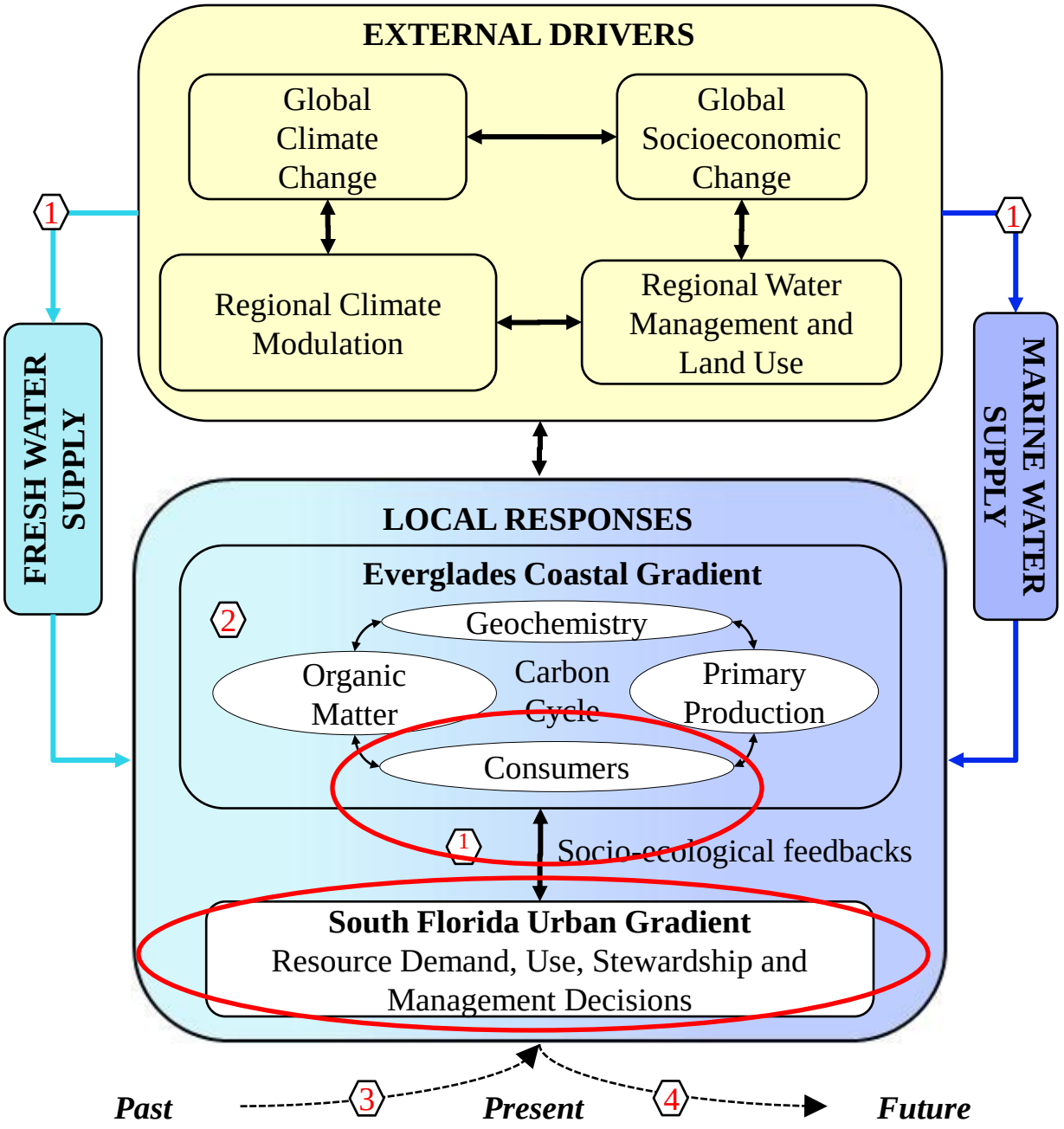
Multi-Scaled Socio-Ecology of the Everglades

FCE III Conceptual Framework



FCE III LTER Goals:

1 ***Water :*** How do water management decisions interact with climate change to determine freshwater distribution?

2 ***Carbon:*** How does the balance of fresh and marine water supplies regulate C uptake, storage, and fluxes by influencing water residence time, nutrient availability, and salinity?

3 ***Legacies:*** How does historic variability in the relative supply of fresh and marine water modify ecosystem sensitivity to further change?

4 ***Scenarios:*** What are alternative socio-ecological futures for South Florida under contrasting climate change and water management scenarios?

Party crashers: displaced marsh consumers regulate a prey subsidy to an estuarine consumer

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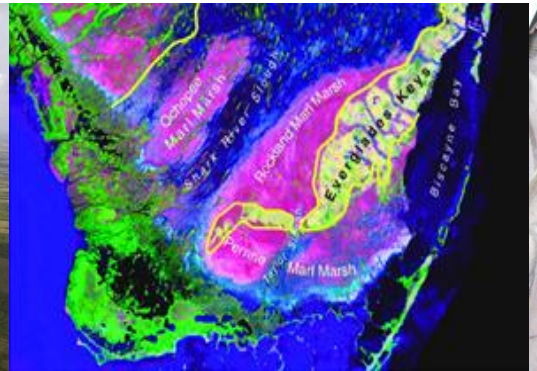
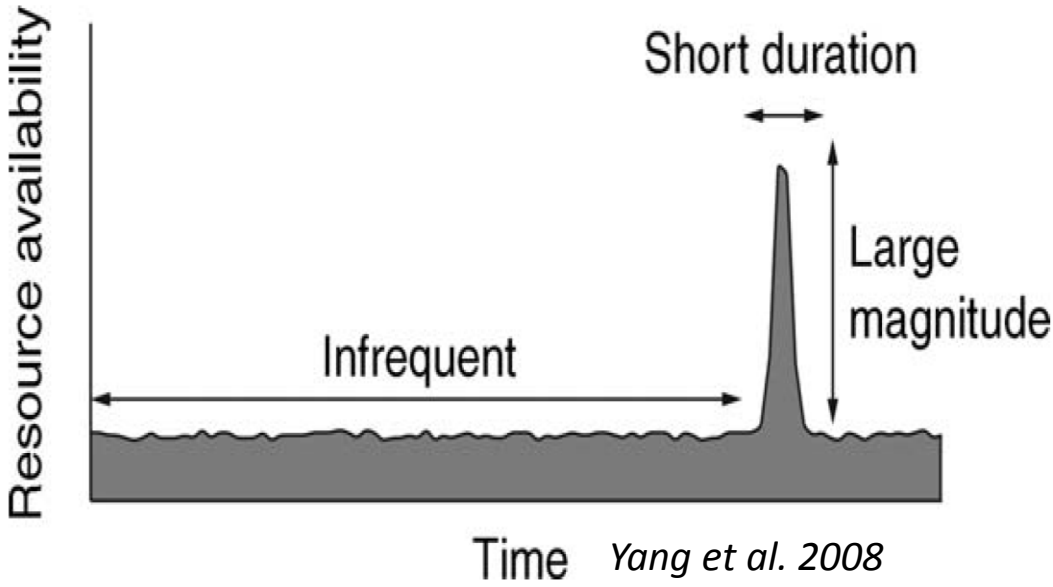


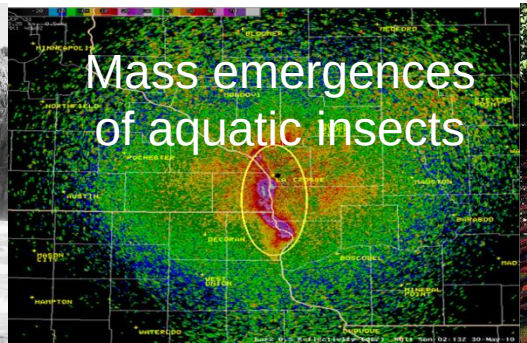

Pulsed resource subsidies

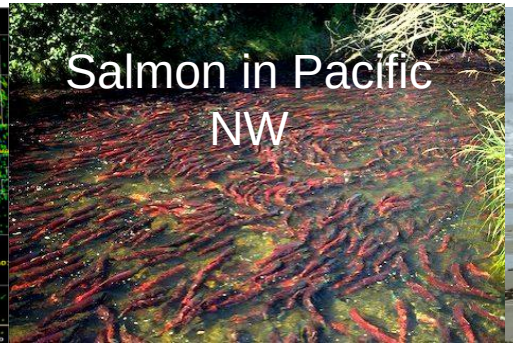
- Resource pulse
  Instantaneous resource increase *(Holt 2008)*

- Subsidy
  Pulses across ecosystem boundaries
  (Anderson et al. 2008)



Yang et al. 2008



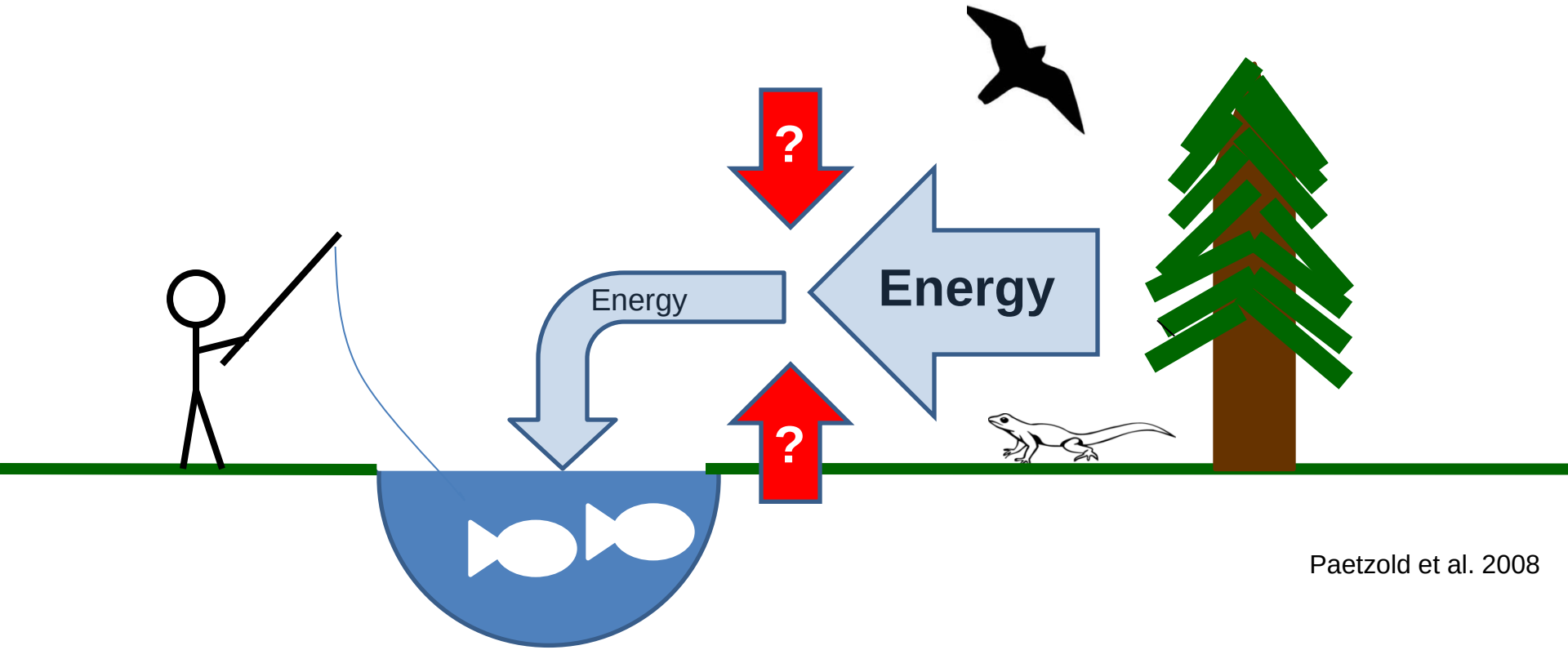


Pulsed resource subsidies

Subsidies can fuel almost all biological activity within recipient ecosystems (Polis et al. 2004; Spiller 2010)

Information gap

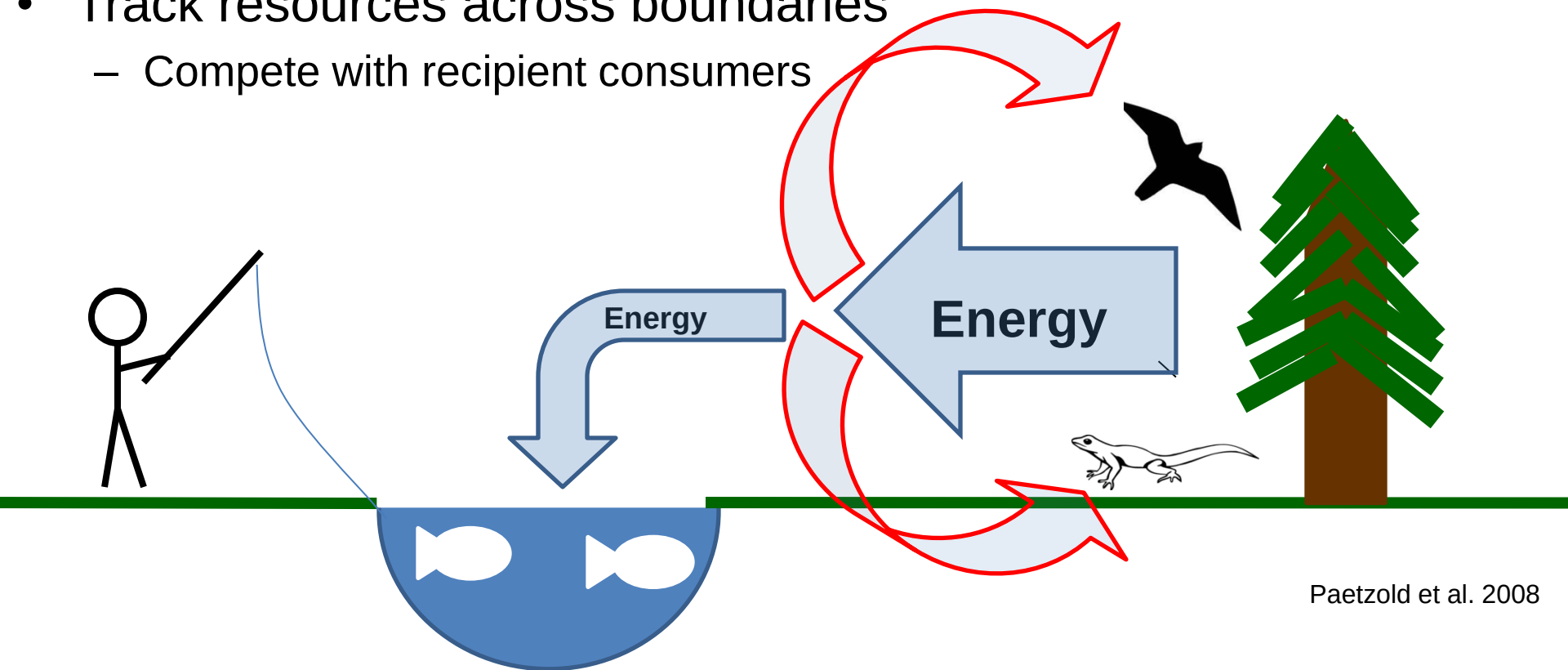
What regulates the flow of resources from one system to another?



