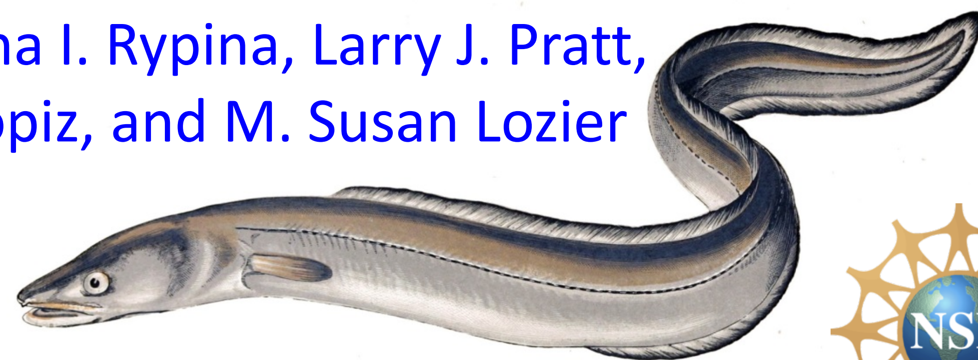
Influence of Ocean Circulation Changes on the Variability of American Eel Larval Dispersal

Irina I. Rypina, Larry J. Pratt,
Joel K. Llopiz, and M. Susan Lozier



WOODS HOLE OCEANOGRAPHIC INSTITUTION 1930

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and

An Overview of the Field Experiment in Aug 2015 in Katama Bay, MA

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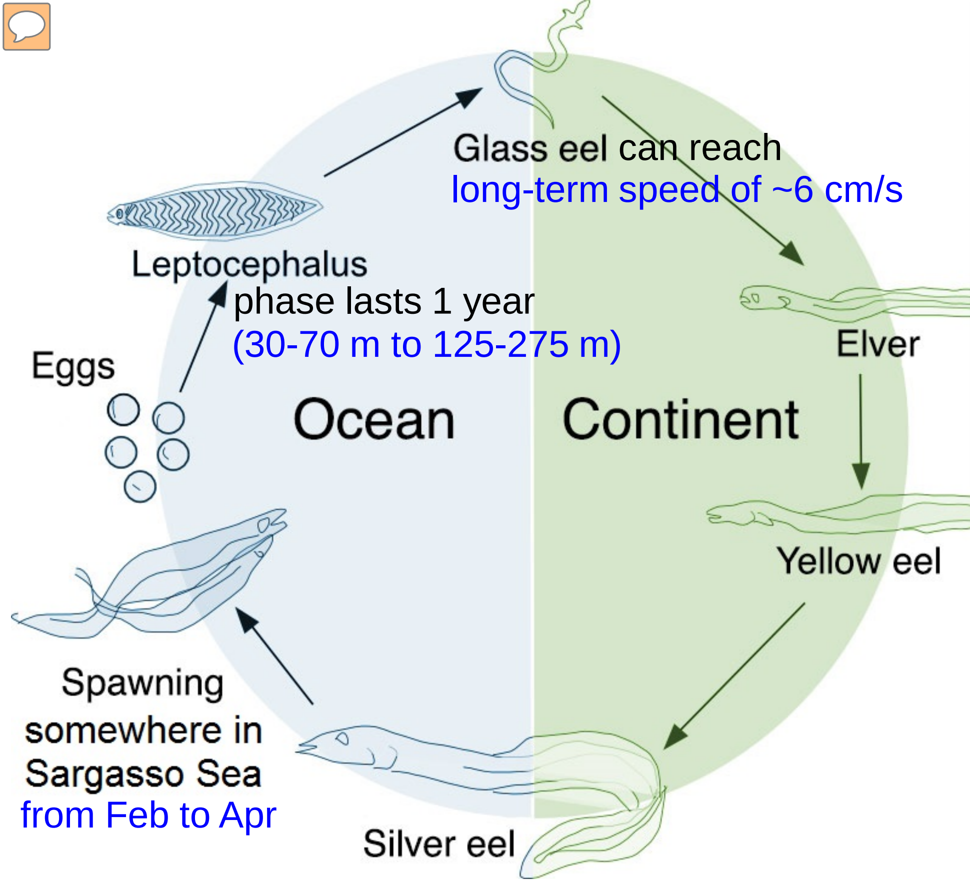
MURI, SCRIPPS, Sep 2015

OCEAN 3D+1

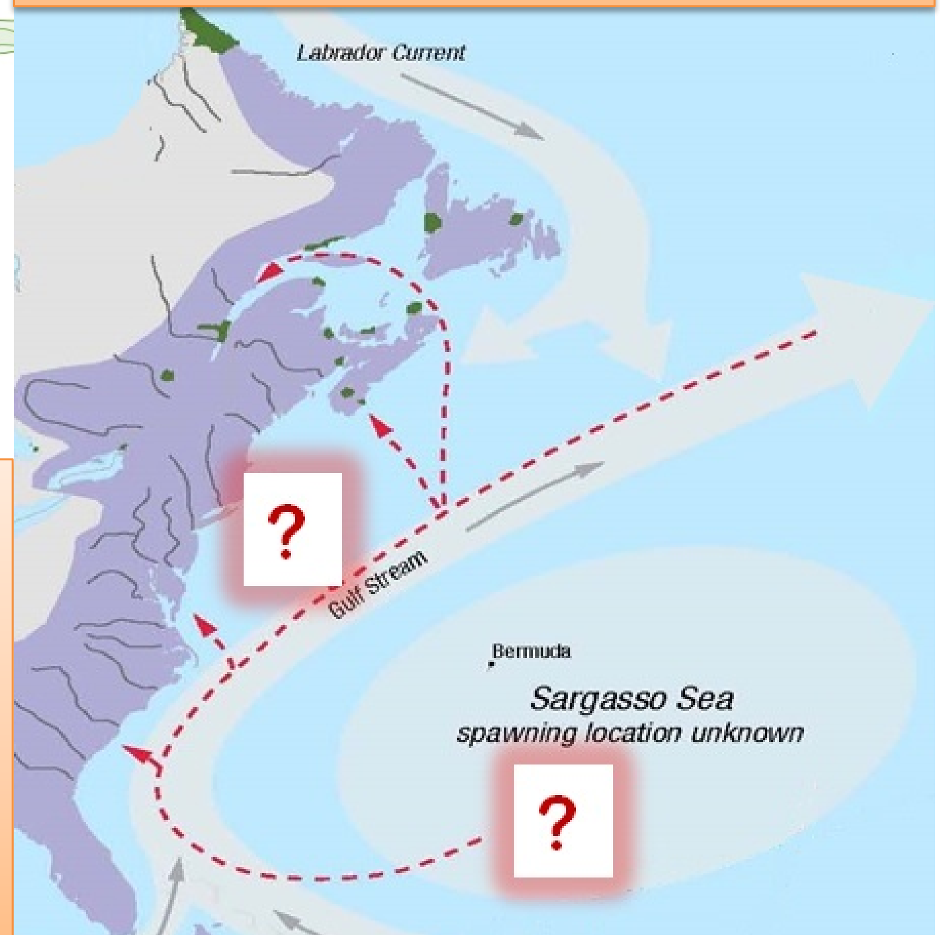
Outline of the first part of the talk

- Introduction
  - Biology and life cycle
  - Open questions
    - navigation strategies of eel larvae
    - spawning locations
    - inter-annual variability of eel population
- Coupled physical-biological model
  - Description
  - Results
- Summary and discussion



<u>We know that:</u>

- adults are found along N. Am. coast
- spawn in Sargasso sea during Feb-Apr
- larvae need to get back to coast in 1yr
- larvae migrate vertically 50m to 250m
- glass eel can swim at ~6 cm/s

