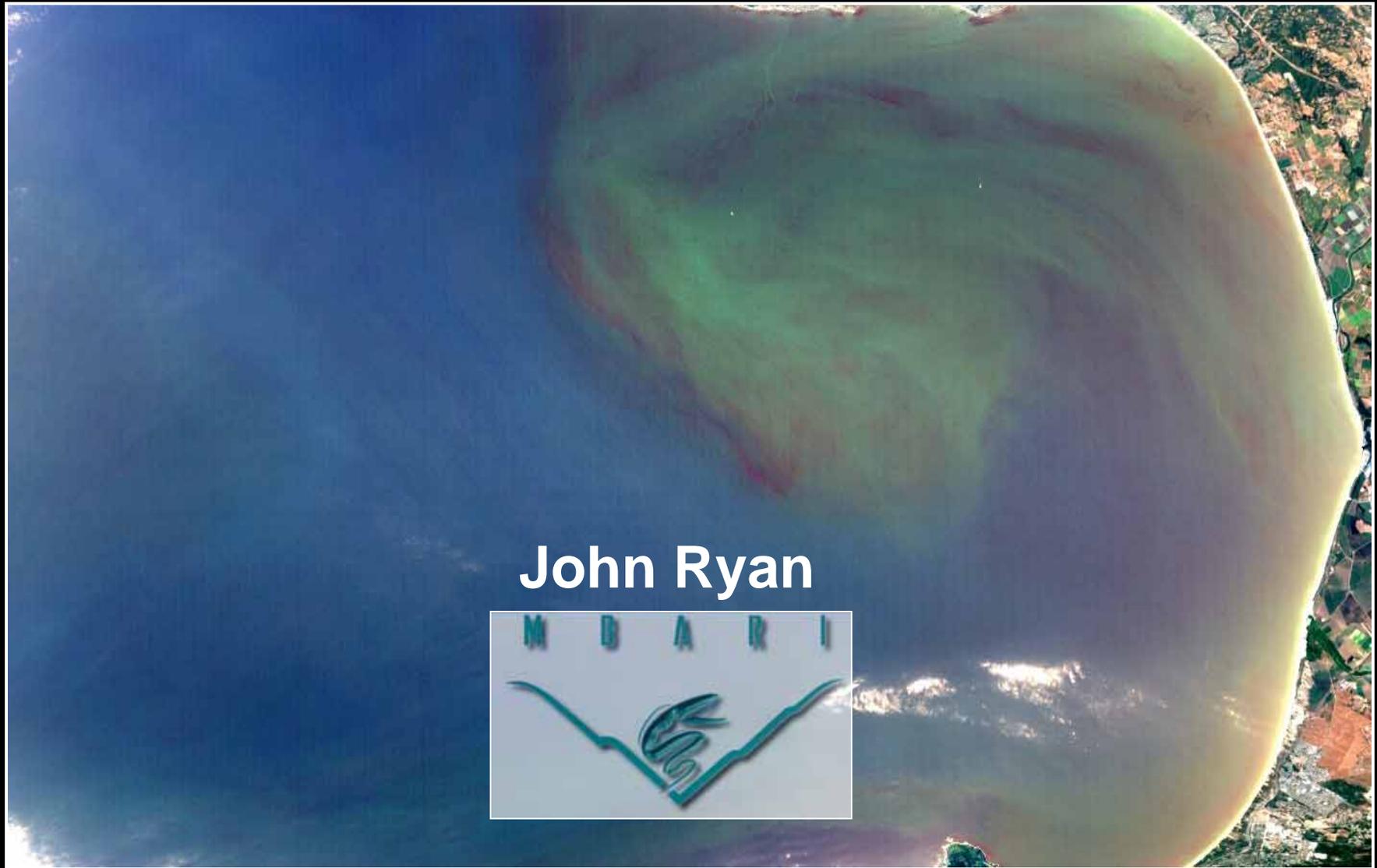


Red Tide & HAB Studies in Monterey Bay



John Ryan



Monterey Bay Sanctuary Advisory Council Meeting August 15, 2008

Phytoplankton



Photos by Susan Coale (UCSC)

- are single-celled, microscopic algae
- fuel most of the oceanic food web through photosynthesis
- produce much of the oxygen we breathe
- are central to biogeochemical cycling, including CO₂
- can impact the ecology and economy of coastal waters as harmful algal blooms (HABs)
- influence ocean optics and physics
- act as biological tracers and indicators of ocean circulation

Red tides & HABs

- ❖ Dense accumulations of certain phytoplankton make the ocean appear reddish. These are commonly called red tides.
- ❖ Some phytoplankton blooms can cause harm via toxins, oxygen depletion, or tissue damage. These are termed Harmful Algal Blooms (HABs).
- ❖ Red tides can be harmful but are not always, & HABs can occur without a dense red tide bloom.
- ❖ HABs can have significant economic impacts: fisheries, human health, recreation & tourism, monitoring & management.
- ❖ Increasing occurrence of HABs is evident globally.
- ❖ About 50% of red tide species & 75% of HAB species are *dinoflagellates*.

In the news...

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SUMMER 2004 DINOFLAGELLATE BLOOM



FACTS & TRENDS

- The brown-colored water seen in many areas of the Monterey Bay is due to a large dinoflagellate bloom.
- The three main dinoflagellates showing up are *Cochlodinium catenatum*, *Gymnodinium sanguineum*, and various species of *Ceratium*.
- This dinoflagellate bloom has not been linked to any human health problems.
- Dinoflagellates are microscopic, photosynthetic organisms that float freely in the open waters of the sanctuary.

During late August and into September of 2004, various areas of the Monterey Bay National Marine Sanctuary showed a brown tinge to the water. This coloring of the ocean water is due to a dense population of dinoflagellates, *Cochlodinium catenatum*, *Gymnodinium sanguineum*, and different species of *Ceratium* including *Prorocentrum micans*. The blooms of these dinoflagellates vary in composition depending on their location in the sanctuary.

Dinoflagellate blooms are thought to be triggered by seasonal fluctuations in nutrient levels in ocean water, but the cause of the

NEWS

Red tide blamed for hundreds of dead, injured seabirds along California's Monterey Bay

By TERENCE CHEA Associated Press Writer
Friday, November 30, 2007

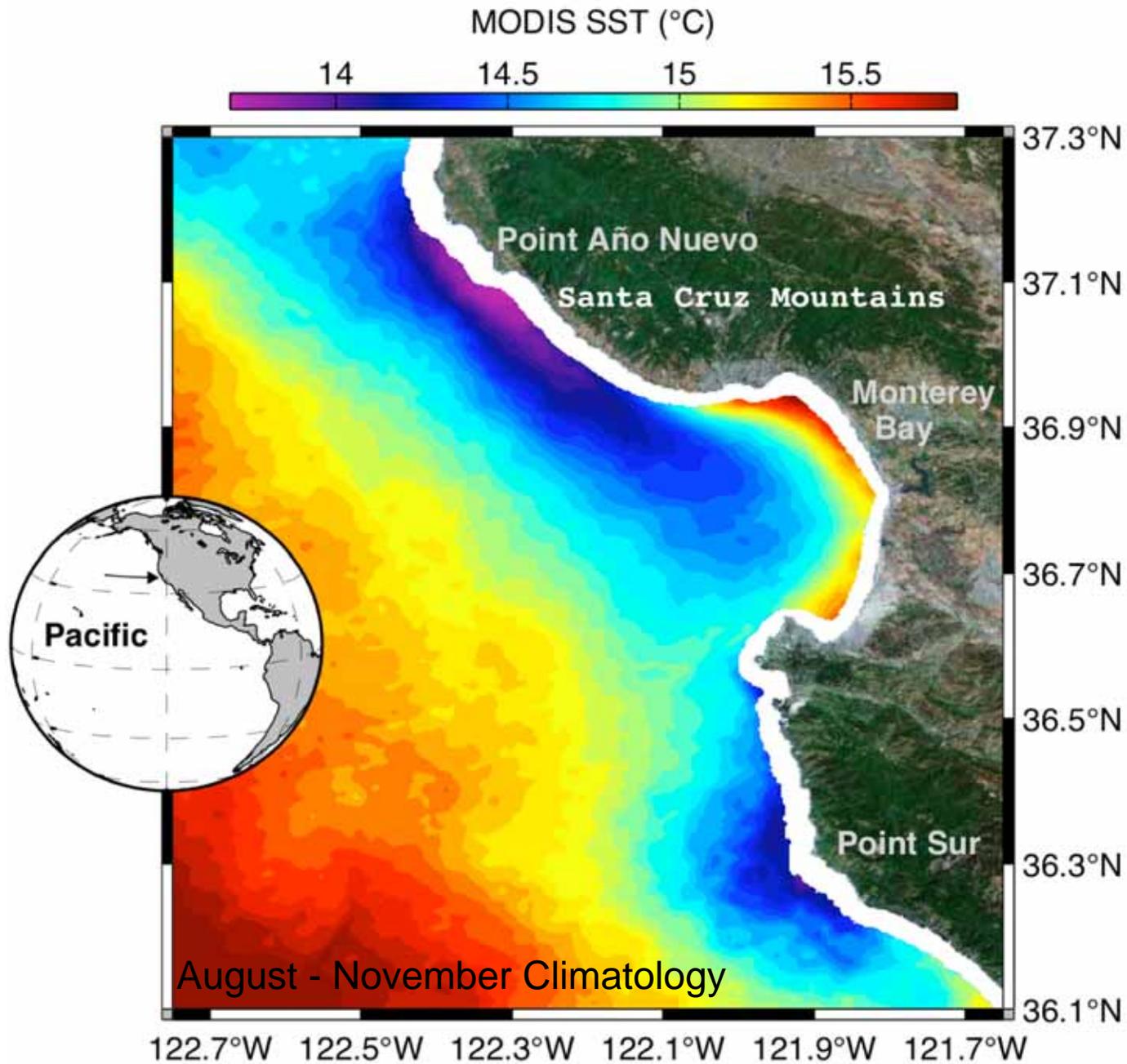
SAN FRANCISCO (AP) — Hundreds of dead or injured seabirds have washed up on the shores of Monterey Bay in recent weeks, and scientists believe a red tide of marine algae is to blame.

About 600 birds have been found stranded on beaches in Monterey and Santa Cruz counties since a large rust-colored algal bloom began circulating in the bay about three weeks ago, scientists say.

Molecular Probes Link Sea Lion Deaths To Toxic Algal Bloom

ScienceDaily (Jan. 7, 2000) — MOSS LANDING, California — New molecular probes used to identify toxic diatoms allowed researchers to link a bloom of these algae to the deaths of more than 400 California sea lions in Monterey Bay during May and June 1998. Dr. Christopher Scholin, a molecular biologist at the Monterey Bay Aquarium Research Institute (MBARI), and colleagues report their research results in the 6 January issue of the journal *Nature*.