Paetzold et al. 2008

Consumers from donor communities important

- Deplete resources locally
  - Nothing to transfer (Epichan et al. 2010)
- Track resources across boundaries
  - Compete with recipient consumers



Paetzold et al. 2008

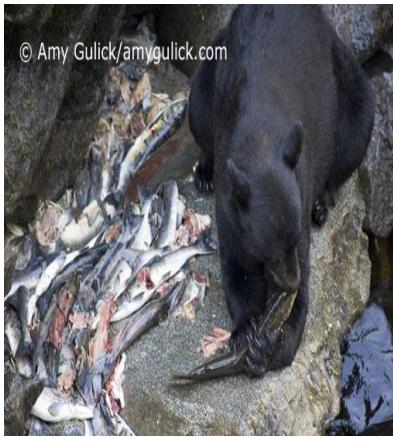
In the Pacific Northwest

Salmon migrate up river to spawn

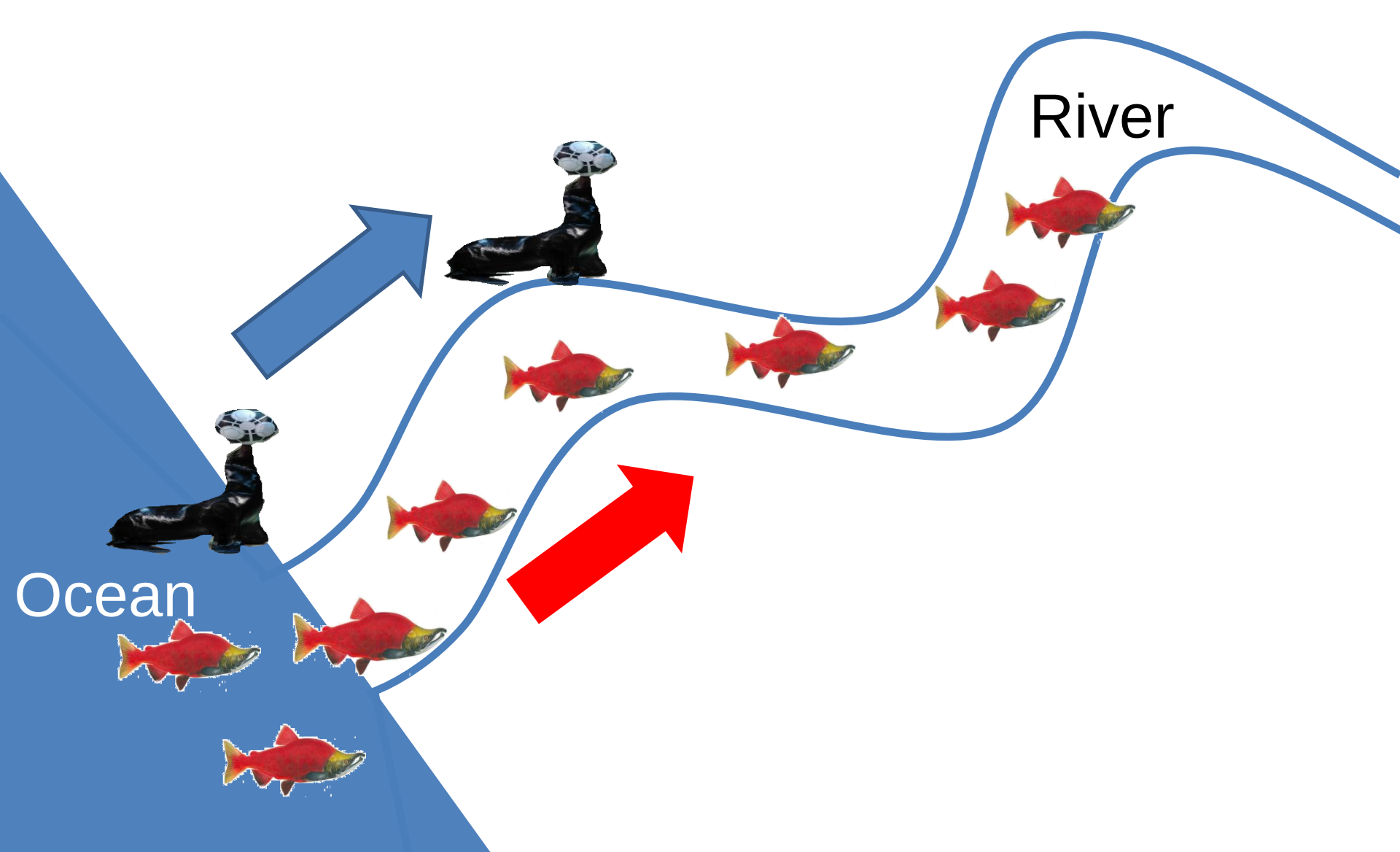
Subsidizing upstream communities

River

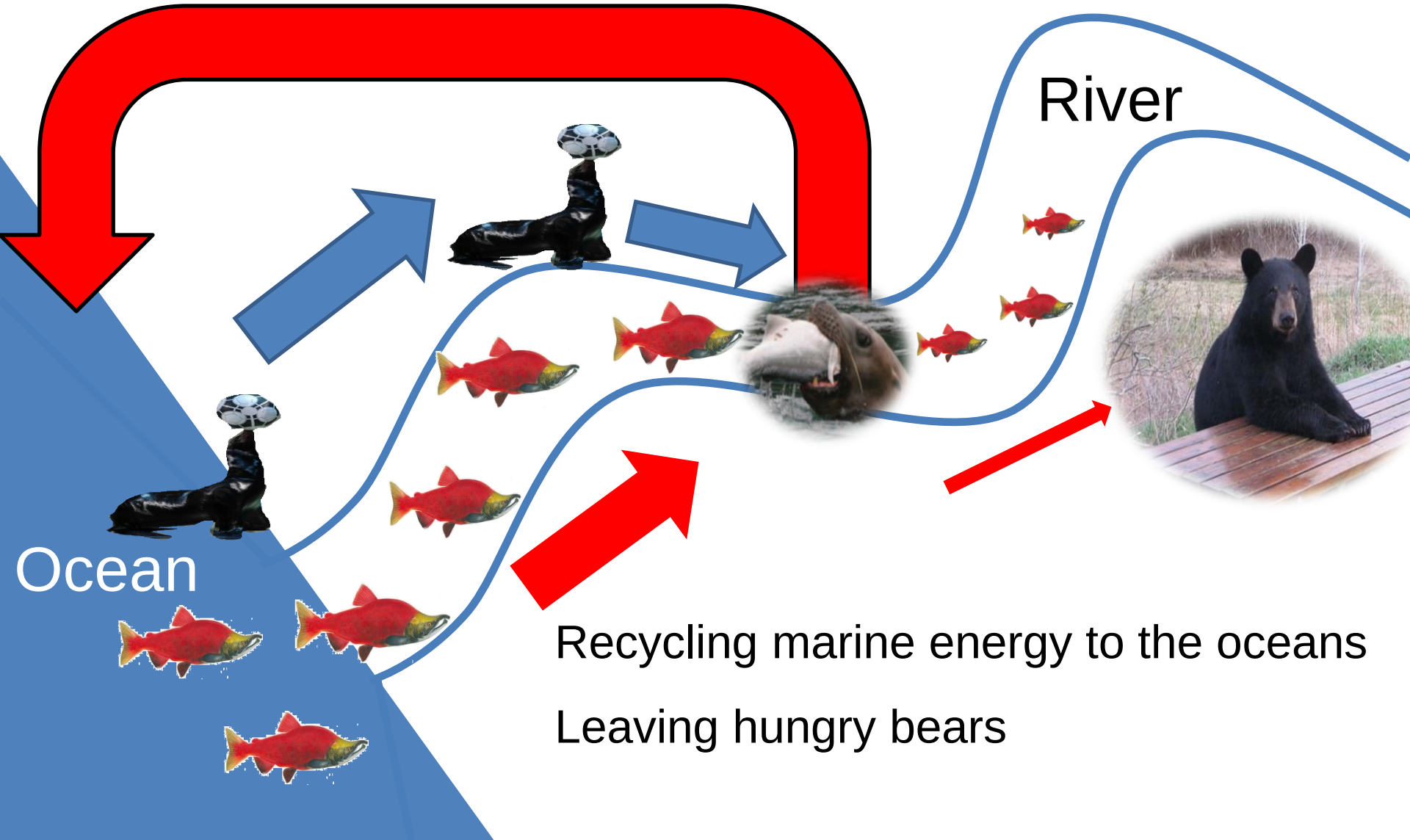
Ocean



Sea lions Track Salmon Up River



Sealions reduce salmon subsidies by 65%



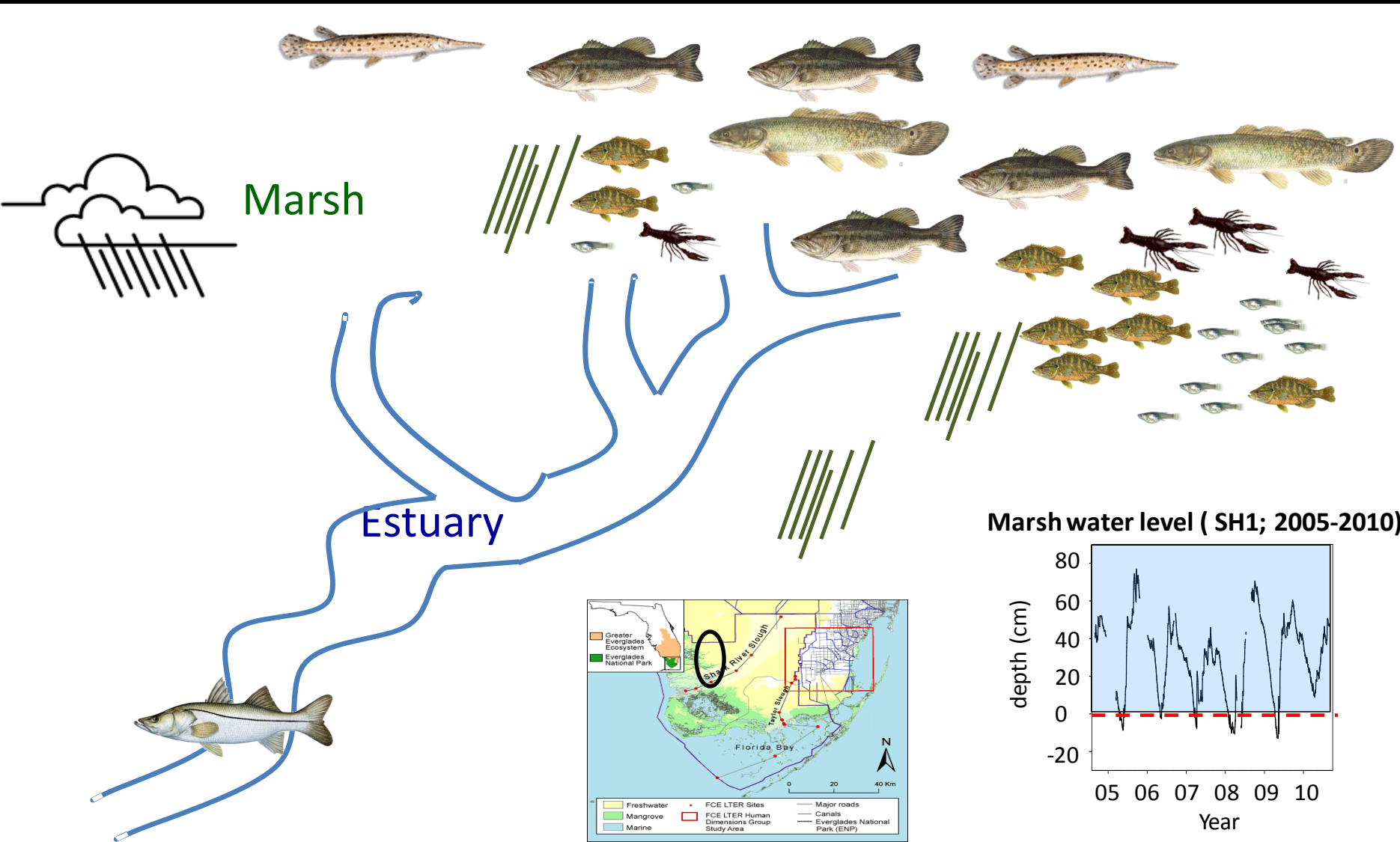
Recycling marine energy to the oceans

Leaving hungry bears

Leading to Aggressive Management

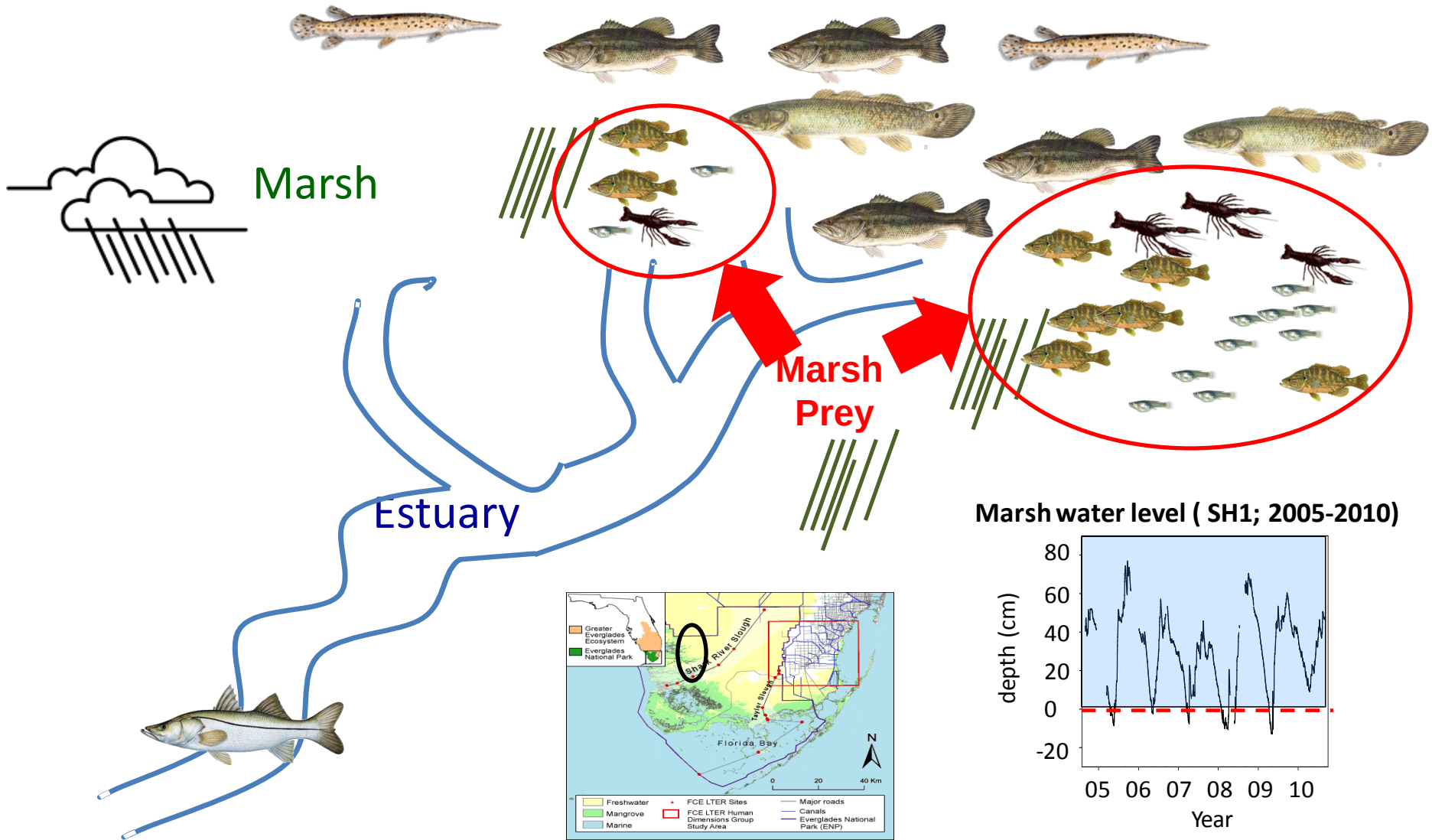
