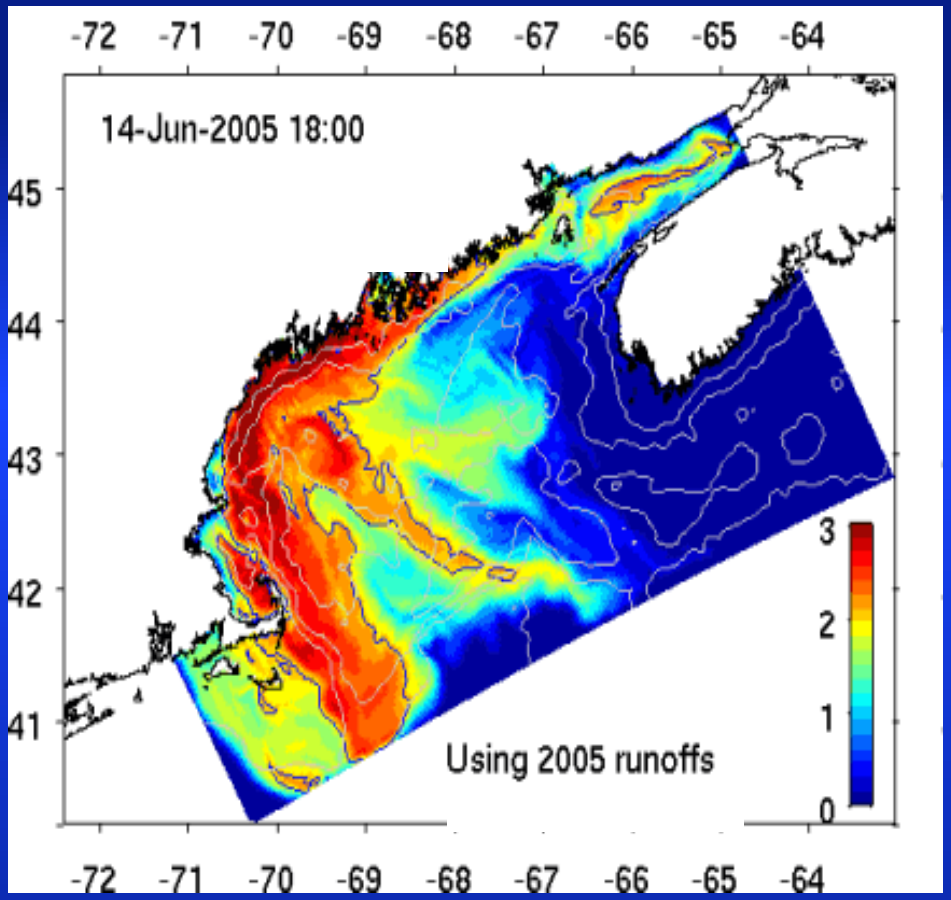
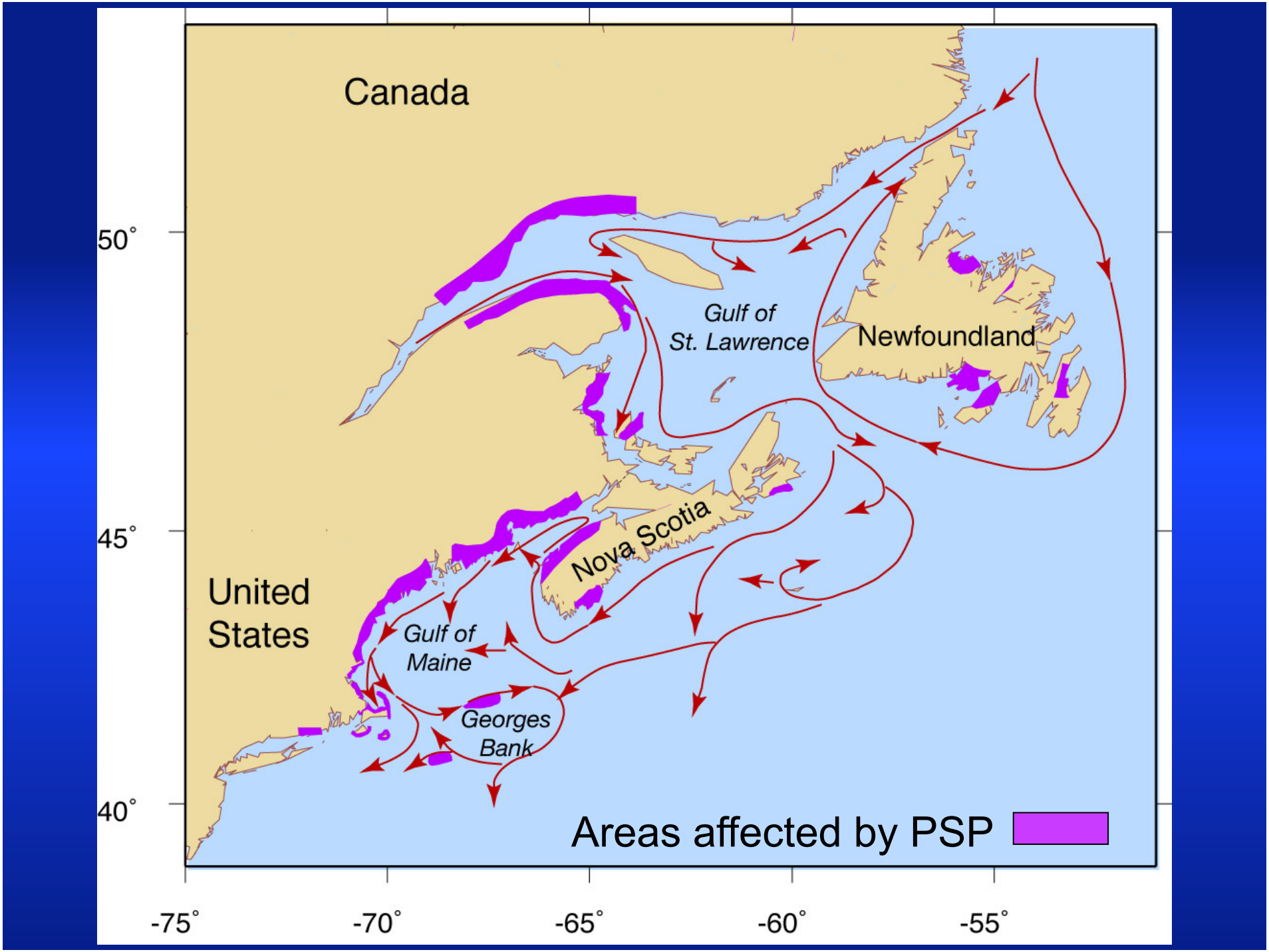
Red tides in Casco Bay and the Gulf of Maine

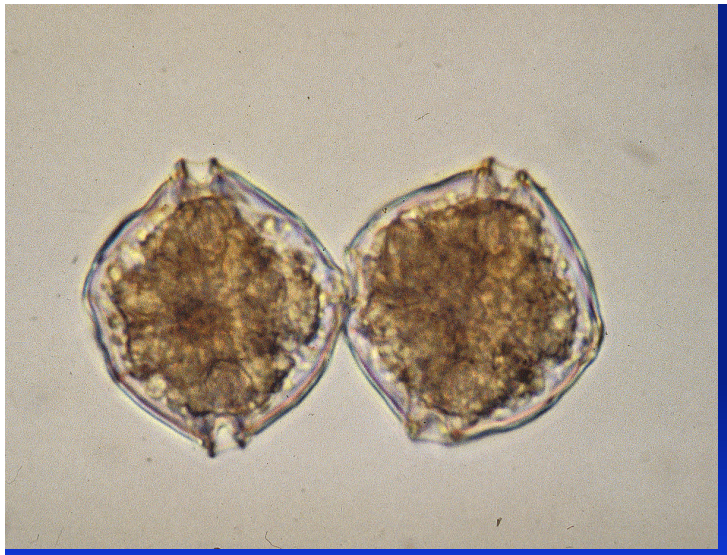


Don Anderson

Woods Hole Oceanographic Institution, Woods Hole, MA 02543

Paralytic Shellfish Poisoning (PSP)


Canada
United States
Gulf of St. Lawrence
Newfoundland
Nova Scotia
Gulf of Maine
Georges Bank
Areas affected by PSP
50°
45°
40°
-75°
-70°
-65°
-60°
-55°



vegetative cells

3: If conditions remain optimal, cells will continue to divide, reproducing exponentially, 2 to 4 to 8. A single cell could produce several hundred cells within a couple of weeks. If other single cells reproduce similarly, then toxicity in shellfish may occur.

3.

gametes

4.

4 and 5: When nutrients are gone, growth stops and gametes are formed. Two gametes join to form one cell, which develops into a zygote and then into a cyst. This falls to the ocean bottom and is capable of germination the following year.

2: Cysts can germinate only during certain times of the year with warmer temperatures and increased light stimulating germination. The cyst breaks open, and a swimming cell emerges. The cell reproduces by simple division within a few days of "hatching."

2.

zygote

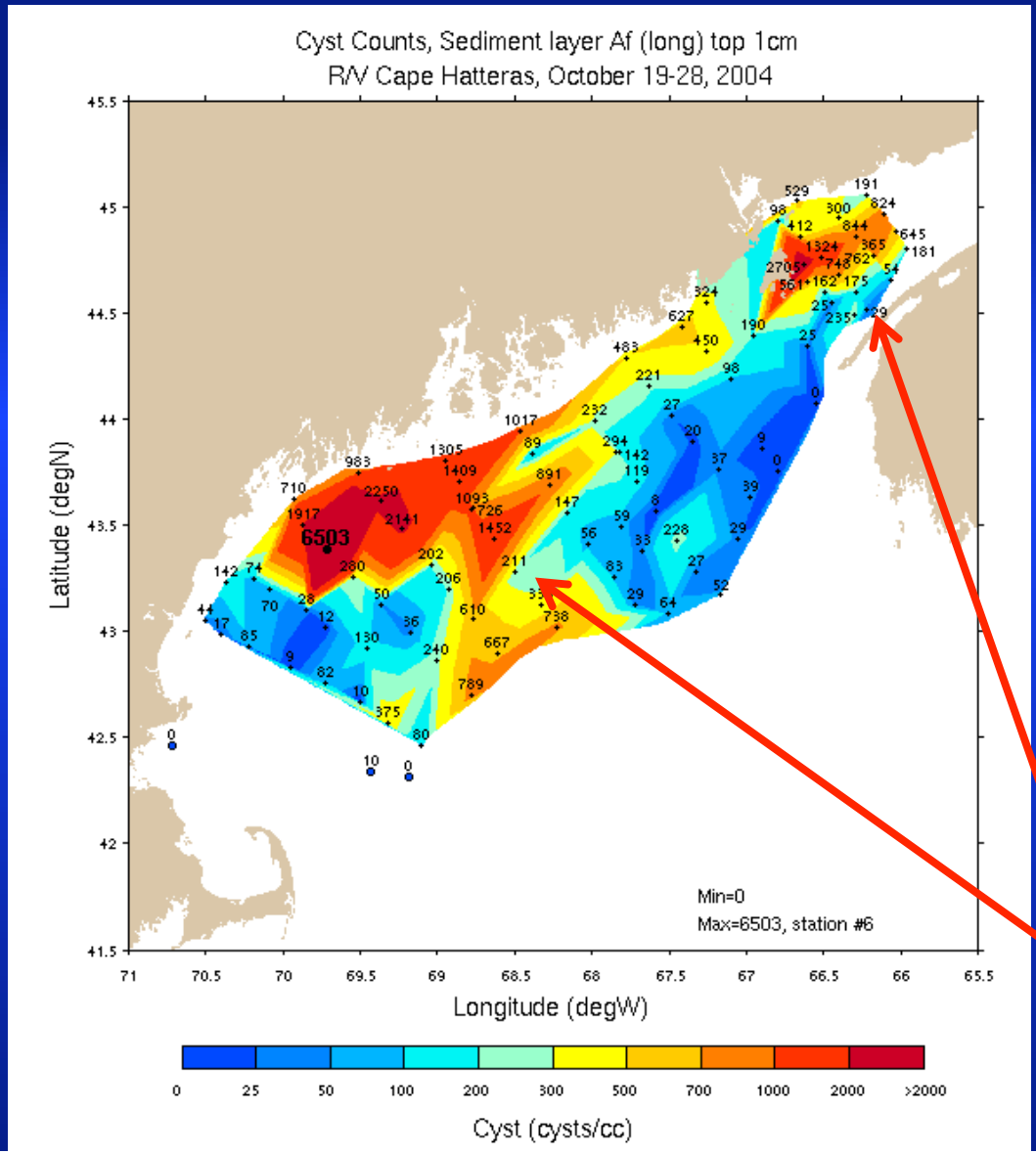
5.

