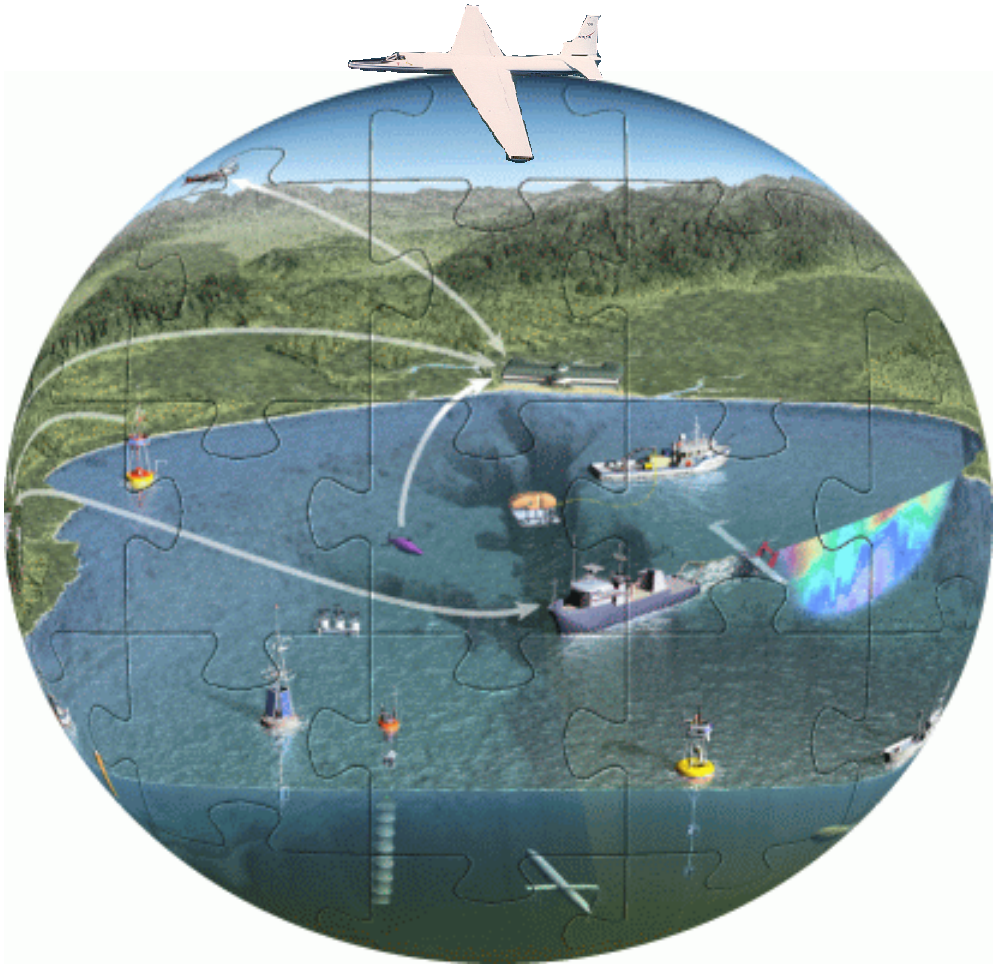
Applying Airborne Remote Sensing for Interdisciplinary Oceanography in Monterey Bay



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Paul Bissett *Florida Environmental Research Institute*
James Gower *Institute of Ocean Sciences*

THANKS

MBARI (vehicles, ships, moorings, sampling)

NASA Ocean Biology and Biogeochemistry Program

AVIRIS team

MAS team (with AVIRIS on ER-2 in 2004)

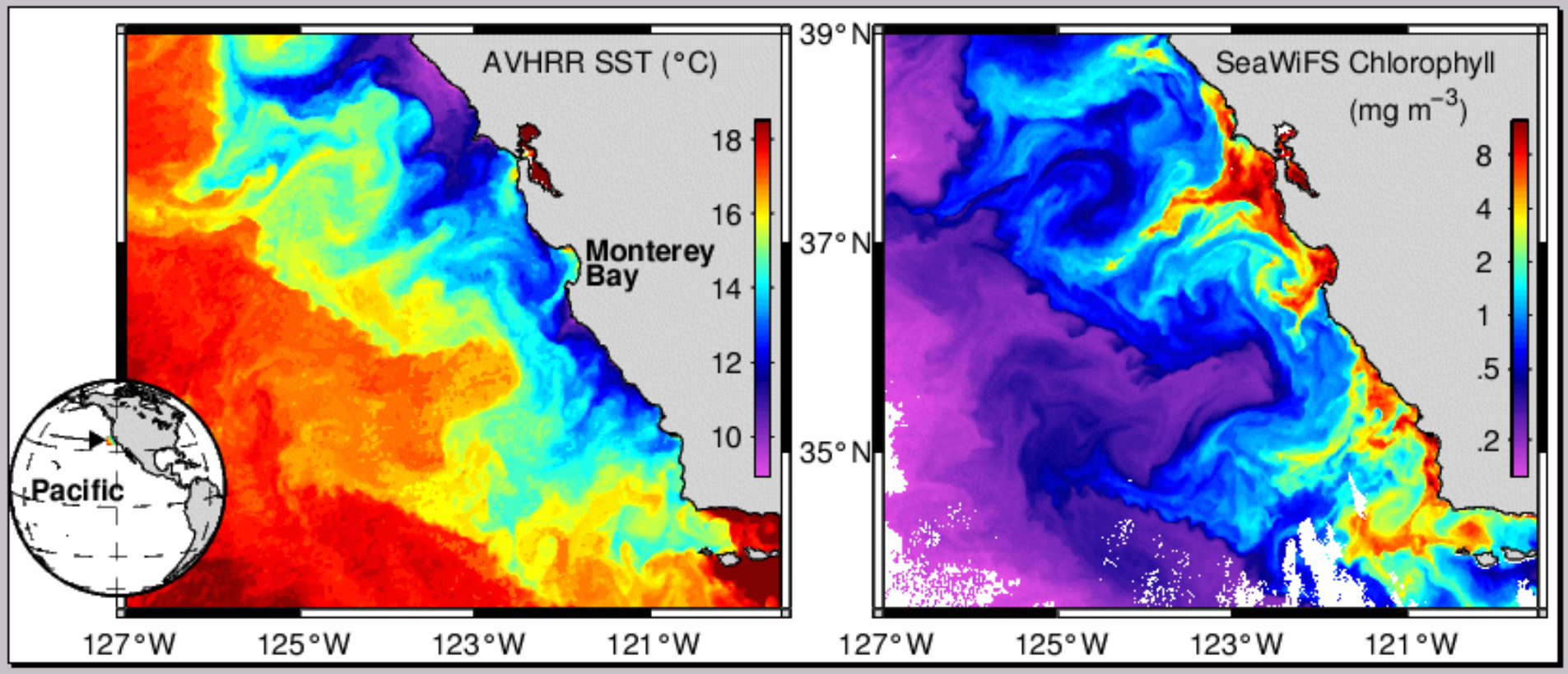
Marcos Montes, NRL (*Tafkaa* atmospheric correction)

UNOLS SCOAR (for this workshop)

OUTLINE

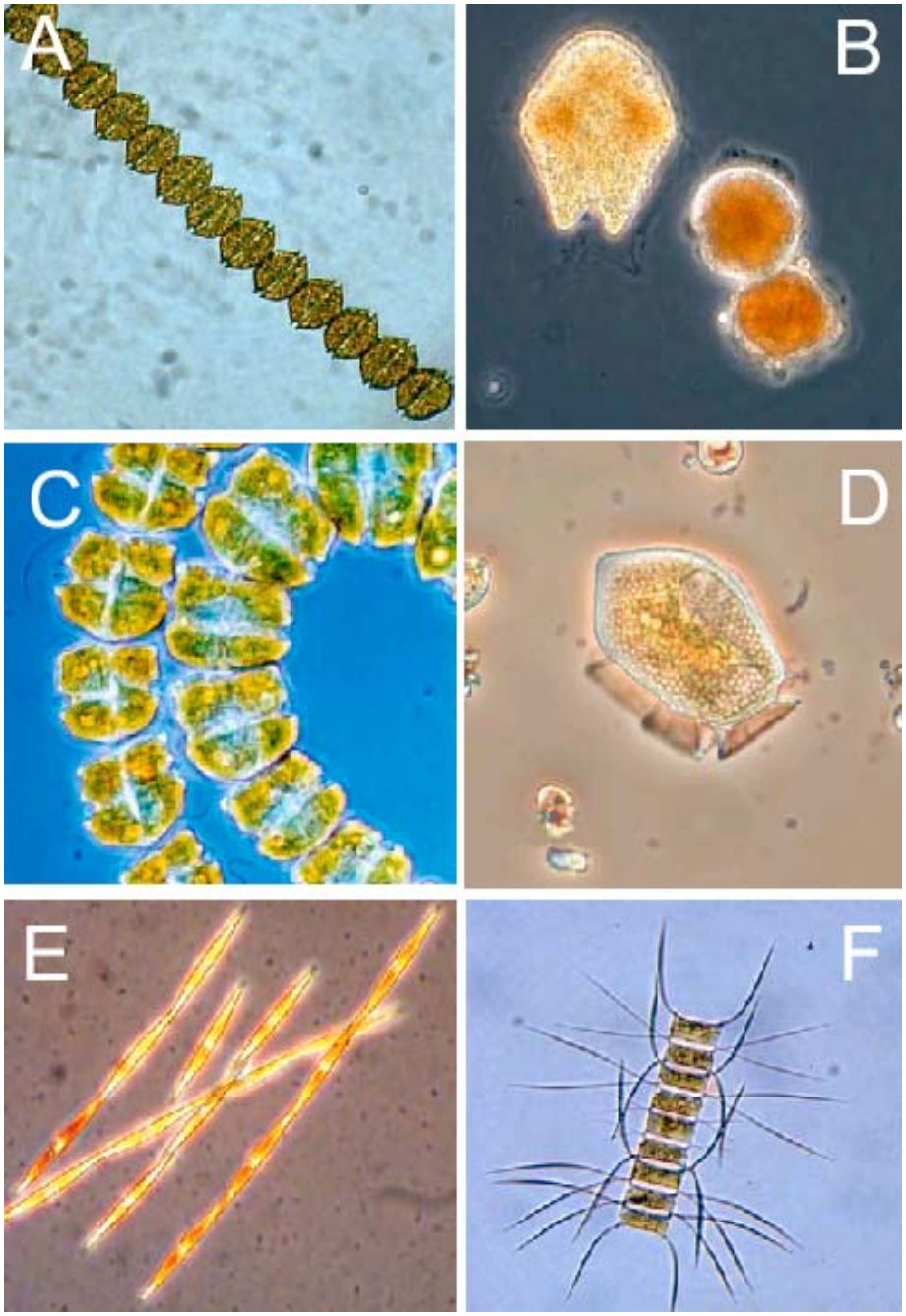
- **Environmental Setting**
- **Red tides & harmful algal blooms**
- **An estuarine plume**

Monterey Bay lies in the highly productive and dynamic California Current upwelling system.



