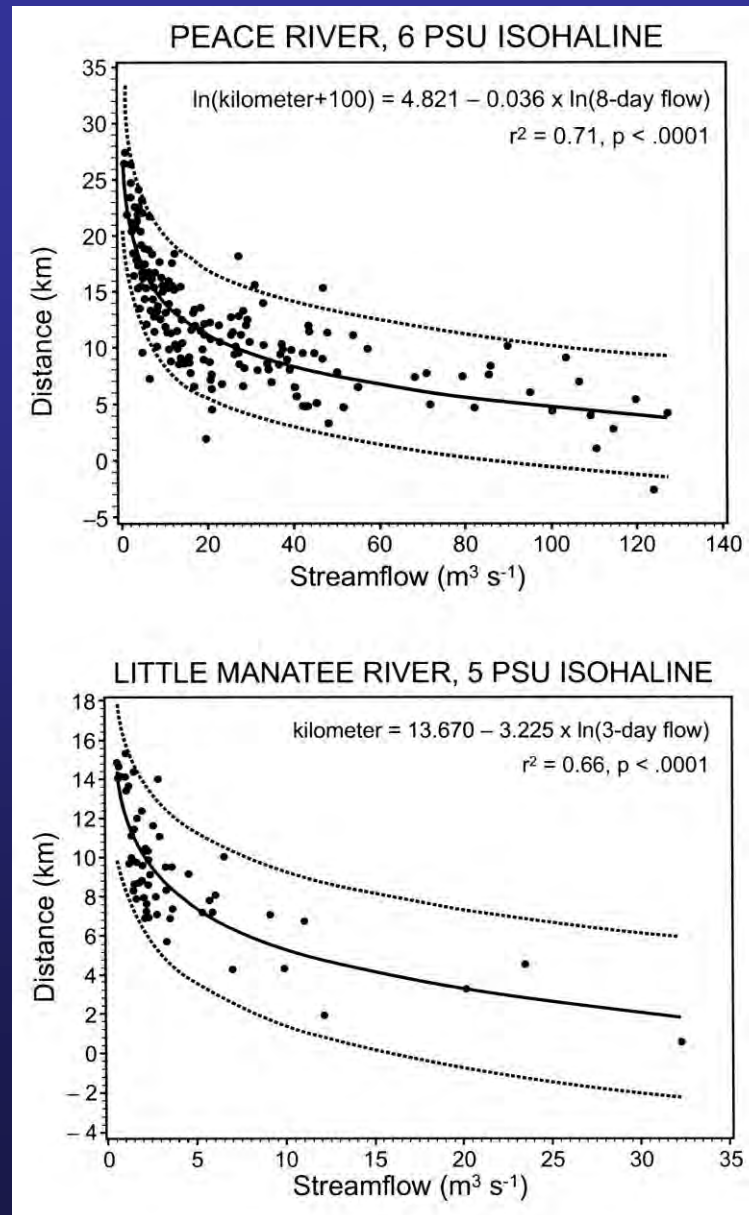


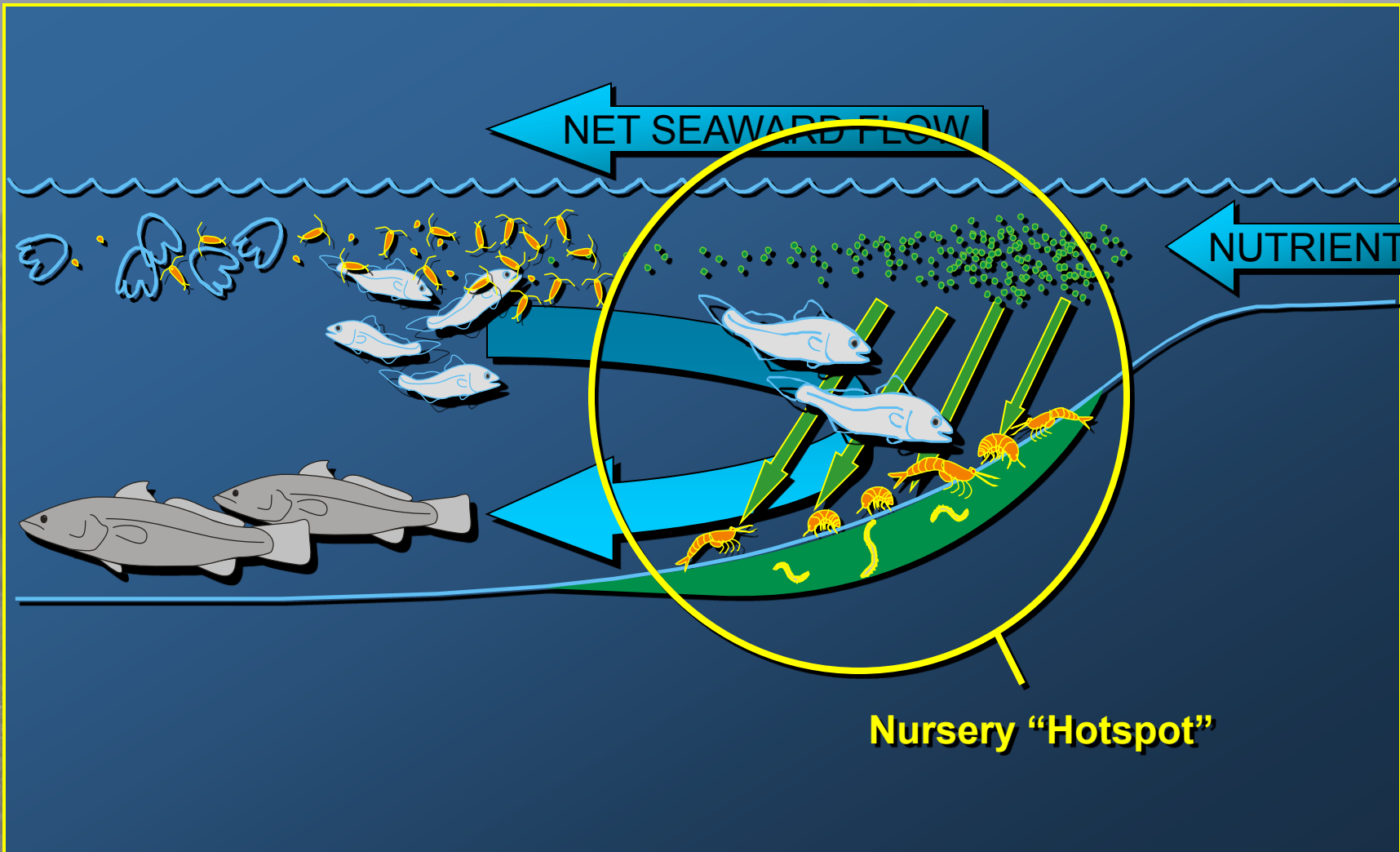
Browder and Moore 1981



Volume of Lower Alafia River by Kilometer

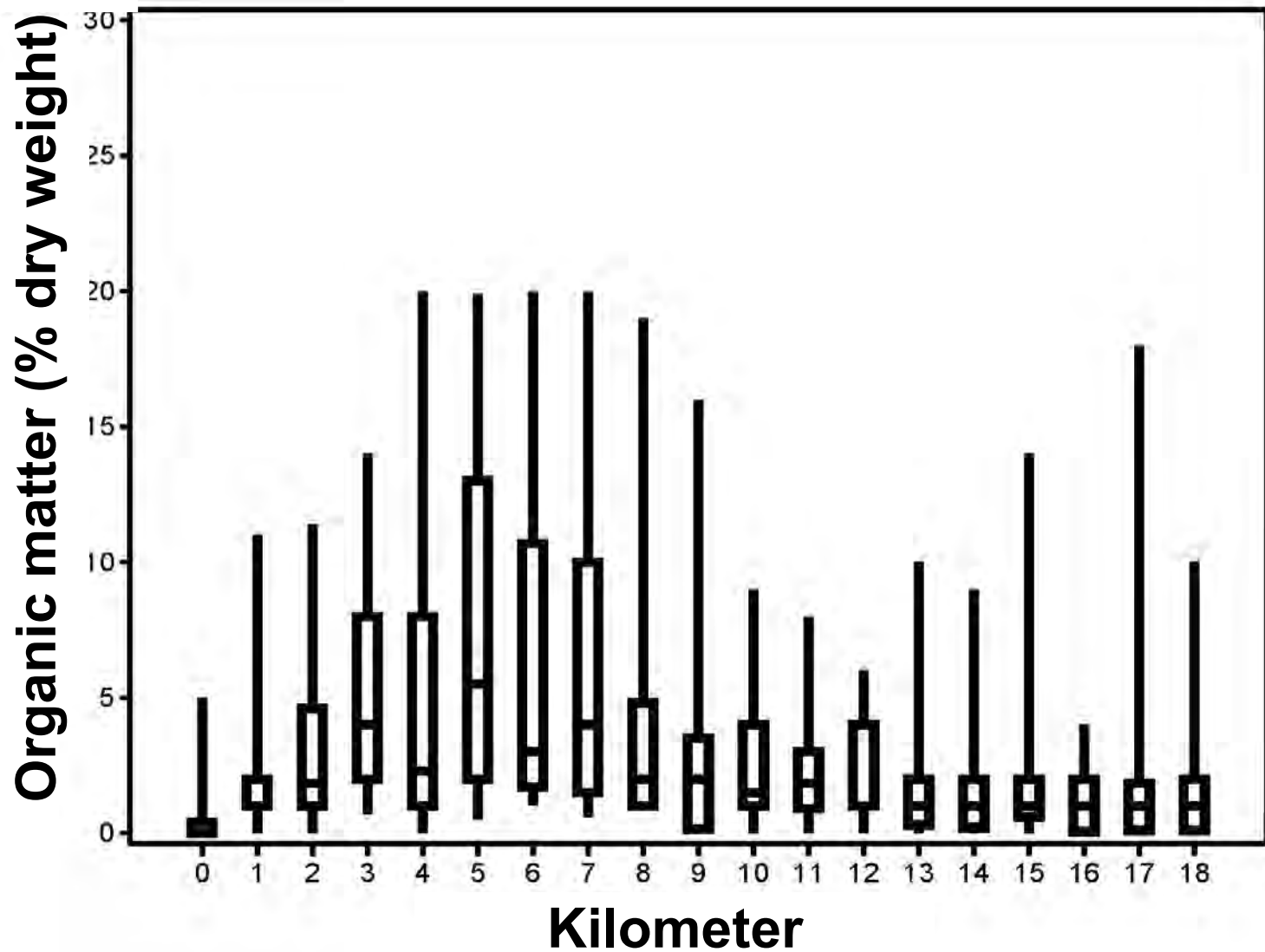
Isohaline (salt line) movements in relation to flow





Nursery "Hotspot"

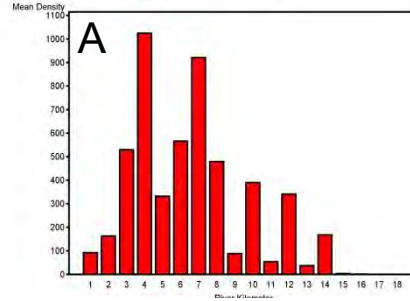
Alafia River - Sediment Organic Matter



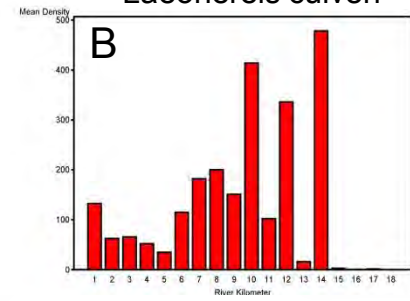
Alafia River

