Food Webs, Interaction Webs, and Monitoring: Using a Trophic Conceptual Model to Select Ecological Indicators

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THE CROC DOCS

RECOVER
assessment
science
evaluation
integration

Everglades Restoration Science Strategy

- Adaptive management

- Performance measures link societal values to actions

- Targets adjust for factors out of the control of managers
  - Example: Inter-annual variation in rainfall
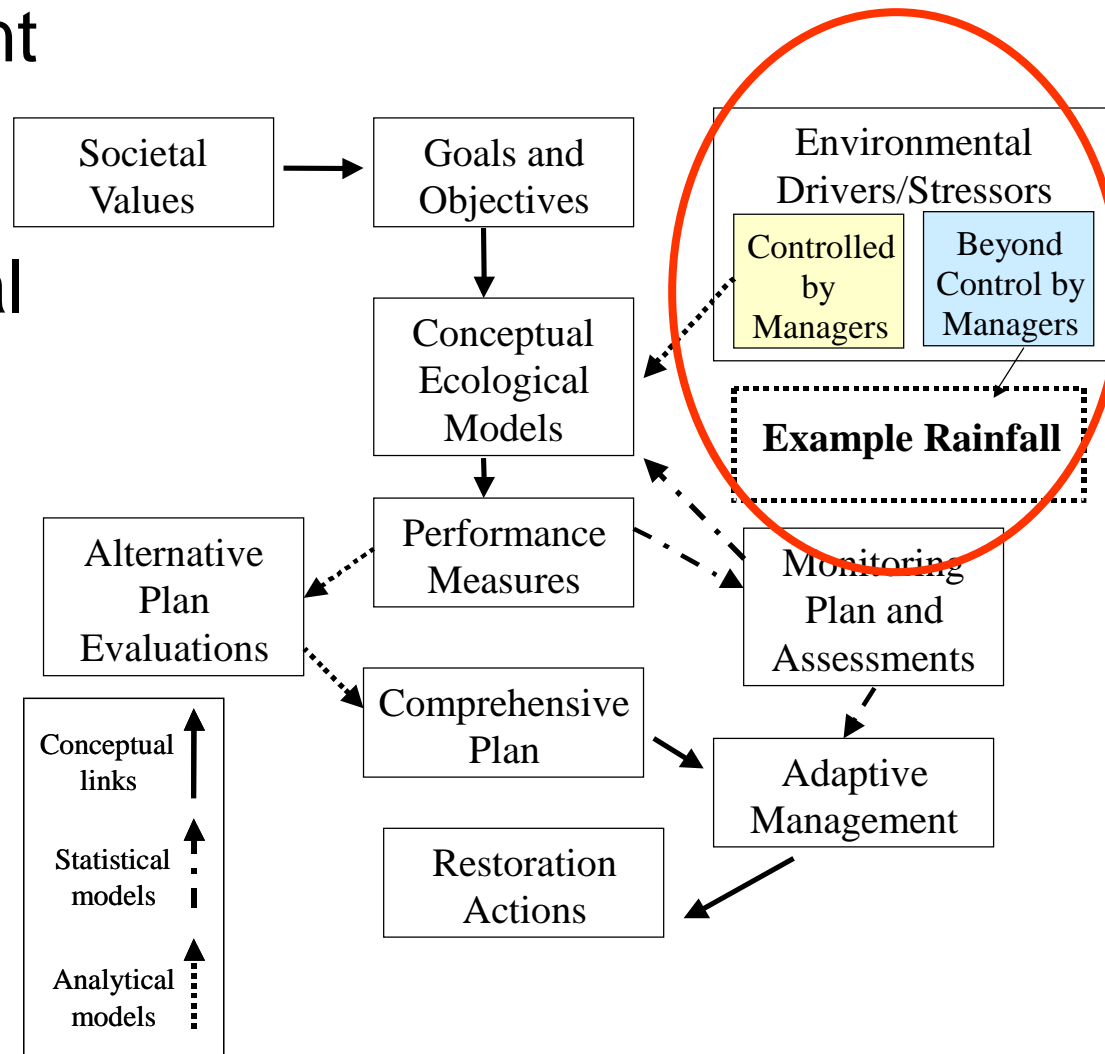
Selecting Ecological Indicators

- Respond at an applicable scale?
- Feasible to implement?
- Sensitive to system drivers with predictable responses?
- Readily interpretable to general audience and scientifically defensible?
- Can a target be identified and deviations from it be documented and assessed?
- Are there situations where a positive trend is negative for restoration?
- Does the indicator have specificity?
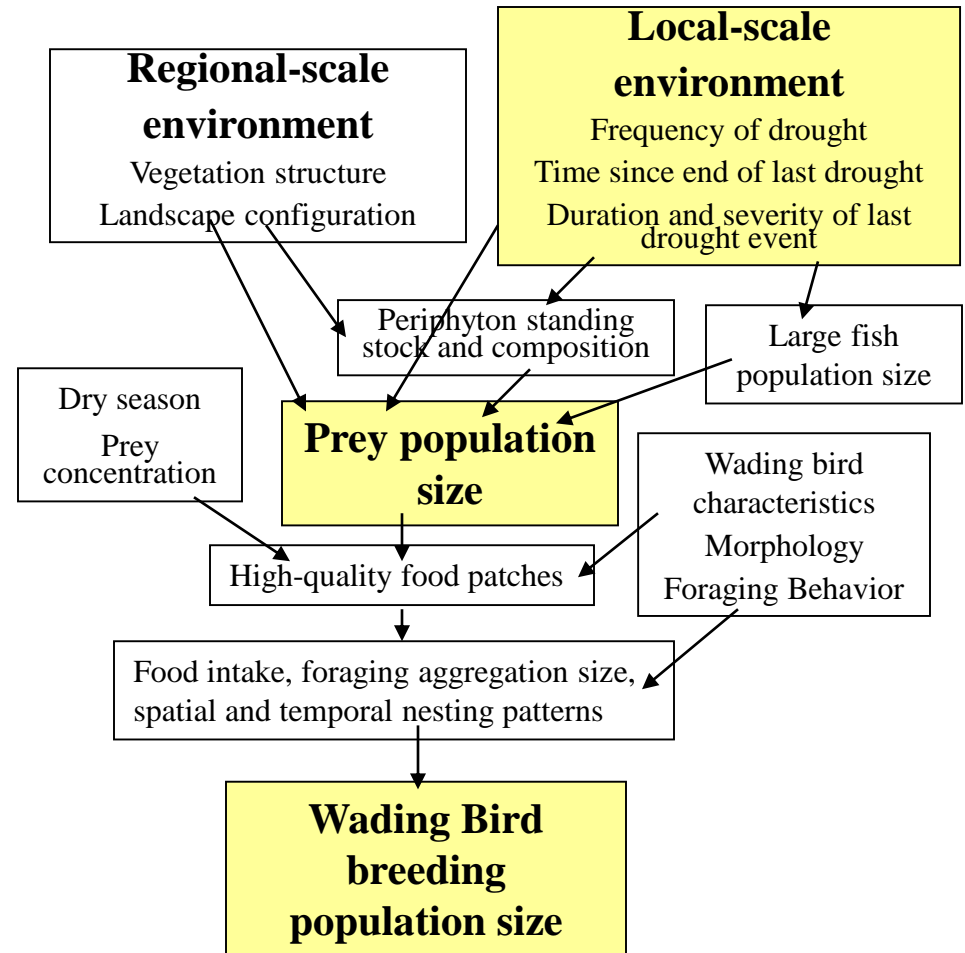- Does the indicator provide an early warning of ecological change?

