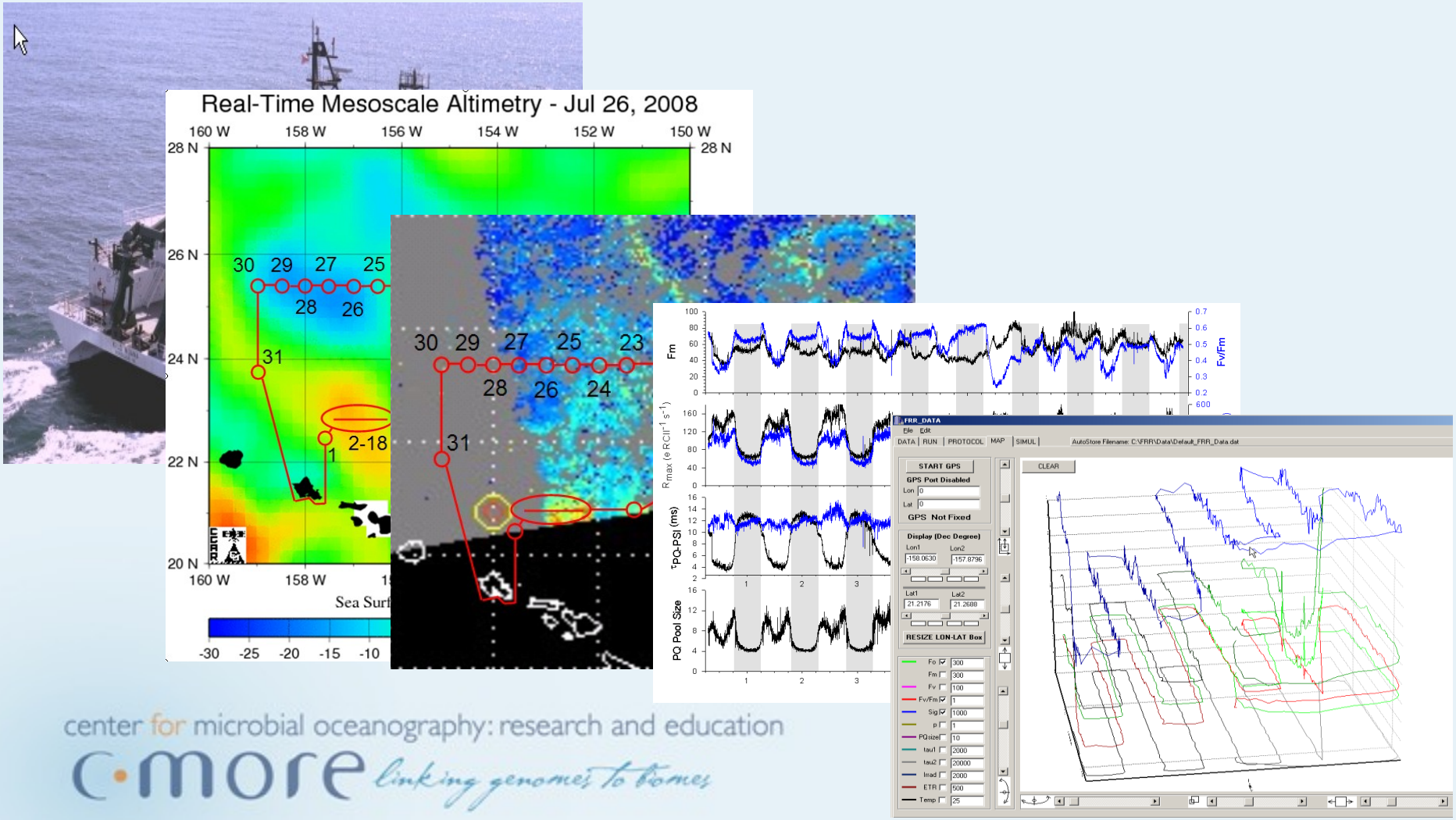
Ocean Perturbation Experiment (OPEREX)

CMORE Cruise, July 30 - August 14, 2008

Objective:

To explore the potential and limitations of perturbation experiments at sea.