Upwelling Shadow

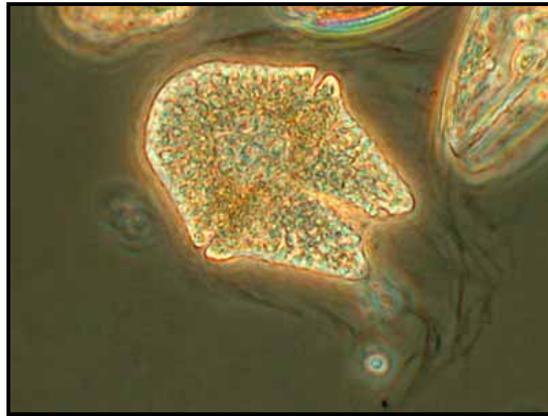


Bird's eye view of a red tide bloom in Monterey Bay

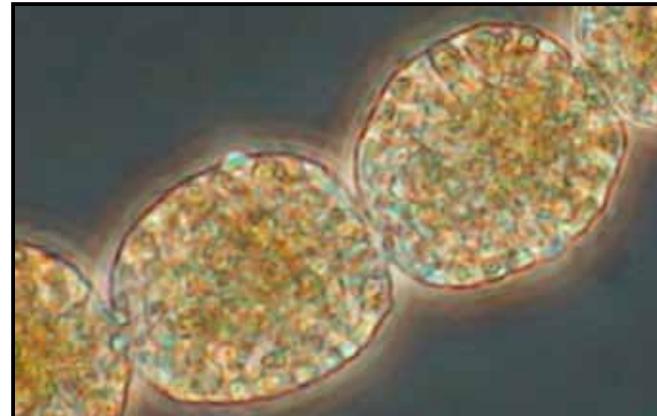


Microscopic view of a bloom... motility!