Benthic Macroinvertebrate Abundance By Kilometer

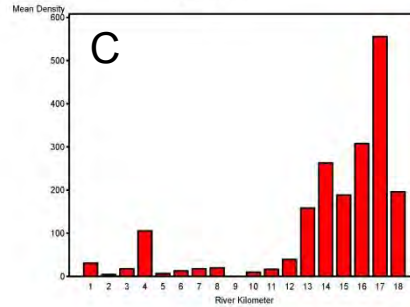
Grandierella bonnieroides



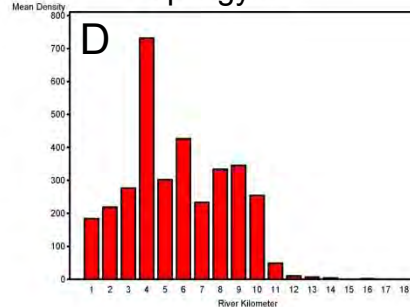
Laeonereis culveri



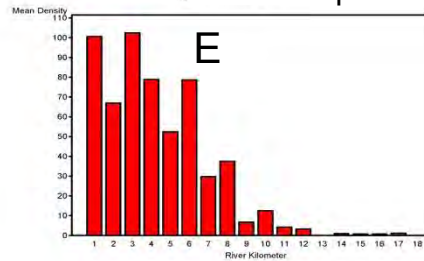
Tubificidae



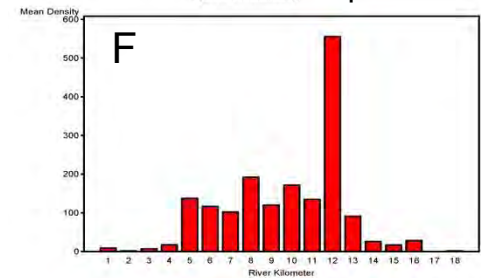
Streblospio gynobranchiata



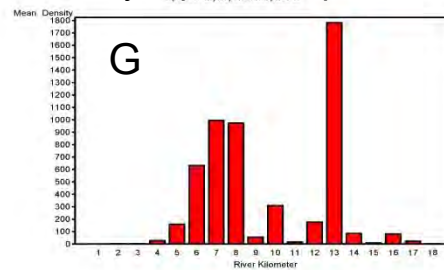
Nemertea sp.



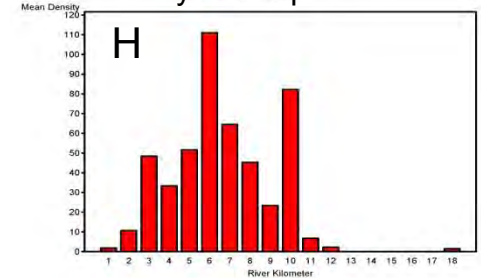
Chironomus sp..



