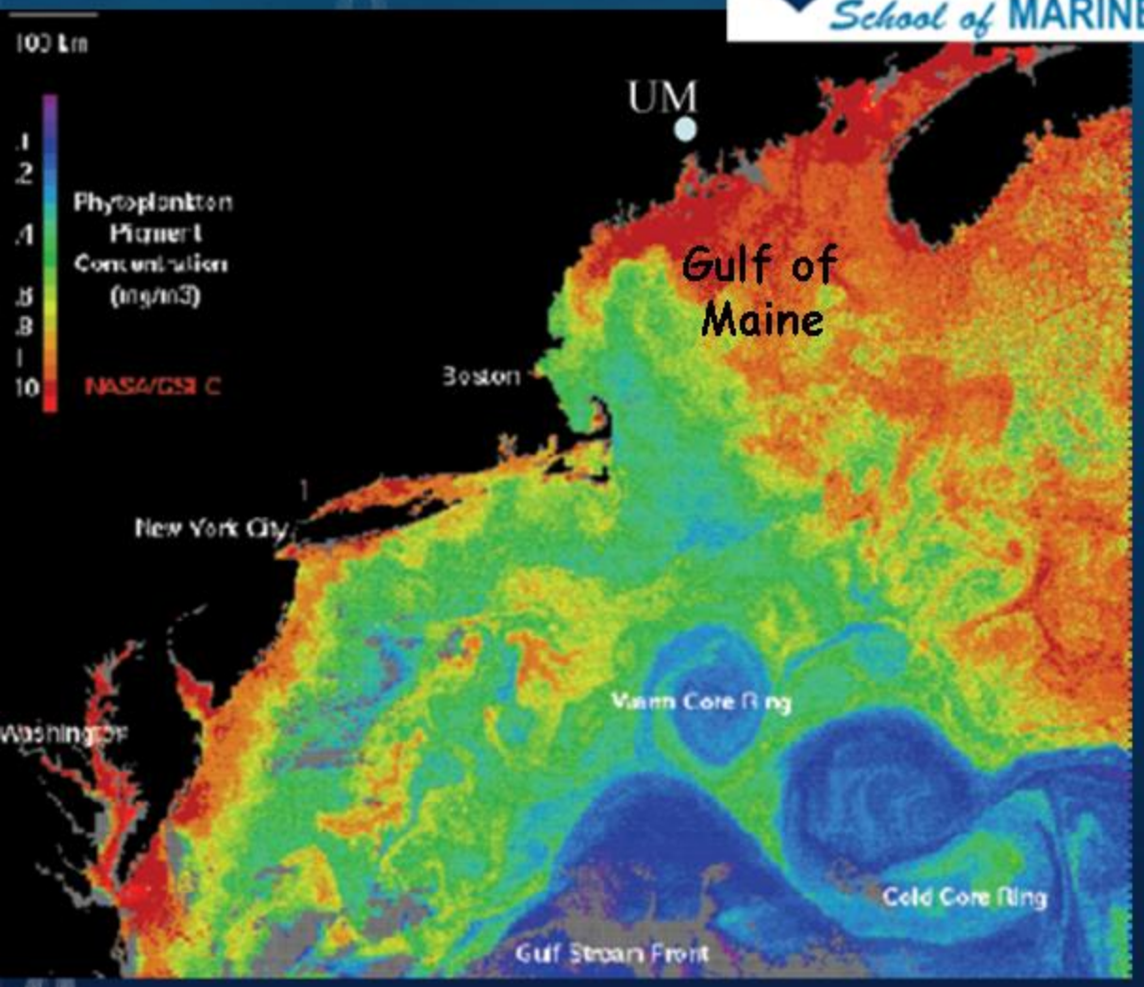
Connectivity of Lobster Populations in the Coastal Gulf of Maine

1865 THE UNIVERSITY OF MAINE
School of MARINE SCIENCES

Huijie XUE
Stephen Cousins
Lewis Incze
Richard Wahle
Andrew Thomas



2nd International Symposium
Effects of Climate Change on the World's Ocean,
May 13-20, 2012, Yeosu, Korea

Lobster Fishery in the Gulf of Maine
A Happy Story

Data Source: Maine DMR

The success has been attributed to:

Loss of predatory species (e.g., cod)
Fishing practices (e.g., trap & bait)
Management policies (legal size, v-notch, self governance, etc.)

Settlement Data

Wahle et al., 2003

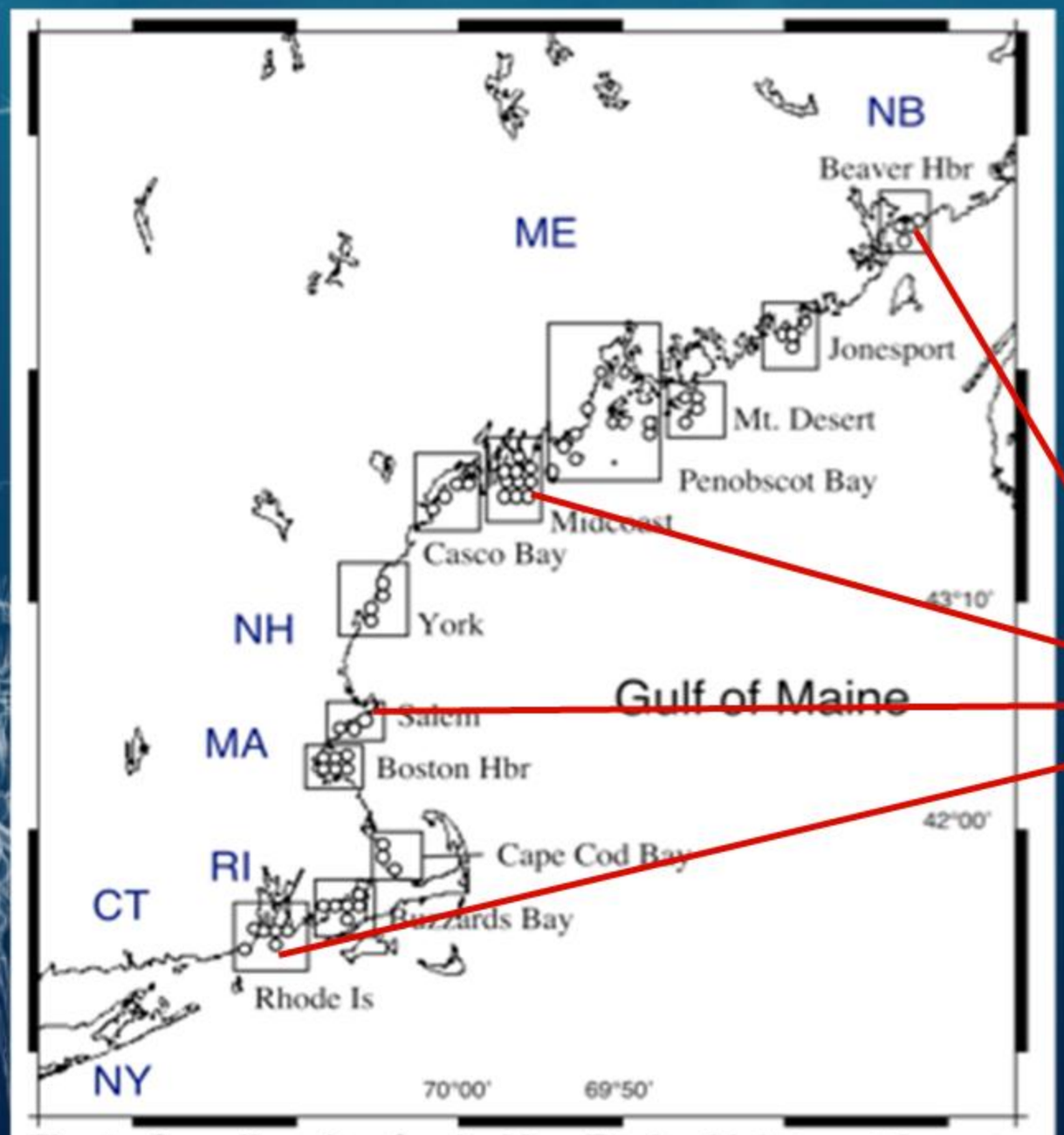


Fig. 1. Sampling sites for the New England lobster settlement index. Boxes surround sites used for regional averages shown in Fig. 2.

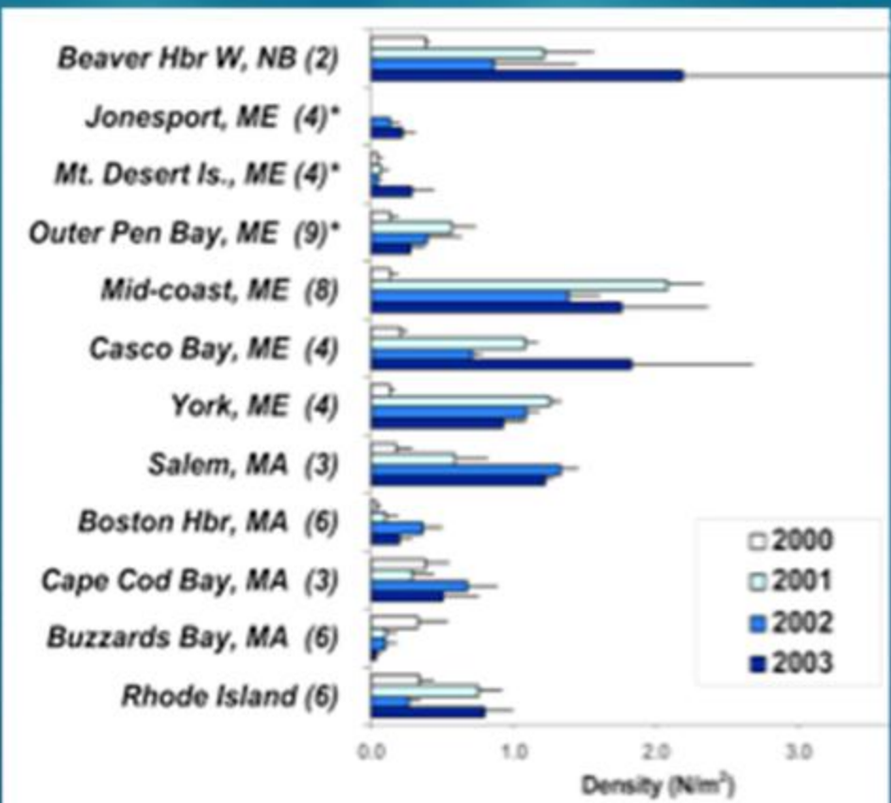


Fig. 2. Regional average lobster settlement throughout New England from 2000 to 2003. In parentheses, the number of sites included in the regional mean. * Some sampling sites in Jonesport, Mt Desert and Penobscot Bay have changed in the past 2 years, so time trends may not be reliable.

