What is the ideal coastal mission?

Janet Campbell, Paul DiGiacomo, and Mary-Elena Carr

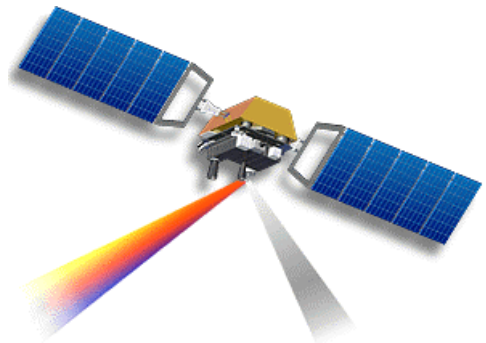
NASA Ocean Color Research Team Meeting

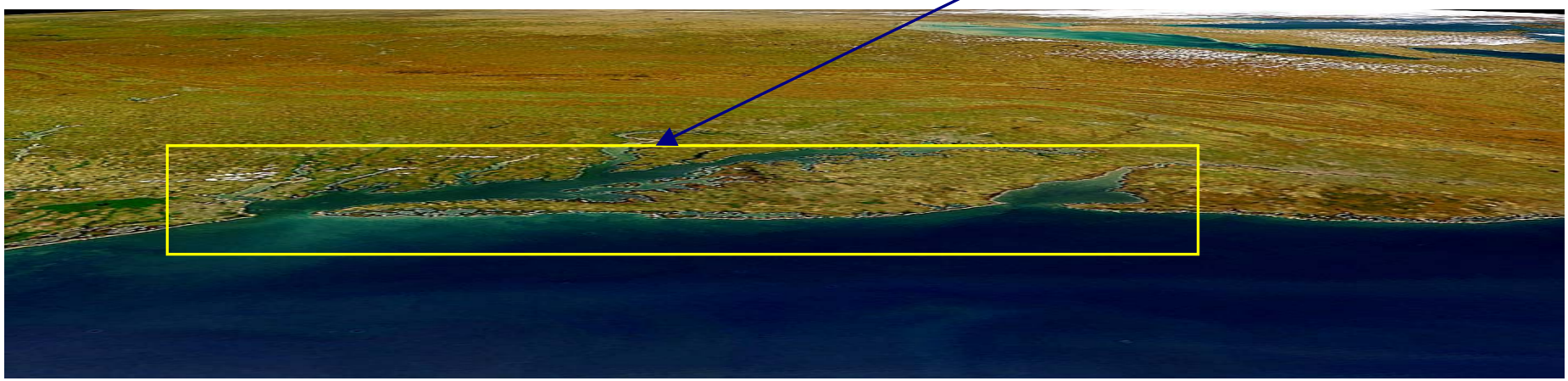
April 15, 2004

Coastal missions have been proposed in the past …

There was the Navy's Coastal Ocean Imaging Spectrometer (COIS) on NEMO …

- Hyperspectral imager (210 bands)
- Sun synchronous (LEO) orbit
- High (but variable) spatial resolution ~30-60 m
- Limited number of target sites

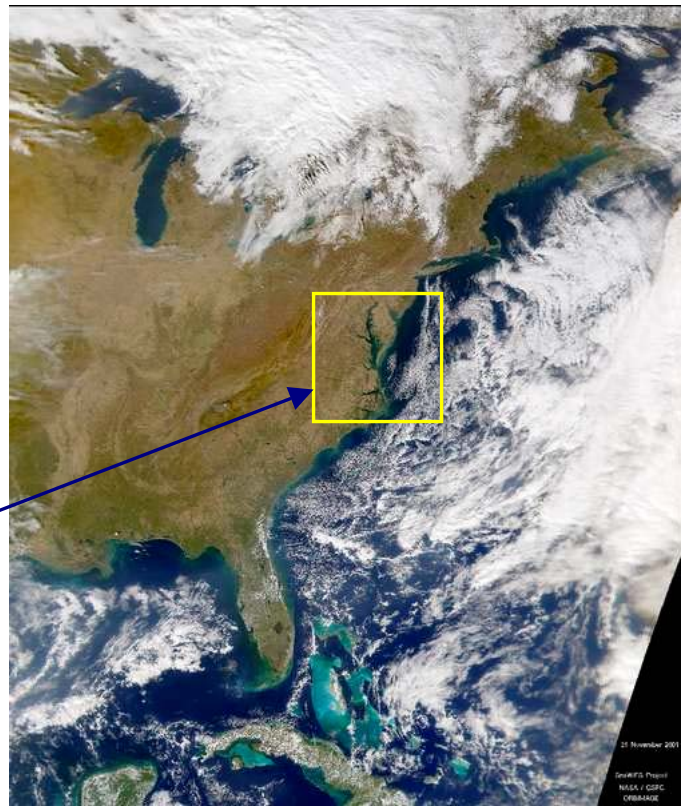




Coastal missions have been proposed in the past …

NASA and NOAA teamed up to propose a Special Events Imager (SEI) …

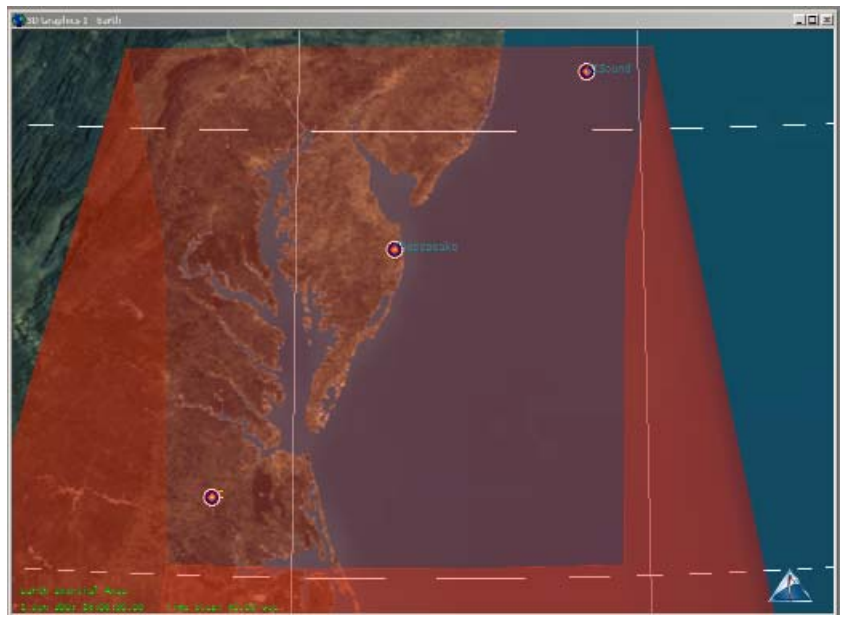
- Multispectral imager (10-12 bands)
- Geostationary (GEO) orbit
- Spatial resolution ~300 m
- Points to image targets of interest



300 km x 300 km
field of view

Yesterday we heard about the plans for the GOES R Hyperspectral Environmental Suite (HES):

- *400 km x 400 km viewing geometry with two modes:*
- *Survey – cover East /Gulf Coast EEZ within 1 to 3 hours & 300-m spatial resolution (at the Equator)*
- *Local – stare at a region of interest with 150- to 300-m spatial resolution (at Eq.)*



Is the ideal coastal mission

Hyperspectral? Geostationary? or both?