Naughton et. al. 2011

Everglades Ecotone: Wet season

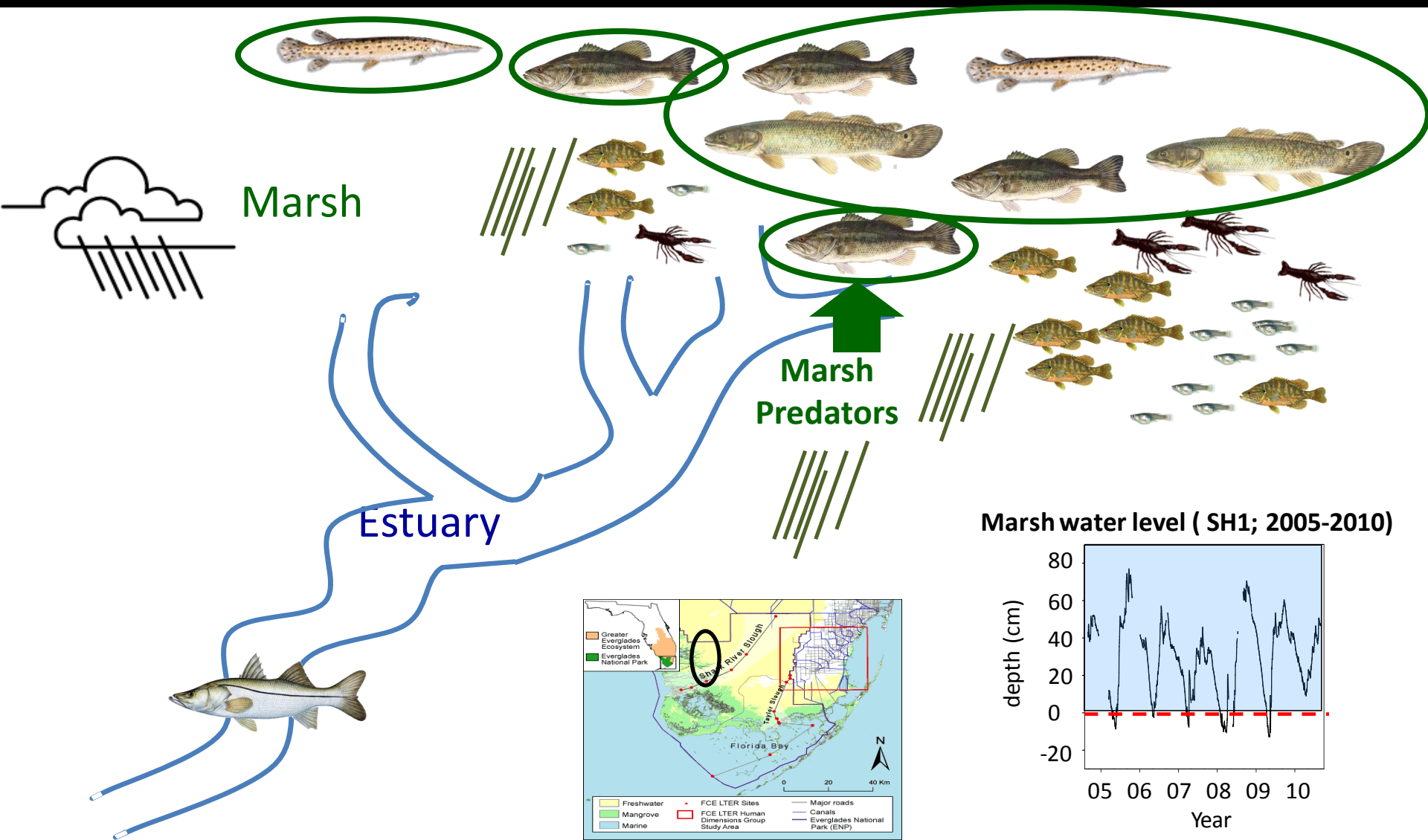


Marsh water level (SH1; 2005-2010)

Everglades Ecotone: Wet season

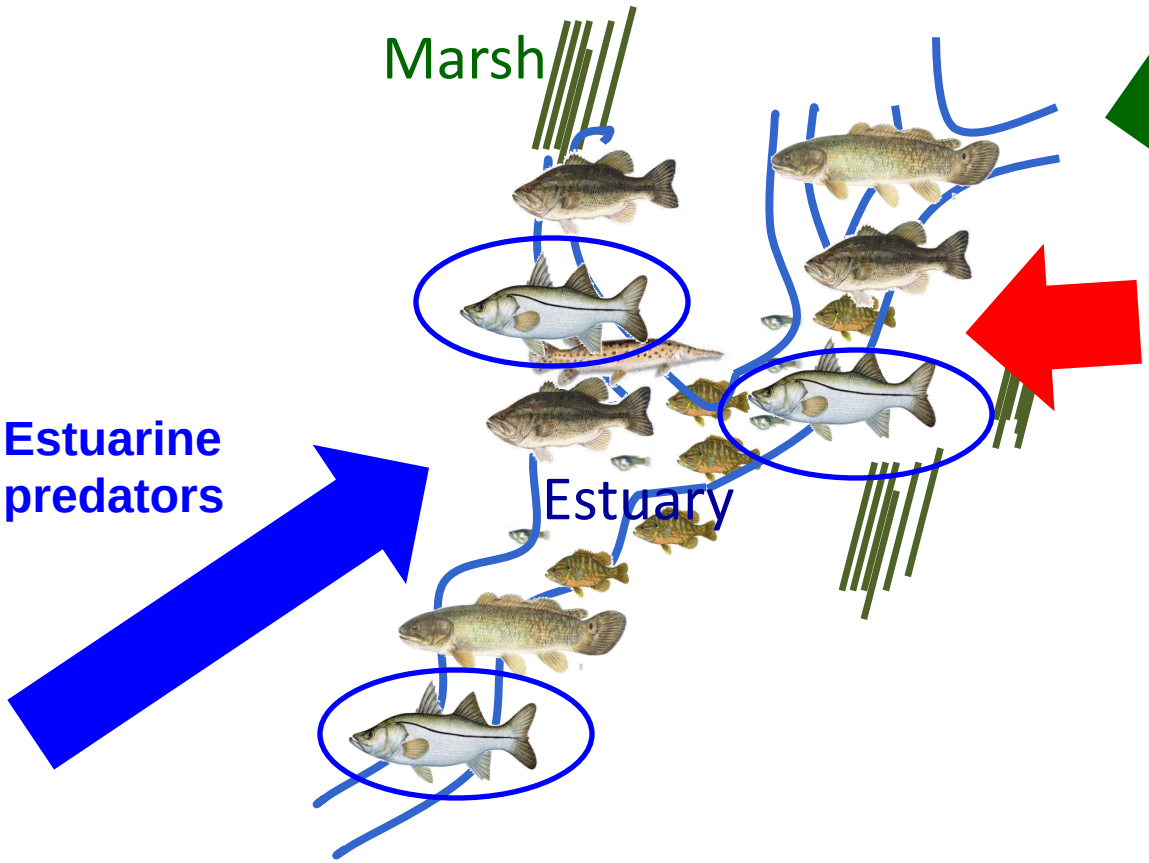


Everglades Ecotone: Wet season



Marsh water level (SH1; 2005-2010)

Everglades Ecotone: Dry Season

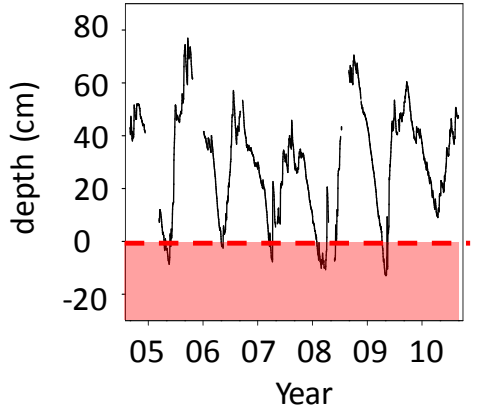


Marsh Predators

Marsh Prey

Estuarine predators

Marsh water level (SH1; 2005-2010)



Research questions

(1) Does marsh drying push freshwater prey into the estuary?

(2) How do consumers respond to the pulse?

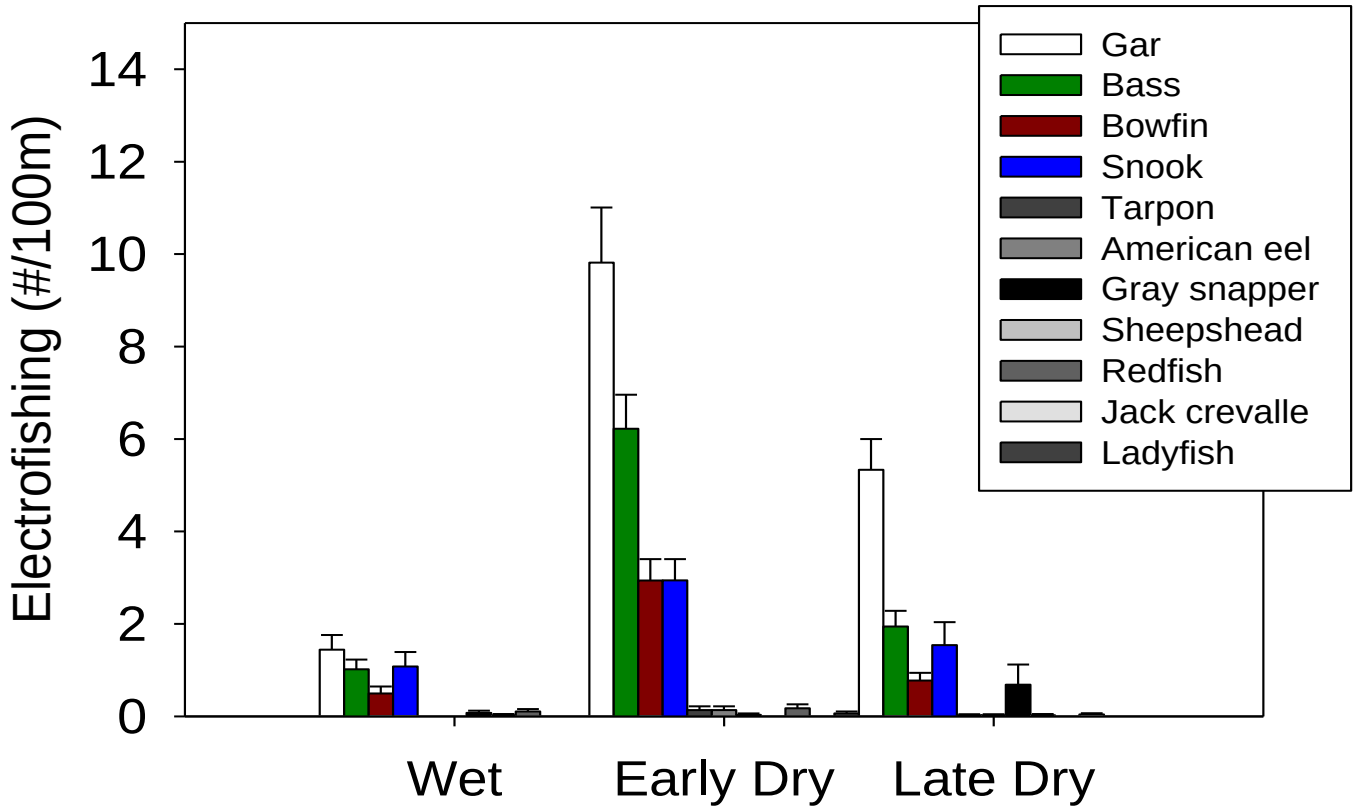
(3) Are freshwater consumers reducing marsh subsidies for estuarine consumers?