Wading Birds and Monitoring Aquatic Fauna

- Wading bird population size is food limited

- Aquatic fauna links environmental drivers controlled by management and wading birds

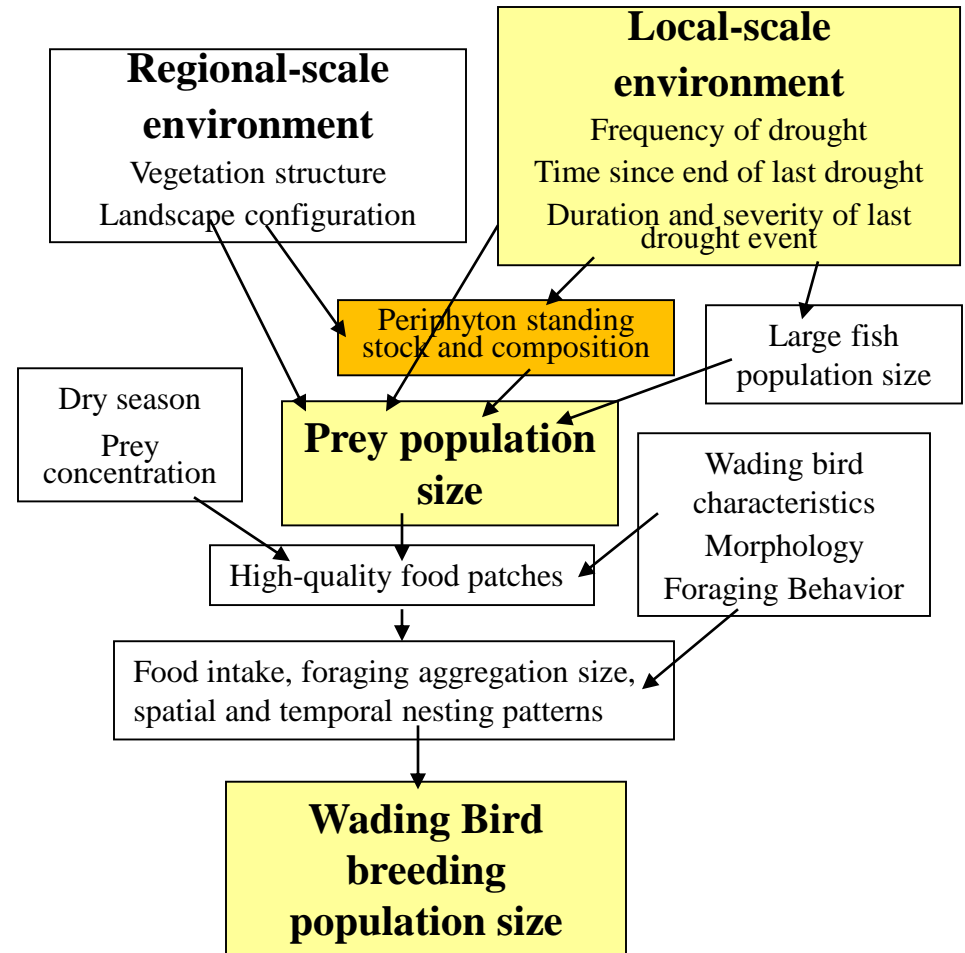- Annual or semi-annual life cycles yield real-time responses to management

Regional-scale environment
Vegetation structure
Landscape configuration

Local-scale environment
Frequency of drought
Time since end of last drought
Duration and severity of last drought event