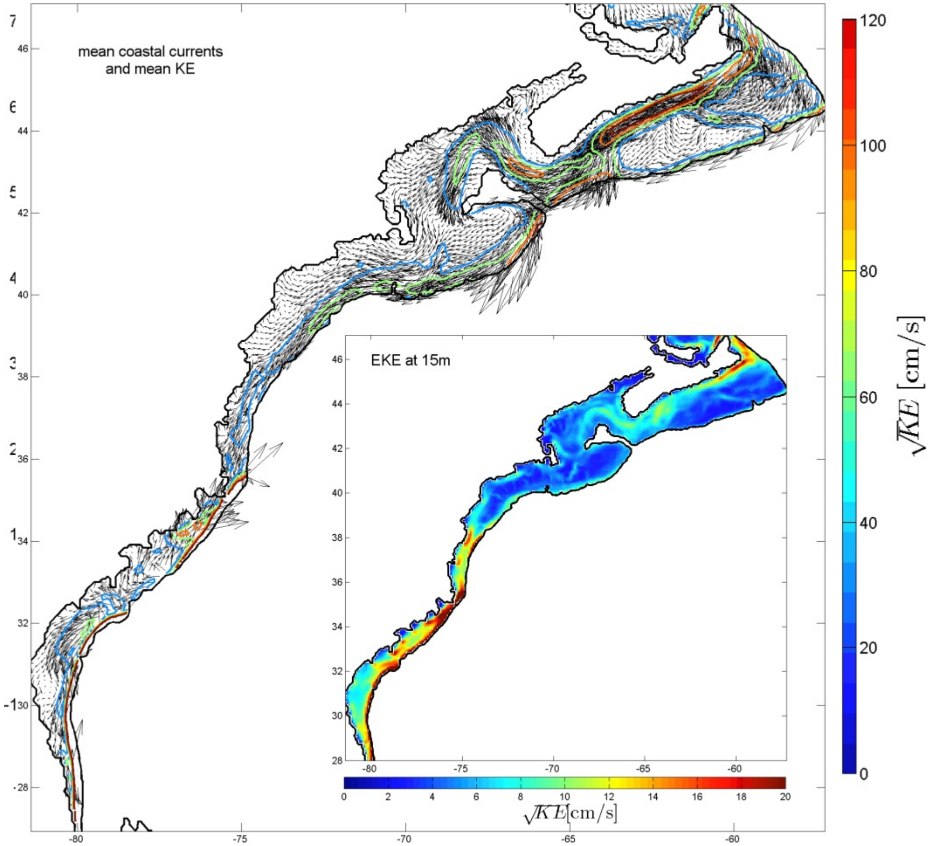


<u>We know very little about:</u>

- exact spawning location in Sargasso sea
- larval dispersal pathways
- success rates
- swimming and navigation strategies
- variability of eel population

Coupled physical biological model =

ocean circulation model FLAME + **simple behavioral adaptations of larvae**

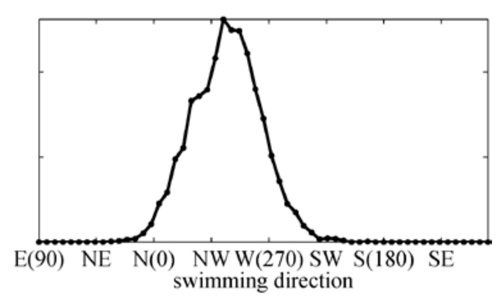


swimming scenarios:

1) passive drift (cannot swim)

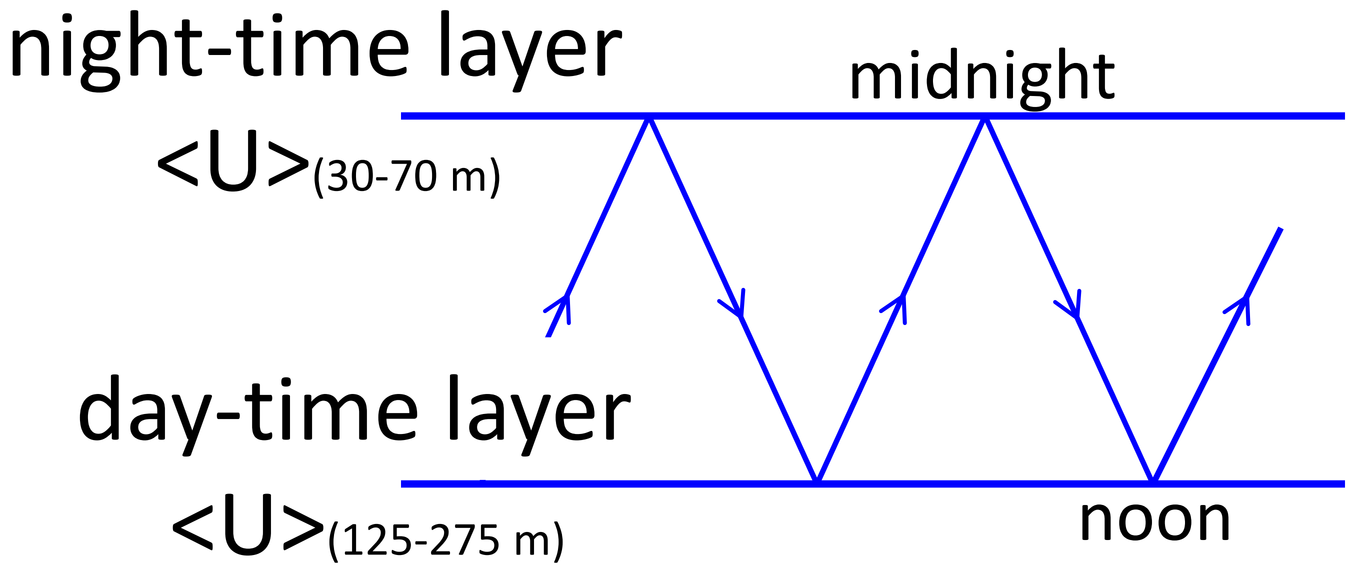
2) random walk (cannot maintain direction)

3) directional swimming

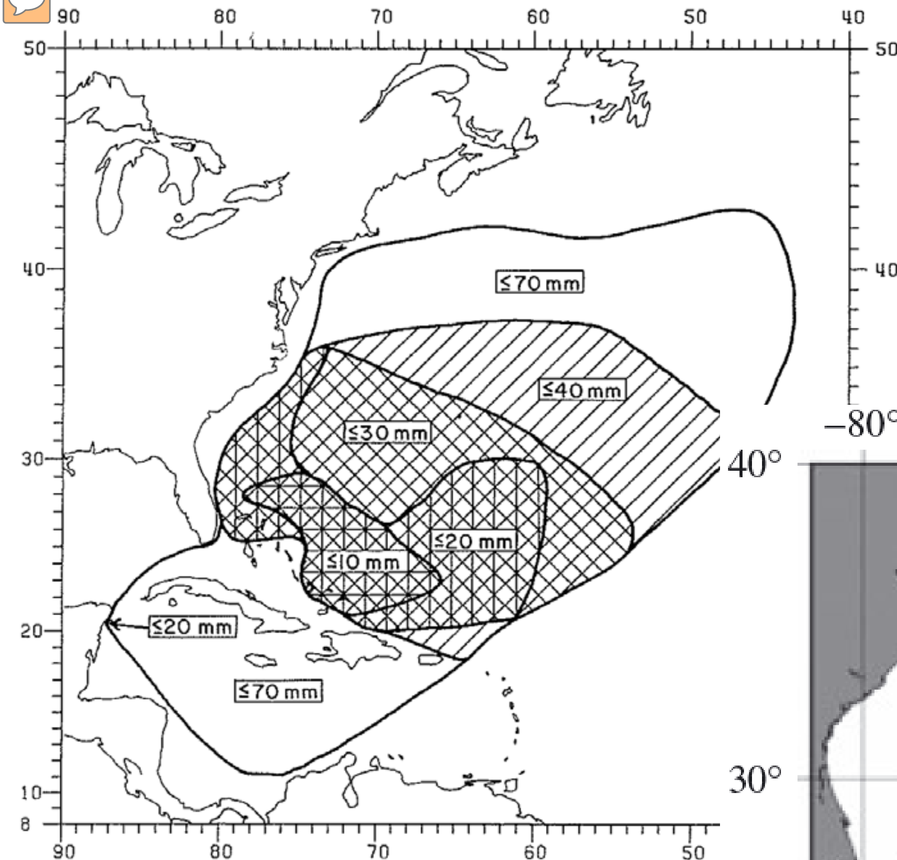


(can swim, can maintain direction, and have genetic memory of where the coast is)