Mytilopsis leucophaeta

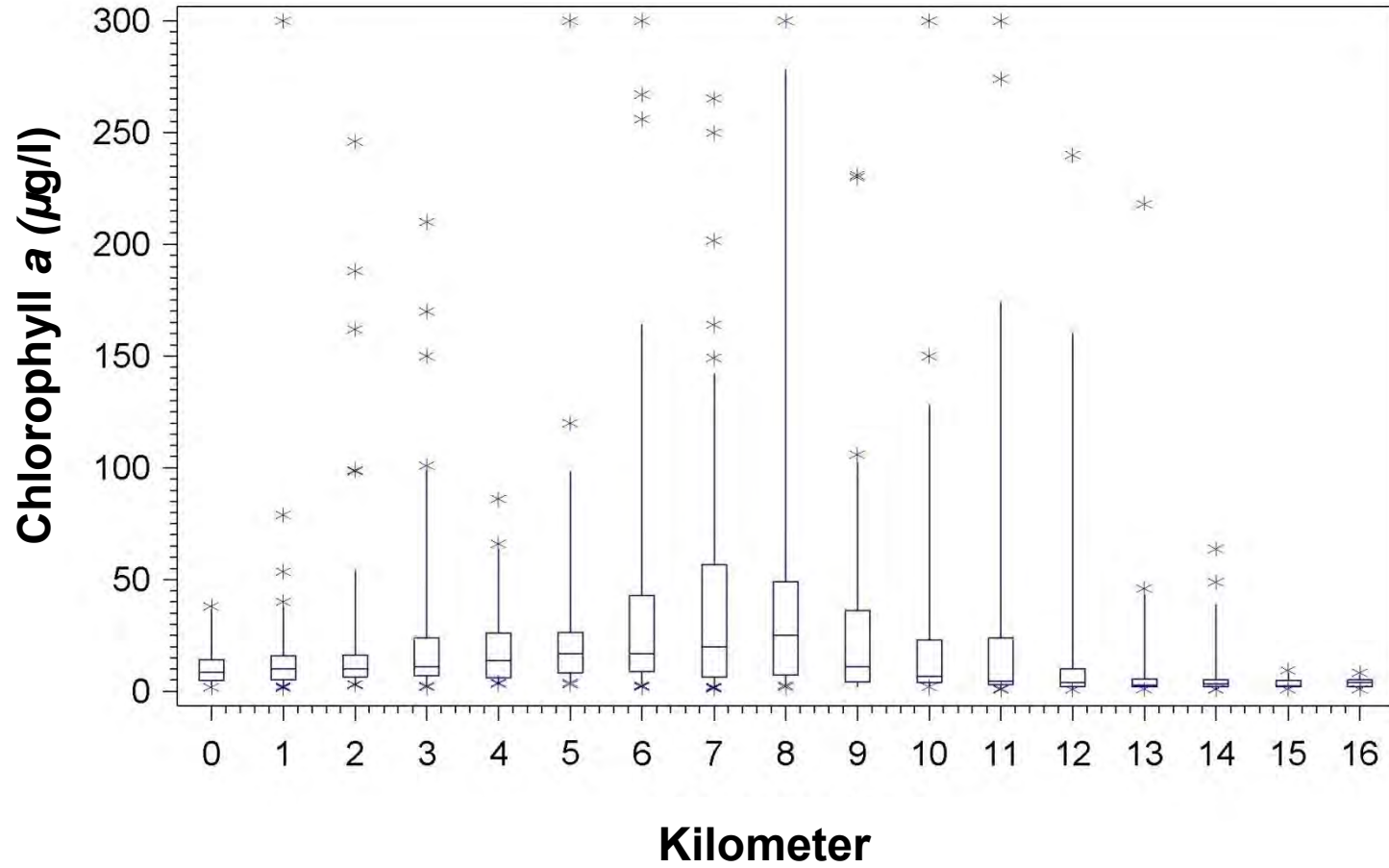


Cyathura polita



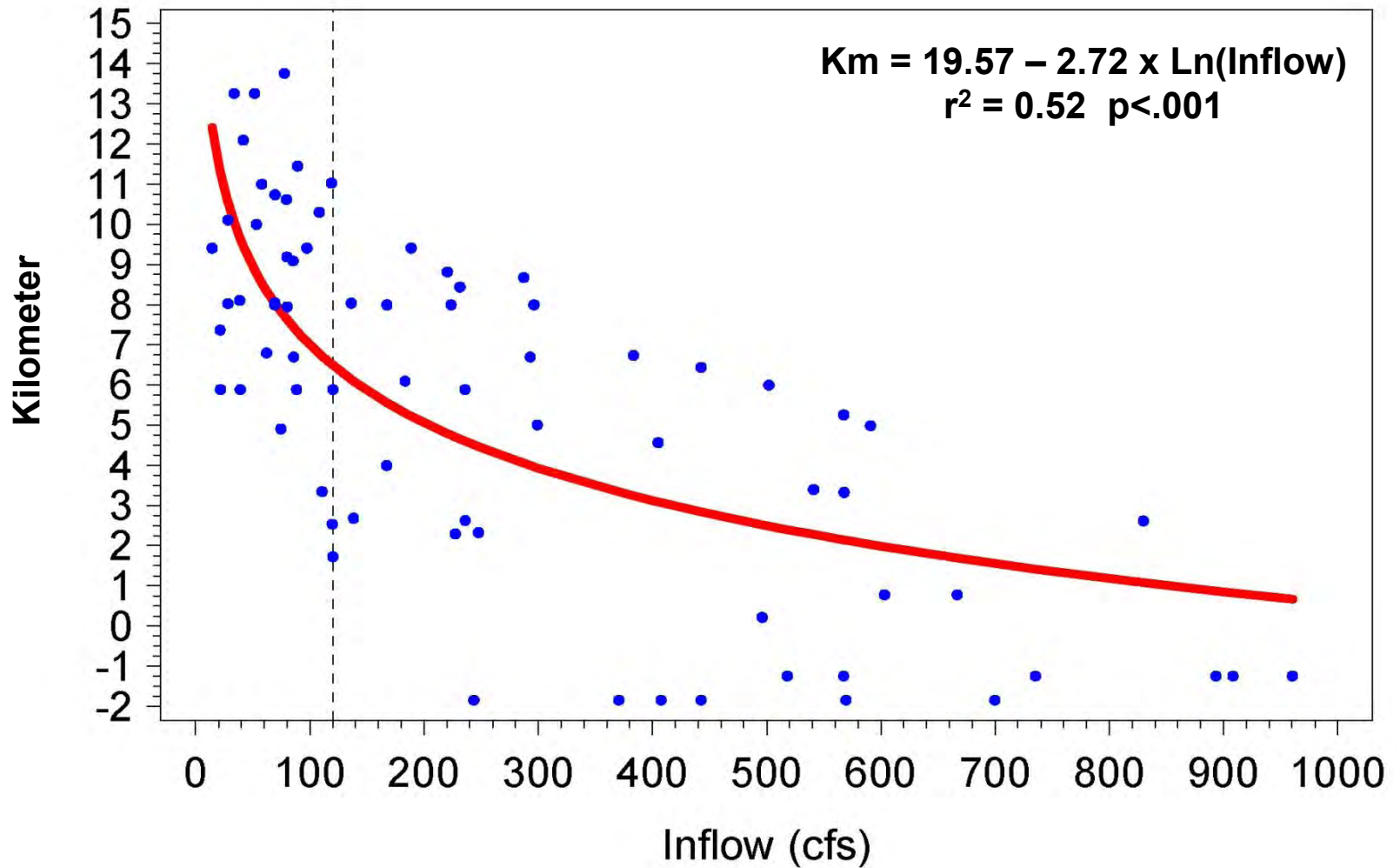
Chlorophyll a values in one kilometer segments