Periphyton standing stock and composition

Large fish population size

Dry season
Prey concentration

Prey population size

Wading bird characteristics
Morphology
Foraging Behavior

High-quality food patches

Food intake, foraging aggregation size, spatial and temporal nesting patterns

Wading Bird breeding population size

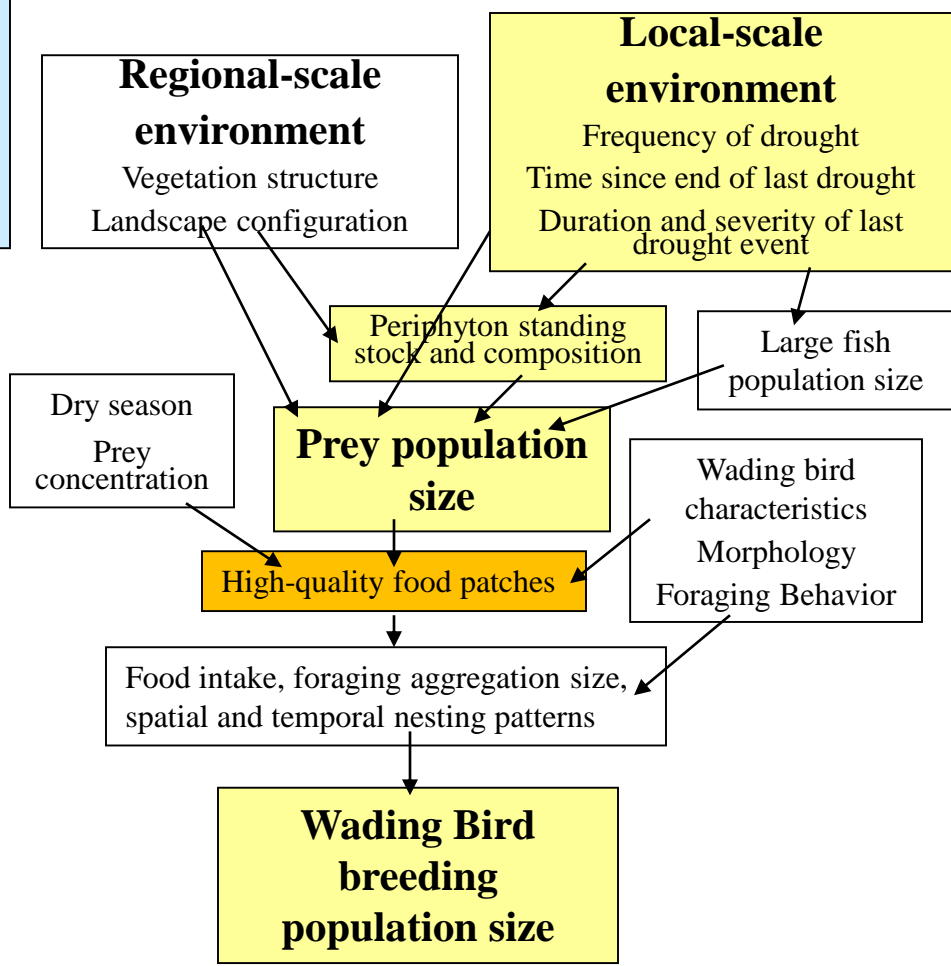© Dan Kaiser

Wading Birds and Monitoring Aquatic Fauna

- We have established link between hydrological drivers and periphyton

- …and periphyton to fish and macroinvertebrate density dynamics

- SEM, field and lab mesocosm studies (citations available upon request)

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Wading Birds and Monitoring Aquatic Fauna

- We have established link between wet-season prey biomass and prey biomass in drying pools.

- Dale Gawlik and Bryan Botson studied aquatic animals in dry-season pools.

- Prey biomass predicted by wet-season biomass, water recession rate, local microtopography.

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Data for Assessment
Six Performance Measures

- Four species selected as Performance Measures to represent different life histories related to effects of marsh drying

- Total fish as a measure of fish availability for higher trophic levels

- Frequency of non-native fish species

Hydrological PMs

- Recover slowly (years), effected by local drying - bluefin killifish

- Recover quickly (months), decline as site remains flooded – flagfish

- Recover quickly (months), effected by local and regional drying – eastern mosquitofish

- Not effected by short drying events, average depth past 6 months, regional drying – Everglades crayfish

(c) 1998 Keith A Crandall

Examples of PMs
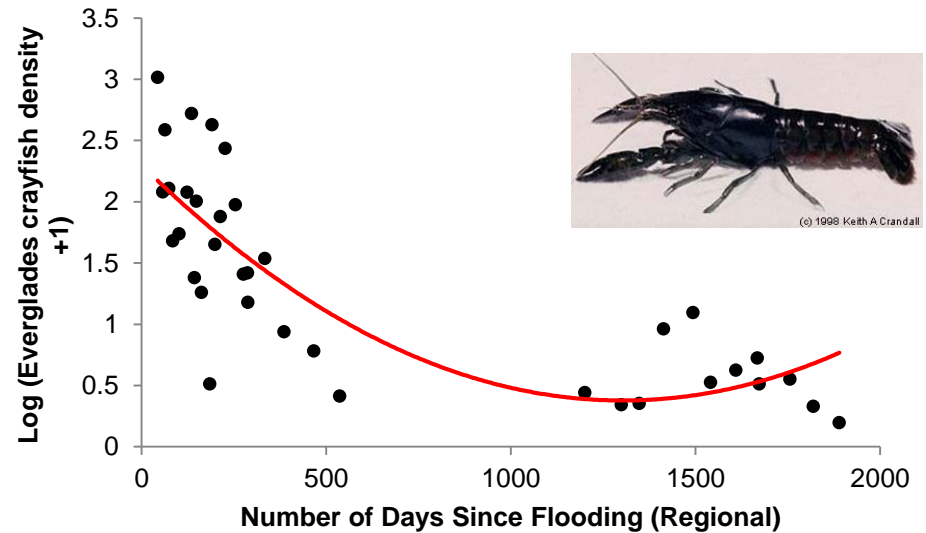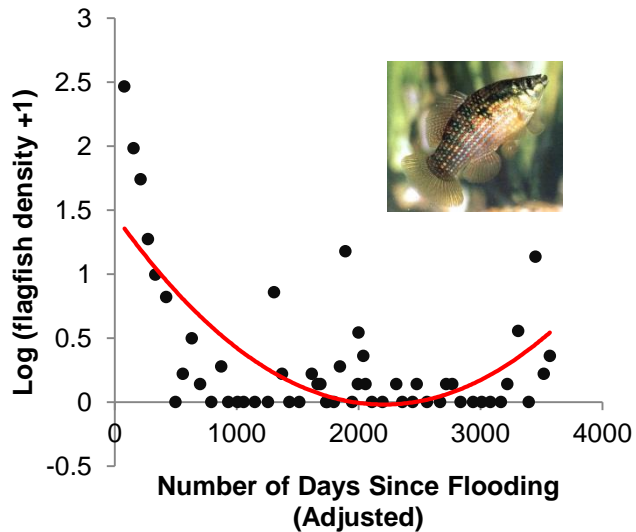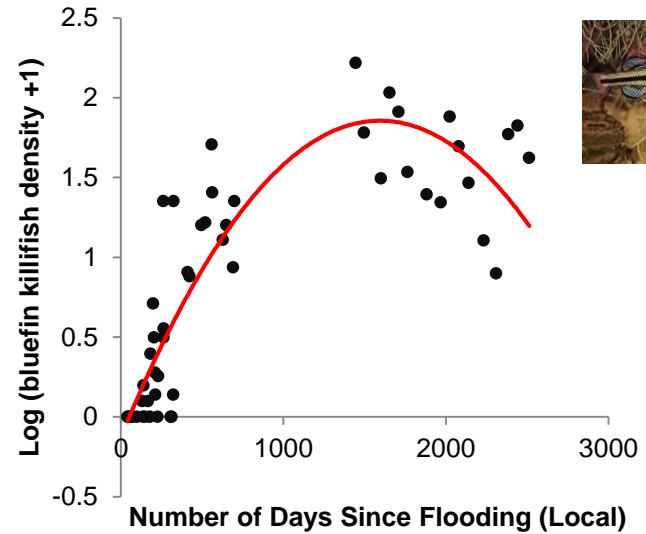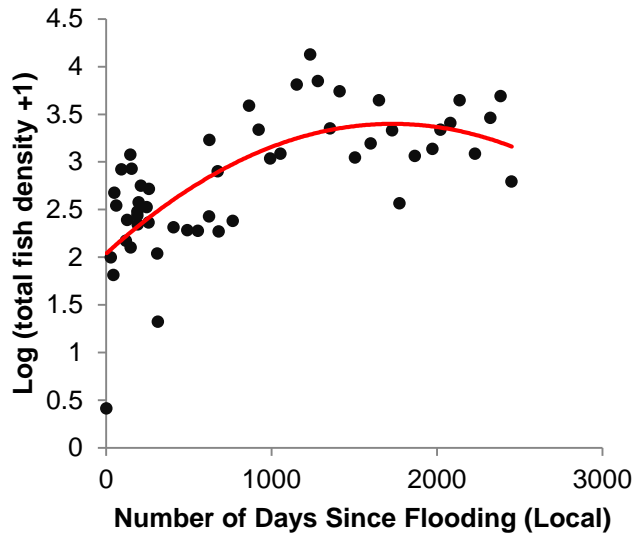
Assessing Impacts of Hydrological Management