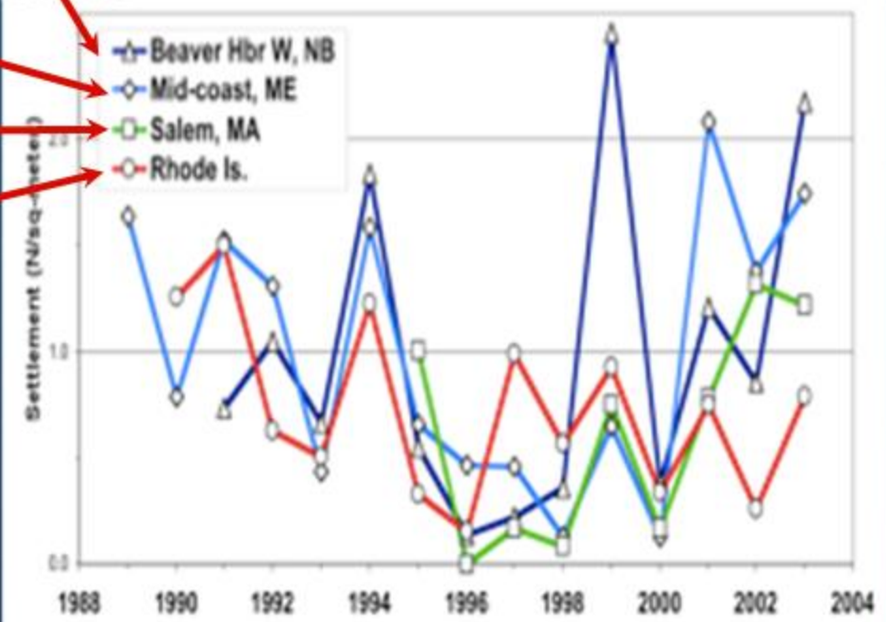
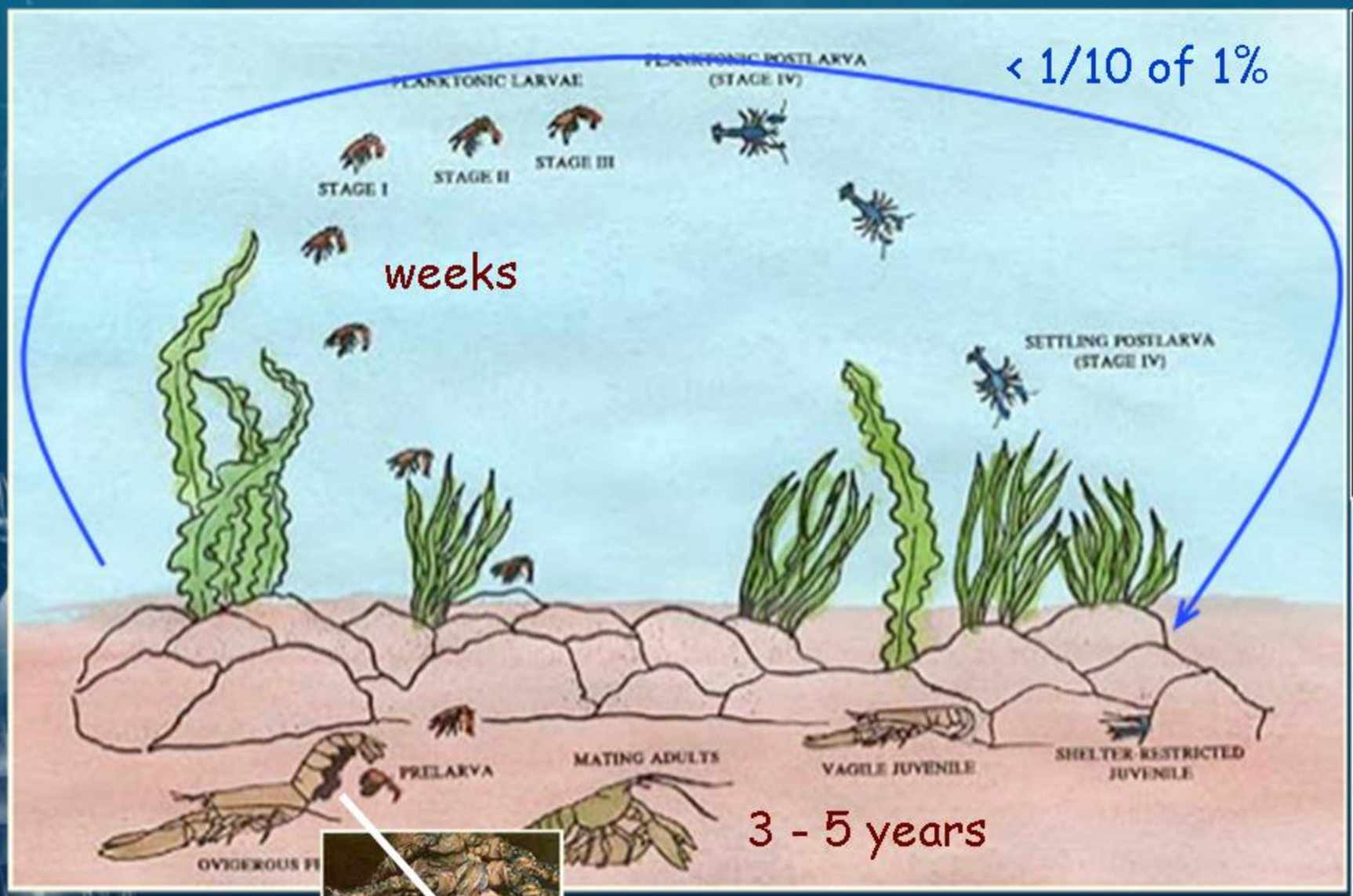


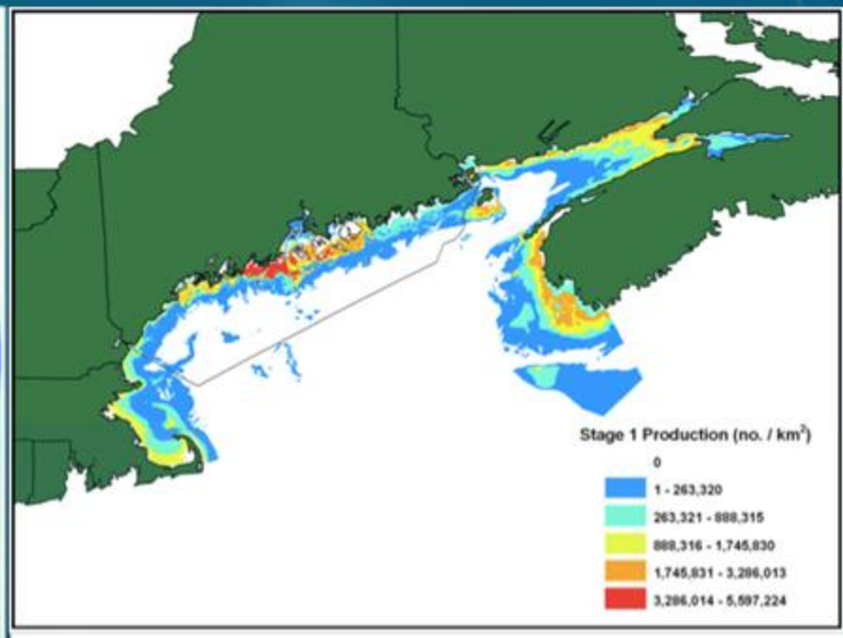
Fig. 3. Lobster settlement index time series for four selected regions spanning the full length of coastline surveyed.