Red Tides & Harmful Algal Blooms

- **Not all HABs are red tides; not all red tides are harmful.**
- **About 50% of red tide species & 75% of HAB species are *dinoflagellates*.**
- **Deleterious impacts of HABs occur primarily through:**
  - **toxins that enter sea life and people through food or aerosols**
  - **direct physical harm to organisms (e.g. gill damage and skin lesions in fish kill events)**
  - **development of hypoxic or anoxic conditions**
- **HABs also have significant economic impacts: fisheries, human health, recreation & tourism, monitoring & management**
- **Global increasing HAB occurrence is evident**



Key HAB species in upwelling regions

(from Kudela et al., 2005)

A. Alexandrium catenella (PSP)

B. Akashiwo sanguinea (yessotoxin poisoning)

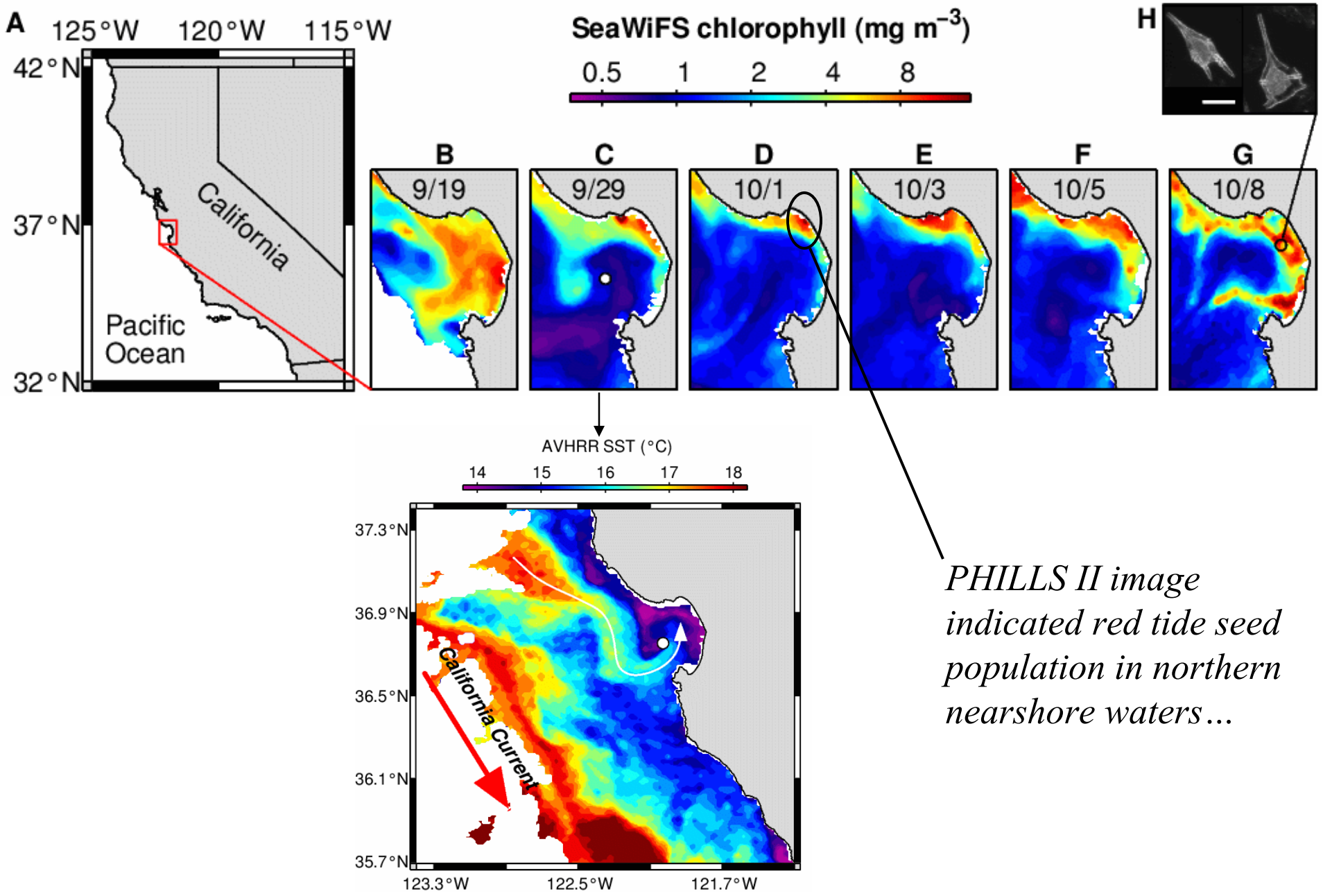
C. Gymnodinium catenatum

D. Dinophysis acuta (DSP)

E. Pseudo-nitzschia australis (ASP)

F. Chaetoceros (fish kills)

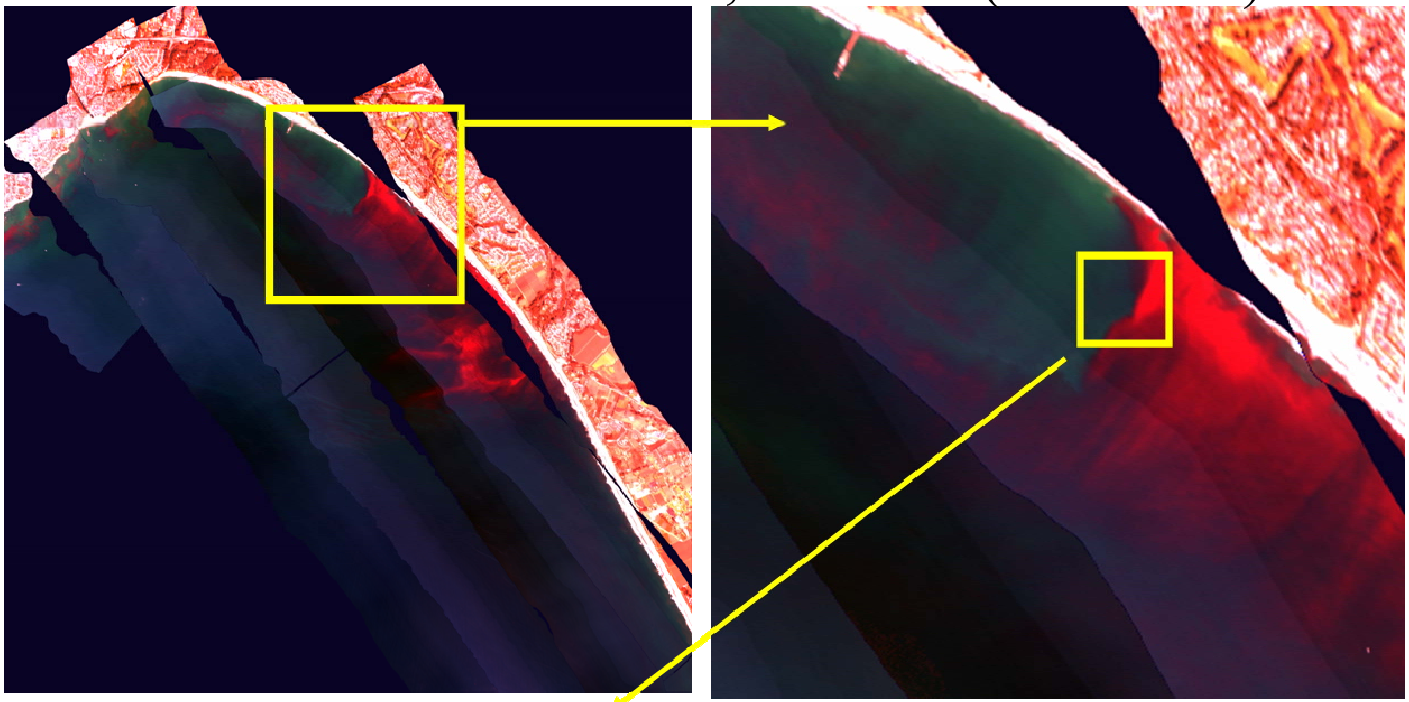
2002 Red Tide

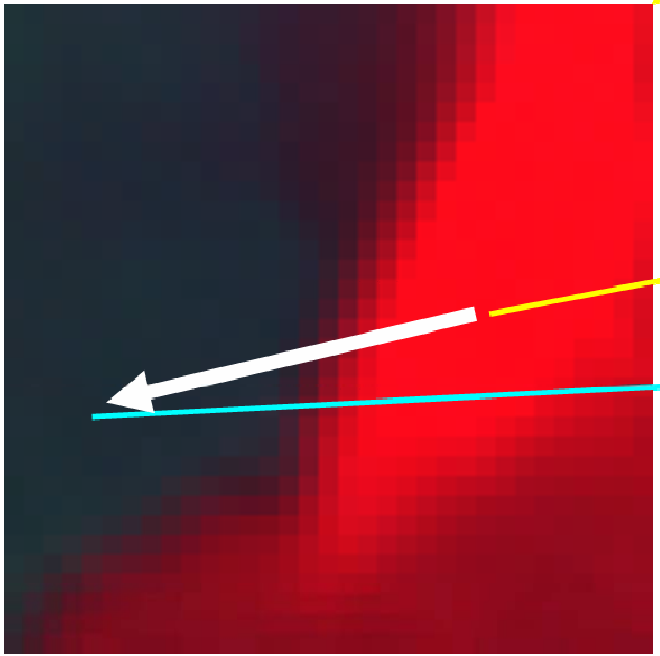


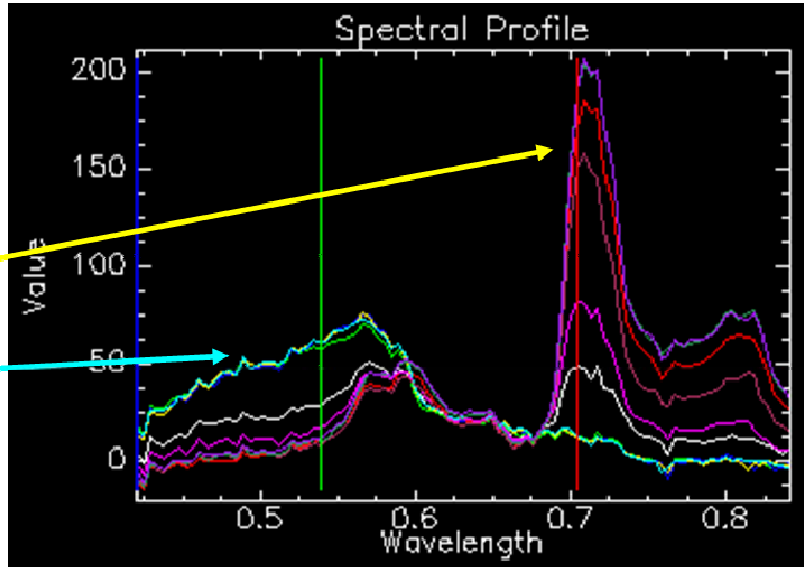
PHILLS II image indicated red tide seed population in northern nearshore waters…

