Linear and non-linear responses of marine and coastal fish populations ~~to physics~~ and habitat: a view from the virtual world

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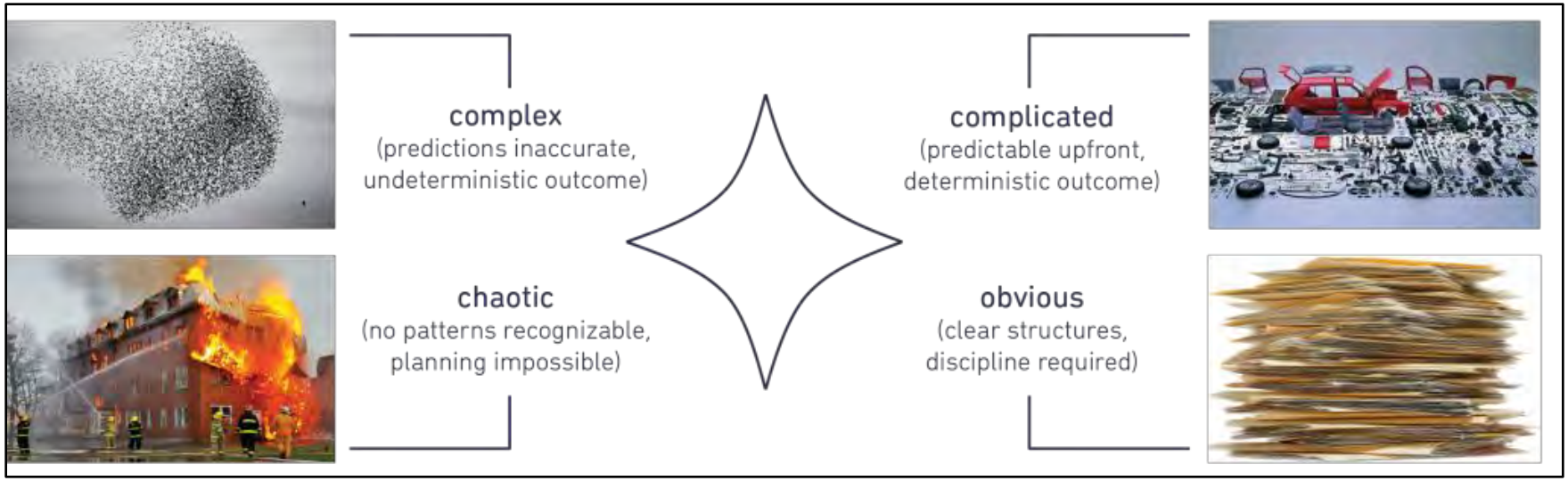
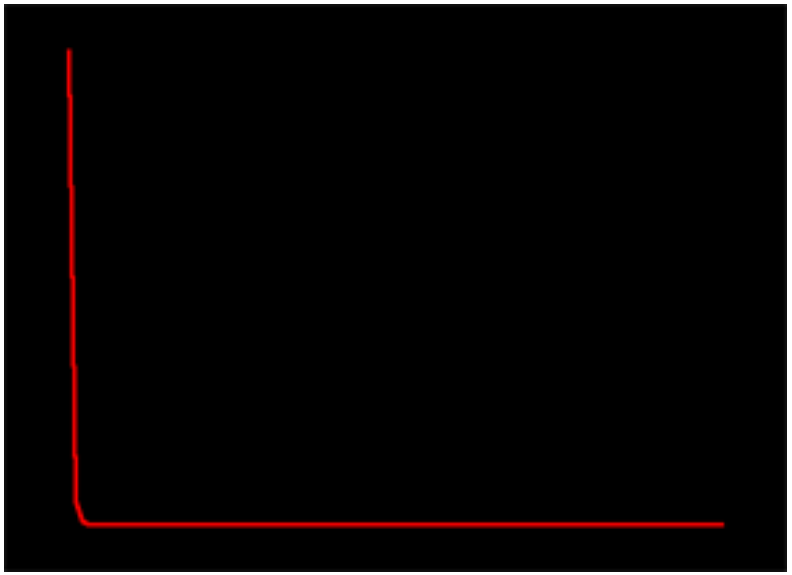
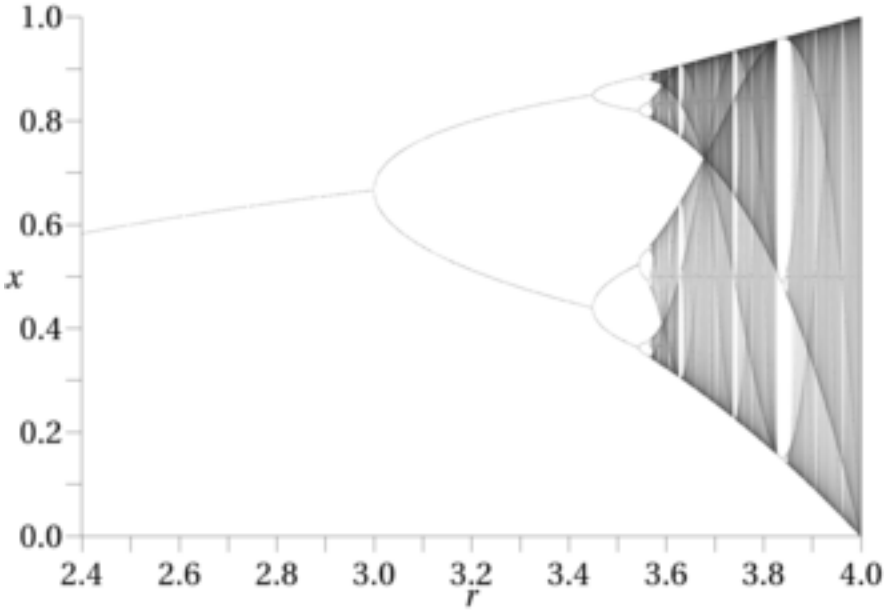


https://beya.io/2016/03/complicated-vs-complex-and-why-it-matters/

$$X_{t+1} = r \cdot X_t(1 - X_t)$$





http://en.wikipedia.org/wiki/Logistic_map

100 generations r 0 to 4

Emergent properties are those that arise through interactions among smaller parts that alone do not exhibit such properties

Example 1 - Shrimp

Roth, B.M., K.A. Rose, L.S. Rozas, and T.J. Minello. 2008. Marine Ecology Progress Series 359: 185-202