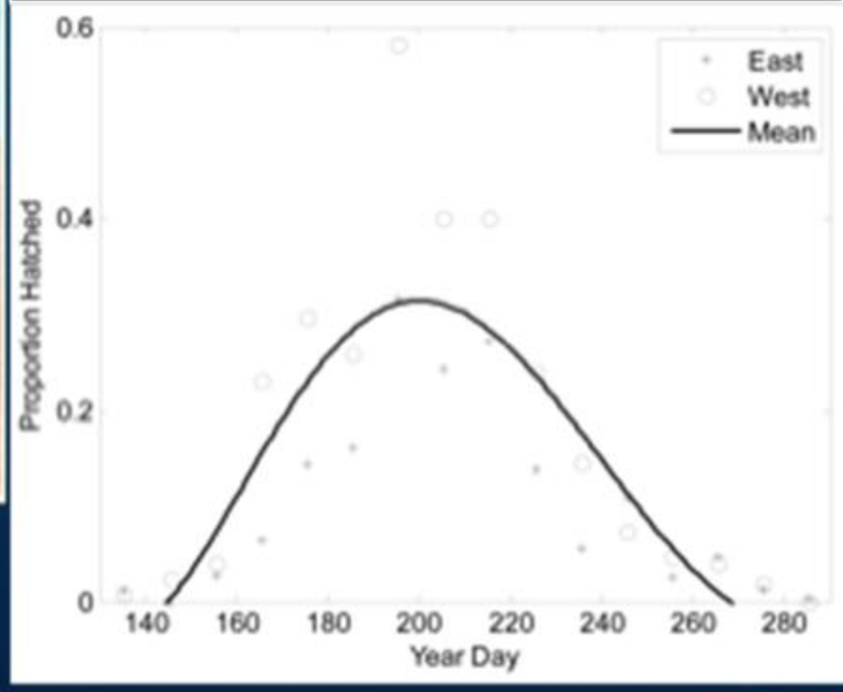
Life History of American Lobsters

< 1/10 of 1%



9 - 11 months

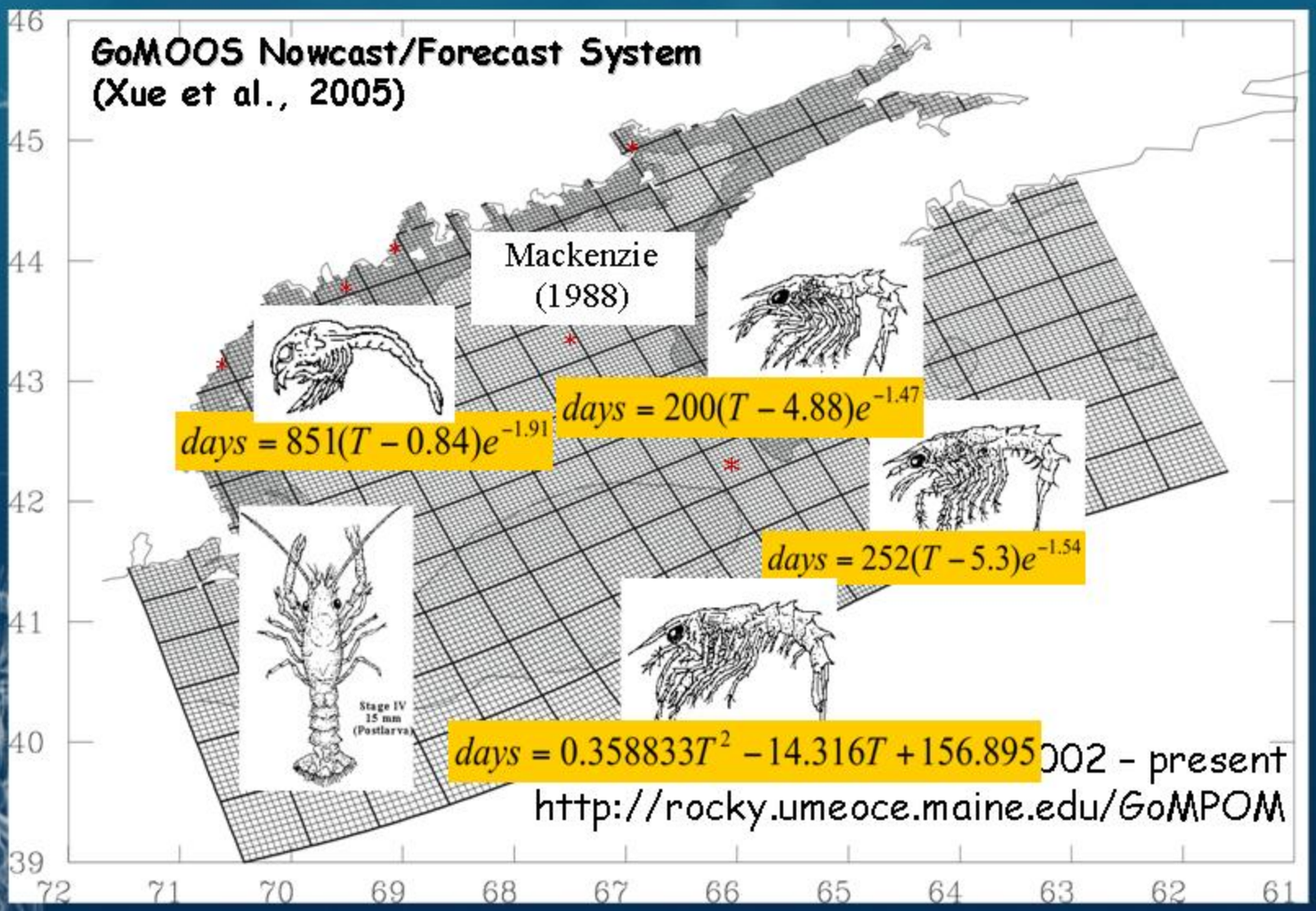




Incze, Xue, et al., 2010, FOG

An IBM for Lobster Larvae

Xue et al. 2008, Incze et al., 2010

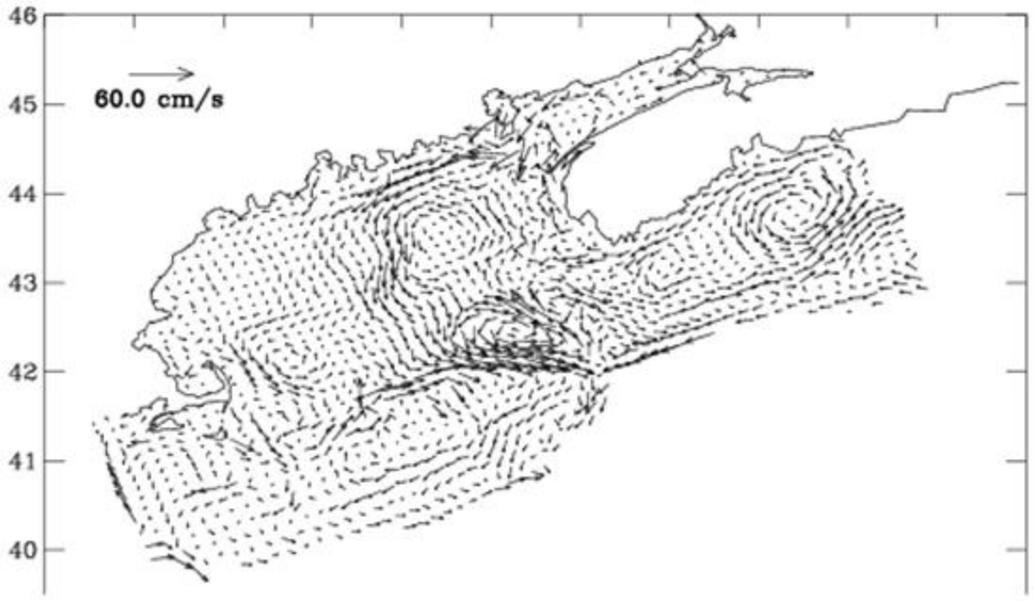


- Biological behaviors included in model runs: Release location, temperature dependent growth, vertical distribution & movement

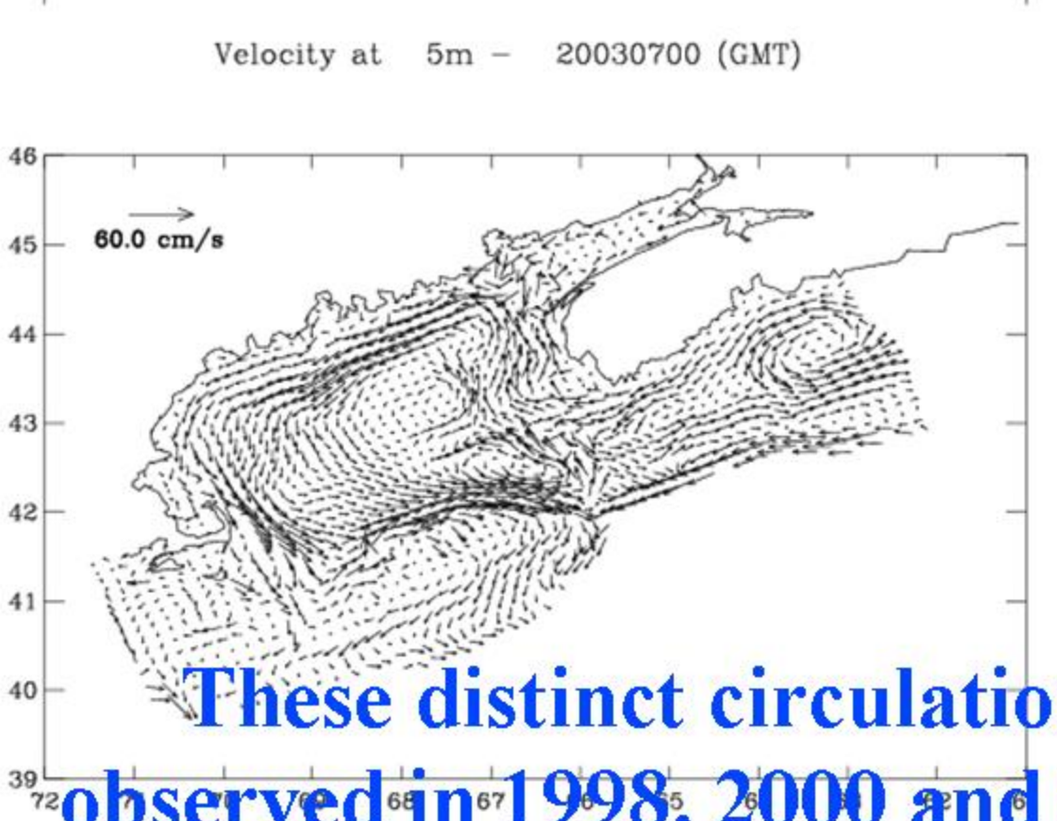
- Three experiments (hatching events) per month from June to September every year. Each experiment lasts 60 days