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Two Types of Ocean Perturbations:

- **Natural perturbations:**
  - Episodic wind driven events
  - Periodic/aperiodic blooms
  - Eddies
  - pH shift in the ocean

  We can observe and interpret natural perturbation. For that we need to detect the presence of these perturbations, to be present at their occurrence, and to apply sampling strategy appropriate for temporal/spatial scales of these perturbations.

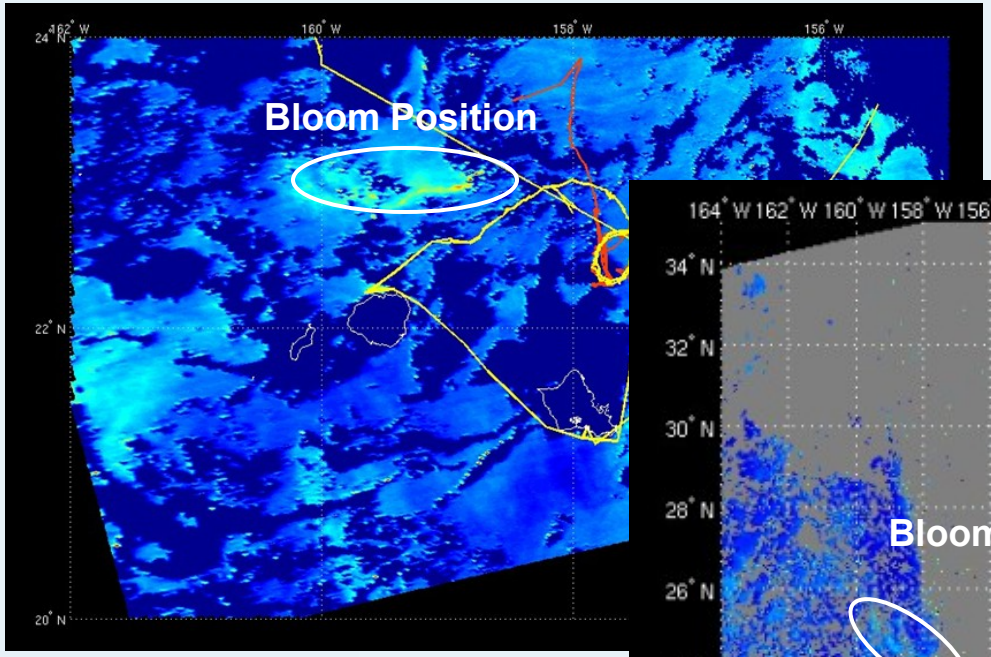
- **Artificial perturbations:**
  - Bench/lab scale incubations
  - Ship deck incubations
  - Mesocosm experiments
  - Mesoscale experiments

  We can perform, observe, and interpret artificial perturbation experiments. We have a freedom to select the site, the scale, and the observation strategy.

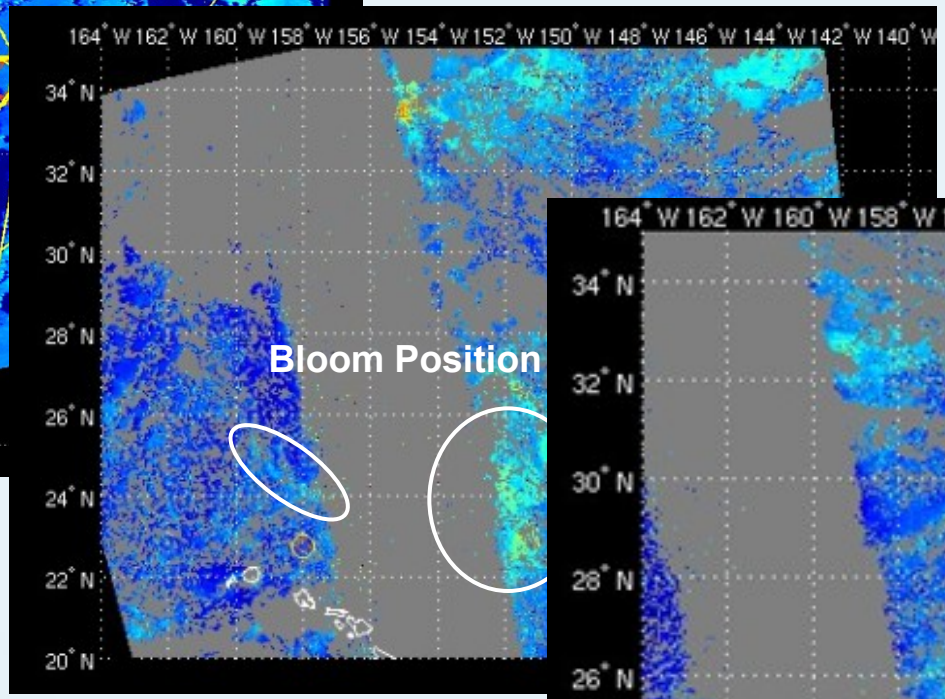
During OPEREX cruise we will follow some of natural perturbations including blooms and eddies, and we will perform some of the artificial perturbation experiments including bench/lab scale incubations, ship deck incubations, and ship deck pH shift experiments.