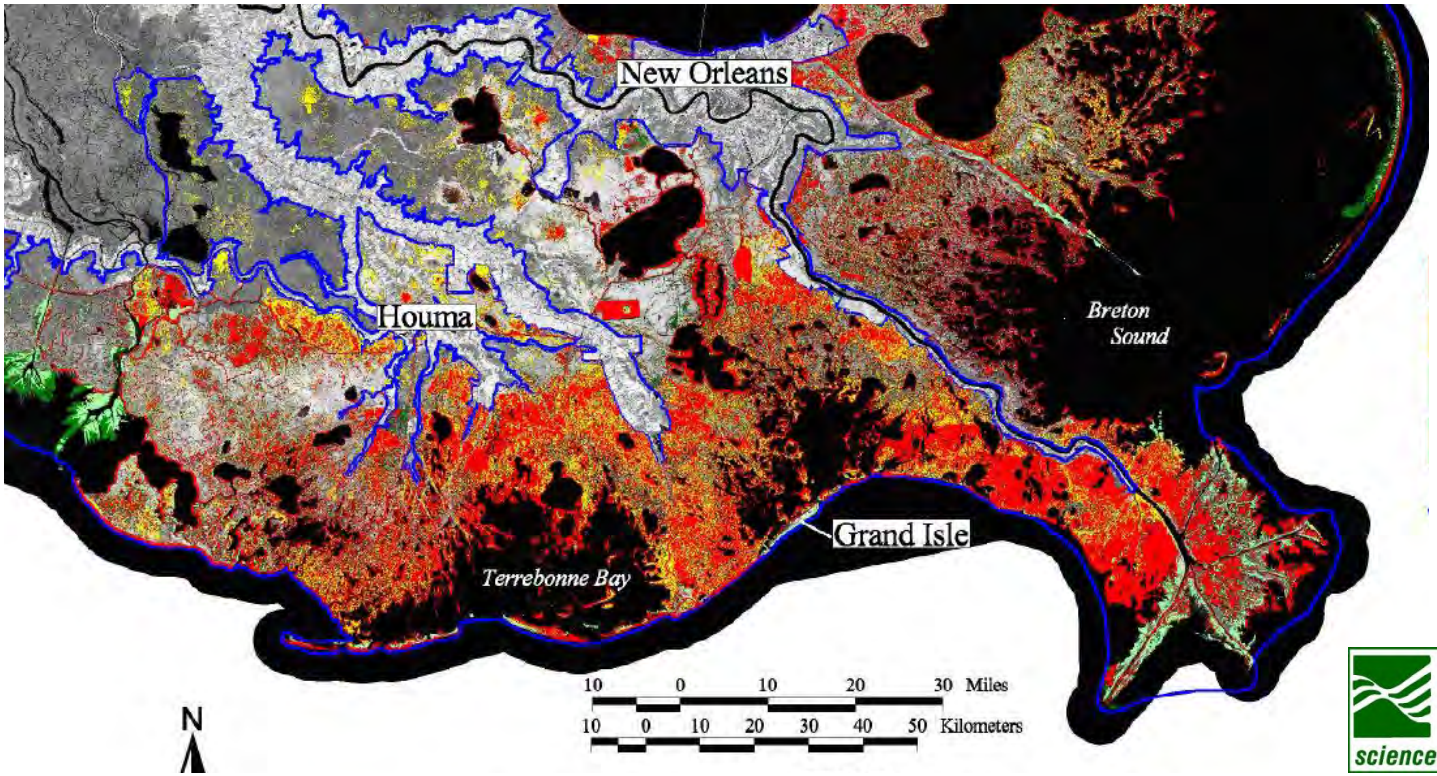
Coastal Louisiana Trends: 1956-2050

Land Loss 1956-2000

Predicted Land Loss 2000-2050

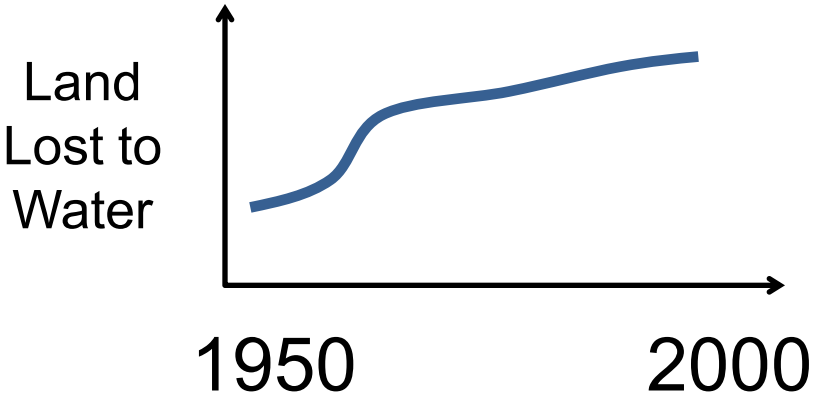
Land Gain 1956-2000

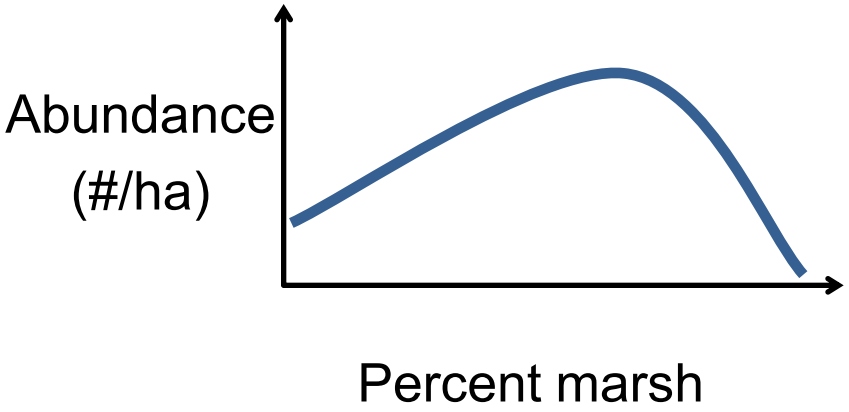
Predicted Land Gain 2000-2050

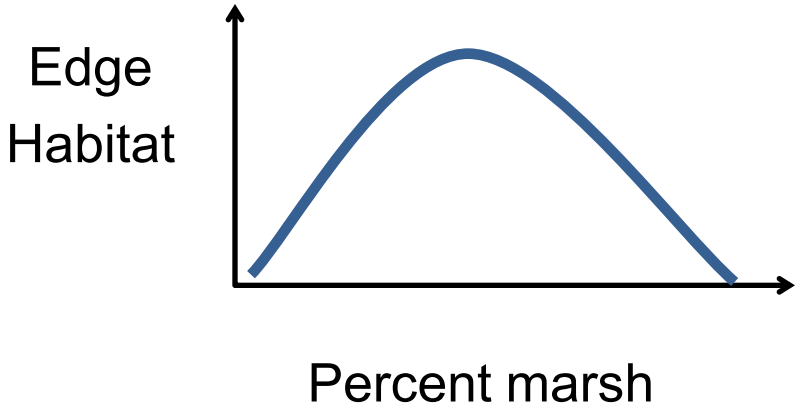


USGS science for a changing world

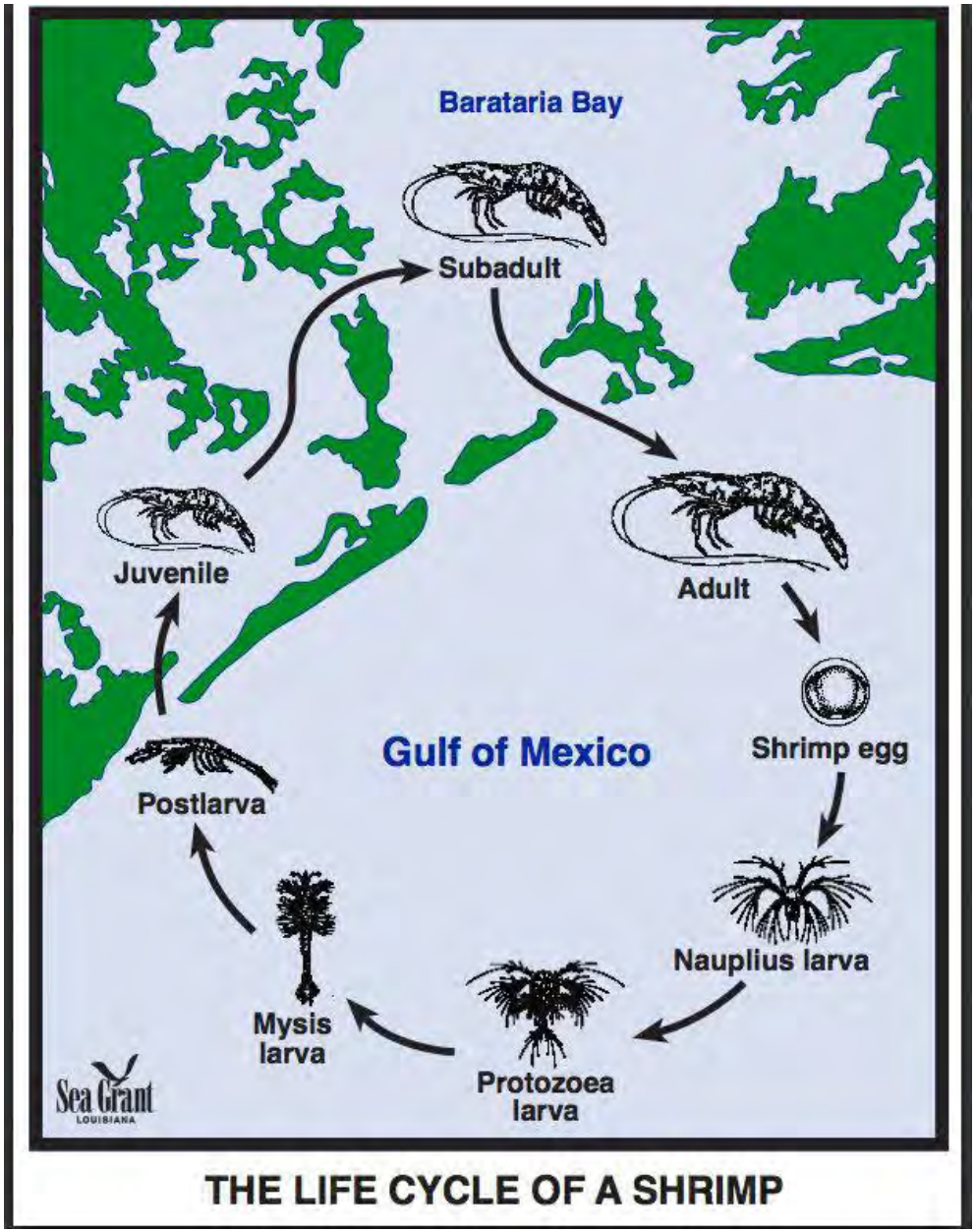
Linkages between marsh habitat and nekton abundance





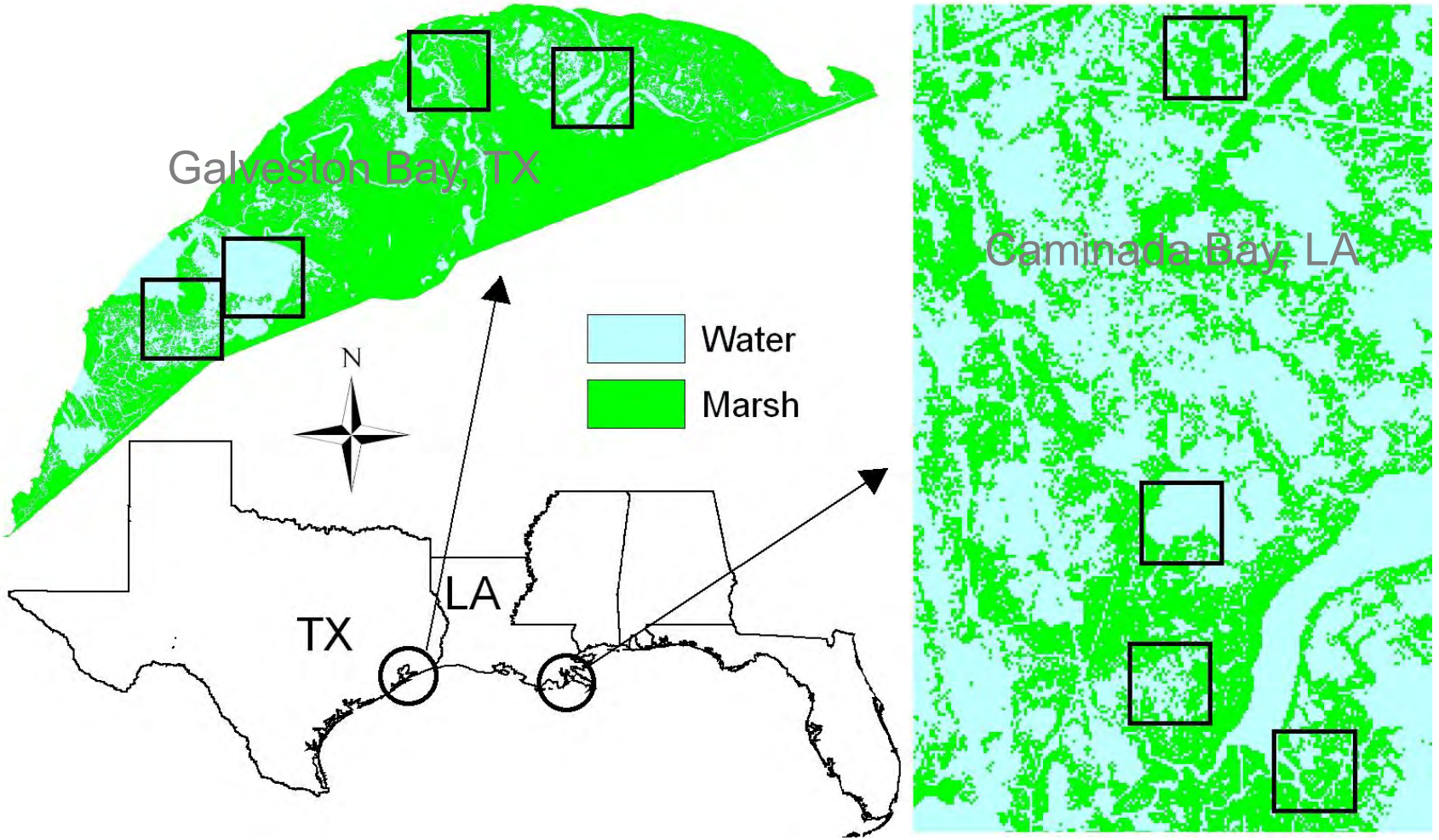


Sources: Minello and Webb 1997, Minello and Rozas 2002, Zimmerman and Minello 1984