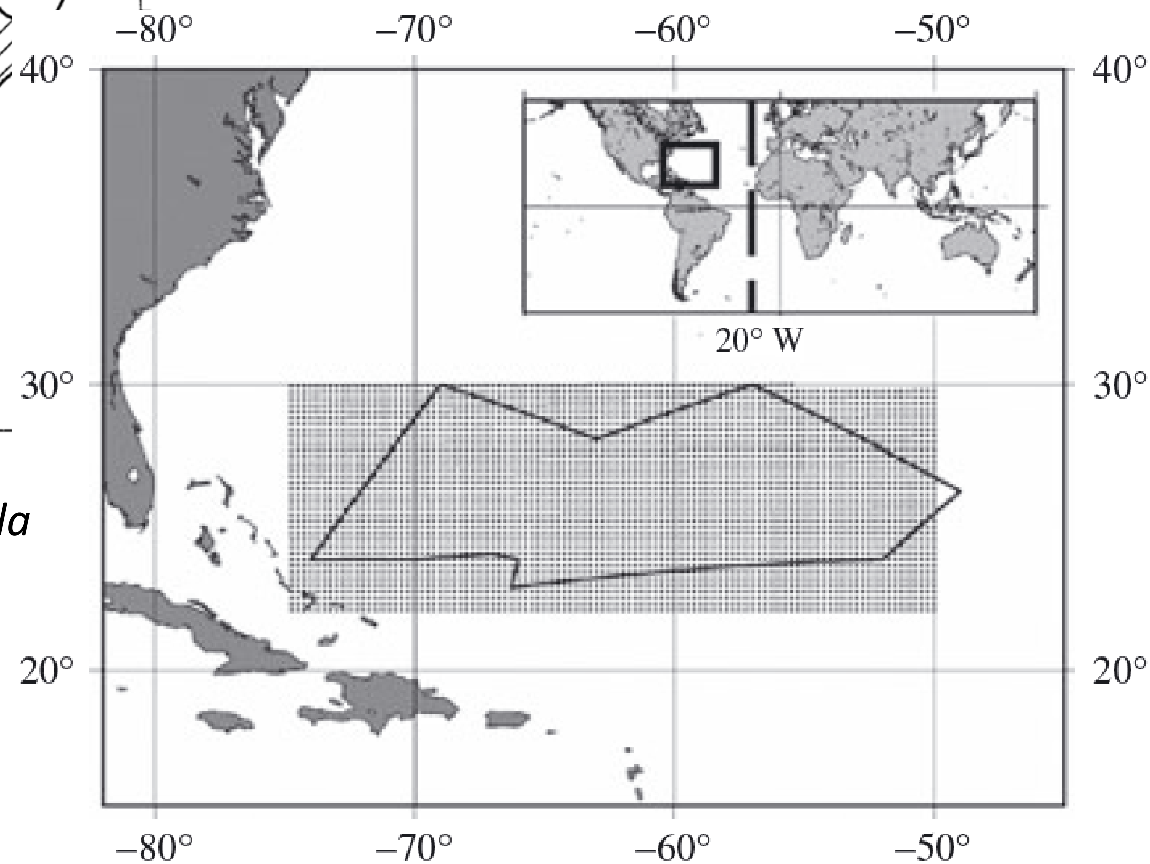
- Dial vertical migration of larvae



- Swimming speed increases linearly with age from 0 cm/s at hatching to 6 cm/s after 1 year
- Mortality (or exponential decay) rate M=3.8 year^{-1} , equivalent to ≃2% of larvae surviving after 1 year (from Bonhommeau et al. 2009)

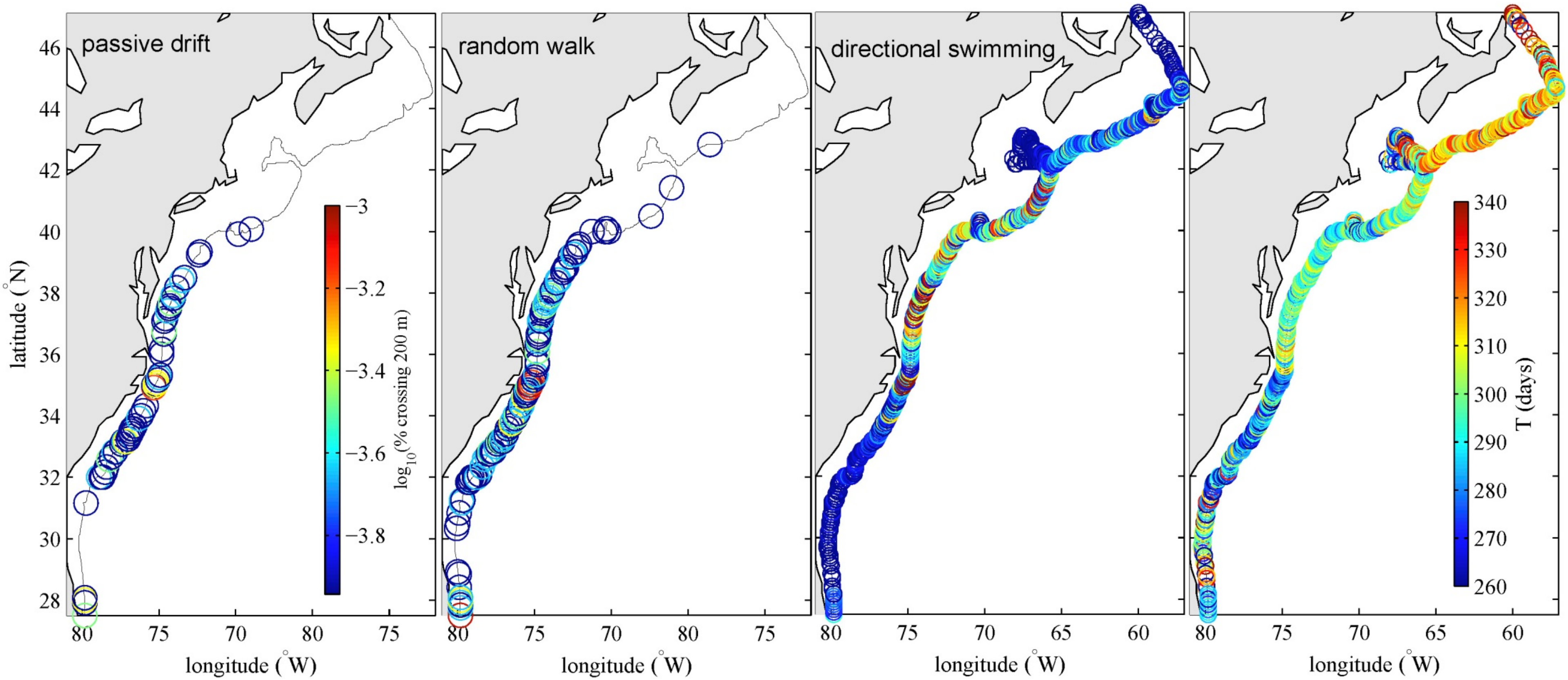


Limits of the distribution of *Anguilla rostrata* of various sizes. From Kleckner and McCleave 1985.