High values set to 300 ug/l

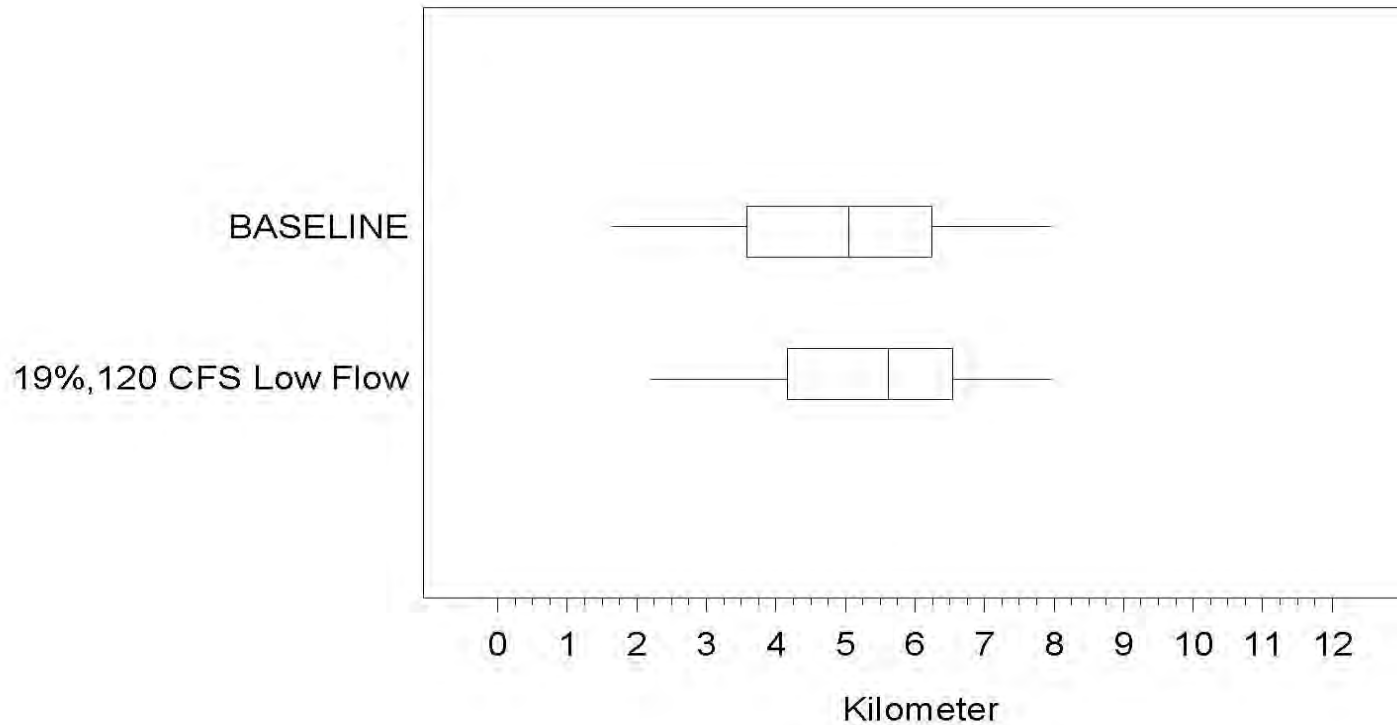


Alafia River

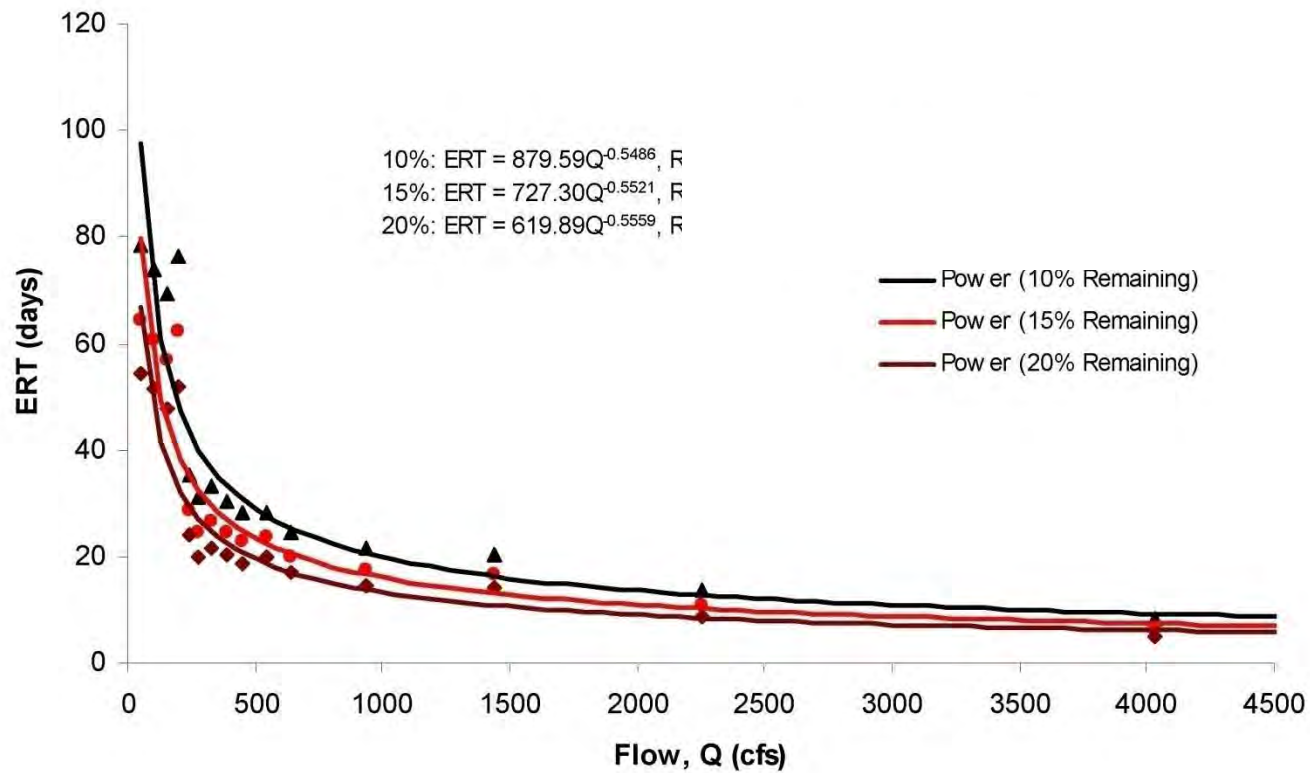
Location of peak chlorophyll *a* concentrations vs. inflow

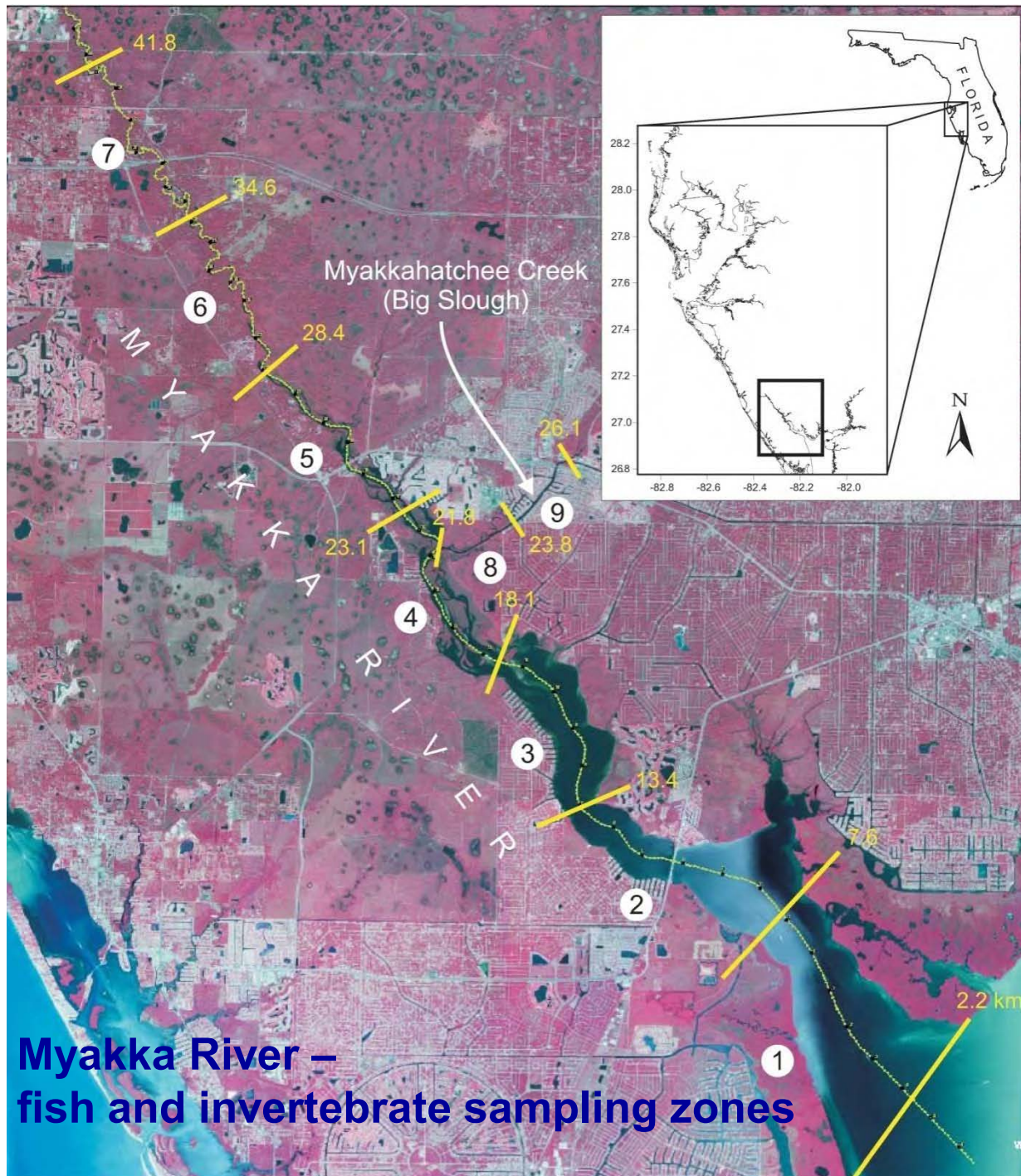


Alafia River
Predicted shift of peak chlorophyll a concentrations
Baseline and MFL withdrawals