1: Alexandrium resting cysts lay dormant on the ocean floor, buried in sediment. If undisturbed by physical or natural forces, they can stay in this state for years. If oxygen is present, germination may proceed if conditions are right.

1.

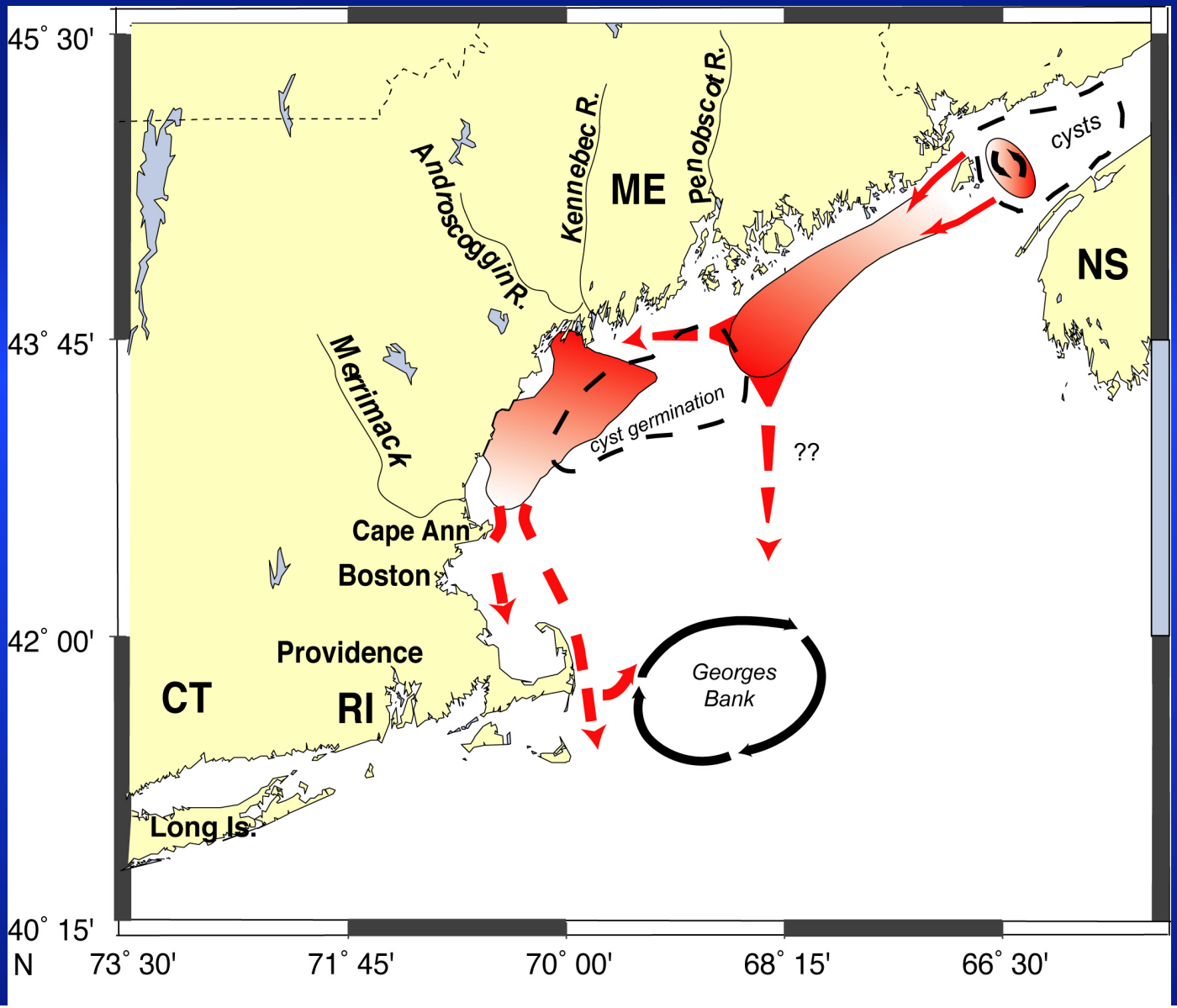
cyst

Where are the cysts?



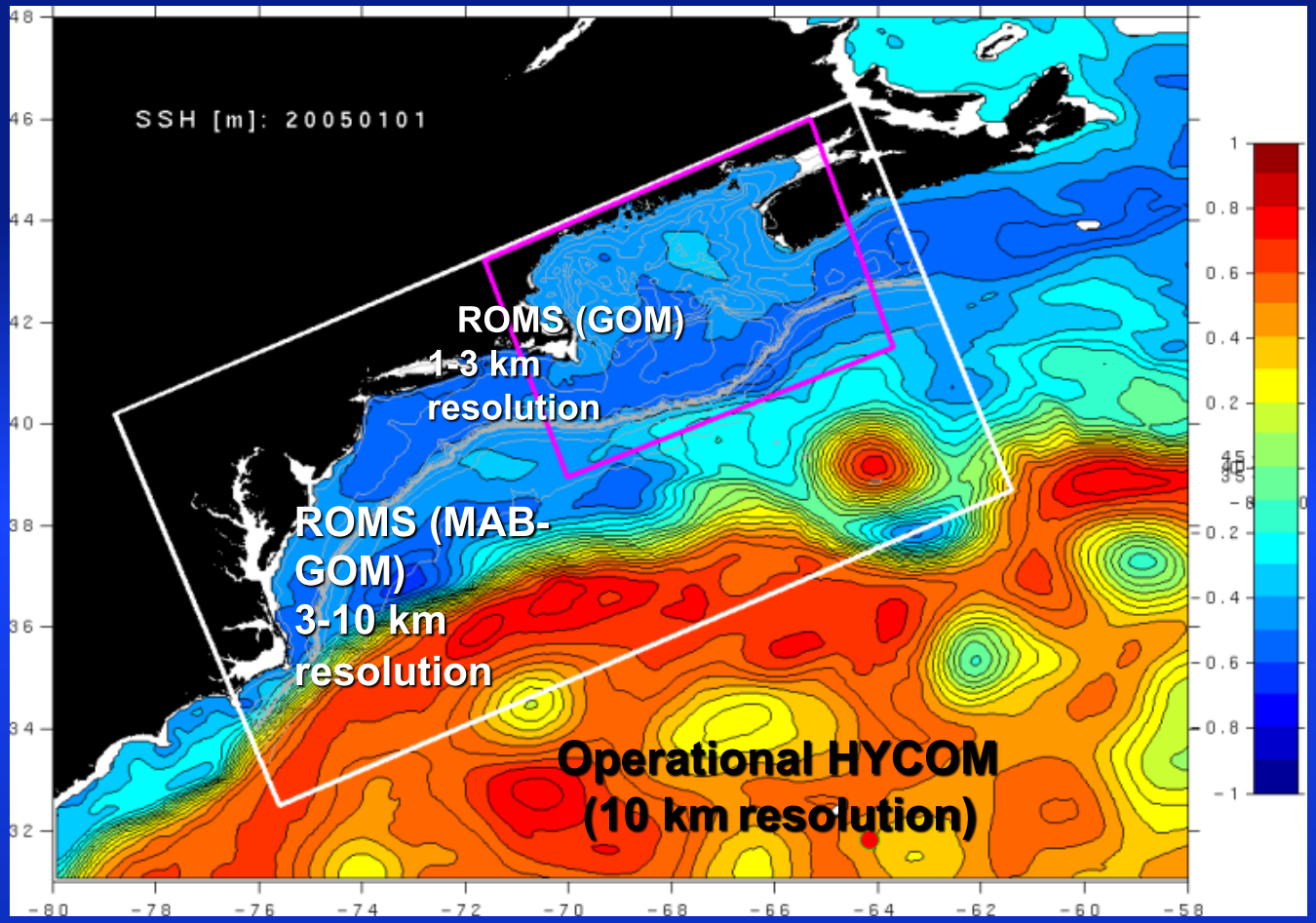
Two major cyst seedbeds

Conceptual Model



A cyst-based numerical model of *Alexandrium* bloom dynamics

Start with a nested hydrodynamic model



The ROMS-GOM model has a spatial resolution of 1-3 km, 36 terrain-following vertical layers.