Akashiwo sanguinea



Cochlodinium fulvescens



S. Coale, UCSC



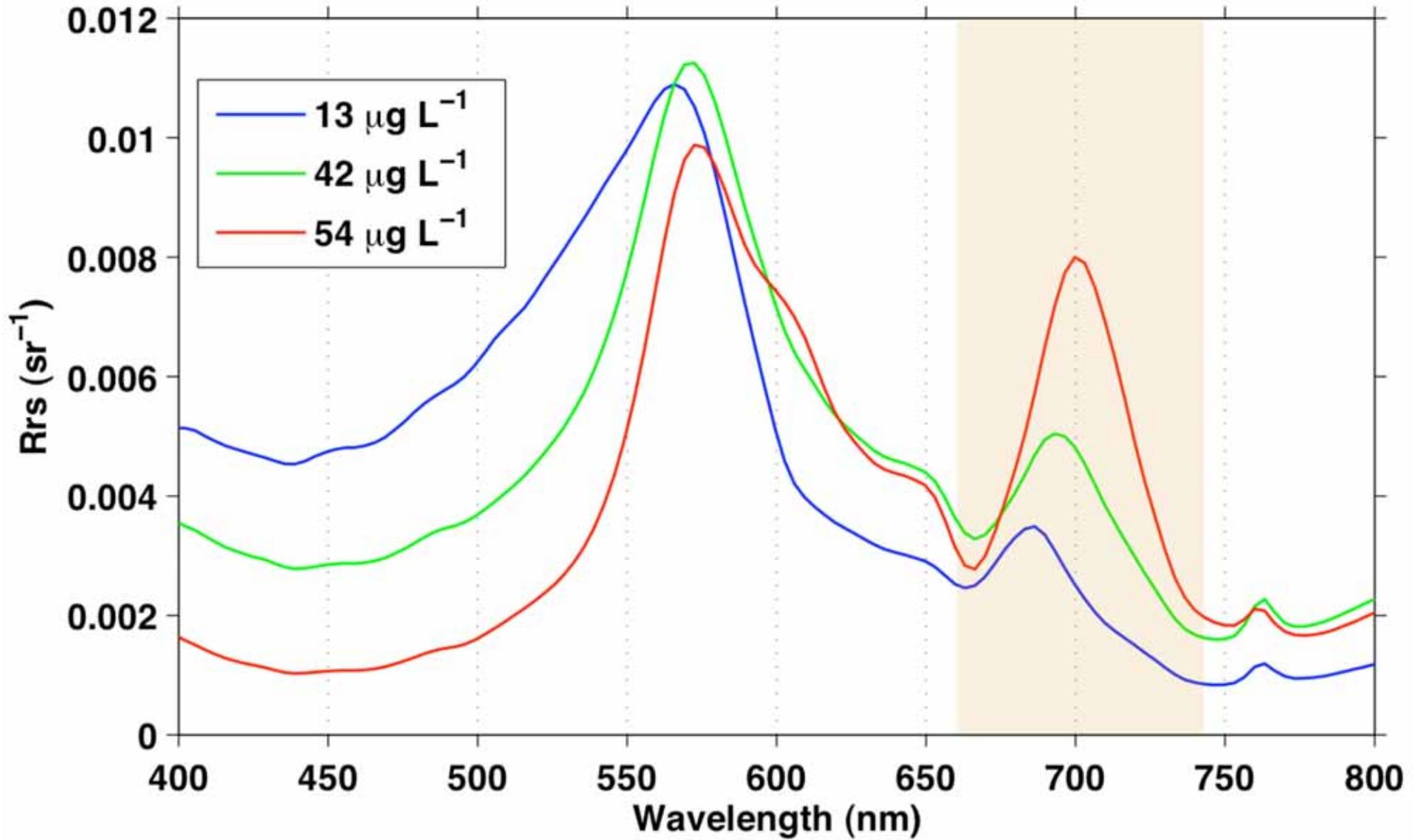
Waterline view

Akashiwo sanguinea



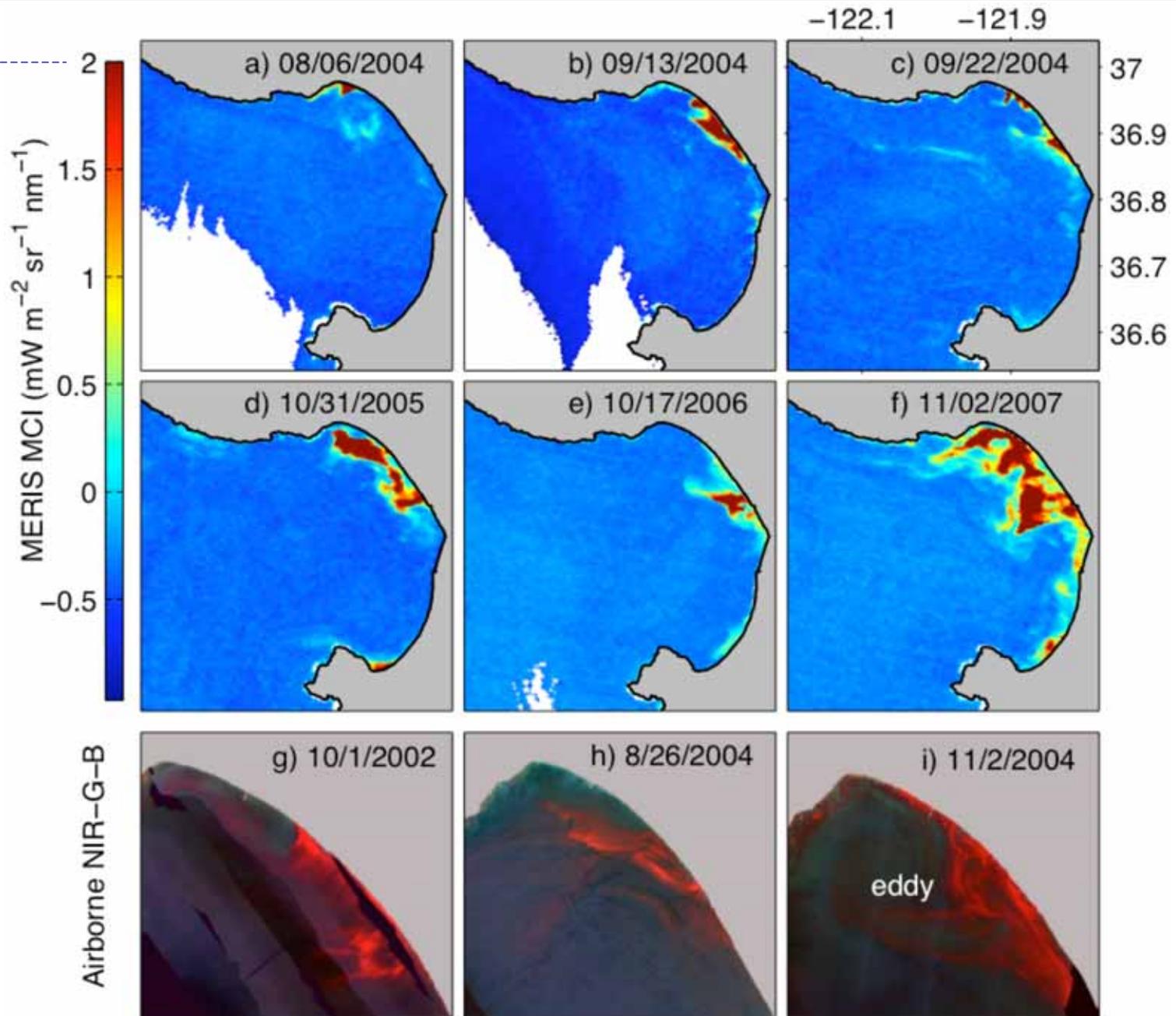
J. Rines, URI

Bloom detection

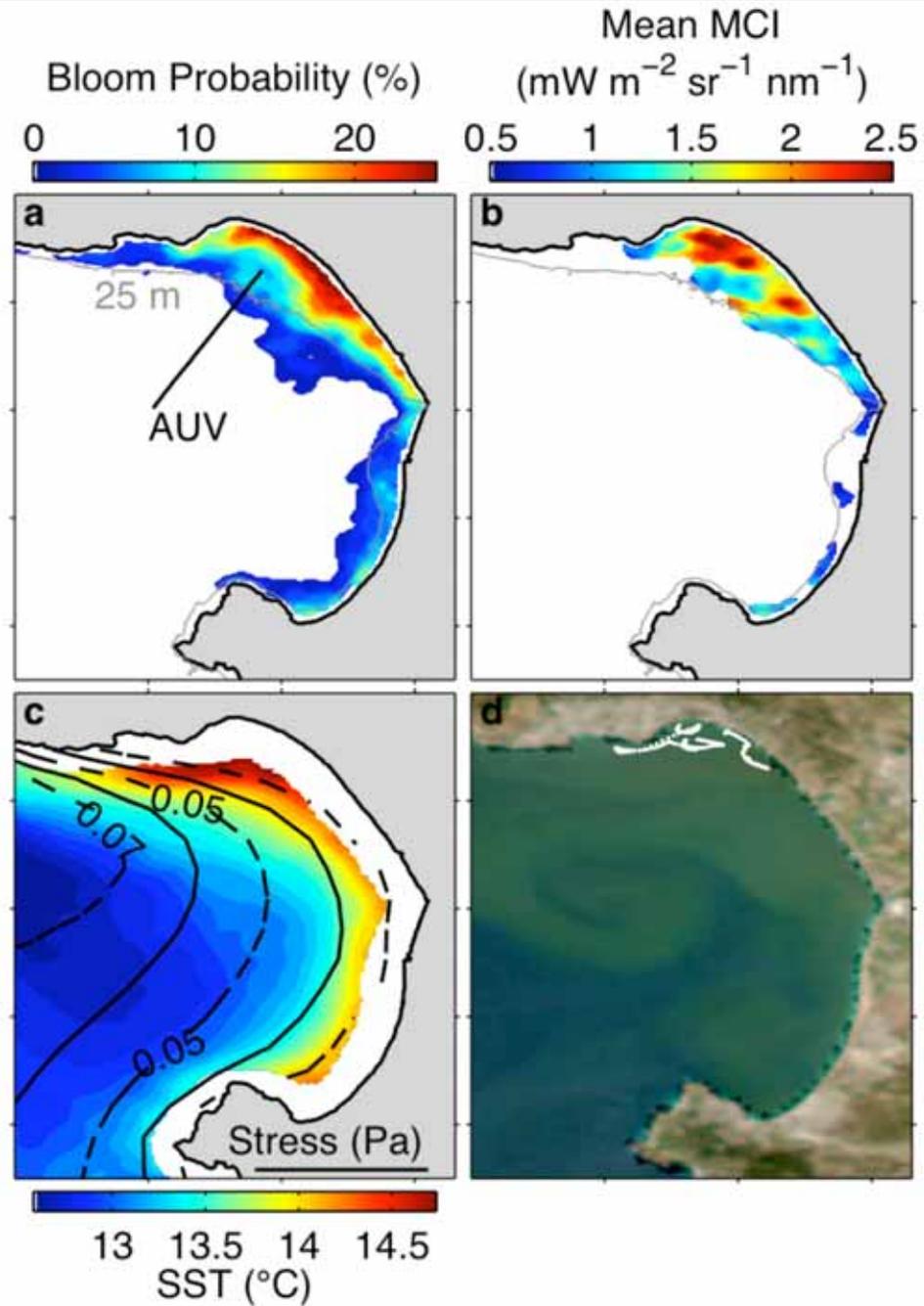


Examples of extreme blooms

MCI = 2
~ 400 mg m⁻³

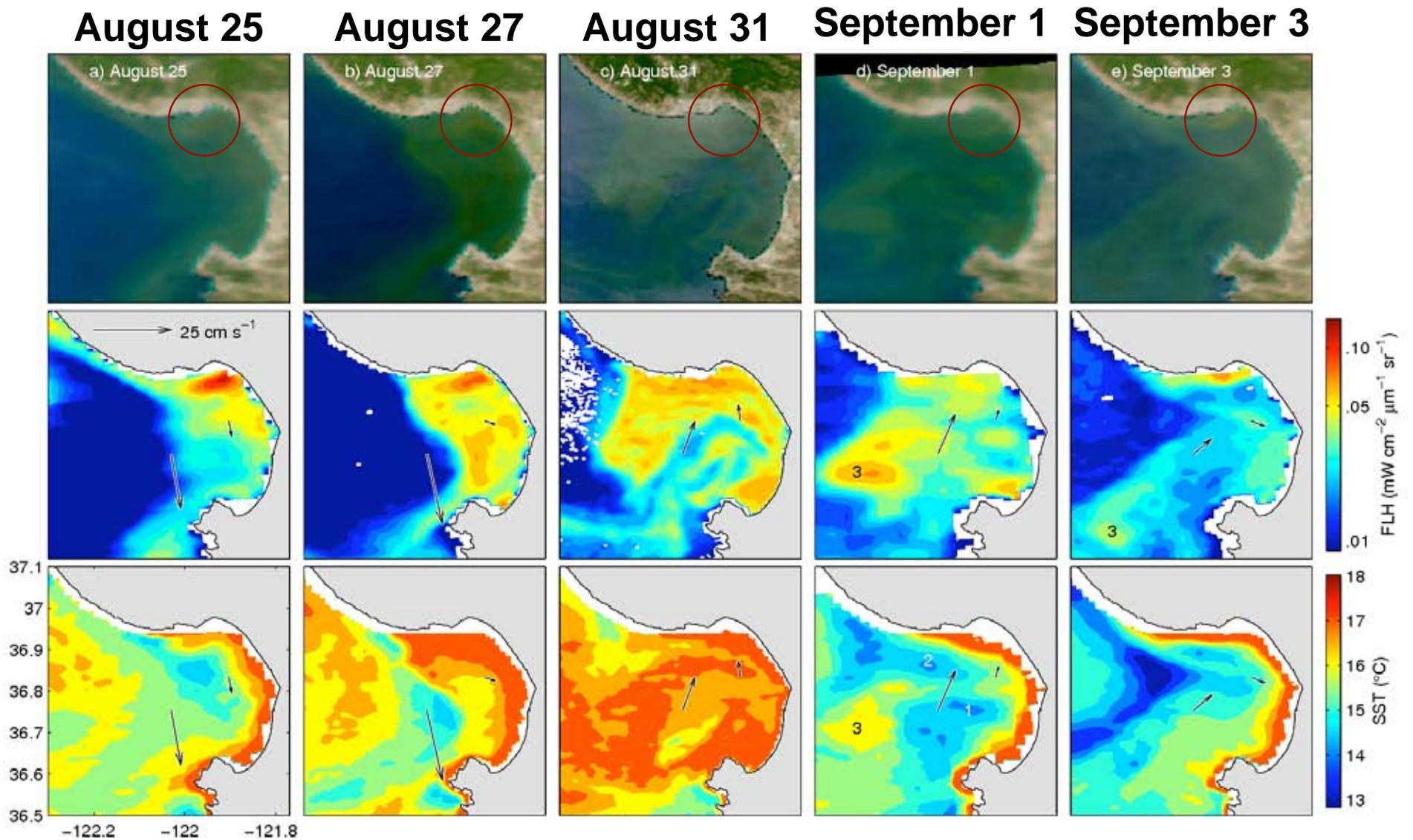


Statistics & environment of extreme blooms

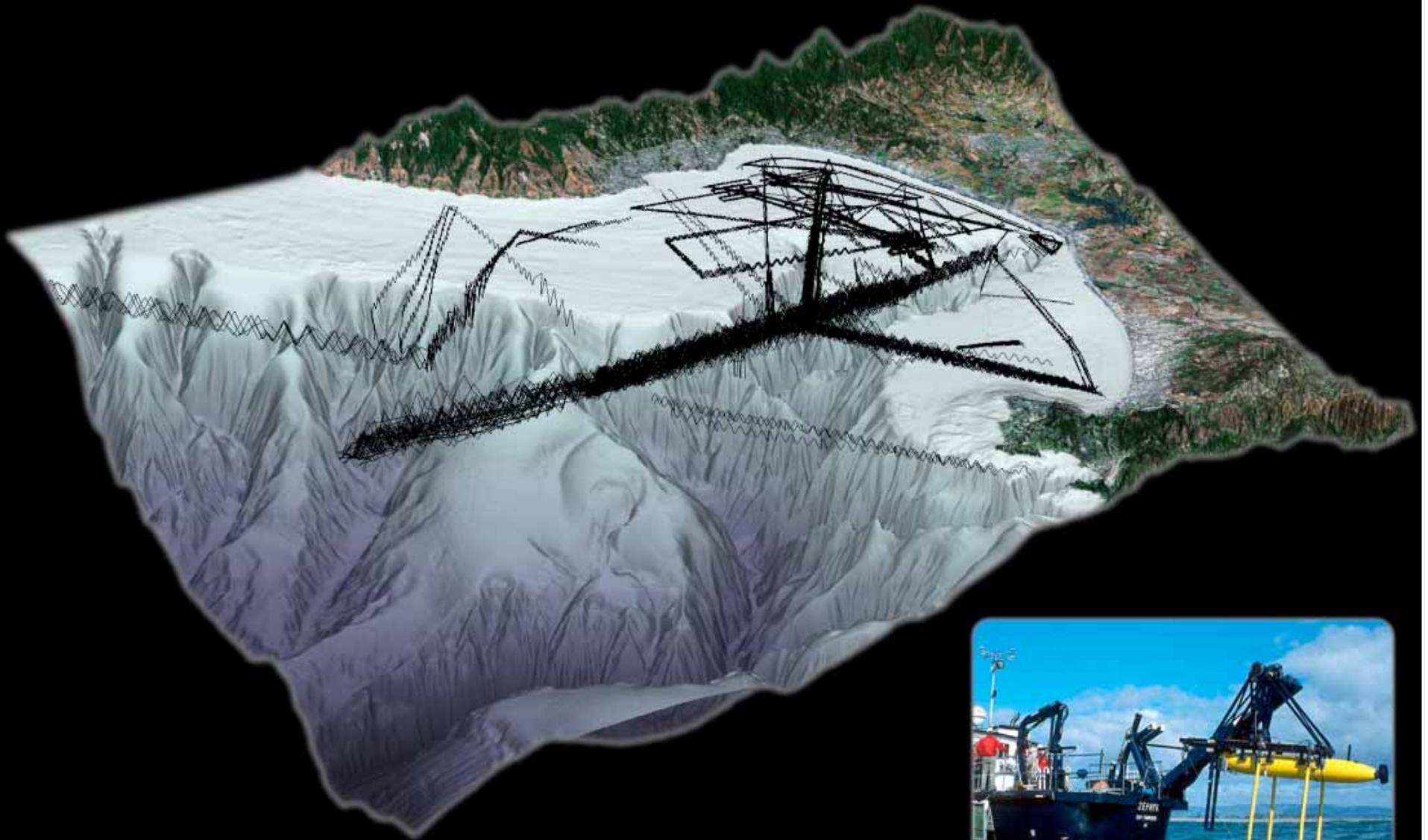


Retention within a "red tide fountain"

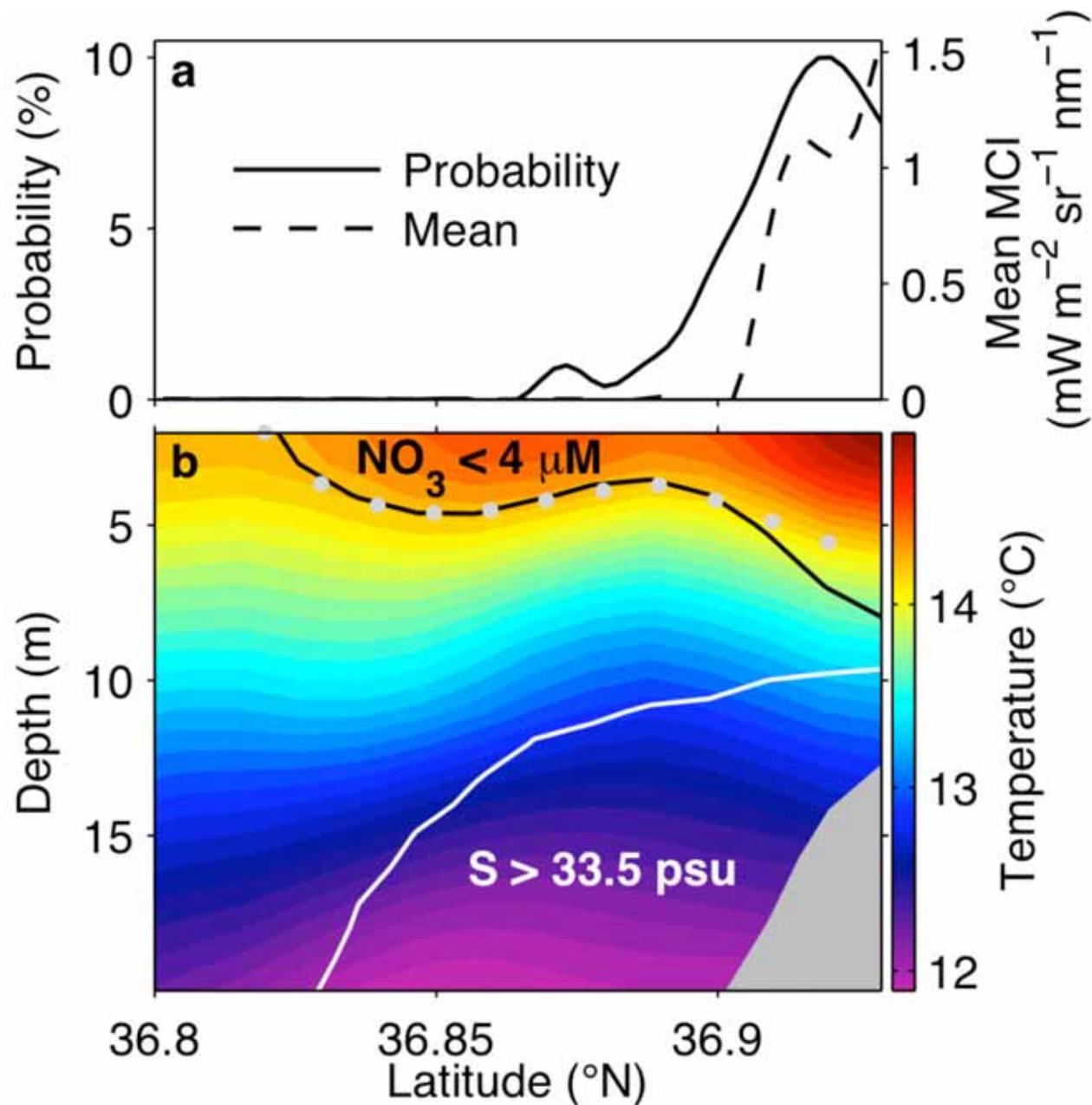
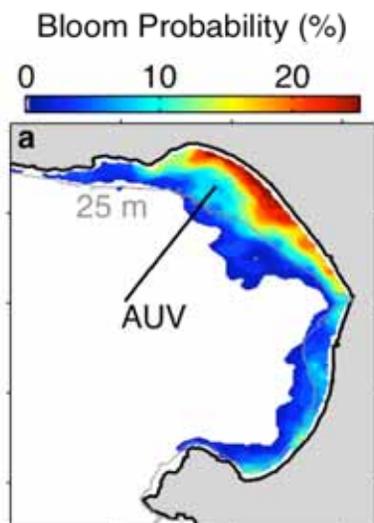
2004 Bloom Study