models to predict fish density

- Identify goals for hydrological management

  – Baseline period: Jan 1993 – Nov 1999

- Assessment period: Dec 1999 – present

- Can we detect an effect of hydrological operations on biological indicators beyond rainfall-driven hydrological variation?

  > **Residual effects = (Old operating + rainfall) – (New operating + rainfall)**
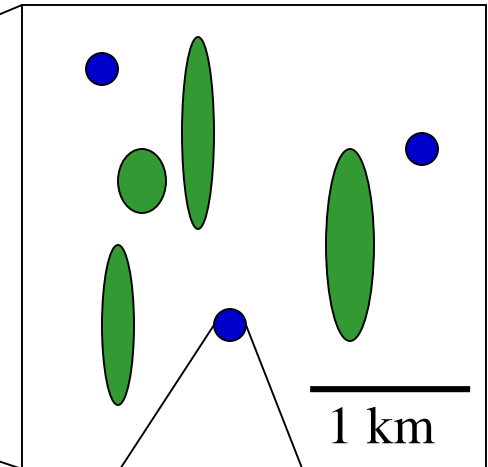
Steps for Assessment

- Select Performance Measures and report temporal pattern 1995 – present

- Model water depth from rainfall during baseline period (1993 – 1999)

- Project water depths for assessment period (late 99 - present) under old operating rules

- Model PM from hydrology

- Project PM during assessment period from for projected hydrology

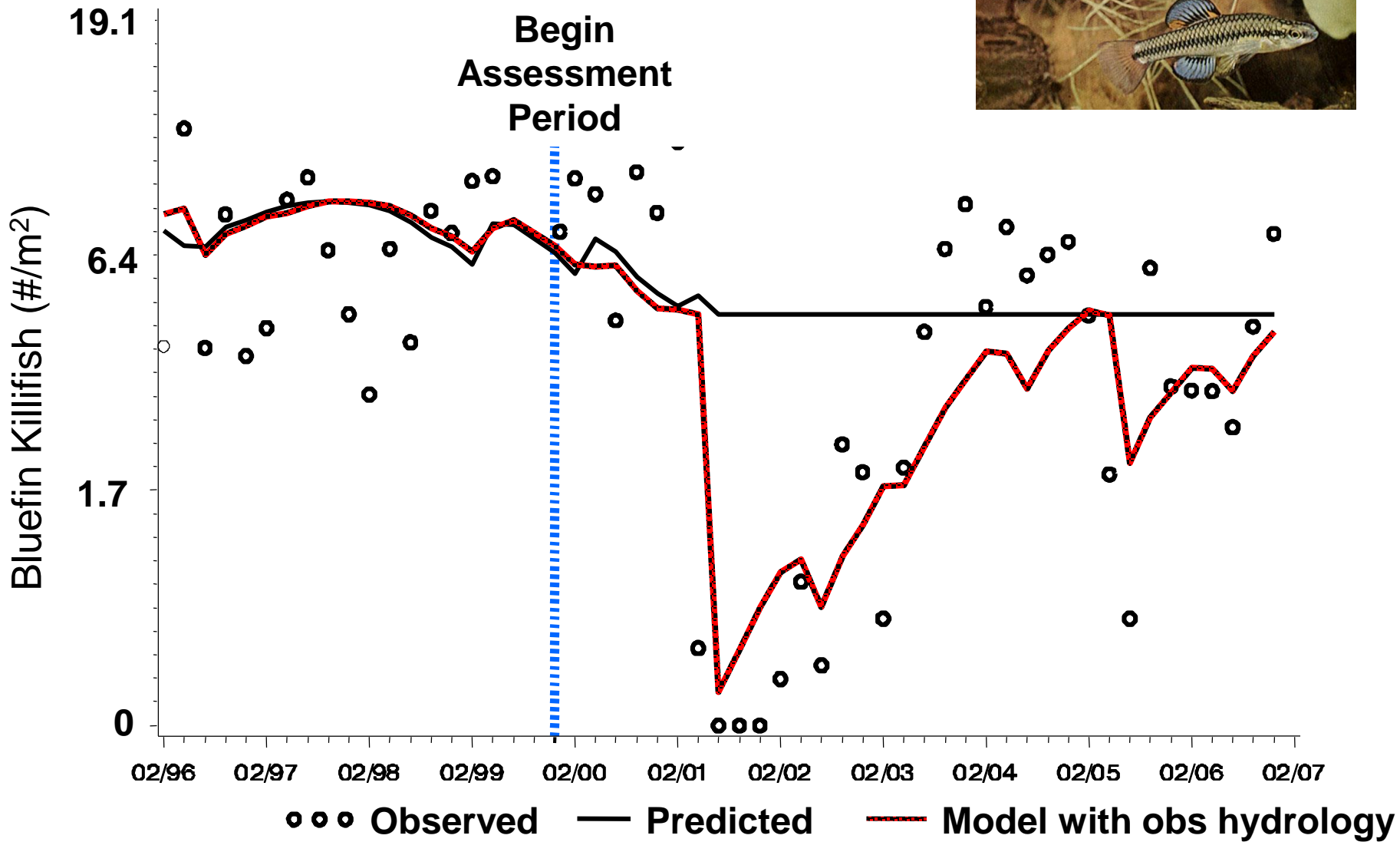- Compare projected PM values to observed
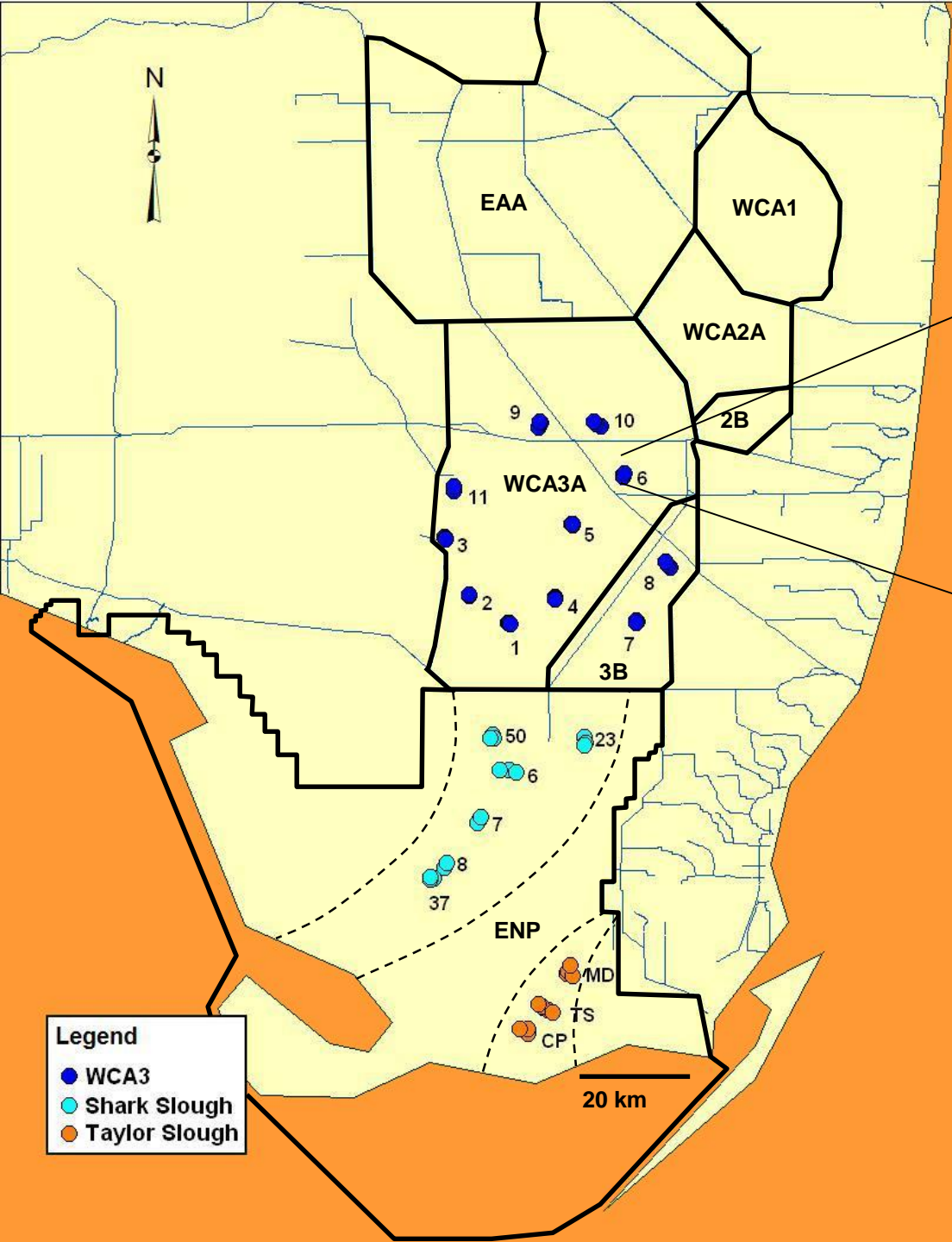
Sampled by throw trap
Plots A-C