HYCOM: Hybrid Coordinate Ocean Model (NRL and U. Miami)
ROMS: Regional Ocean Modeling System (Rutgers and UCLA)

Forcing Fields for the GOM Coupled Model Simulation

-Physical circulation model

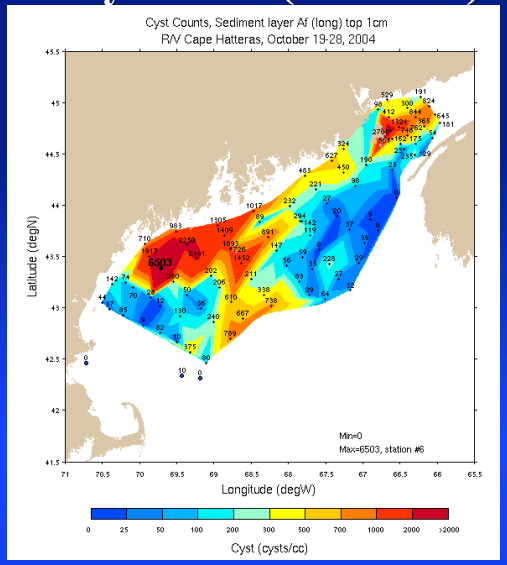
- Tides (M_2, S_2, N_2, K_2, K_1, O_1, Q_1)
- 3-h wind and heat fluxes from NCEP EDAS
- River runoff from USGS gauges
- Open boundary conditions from larger-scale 'parent' model

***-A. fundyense* model**

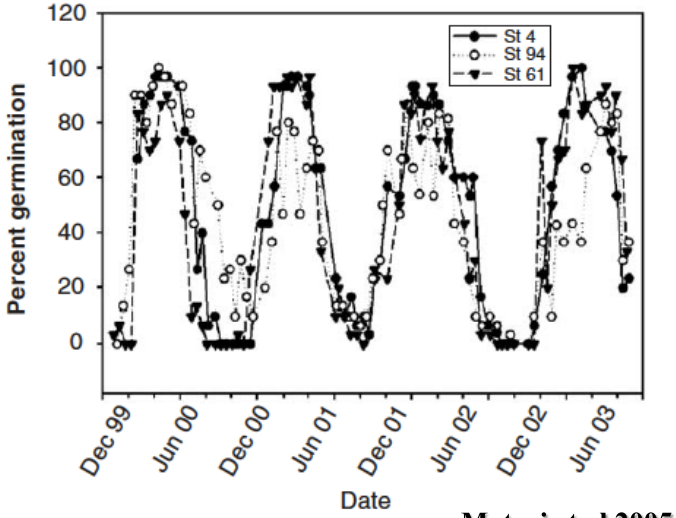
- Solar radiation from NCEP
- Cyst abundance from fall cyst survey in the previous year
- 3-D monthly DIN climatology from David Townsend

Alexandrium Population Dynamics Model

Cyst Dist. (# / cm^2)

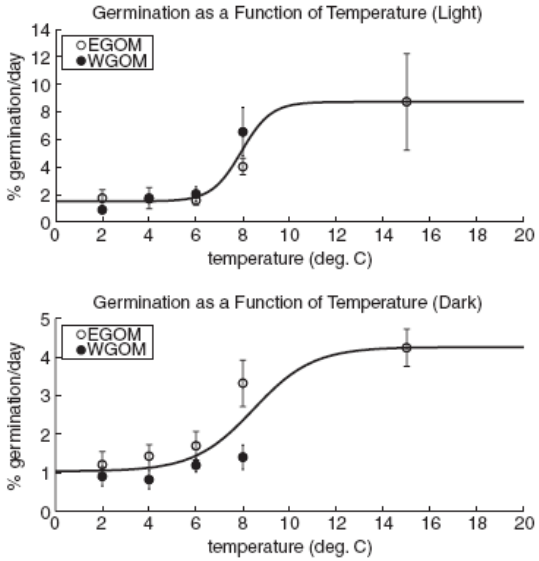


Endogenous Clock

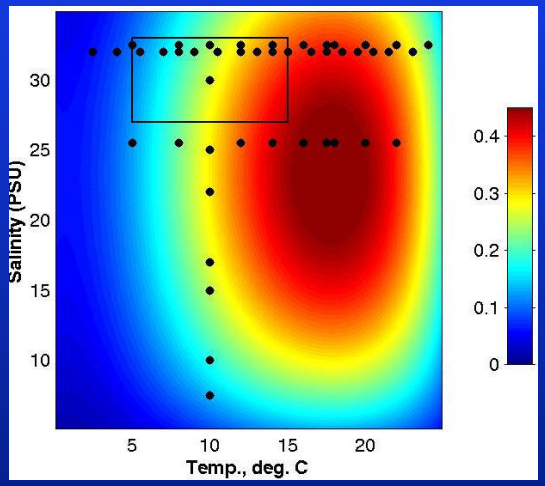


Matrai et al 2005

Germ. rate (% / day)



Growth (per day)

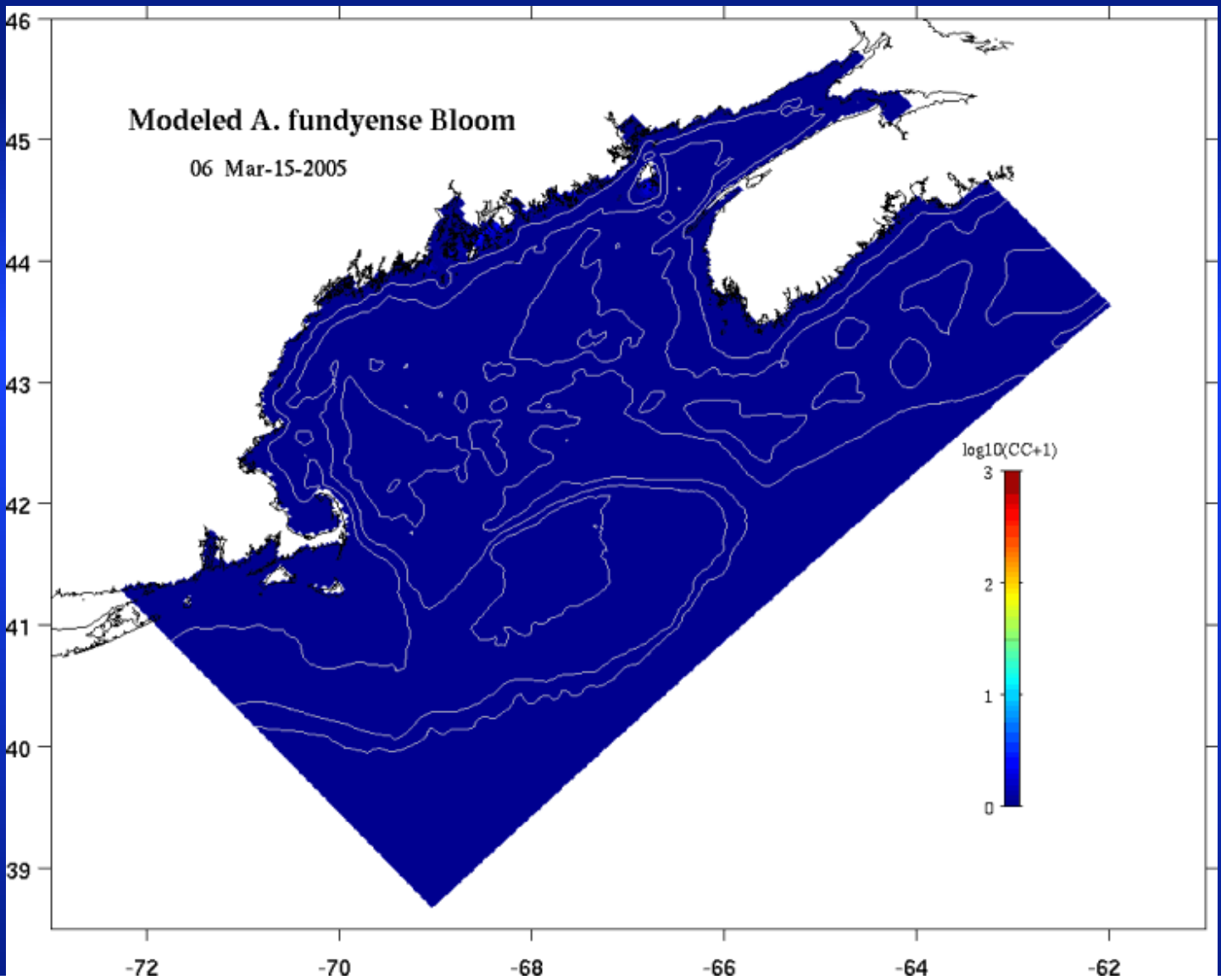


Growth = min (f(PAR) , g(T,S))

Upward swimming 10 m/day

"Mortality" = Q_{10} temperature dependence

Physical/biological model of 2005 *A. fundyense* bloom dynamics in the Gulf of Maine (initiated using 2004 cyst map)



Population dynamics modeling in support of research and management

1. Hindcasts for hypothesis testing
2. Weekly forecasts
3. Annual or seasonal forecasts

To: northeastpsp@whoi.edu
List-Id: Northeast Paralytic Shellfish Poisoning <northeastpsp.whoi.edu>

Dear All,

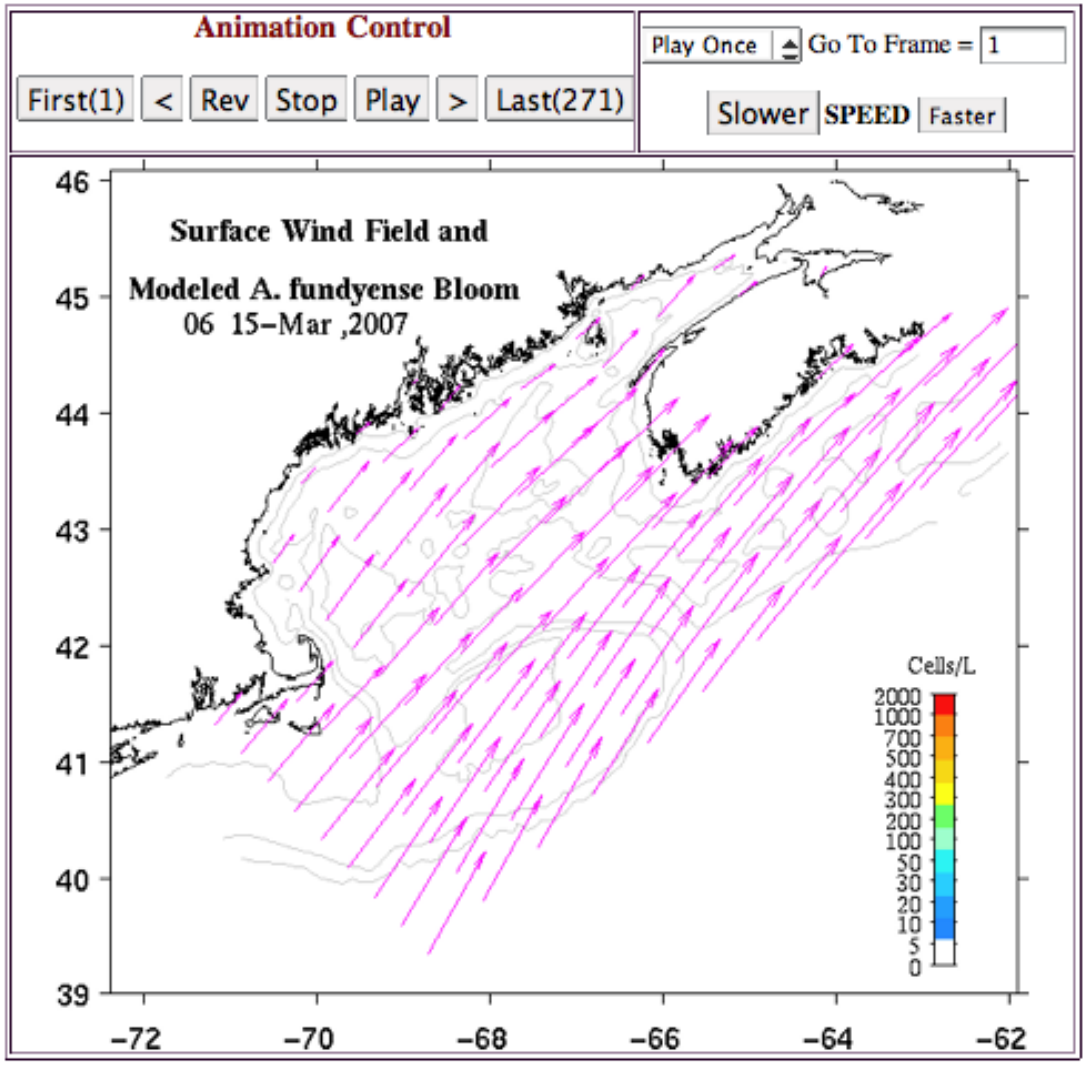
Updated model solutions (as of June 25) are now available at:

http://omgrhe.meas.ncsu.edu/Redtide/Redtide_07/

As more in-situ observations coming in, we are working diligently to validate and improve the model performance. For instance, we see the cells reach Georges Bank in the model but do not grow there as opposed to what's been observed by the first Endeavor survey. We think that it may be a result of the way nutrients are currently handled in the model, with the concentration specified from climatology. Work is now underway to upgrade the model by simulating the 3-dimensional nutrient concentration as a part of A.f. bloom prediction.