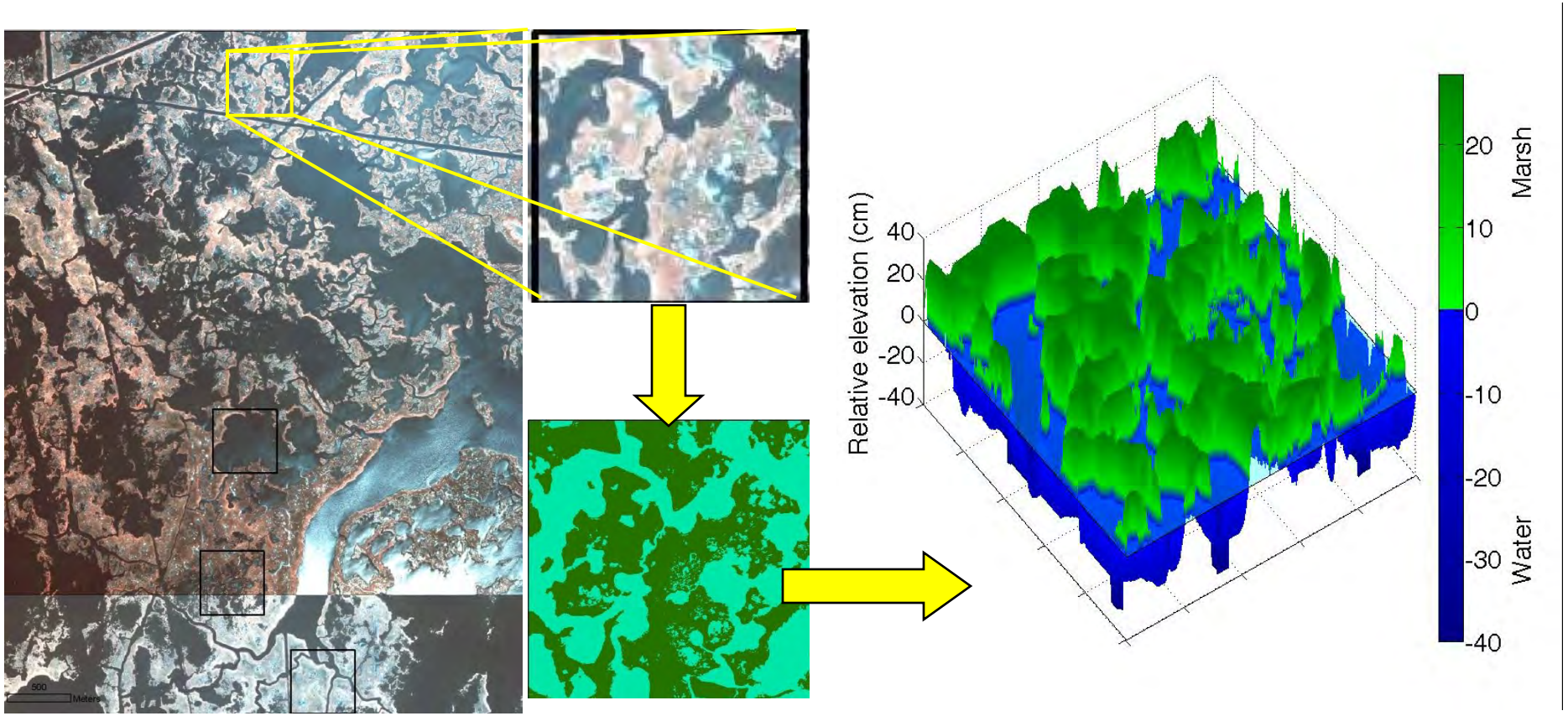


THE LIFE CYCLE OF A SHRIMP

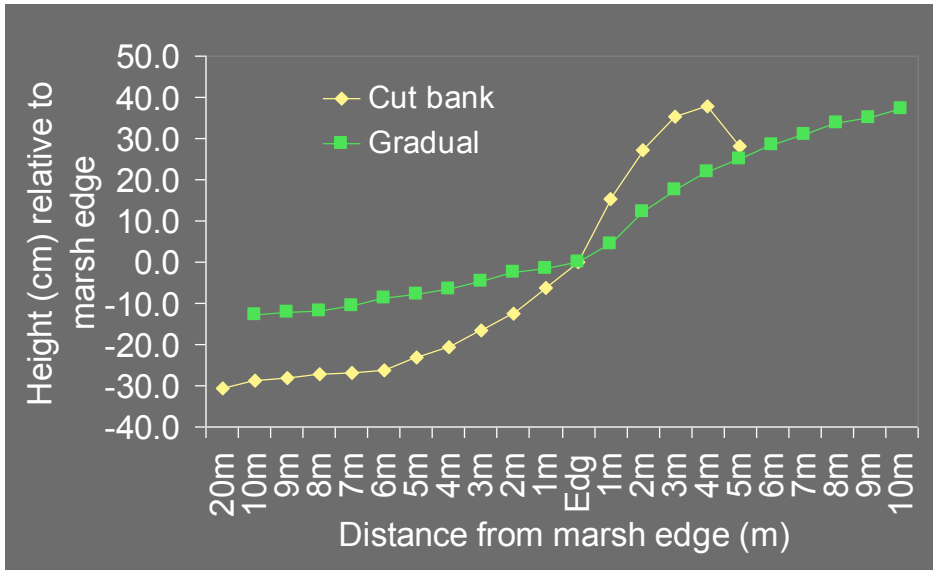
Study locations

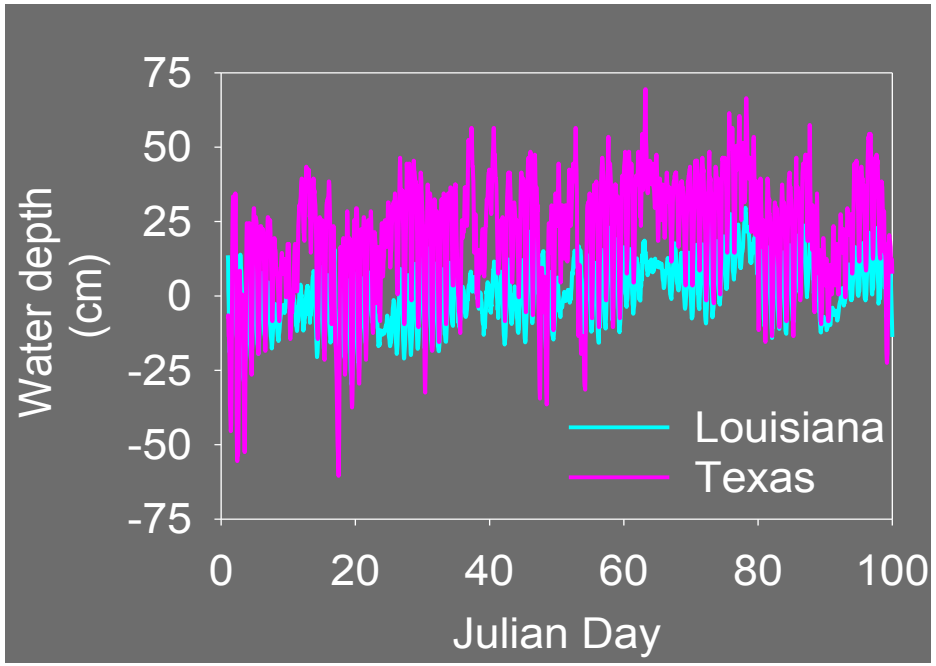


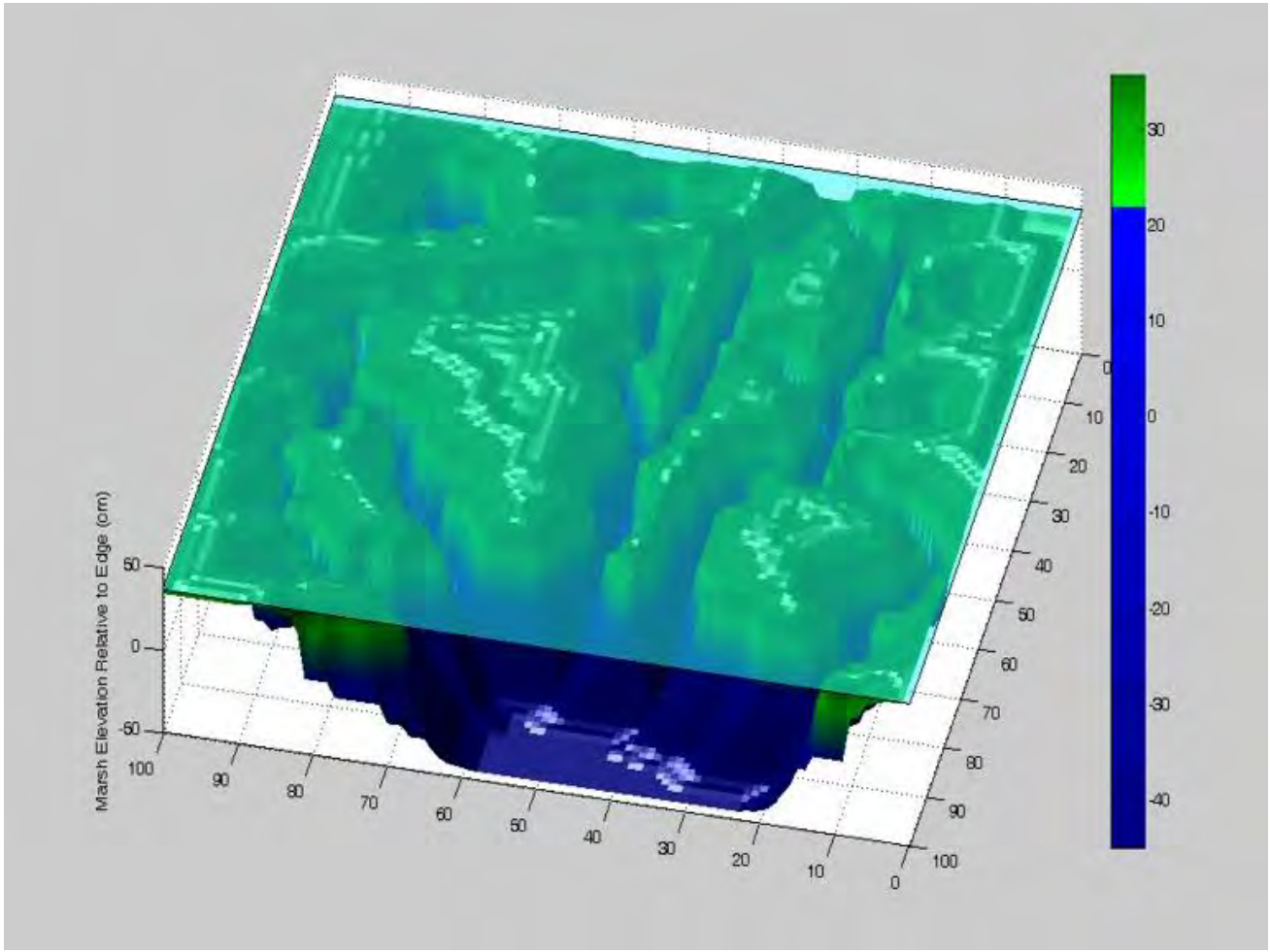
Creating 3D Marshscapes



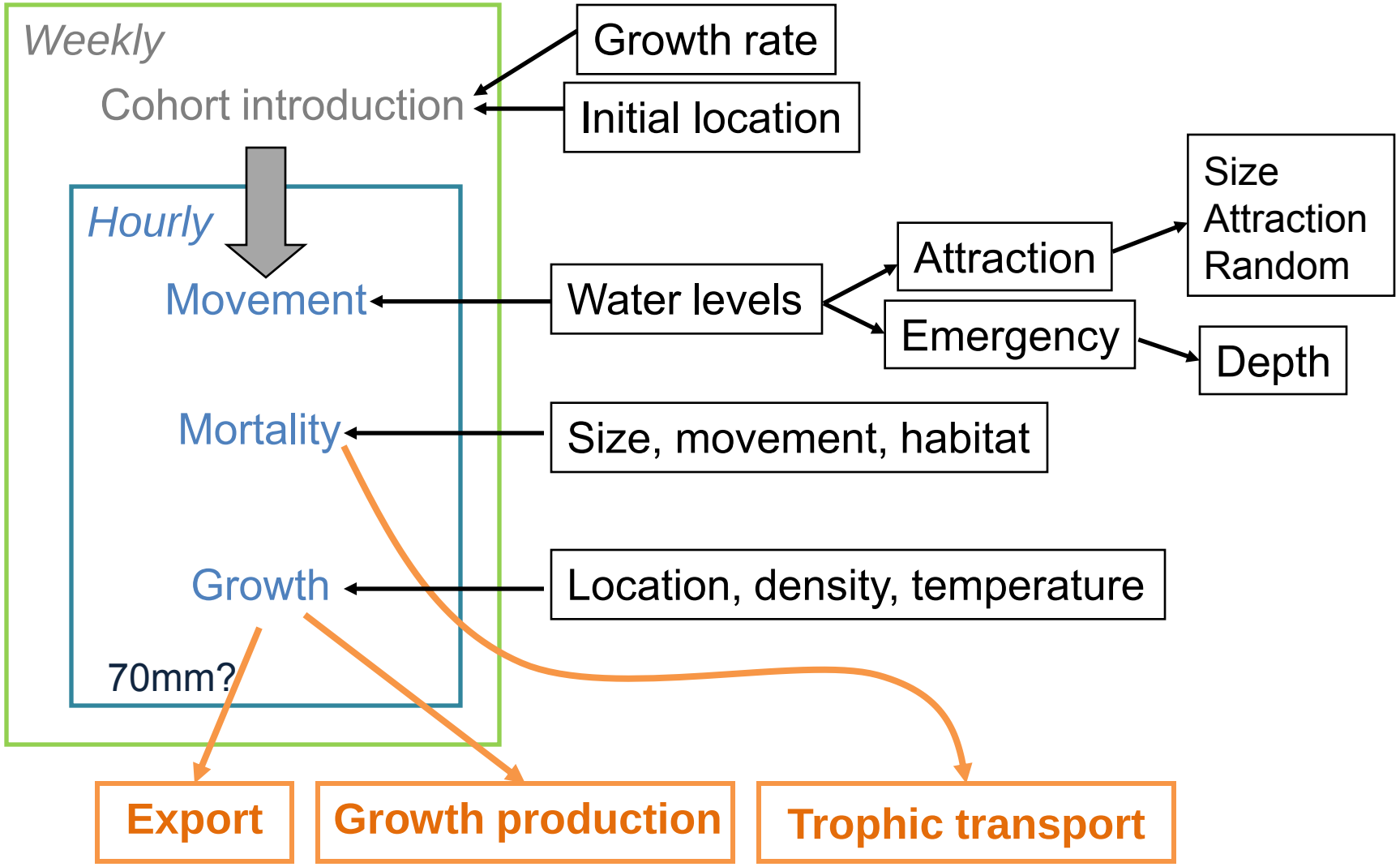
Inundation


Height (cm) relative to marsh edge
50.0
40.0
30.0
20.0
10.0
0.0
-10.0
-20.0
-30.0
-40.0
Cut bank
Gradual
20m
10m
9m
8m
7m
6m
5m
4m
3m
2m
1m
Edg
1m
2m
3m
4m
5m
6m
7m
8m
9m
10m
Distance from marsh edge (m)

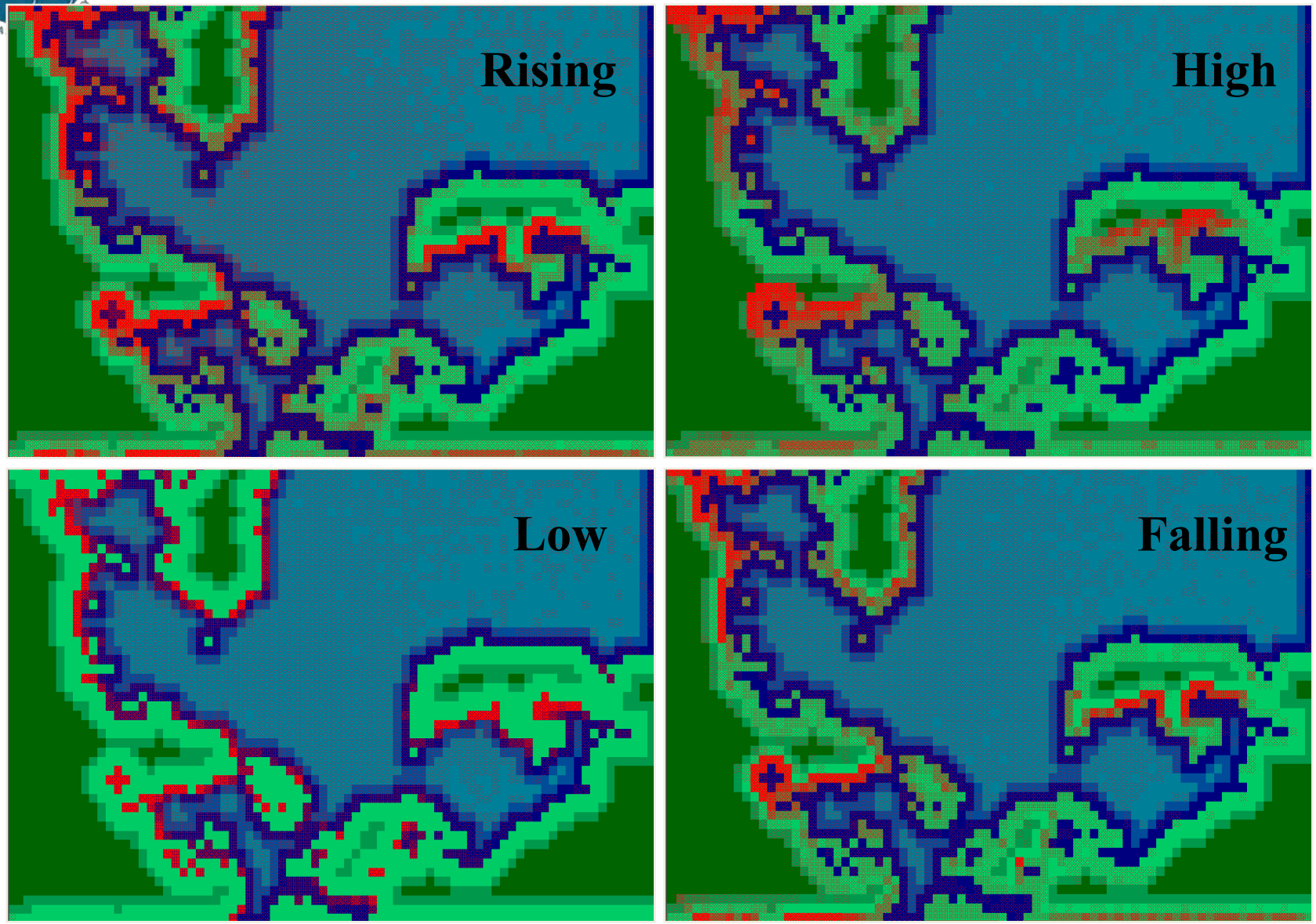

Water depth (cm)
75
50
25
0
-25
-50
-75
Louisiana
Texas
0
20
40
60
80
100
Julian Day


Marsh Elevation Relative to Edge (cm)
50
0
-50
100
90
80
70
60
50
40
30
20
10
0
0
10
20
30
40
50
60
70
80
90
100
30
20
10
0
-10
-20
-30
-40

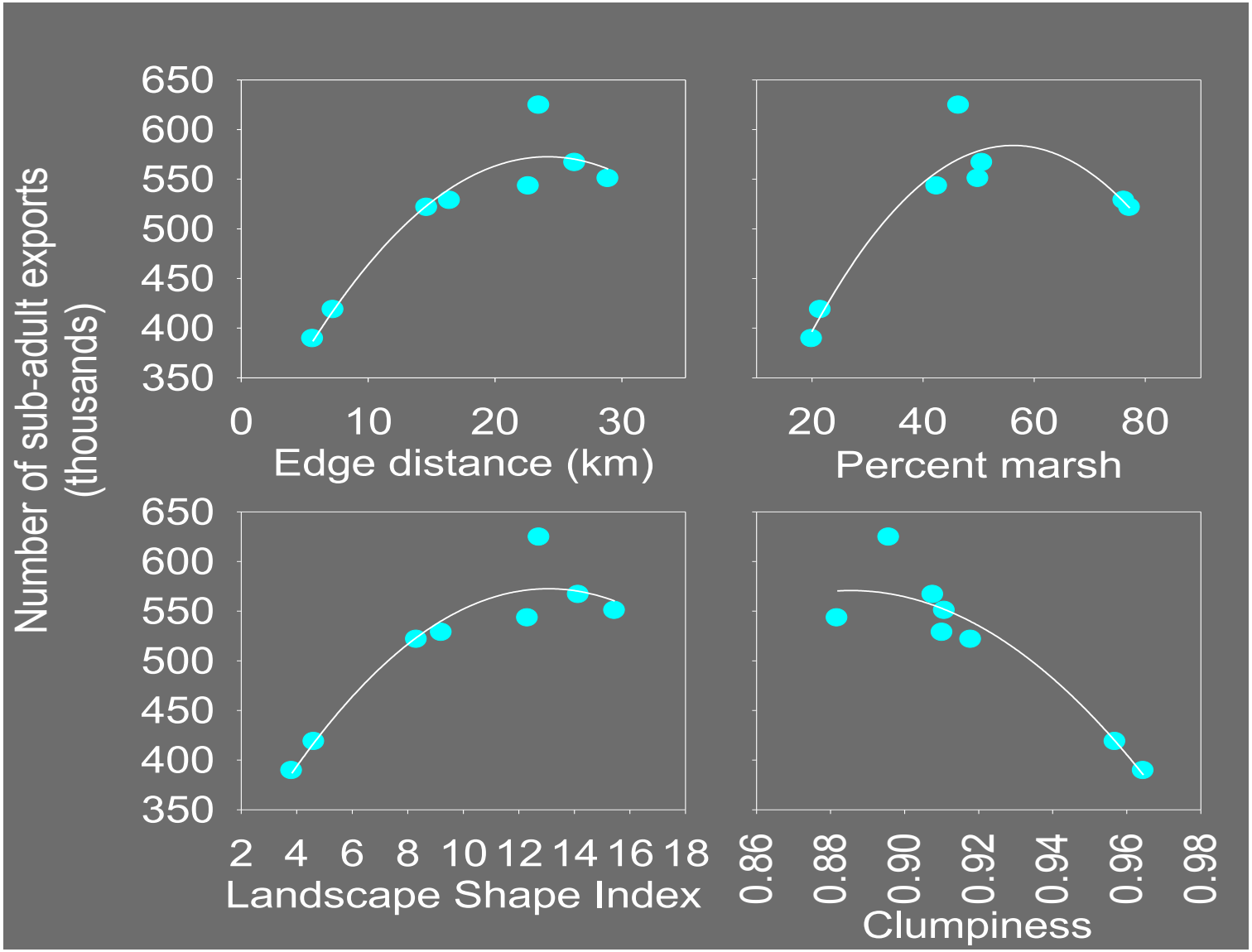
Model


Weekly
Cohort introduction
Growth rate
Initial location
Hourly
Movement
Water levels
Attraction
Size
Attraction
Random
Emergency
Depth
Mortality
Size, movement, habitat
Growth
Location, density, temperature
70mm?
Export
Growth production
Trophic transport