The case for Hyperspectral can be made based on:

- Optical complexity of coastal waters
- Bottom albedo as additional signal
- Heterogeneous aerosol properties
- Chlorophyll fluorescence as valuable signal
- Potential to differentiate algal functional groups

The case for Geostationary can be made based on:

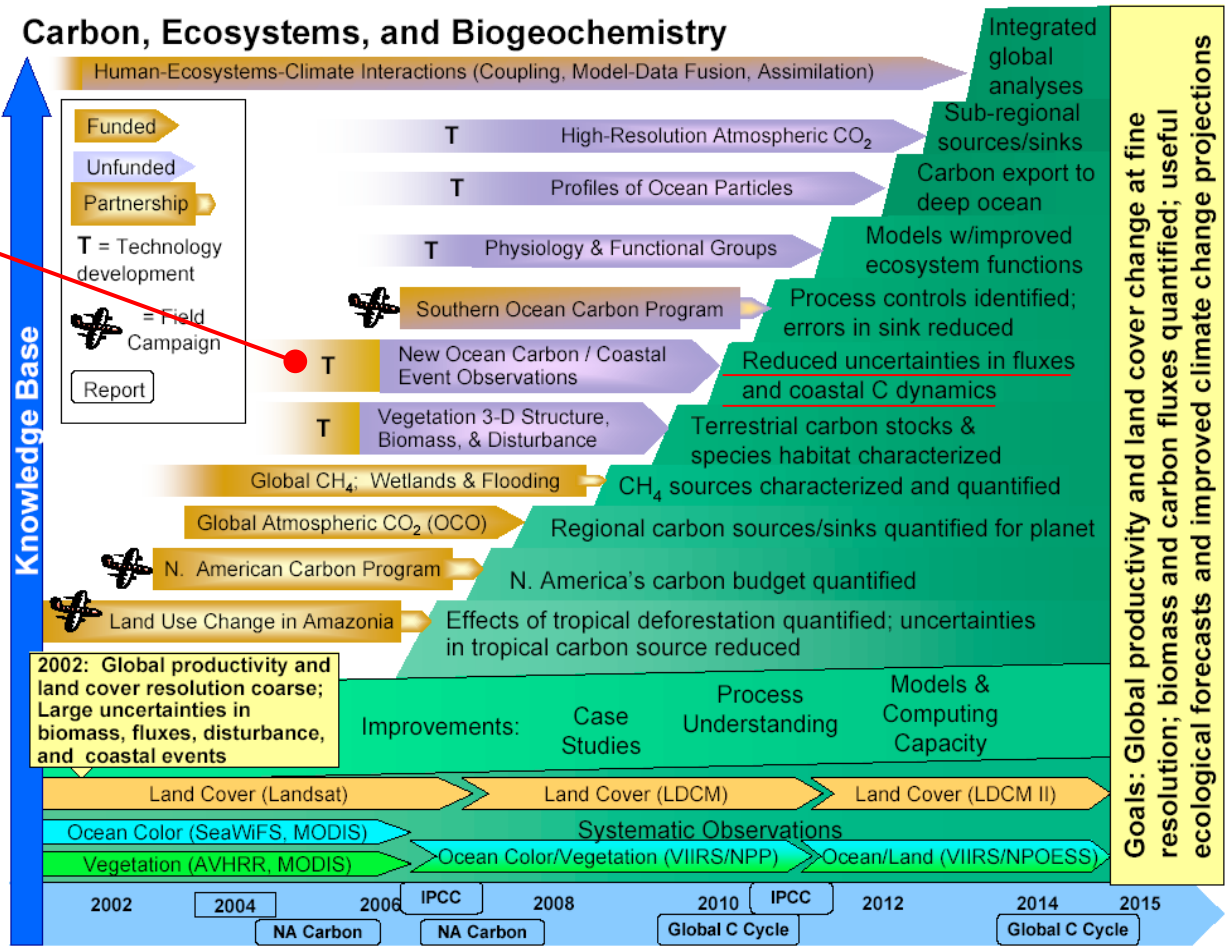
- Short time scales associated with coastal processes

"Development of hyperspectral, geostationary satellites capable of even higher resolution and more extensive use of both landbased and aircraft-borne sensors will be important for resolving nearshore dynamics."