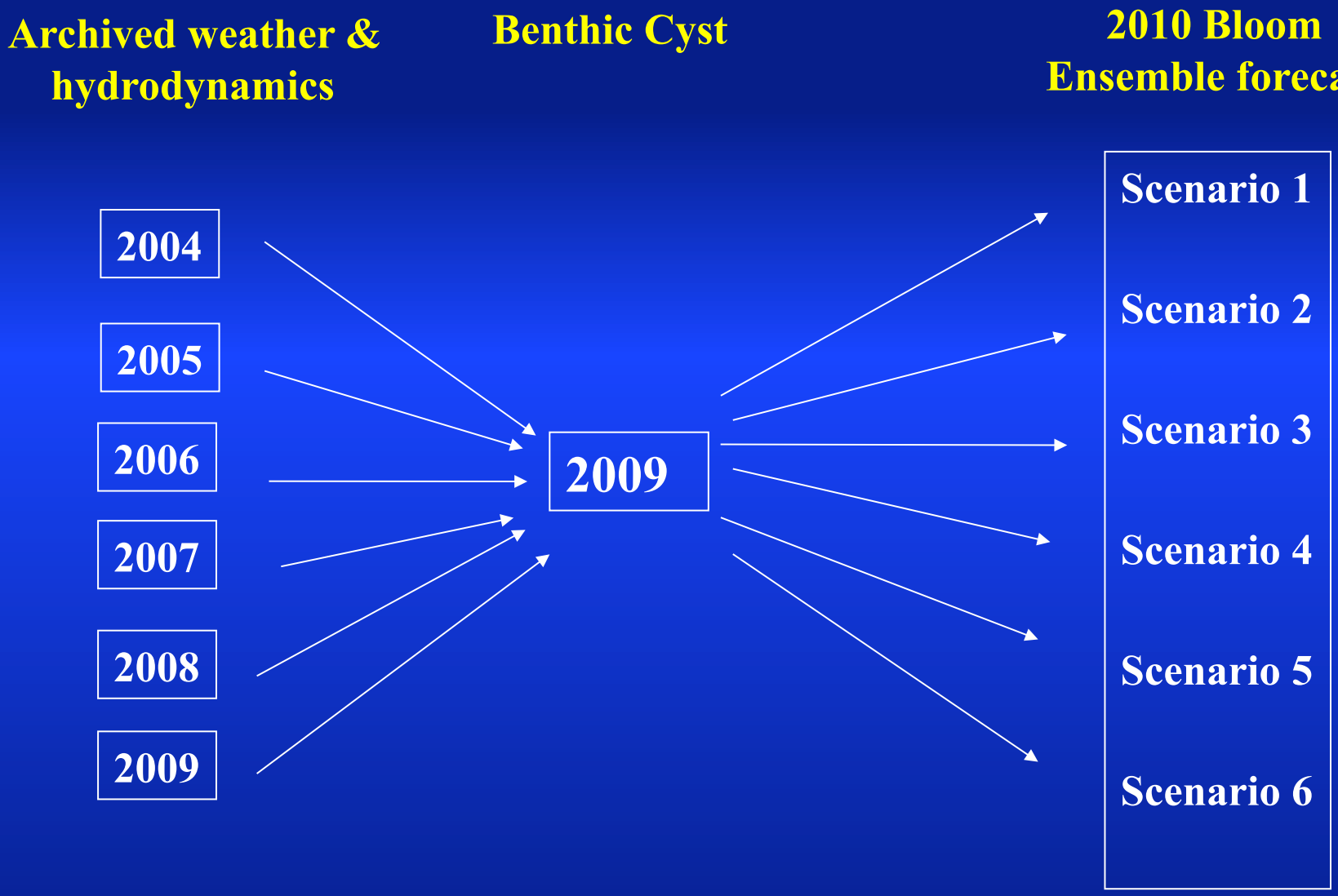
We will continue posting results from our current version of model for now, and will let you know when solutions from new version of the model become available, so stay tuned.

Gulf of Maine Redtide -2007

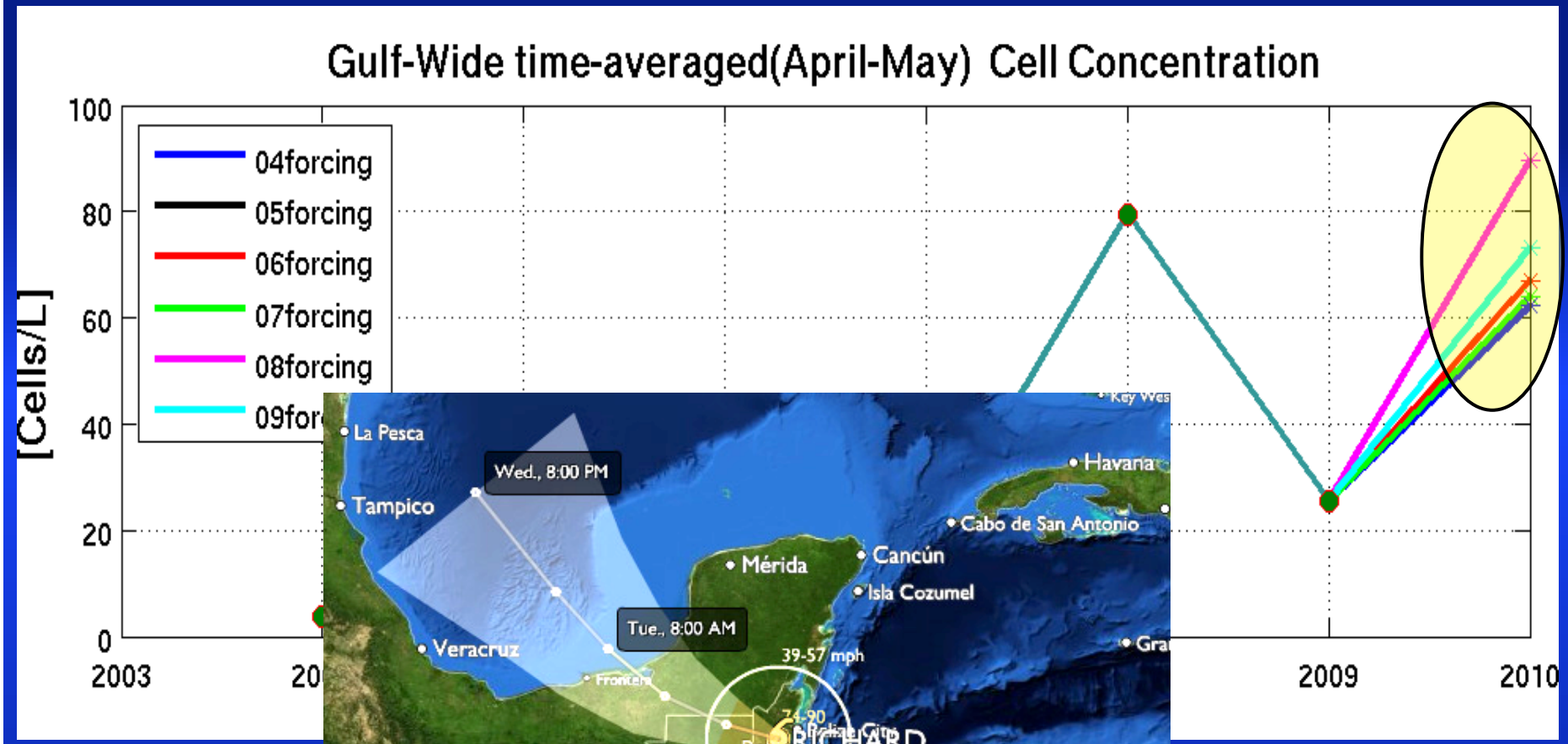


This animation requires JavaScript. You will need Netscape version 3.0 or higher or Internet Explorer 4.0 or higher and JavaScript enabled to view this.

Seasonal Ensemble Forecast for 2010



2010 ensemble forecast



News Release : In Computer Models and Seafloor Observations, Researchers See Potential for Significant 2008 "Red Tide" Season

Conditions are ripe for another large bloom in New England waters; weather and ocean conditions will determine outcome

FOR IMMEDIATE RELEASE
(508) 289-3340
media@whoi.edu

April 24, 2008
Media Relations Office
Bell House MS #54
Woods Hole Oceanographic Institution

Source: Media Relations

The end of April usually brings the first signs of harmful algae in New England waters, and this year, a research team led by the Woods Hole Oceanographic Institution (WHOI) is preparing for a potentially big bloom.

A combination of abundant beds of algal seeds and excess winter precipitation have set the stage for a harmful algal bloom similar to the historic "red tide" of 2005, according to WHOI biologist Don Anderson, principal investigator of the Gulf of Maine Toxicity (GOMTOX) study. The 2005 bloom shut down shellfish beds from the Bay of Fundy to Martha's Vineyard for several months and caused an estimated $50 million in losses to the Massachusetts shellfish industry alone.

Weather patterns and ocean conditions over the next few months will determine whether this year's algal growth approaches the troubles of 2005.

Oceanographers Dennis McGillicuddy (WHOI) and Ruoying He (North Carolina State University) are several years along in the development of a computer model to predict the intensity and location of blooms of the toxic algae *Alexandrium fundyense* in the Gulf of Maine.

Scientists are reluctant to make a "forecast" of precisely where and when the bloom will make landfall because bloom transport depends on weather events that cannot be predicted months in advance. However, colleagues in coastal management and fisheries believe that the regional-scale, seasonal forecast that McGillicuddy and colleagues produce can be useful in preparing for contingencies.

"With advance warning of a potentially troublesome year for algae, shellfish farmers and fishermen might shift the timing of their harvest or postpone plans for expansion of aquaculture beds," said Anderson, a WHOI senior scientist in the Biology Department and director of the Coastal Ocean Institute.

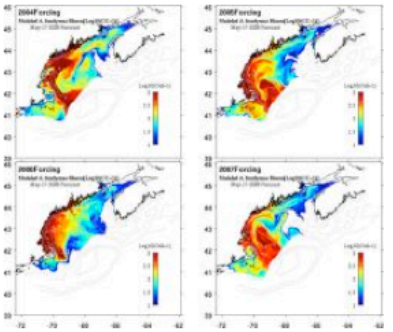
"Restaurants might make contingency plans for supplies of seafood during the summer," Anderson added, "and state agencies can ensure they have adequate staff for the significant monitoring efforts that might be required to protect public health and the shellfish industry."

Seeds or "cysts" of *A. fundyense* naturally germinate and turn into cells that swim up from the seafloor around April 1 of each year. By the end of April, cells usually begin to appear in large numbers in the waters off coastal Maine.