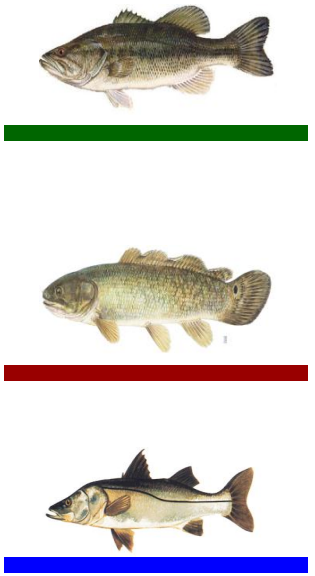



Focal taxa: 2 freshwater + 1 estuarine consumer

Gar, bass, bowfin and snook dominate

Consumers show marked seasonality



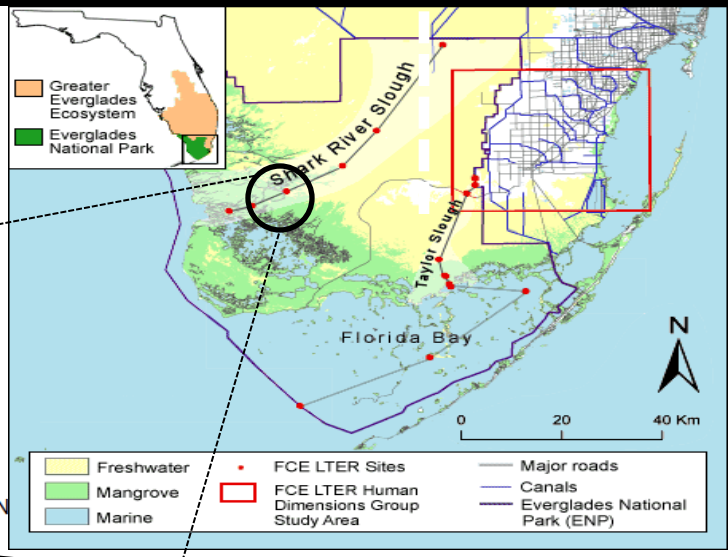


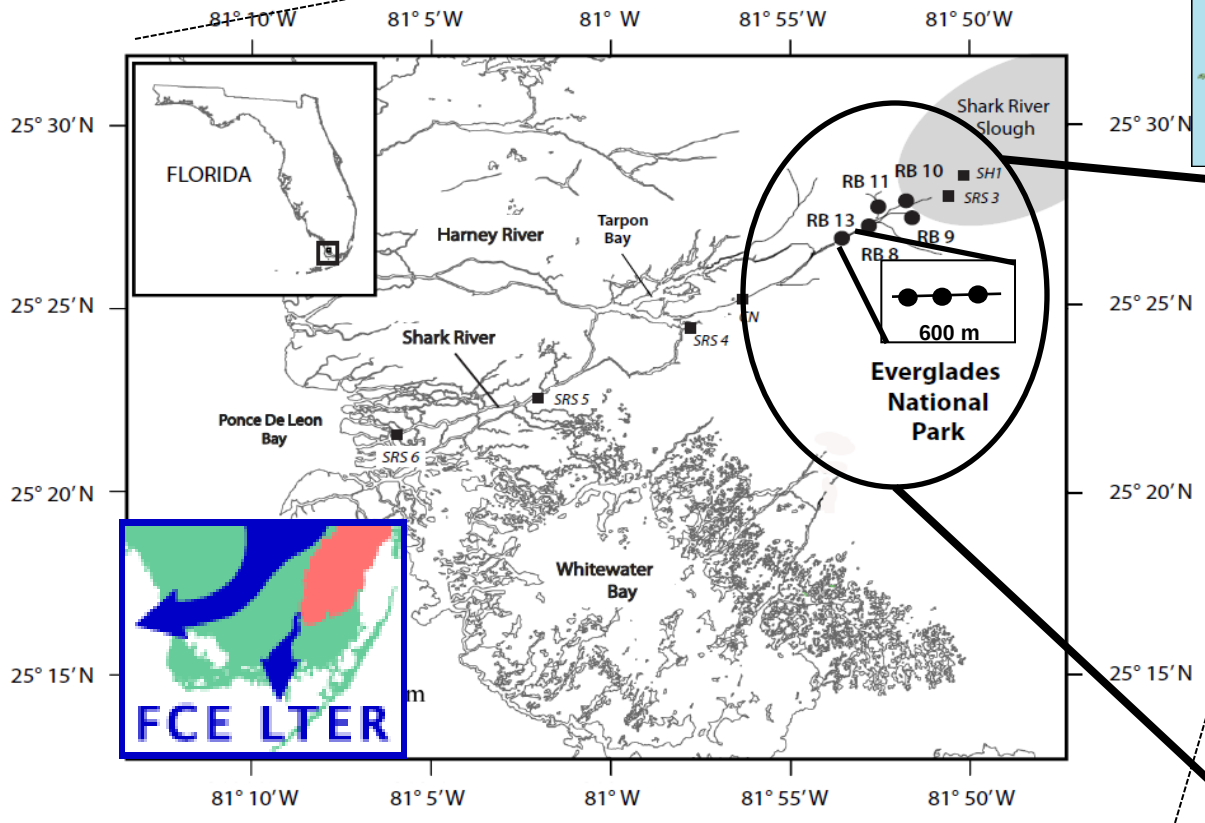
Study system: ecotonal sites at ENP

First and second order oligohaline estuarine creeks

< 1.2 m depth

< 10 PSU salinity





Hypotheses

During drydown		Post drydown	
Prey abundance	↑	Prey abundance	↓
Predator abundance	↑	Predator abundance	↓
Marsh prey consumption	↑	Marsh prey consumption	↓
Diet segregation	↑	Diet segregation	↓
Predator condition	↑	Predator condition	↓

Tracking predator-prey abundance

Data collection

- Continuously sampled 5 sites
- Nov 2010 to June 2011
- Electrofishing
- Minnow traps

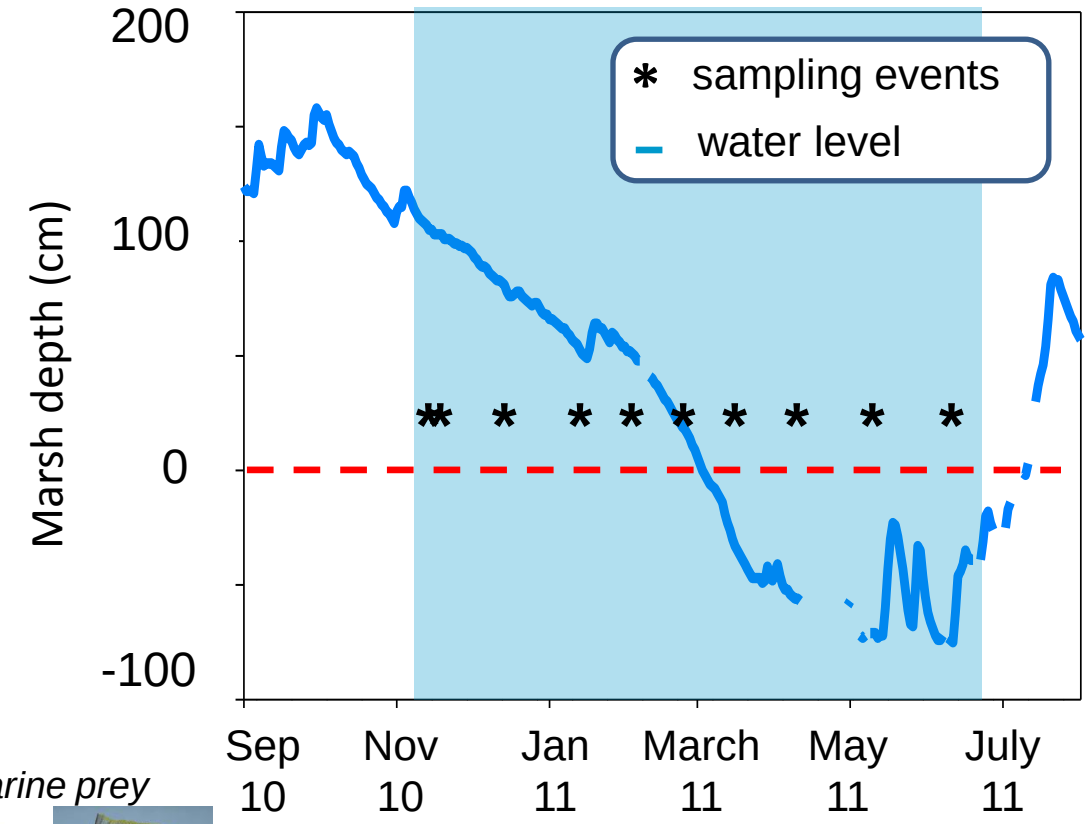
Statistics

Compared time & species using GLMs

- Predator abundance
- Prey abundance

4 functional groups

Sunfishes Cyprinodontoids Invertebrates Estuarine prey



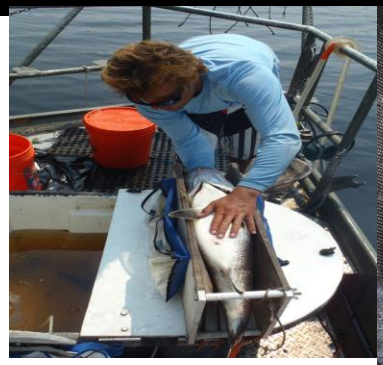
USGS station SH1

Stomach contents

Data Collection

Pulsed gastric lavage

100% effective in bass & snook
(Adams et al. 2009 Hartleb & Moring 1995)



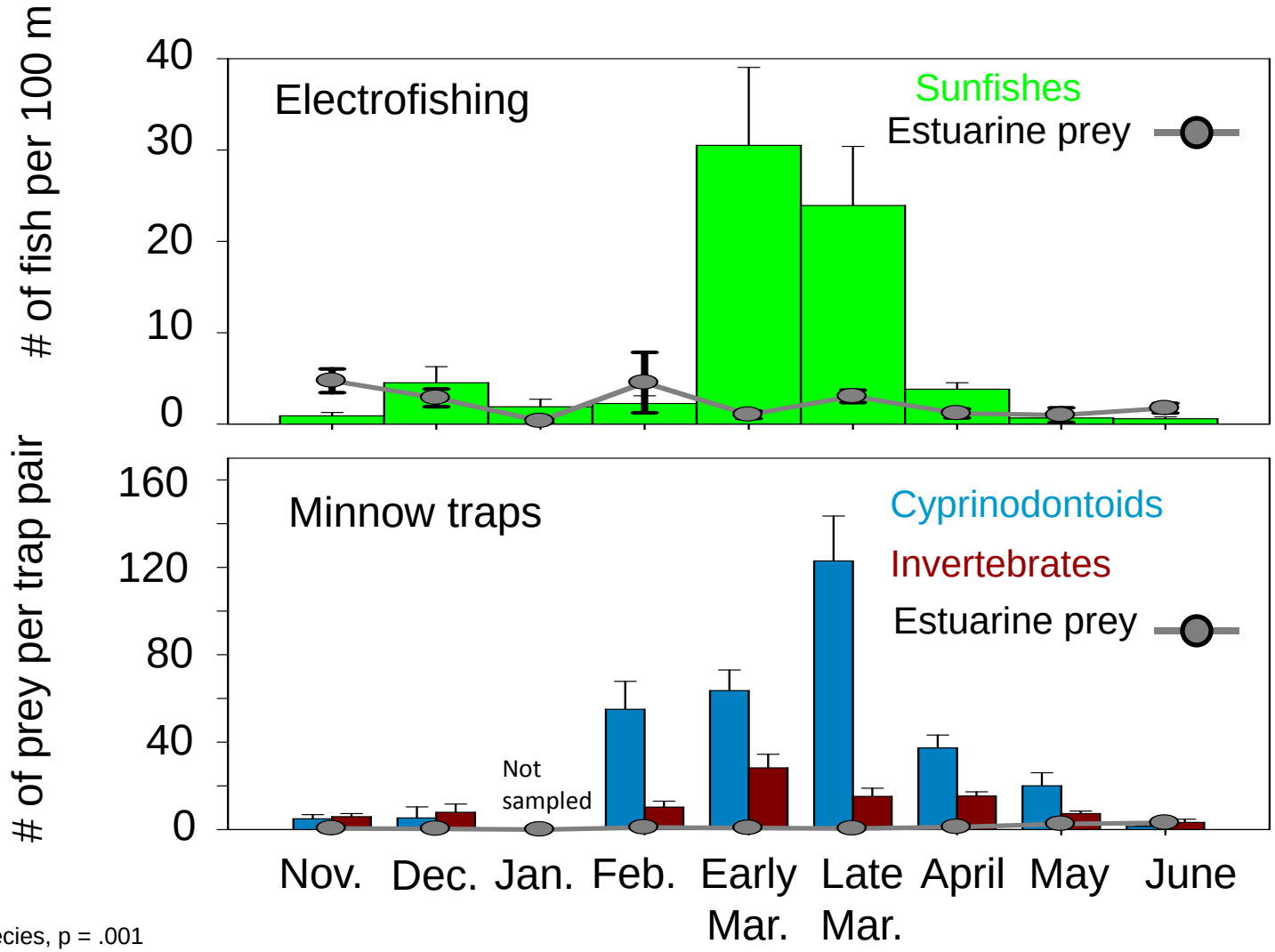
Statistics

Compared effects of time & species using Scheirer-Ray-Hare test (Dytham 1999)