1. Local features/blooms bloom chasing experiment

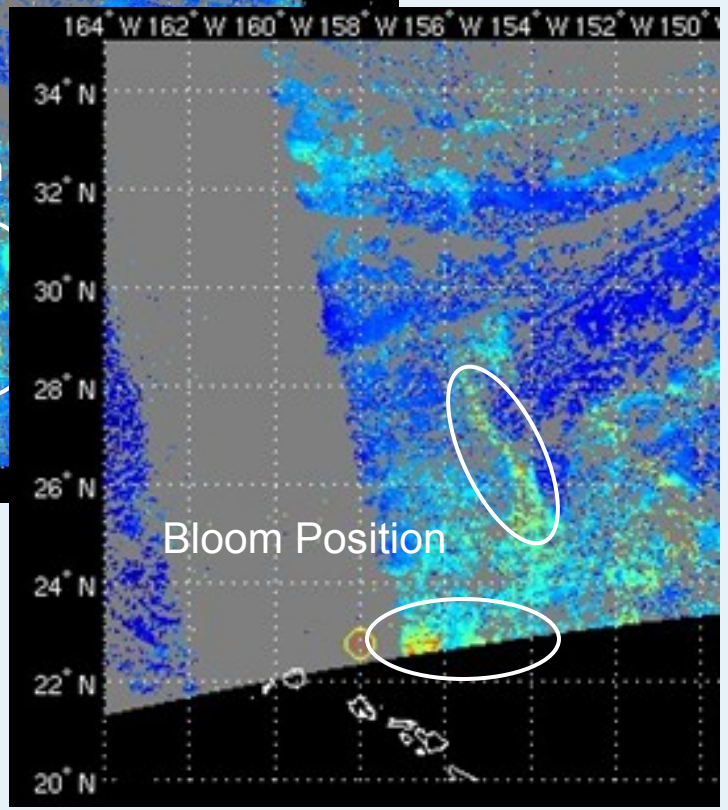
July 14, 2008



July 20, 2008



July 24, 2008



1. Can we identify local blooms?
2. Can we be present at their occurrences?

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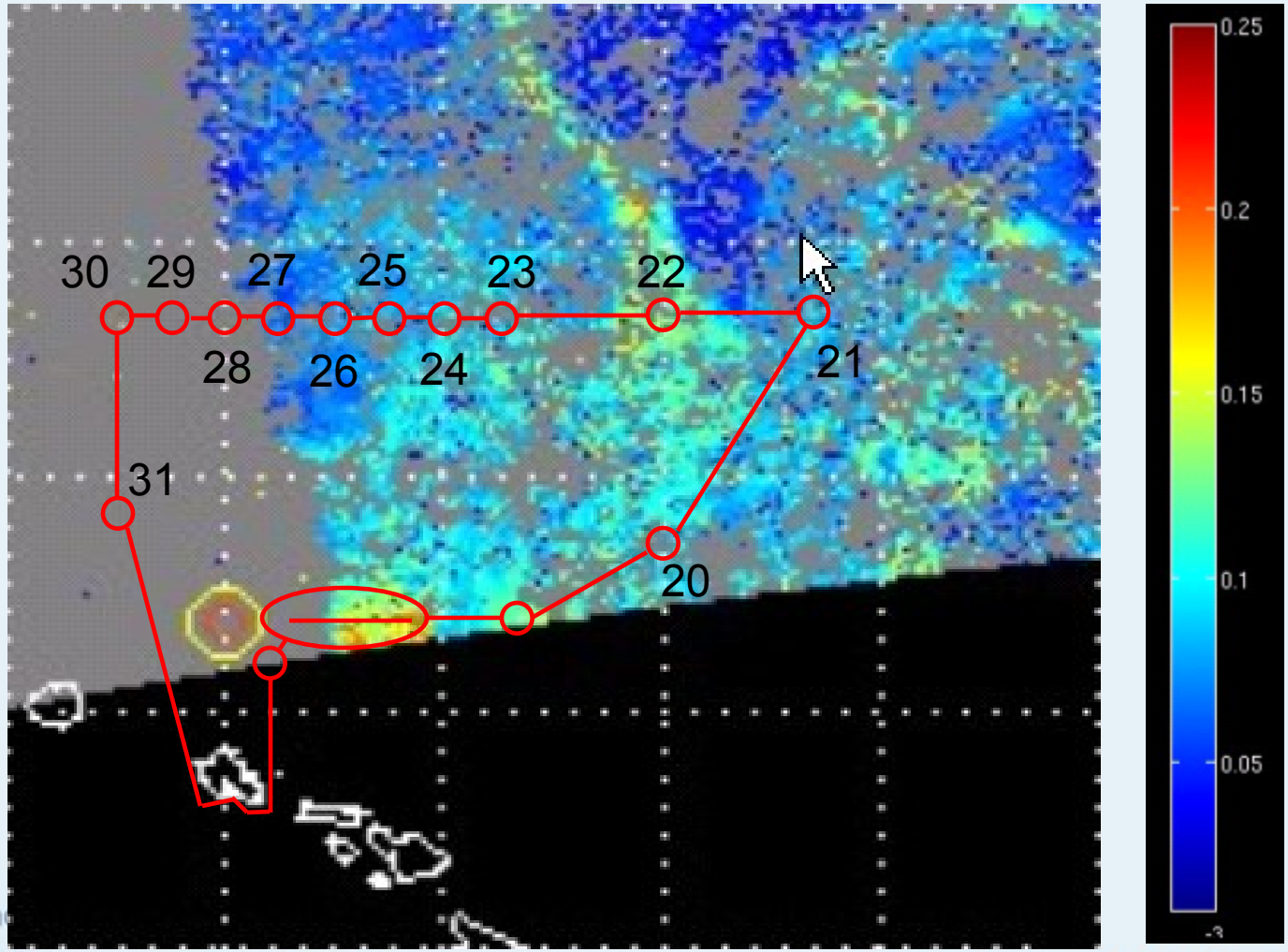
Local Blooms Questions

1. What controls the presence of local blooms/features
    - unusual patterns of local upwelling?
    - unusual configuration of the eddy field?
    - local presence of nitrogen fixation?
2. What is the vertical distribution of these features?
3. How dynamic are they spatially and temporally?
4. Do they export carbon?