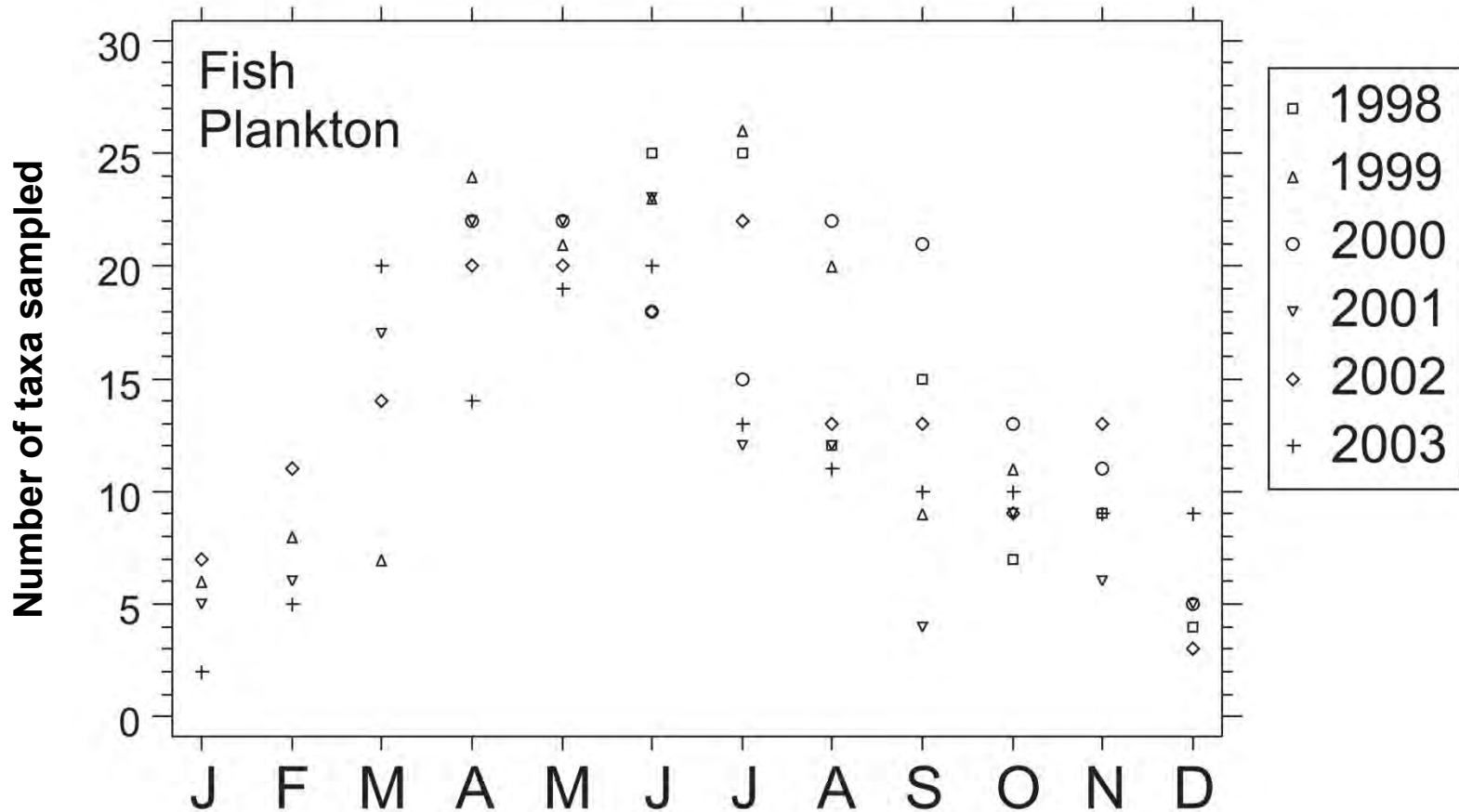
Water Residence Time vs. Flow Lower Peace River



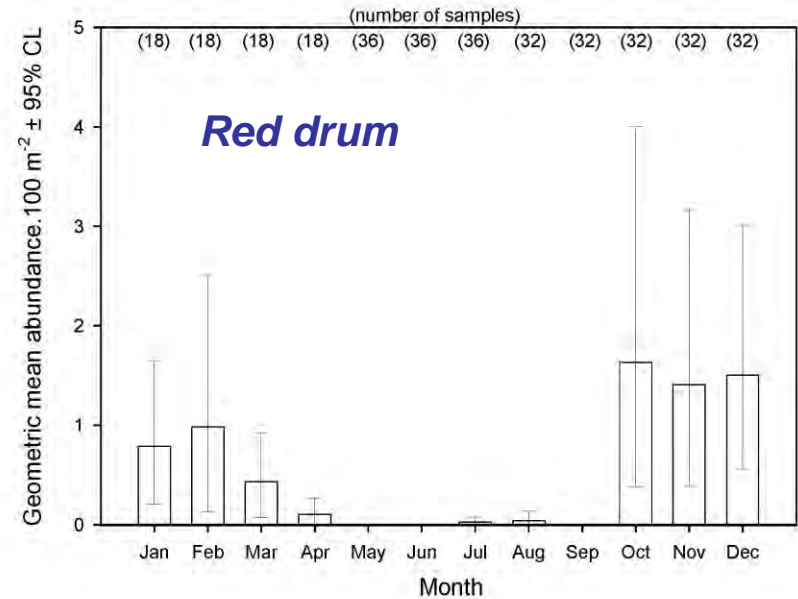
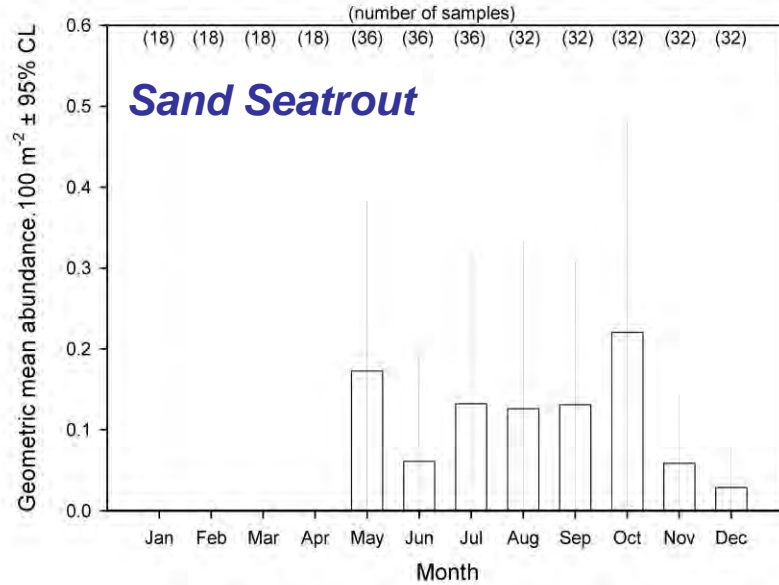