1 km

Plots approx
100m x 100m

5-7 throws

EAA

WCA1

WCA2A

2B

9   10

WCA3A

11   6

3   5

2   4   8

1   7

3B

50   23

6

7

8

37

ENP

MD

TS

CP

N

Legend
● WCA3
● Shark Slough
● Taylor Slough

20 km

Shark River Slough   Plot 6C

Bluefin Killifish (#/m²)

19.1

6.4

1.7

0

Begin Assessment Period

02/96 02/97 02/98 02/99 02/00 02/01 02/02 02/03 02/04 02/05 02/06 02/07

○ ○ ○ **Observed** —— **Predicted** ‐‐‐ **Model with obs hydrology**

Criteria for Red Stoplights 🔴

Deviation from Target

- Type A: one year at least three standard errors above/below limits of objective interval

3.0 std err

- Type B: two out of three consecutive years at least two standard errors above/below limits of objective interval

2.0 std err

- Type C: four out of five consecutive years with at least 1.5 standard errors above/below limits of objective interval

1.5 std err
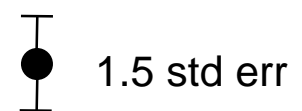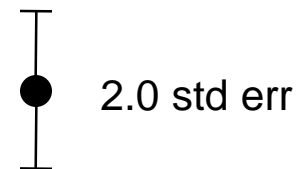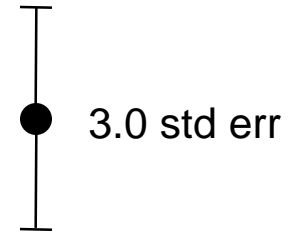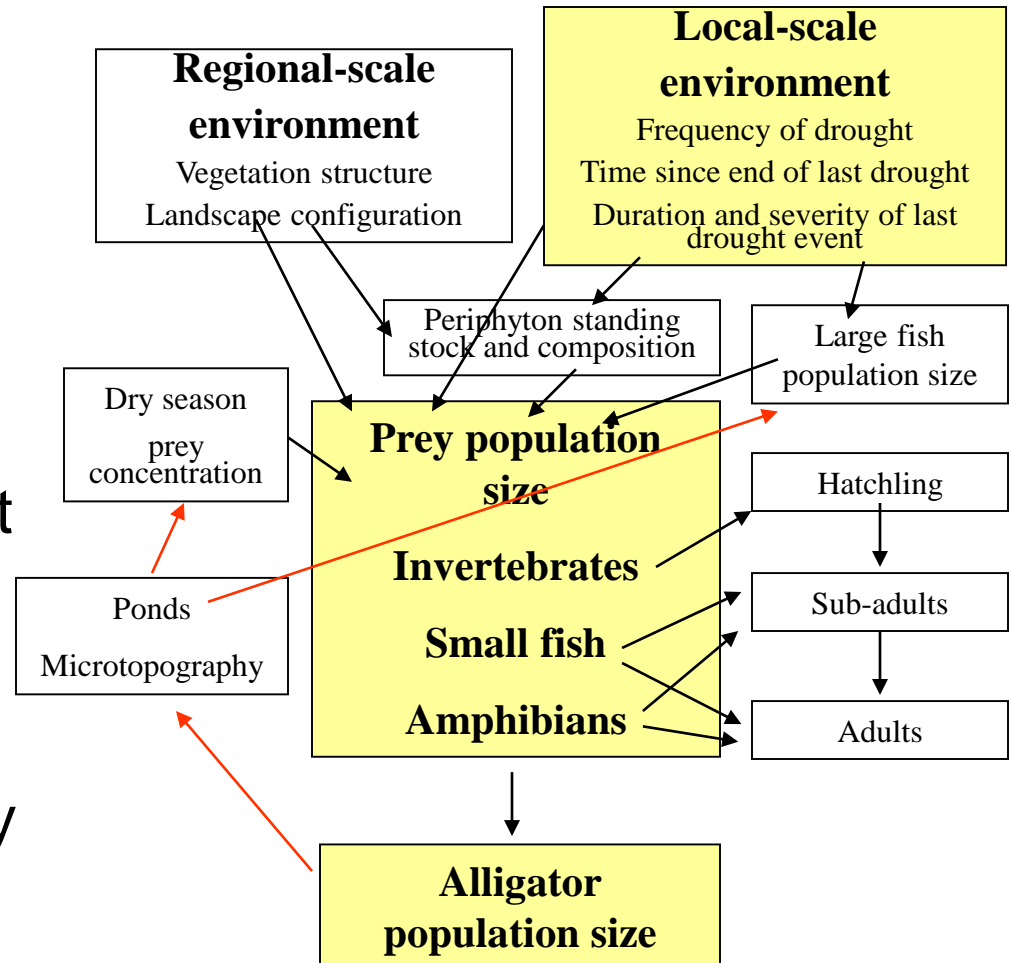
Bluefish Killifish Fish
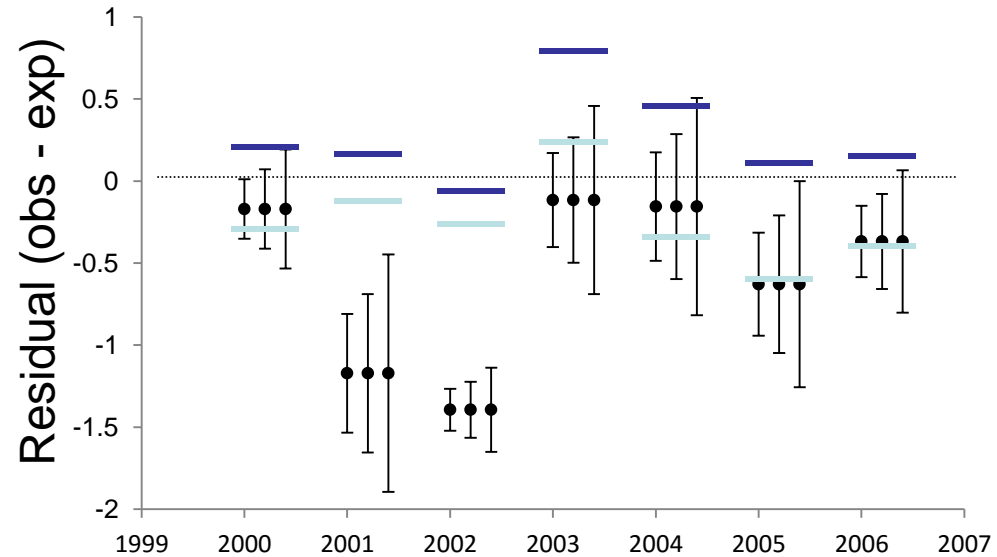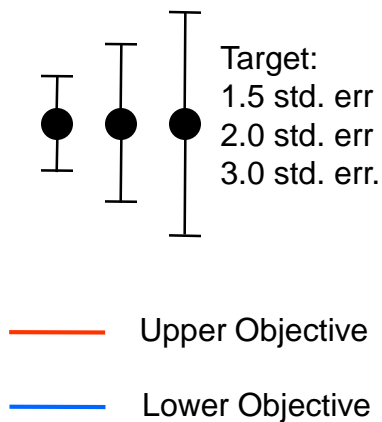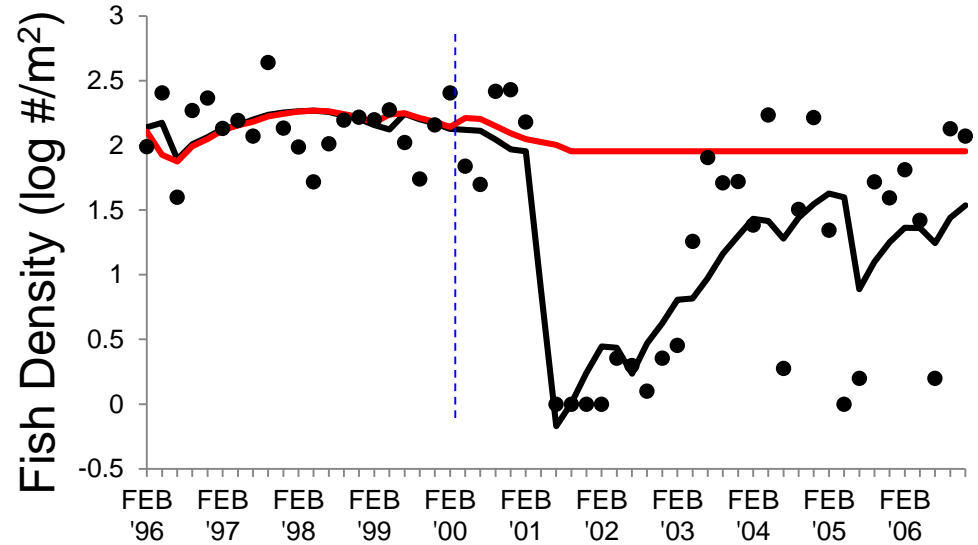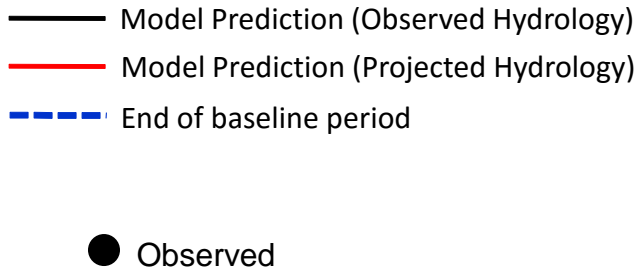
Annual Stoplight Assessments