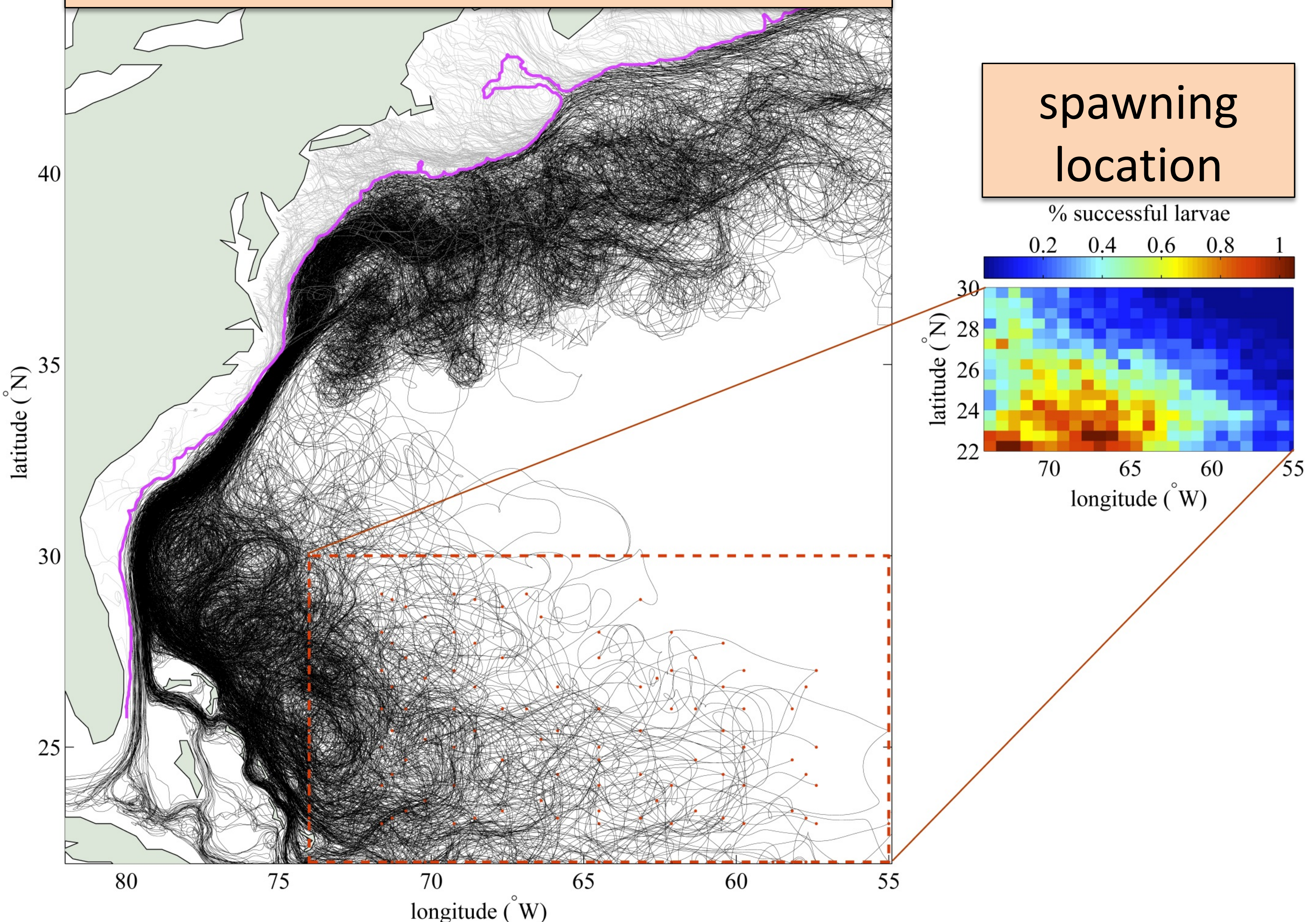


Location of the *Anguilla anguilla* spawning area. From Bonhommeau et al. 2009. We will use the same box.

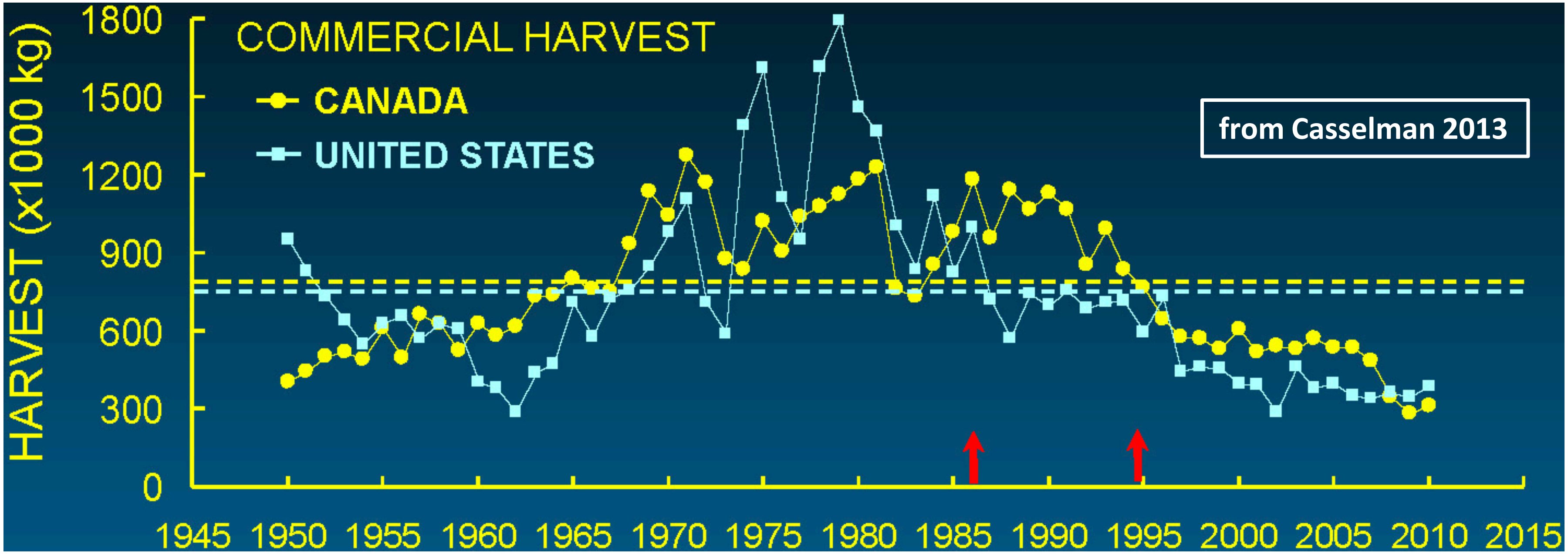
Distributions of larvae along the 200 m isobath for different swimming scenarios