NSF Coastal Observatories Research Arrays Report, Dec. 2003

The ESE roadmap for the Carbon, Ecosystems, and Biogeochemistry Theme includes …

a coastal **carbon** mission



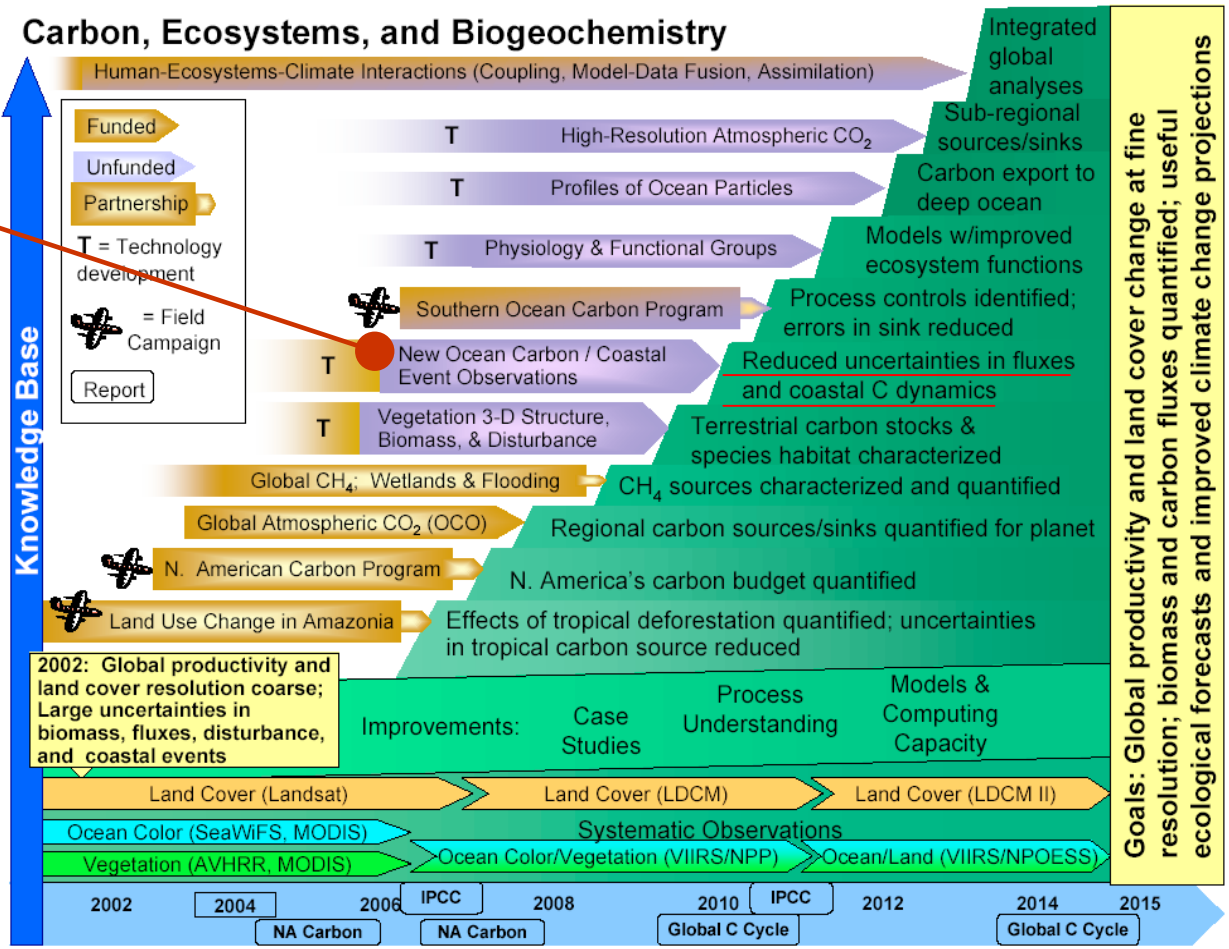
COCOA fits into the Code Y Carbon roadmap:

COCOA

COCOA is a mission concept that is being developed by JPL and a team of scientists

JPL Contributions:

- Science Team
- Instrument Provider
- Mission Management
- Mission Operations
- Science Data Processing
- Archive & Distribution



Coastal Ocean Carbon Observations and Applications (COCOA)

P.I. Janet Campbell (University of New Hampshire)

Carl F. Bruce Jr

Paul M. DiGiacomo

Mary-Elena Carr

Andrew Bingham

Lloyd French

Robert Green

Acknowledgements: We thank JPL and the Earth Science Directorate for their support in exploring this ESSP concept.

COCOA Mission & Science Objective:

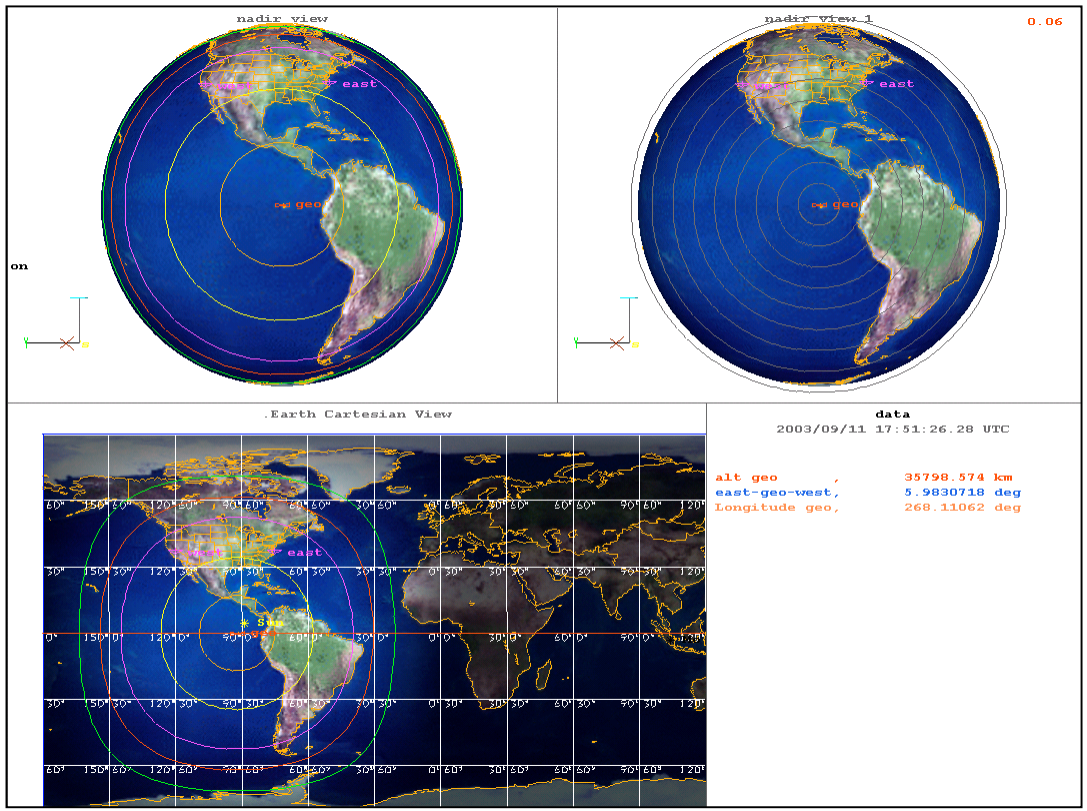
- COCOA is a geostationary coastal carbon mission to be proposed as an Earth System Science Pathfinder (ESSP) mission
- COCOA will quantify the carbon pools and pathways of the coastal ocean.
- By intensively focusing on North America, we can accurately quantify representative coastal processes that impact the *global* carbon cycle:

  - Eastern boundary current and coastal upwelling (California Current)
  - Western boundary current (Gulf Stream)
  - Major riverine inputs (Mississippi River)
  - Episodic features (hurricanes, harmful algal blooms)