- Time partitioned into 4 hydrologic stages
- biomass of freshwater and estuarine prey consumed
- Numerical proportions of each prey functional group

	Bass	Bowfin	Snook
stomachs sampled	**247**	**159**	**99**

Prey | Predators | Diet | Fitness gains



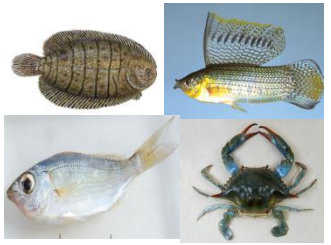
Species, p = .001
Time, p = .001
Species x time, p =.001

Sunfishes

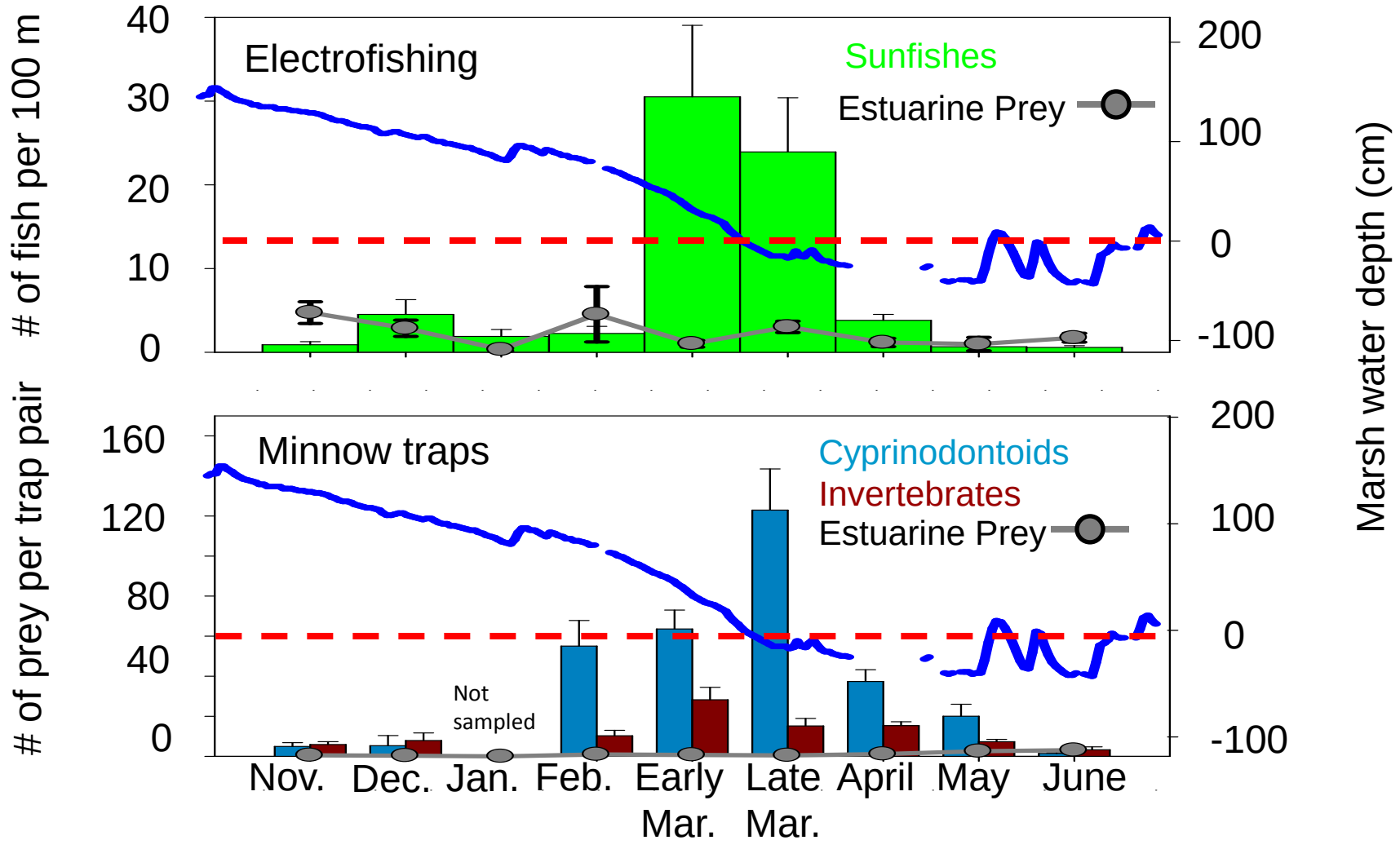
Cyprinodontoids

Invertebrates

Estuarine Prey

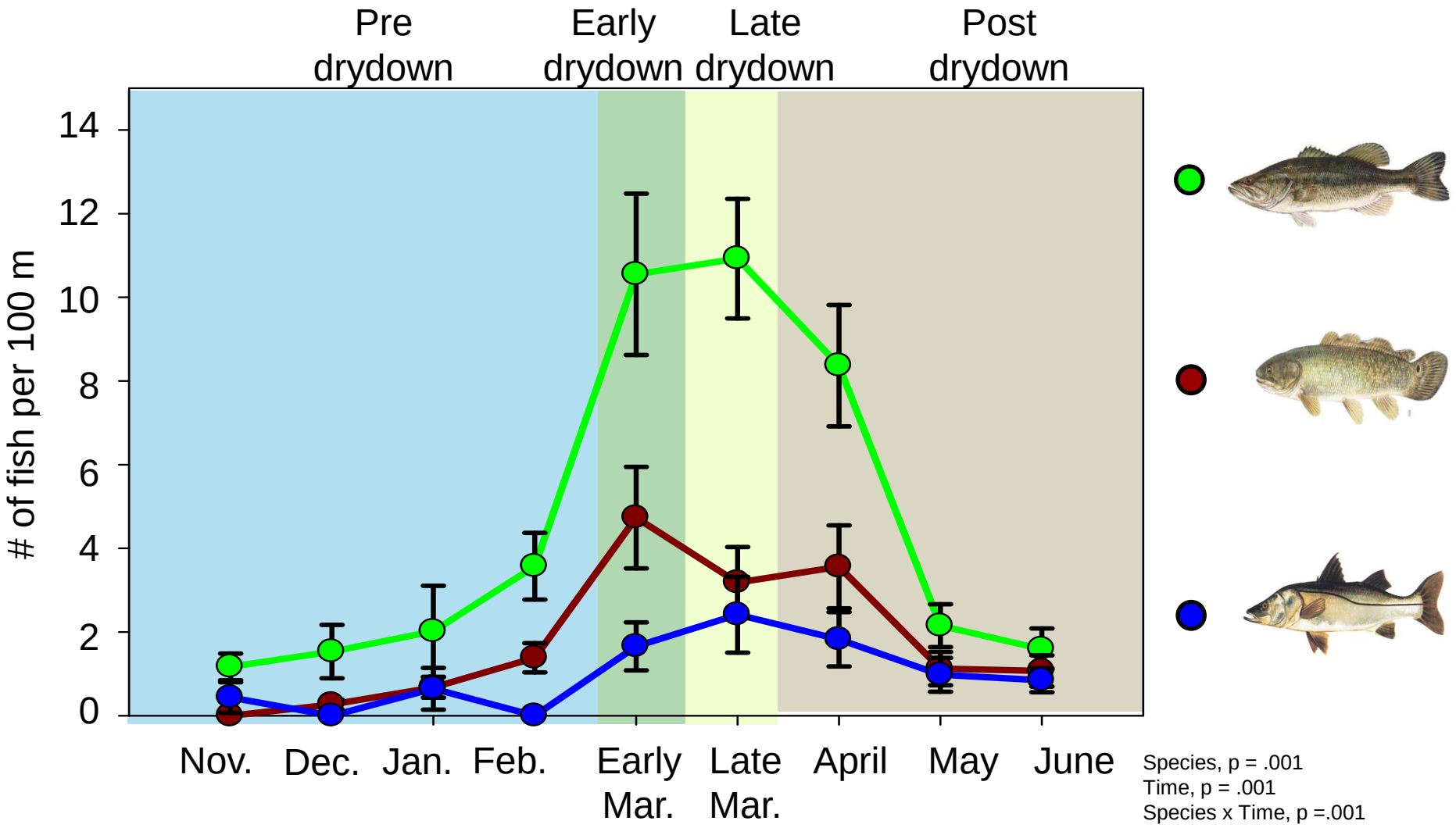


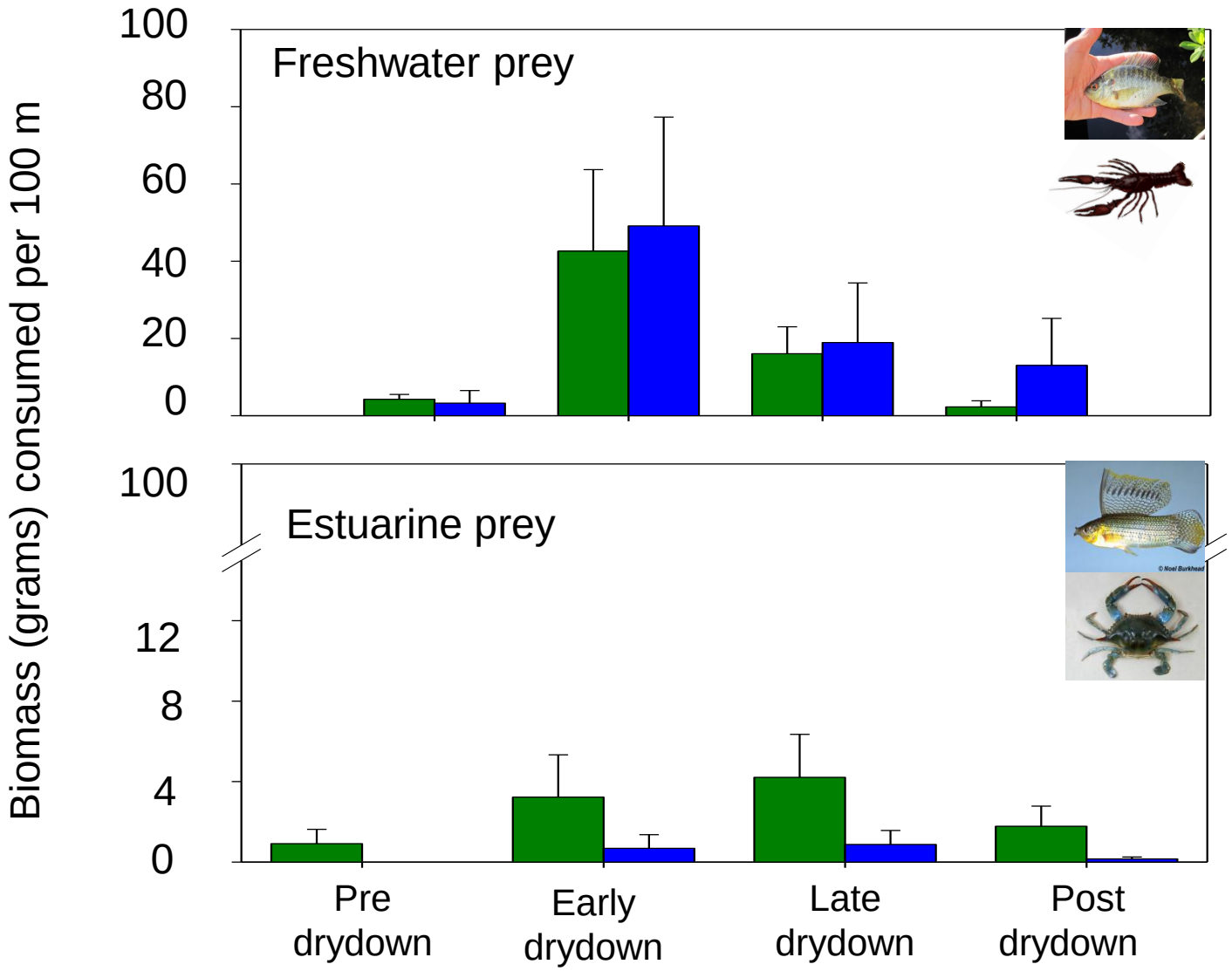
Prey | Predators | Diet | Fitness gains



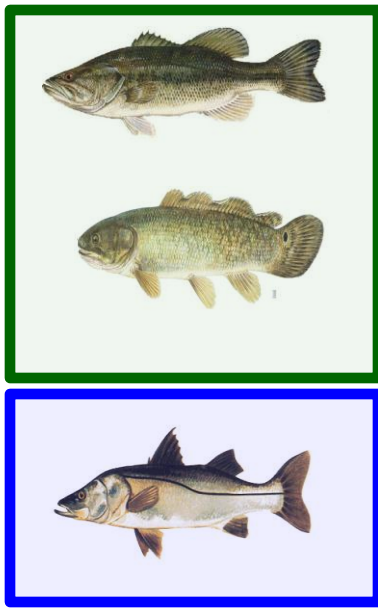
USGS station SH1

Species, p = .001
Time, p = .001
Species x Time, p =.001

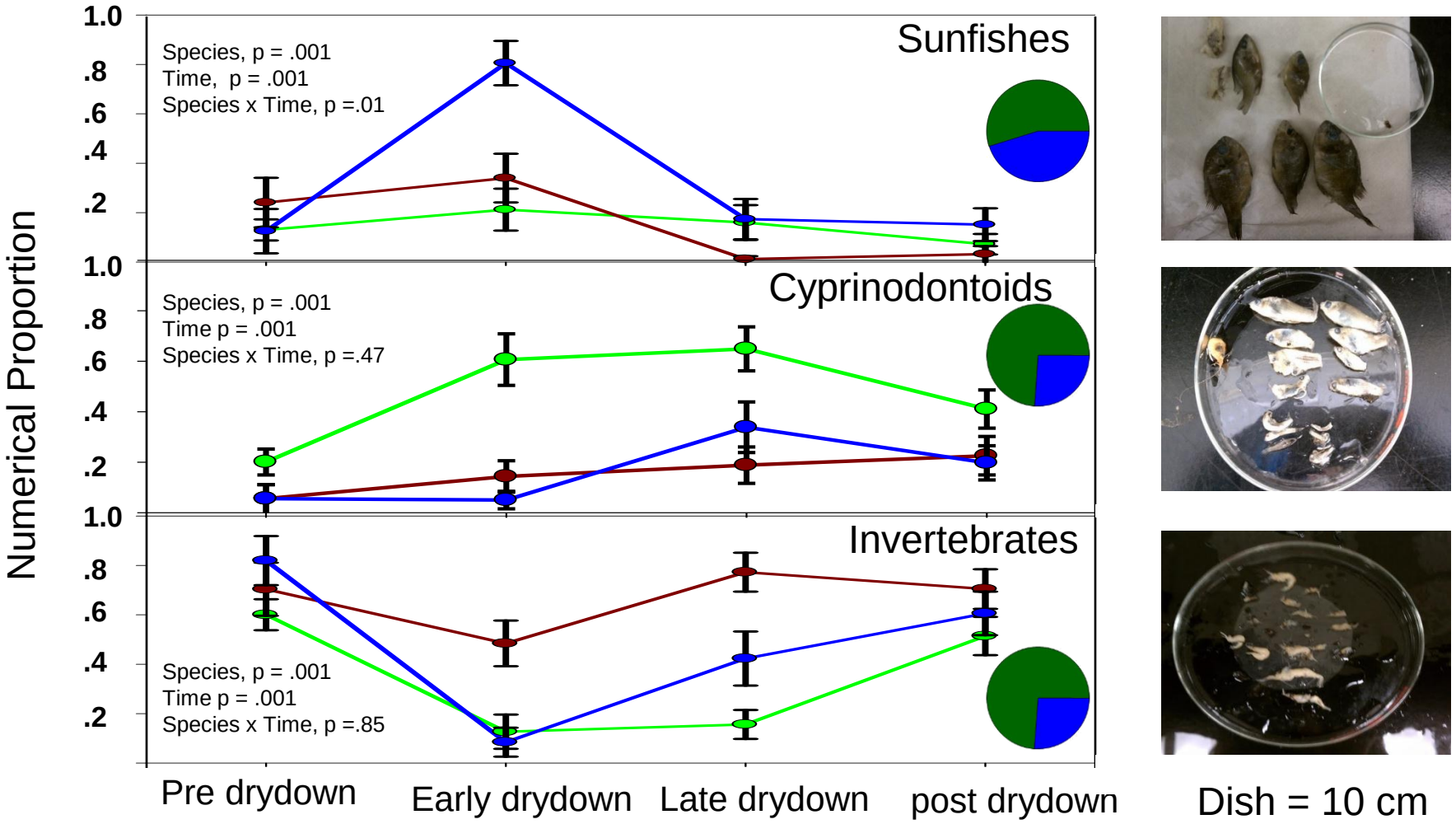

Pre drydown
Early drydown
Late drydown
Post drydown
# of fish per 100 m
0
2
4
6
8
10
12
14
Nov.
Dec.
Jan.
Feb.
Early Mar.
Late Mar.
April
May
June
Species, p = .001
Time, p = .001
Species x Time, p =.001



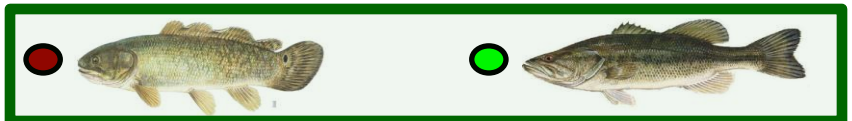
Species, p < .001
Time, p < .001
Species x Time, p =.568

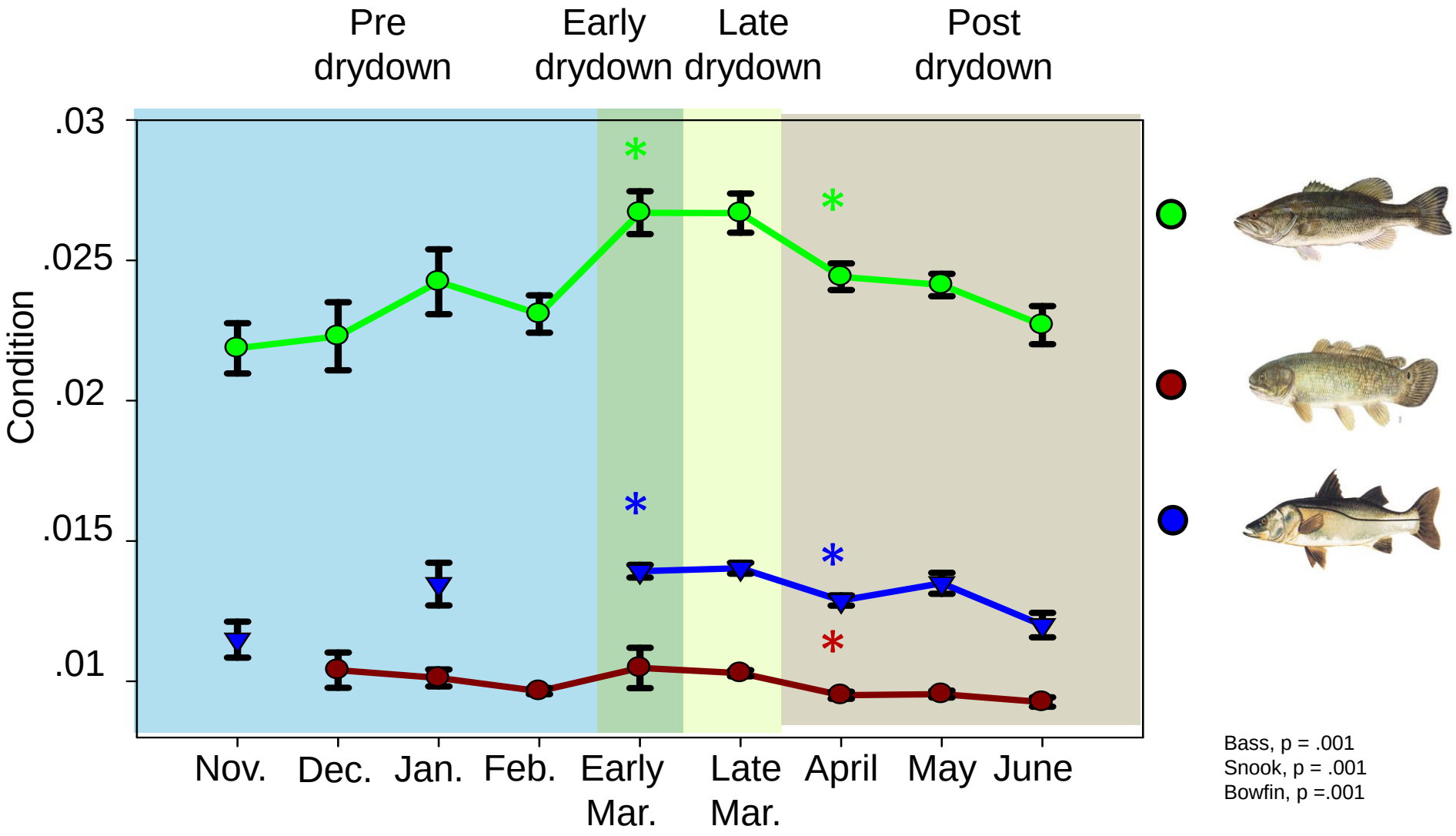


Species, p < .001
Time, p = .2915
Species x Time, p =.965


Numerical Proportion
1.0
.8
.6
.4
.2
Sunfishes
Species, p = .001
Time, p = .001
Species x Time, p =.01
Cyprinodontoids
Species, p = .001
Time p = .001
Species x Time, p =.47
Invertebrates
Species, p = .001
Time p = .001
Species x Time, p =.85
Pre drydown
Early drydown
Late drydown
post drydown

Dish = 10 cm





Bass, p = .001
Snook, p = .001
Bowfin, p =.001