PHILLS II October 1, 2002 (P. Bissett)

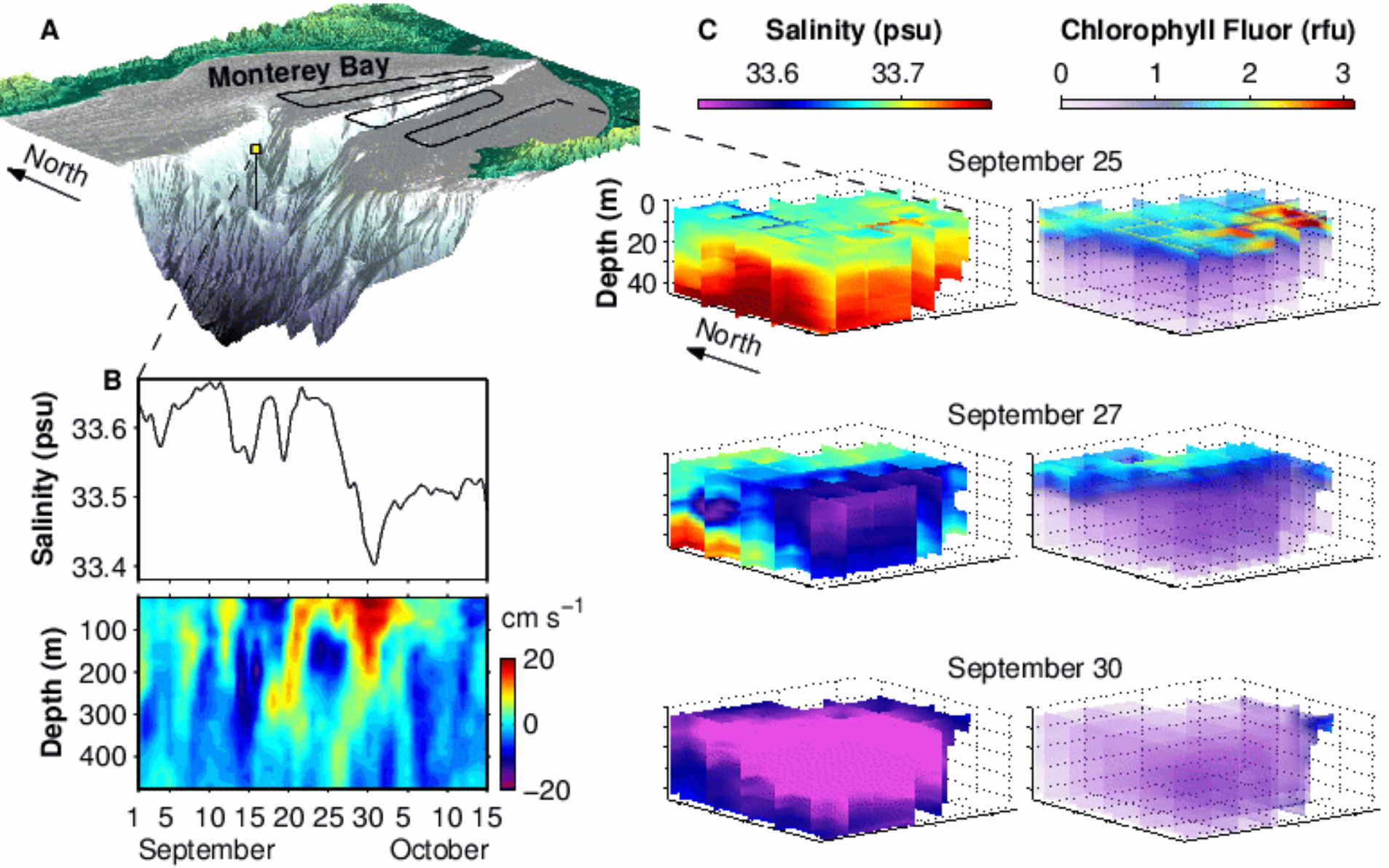
Where were the dense surface aggregations?