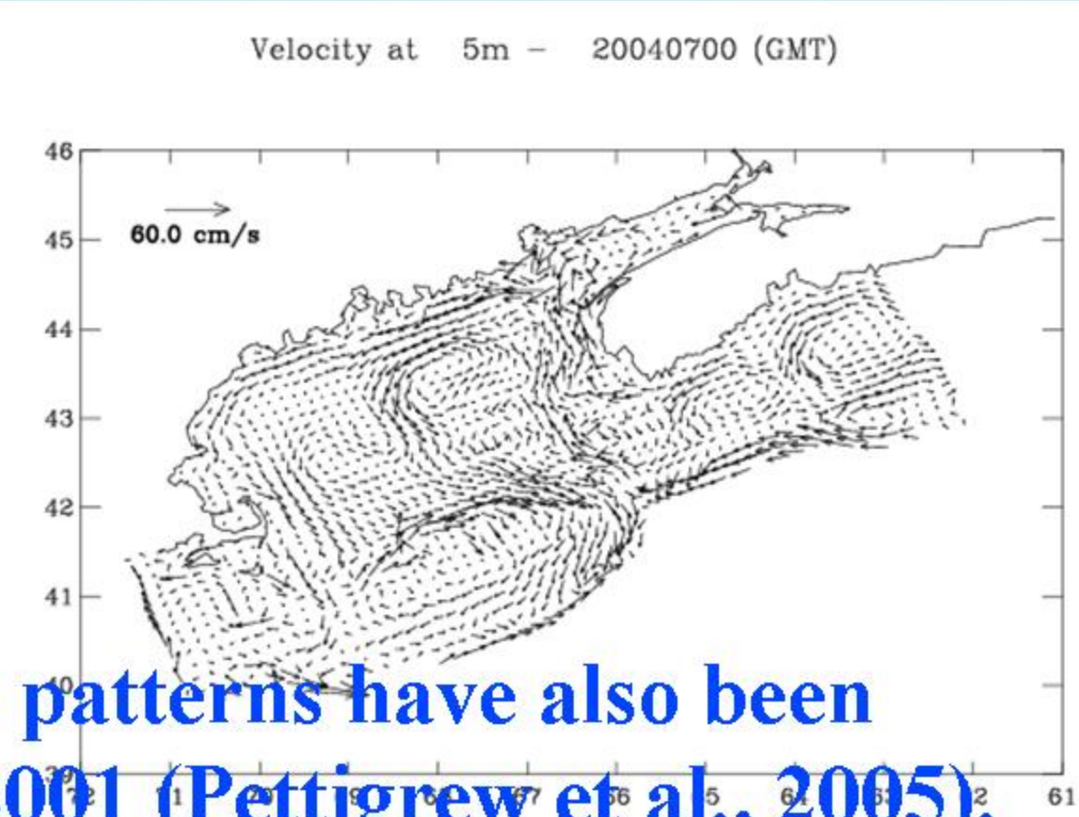
- Biological behaviors included in post-processing: egg density, hatching curve, mortality

Variability of MCC



QuickTime™ and a
GIF decompressor
are needed to see this picture.





These distinct circulation patterns have also been observed in 1998, 2000 and 2001 (Pettigrew et al., 2005).

Xue et al., 2008

Larval Transport and Development

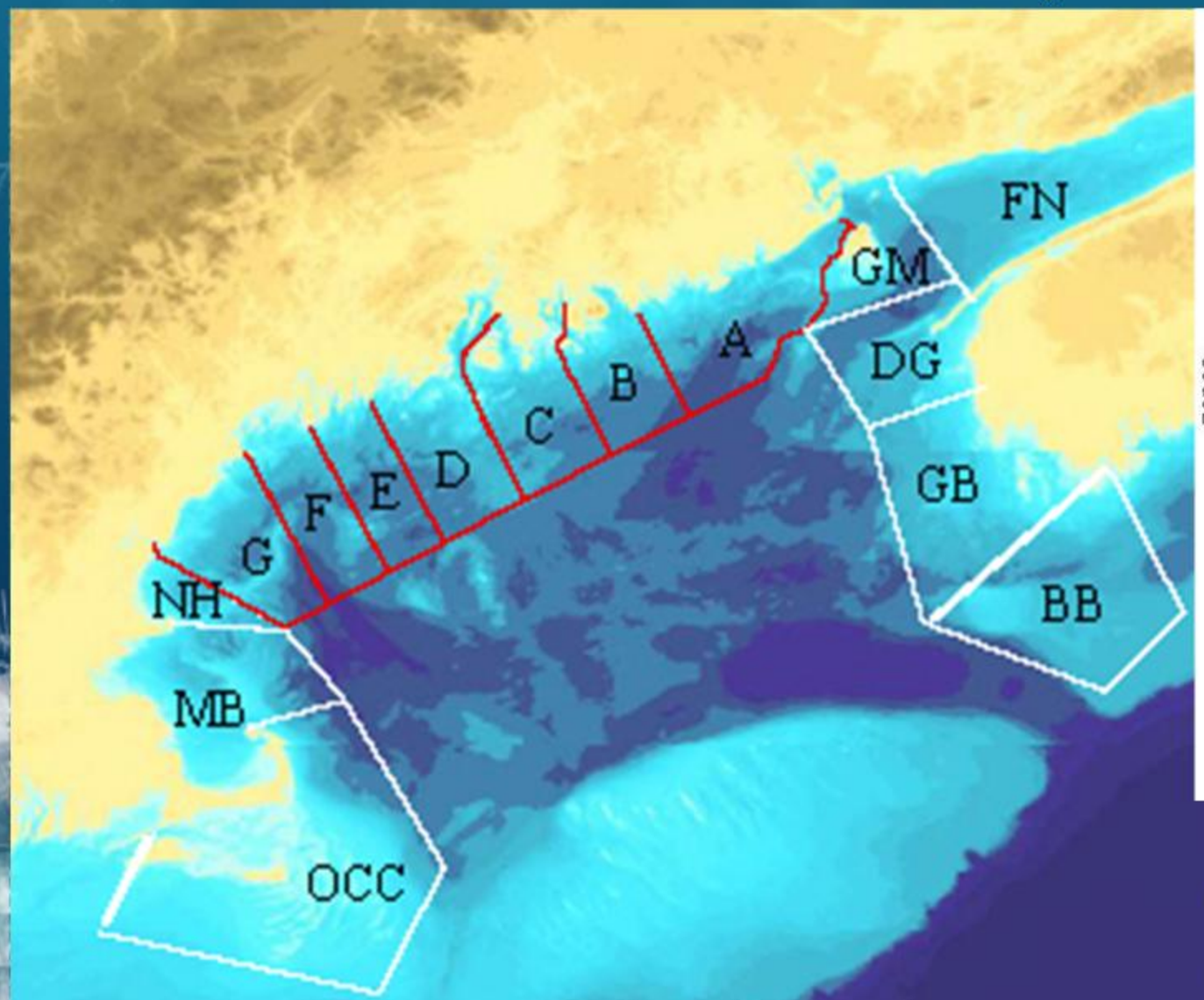
1 June 2005 @ 15m

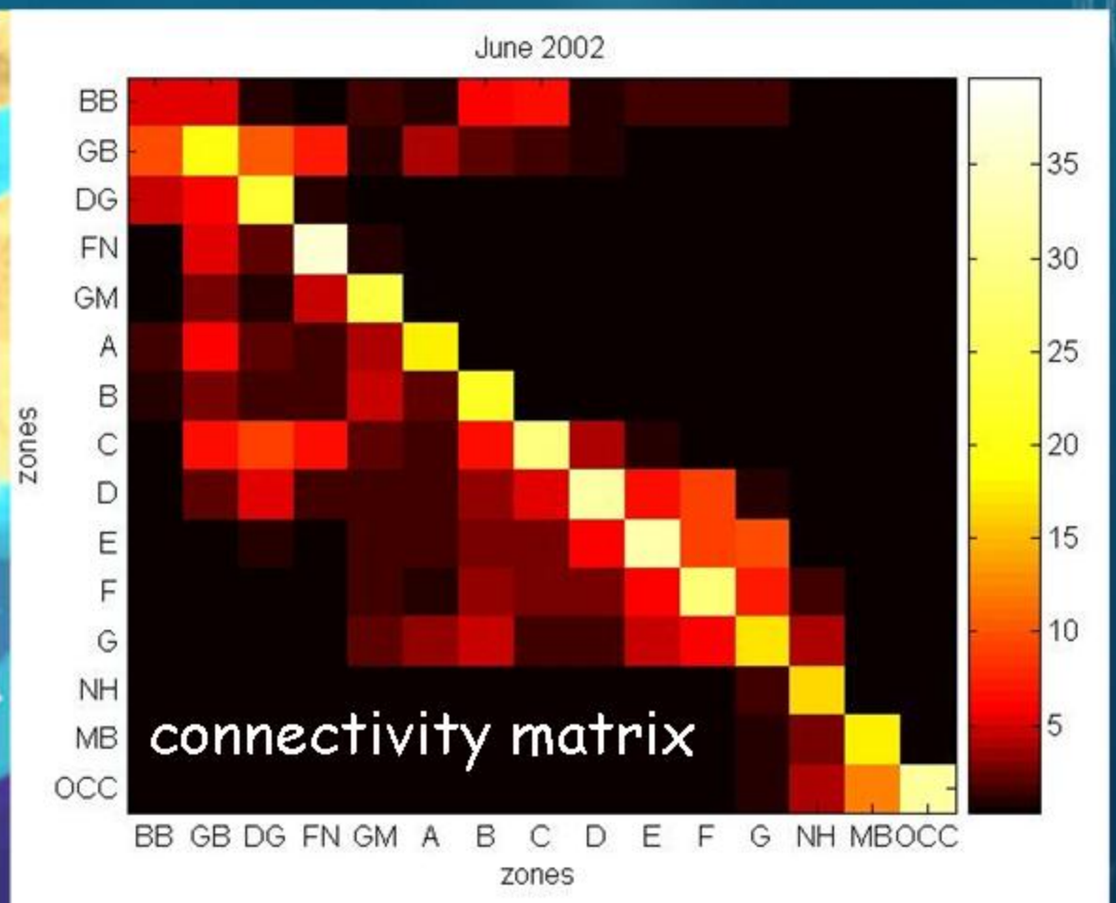
QuickTime™ and a
decompressor
are needed to see this picture.

Individual tracks and development are sensitive to release time and location as well as numerical approximations of subgrid scale processes and boundary conditions!