Corroboration: Density Patterns



Landscape influences shrimp export…

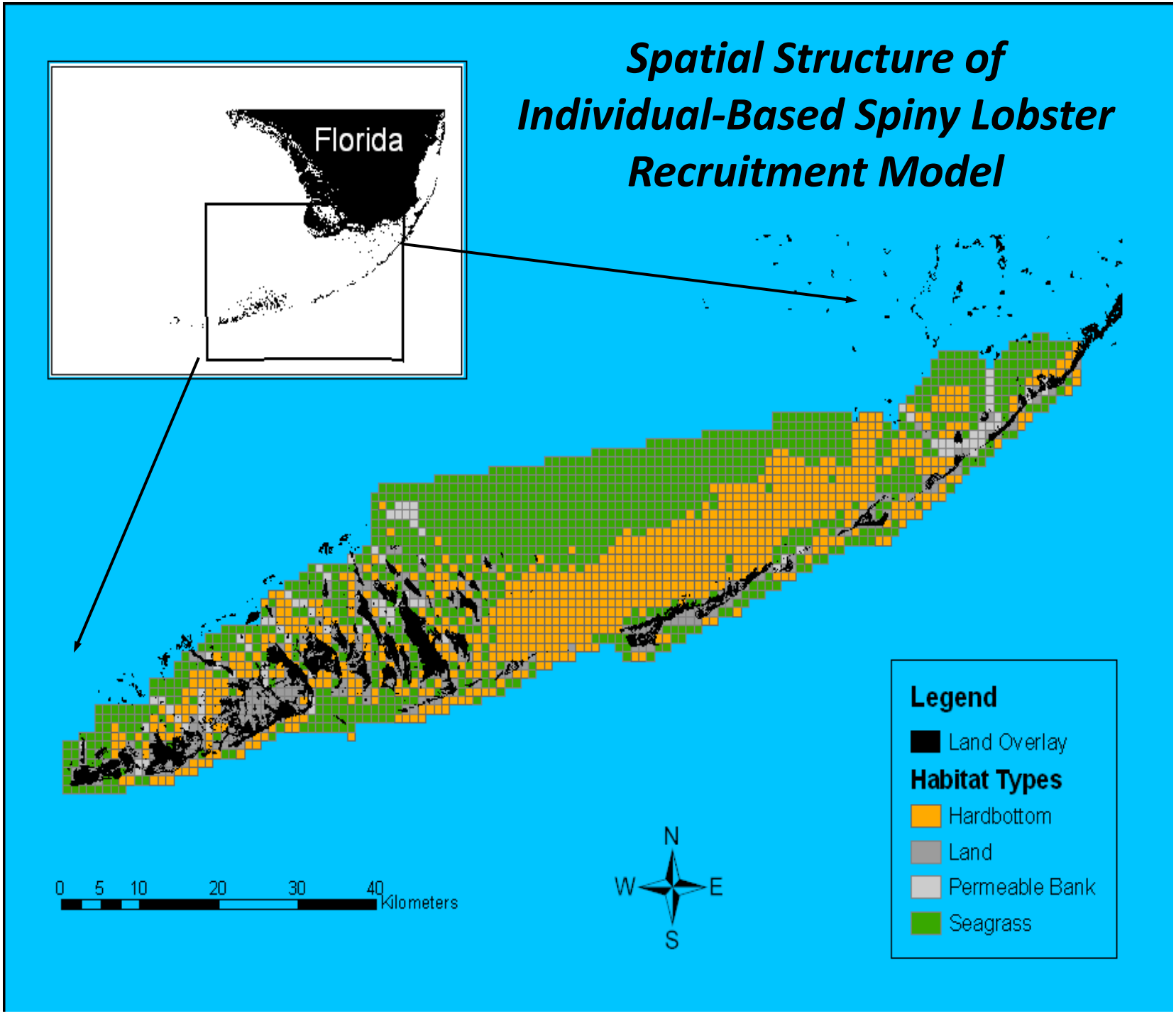


Do these marshes function similarly?

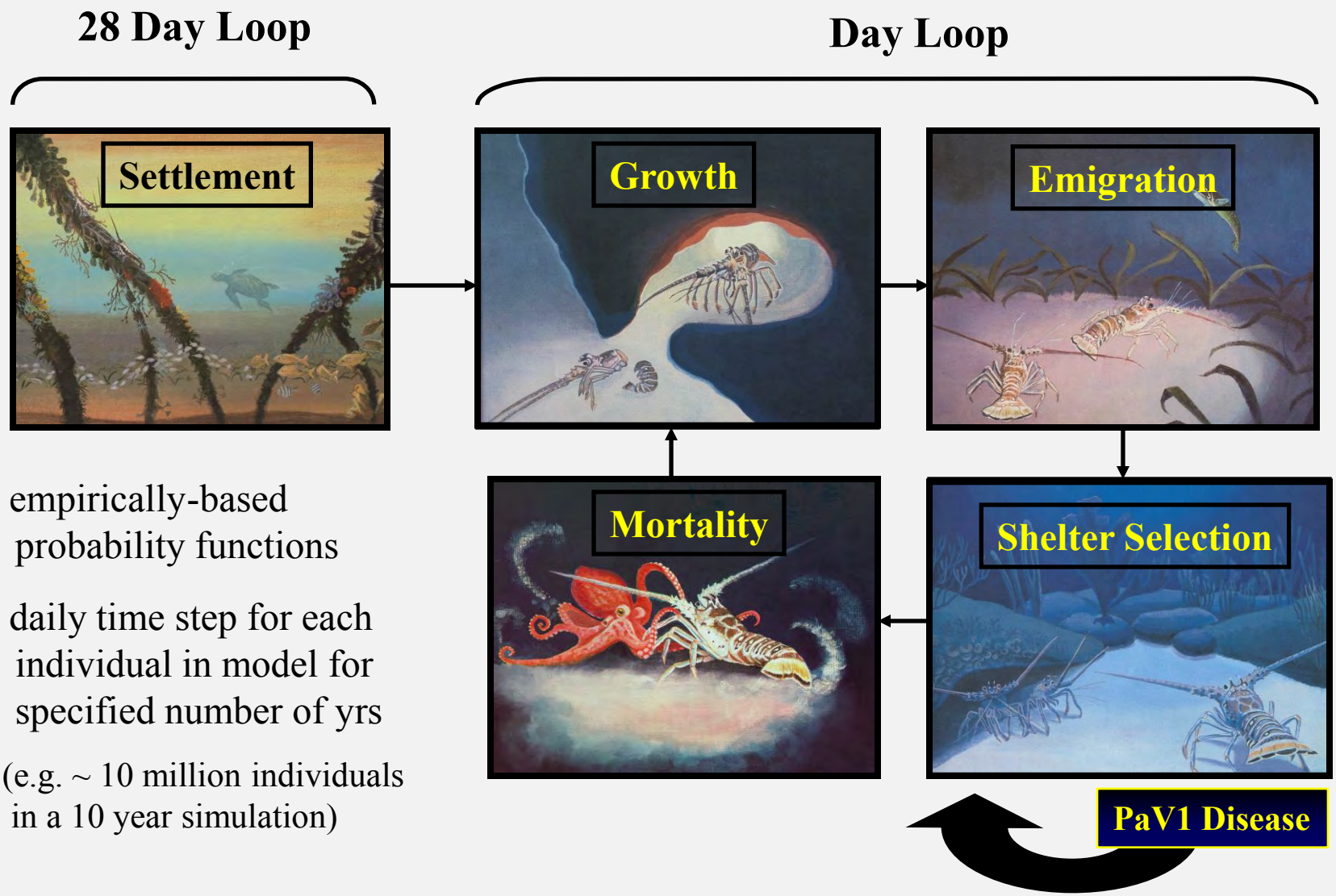
Courtesy of Lawrence Rozas

Example 2: Spiny Lobster

Butler, M.J., J.H. Hunt, W.F. Herrnkind, K.A. Rose, and T. Dolan. 2005. Ecological Applications 15:902-918.


Spatial Structure of Individual-Based Spiny Lobster Recruitment Model
Florida
0 5 10 20 30 40
Kilometers
N
W
E
S
Legend
Land Overlay
Habitat Types
Hardbottom
Land
Permeable Bank
Seagrass

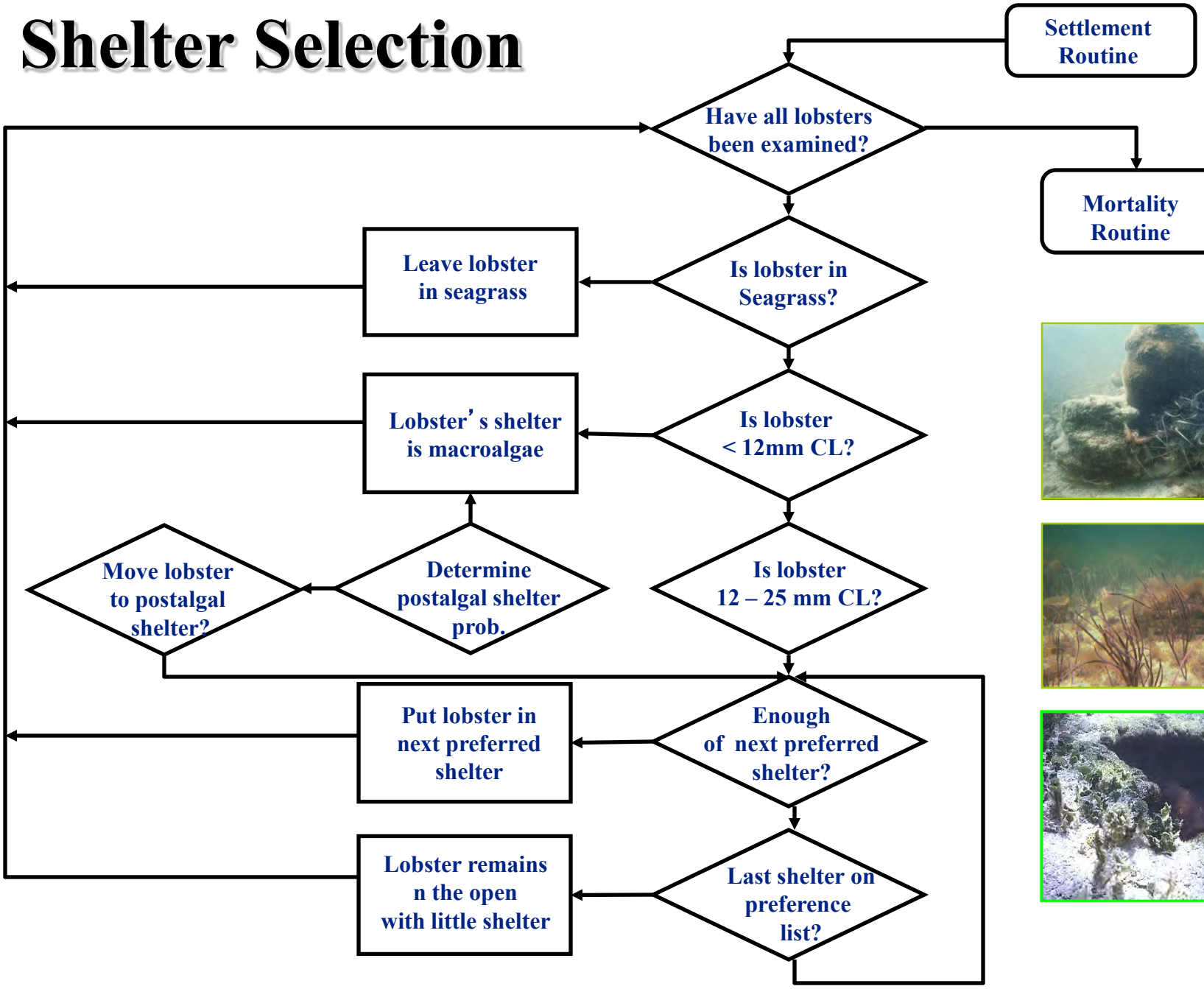
Individual-based Population Dynamics



- empirically-based probability functions
- daily time step for each individual in model for specified number of yrs

(e.g. ~ 10 million individuals in a 10 year simulation)

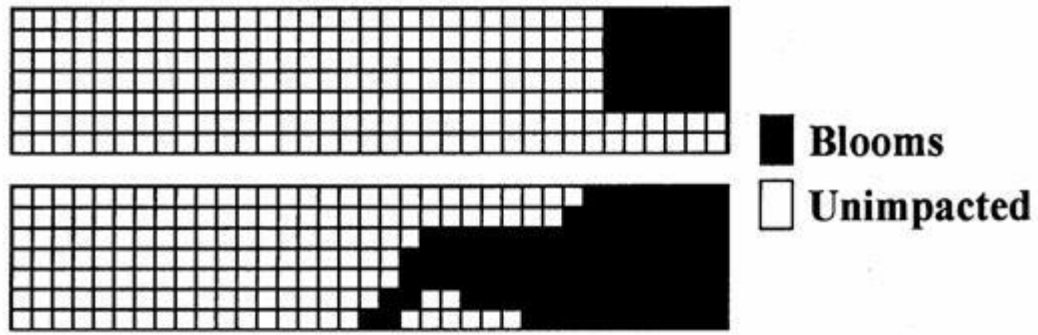
Shelter Selection



Massive Habitat Loss

- Blue-green algal blooms killed about 60% of all sponges in bloom-impacted areas