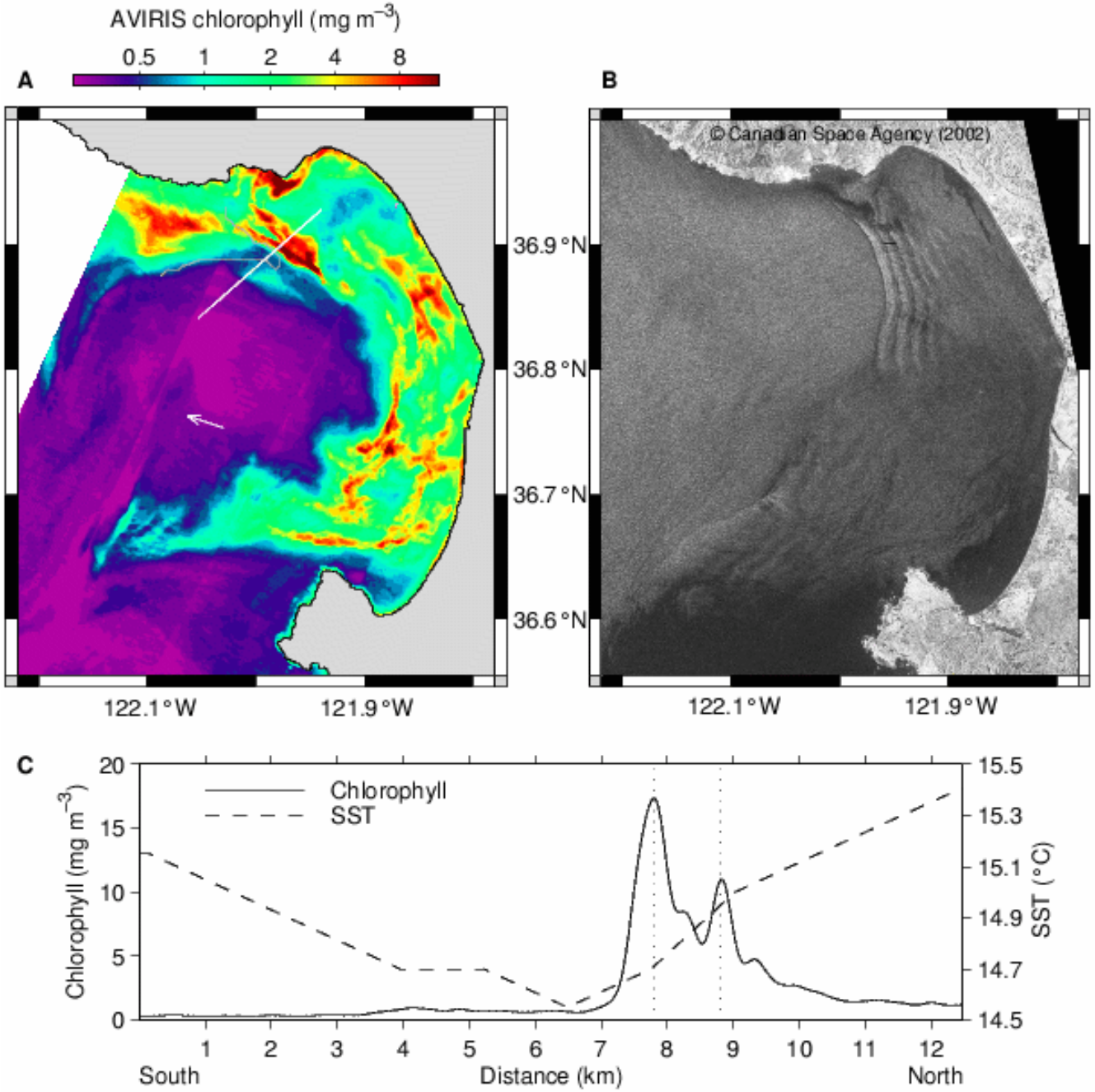


The bay flushing caused rapid, extensive ecosystem change…

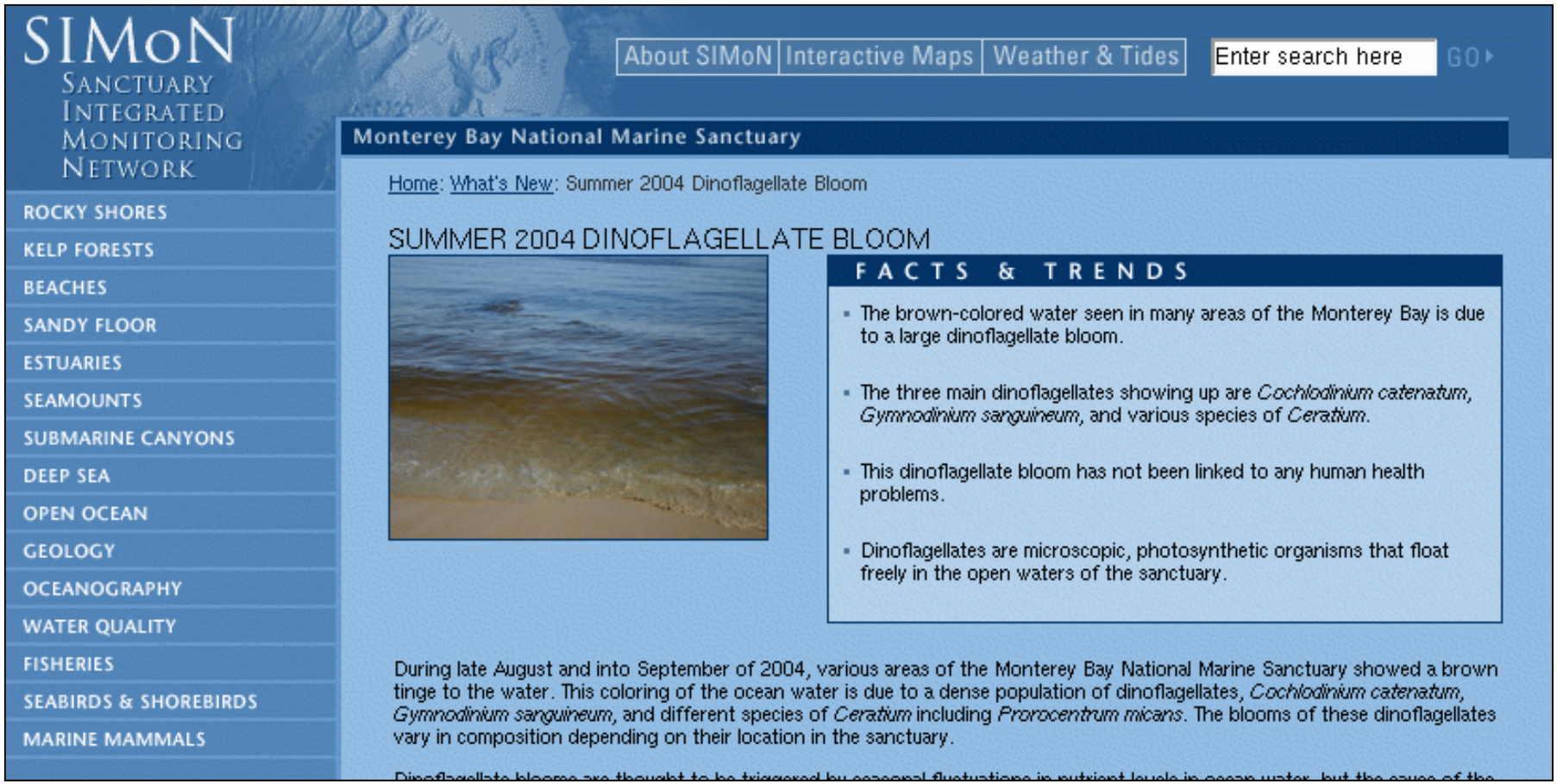


…ending with conditions favorable for dinoflagellates.

AVIRIS described patchiness at the peak of the red tide bloom…

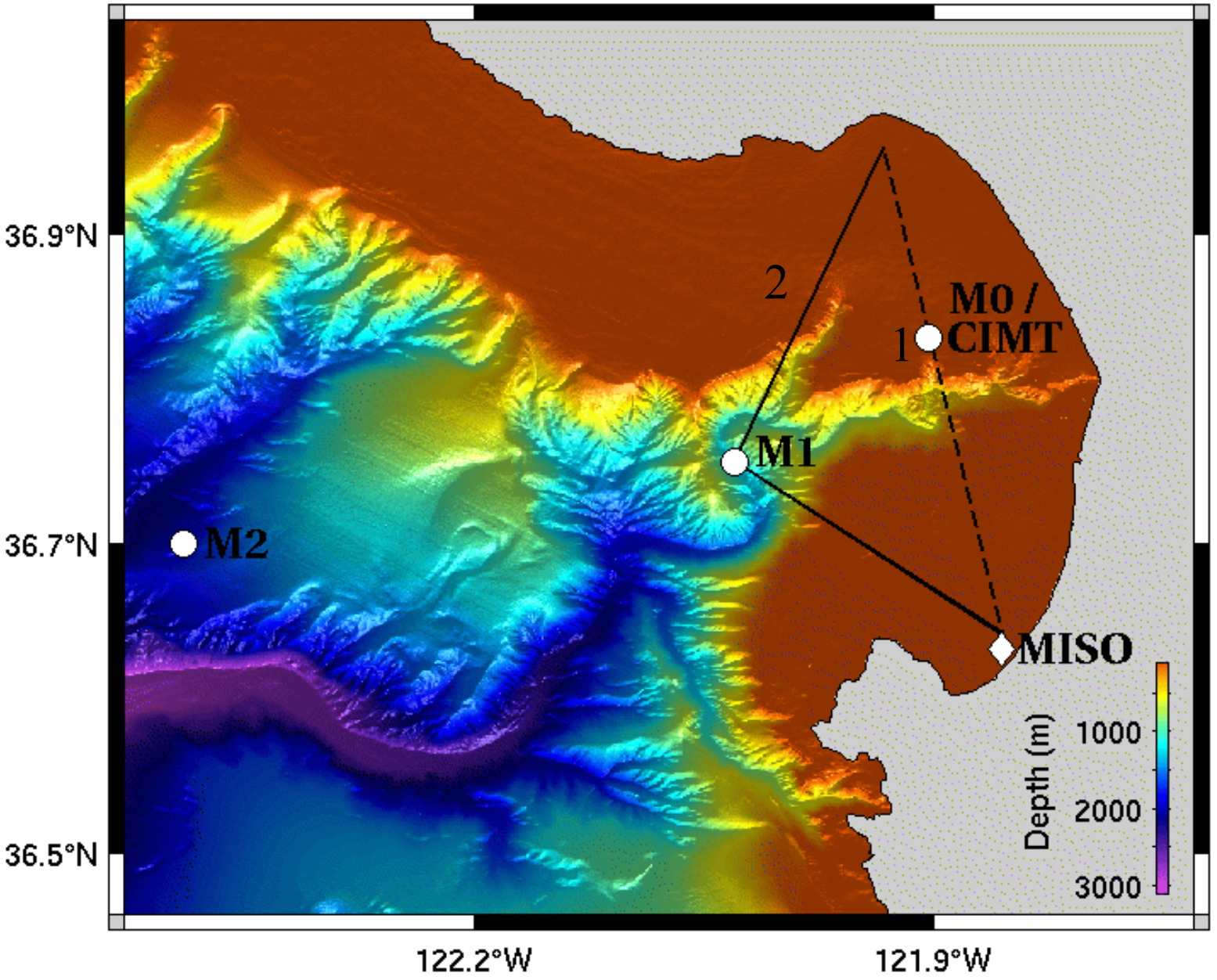


Summer 2004 Red Tide



The dinoflagellate bloom included *Cochlodinium catenatum*, a toxin producing species not previously noted in this region. Mary Silver (UCSC) found that mussels died in response to a local bloom of this species off Santa Cruz.

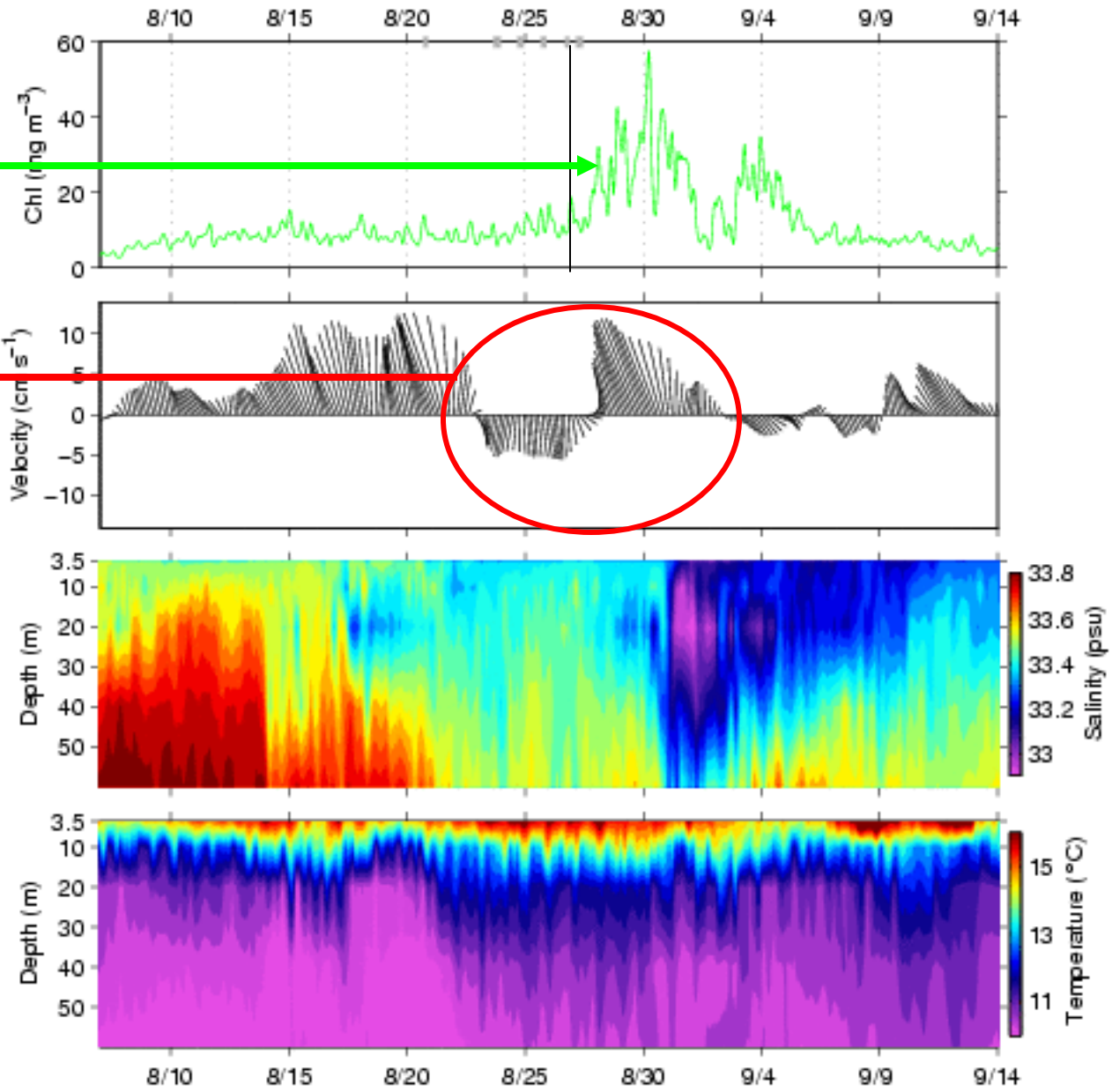
Locations of moorings and autonomous underwater vehicle transects:



Red tide signal observed at M0/CIMT:

Local bloom

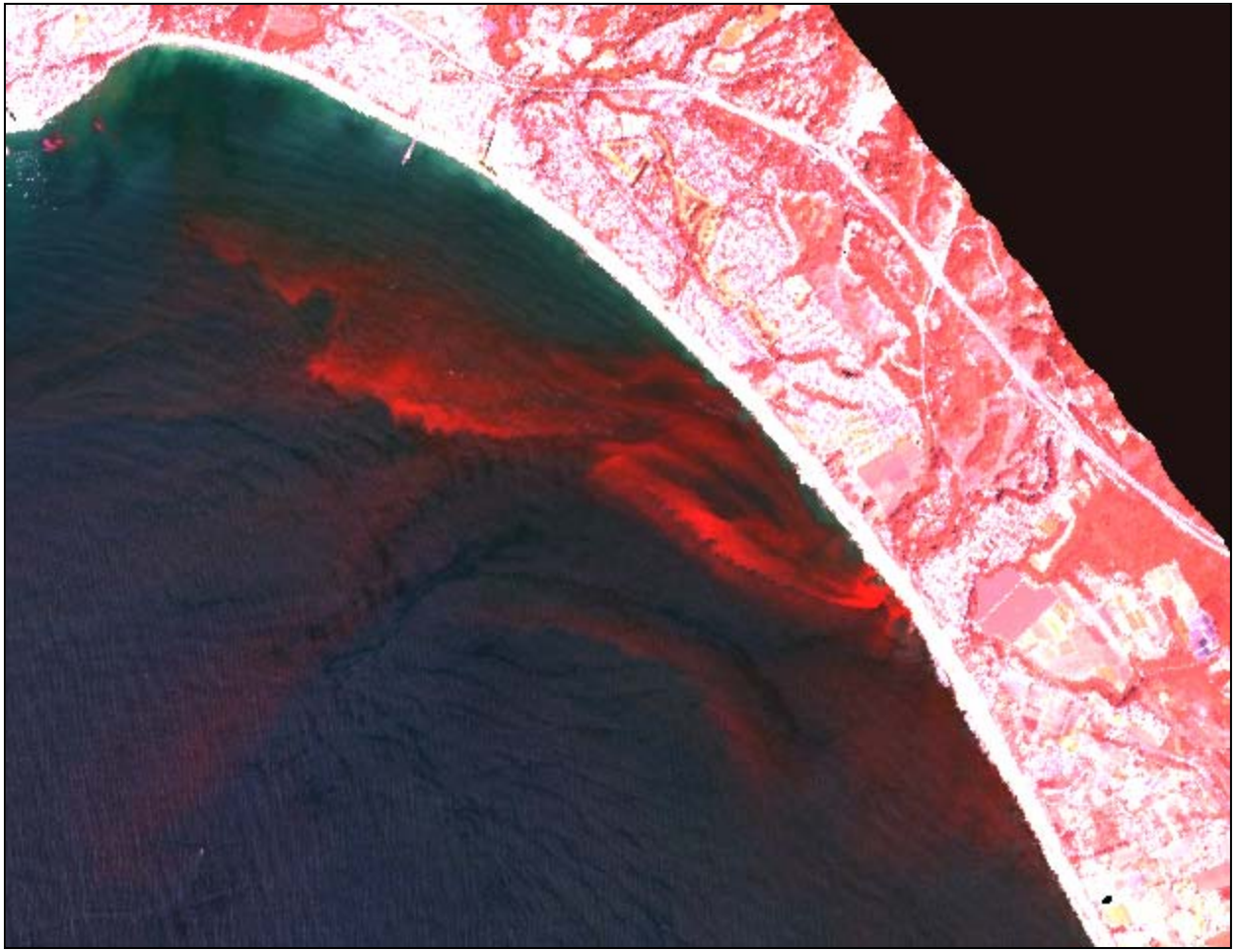
after stirring?



Other observations during this period from satellites, aircraft and AUV…

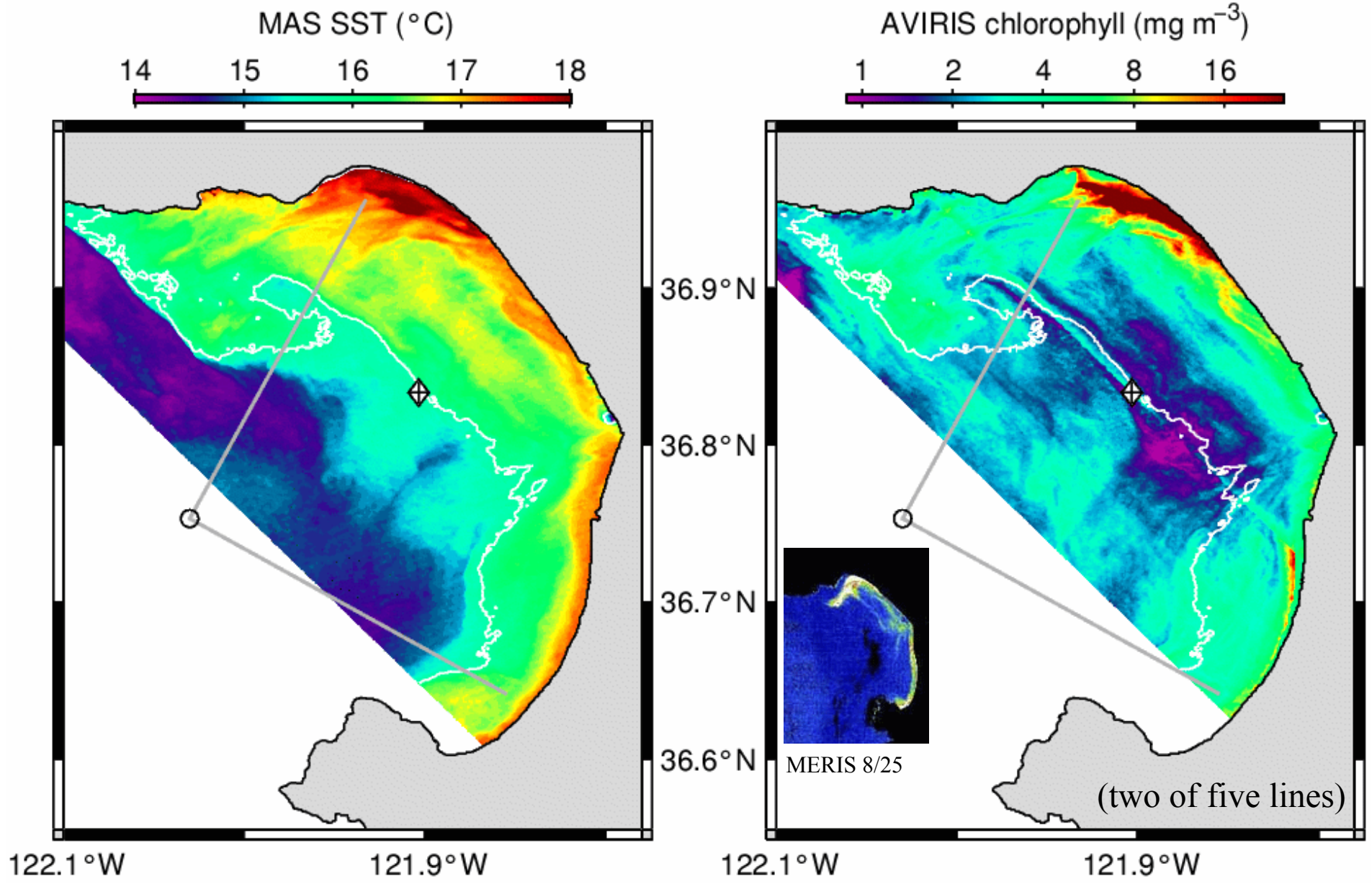
Similar to observations before the widespread 2002 red tide, hyperspectral airborne remote sensing revealed a strong signature in the far red in northern nearshore waters of the bay.

Where were the dense surface aggregations?