Shark River Slough

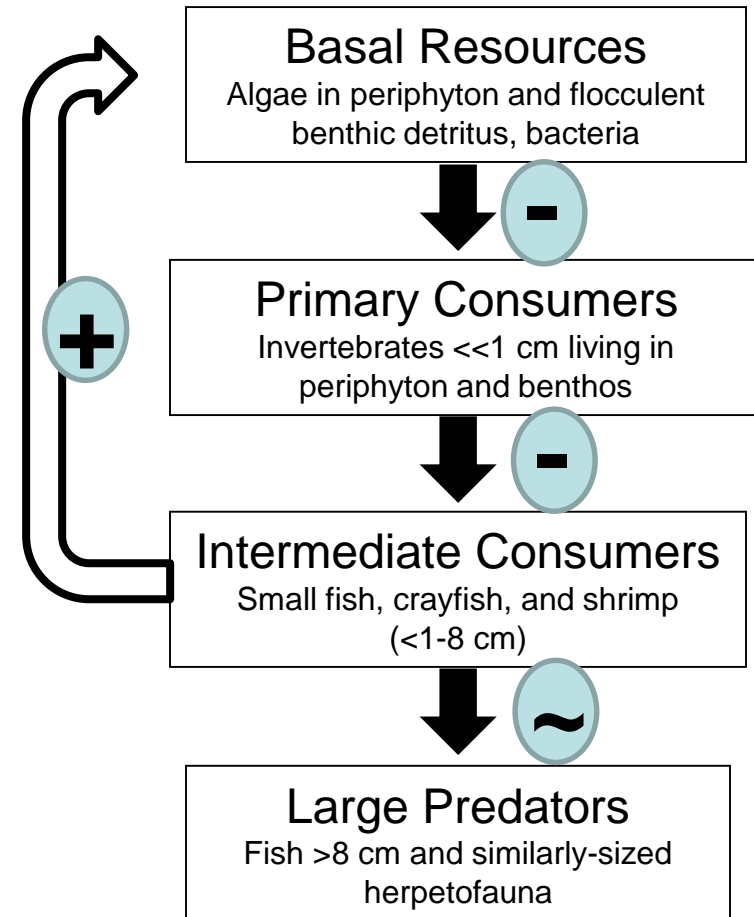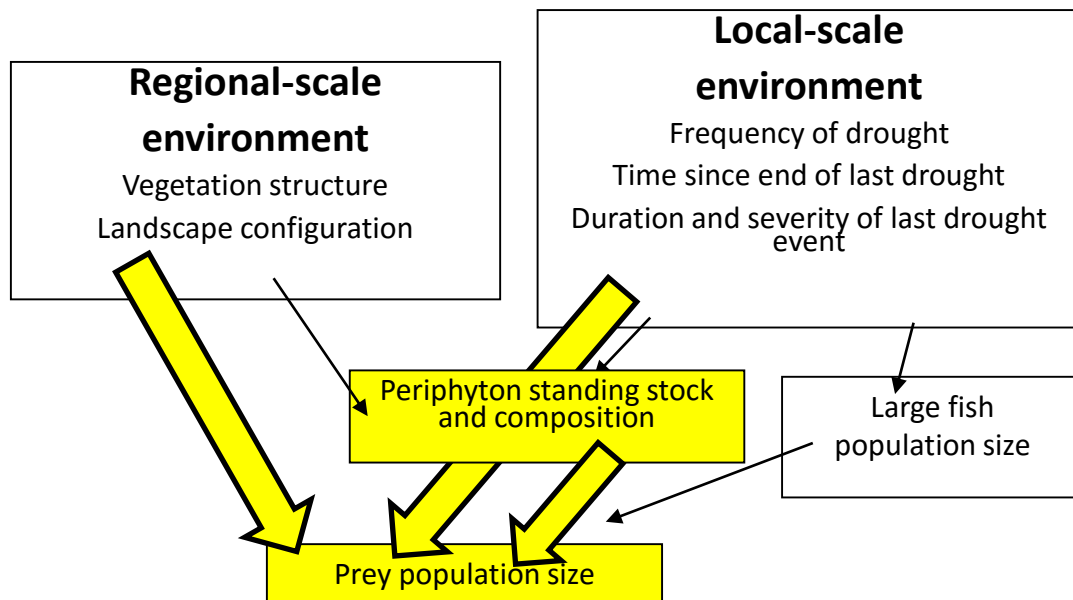|	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Total Fish	G	G	Y	Y	Y	Y	Y	Y	R	R	Y	Y	Y	Y	R
Non-native Fishes	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	R
Bluefin Killifish	G	Y	Y	R	R	R	Y	Y	Y	R	R	R	R	R	R
Flagfish	G	G	Y	Y	G	Y	G	Y	G	Y	G	Y	Y	Y	Y
Eastern Mosquitofish	G	G	G	G	G	G	G	Y	Y	Y	Y	Y	G	Y	Y
Everglades Crayfish	G	G	Y	Y	R	R	G	Y	W	W	G	Y	Y	G	Y

Alligators and Monitoring Aquatic Fauna?

- American alligators are food limited in freshwater Everglades

- Aquatic fauna links environmental drivers controlled by management and alligators

- Alligators may create positive feedbacks on prey production (red arrows)

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Dry season prey concentration

Prey population size

Invertebrates

Small fish

Amphibians

Ponds
Microtopography

Hatchling

Sub-adults

Adults

Alligator population size

Trophic Hypothesis

- Trophic hypothesis is completely bottom-up

- Ignores top-down control, indirect effects, and trophic cascades

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Basal Resources
Algae in periphyton and flocculent benthic detritus, bacteria

−

Primary Consumers
Invertebrates <<1 cm living in periphyton and benthos

−

Intermediate Consumers
Small fish, crayfish, and shrimp (<1-8 cm)