The Science Team has been formed. We held a workshop at JPL in August 2003…

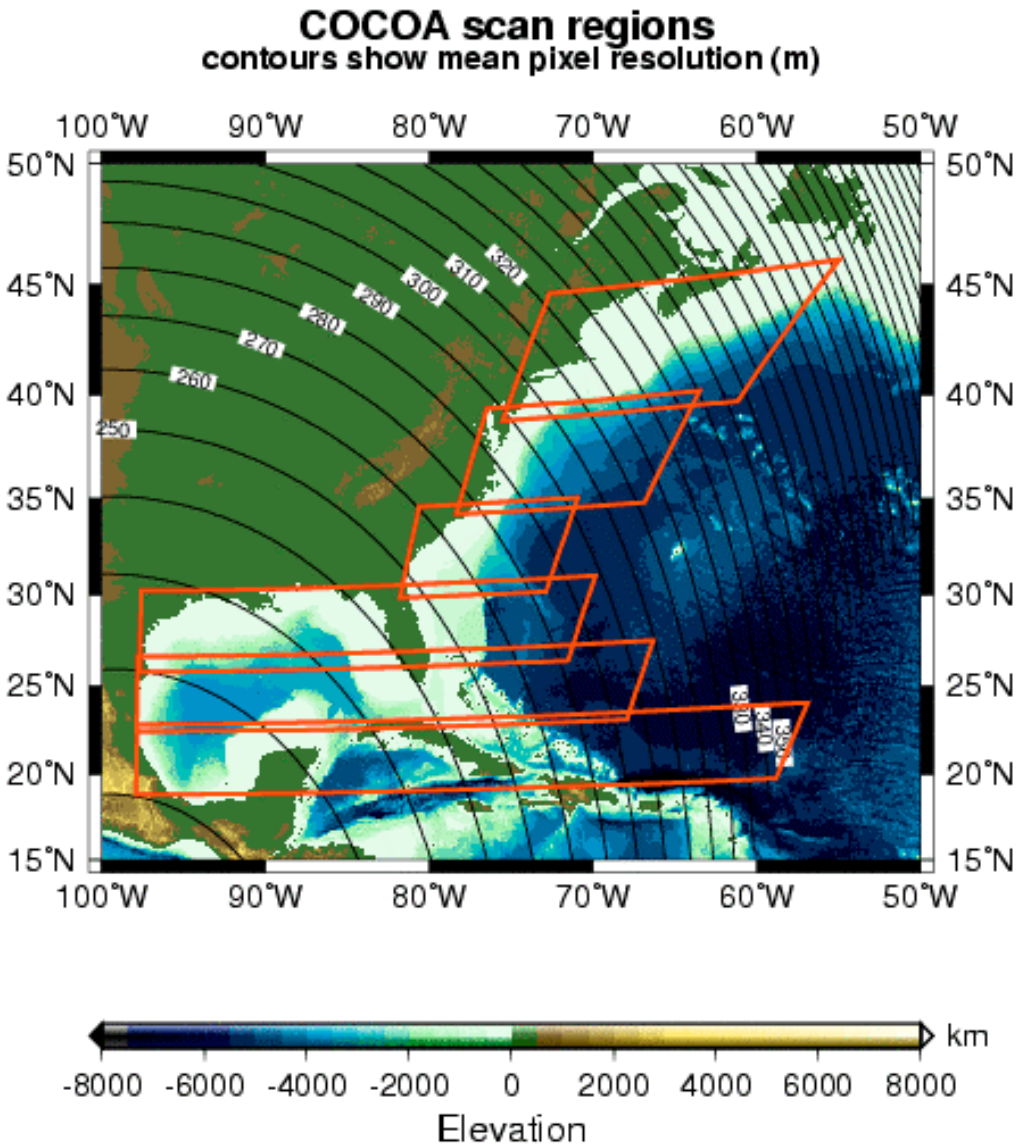
Janet Campbell, Professor and Team Leader, University of New Hampshire
Paul DiGiacomo, Scientist, Jet Propulsion Laboratory
Mary-Elena Carr, Research Scientist, Jet Propulsion Laboratory
Robert Green, AVIRIS Experiment Scientist, Jet Propulsion Laboratory
Robert Arnone, Head Ocean Sciences Branch, Naval Research Laboratory
Francisco Chavez, Senior Scientist, Monterey Bay Aquarium Research Institute
Mark Dowell, Research Professor, University of New Hampshire
Nicolas Gruber, Assistant Professor, University of California, Los Angeles
Chuanmin Hu, Research Professor, University of South Florida
Marlon Lewis, Professor, Dalhousie University and President, Satlantic Inc.
Stephane Maritorena, Research Professor, University of California, Santa Barbara
Curt Mobley, Vice President and Senior Scientist, Sequoia Scientific, Inc
Mark Moline, Assoc. Professor, California Polytechnic State University
John Ryan, Project Scientist, Monterey Bay Aquarium Research Institute
Dariusz Stramski, Professor, Scripps Institution of Oceanography, UCSD
Chuck Trees, Research Professor, San Diego Sate University
Kirk Waters, Program Officer, NOAA Coastal Services Center

Engineering teams at JPL conducted feasibility studies in summer of 2003:



Mission Description:

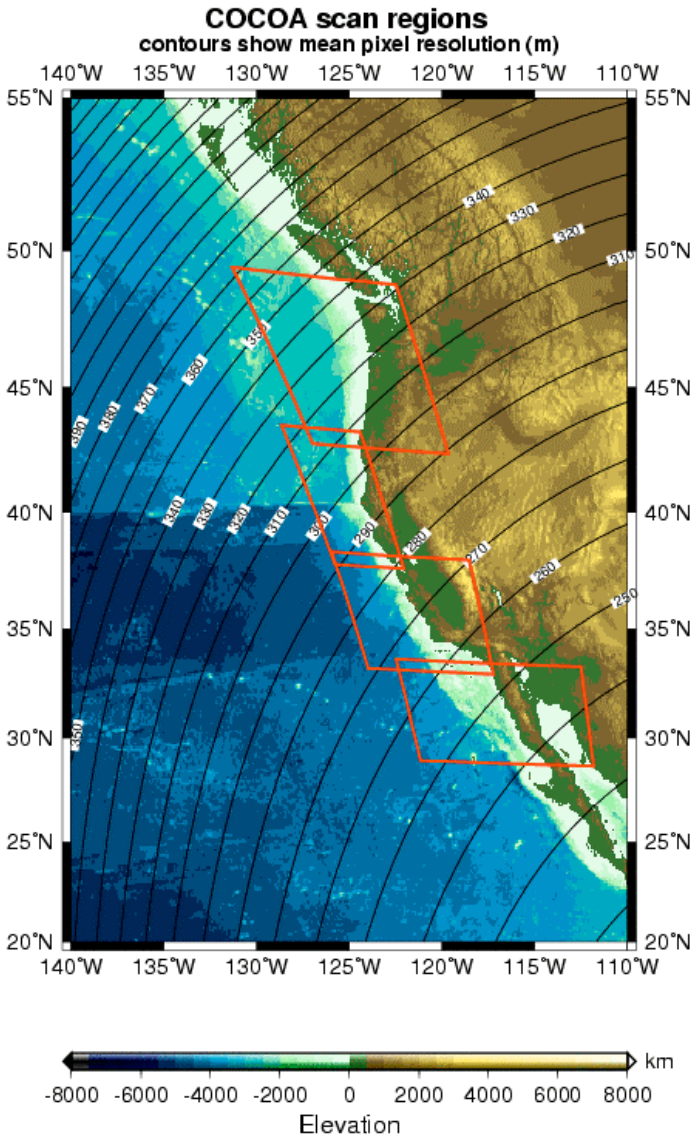
- Orbits
  - Numerous orbital configurations were studied: Geosynchronous with various inclinations, MEO, Elliptical – Molniya, GTO, LEO
  - We selected the **geostationary** orbit at 100° - 90° West longitude because it provided the greatest amount of annual revisit time for the coastal U.S.



• Six scans are required to image the entire U.S. East and Gulf coast.

• The scan regions illustrated here cover a zone 200 km from the coast line. This region includes the continental shelf and beyond.

• The mean pixel resolution over the Gulf of Mexico is less than 250 m. In the north-east it exceeds 300 m.



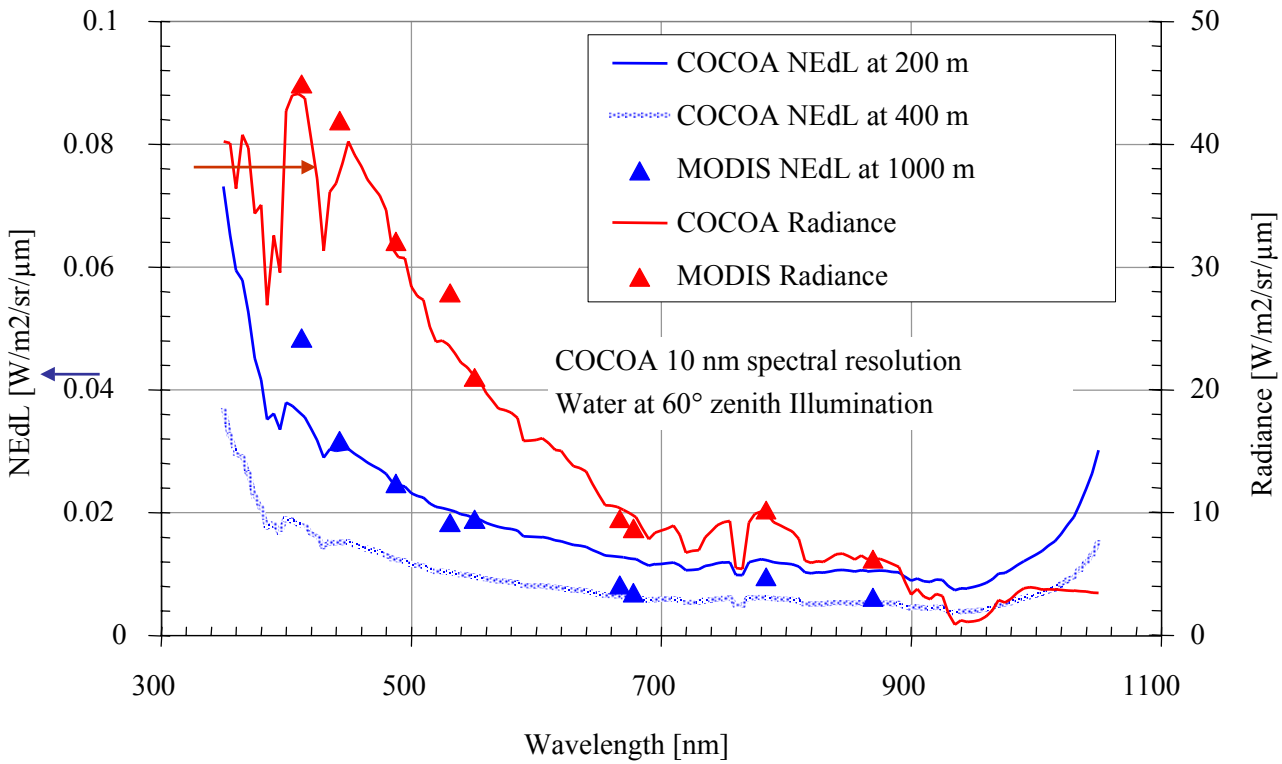
- Four scans are required to image the key coastal zones of the eastern Pacific as defined by the COCOA Science Team.

- The scan regions illustrated here covers a zone 100 km. This region includes the continental shelf and beyond.

- The mean pixel resolution ranges from 260 m in Los Angeles to 320 m in Seattle.

COCOA will employ spectroscopy (hyperspectral imager)

- Instrument Sensitivity
  - End to End instrument performance is modeled.
  - COCOA leverages integration time to obtain more sensitivity than MODIS at smaller spatial scales.



Mission Description:

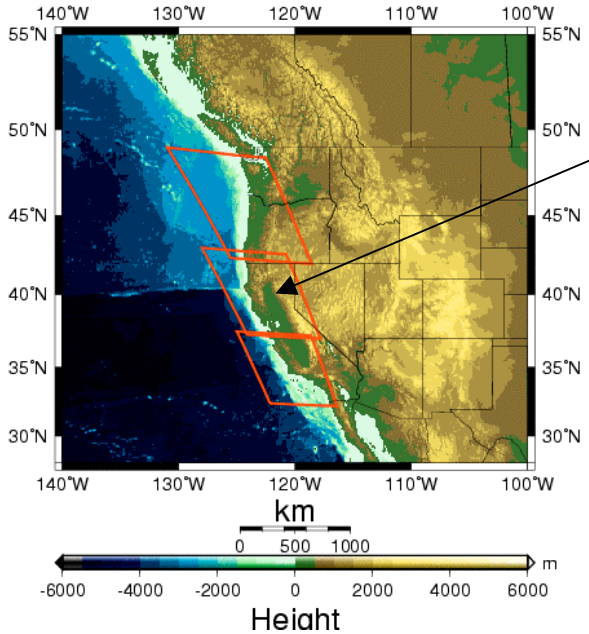
- Spacecraft Scanning

COCOA will have two modes of operation. In synoptic mode the entire U.S. coastal zone will be imaged 4-6 times per day. The Experimental & Event mode will be used to intensively image regions during the science experiments outlined earlier or during significant events identified by the Science Team and/or Partners.