Summary of results

During drydown

Prey abundance ↑ YES

Predator abundance ↑

Marsh prey consumption ↑

Diet segregation ↑

Predator condition ↑

Post drydown

Prey abundance ↓ YES

Predator abundance ↓

Marsh prey consumption ↓

Diet segregation ↓

Predator condition ↓

Summary of results

During drydown

Prey abundance ↑ YES

Predator abundance ↑ YES

Marsh prey consumption ↑

Diet segregation ↑

Predator condition ↑

Post drydown

Prey abundance ↓ YES

Predator abundance ↓ YES

Marsh prey consumption ↓

Diet segregation ↓

Predator condition ↓

Summary of results

During drydown

Prey abundance ↑ YES

Predator abundance ↑ YES

Marsh prey consumption ↑ YES

Diet segregation ↑

Predator condition ↑

Post drydown

Prey abundance ↓ YES

Predator abundance ↓ YES

Marsh prey consumption ↓ YES

Diet segregation ↓

Predator condition ↓

Summary of results

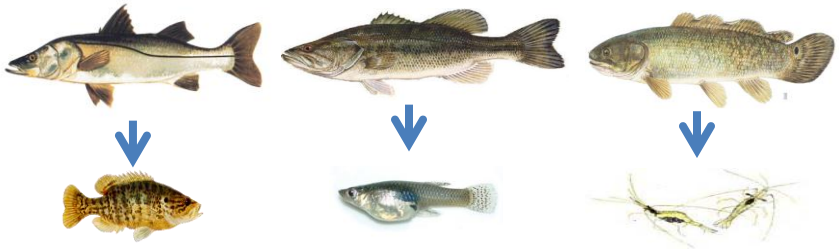
During Drydown

Prey Abundance ↑ YES

Predator Abundance ↑ YES

Marsh prey consumption ↑ YES

Diet Segregation ↑ YES



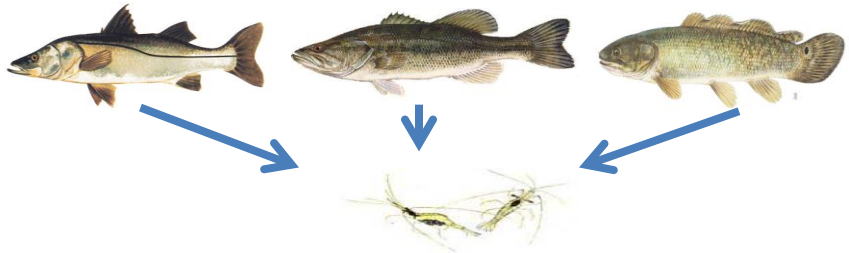
Post Drydown

Prey Abundance ↓ YES

Predator Abundance ↓ YES

Marsh prey consumption ↓ YES

Diet Segregation ↓ YES

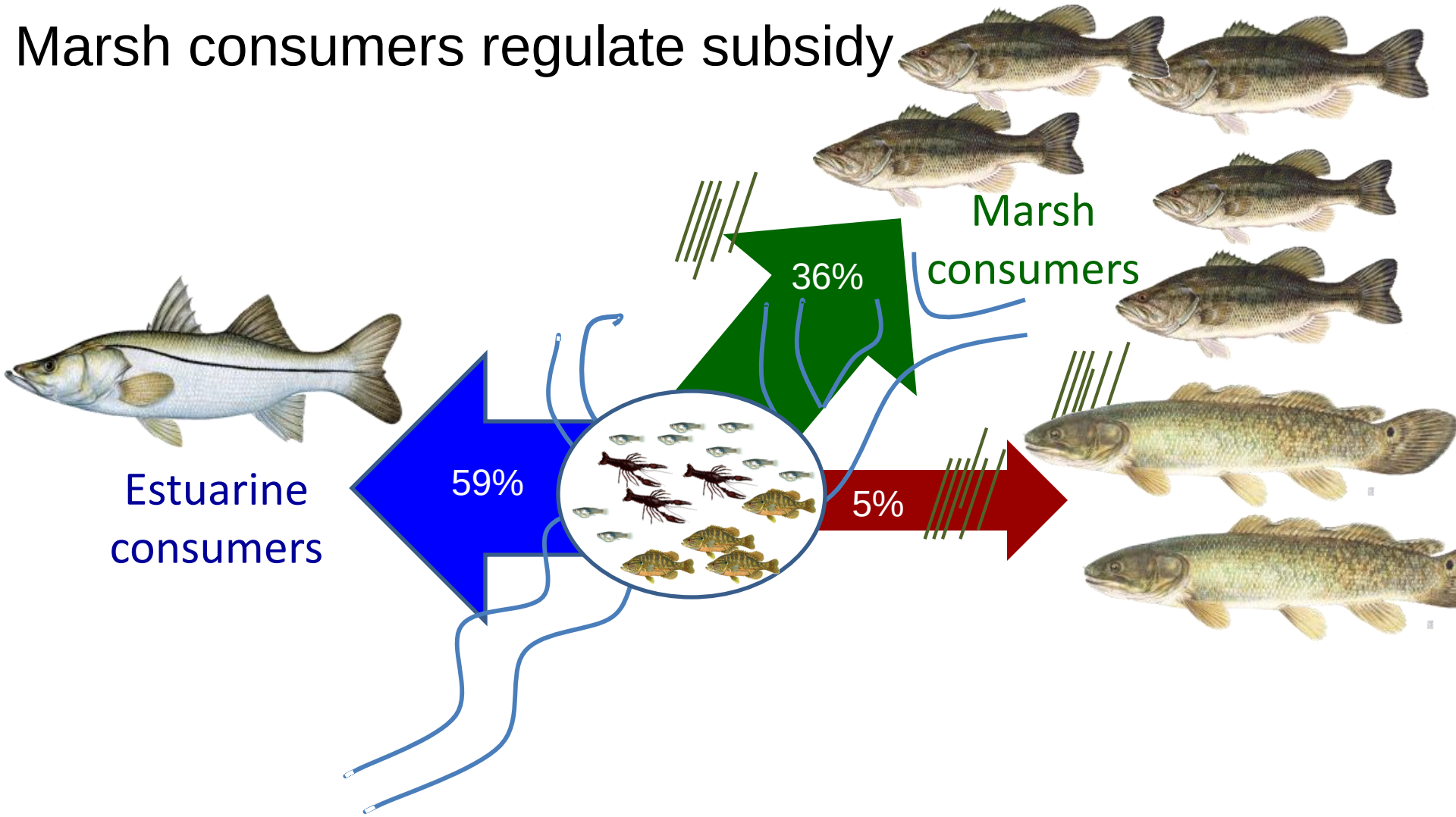


Summary of results

During drydown		Post drydown	
Prey abundance	YES	Prey abundance	YES
Predator abundance	YES	Predator abundance	YES
Marsh prey consumption	YES	Marsh prey consumption	YES
Diet segregation	YES	Diet segregation	YES
Predator condition	YES	Predator condition	YES