The algae are notorious for producing a toxin that accumulates in clams, mussels, and other shellfish and can cause paralytic shellfish poisoning (PSP) in humans who consume them.

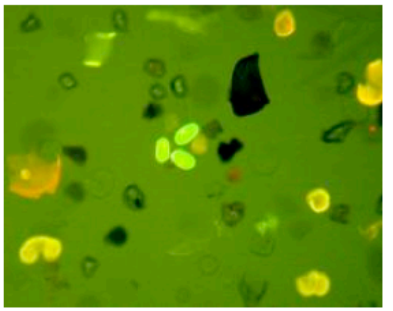
According to a seafloor survey conducted in the fall of 2007 by Anderson's team, the number of *Alexandrium* cysts—the dormant, seed-like stage of the algae's life-cycle—is more than 30 percent higher than what was observed in the sediments prior to the historic bloom of 2005.

The seed beds were especially rich in mid-coast Maine, origin of many of the cells that affect western Maine, New Hampshire, and Massachusetts.



Enlarge Image

Maps show the results of four different runs of a computer simulation of the cell concentrations of *Alexandrium fundyense* under four different weather scenarios. (Graphic by Dennis McGillicuddy, Woods Hole Oceanographic Institution, and Ruoying He, North Carolina State University)

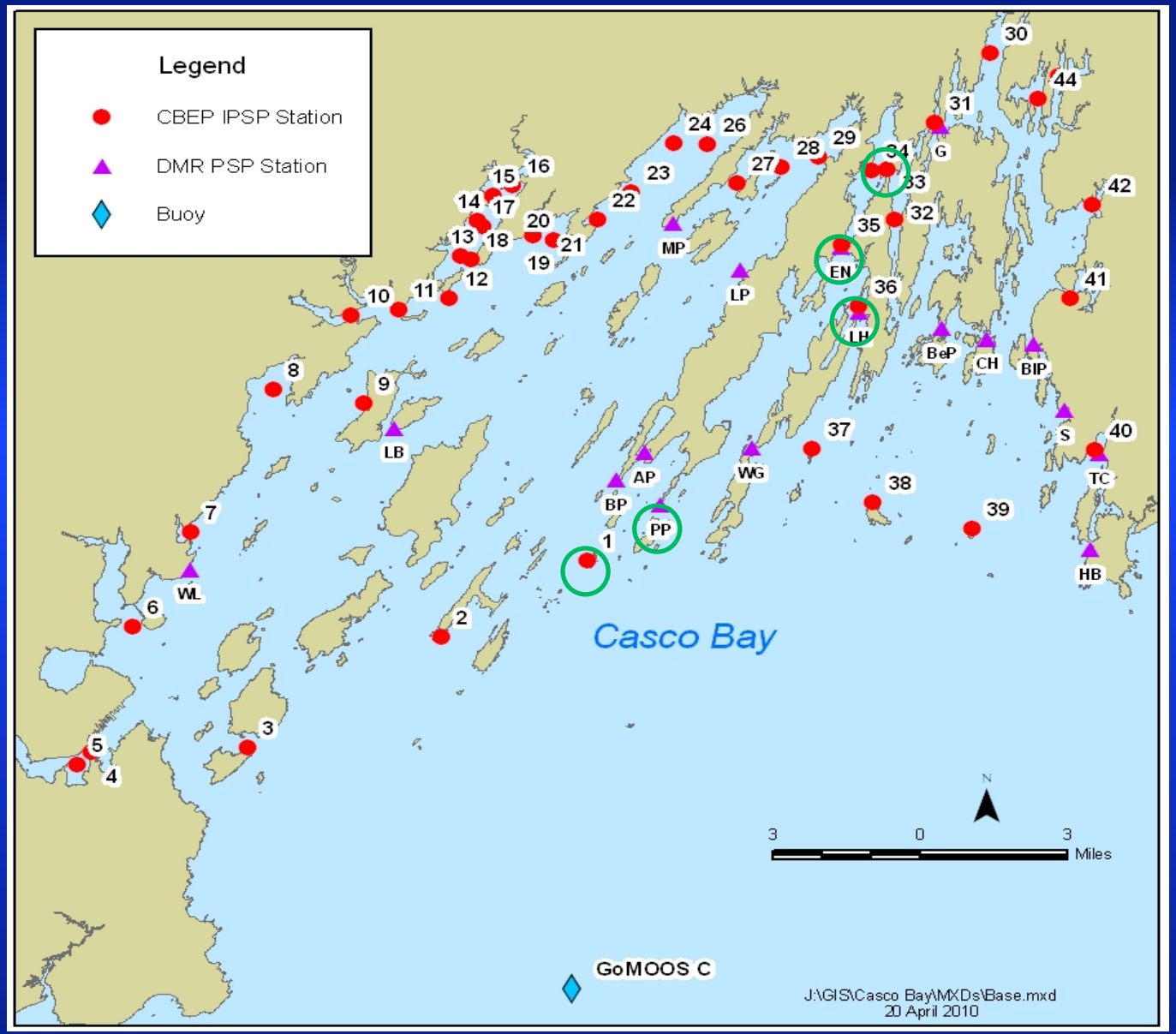


Enlarge Image

Stained with primulin dye and viewed under a microscope, cysts of *Alexandrium fundyense* and