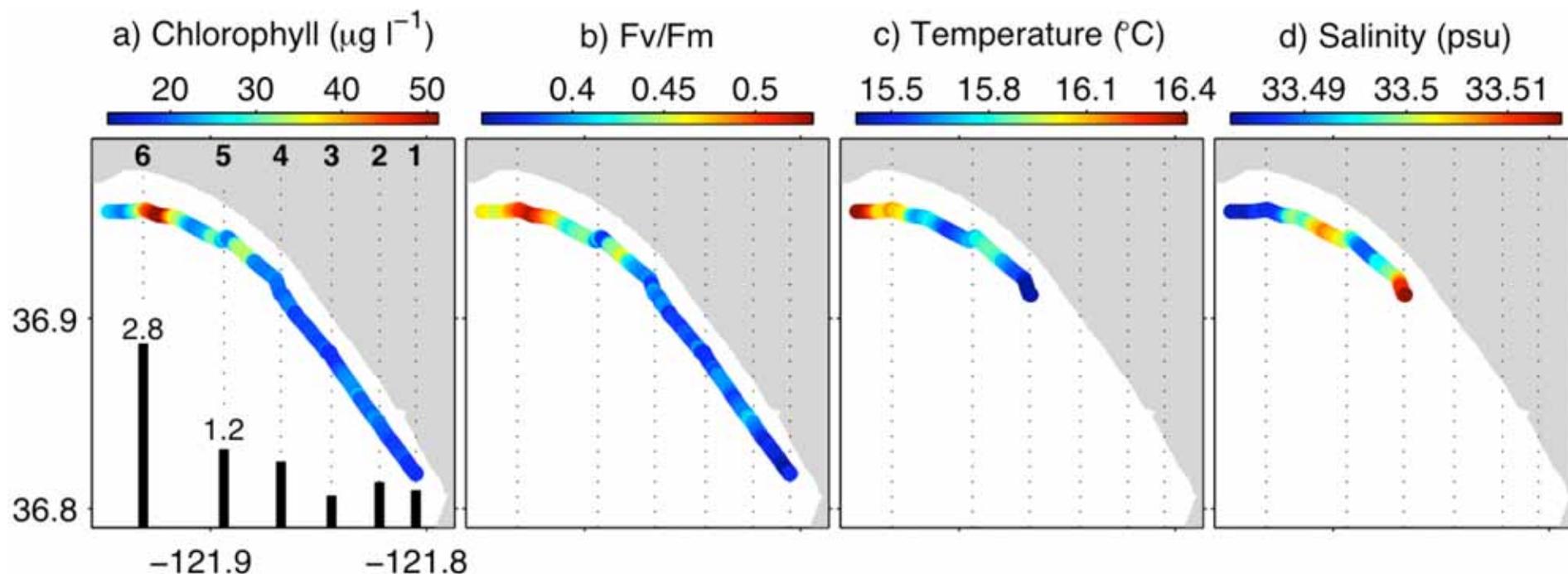
Travels and tales of a robotic submarine...



Water column structure beneath the “incubator”



Example of bloom patch observed in situ



A diverse assemblage of dinoflagellates

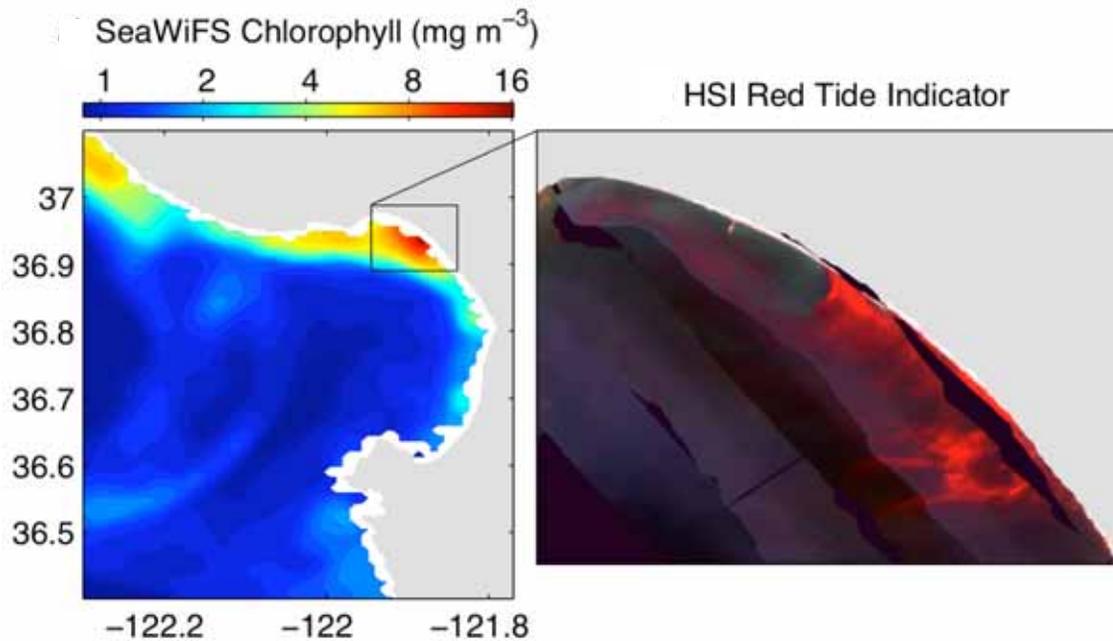
Dominant: *Ceratium cf. divaricatum*

Common: *Akashiwo sanguinea*, *Ceratium furca*, *Ceratium cf. lineatum*,
Cochlodinium cf. fulvescens, *Preperidinium sp.*

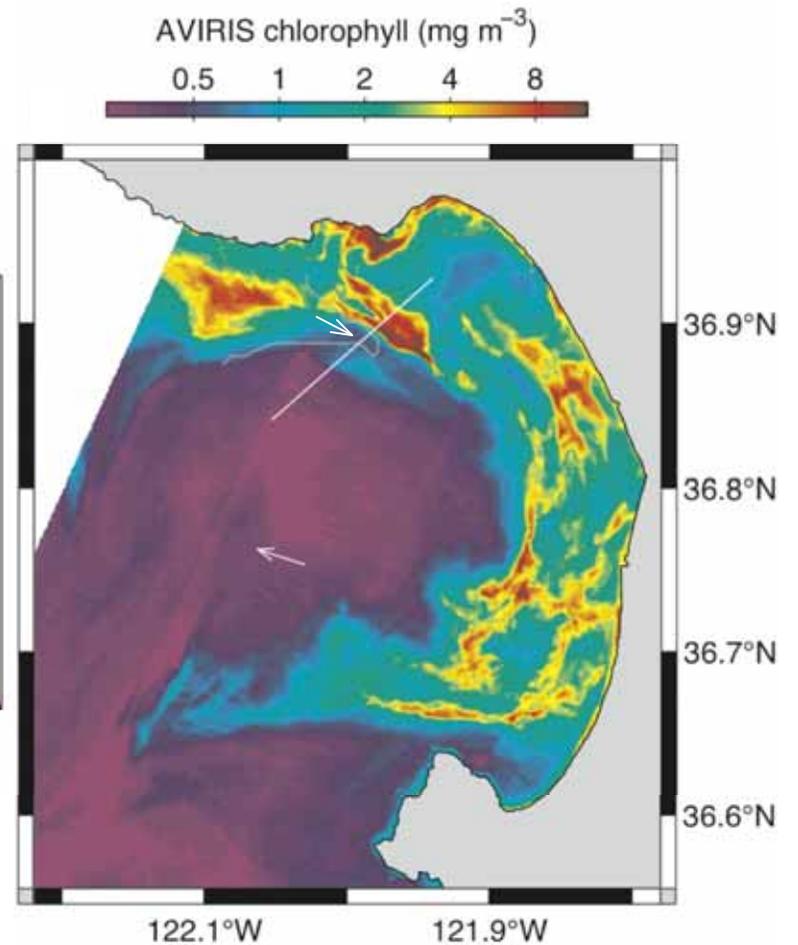
Present: *Alexandrium catenella*, *Prorocentrum gracilis*, *Oxyphysis oxytoides*,
Dinophysis sp., *Gonyaulax sp.*