**Myakka River –
fish and invertebrate sampling zones**

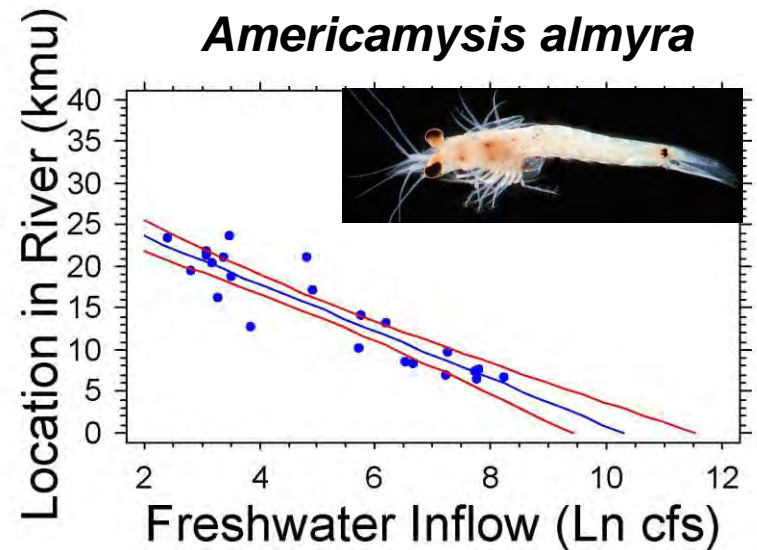
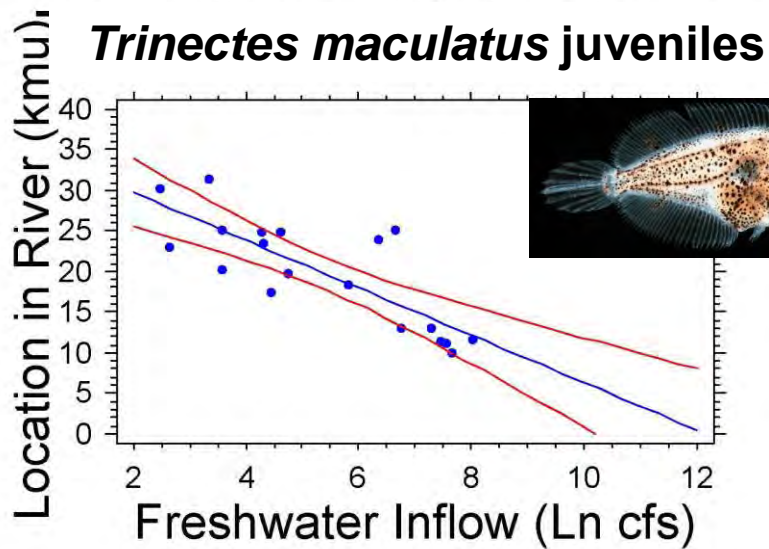
Larval and early juvenile fish species richness by month



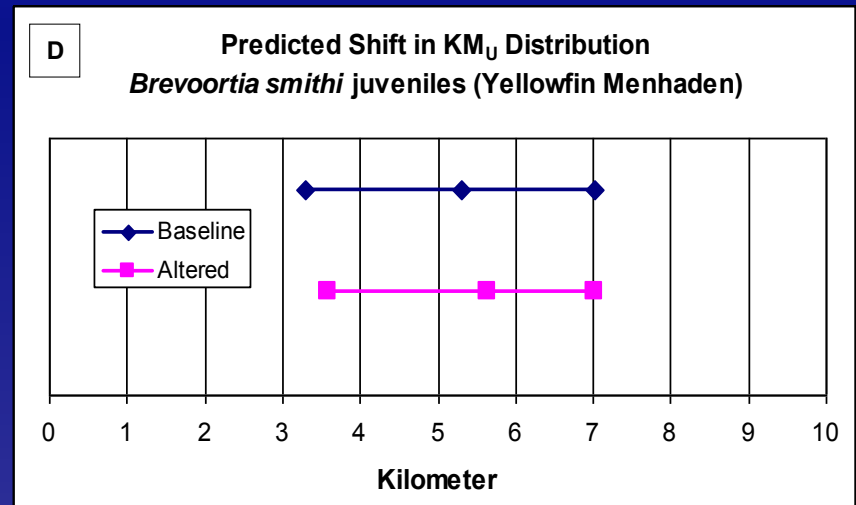
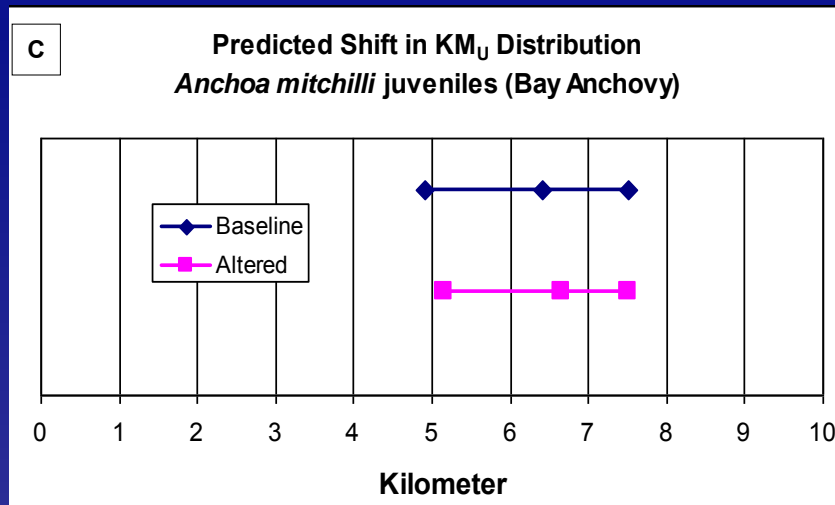
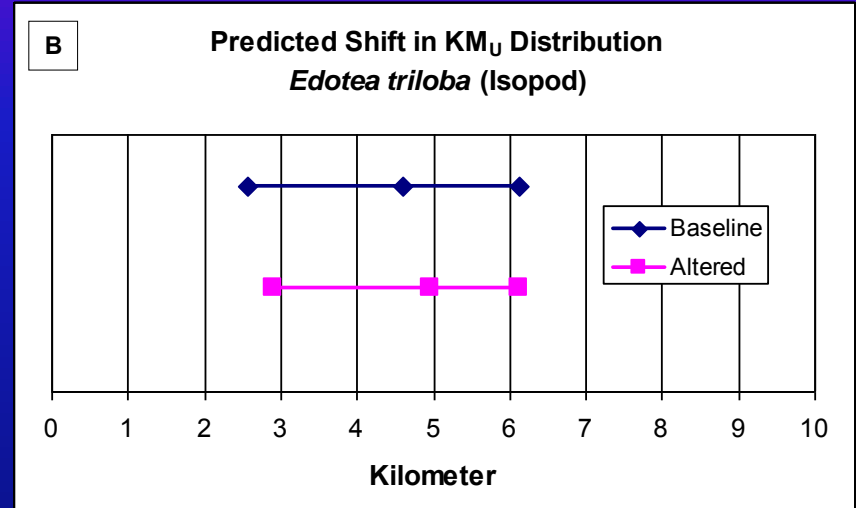
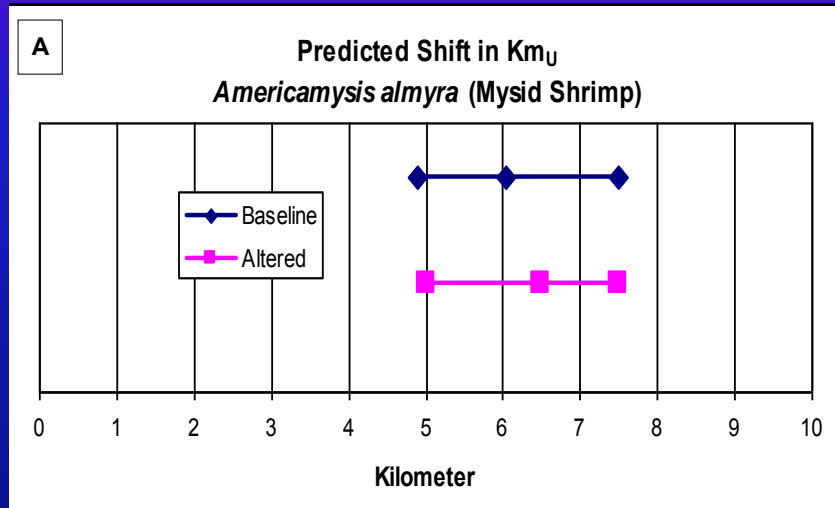
Seasonal nursery use of the estuary (seines)