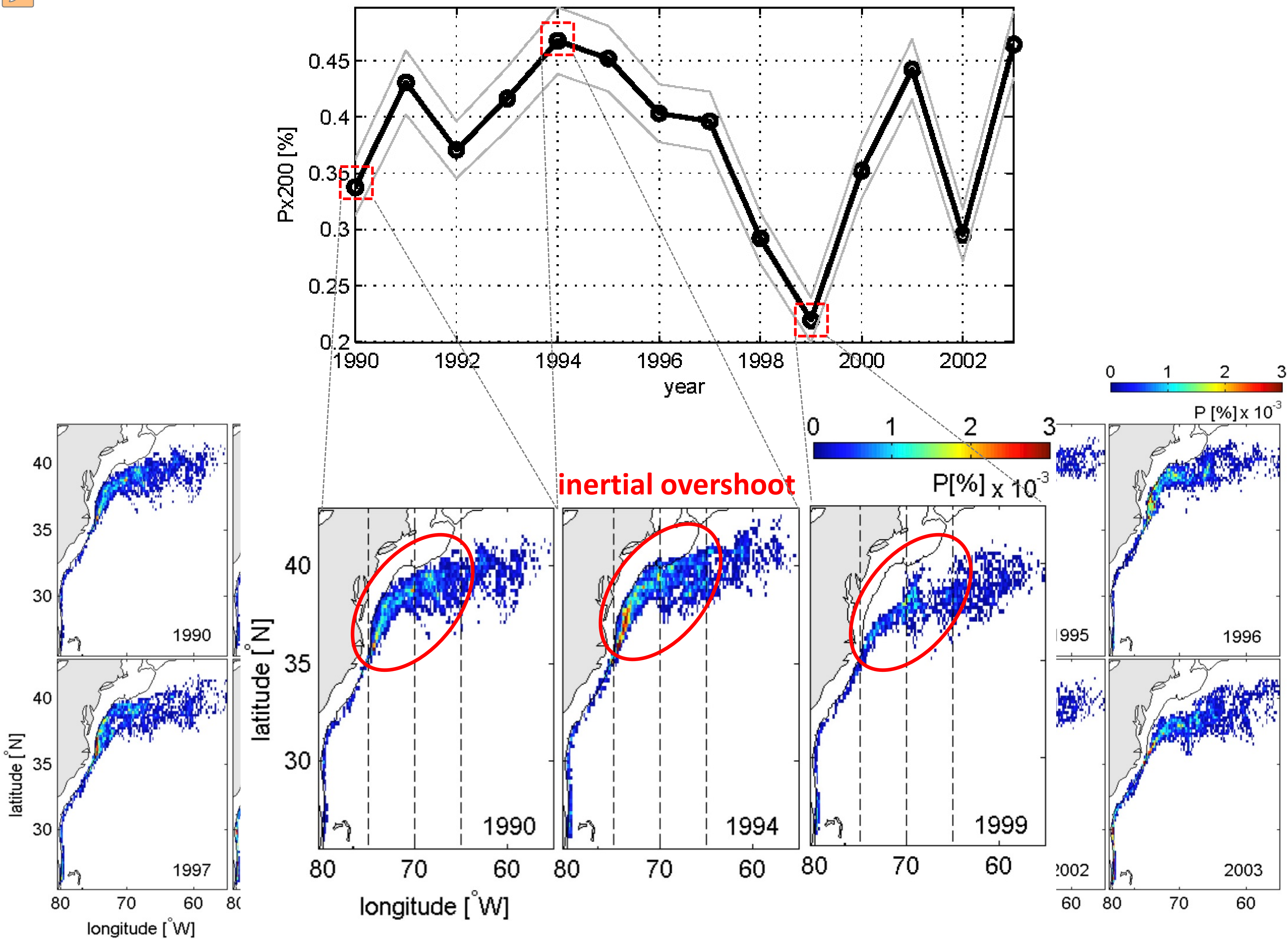
Larval dispersal pathways



Inter-annual variability and its causes

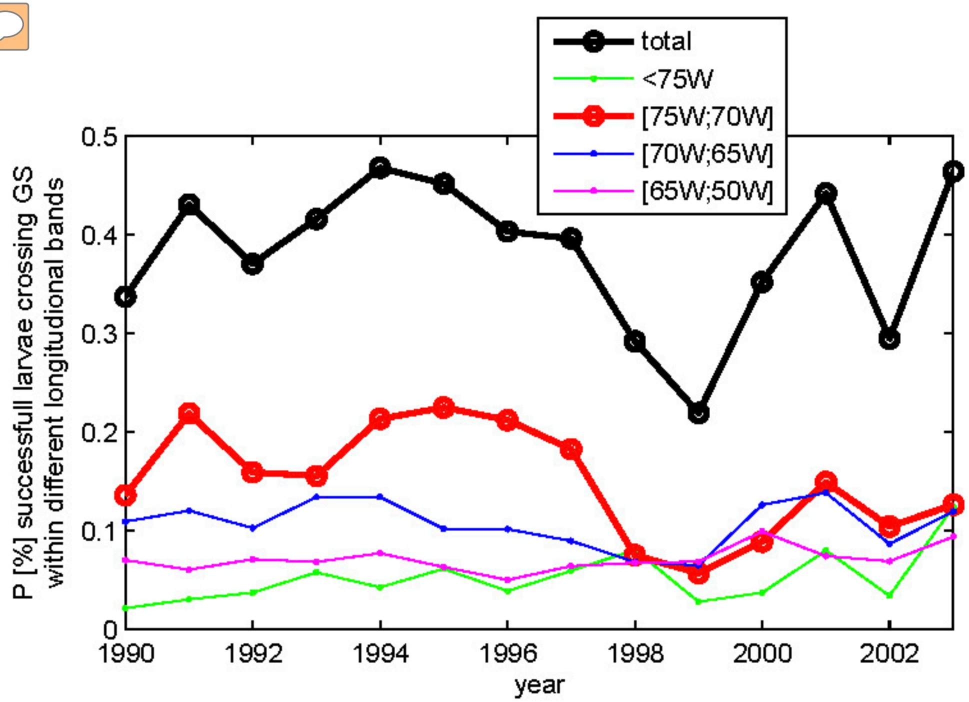


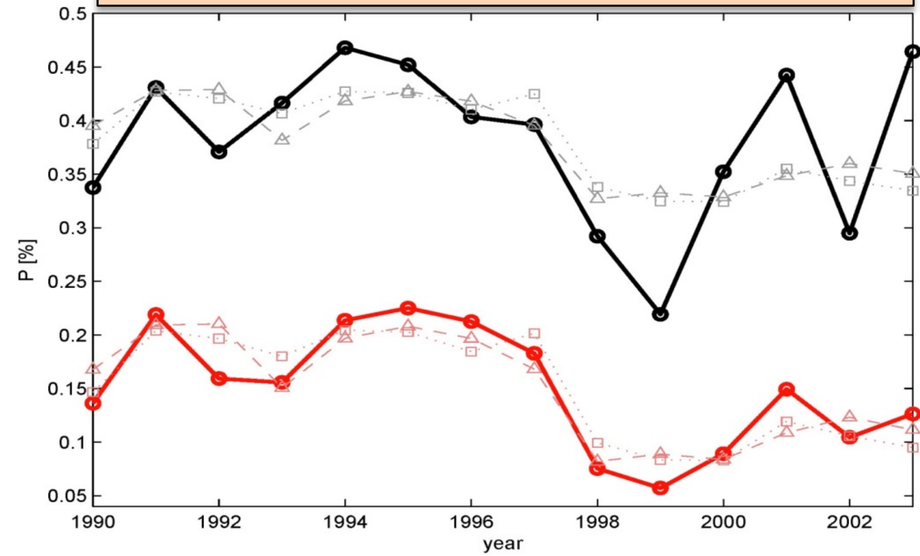
- Can these changes, at least partially, be linked to changes in oceanic circulation?