Incubator as source, example 1

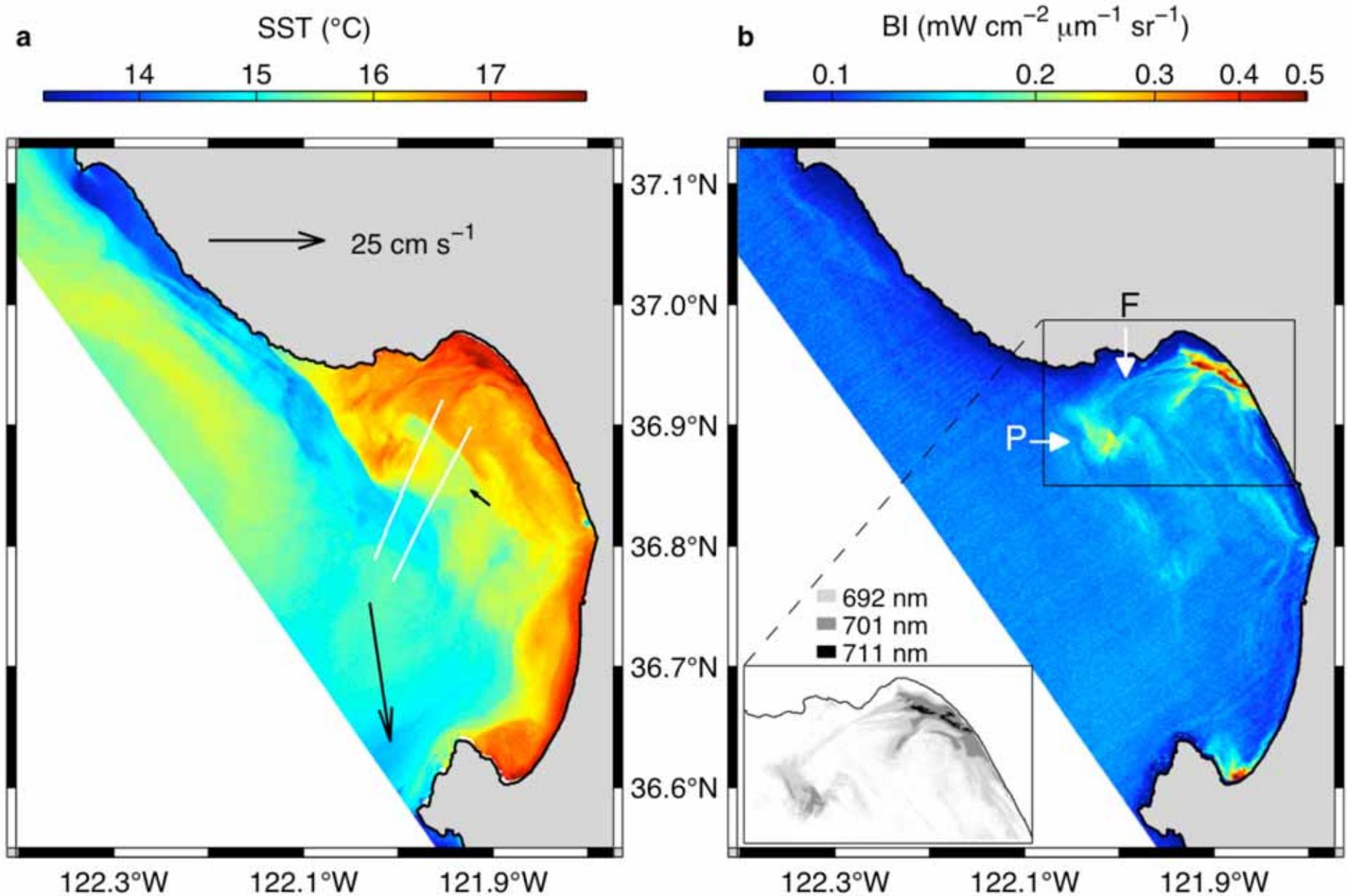
October 1, 2002



October 7, 2002

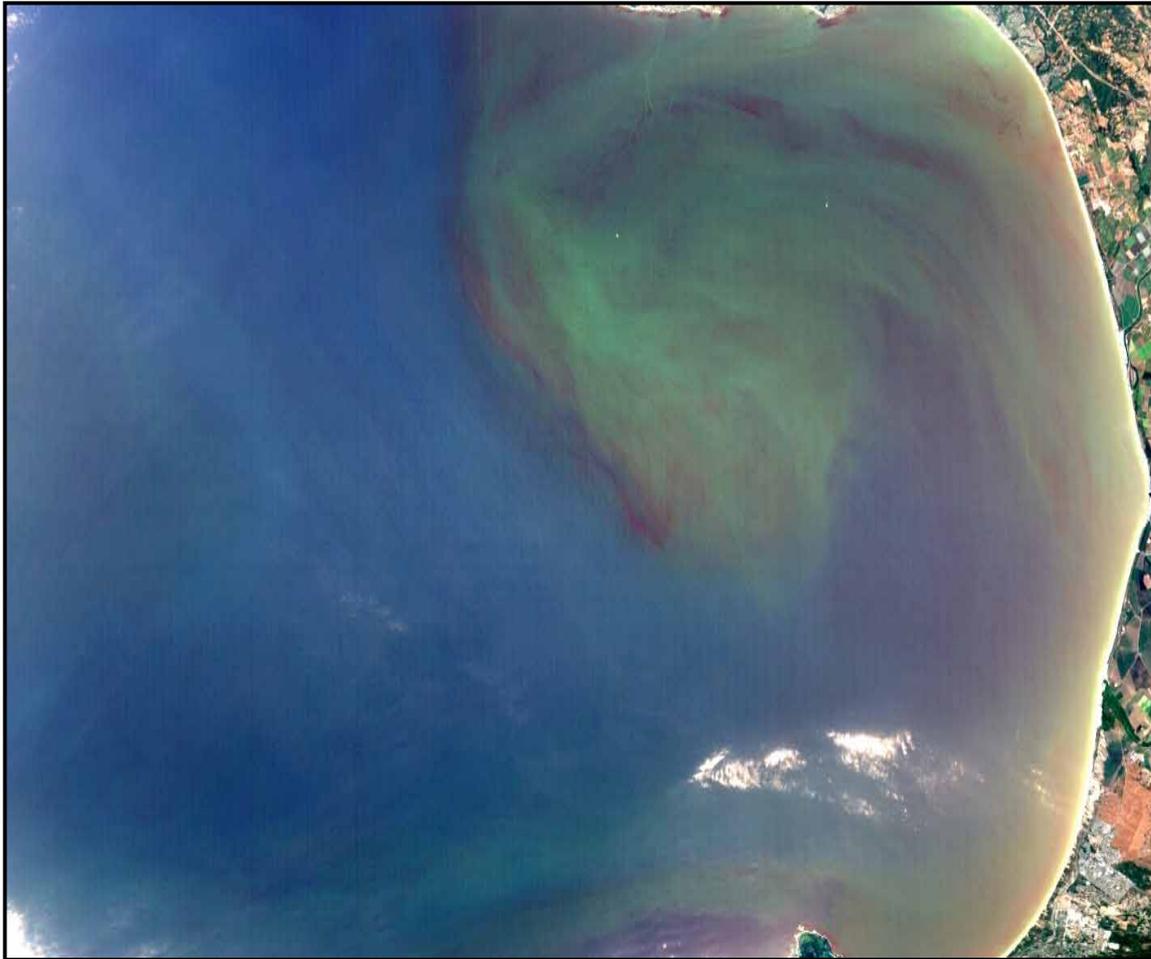


Incubator as source, example 2



The central bay is a land-sea artery

Santa Cruz

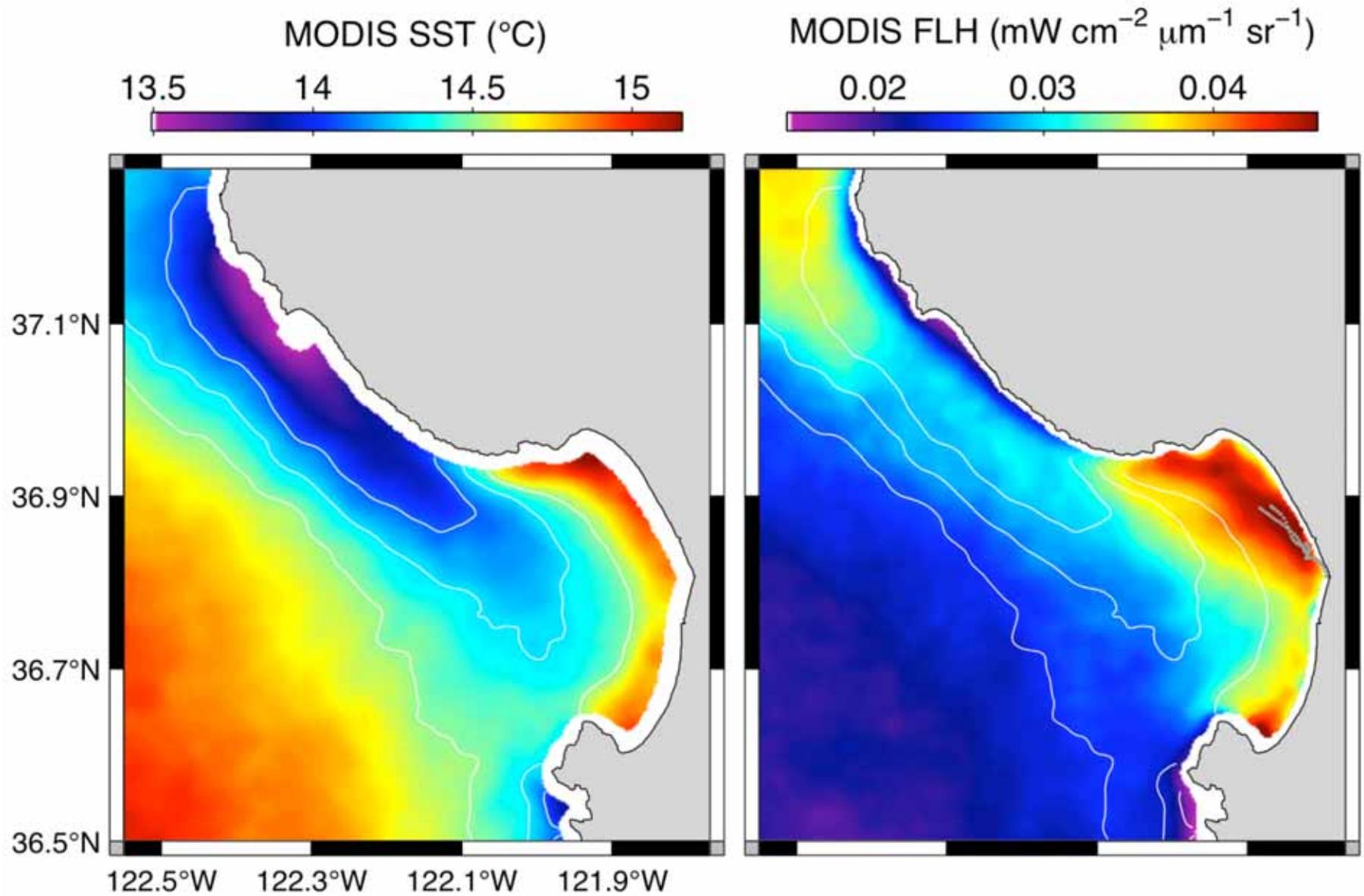


Monterey



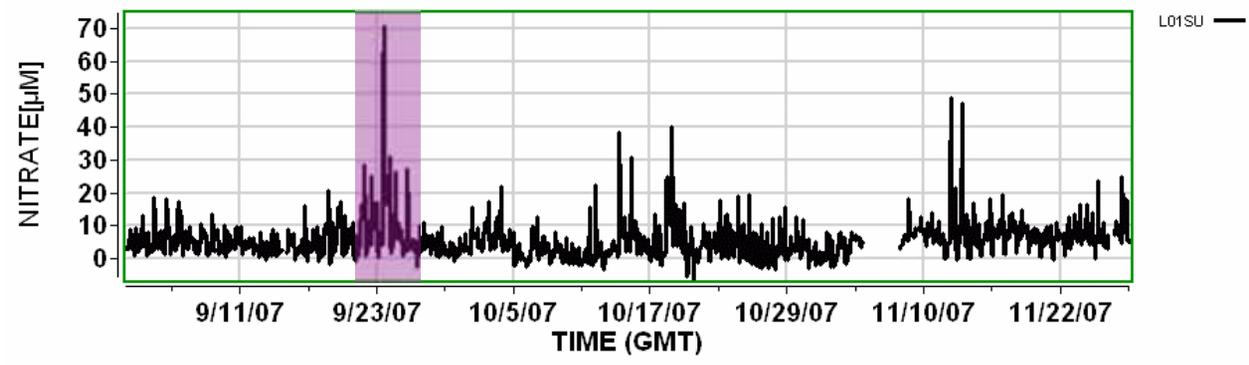