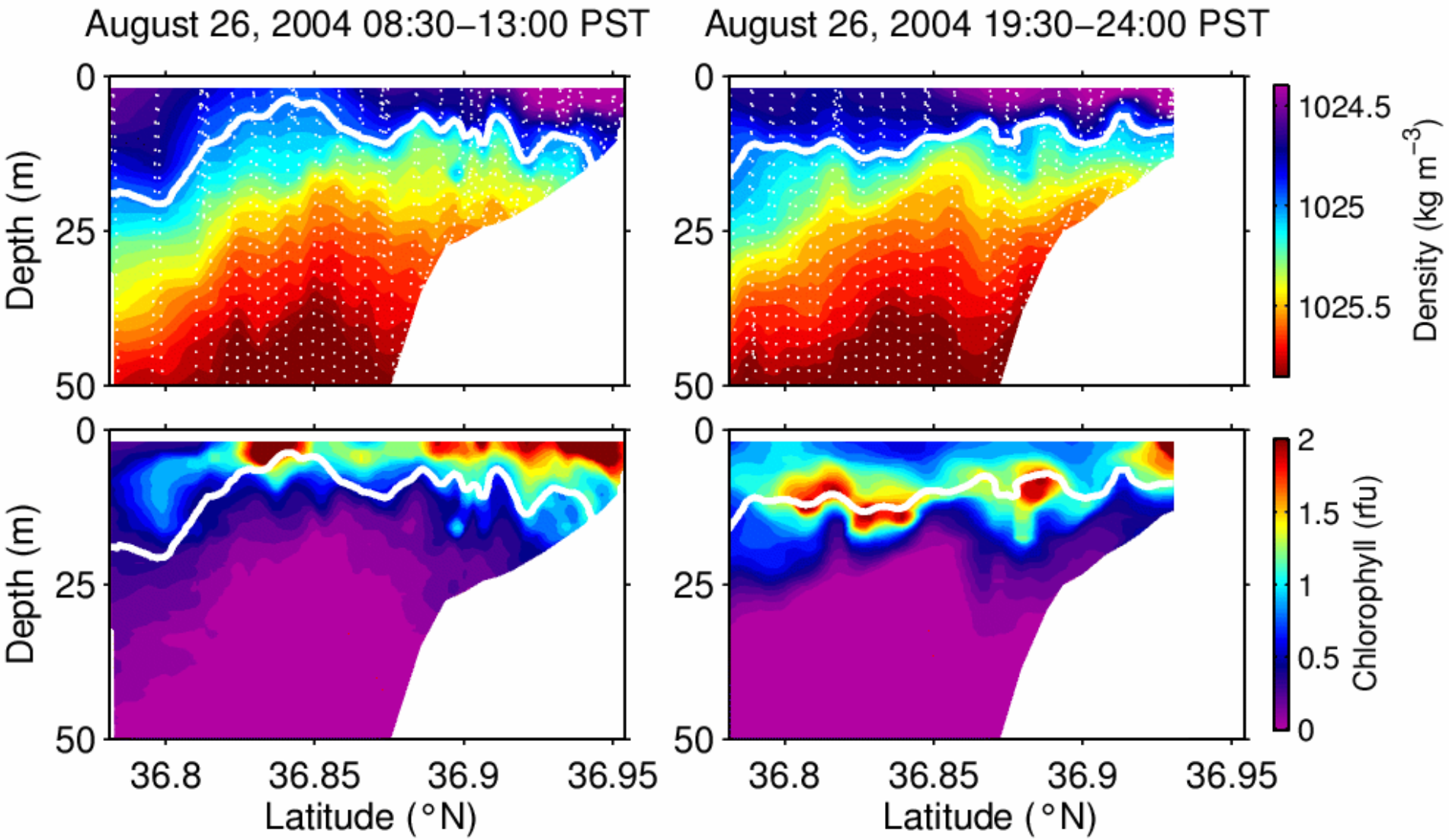
AVIRIS August 26, 2004 709 nm

August 26, 2004: AVIRIS & MAS acquisitions.



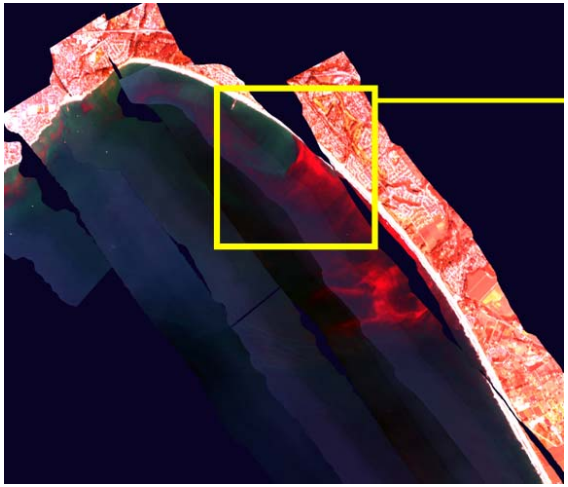
Stirring and seeding in progress?

Dinoflagellates migrate vertically (downward at night)…

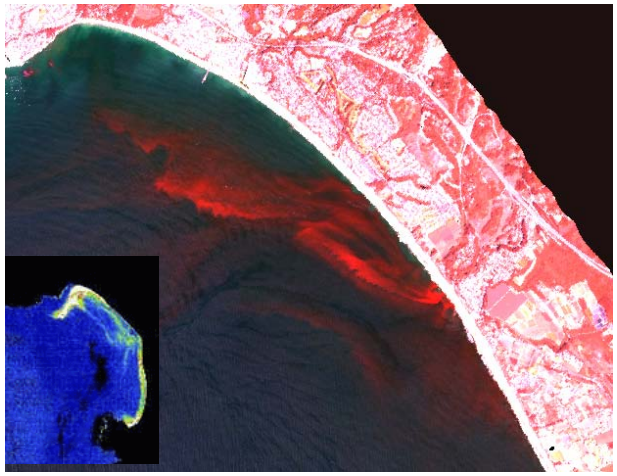


A red tide incubator in northern Monterey Bay?

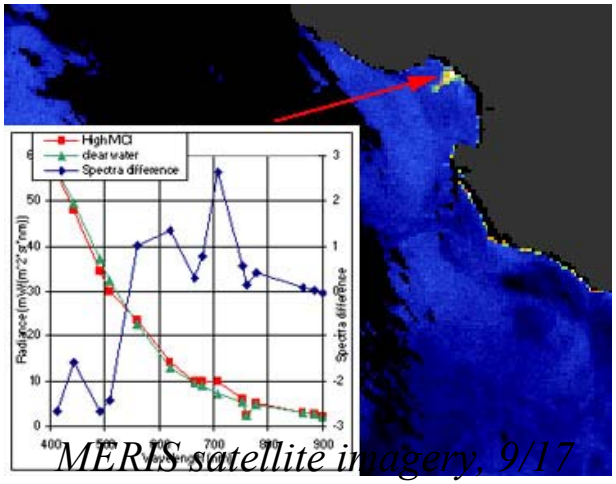
Before 2002 red tide



Before 2004 red tide



2005?

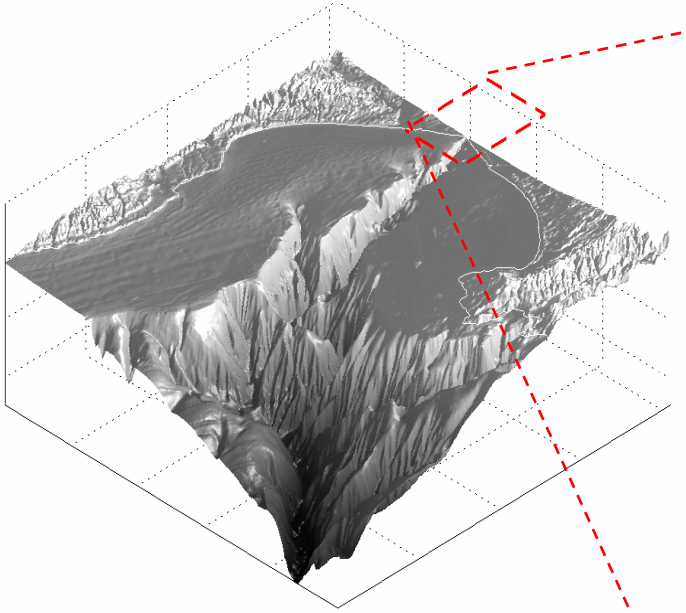


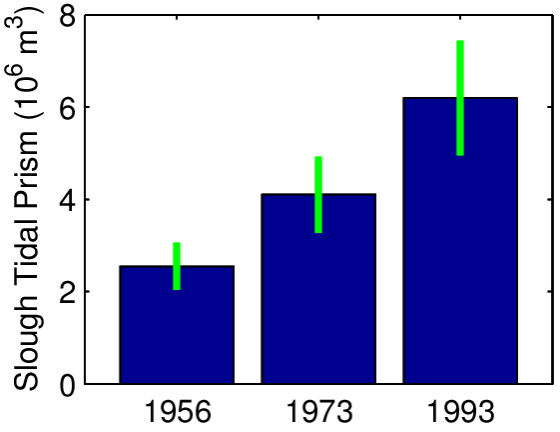
MERIS satellite imagery, 9/17

Physical, chemical and biological influences in this region:

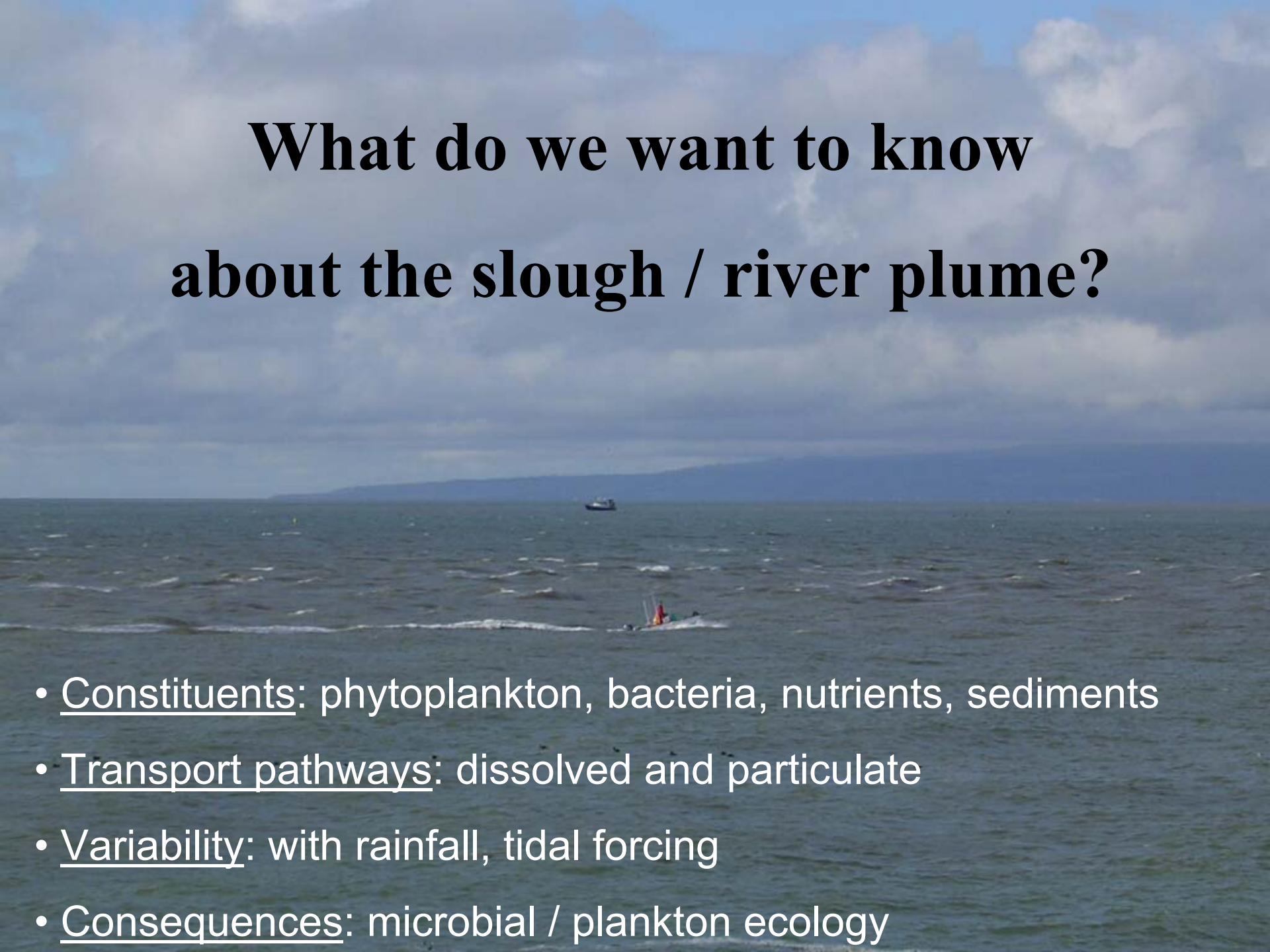
- *In the upwelling shadow (stratification), residence time further enhanced by local dynamics?*
- *Nutrients pumped from the canyon into near-bottom inner shelf*
- *Dinoflagellate cyst population dynamics*
- *Downstream of Elkhorn Slough plume (stratification, nutrients, dinoflagellate seed populations)*

Estuarine Plume: Slough, river and harbor meet the coastal ocean at the head of Monterey Submarine Canyon. Observing systems are in place in the slough / river system, and in / outside the bay.