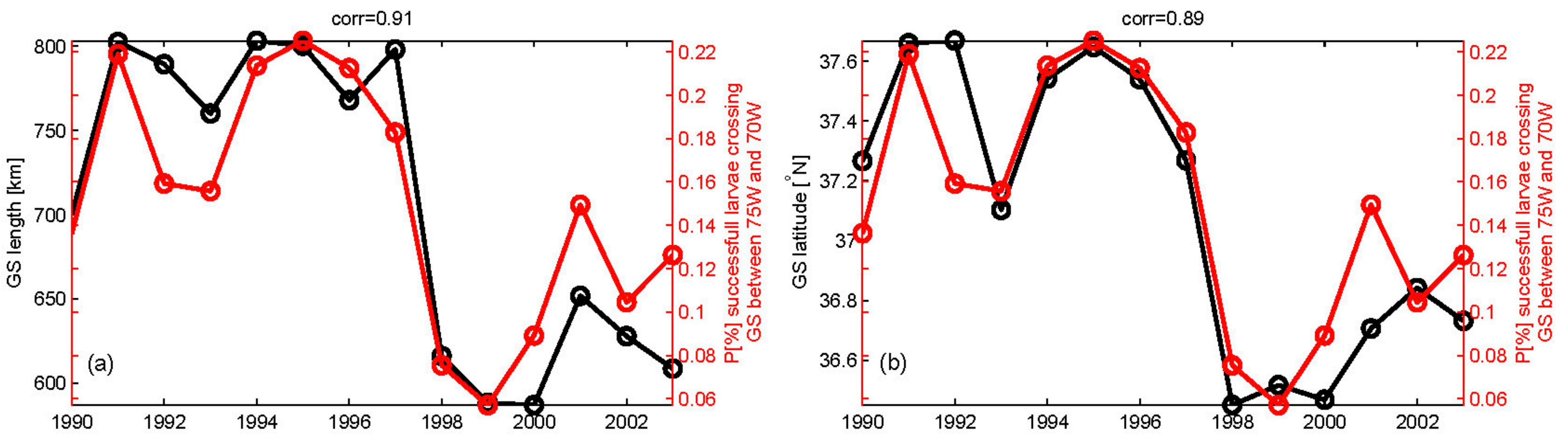


Px200 [%]
0.45
0.4
0.35
0.3
0.25
0.2
1990
1992
1994
1996
1998
2000
2002
year
inertial overshoot
P[%] x 10^-3
P [%] x 10^-3
latitude [°N]
longitude [°W]
1990
1994
1999
1995
1996
1997
2002
2003

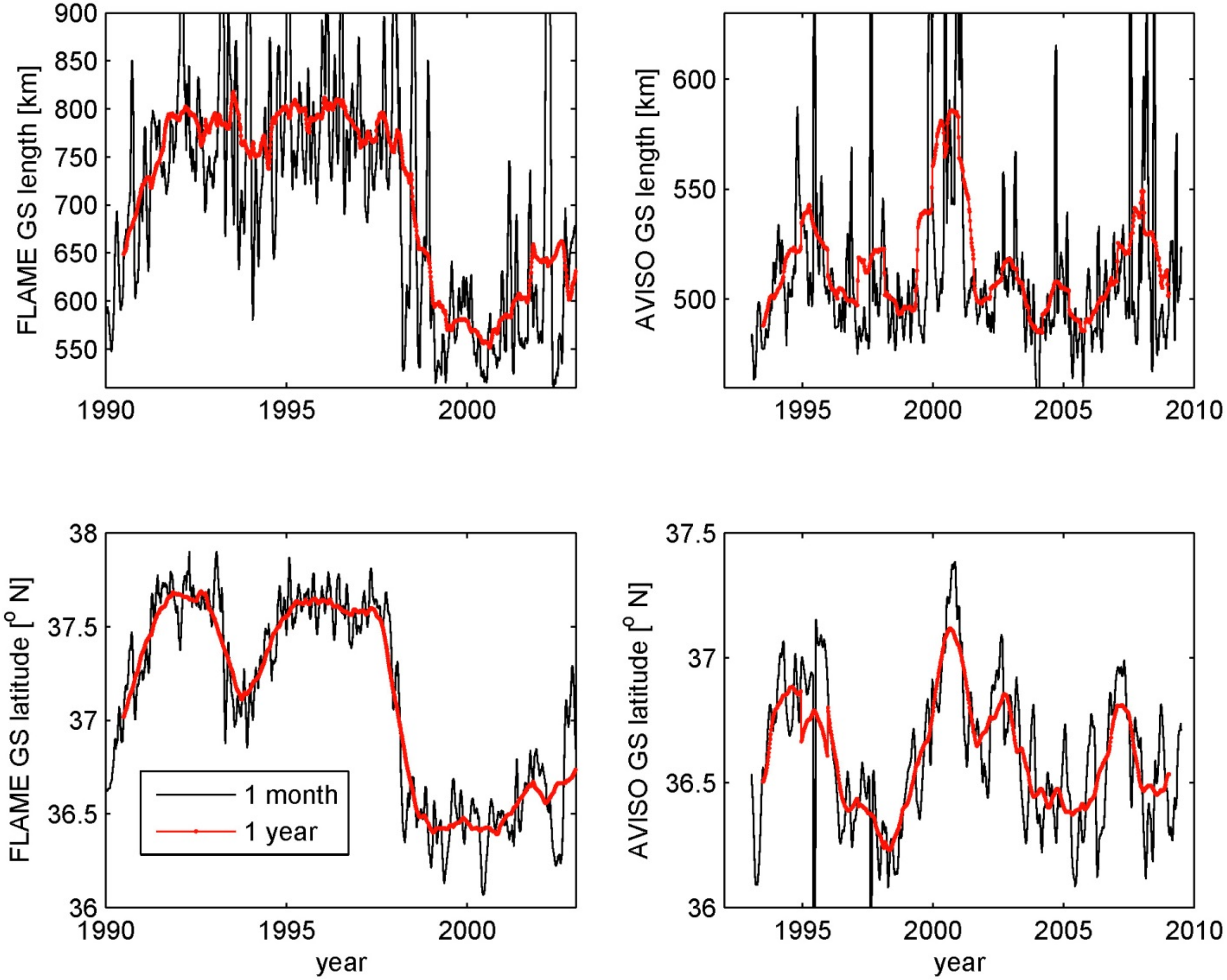
Reconstructing larval success from GS length/GS latitude using linear regression







FLAME vs AVISO



Summary

- We used a coupled biological-physical model to study dispersal pathways, success rates, swimming and navigation strategies, and variability of American eel larvae
- We tested a variety of swimming behaviors—passive drift, random walk, and directional swimming
  - the last strategy stands out as the most realistic and yields transit times of about 1 year, which agrees with observations
- Oceanic variability leads to a factor of 2 changes in eel success rates in FLAME, and factor of 1.75 in AVISO
- Success rates are strongly affected by the GS inertial overshoot events, with largest success in overshoot years
- Mean GS length and latitude between 75W and 70W can be used as proxies for overshoot events, and as predictors of larval success rates

Overview of the 2015 Katama Bay Experiment

with Larry Pratt,
Laura Slivinski, Steve Elgar
and Britt Raubenheimer

- **Test Lagrangian data assimilation in realistic oceanic settings** by assimilating real drifter tracks into a realistic numerical model and then quantifying the performance of LaDA by comparing with independent mooring data