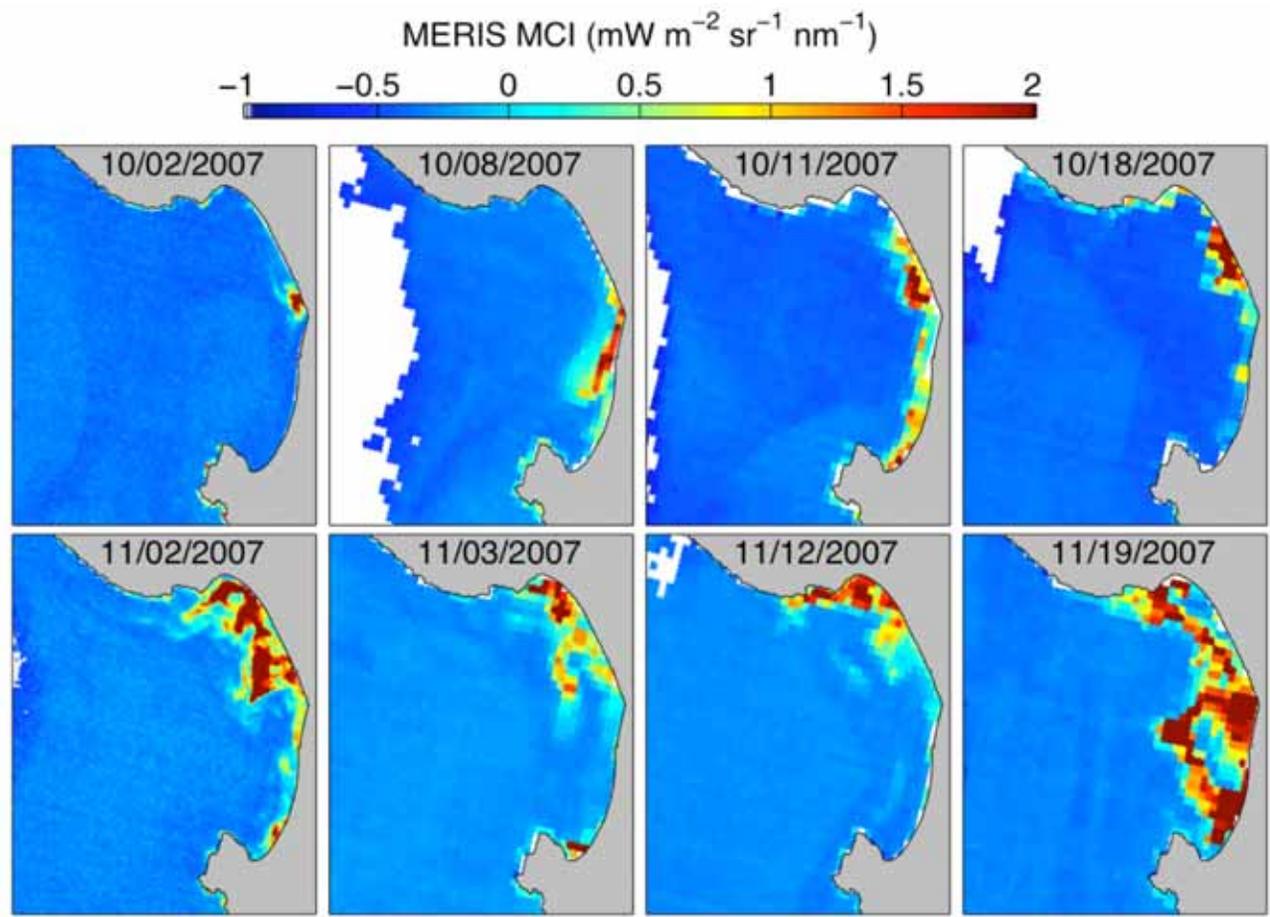
The “extreme bloom season” overlaps with the rainy season.

A bio-optical signature of land-sea arterial flow?

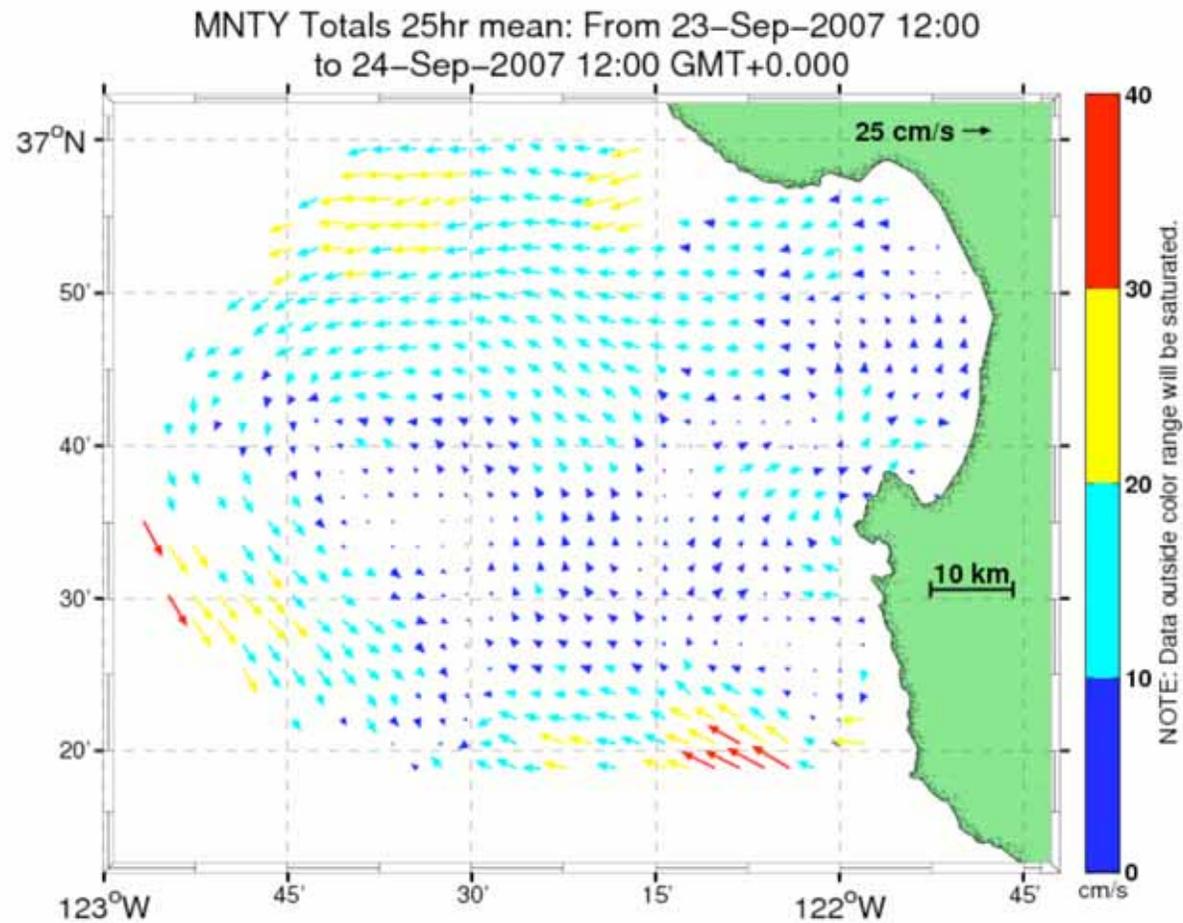


Average during "extreme bloom season" (August - November)

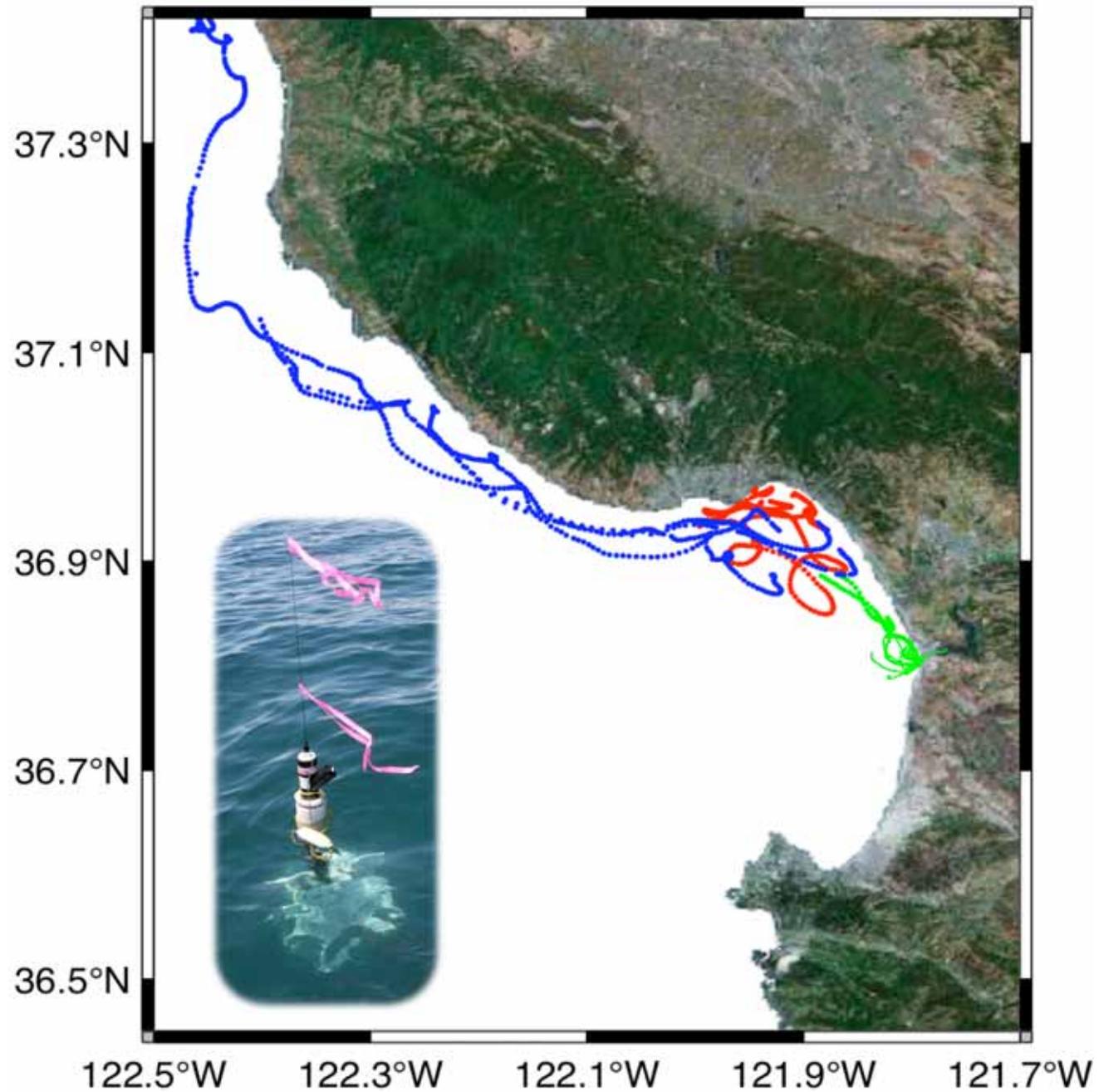
Land-Sea coupling indicated in harmful 2007 bloom