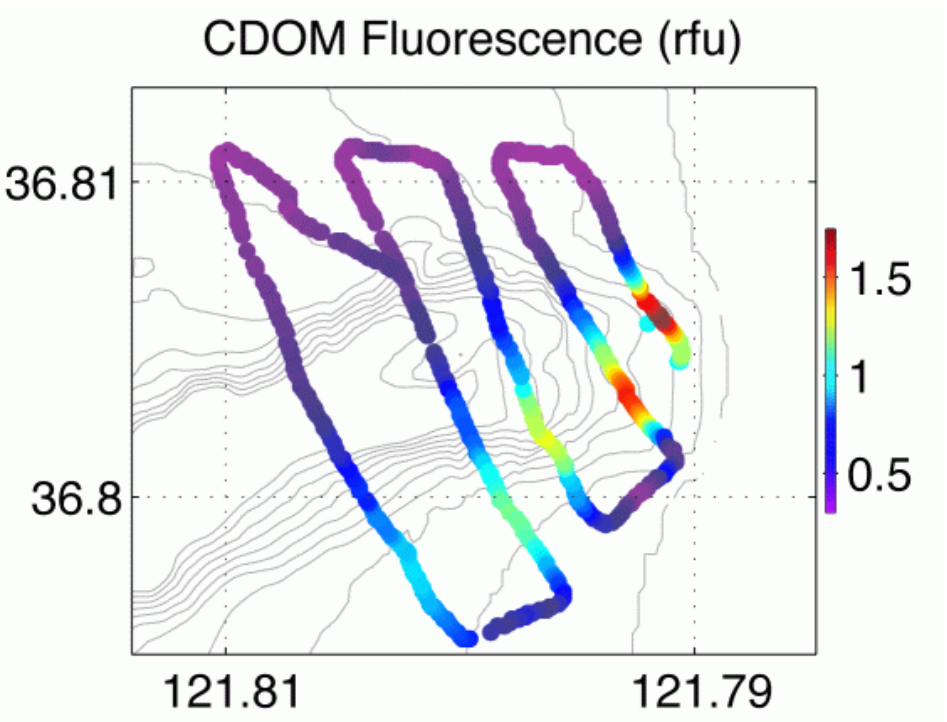
Tidal prism data from L. Breaker, MLML.

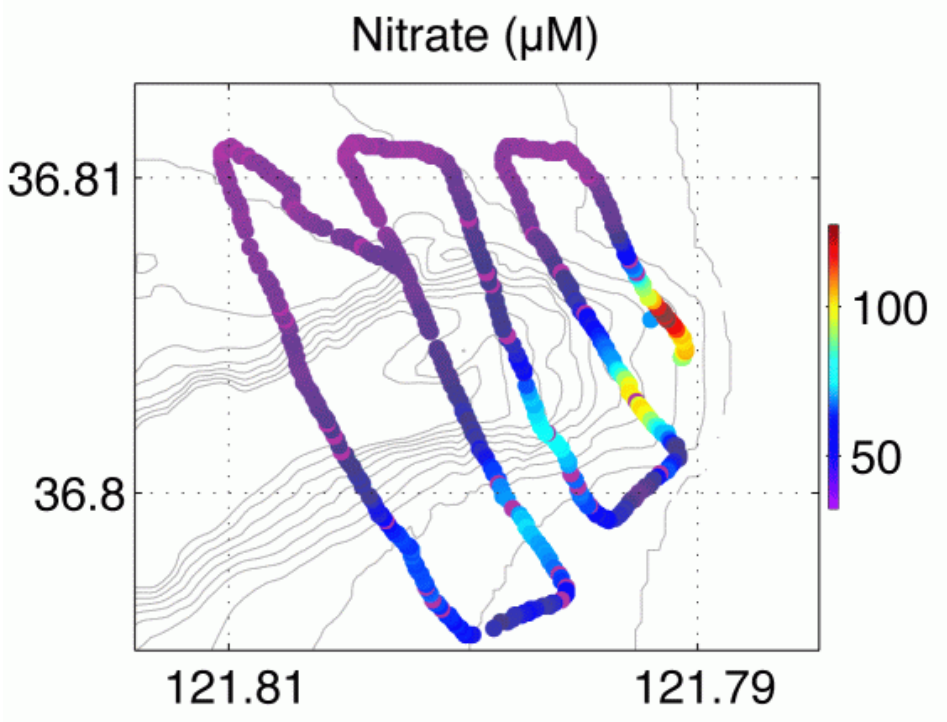


What do we want to know about the slough / river plume?

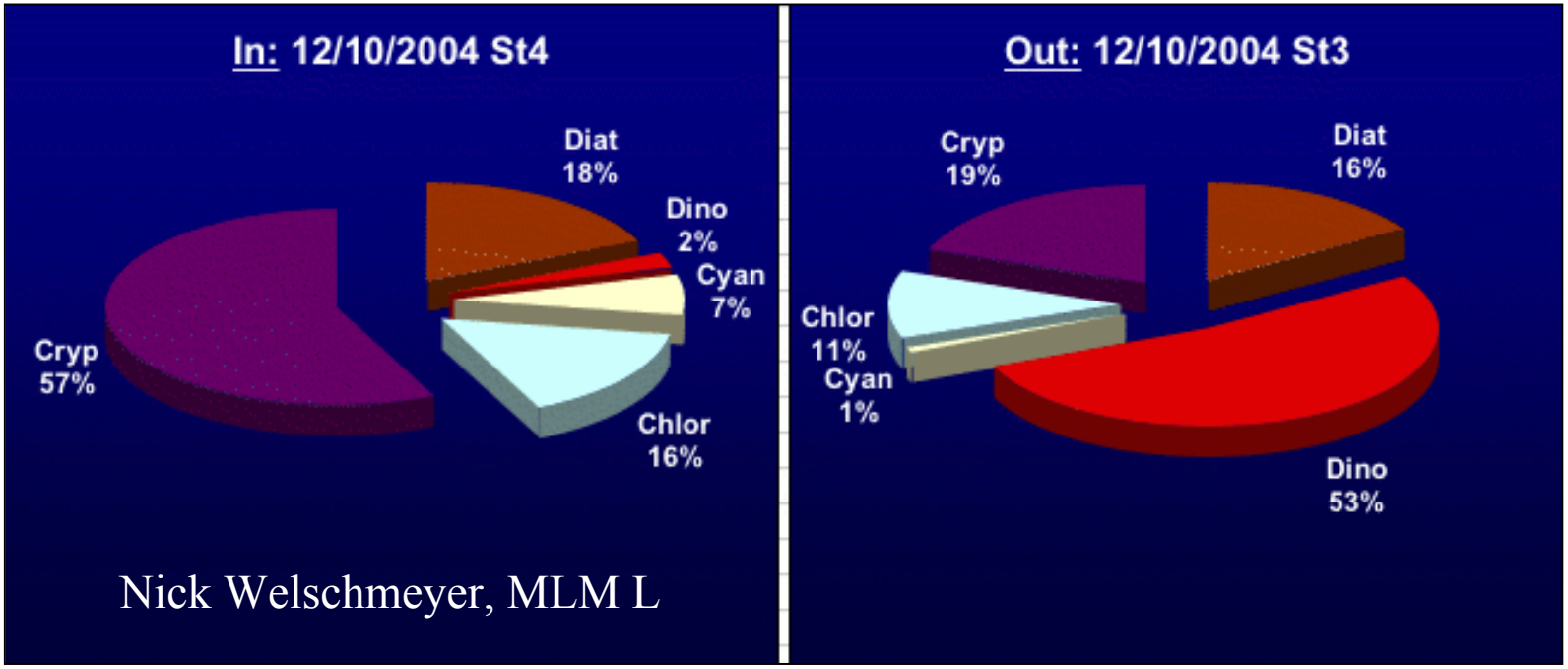
- Constituents: phytoplankton, bacteria, nutrients, sediments
- Transport pathways: dissolved and particulate
- Variability: with rainfall, tidal forcing
- Consequences: microbial / plankton ecology

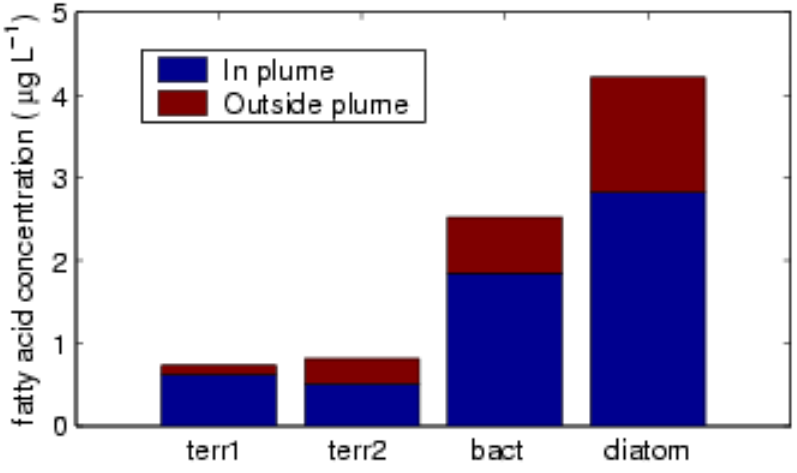
Small boats: surface underway mapping, deploy/recover drifters, take water samples (pigments, fatty acids, total suspended solids), *in situ* hyperspectral ground truth.