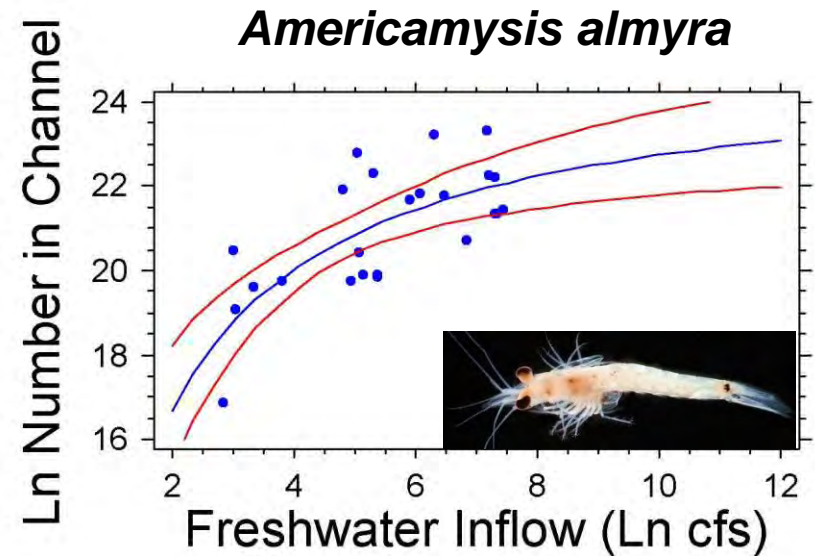
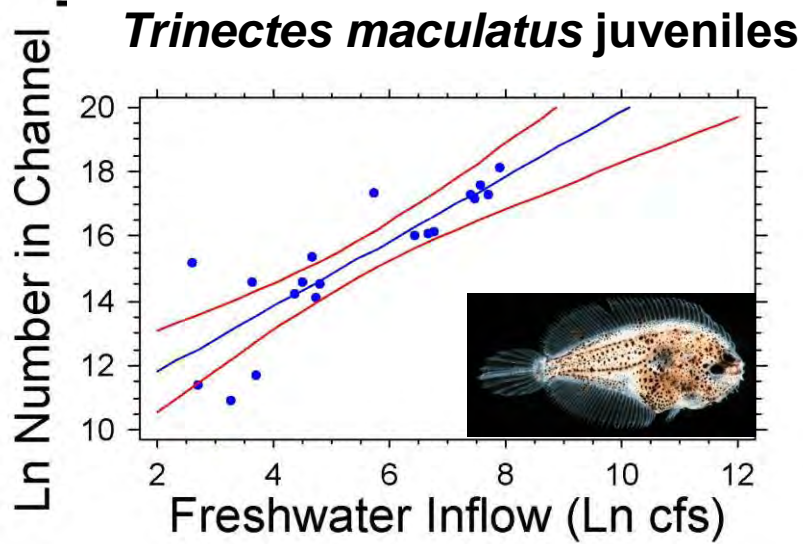
Fish / Invertebrate distribution response to inflow



Effect of minimum flows – Lower Alafia Distribution of fishes and invertebrates



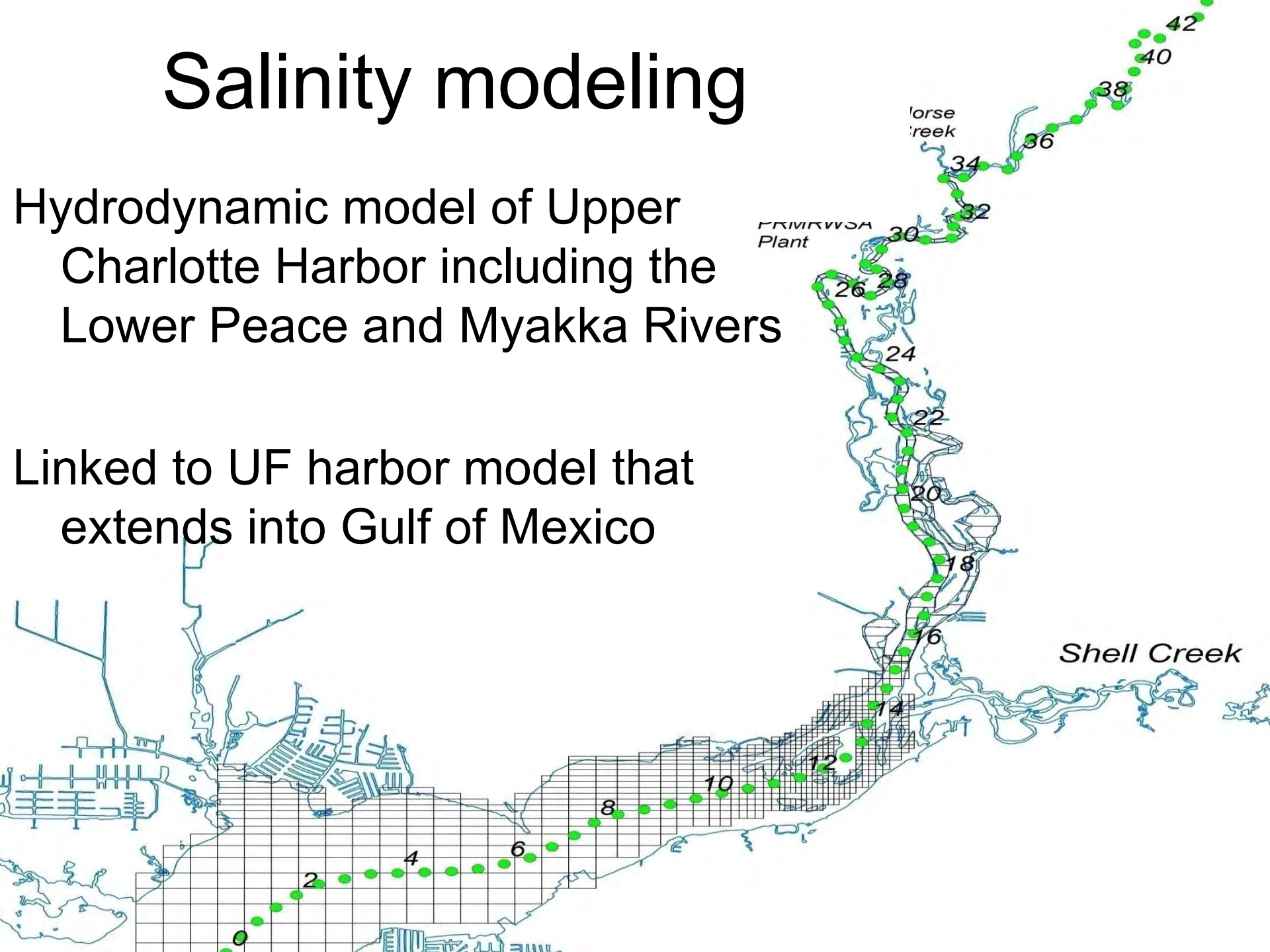
Fish / Invertebrate abundance response to inflow