~ 20,000 particles per depth;
12 runs per year

Lobster Management Zones & Analysis Grids

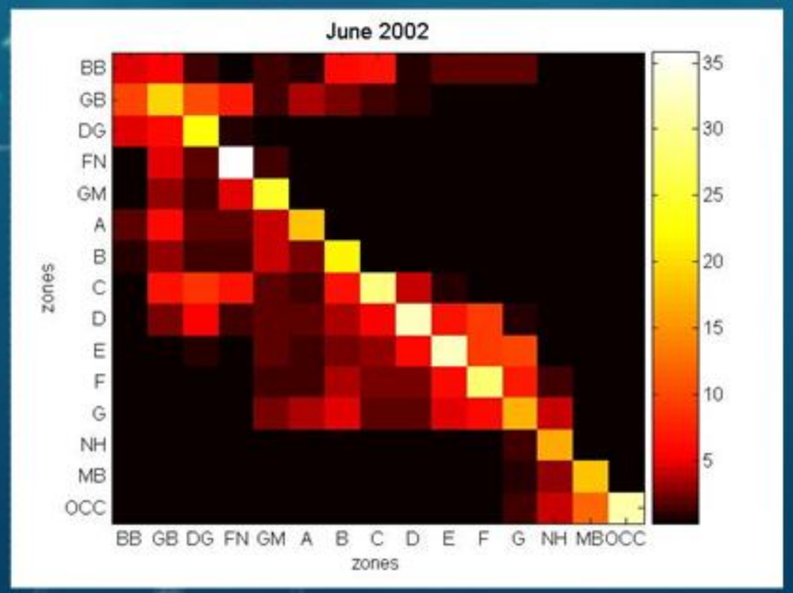




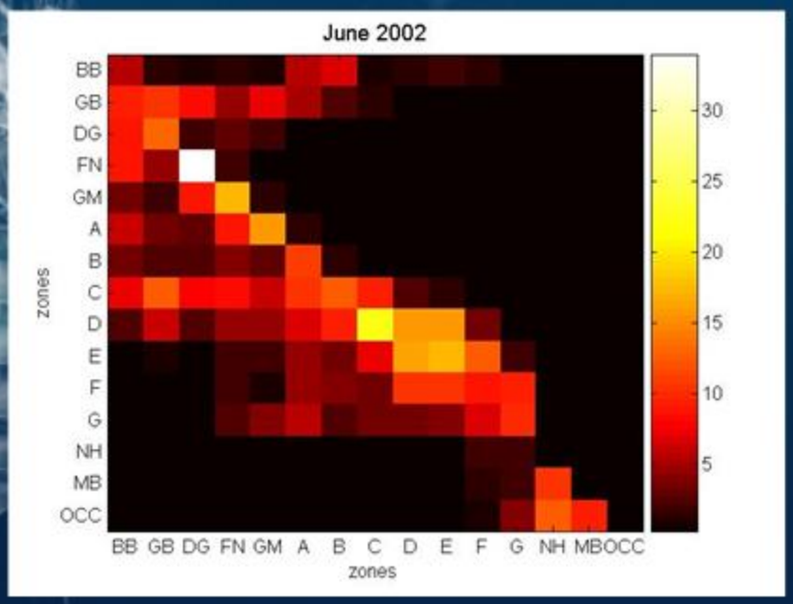
- **Advection dominates**
  - follow the cyclonic circulation
  - wind-driven effects
  - Recirculation between D-F
- **High retention rate**

Xue et al., 2008

Effects of Boundary Condition



Particles stop when they hit the land boundary.

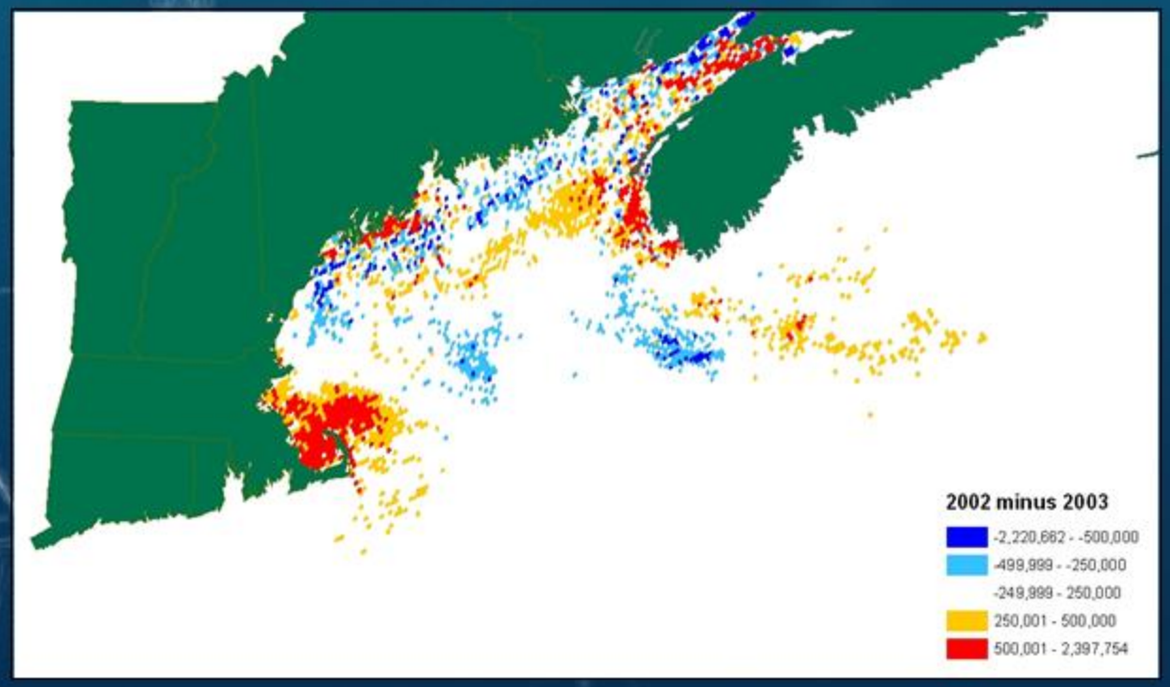


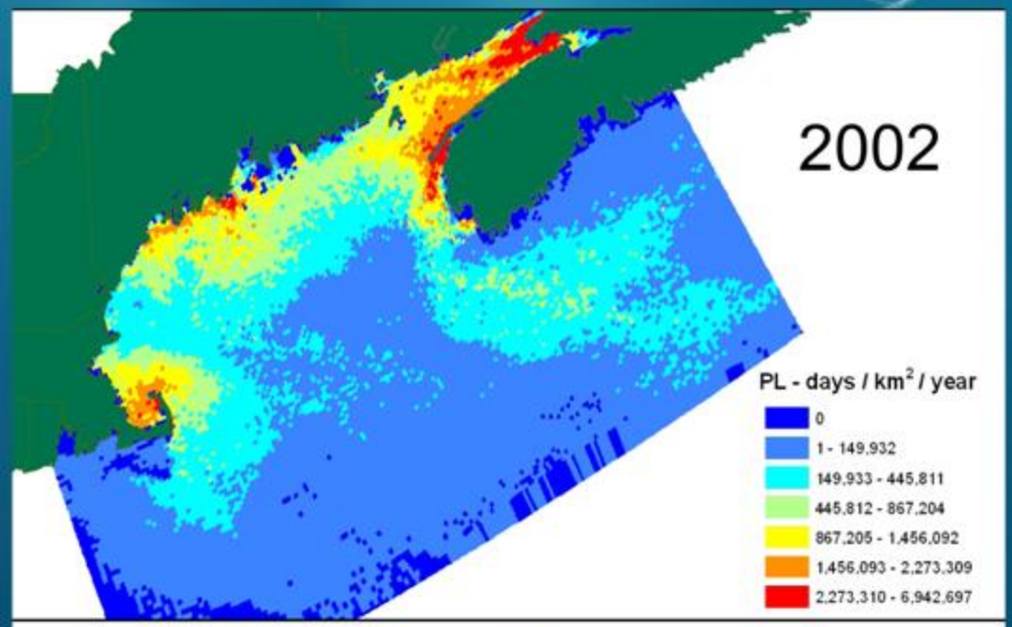
When particles hit the land boundary, random kicks act upon to bring some back to the water and they continue on.
Less local retention, more downstream advection!