Sluggish circulation nearshore: retention of perturbation



Along-coast connectivity



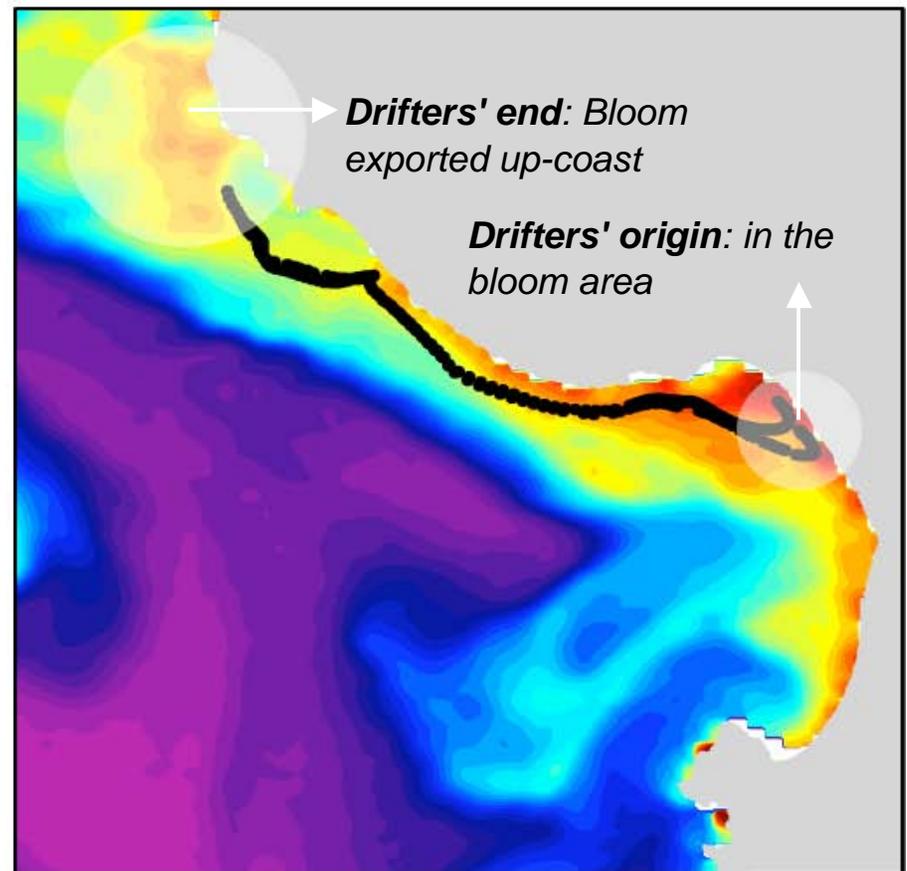
Northward export of a bloom

Drifters: July 10 1200 to July 13 1000, MODIS: July 12 2007

MODIS True-color

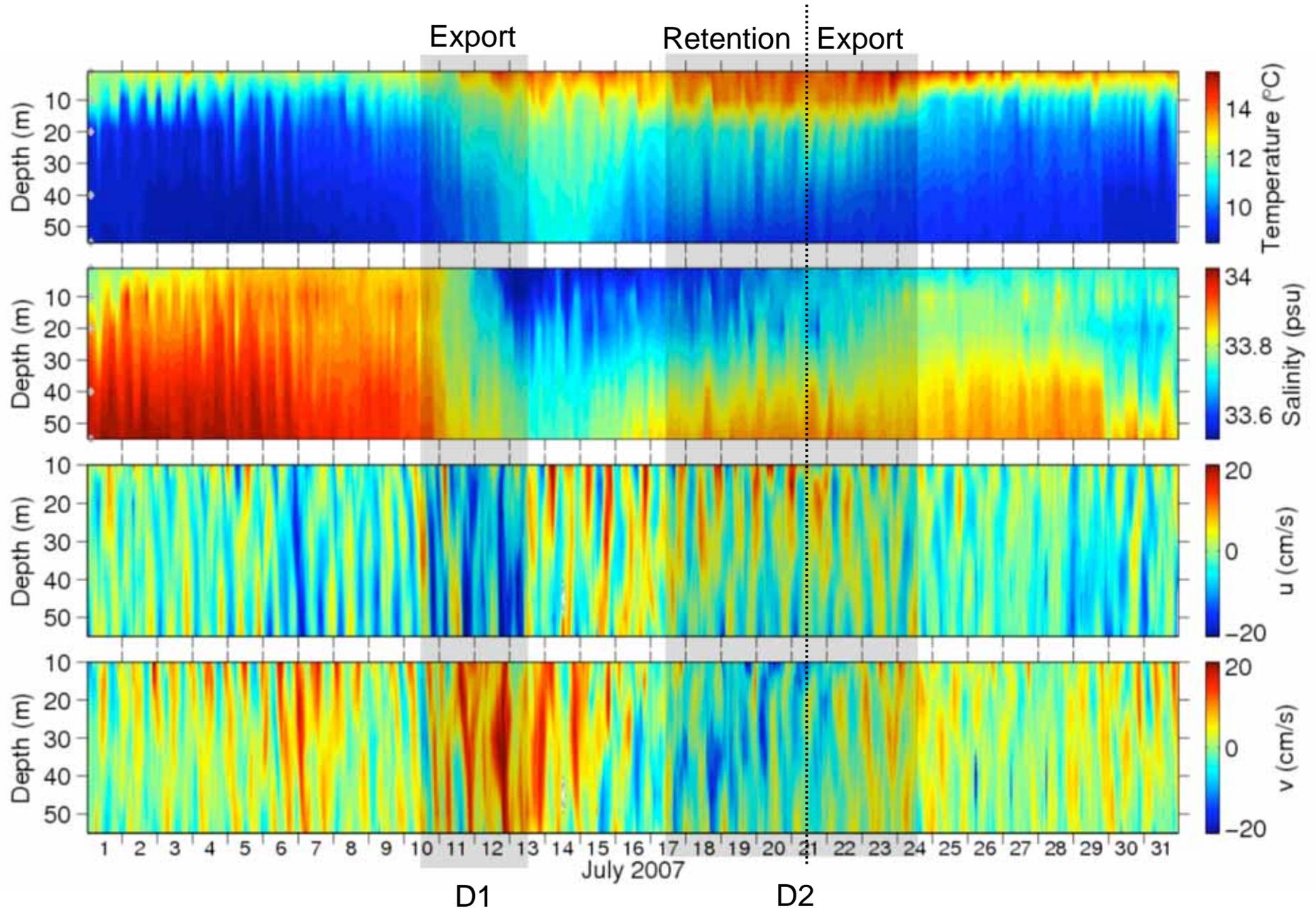


MODIS Chlorophyll (mg m^{-3})

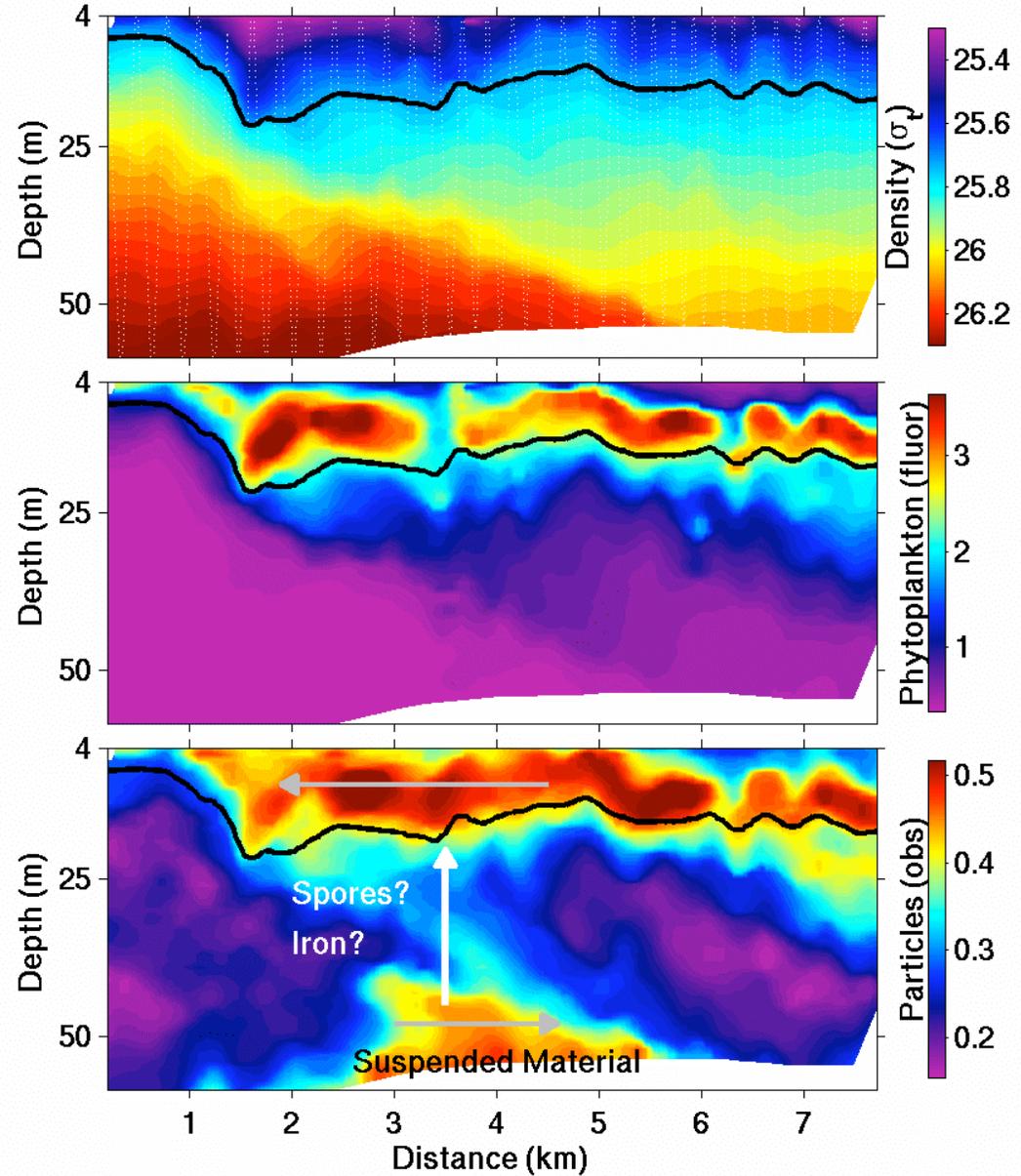
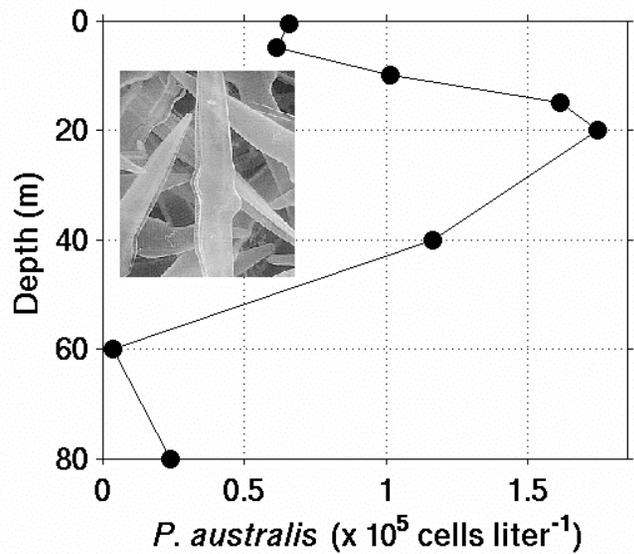
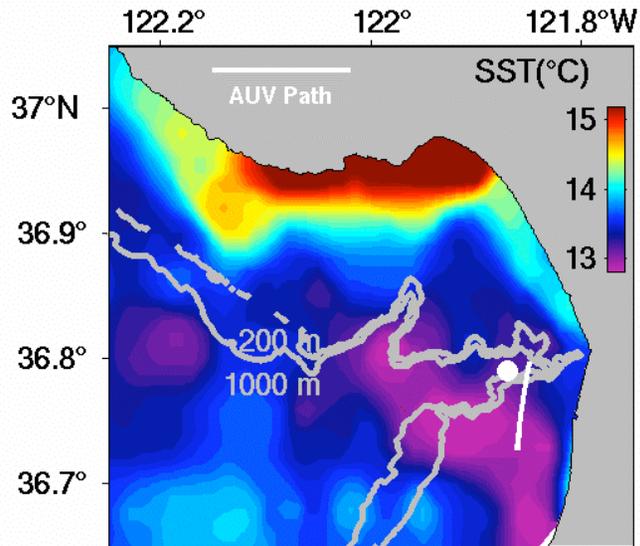


* A third drifter released further south was lost...and found right next to the other two.