Mode	Maximum number of scans	Total scan time	Total volume	Maximum number of opportunities
Synoptic	**10**	**2-3 hours**	**~30 GBytes**	**≤ 6**
Experimental & Event	**1**	**10-15 min**	**~2 GBytes**	**>20**

Focused Experiments

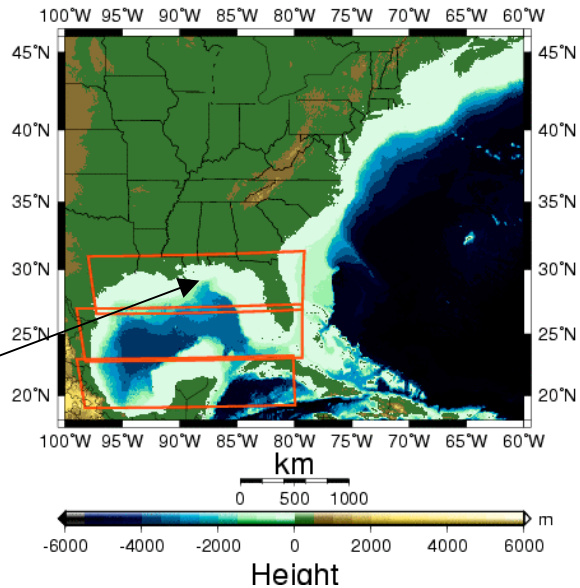
Harmful algal blooms

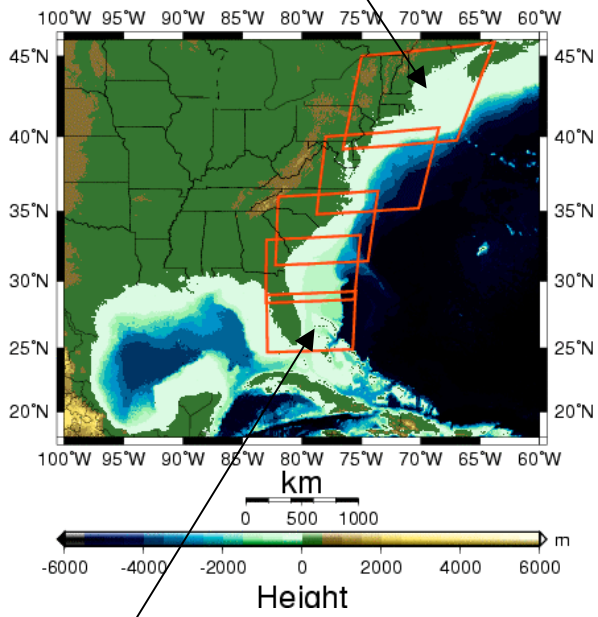


Upwelling systems

West Coast

Gulf of Mexico





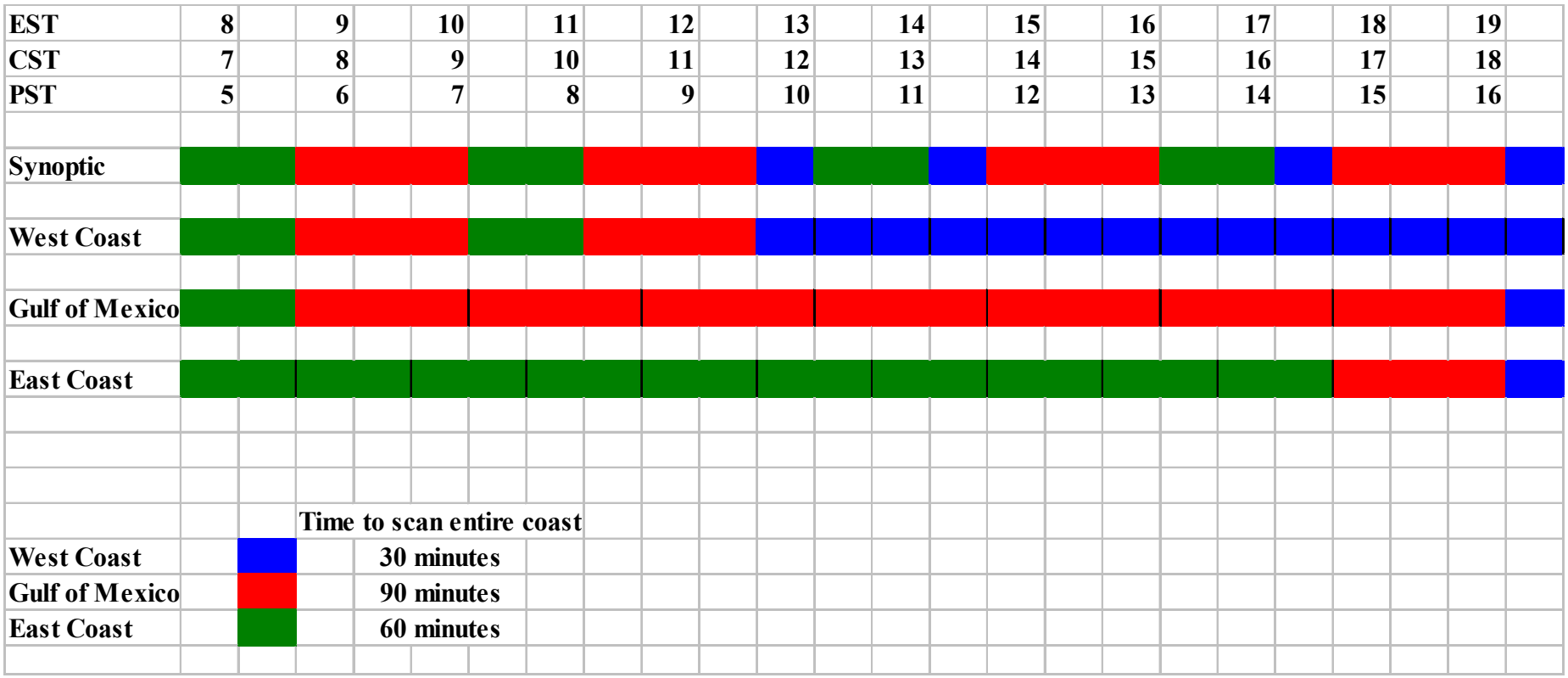
East Coast

Riverine fluxes

Hurricanes and other storm events

Sampling scenarios. The Synoptic Mode provides 4 looks per day of each coast.