5. What determines their intensity?

Approach

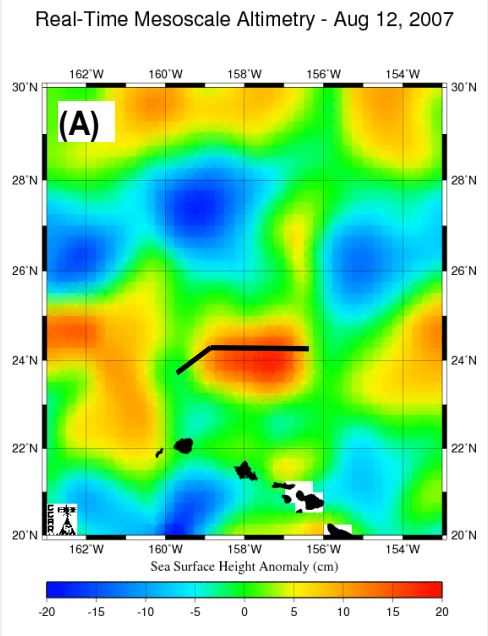
1. Identify approximate bloom location using ocean color data.
2. Survey the bloom area with on-line FRR fluorometry to estimate the spatial extent of the bloom.
3. Monitor the evolution of the chemical and biological properties of the bloom over a period of nine days
    - Occupy IN-BLOOM and OUT-BLOOM stations once a day, perform double/triple cast CTD at each of these stations
    - Measure 3-D distribution of the bloom biological fields using pumping CTD operating in YOYO mode
    - Run a series of deck incubations to determine physiological properties of IN-BLOOM and OUT-BLOOM populations