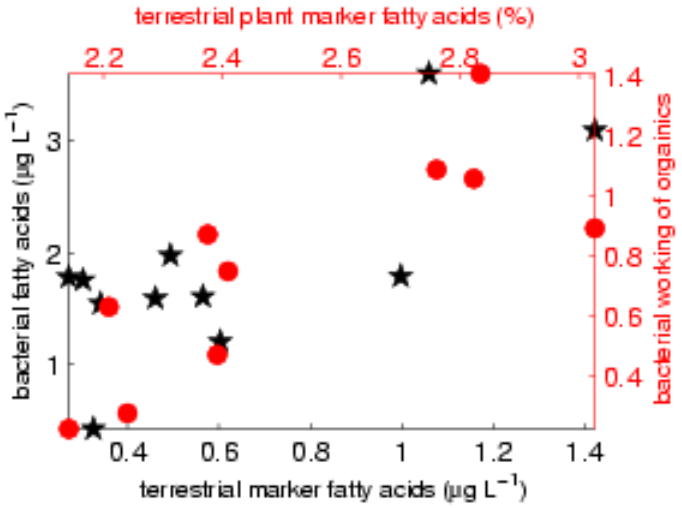




Analysis of pigments and fatty acids to characterize the microbial community:

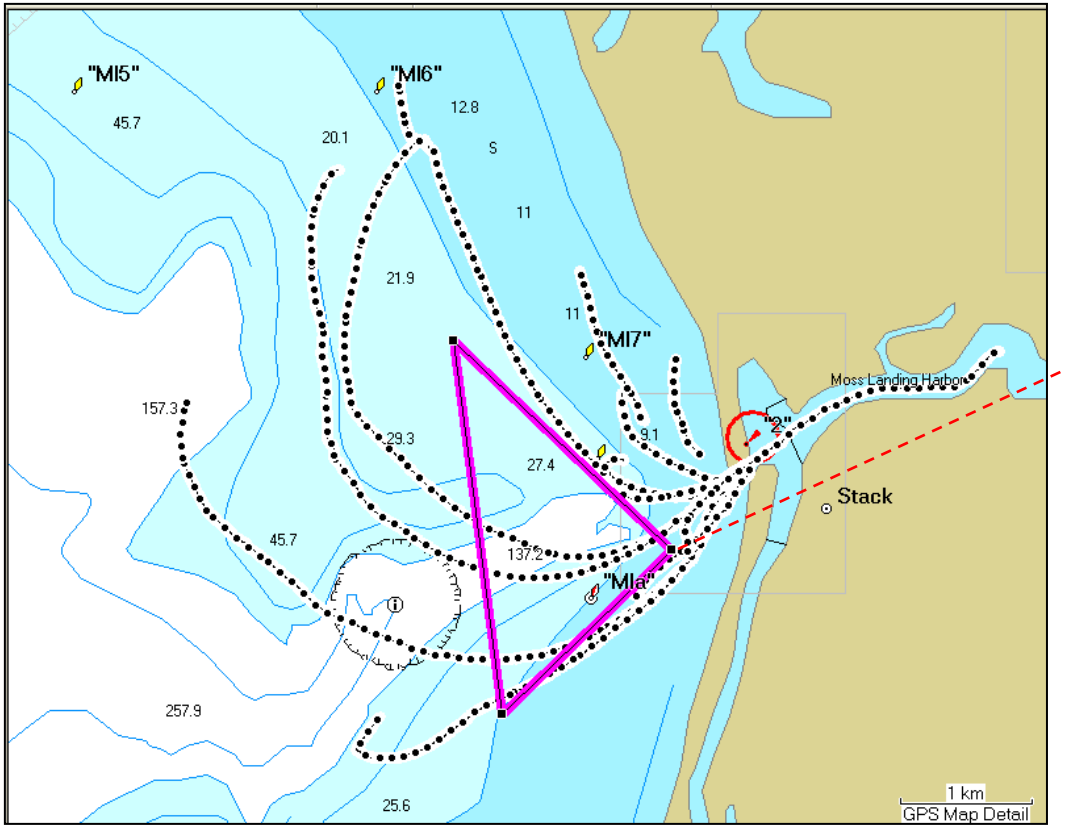


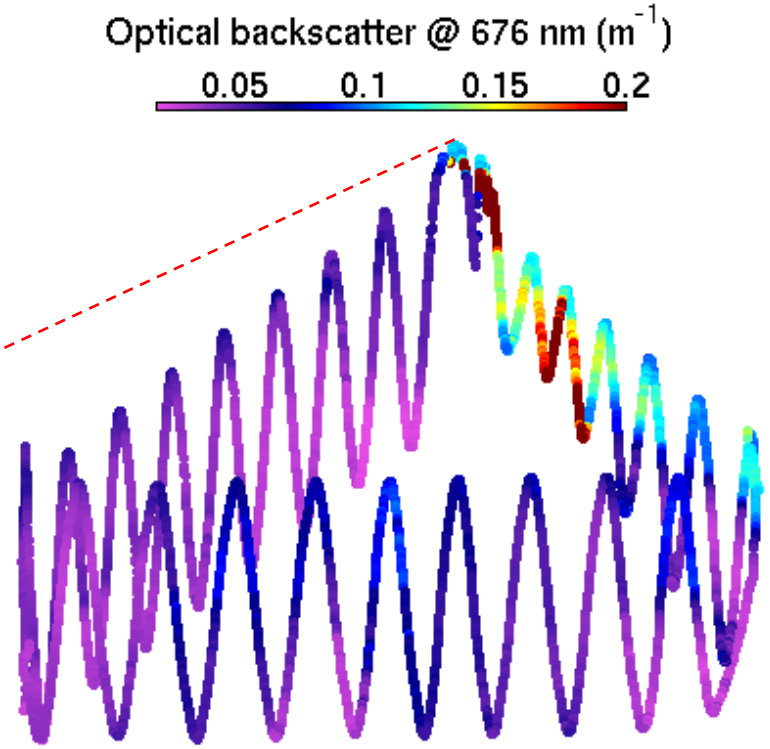




AUV: synoptic, multidisciplinary volume mapping

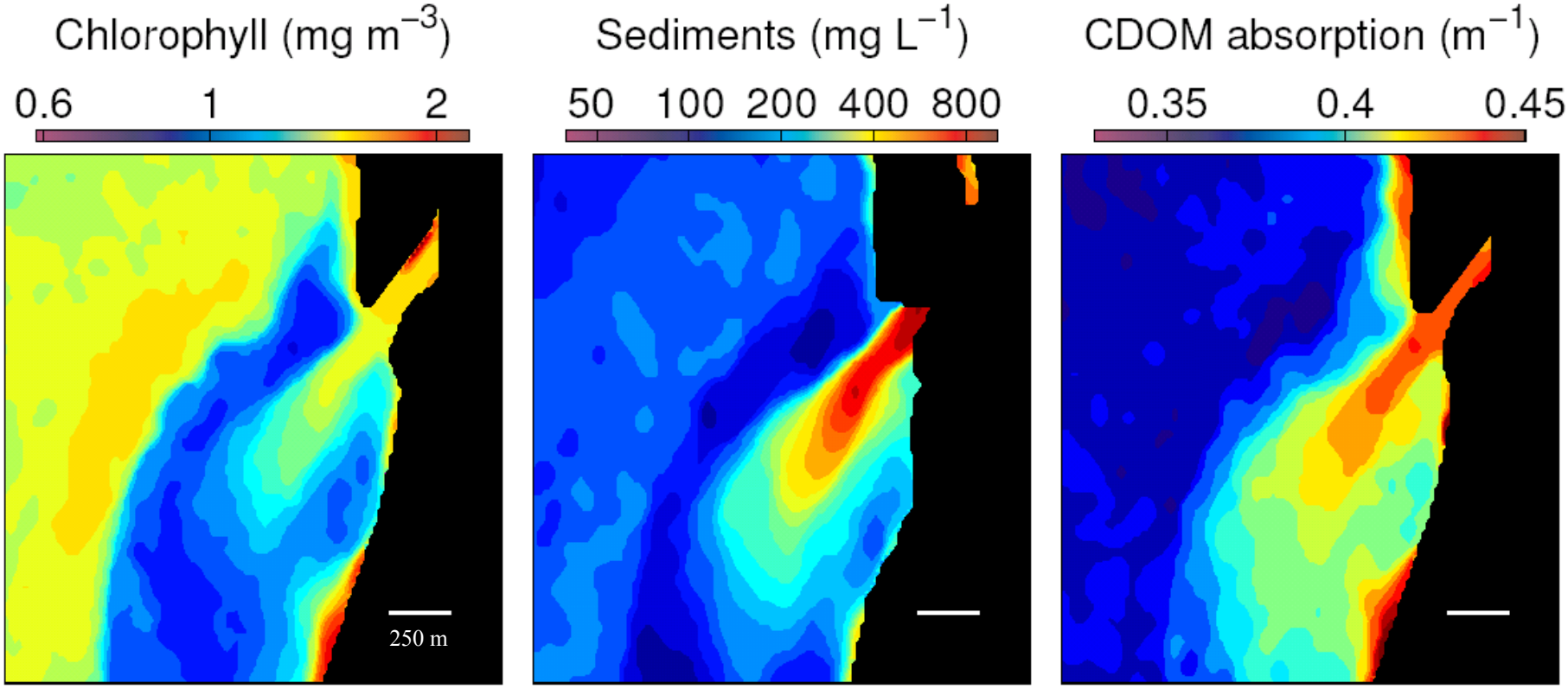
Drifters: tracing surface flow pathways





Heaviest sediment load along southern plume edge…

AVIRIS: Synoptic images of plume from which important constituents can be quantified and validated.



End Note

Airborne remote sensing fills an important part of the observation spectrum required for studies of complex coastal ocean processes.