PSP and *Alexandrium* in Casco Bay

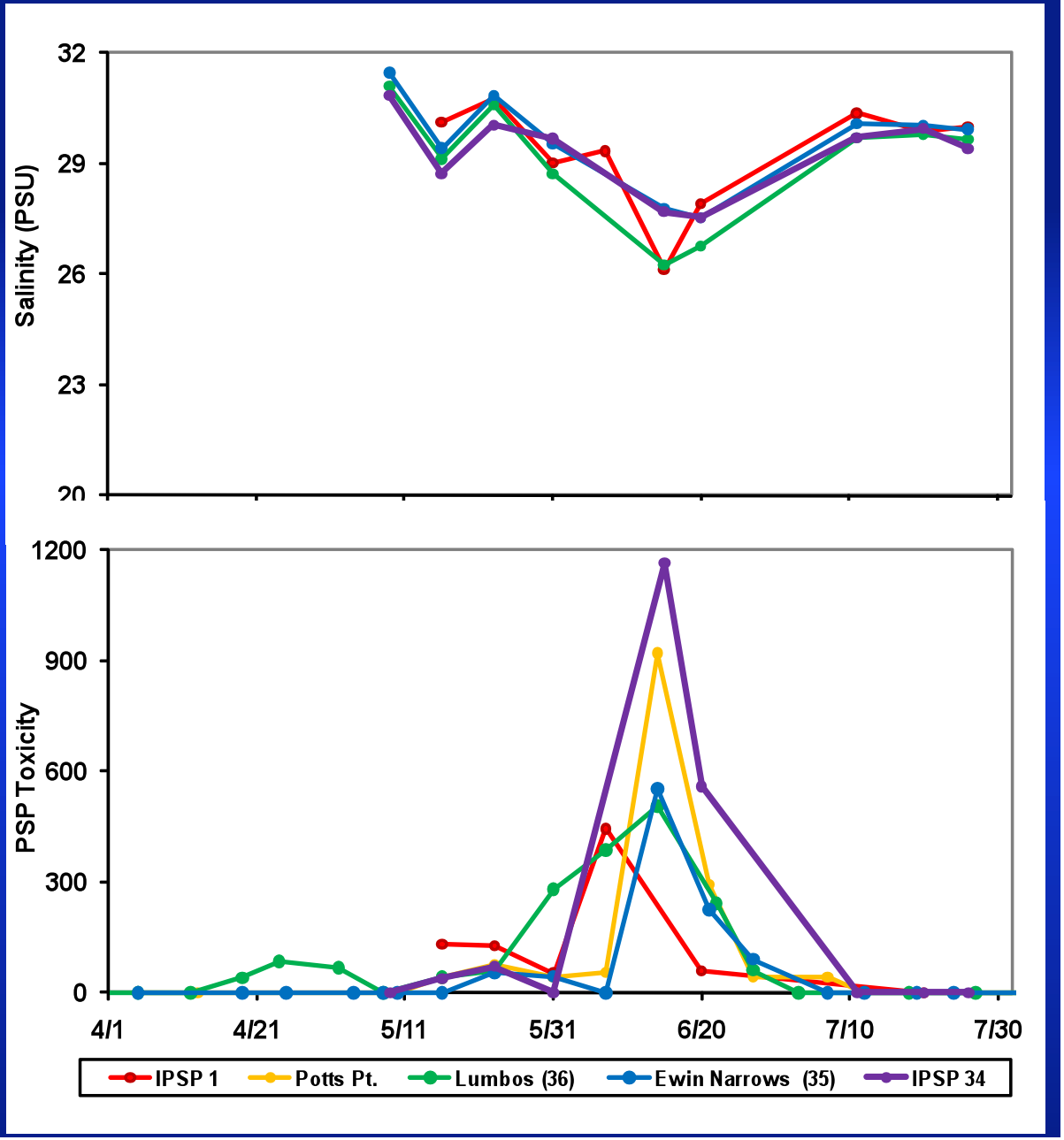
CBEP IPSP and DMR PSP Stations



Source: Libby and Anderson, CBEP 2010

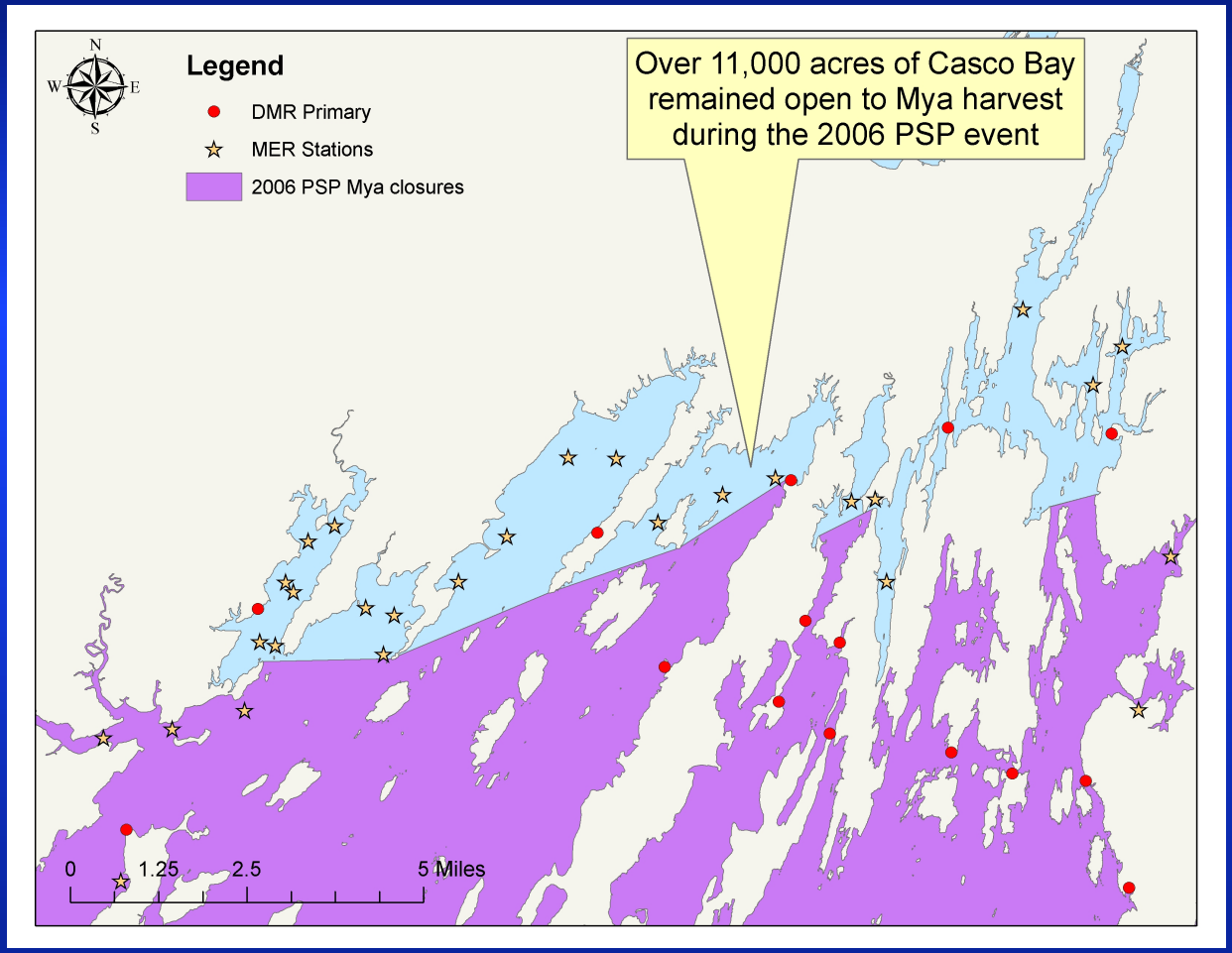
Harpswell Sound Data 2006

- Early toxicity at Lumbo's Hole
- Offshore toxicity in mid May
- Increasing offshore in early June before peaking in mid June
- Coincident with lower salinity water from Kennebec River plume ME DMR
- Suggests an early internal bloom and the subsequent intrusion of offshore bloom



Source: Libby and Anderson, CBEP 2010

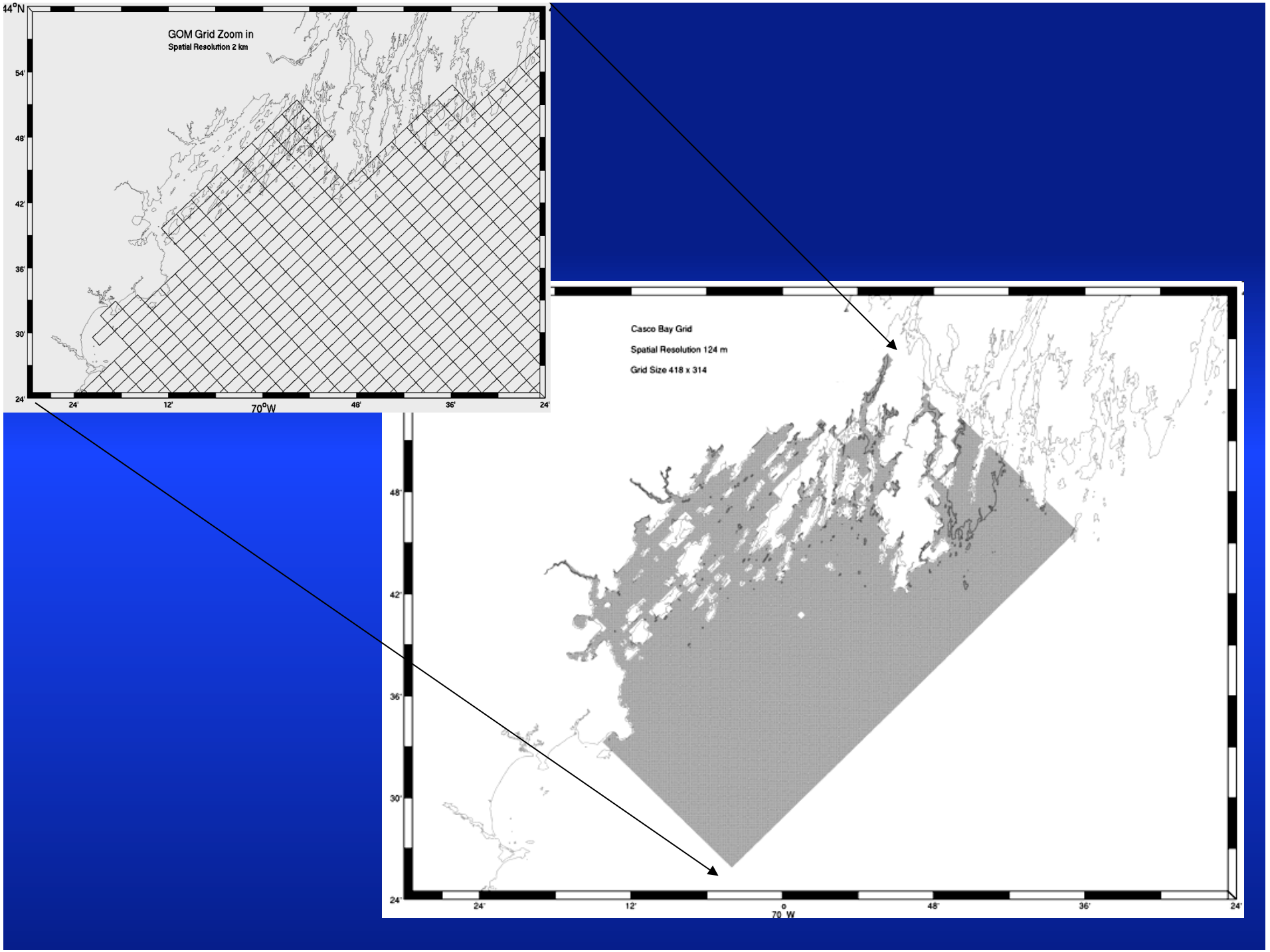
Management Goal - Surgical PSP Closures



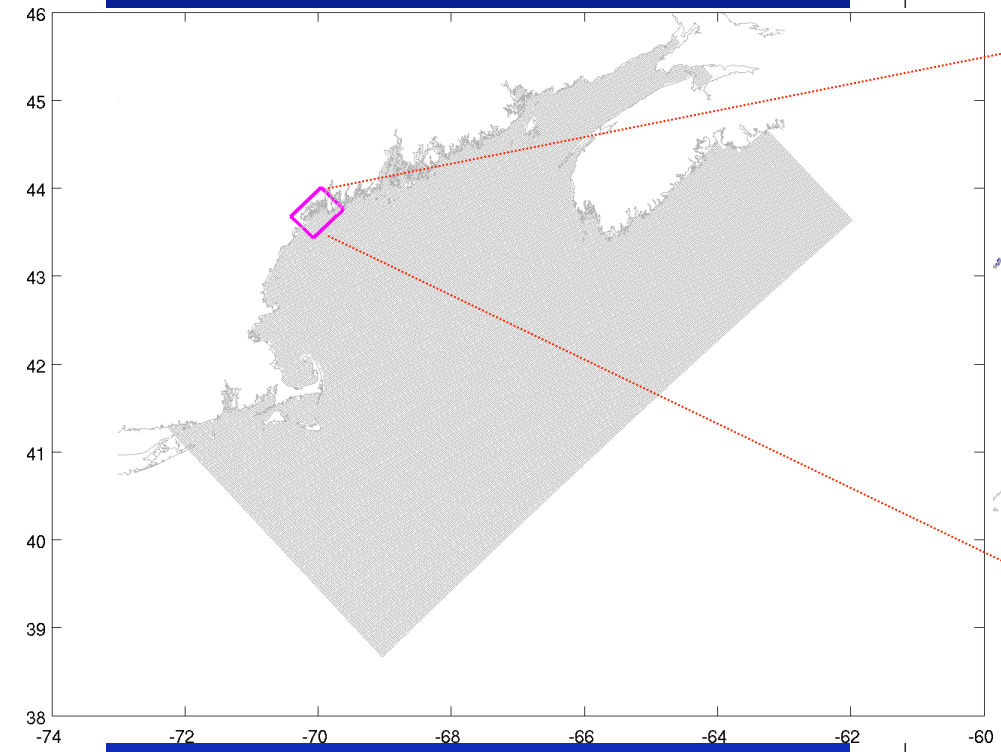
Source: D. Couture, Maine DMR

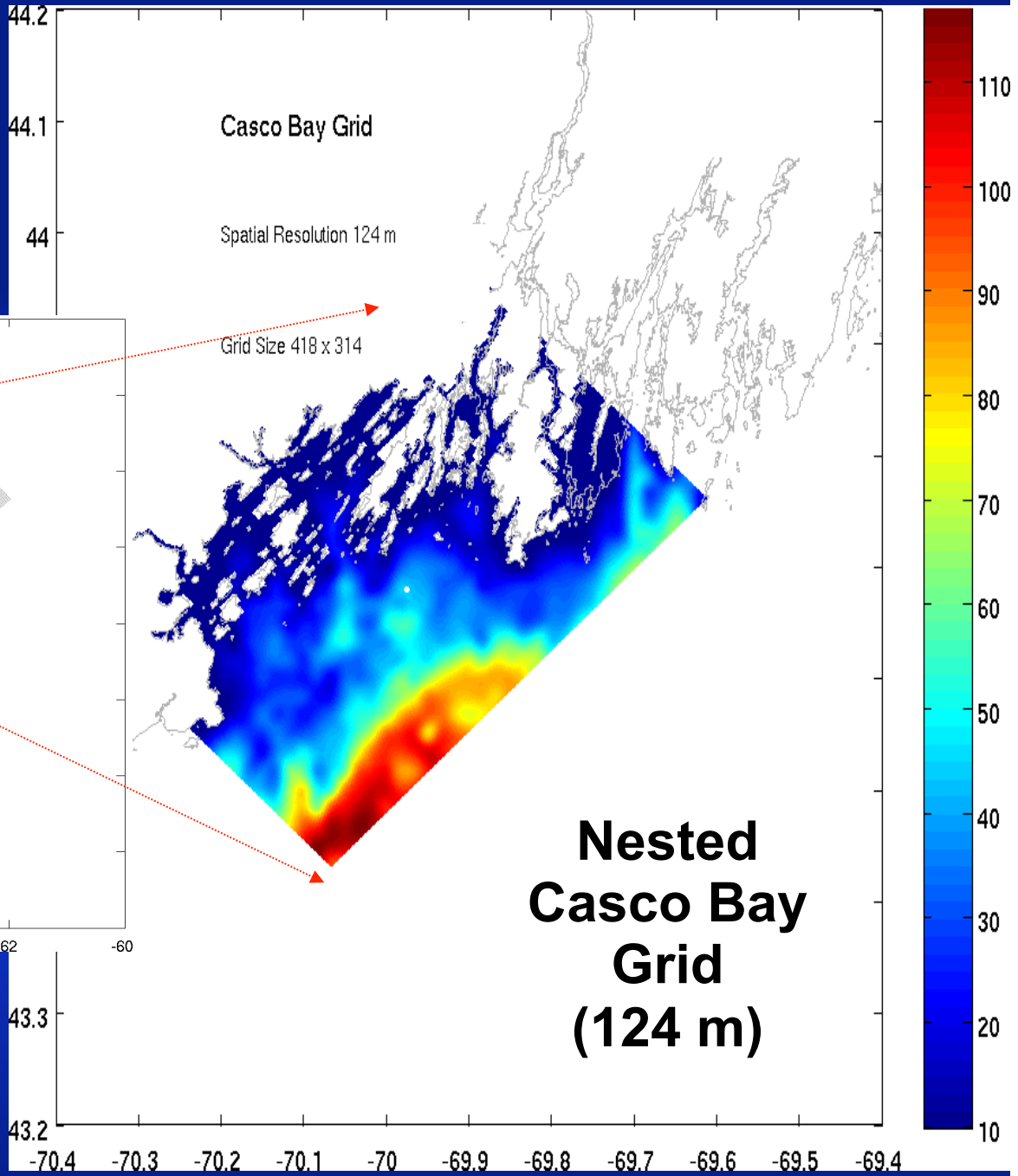
Needs: Data and capabilities

1. High resolution Casco Bay hydrographic model nested within the *Alexandrium* population dynamics model


GOM Grid Zoom in
Spatial Resolution 2 km
44°N
54'
48'
42'
36'
30'
24'
24'
12'
48'
36'
24'
70°W
Casco Bay Grid
Spatial Resolution 124 m
Grid Size 418 x 314
48'
42'
36'
30'
24'
24'
12'
48'
36'
24'
70 W