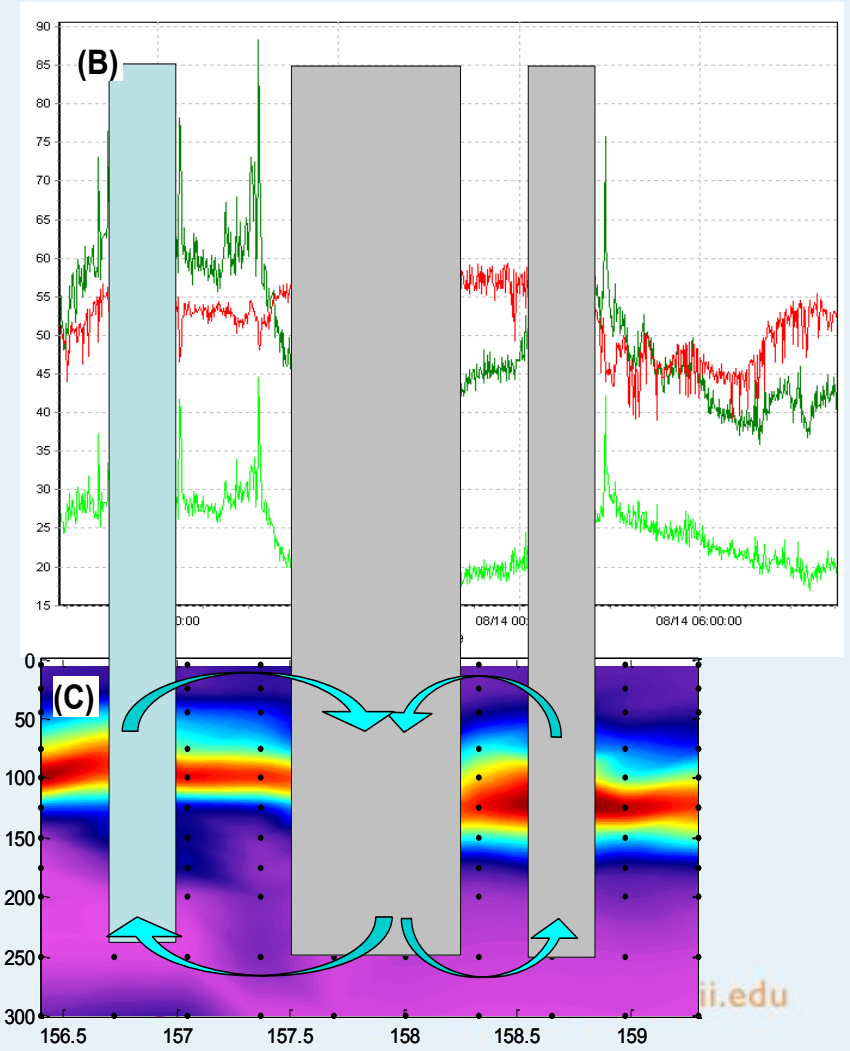
Cruise track based on bloom distribution as of July 24, 2008



2. Eddy Sampling experiment:

Based on BIOOMER 2007 cruise, there is strong indication of biological responses to water circulation induced by the eddy system. This may modify the local biogeography within the downwelling and upwelling eddies.