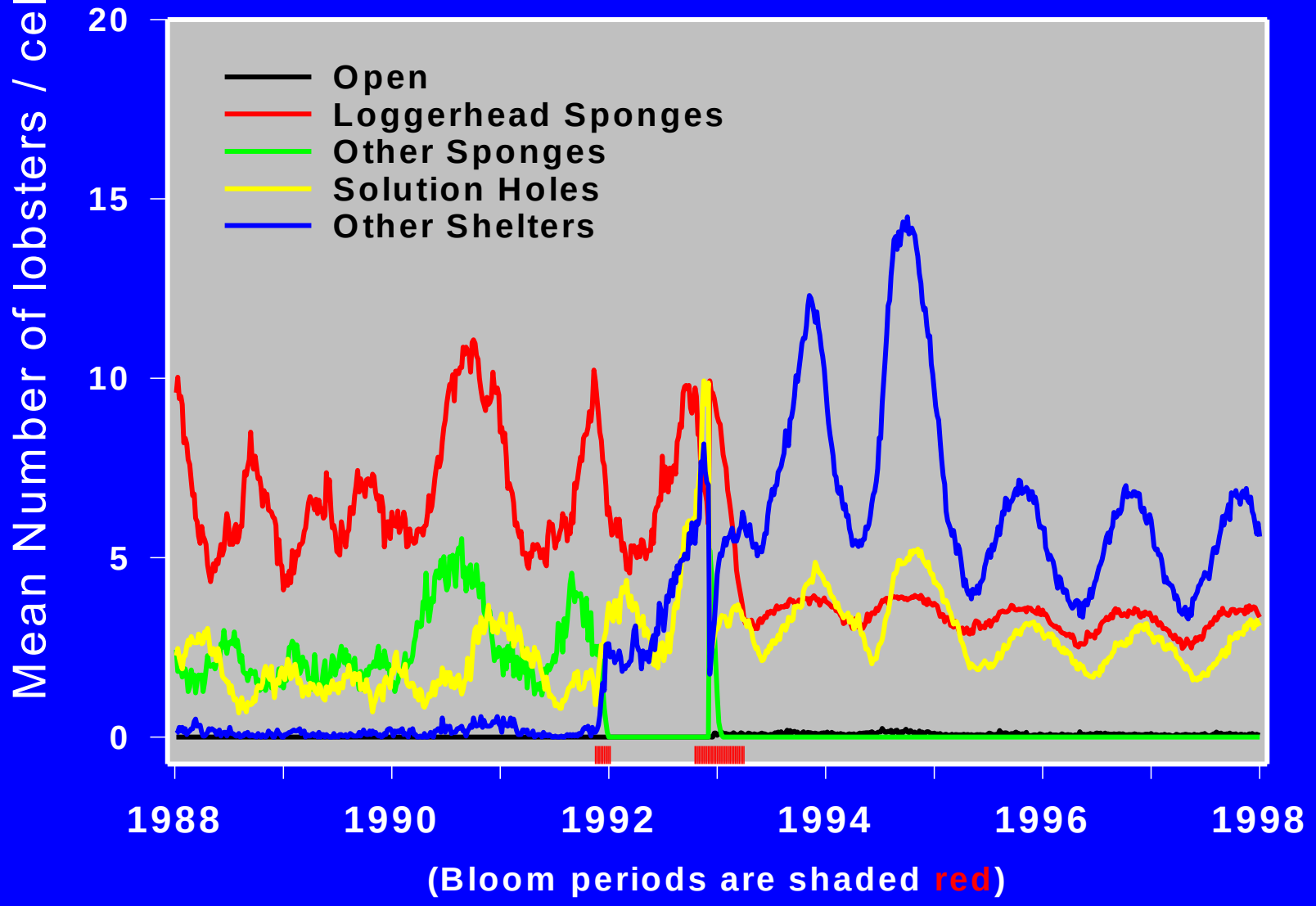
- 1991: November 15 through January 2



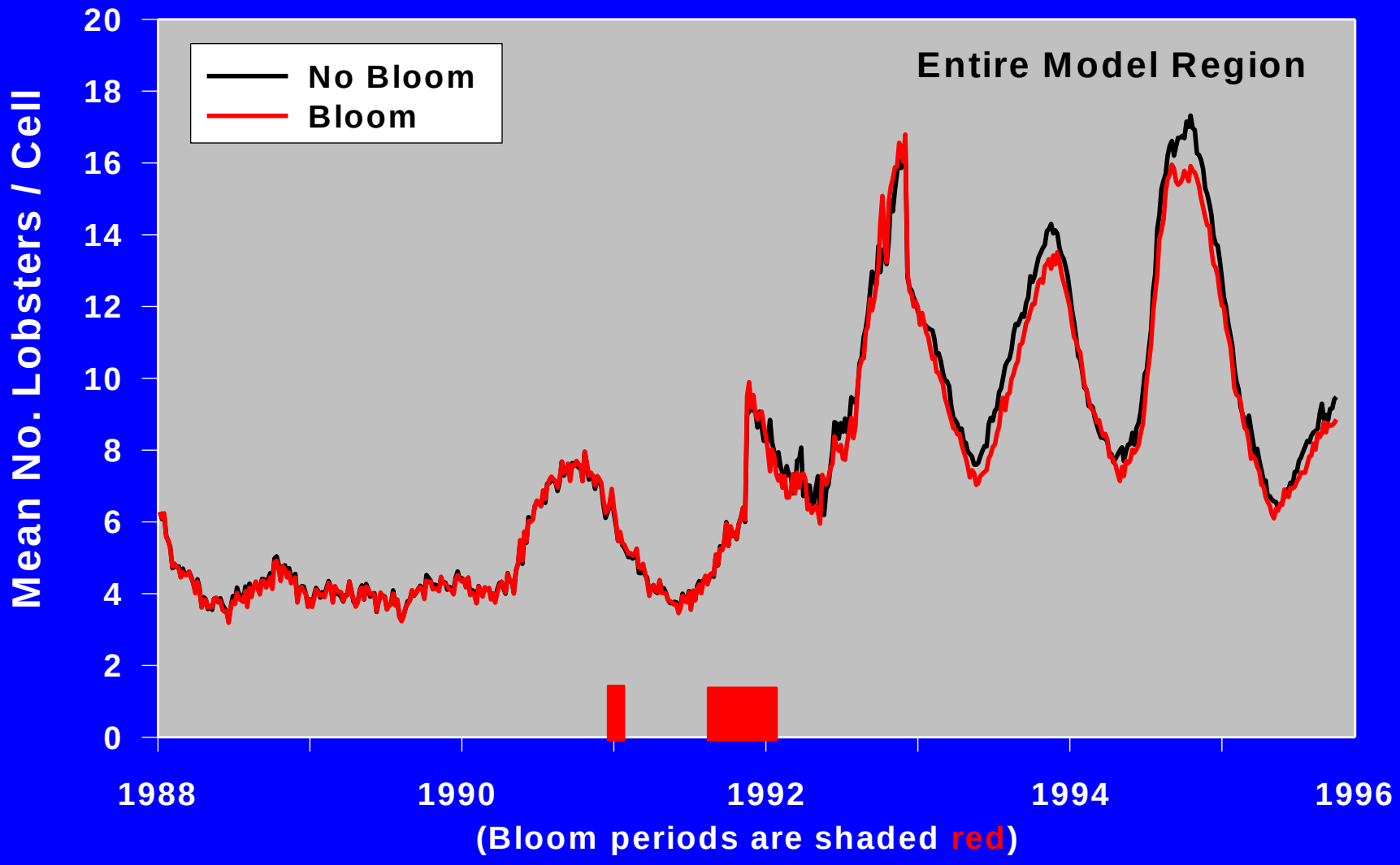
- 1992: October 1 through January 27

Predicted Effect of Bloom on Lobster Shelter Use

Perturbed Region



Predicted Effect of Habitat Change on Juvenile Lobster Abundance

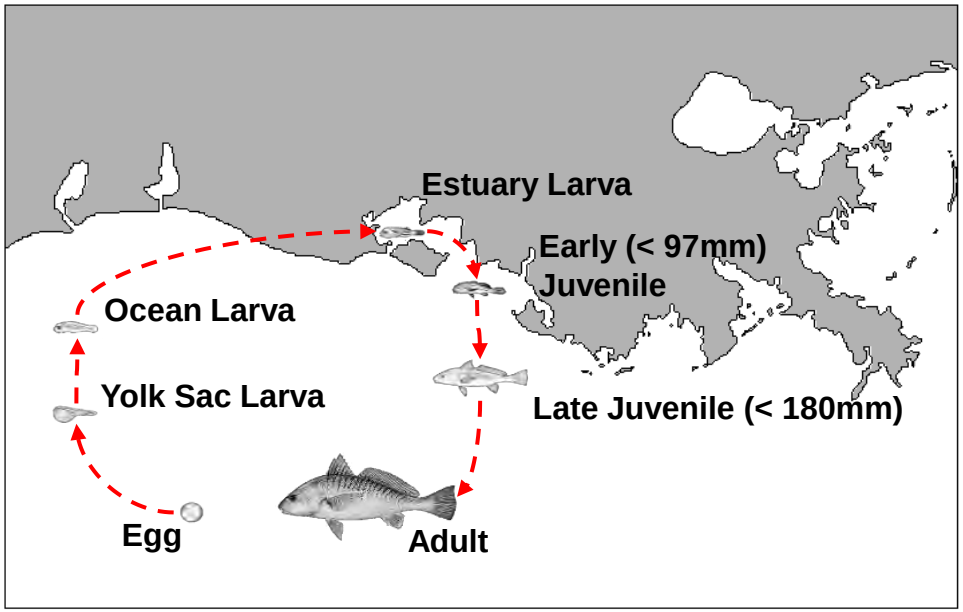


Example 3: Croaker

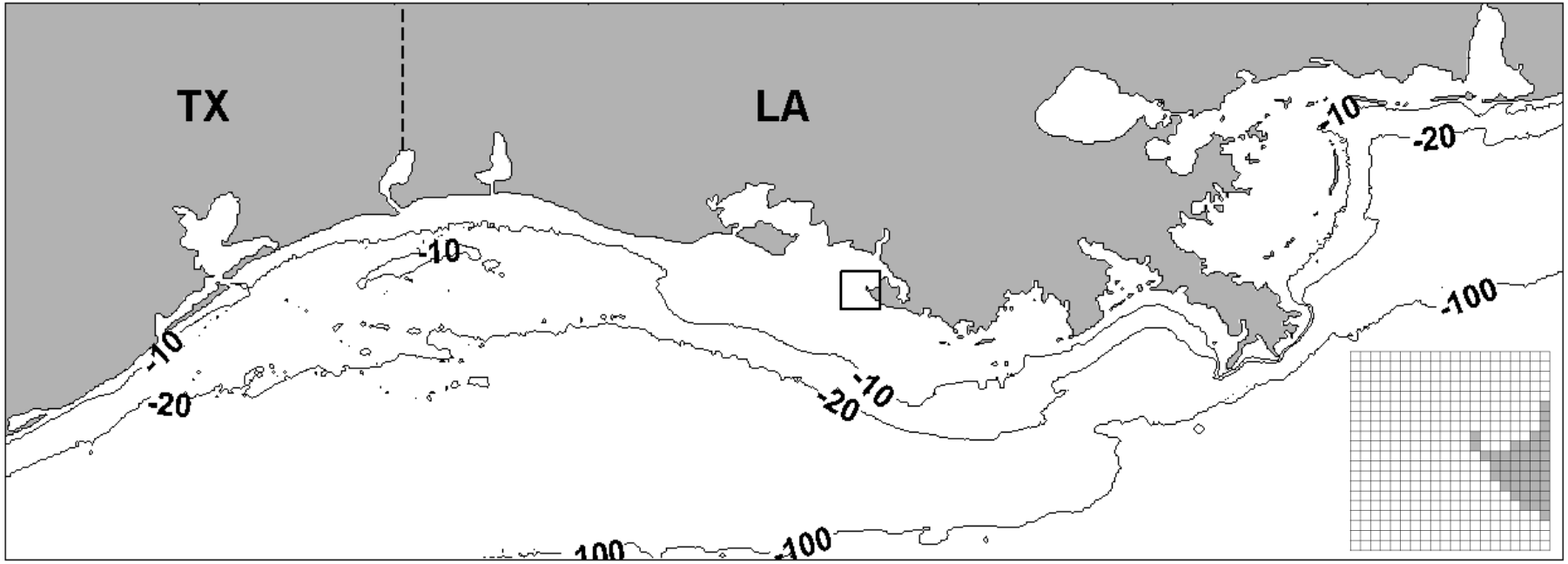
Rose, K.A., S. Creekmore, D. Justic, P. Thomas, J.K. Craig, R. Miller Neilan, L. Wang, Md S. Rahman, and D. Kidwell. In review. Modeling the population effects of hypoxia on Atlantic croaker (*Micropogonias undulat*us) in the northwestern Gulf of Mexico: Part 2 – Realistic hypoxia and eutrophication

Model Overview

- Spatially explicit, IBM
  - Follows 7 stages to age 8
  - September 1 birthday
  - Model year begins Sept. 1
  - Each year 365 days long
- Hourly processes
  - Growth
  - Mortality
  - Reproduction
  - Movement (routine & avoidance)
- Environmental conditions simulated on a 2-D spatial grid
  - Climatological temperature
  - Climatological surface Chl-a
  - Dissolved oxygen from 3-D hydrodynamics-WQ model