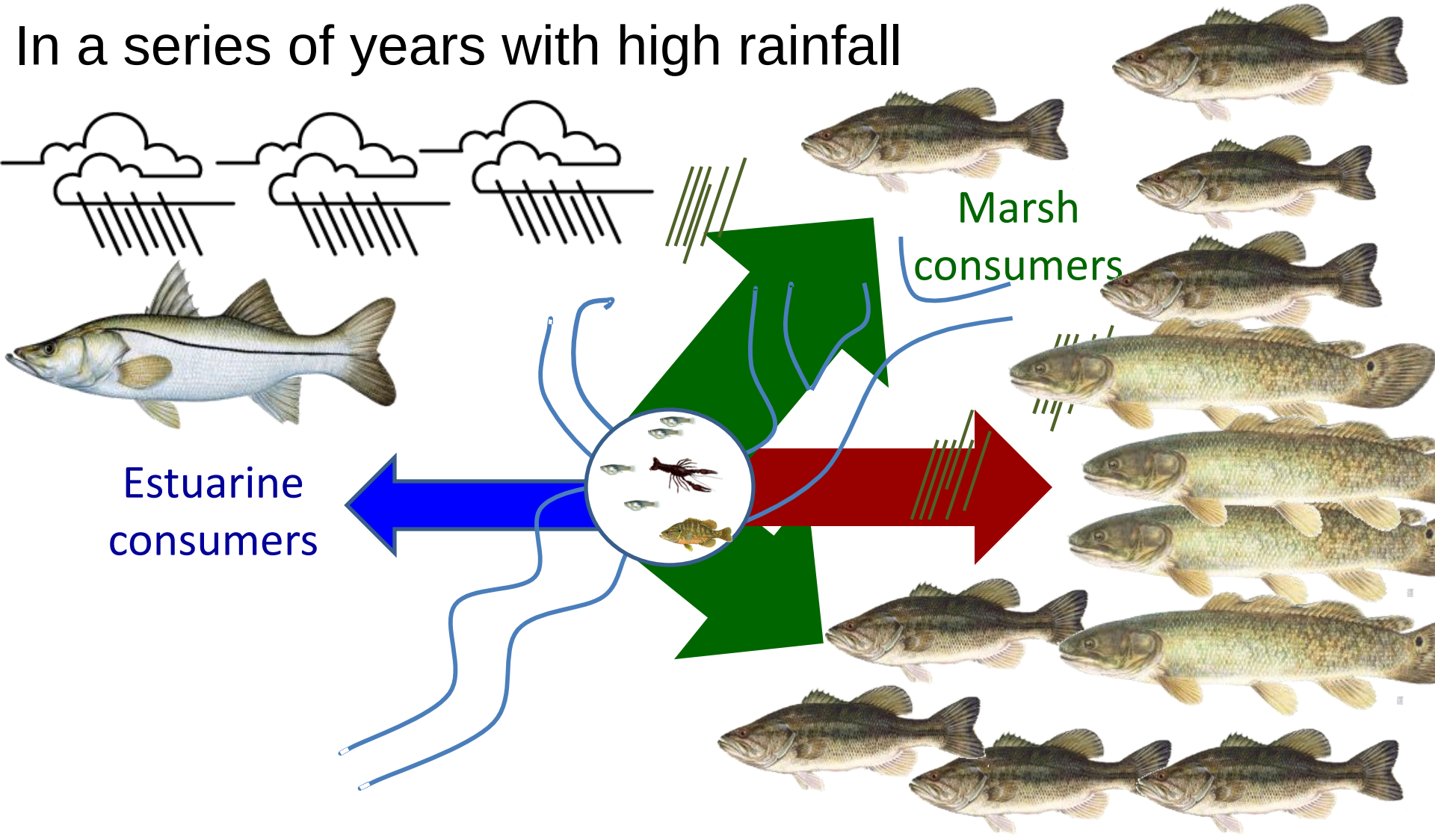
Implications

Marsh consumers regulate subsidy



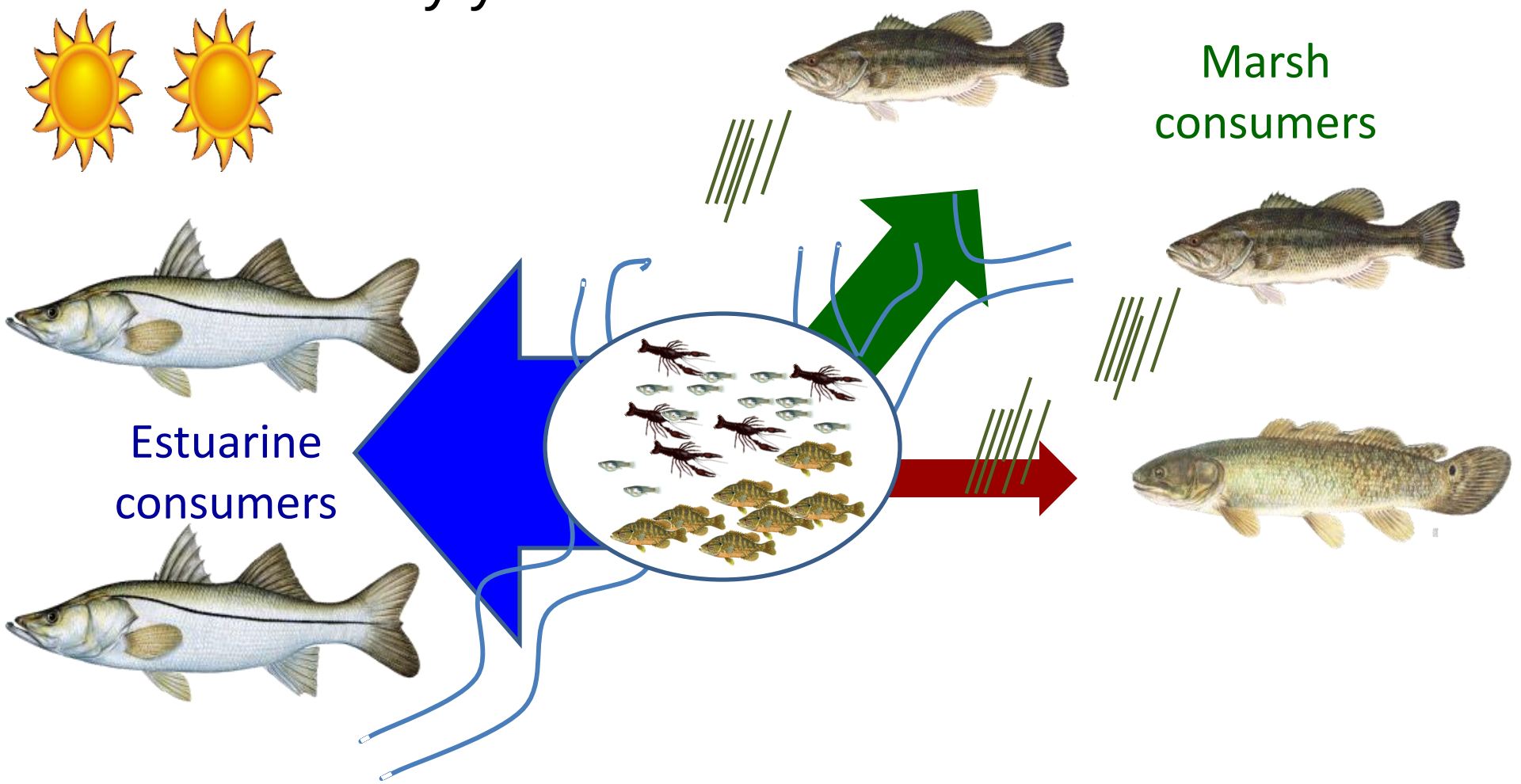
Implications

In a series of years with high rainfall

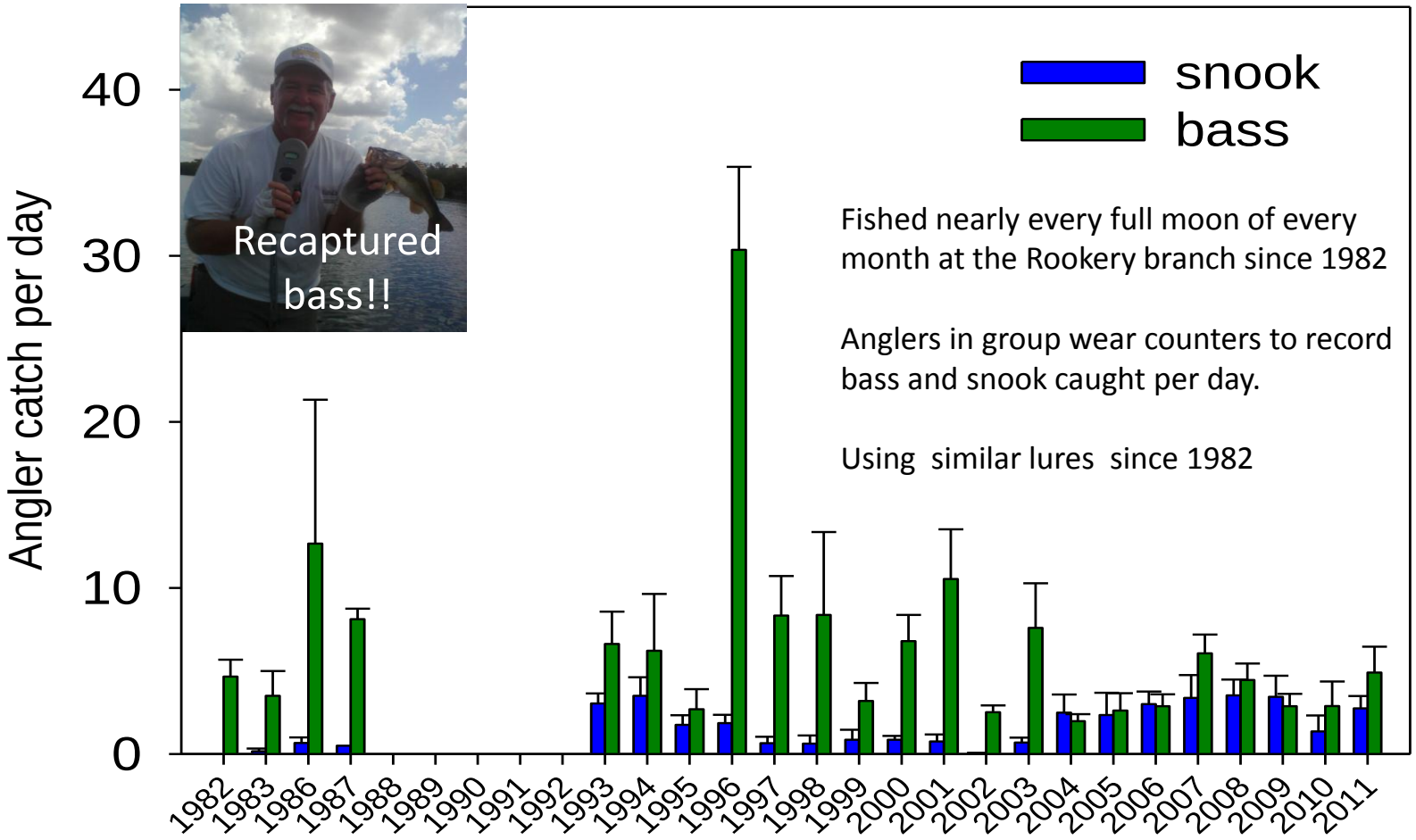


Implications

In a series of dry years



Implications: Angler catches, Feb-June

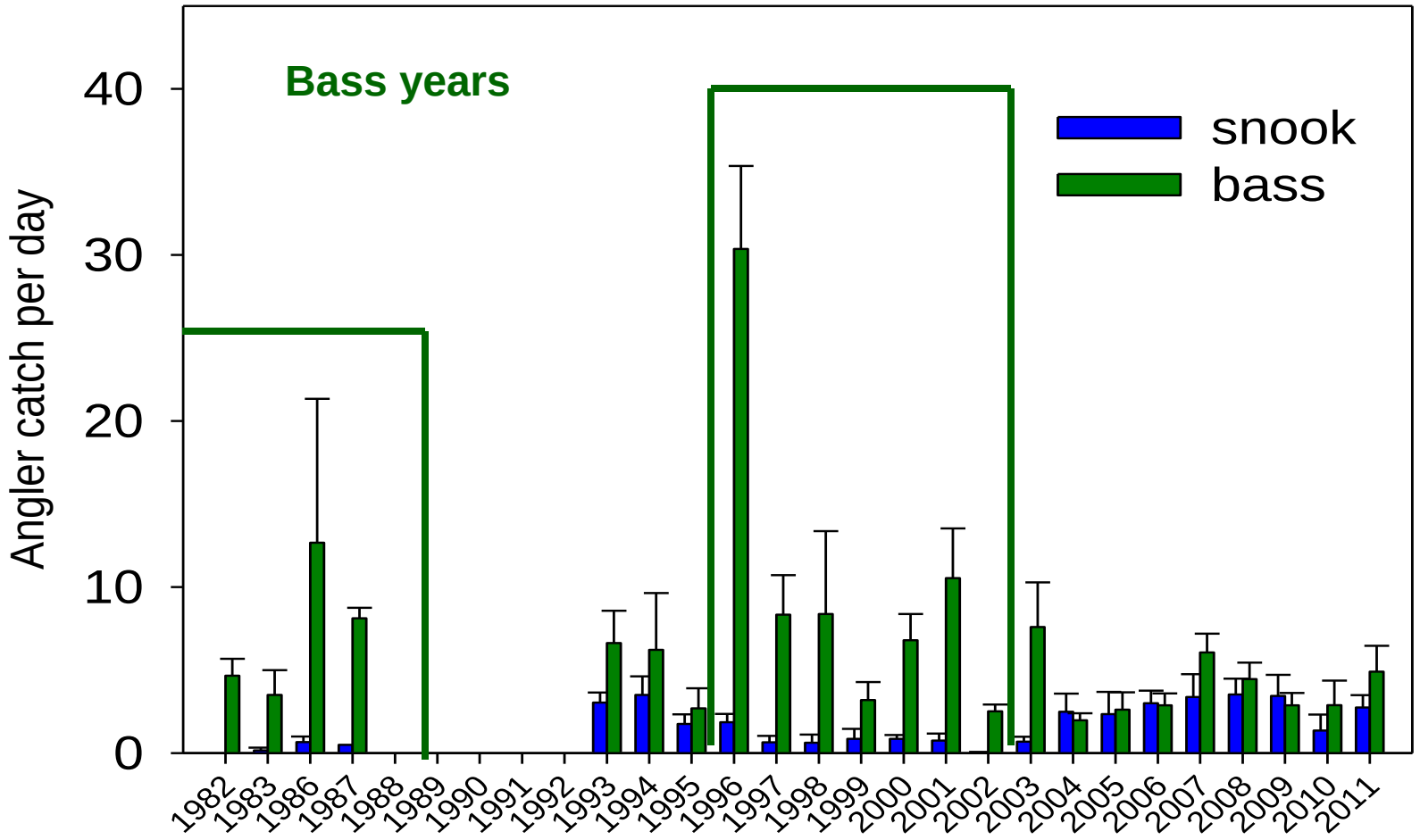


Fished nearly every full moon of every month at the Rookery branch since 1982

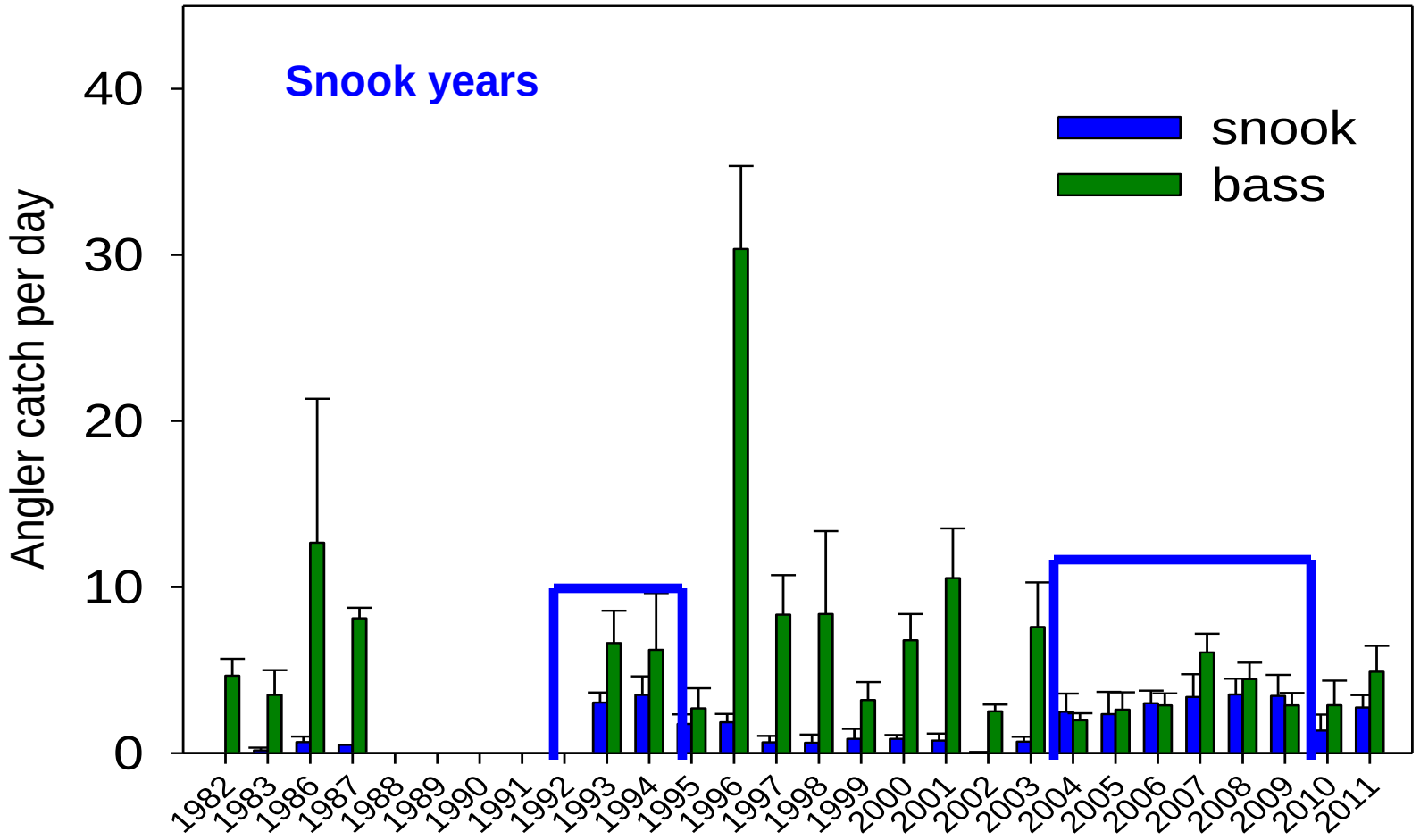
Anglers in group wear counters to record bass and snook caught per day.

Using similar lures since 1982

Implications: Angler catches Feb-June



Implications: Angler catches, Feb - June



Everglades: World Class Snook Fishery

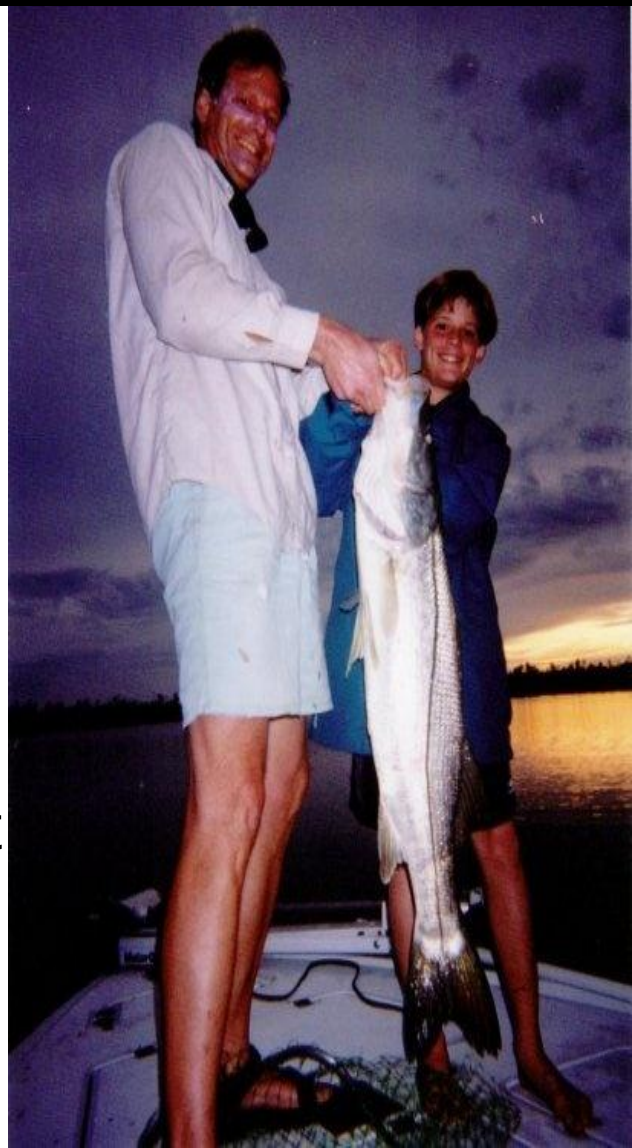