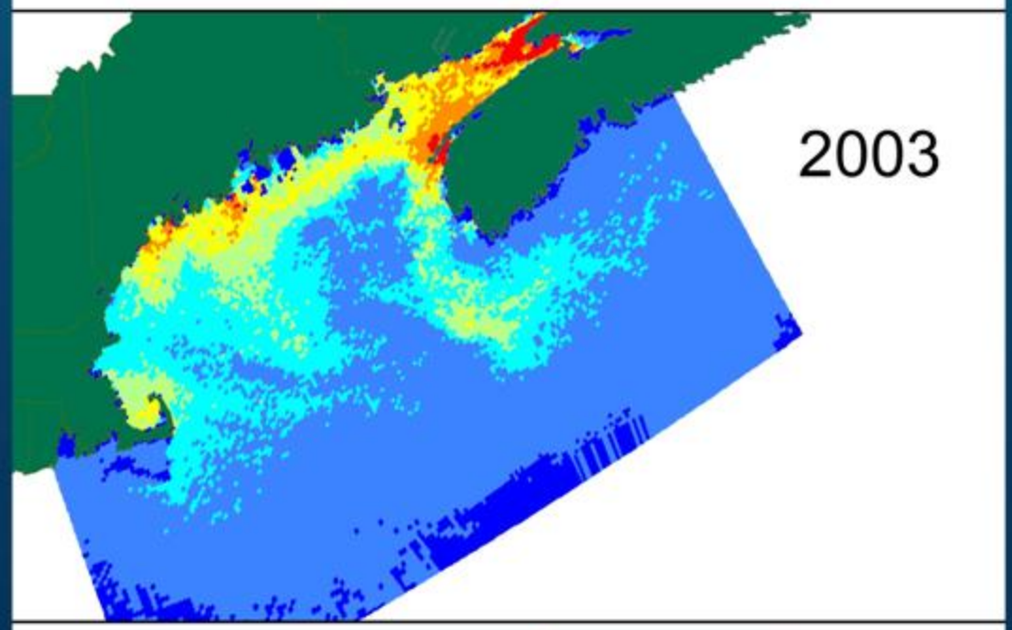
Xue et al., 2008

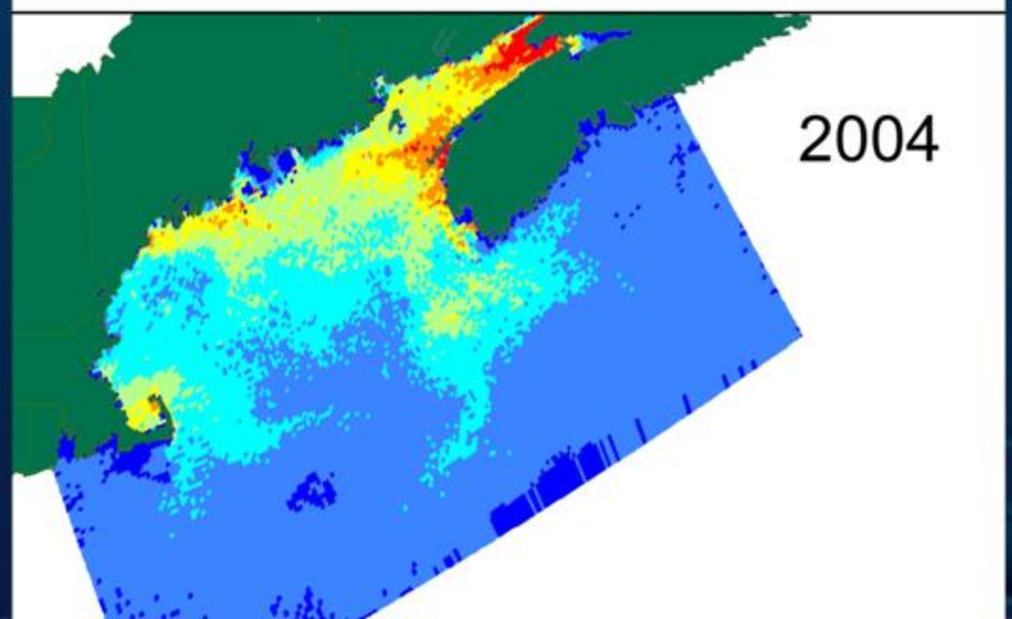
Postlarval Abundance

Sum of the # of postlarvae when they are first ready to settle





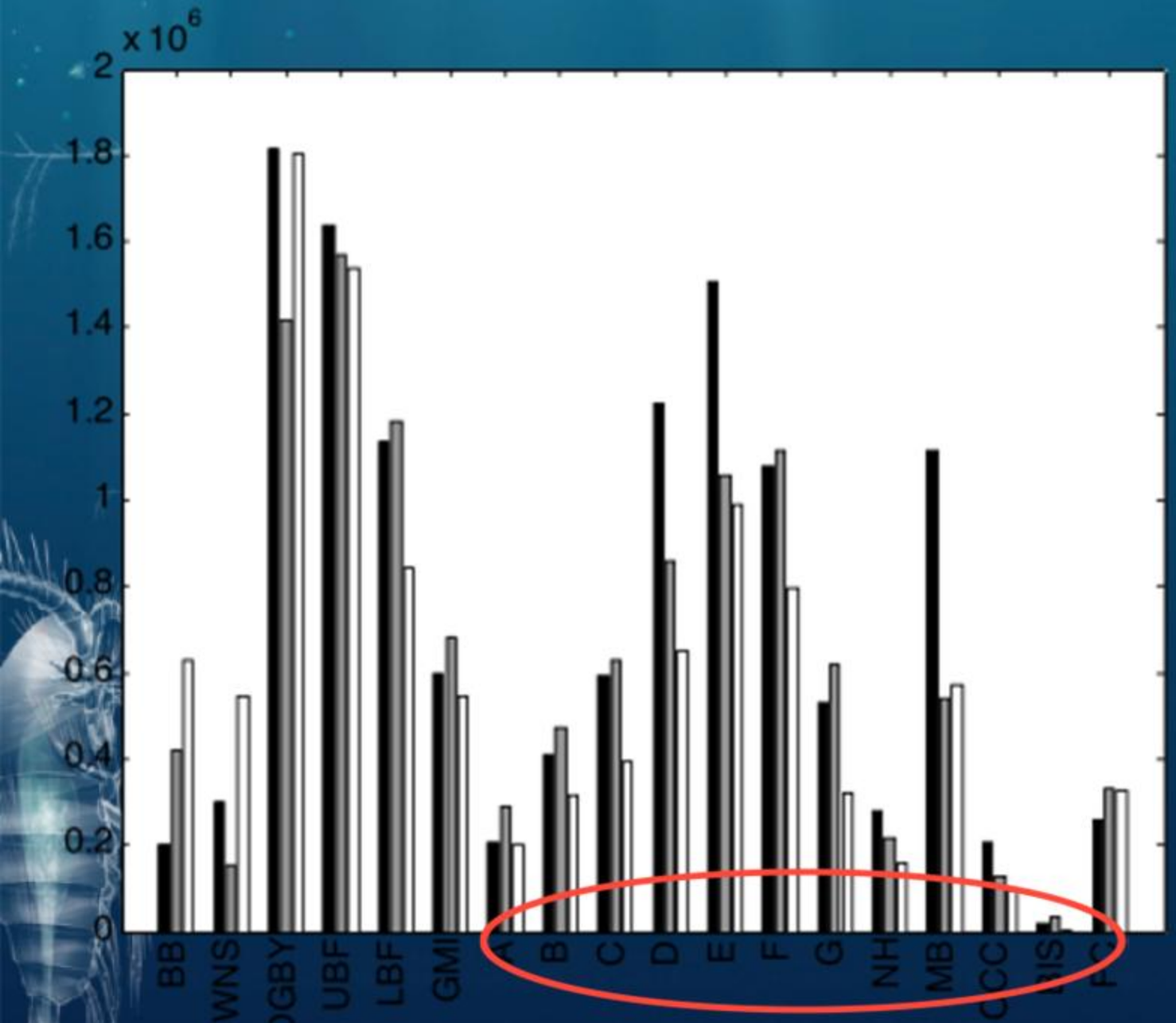




Note in the model, interannual difference is purely physical driven

Incze et al., FOG, 2010

Postlarval Abundance



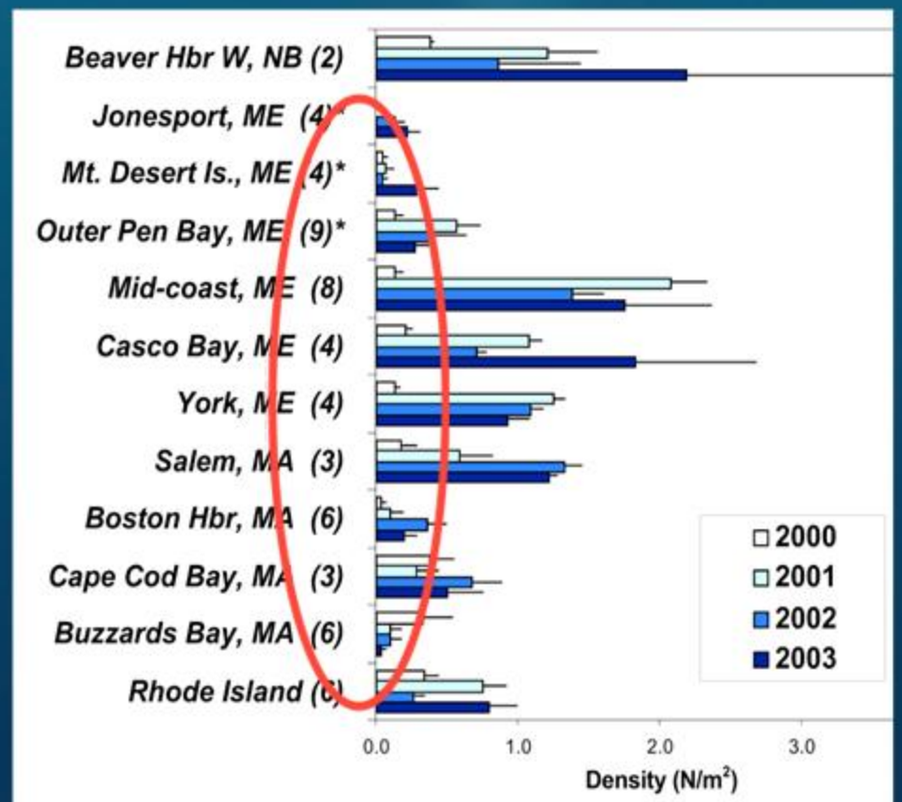
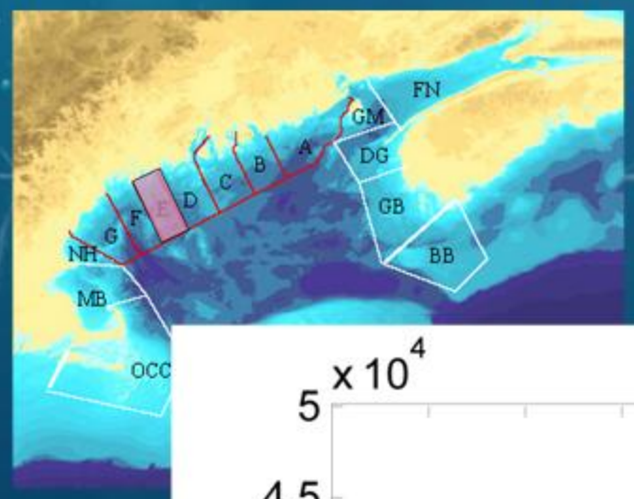