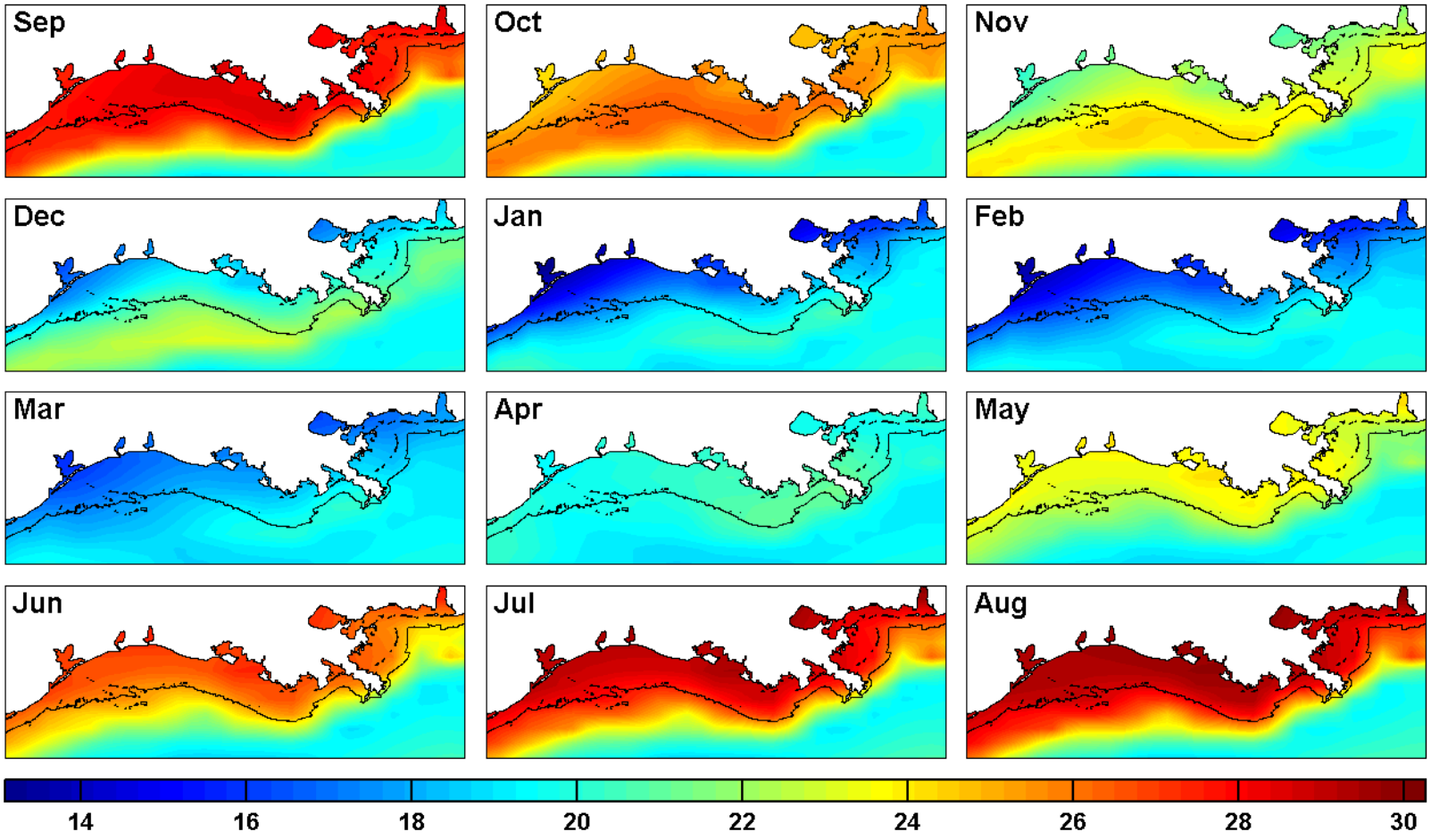


Model Grid



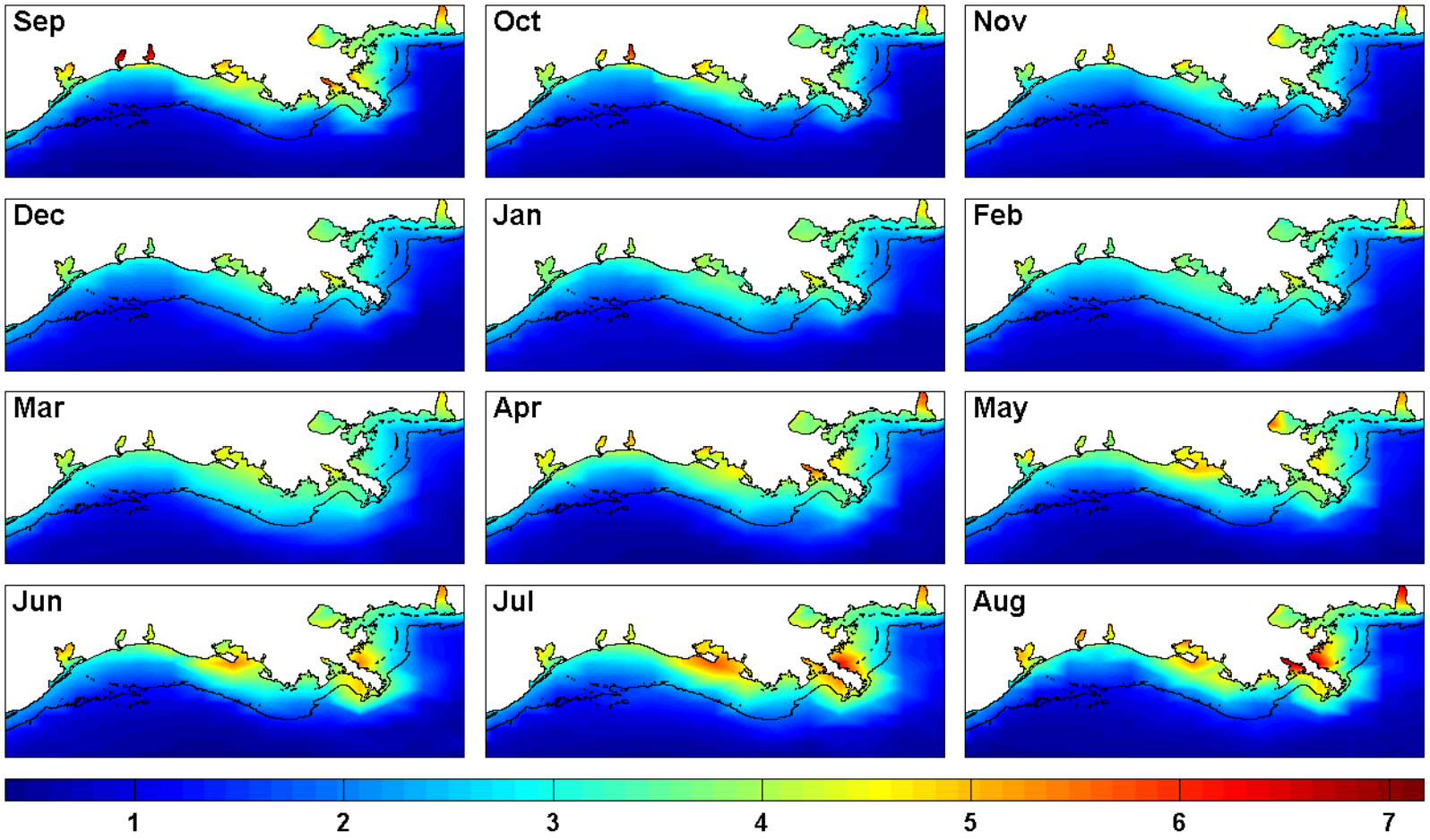
- Idealized 300 x 800 cell grid (1 km resolution)
- Bottom elevation for each cell is truncated beyond 100 m

Temperature

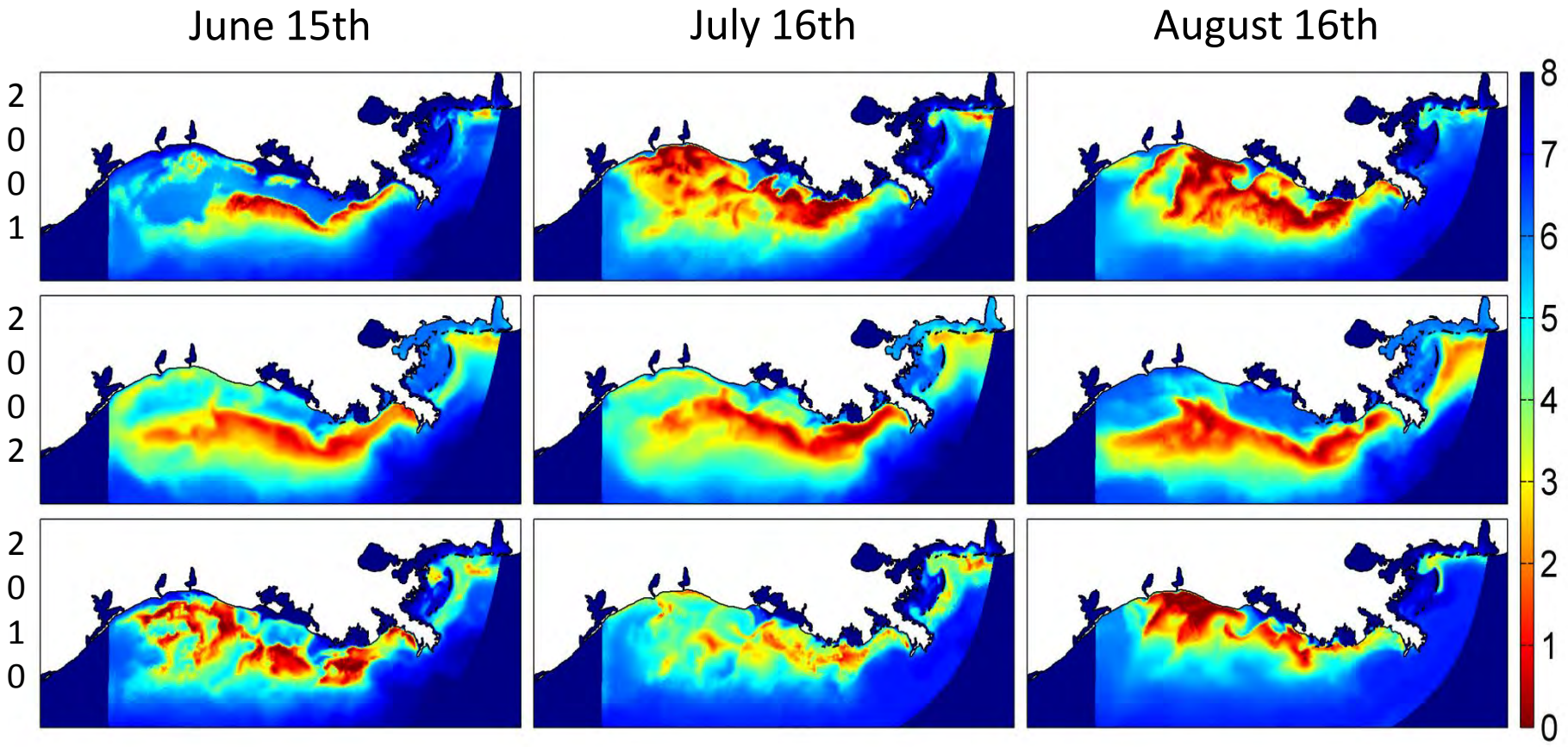


Chlorophyll-a

(mg/m³, sqr-transformed)

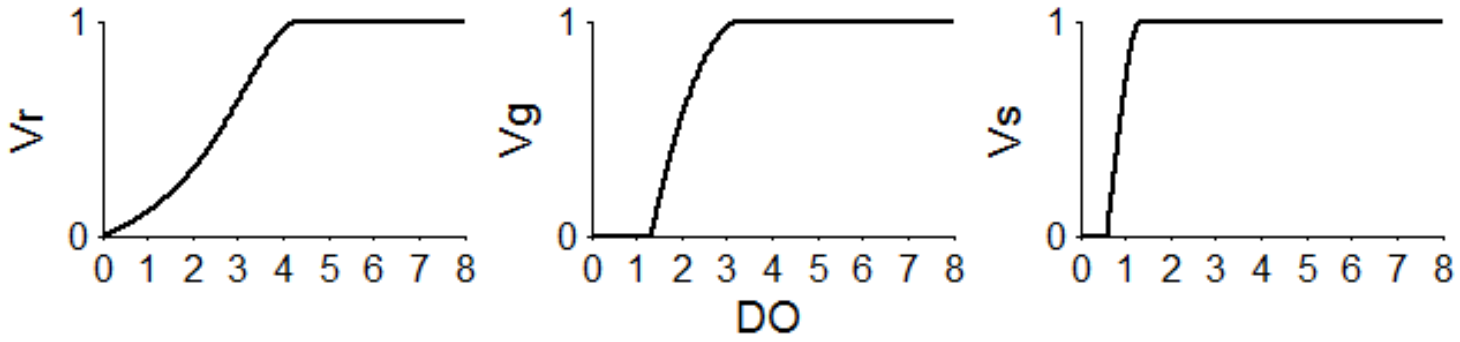


Dissolved Oxygen



Direct Effects of Low DO

- Exposure-effects sub-models (Neilan and Rose 2014)

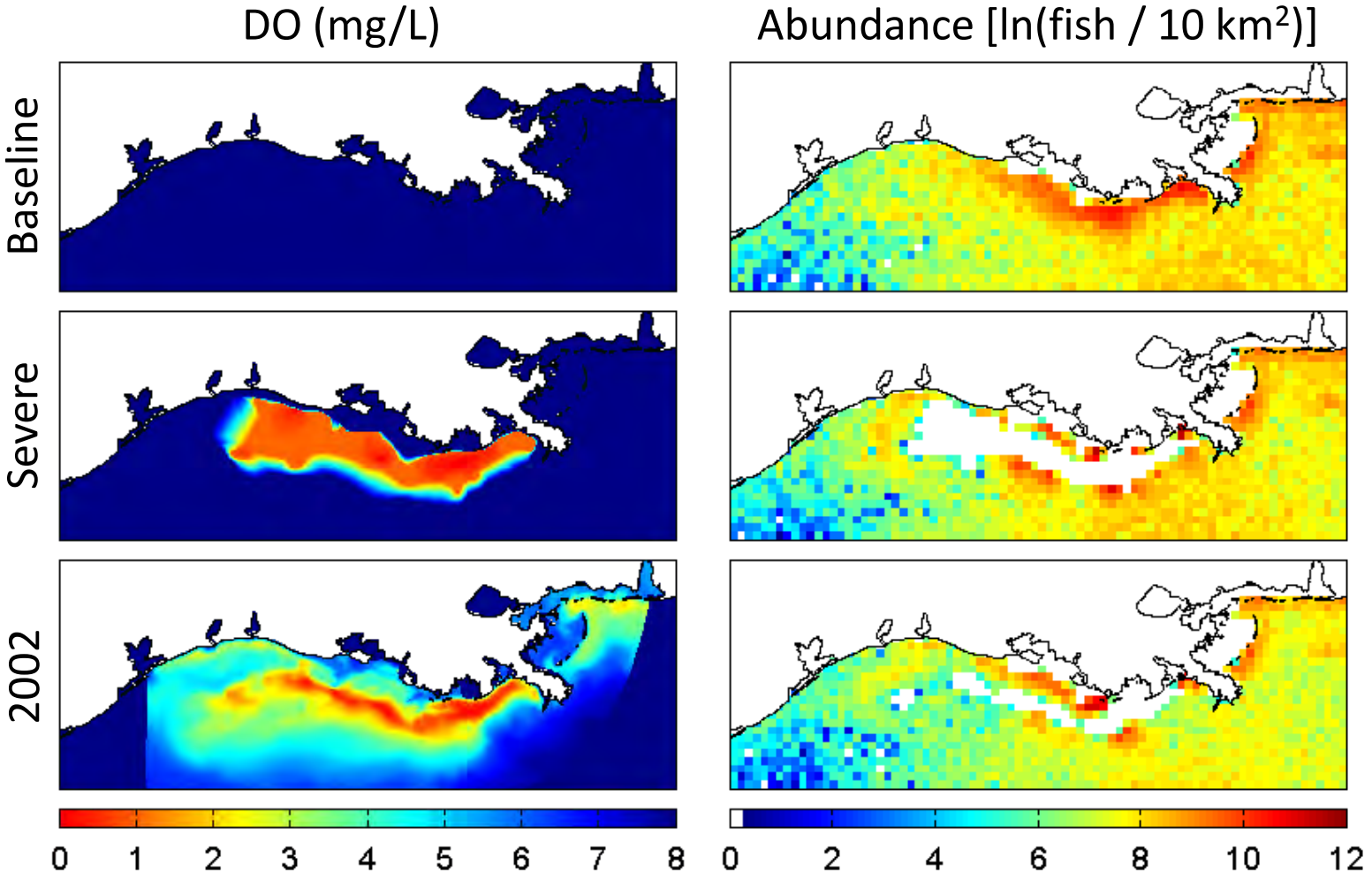


- Estimated from experiments (Thomas and Rahman 2012, Rahman and Thomas 2012)