~

Large Predators
Fish >8 cm and similarly-sized herpetofauna

+

Periphyton Infauna

- Midge larvae, amphipods, nematods live inside periphyton mats
- SEM preferred model includes bottom-up and top-down effect
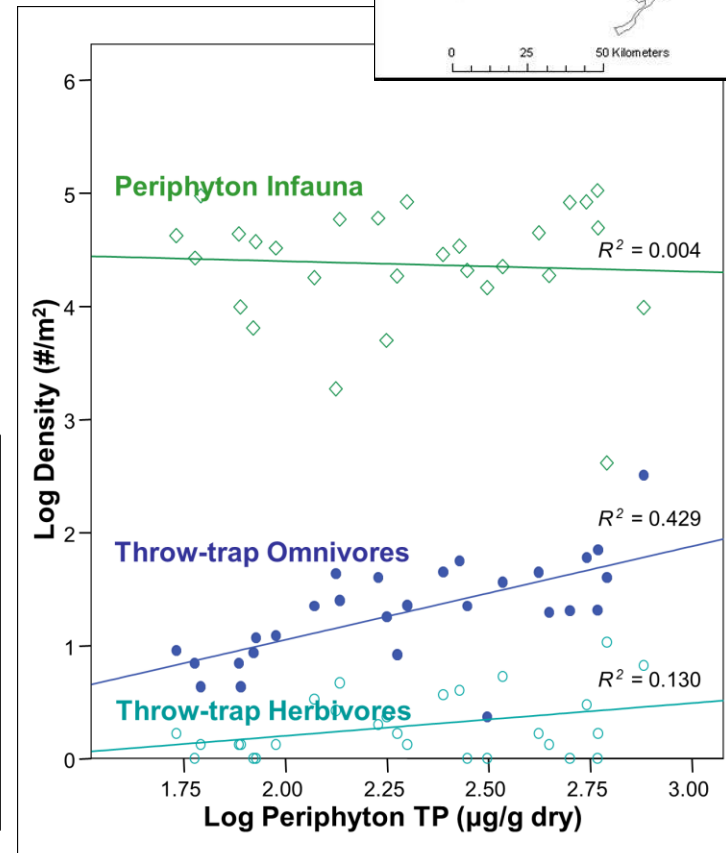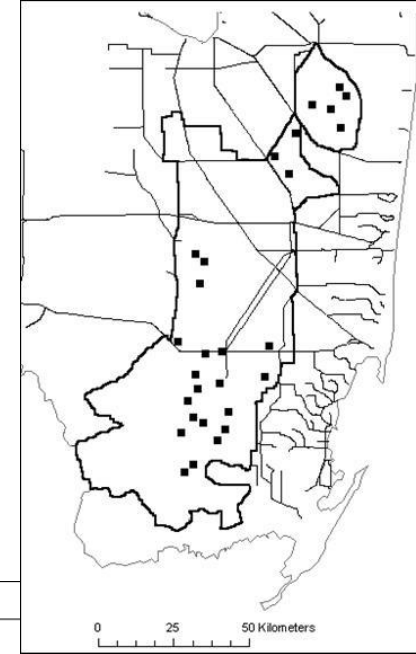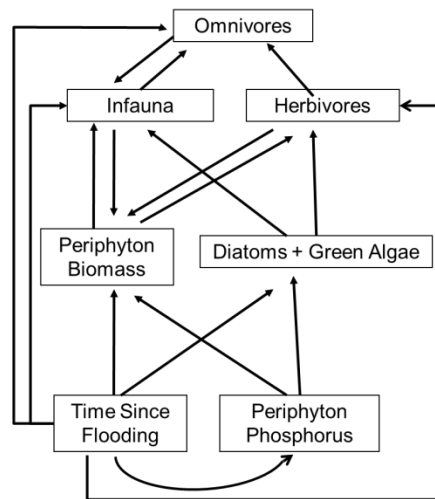
Planorbid snails

- Ramshorn snails are most abundant in the Everglades.
- Density does not varies along nutrient gradients though algal quality does
- Hypothesis that predation risk and food resources balance near and far from canals
- Tested with reciprocal transplant of periphyton
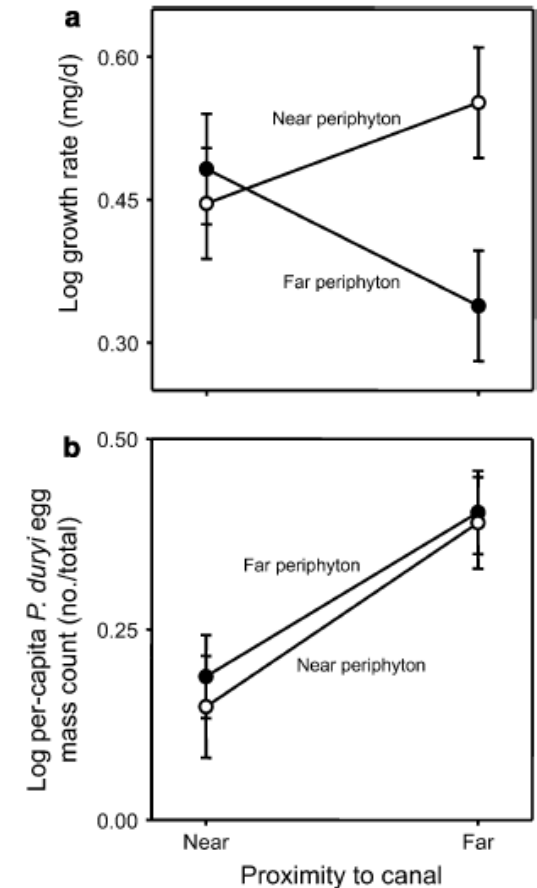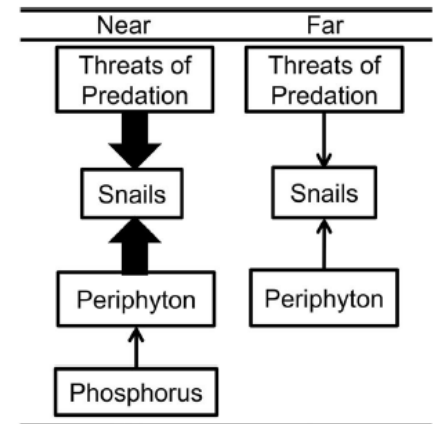
Summary and Conclusions

- The CERP Monitoring and Assessment Plan links management actions to societal values

- We illustrated MAP implementation and Performance Measure selection and application for the trophic hypothesis for wading birds.

- Recovery and sustenance of healthy alligator populations is a societal value captured in the CERP Monitoring and Assessment Plan.

- A 'trophic hypothesis' for alligators reveals key positive feedbacks to their prey by their role as ecosystem engineers.

- Positive feedbacks may mask trophic linkages observable in descriptive data.

Acknowledgments

http://www.trexlerlab.com/

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