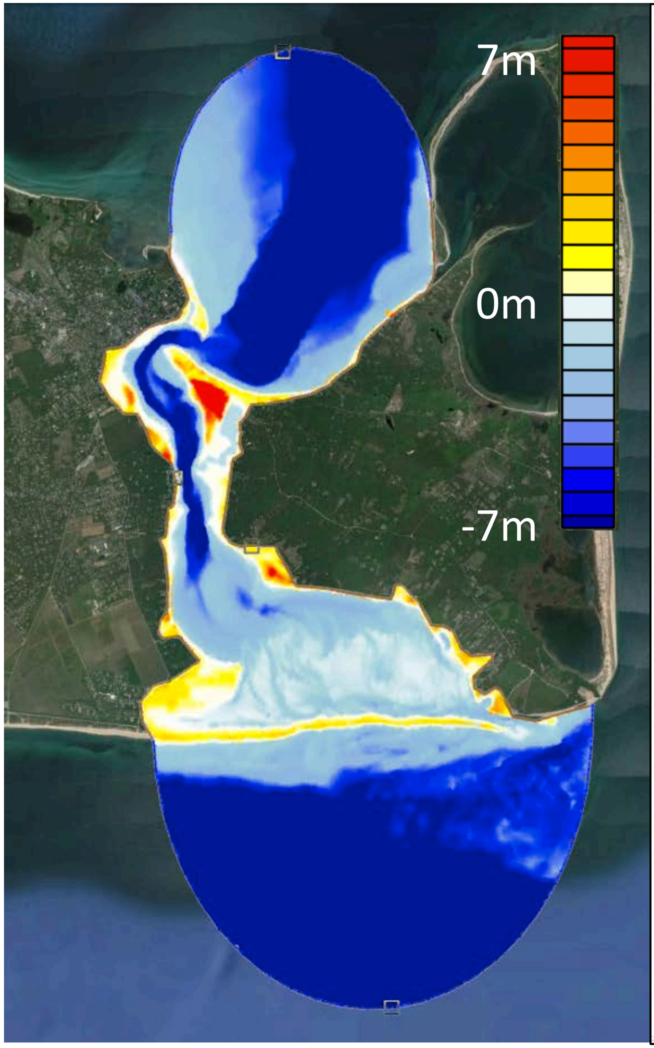
Nautical Chart of Martha's Vineyard and Nantucket 1857

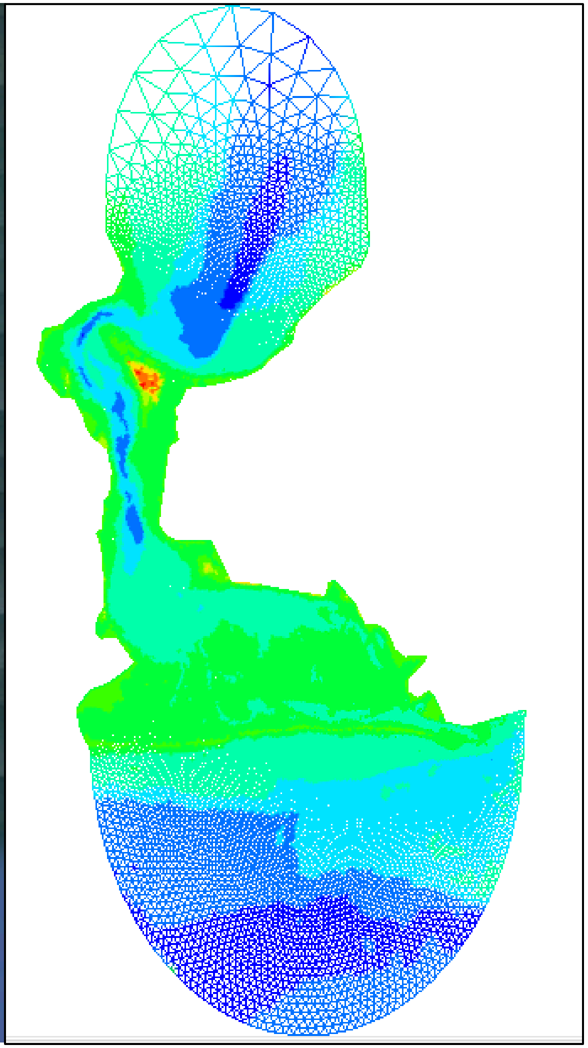
Nautical Chart of Martha's Vineyard and Nantucket 1857 US Coast Survey Taken from *Preliminary Chart No. 4 of the Sea Coast of the United States from Plymouth Mass. tp Saughkonnet River R.I.*

October 2007
4000'
June 2008
5000'
June 2009
3000'
May 2010
5000'
Katama Bay
Pocha Pond
2011
2013
2015

Katama Bay Oyster farms

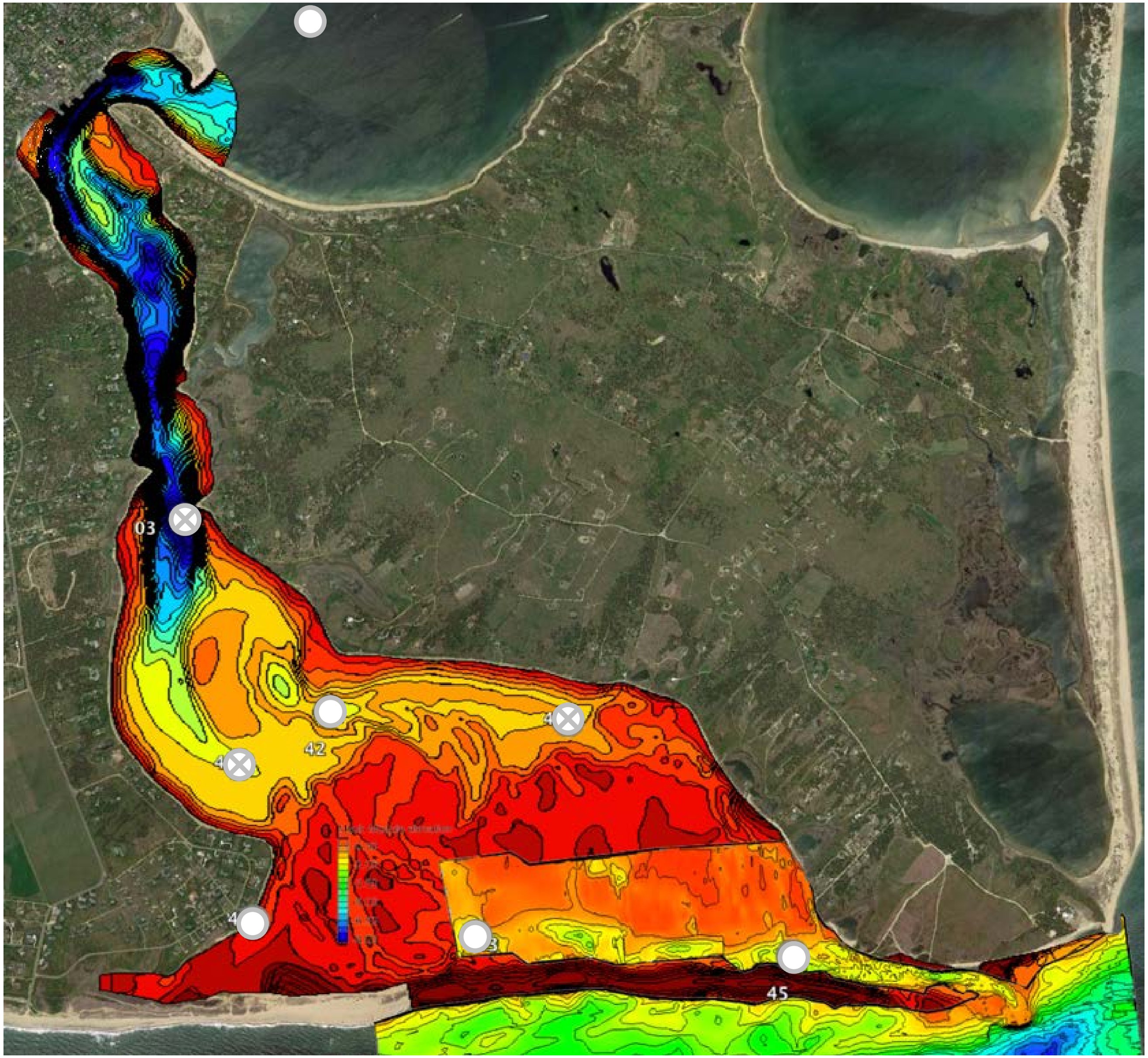
ADvanced CIRCulation Model (ADCIRC)