BLOOMER 2007 data

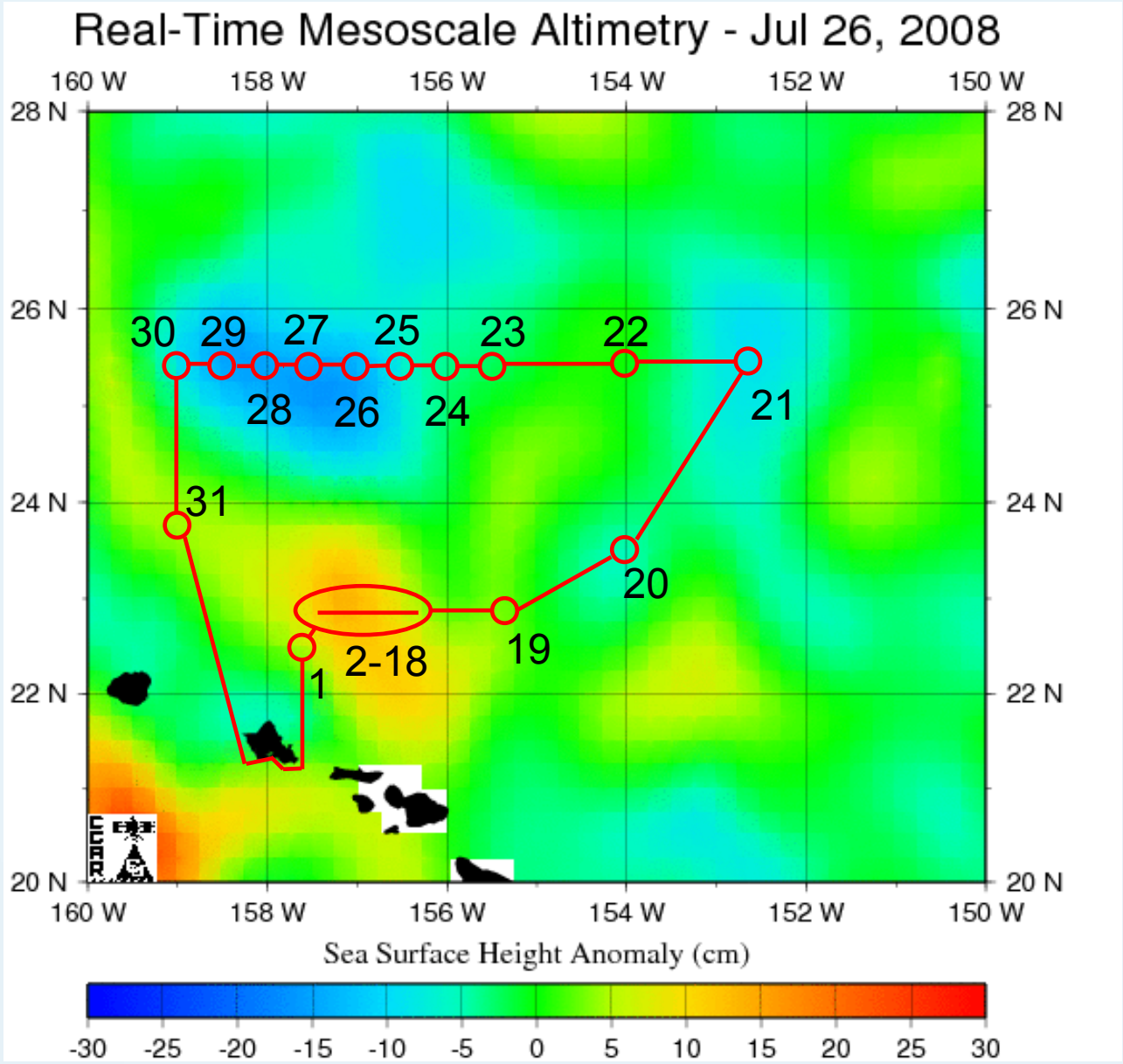
Questions

1. What are the patterns of water circulation within the upwelling/downwelling eddies?
2. How these patterns affect local nutrient transport and light exposure?
3. How this affects local biogeography, local patterns of nitrogen fixation, local patterns of primary, secondary, and export production?