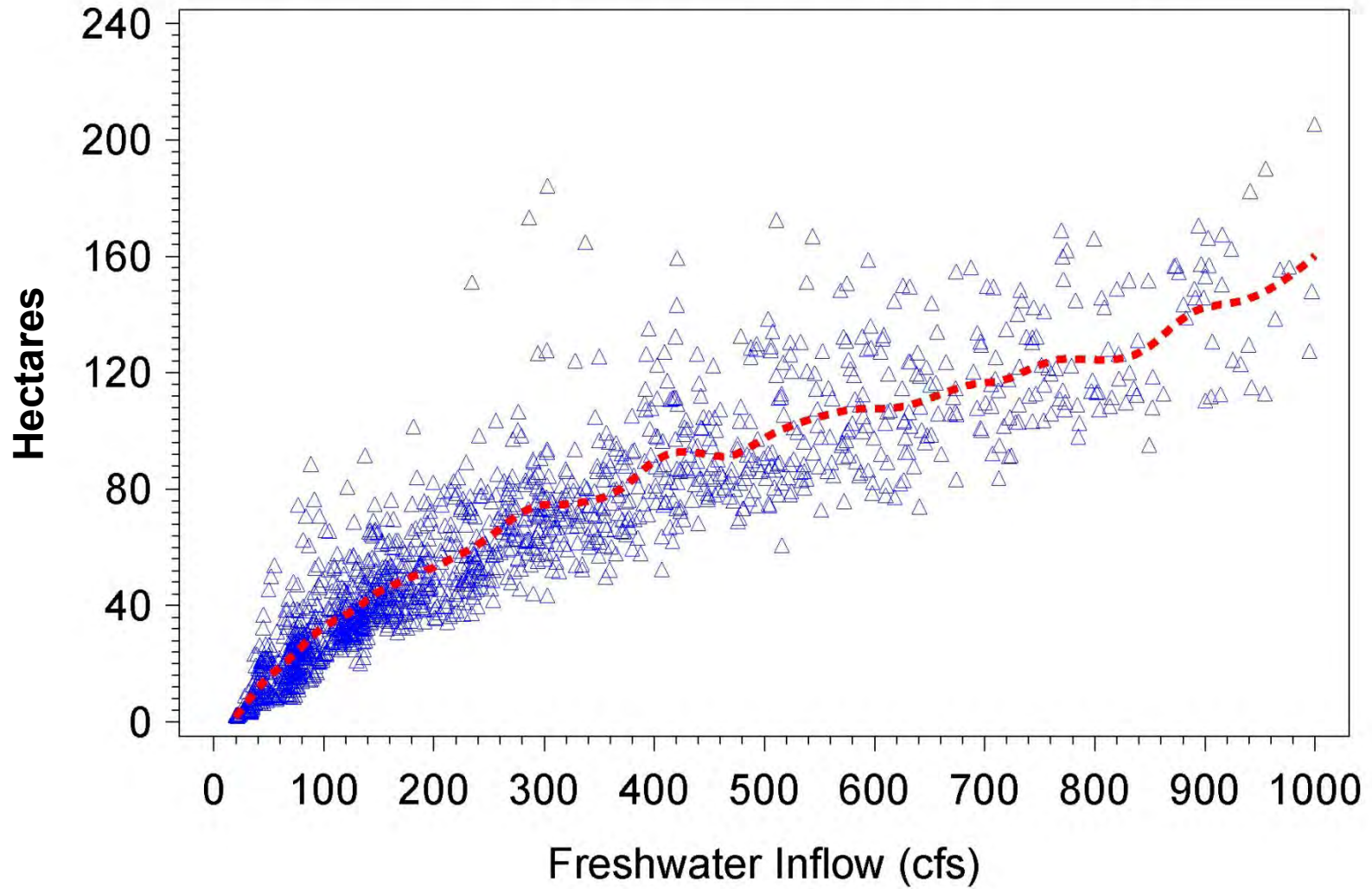
Salinity modeling

Hydrodynamic model of Upper Charlotte Harbor including the Lower Peace and Myakka Rivers

Linked to UF harbor model that extends into Gulf of Mexico

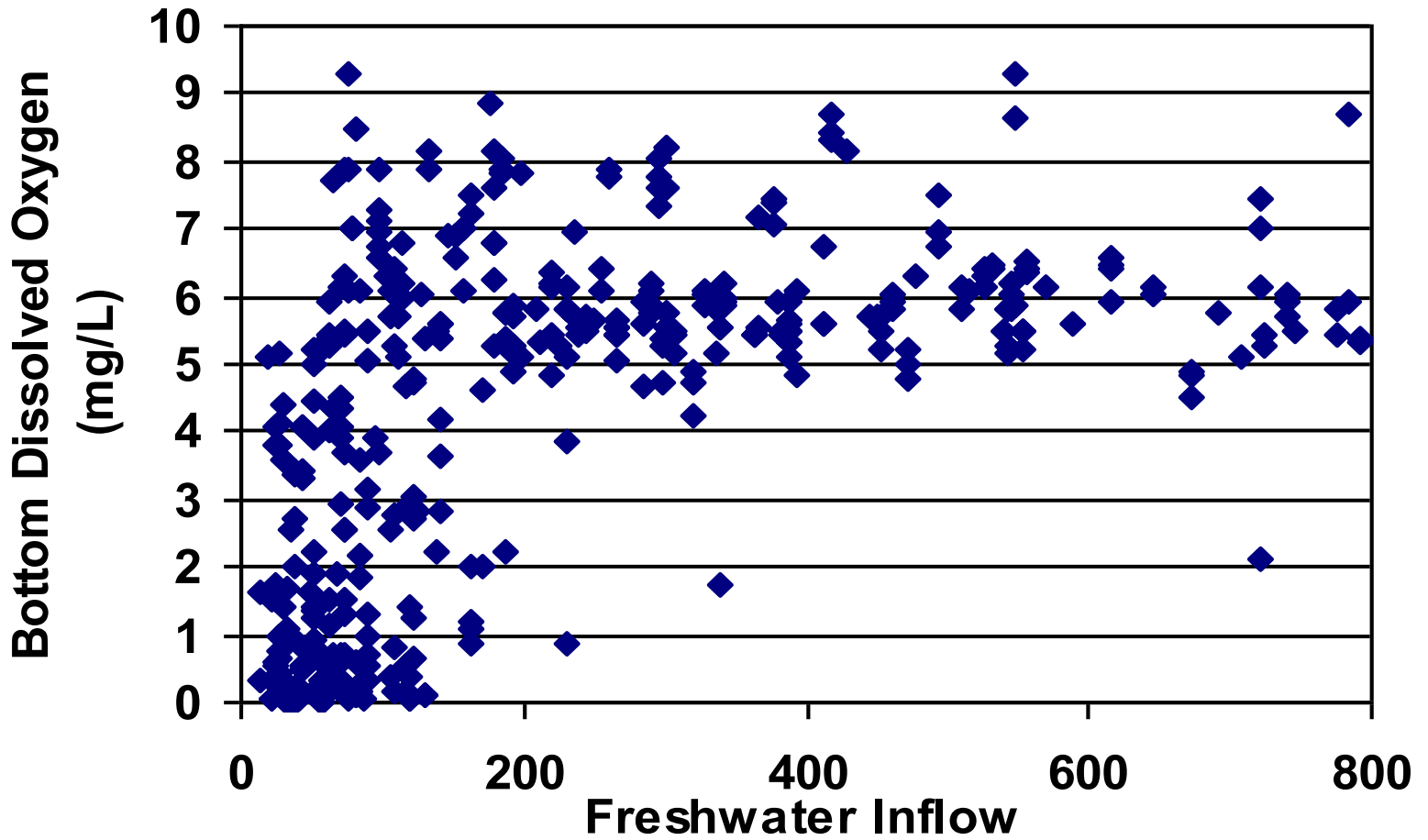


Bottom Area with Salinity < 6 psu vs. Inflow



Π

Bottom Dissolved Oxygen vs Freshwater Inflow Kilometers 12 to 15



Summary

- Florida has many unimpounded rivers with largely intact natural flow regimes
- Withdrawal schedules need to consider seasonal aspects of biological use and the nonlinear response of many variables to low and high flows

Hydrobiological approach to percent-of flow method

- Assess historical changes in river's flow regime (trend analysis of different flow parameters)
- Account for human effects on flows (e.g., withdrawals, agriculture, physical alterations)
- Create baseline flow record - select time period for baseline assessment
- Use various predictive models to reconstruct salinity, water quality, and biological characteristics of the estuary under baseline flows
- Simulate ecological effects of different percent flow reductions from the baseline condition

Estuarine Resources Evaluated

Estuarine Minimum Flows

- Area, volume, and shoreline length of salinity zones for fish, invertebrate and wetlands communities
- Relationships of flow with primary production
- Relationships of flow with water residence time
- Relationships of flow with water quality and dissolved oxygen

Relationships of flow with Fish and invertebrate distribution and abundance

Thermal requirements for manatees