The three “coastal” modes were created for experiments when one coast would be sampled more frequently for a period of time (e.g., continuously for a month during a focused experiment) or to capture an “event”.



For each region, we will demonstrate how the hyperspectral observations made several times per day, together with ancillary information and models, will be used to quantify the pools and pathways of carbon in the coastal ocean. In this ESSP mission, we will demonstrate this for selected regions …

Ancillary Information:

- Data from other satellites (SST, PAR, winds, salinity)
- *In situ d*ata from moorings, HF radar, and other assets provided by the IOOS and ORION (aerosols, temperature profiles, currents, nutrients, …)
- Bathymetry and bottom albedo
- Hydrology (river discharge, rainfall, …)
- Tides and sea-level

COCOA observes carbon pools at times t_1, t_2, … throughout the day.

Derived variables (pools):

POC: phytoplankton biomass and detritus

PIC: calcite, inorganic sediment

DOC: region-specific relationship with CDOM

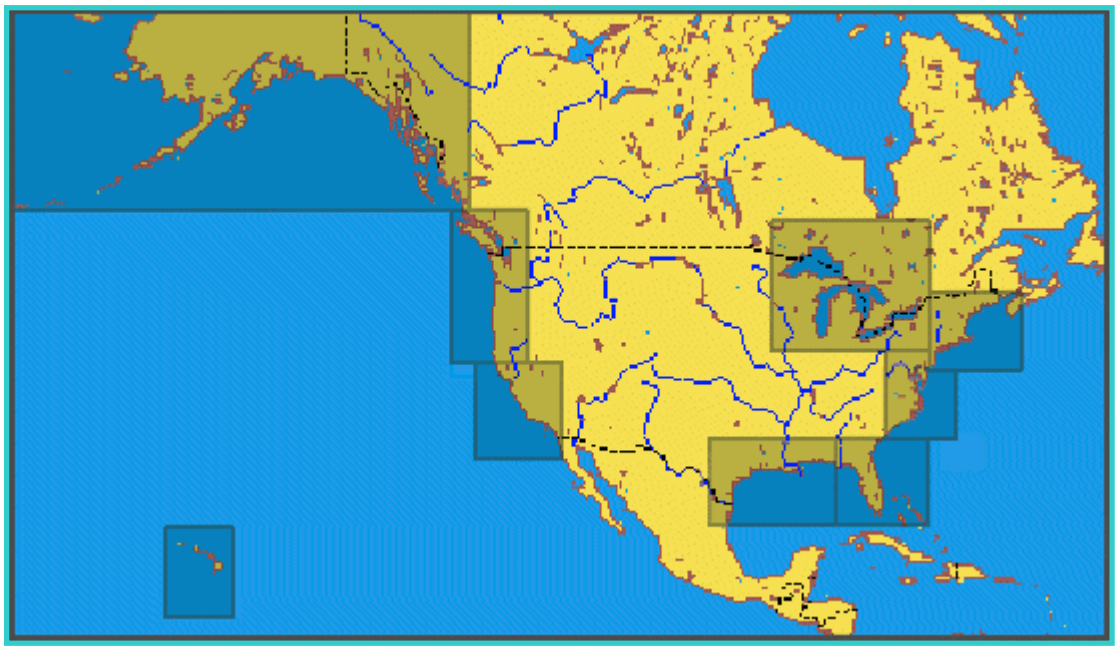
DIC: surface ocean pCO2, carbonate and bicarbonate

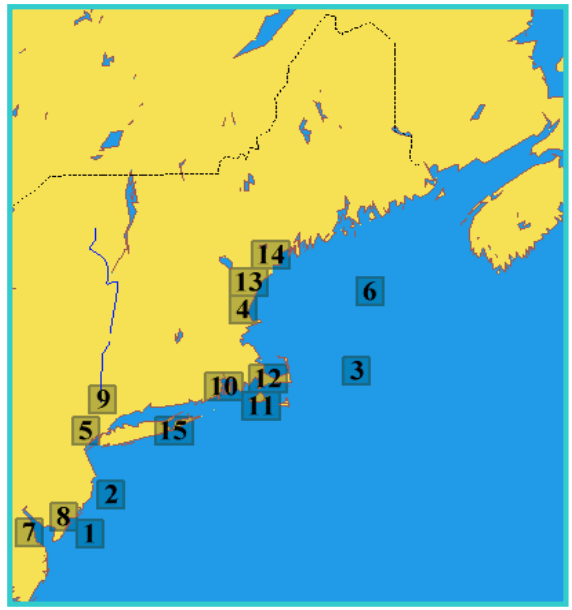
Models: System of models in which the regional carbon-cycle model is nested within a basin-scale ocean and atmospheric circulation model. Within the region, carbon cycle model includes the effects of the physical circulation, biology and biogeochemistry.

Observed rates of change will be modeled as sum of *in situ* production, losses, and changes due to advection: $dC_x/dt = P - L + \text{horizontal} + \text{vertical}$

Regional consortia will be part of the National IOOS….