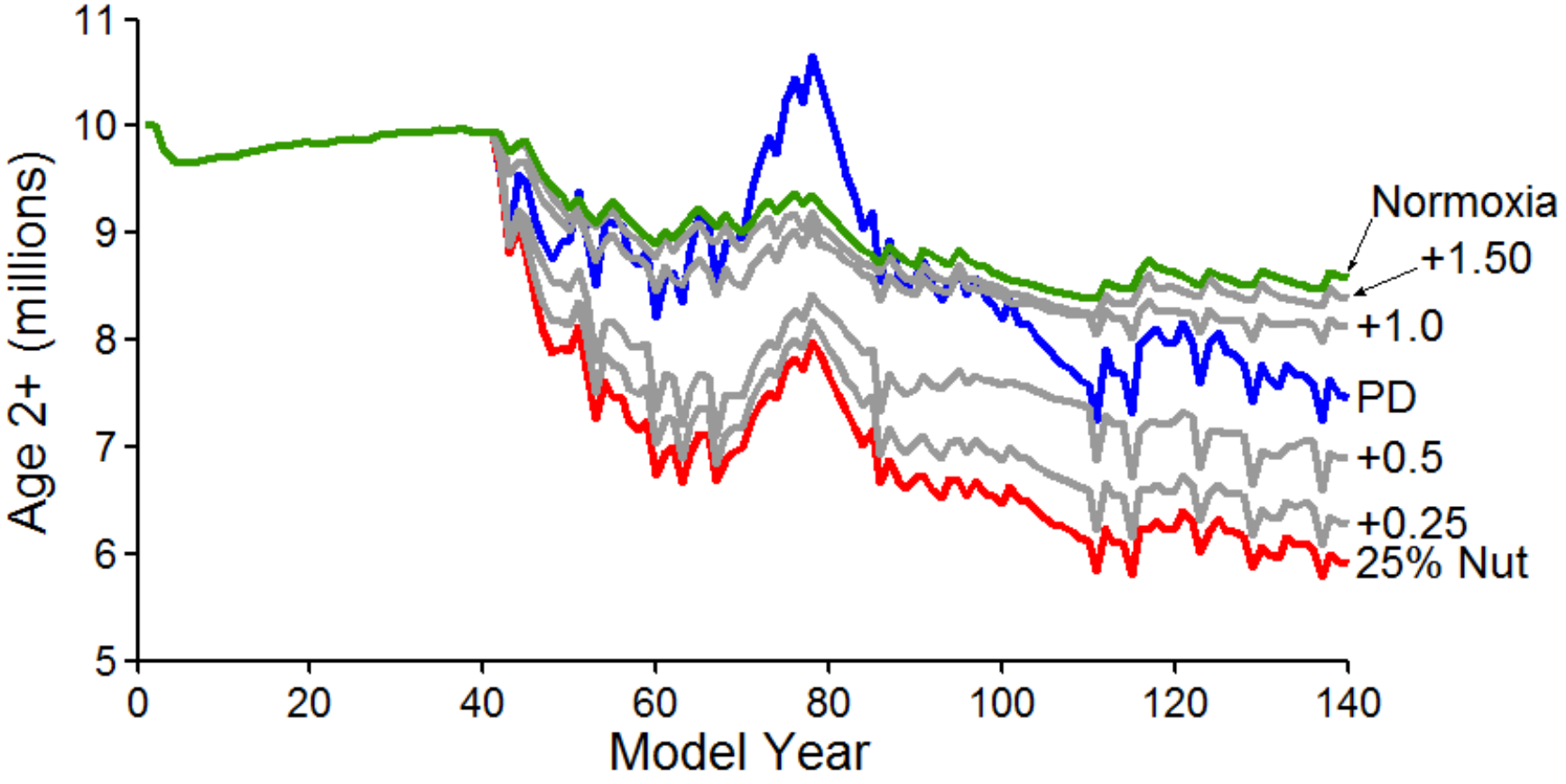
- Only imposed on late juveniles, age-1, and age-2

Avoidance

(July 16th)



25% Reduced Nutrient Loadings

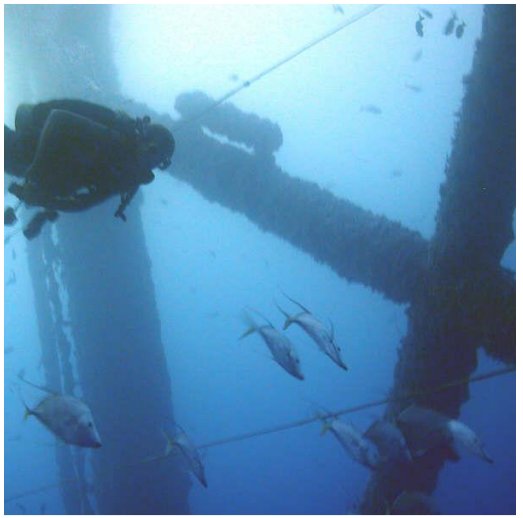


Example 4: Red Snapper

Campbell, M.D., K.A. Rose, K. Boswell, and J.H. Cowan. 2011. Ecological Modelling 222:3895-3909.

Introduction

Coastal Louisiana Habitats
Petroleum Platforms
Artificial Reef Communities
Construction/Deconstruction

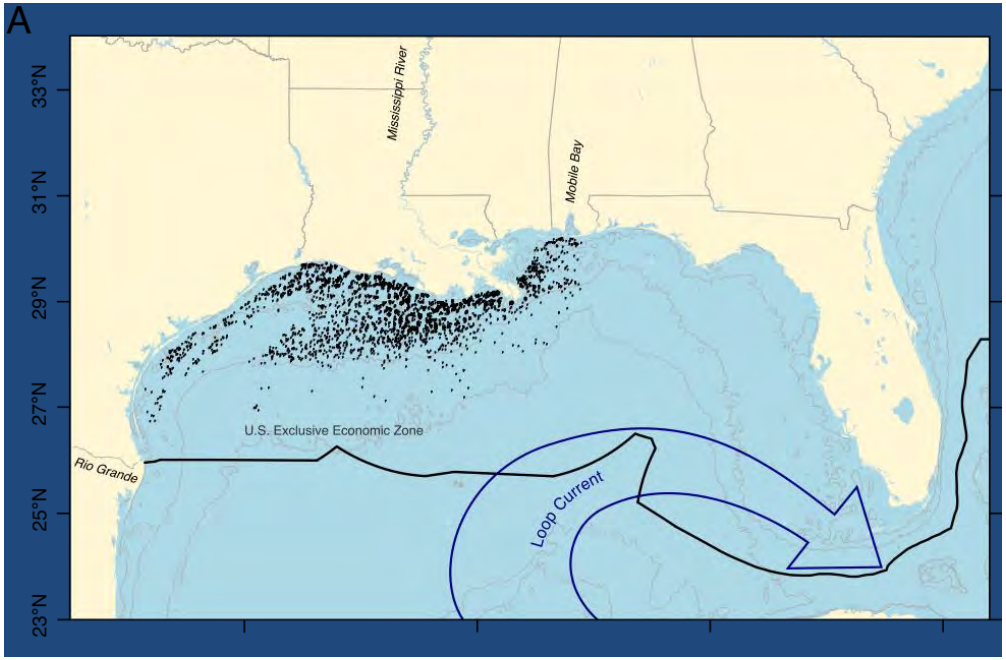


Dismantling unused oil rigs could boost Louisiana's artificial reef program

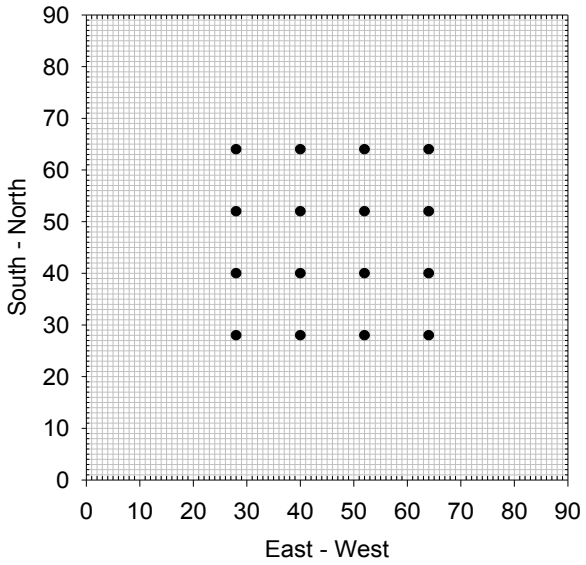
By Richard Thompson, Times-Picayune
Sunday, October 24, 2010

What is the effect of increasing the number and spacing of artificial reefs on:

- Species movement patterns
- Species abundance and productivity
- Prey densities around platform – halo effect



Spatial Grid



Designate Habitat

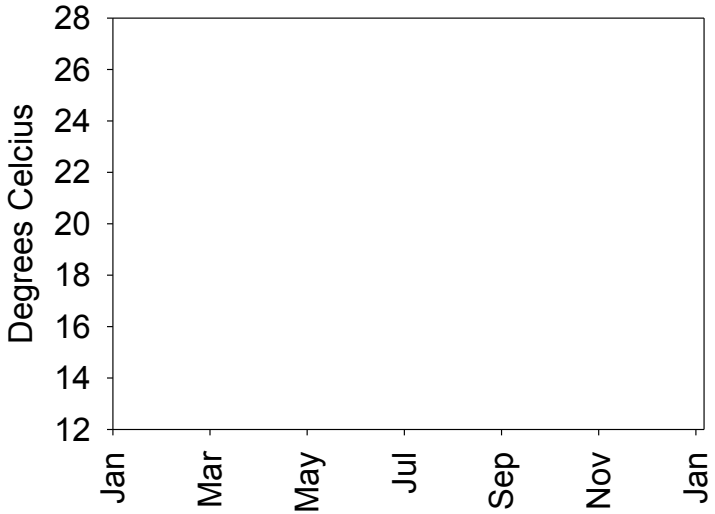
- 90 x 90 cells , 324 km^2
- Each cell is 4000 m^2
- Cells are rig or benthic

Prey Distribution

- 5 prey types: copepods, shrimp, crabs, pelagic fish, and benthic fish
- Prey population on each cell updated hourly with logistic

Temperature

- Assumed to be constant across the grid
- Function of calendar day

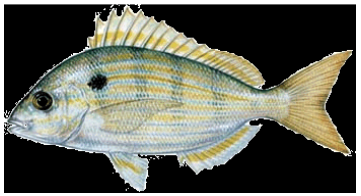


Fish Community and Species Types

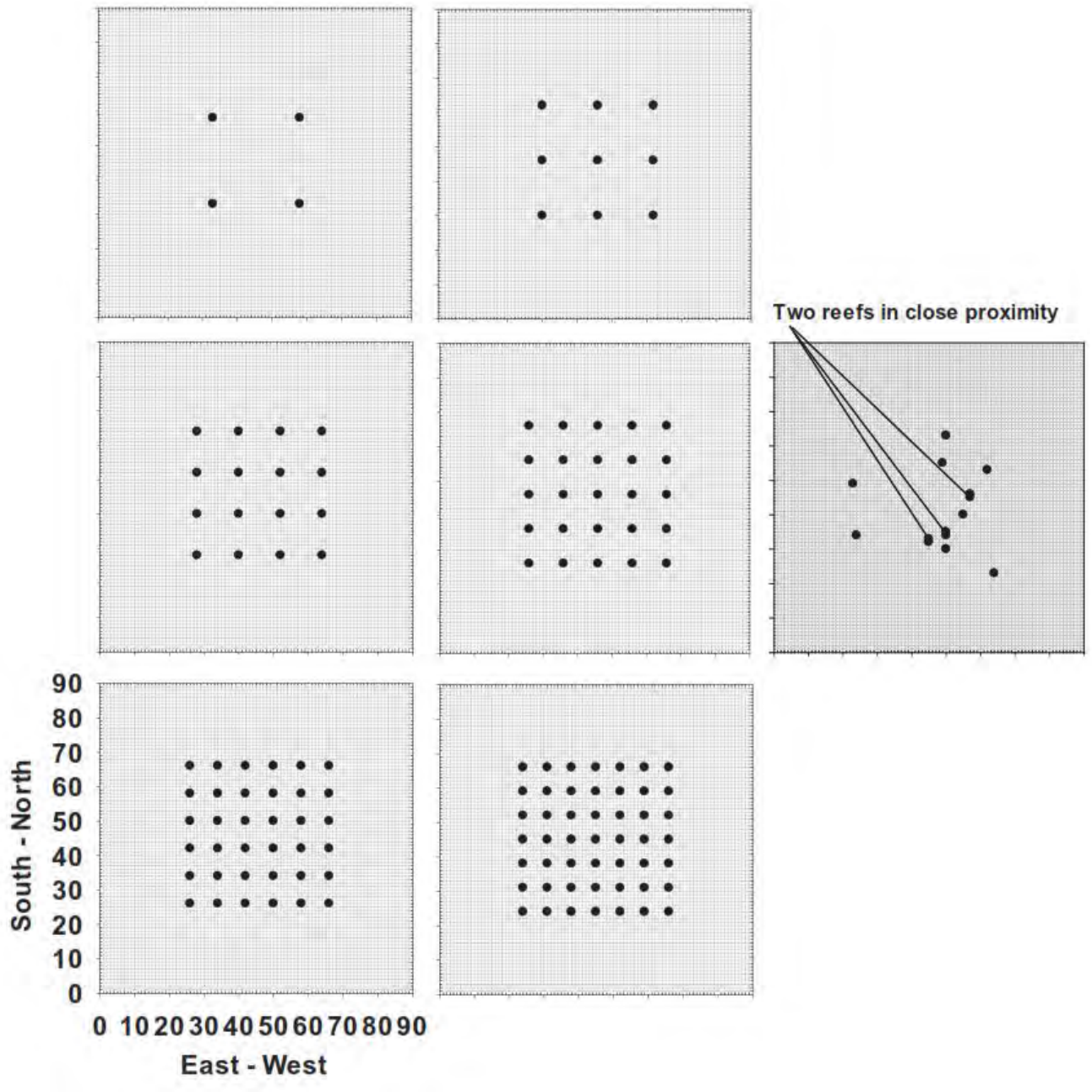
Primary Community:
- Red snapper, pinfish, Atlantic croaker
- Movement, consumption, growth
- Mortality and recruitment