GoM Grid (2-km resolution)





Nested Casco Bay Grid (124 m)

Needs: Data and capabilities

1. High resolution Casco Bay hydrographic model nested within the *Alexandrium* population dynamics model
2. High resolution hydrography and *Alexandrium* cell abundance data within Casco Bay to calibrate model

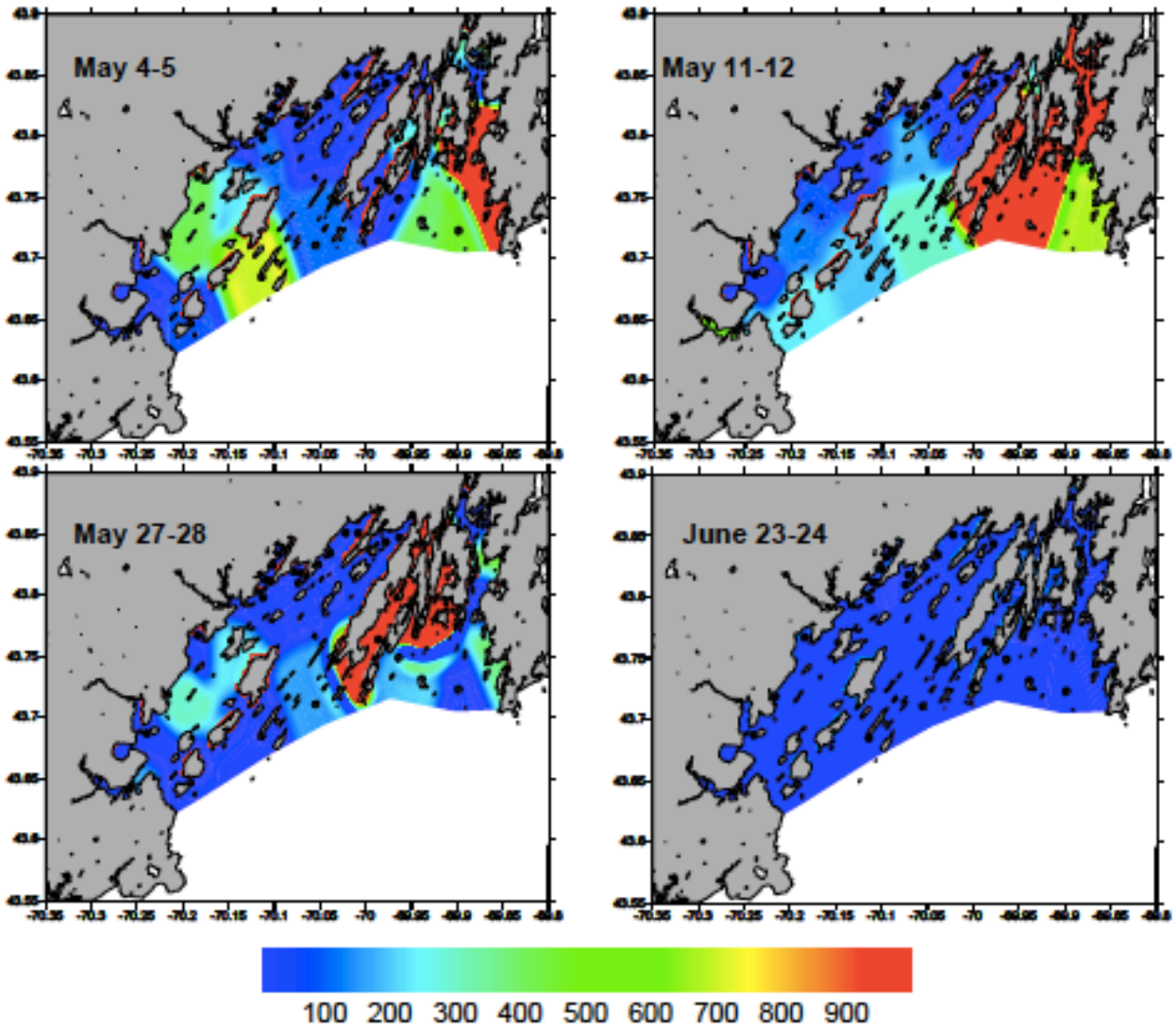
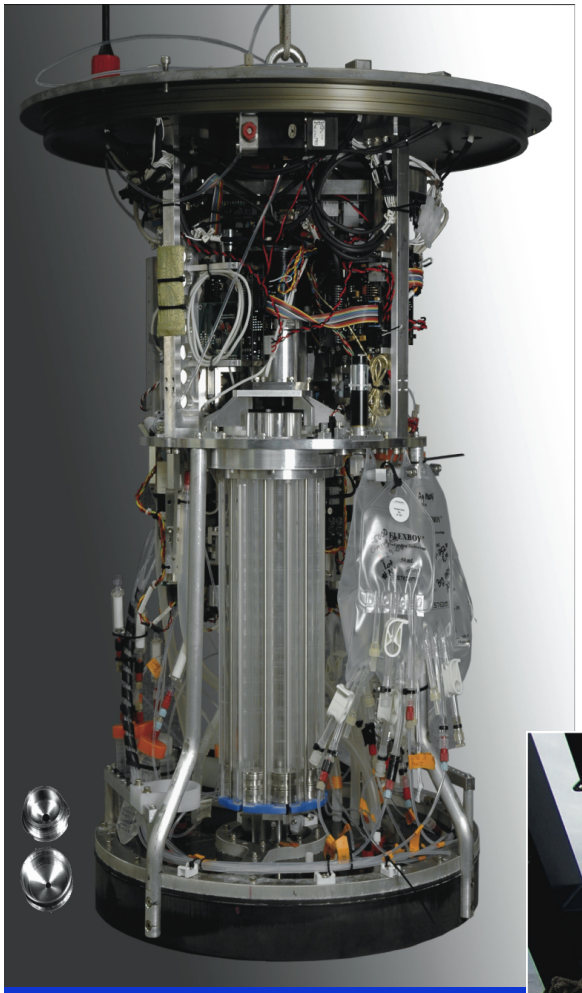


Figure 17. ***Alexandrium*** **abundance (cells/L) during selected 2008 surveys.**

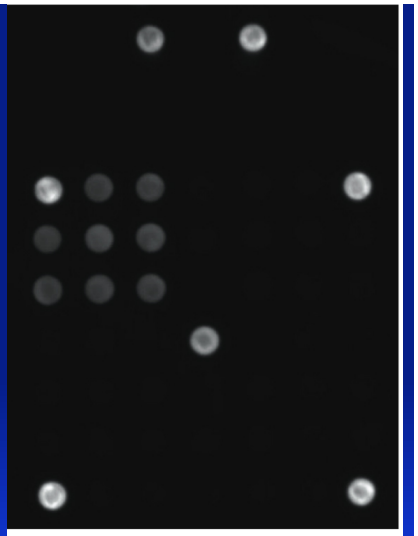
Source: Libby and Anderson, CBEP 2010

Needs: Data and capabilities

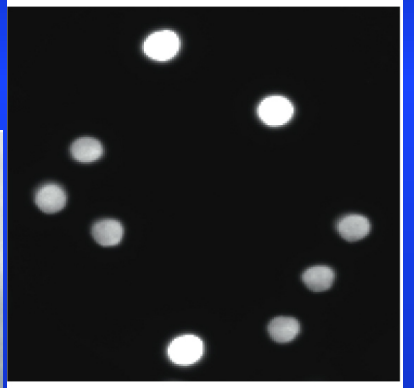
1. High resolution Casco Bay hydrographic model nested within the *Alexandrium* population dynamics model
2. High resolution hydrographic *Alexandrium* cell abundance data within Casco Bay to calibrate model
3. Real-time *Alexandrium* cell concentration measurements outside and within Casco Bay



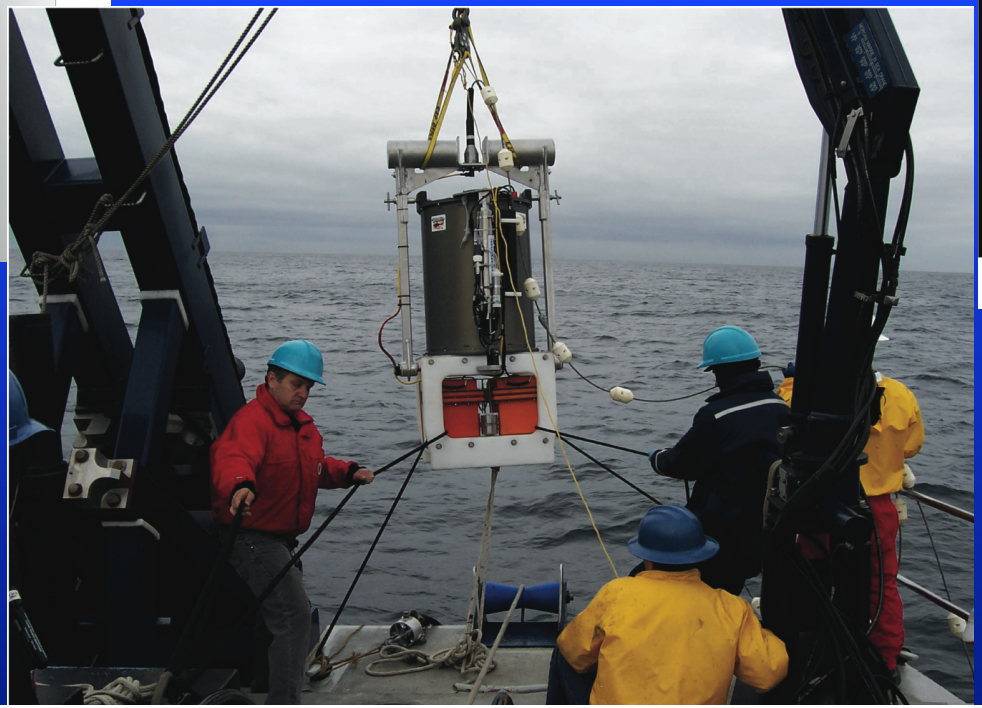
The Environmental Sample Processor (ESP) for near-real-time *Alexandrium* monitoring