Approach

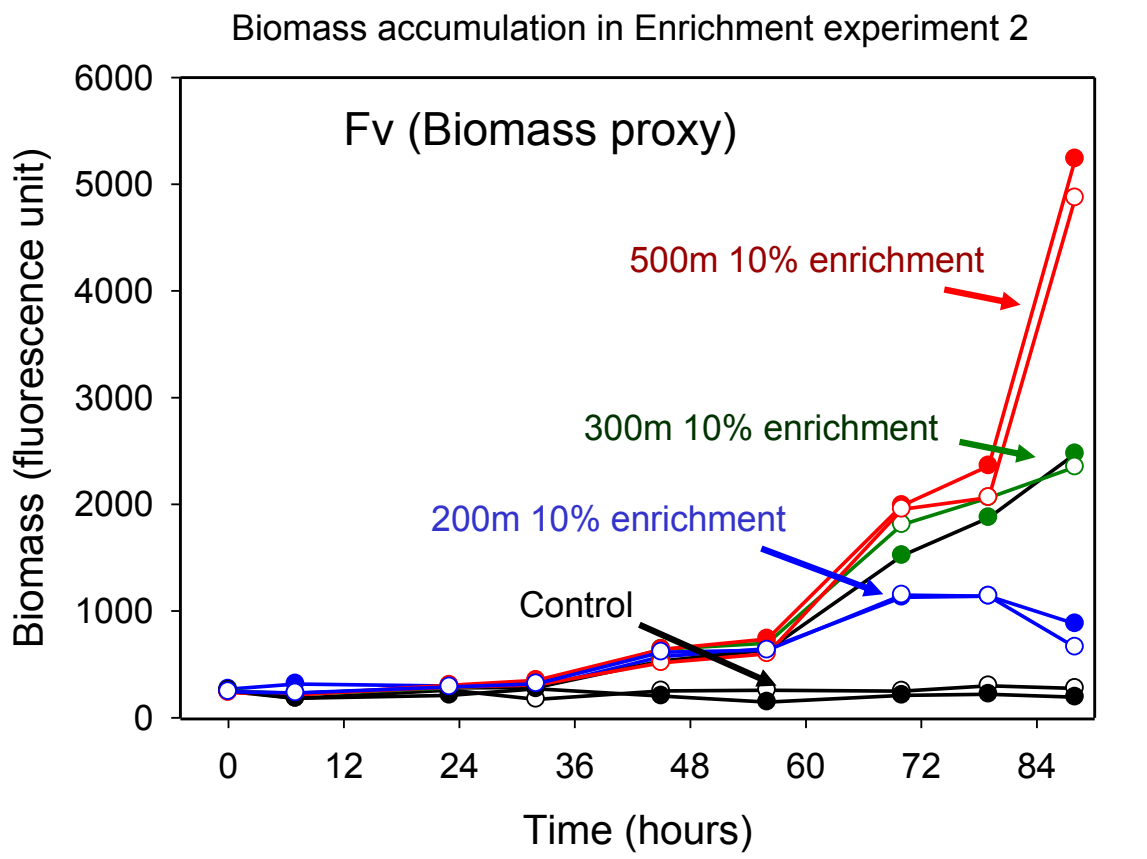
1. Select a cruise track to cover several downwelling/upwelling eddies based on SSH/Ocean Color data
2. Measure the physical/chemical/biological properties of the water column in stations centered at these eddies.
3. Perform detailed sampling of one of the eddies with 8 CTD casts at 25-30 miles intervals.

Cruise track over actual SSH distribution as of July 24, 2008



3. Deep water enrichment experiment (deck incubations)

BLOOMER 2007 data indicate strong response of the mixed layer phytoplankton populations to deep water enrichment.



2007 BLOOMER data

Questions

1. What are the mechanisms of deep water enrichment?
2. What (nutrients vs irradiance) control the initial slope of biomass increase, the maximal level of biomass accumulation, and the rate of biomass decline following the local bloom?
3. Which species are responding at different nutrients/irradiance levels
   - deep populations exposed to high irradiance levels?
   - shallow populations exposed to enriched nutrient levels?
   - nitrogen fixers exposed to enriched phosphorus/iron levels?
4. Can these incubations explain the local biogeography within the downwelling/upwelling eddies?