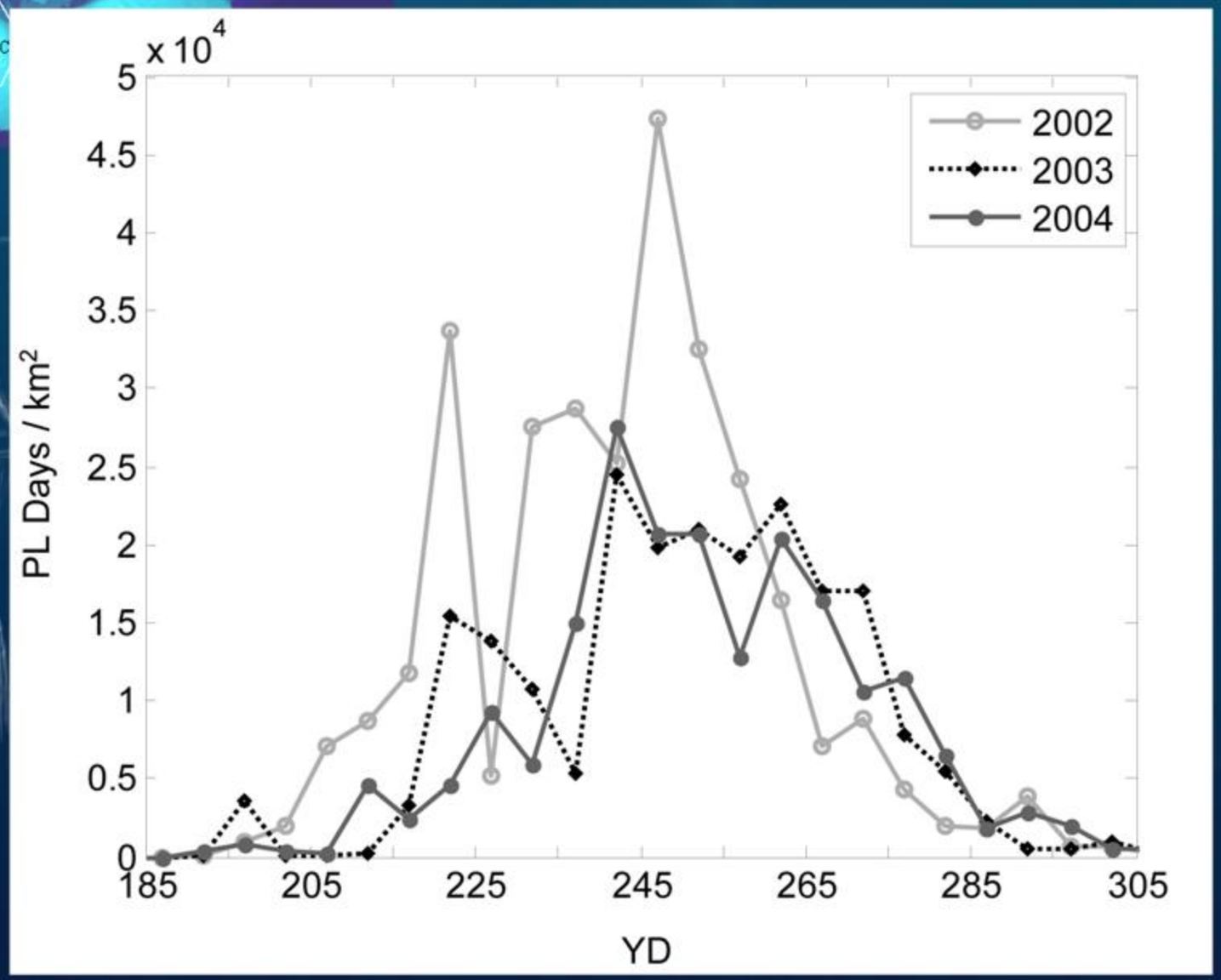
Fig. 2. Regional average lobster settlement throughout New England from 2000 to 2003. In parentheses, the number of sites included in the regional mean. * Some sampling sites in Jonesport, Mt Desert and Penobscot Bay have changed in the past 2 years, so time trends may not be reliable.

R^2 reaches 0.91

Incze et al., FOG, 2010

Postlarval Abundance for Zone E

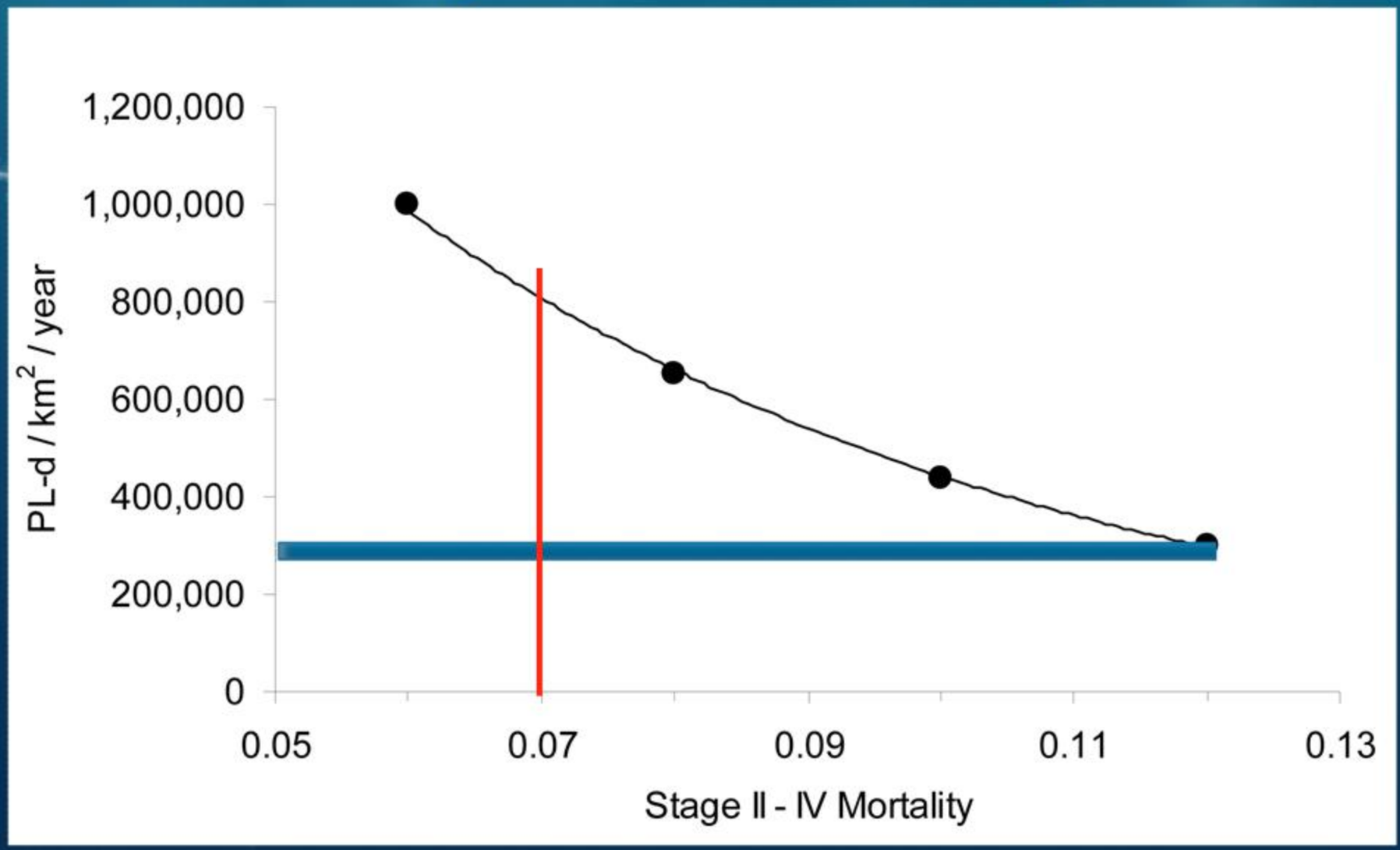




- Delay & decrease from 2002 to 2004 due to temperature
- Seasons are later & longer by 5-10 days compared to historical data
- Density is ~2.5x