Snook fishery maybe enhanced by subsidies

≈18,246 of anglers target snook at ENP /yr
(Osborne 2006)

Generating 4 million dollars per year

(Fedler 2009 & Ault et al. 2010)

Understanding and conserving snook
High quality foraging opportunities important

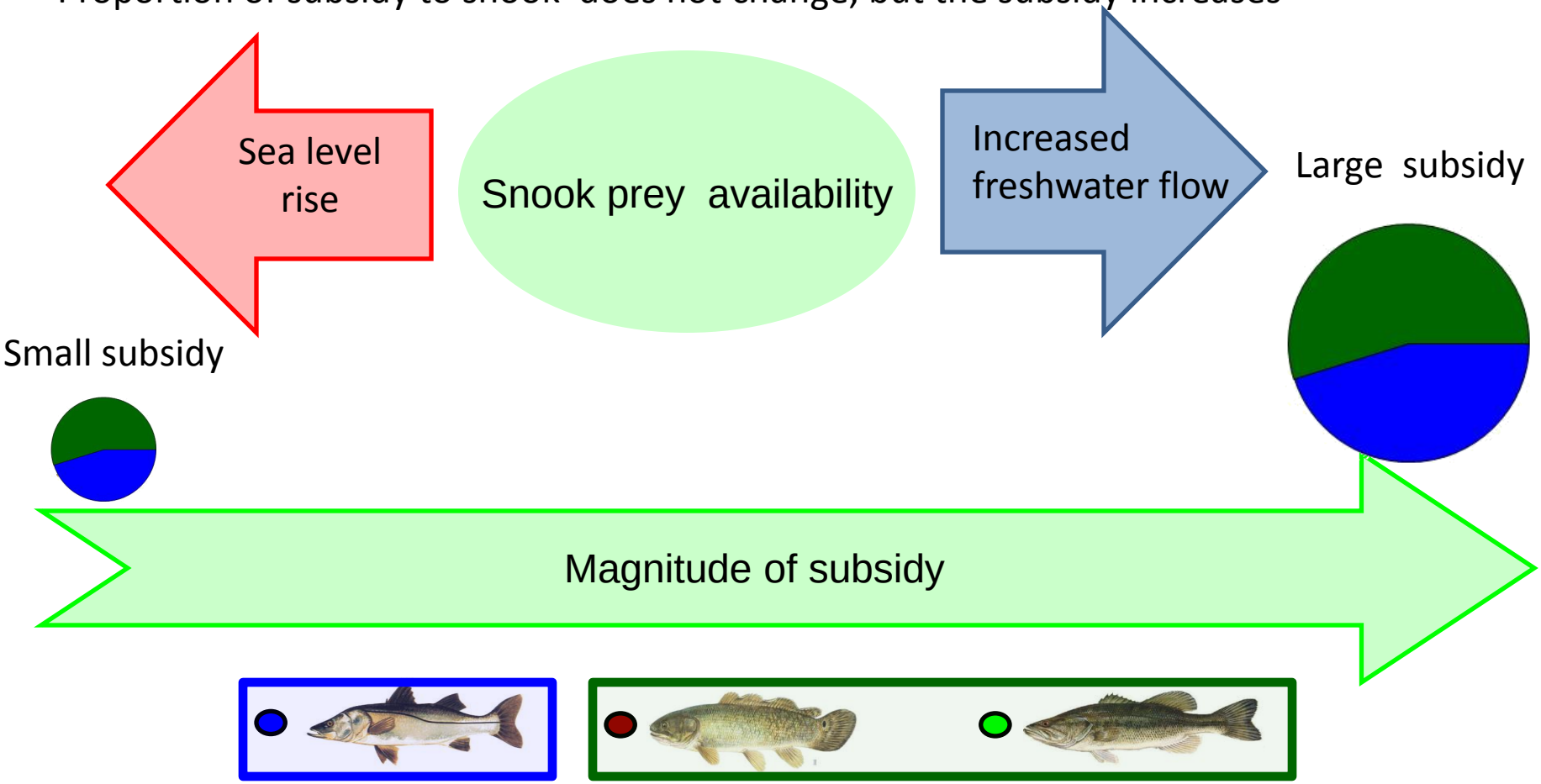


Moving on to FCE III

Trexler et al. 2005

increased freshwater flow increases marsh fish production

Proportion of subsidy to snook does not change, but the subsidy increases



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Acknowledgements

- USGS
- RECOVER
- FCE LTER
- FIU
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- Michael Heithaus
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