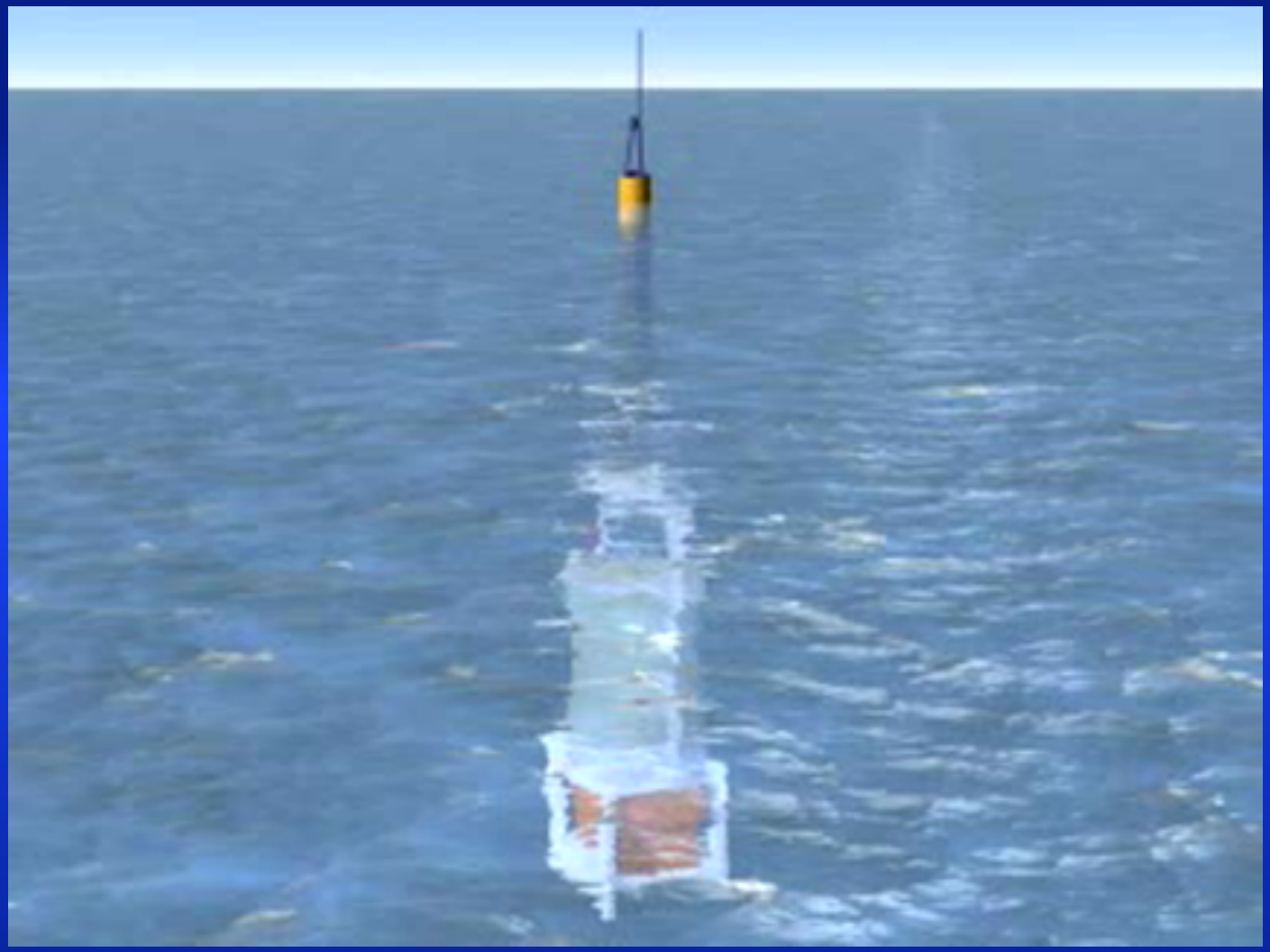
HAB species array



HAB toxin array

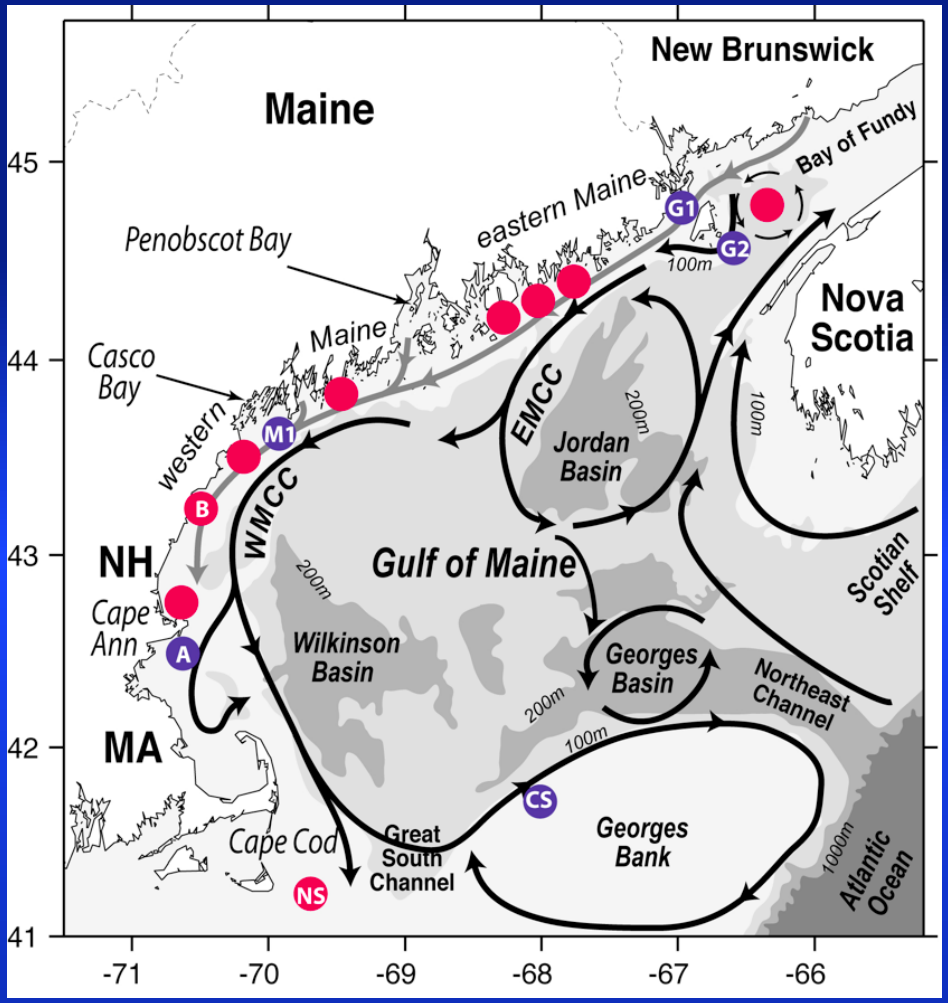


C. Scholin, MBARI



A vision of the future: proposed locations for HAB sensors moored in the Gulf of Maine.

Six ESPs will be available soon (NSF, EPA)



Hi Everyone –

Just a very quick update on the status of western Maine…

We are almost done going through stations from southern Maine and buoy stations in Casco Bay, and we are seeing stable scores in southern Maine, but elevated mussel scores in Casco Bay, including the Harpswell area. The Casco Bay area is mostly dilutions, so I don't have final scores yet, but my guess based on the times are that they are in excess of 150 and upward. We will be going through the New Meadows buoy stations tomorrow, and that will tell me if we can maintain the mussel exception area in the upper New Meadows or not. Based on what we have seen in the rest of Casco Bay, folks should consider that we may need to close the entire New Meadows to mussel harvest by the end of the day tomorrow. We will know more by mid-day, and I will do another update if/when we issue a new legal notice.

Still no scores in clams, but again, I just want folks to keep in mind that with elevated mussel scores, we may start to see PSP show up in Casco Bay and Harpswell clams within the next week or two. We will also be sampling surf clams in southern Maine and the Scarborough area this week, and should have those results by Friday.

Darcie Couture
Acting Director, Public Health Division
Maine Department of Marine Resources

Needs: Data and capabilities

1. High resolution Casco Bay hydrographic model nested within the *Alexandrium* population dynamics model
2. High resolution hydrography and *Alexandrium* cell abundance data within Casco Bay to calibrate model
3. Real-time *Alexandrium* cell concentration measurements outside and within Casco Bay
4. More studies of anthropogenic nutrients and *Alexandrium* blooms in Casco Bay

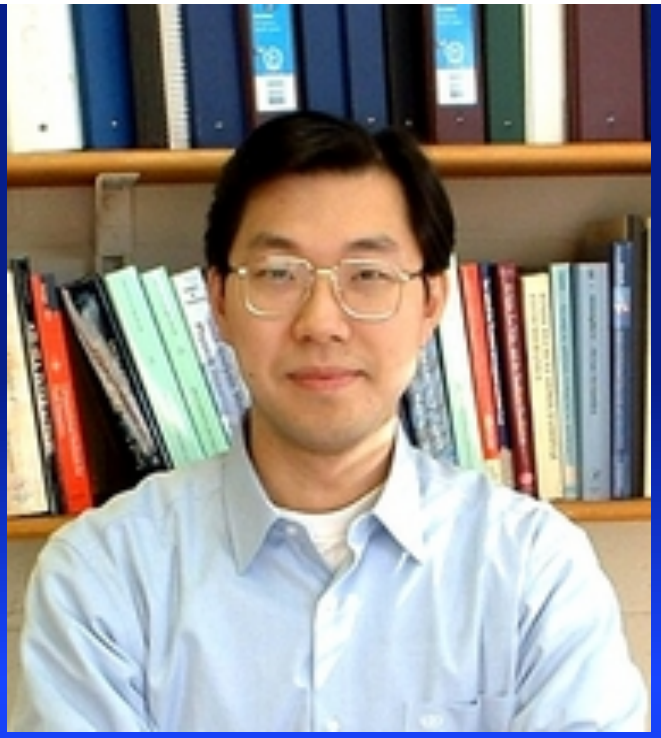
Summary

1. *Alexandrium* blooms and PSP toxicity in shellfish are significant problems in the Casco Bay region.

2. A physical/biological model of *Alexandrium* dynamics has been developed for the Gulf of Maine region. It's current focus in on the large-scale (regional) distribution and abundance of *Alexandrium* cells. There is interest and justification for modeling at smaller scales, such as in Casco Bay, but nearshore resolution is currently inadequate.

Summary

3. Data and capability needs relative to this resource issue include:
   - High resolution Casco Bay hydrographic model nested within the *Alexandrium* population dynamics model
   - High resolution hydrography and *Alexandrium* cell abundance data within Casco Bay to calibrate model
   - Real-time *Alexandrium* cell concentration measurements outside and within Casco Bay
4. More studies of anthropogenic nutrients and *Alexandrium* blooms in Casco Bay



Dennis McGillicuddy
WHOI AOP&E

Ruoying He
NCSU

WOODS HOLE OCEANOGRAPHIC INSTITUTION
1930

NCCOS
NOAA