Incze et al., FOG, 2010

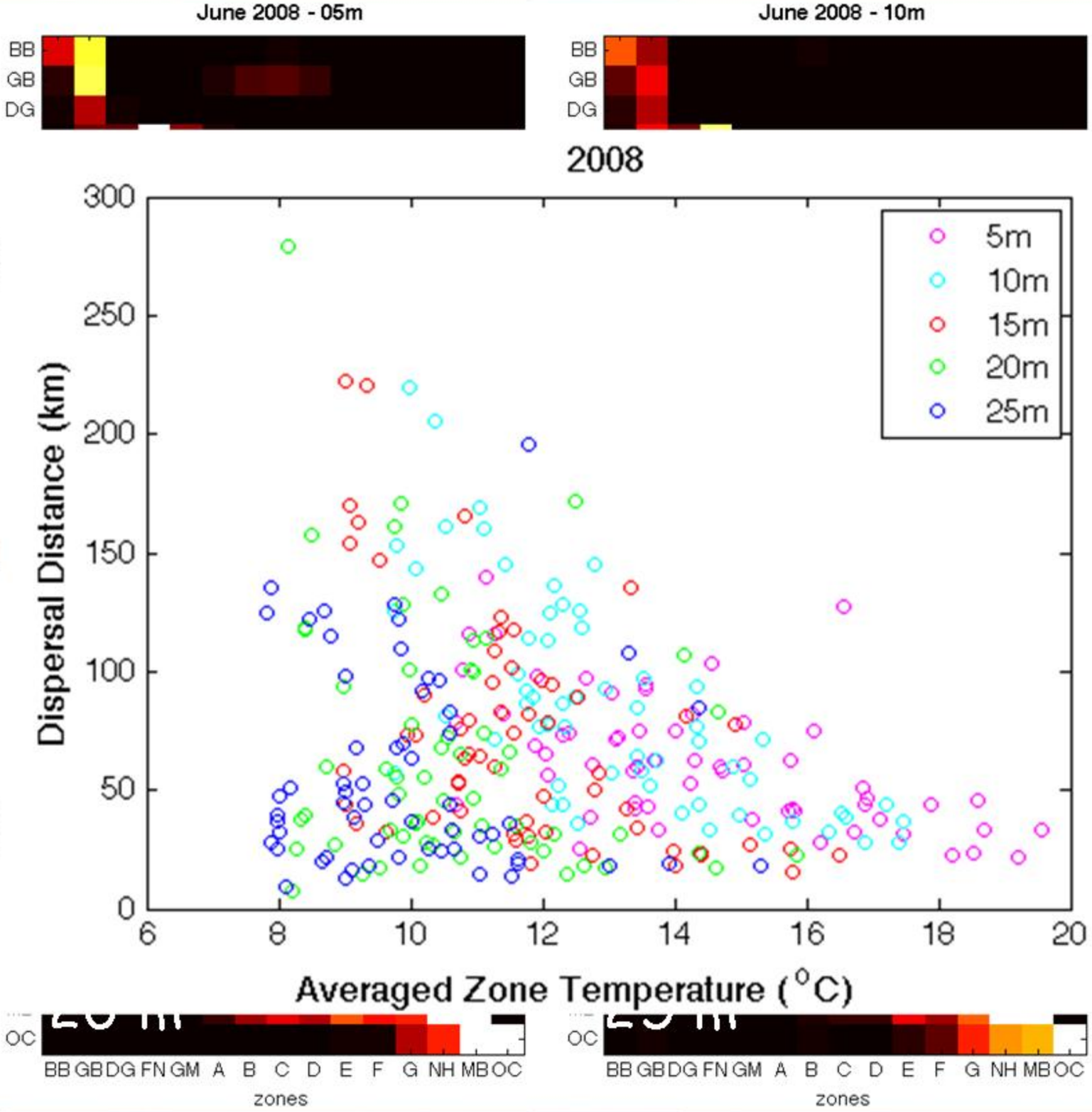
Sensitivity to Mortality Rate



Uncertainties in this estimate include egg density, growth (temperature/depth), and actual time to settle.

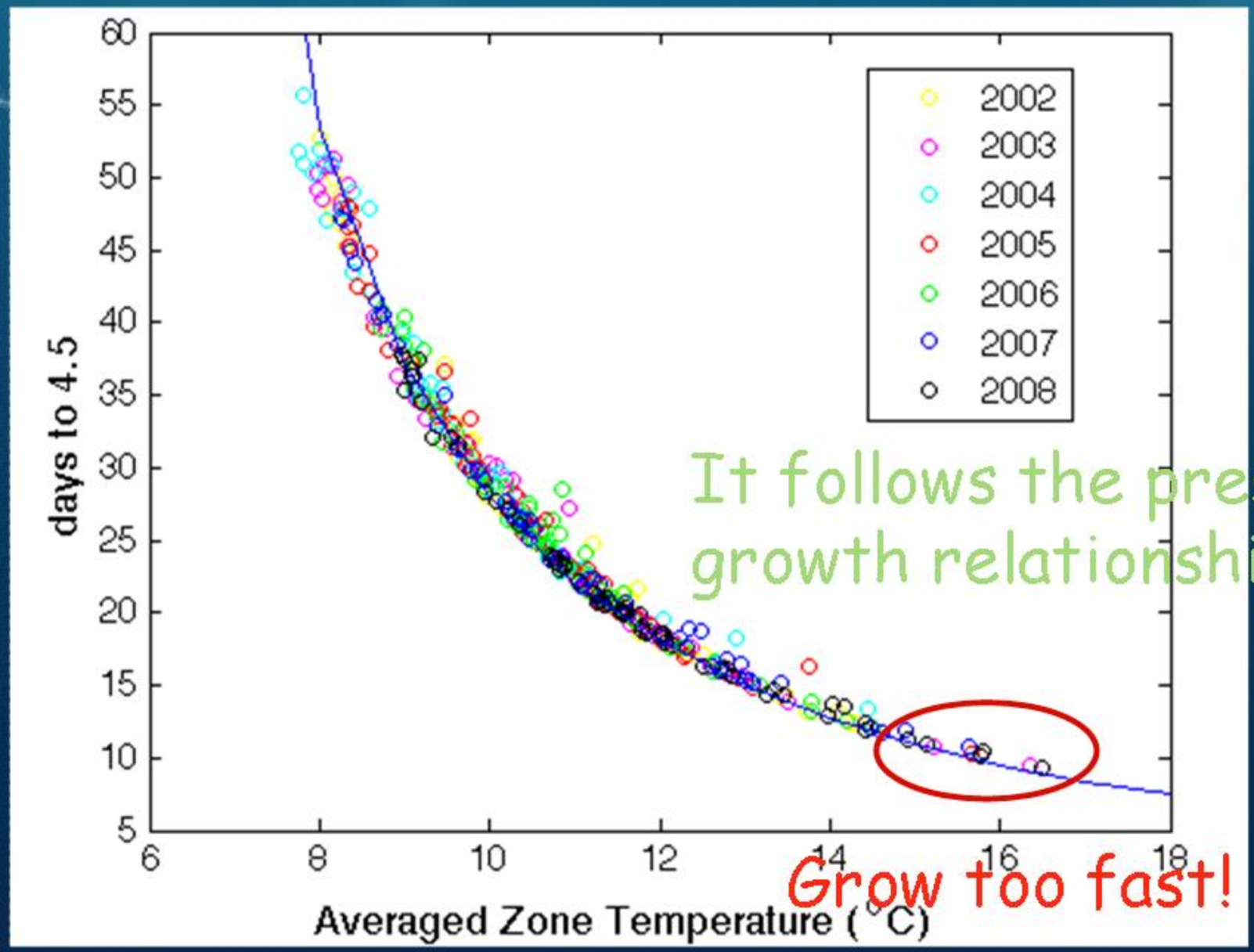
Incze et al., FOG, 2010

Egg Hatching Depths



What determines the dispersion is not only the current but also how fast larvae can grow (i.e., T dependent).

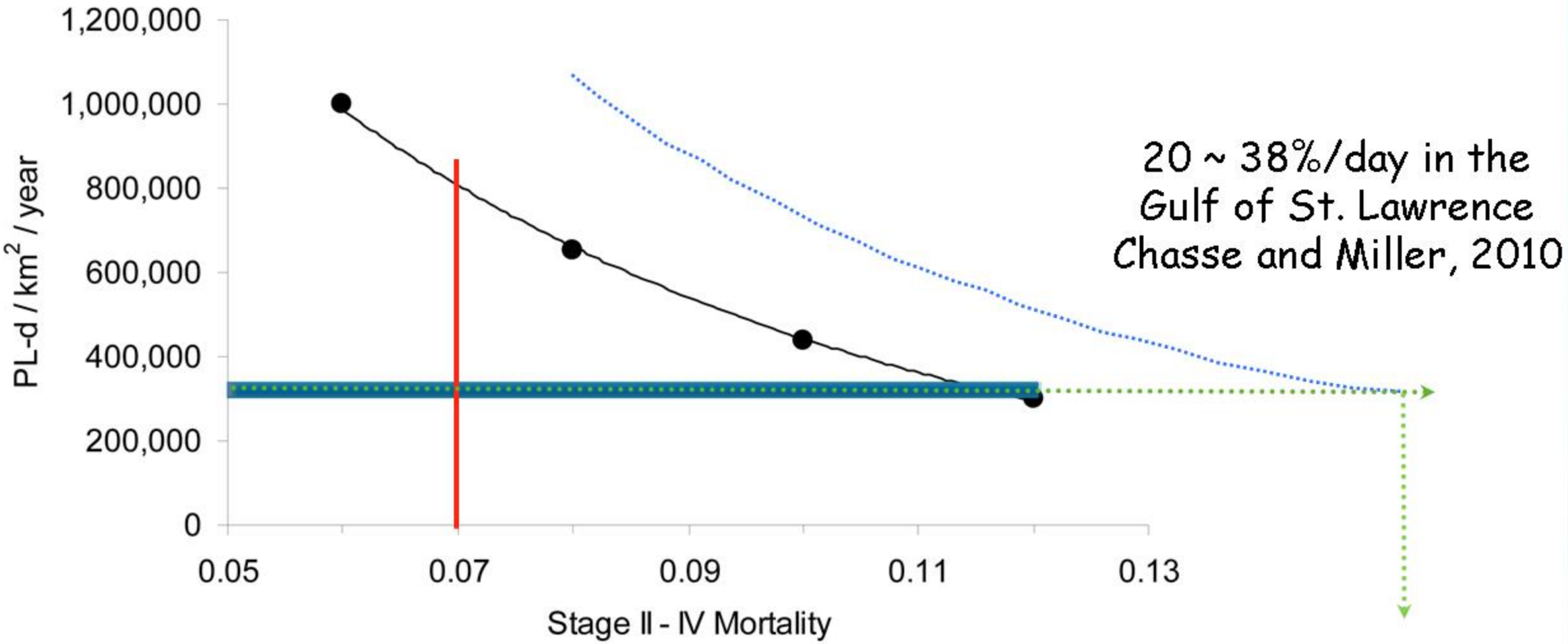
Averaged Growth Period and Temperature



It follows the prescribed growth relationship very well!

Grow too fast!

Implication



Summary

- The predominant direction of larval movement is southwestward following the cyclonic coastal current system, but the within-year and interannual variations provide important insights that add to the generalized expectations.
- Wind[illegible]ward drift[illegible]open gulf.
- Accu[illegible]he eastern Maine coast, whereas the western Maine coast appears to receive larvae brought from the east by the coastal current system. The spatial pattern of settlement is consistent with the historical data.

Advection dominated transport!

Summary

- There is a significant amount of retention in most zones, indicating potentially considerable self-recruitment in populations. Downstream transport becomes more important if larvae are randomly kicked back to the water column after they encounter the land boundary.
- Larval development is sensitive to interannual variations in temperature, can be delayed by as much as 5 days in colder years.
- Mortality rate might be much higher than the previous estimate.