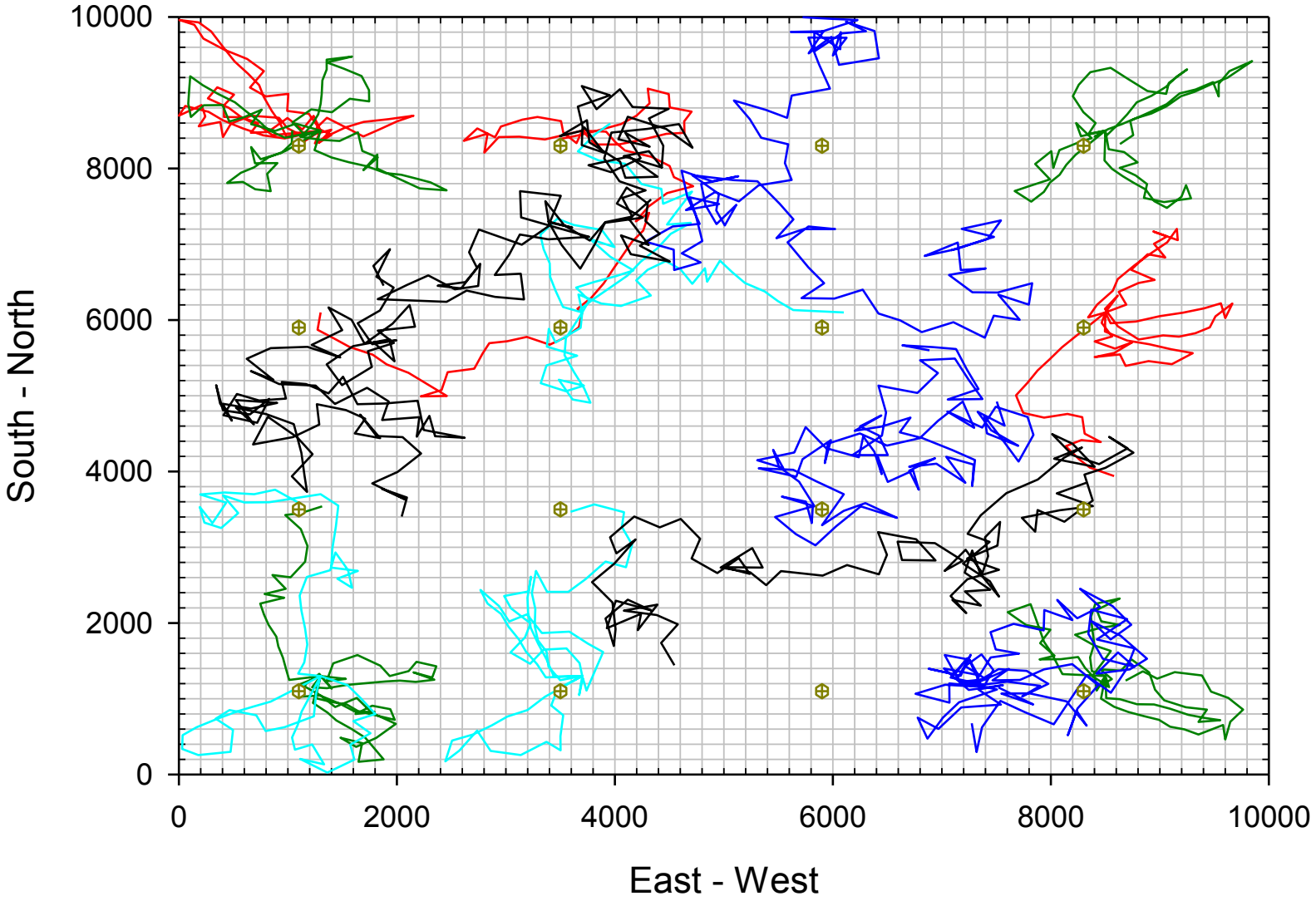
Competitor and Predator:
- Bluefish
- Movement, consumption, and predation
- Influence on primary community

Predator Only:
- Jack spp.
- Movement and predation
- Influence on primary community



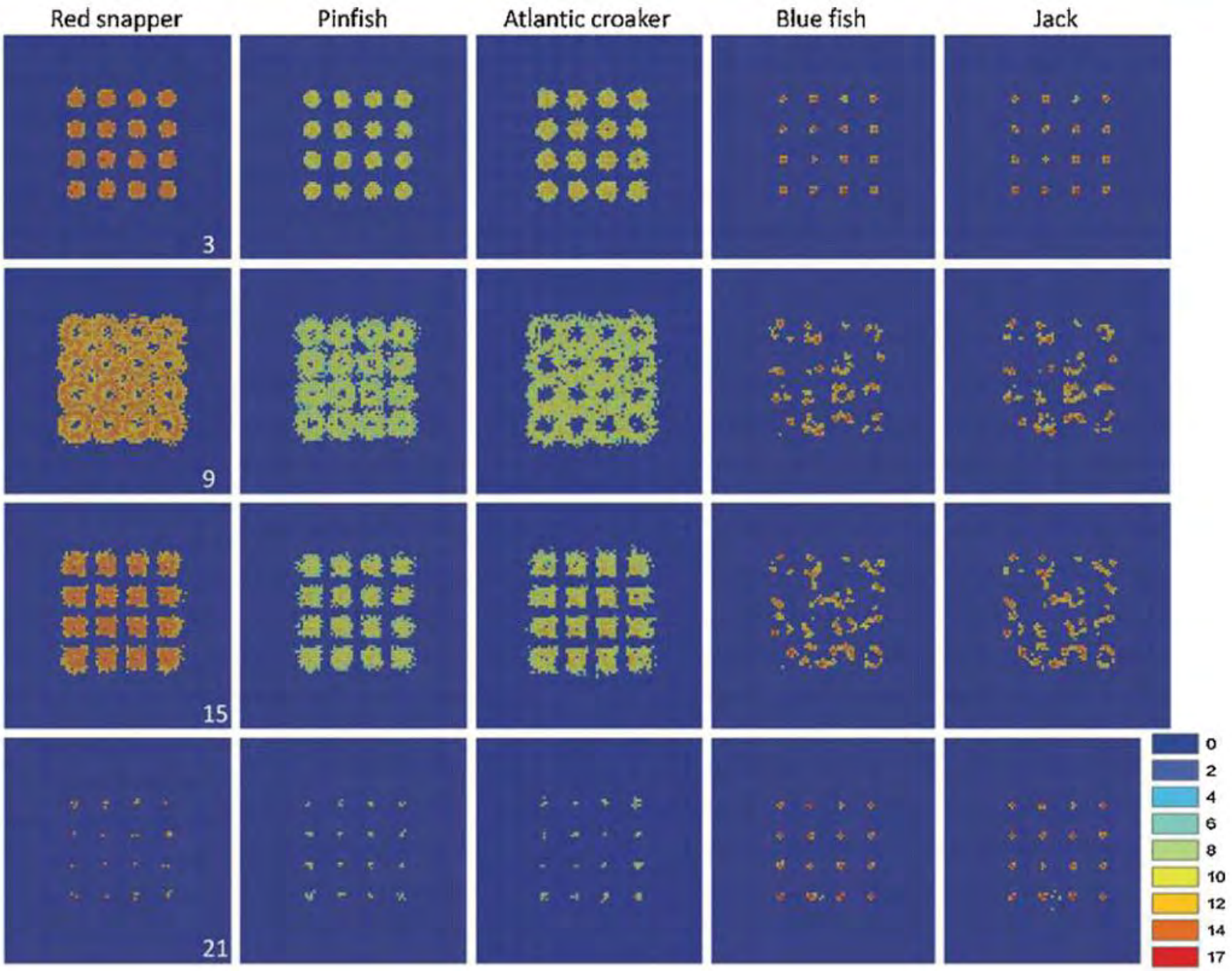
Photos courtesy of - http://floridasportfishing.com
* Not to scale

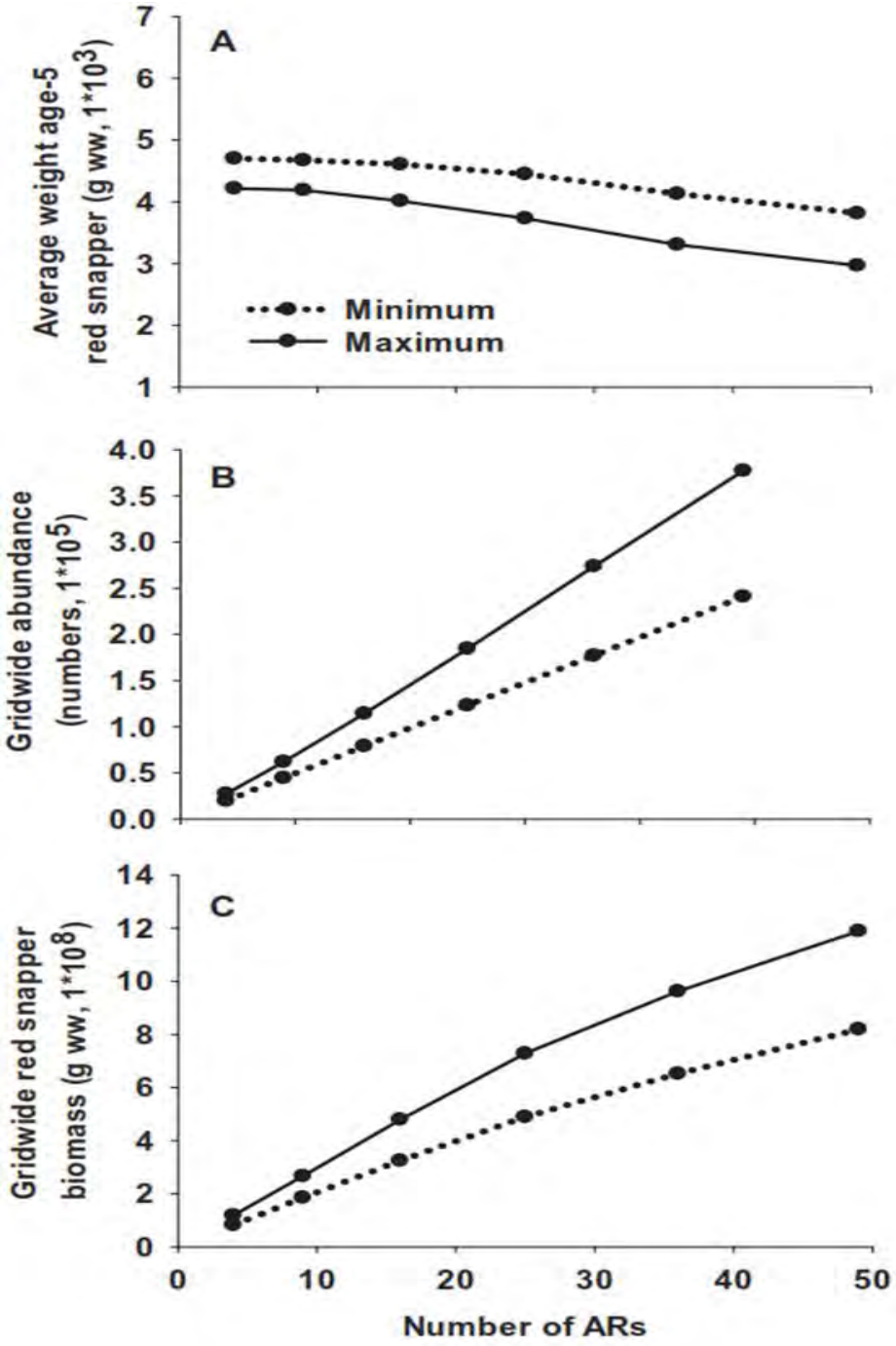

Two reefs in close proximity
South - North
0
10
20
30
40
50
60
70
80
90
0 10 20 30 40 50 60 70 80 90
East - West



Hourly positions during four days in year 20 of a 16 AR simulation

red snapper (red), pinfish (green), Atlantic croaker (light blue), bluefish (blue), jack-like species (black)


Red snapper
Pinfish
Atlantic croaker
Blue fish
Jack
3
9
15
21
0
2
4
6
8
10
12
14
17


A
Average weight age-5 red snapper (g ww, 1*10^3)
Minimum
Maximum
B
Gridwide abundance (numbers, 1*10^5)
C
Gridwide red snapper biomass (g ww, 1*10^8)
Number of ARs

Insights?

- Capabilities for assessing habitat effects on upper trophic level dynamics seems:
  - Limited
  - Stalled: from capacity to abundance

- Behavioral movement drives the results

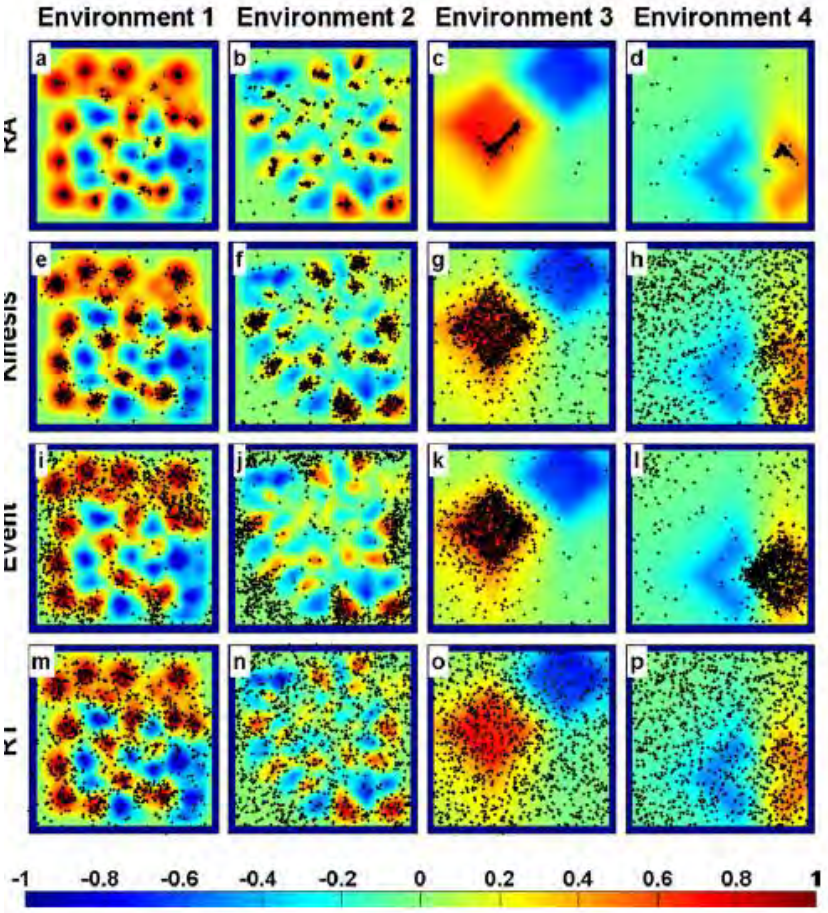
Insights?

- Integration of spatial and temporal scales across variables and linking to processes appears “arbitrary”

- We confuse inputs and emergent outputs?
  - Rule or random walk based approaches are inputs
  - Without considering the energetics and other costs of altered movements, we show that the code works

Insights?

- Decision-making
- Adaptive
- Costs
- Model coupling
- Validation data



Watkins and Rose. 2013.