- Two-dimensional finite element model
- Based on the shallow water equations, which govern fluid depth and velocity at each grid point
- Variable domain resolution: 10m in inlets, 15m in bay interior
- Two open boundaries forced by data from a mooring (in the north) and MVCO (in the south)

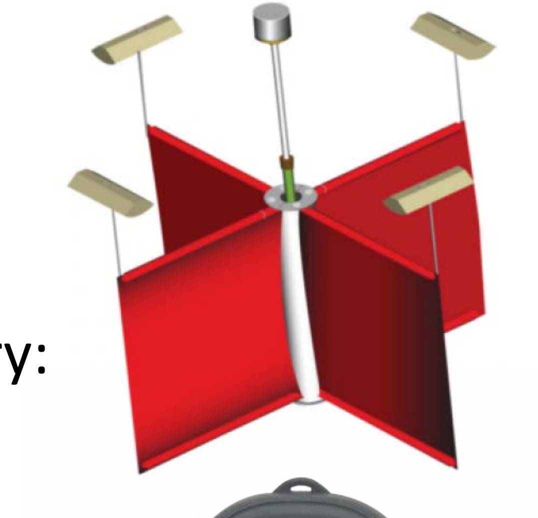
2015 field program: moored instruments



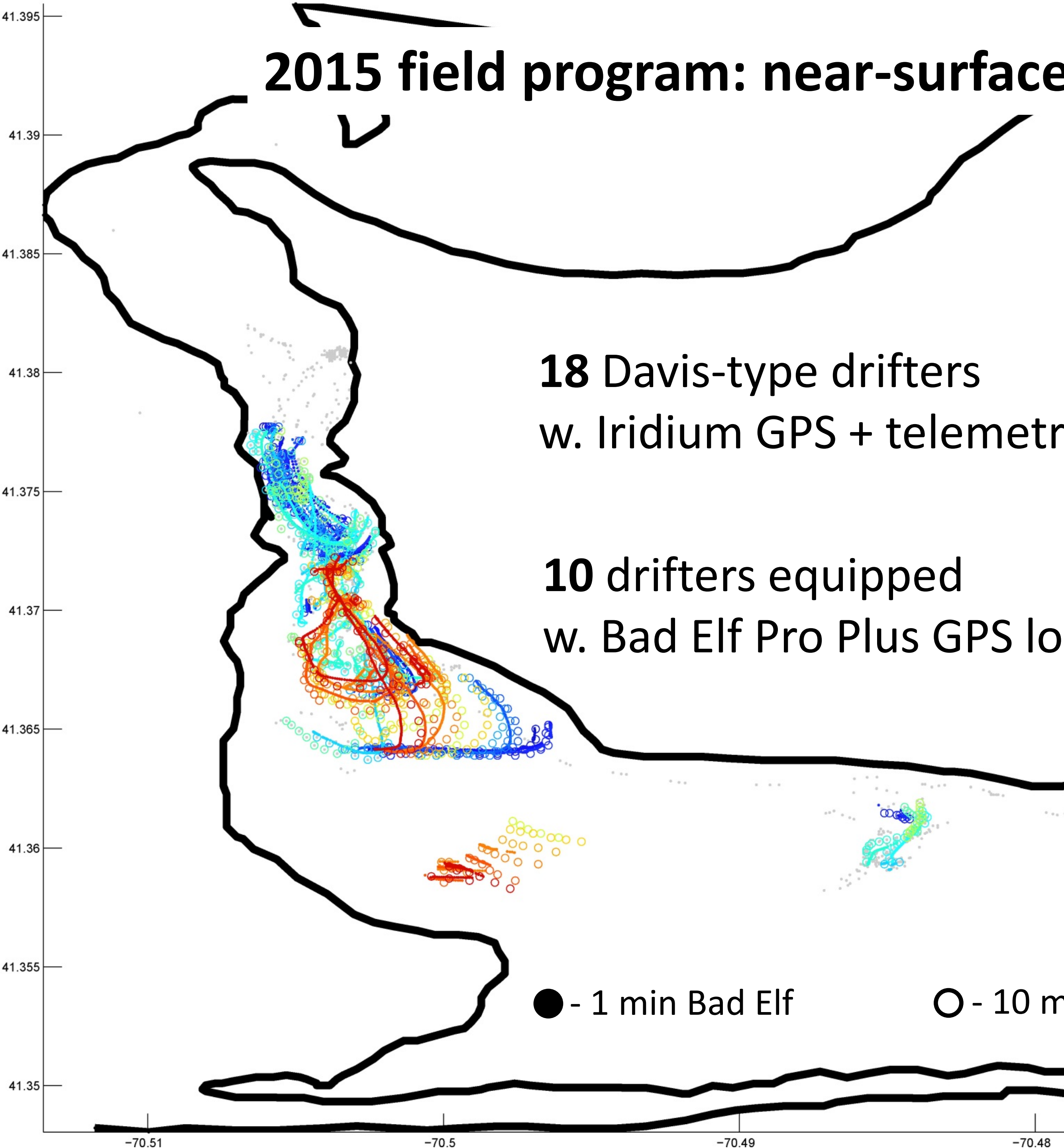
⊗ - current meter   O - pressure gauge

2015 field program: near-surface drifters

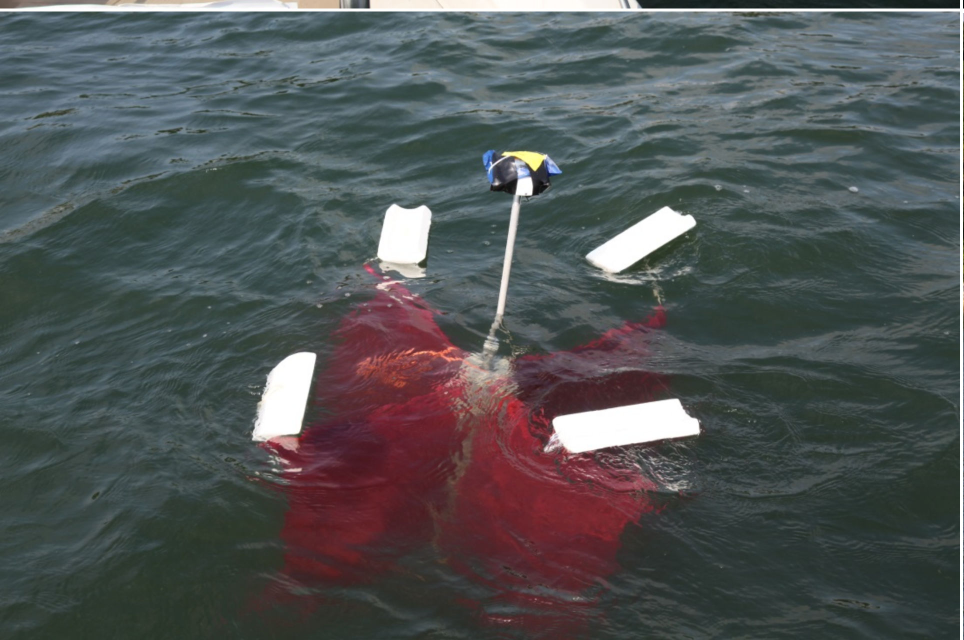
18 Davis-type drifters
w. Iridium GPS + telemetry:



10 drifters equipped
w. Bad Elf Pro Plus GPS logger:



2 days; 3 boats; 6 drifters per boat



2015 field program: near-surface drifters