Approach

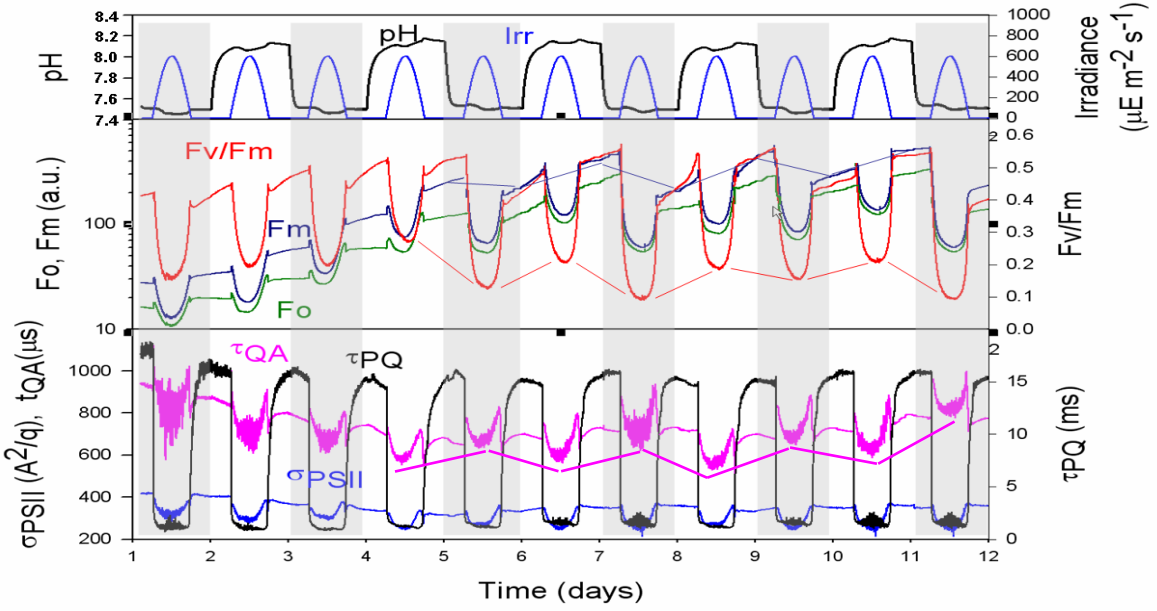
1. Perform deep water enrichment experiments at two different light levels (40% and 16% surface light).
2. Monitor photosynthetic properties twice a day (before dawn and after sunset).
3. Run three, 4-days long incubation experiments over the length of the cruise.
4. Following experiment termination, analyze the sample for
   - CHla and HPLC
   - fluorescence properties (FRRf)
   - particulate P, C, N, Si
   - LLN/LLP
   - dissolved nutrients (including Si)
   - DIC/DOC
   - pH
   - PP
   - oxygen
   - flow cytometry cell analysis

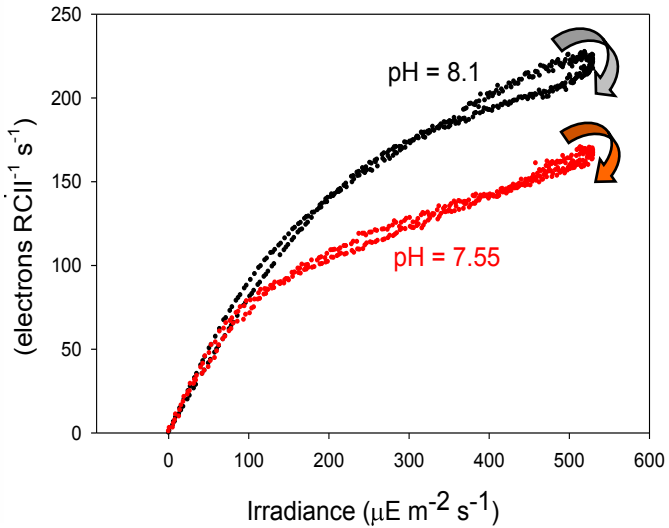
Other types of incubation experiments planned for OPERX cruise:

1. Effects on phosphorus addition on nitrogen fixation.
2. Effects of phosphonates on phosphorus utilization gene expression.
3. Dissolved Organic Carbon incubations.
4. Effects of pH shift on photosynthetic performance of phytoplankton.

4. Ship lab incubation experiments.

Laboratory experiment indicate phytoplankton responses to a variety of environmental factors such as temperature, nutrients, and pH level. To assess the responses of open ocean phytoplankton communities, we will carry these experiment during OPEREX cruise.





Questions

1. Ship lab incubations experiments: can they produce results that are representative of phytoplankton responses in their natural environment?
2. What kinds of lab incubation experiments are possible, what kinds are useful?
3. How these experiments compare with deck incubation experiments?

Approach

1. Operate two computer-controlled incubation chambers on OPEREX cruise
2. Perform short, 2-3 days long incubations on water samples from mixed depth layer.
3. Perform some of these experiments in parallel with deck incubations.