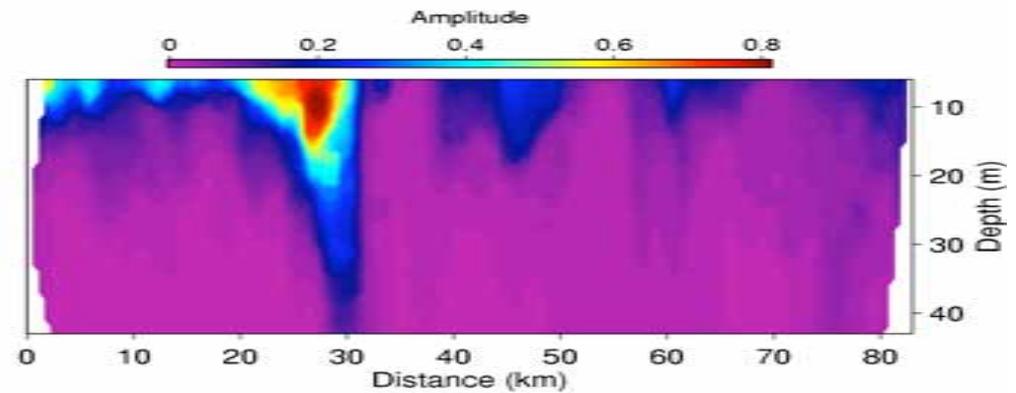
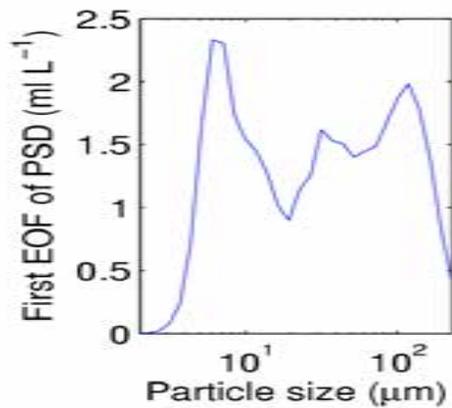
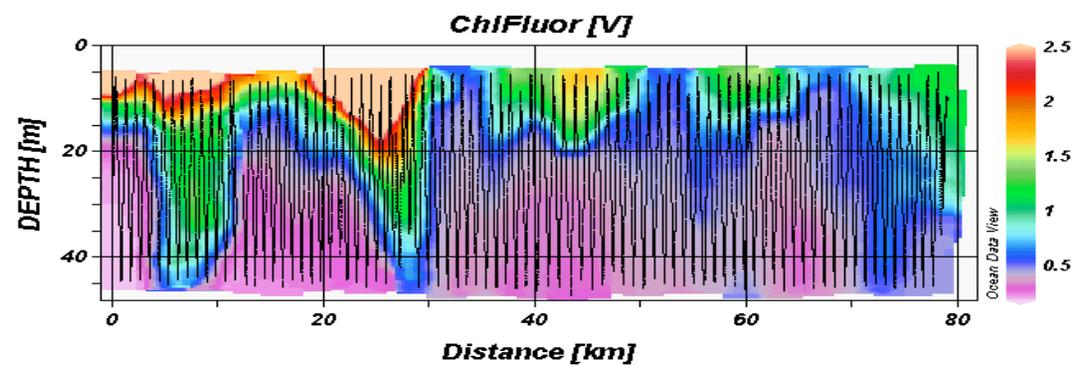
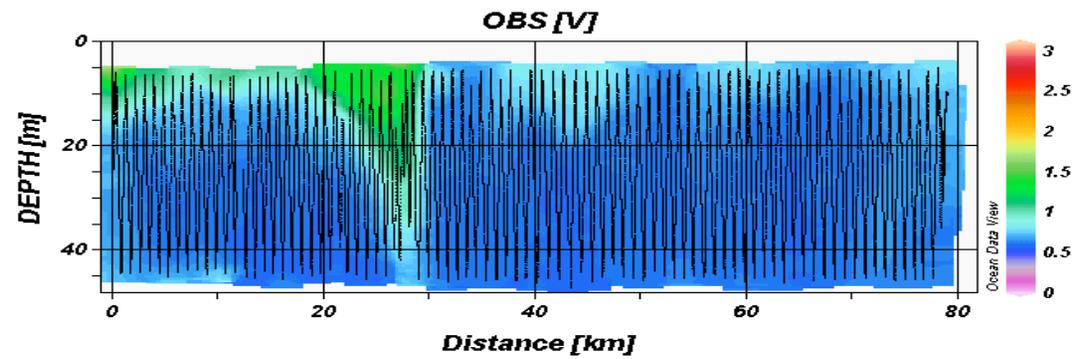
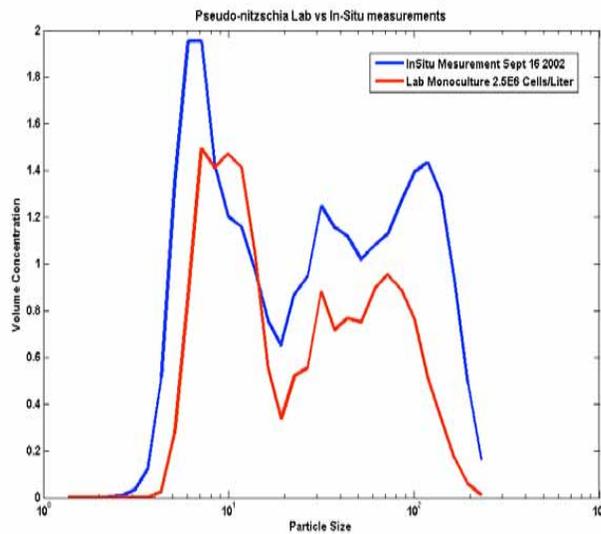
Northward export as seen from a mooring



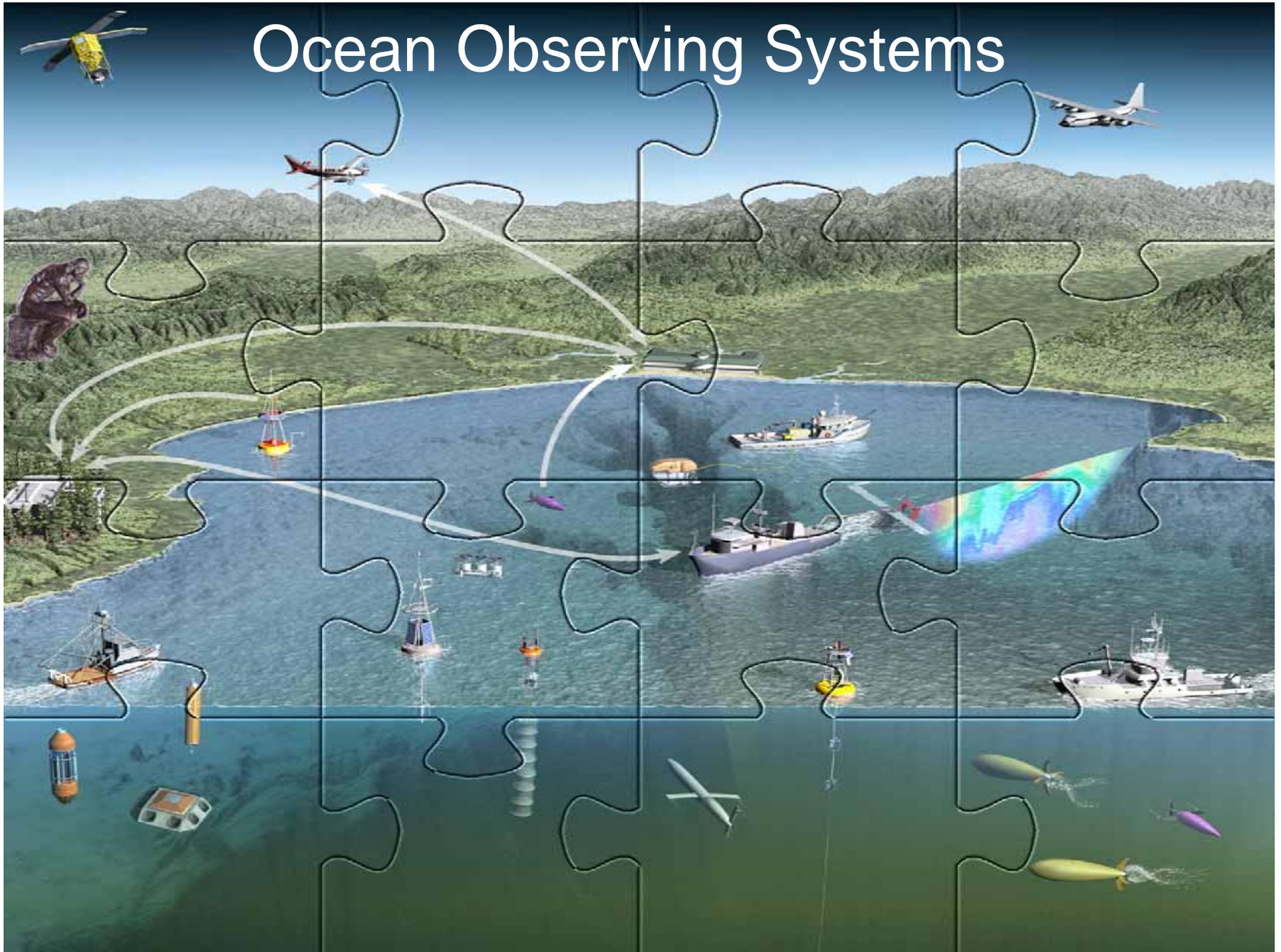
Environmental influences on a diatom HAB species



Mapping and tracking a diatom HAB species



Ocean Observing Systems



SUMMARY

- Phytoplankton do much good, however their blooms can cause harm at times.
- Coastal ocean environments are extremely complex and challenging to understand. Technology helps us understand.
- A very important research area is understanding the linkages between human activities and coastal ecosystem health.
- Monterey Bay is an excellent model system.