U.S. Coastal Observing Systems



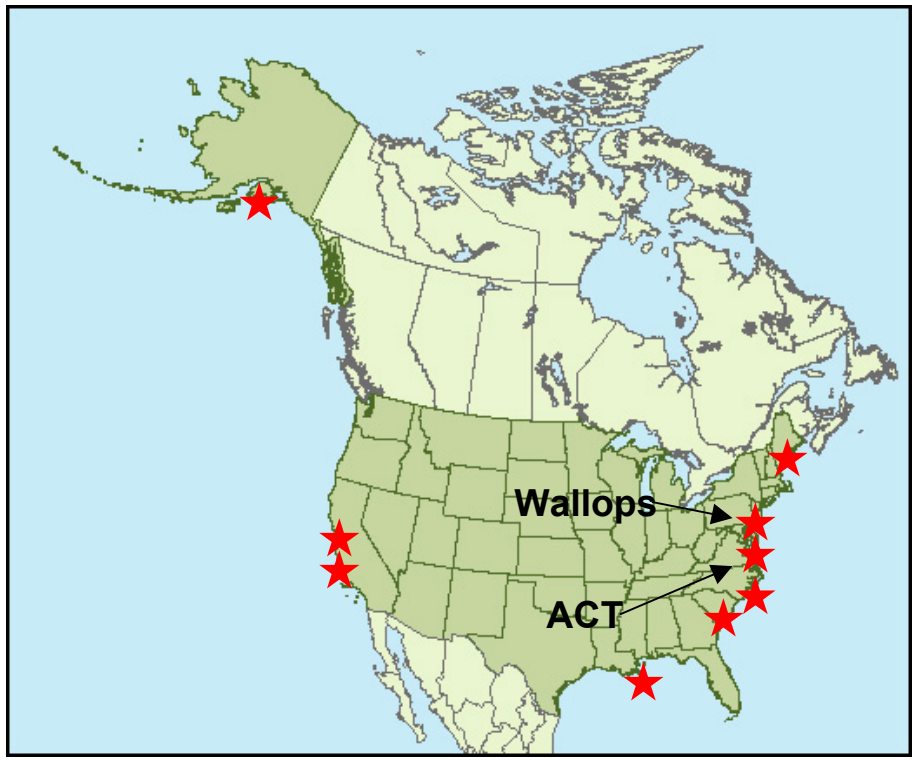


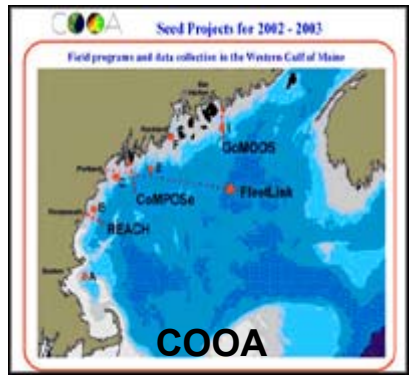
1 - Coastal Ocean Observation Laboratory
2 - New Jersey Coastal Monitoring Network
3 - National Data Buoy Center Moored Buoys and C-MAN Stations | 4 - National Water Level Observation Network | 5 - Physical Oceanographic Real-Time System | 6 - Gulf of Maine Ocean Observing System | 7 - Delaware NERR | 8 - Jacques Cousteau NERR | 9 - Hudson River NERR | 10 - Narragansett Bay NERR | 11 - Martha's Vineyard Coastal Observatory | 12 - Waquoit Bay NERR | 13 - Great Bay NERR | 14 - Wells NERR | 15 - US Army Corps of Engineers Wave Data Sites

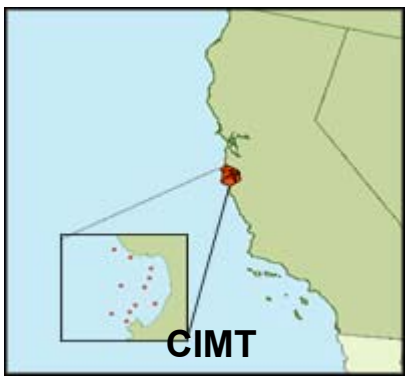
http://www.csc.noaa.gov/coos/

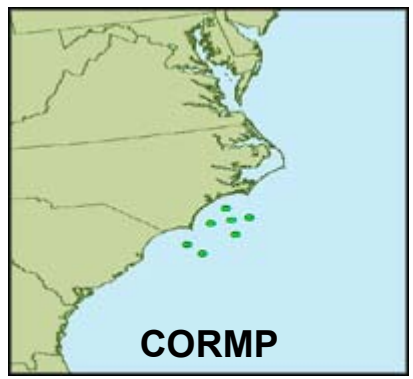
Coastal Observation Technology System

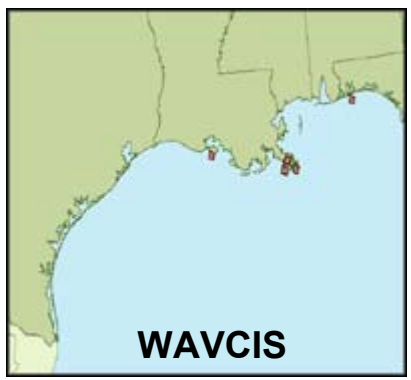
Alliance of 9 coastal organizations developing observing systems



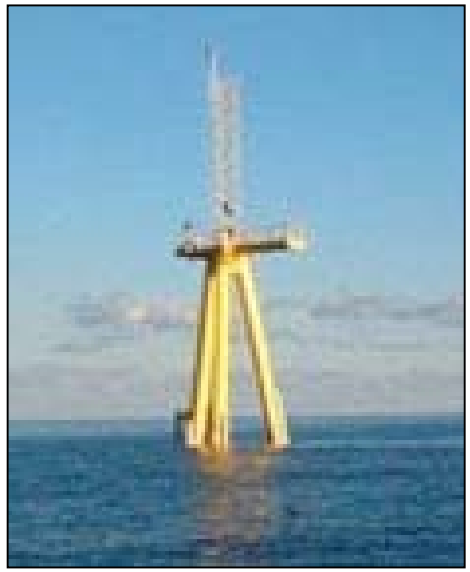




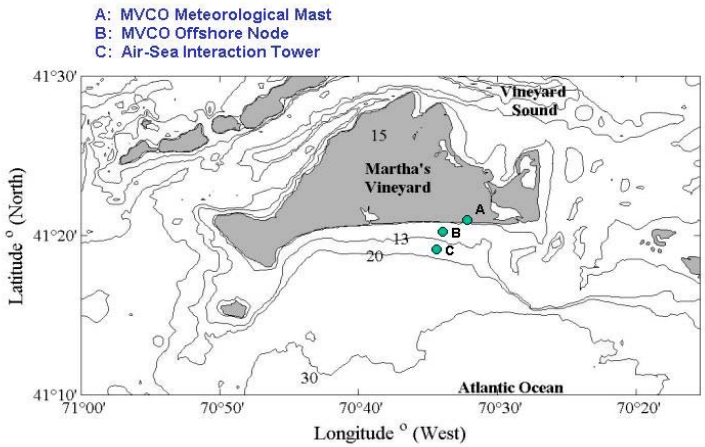




Coastal Carbon: Resolving Fluxes in Time and Space



The objective is to develop a coastal carbon time-series (CCTS) measurement program off coastal New England.



This work involves collaboration between UNH and Woods Hole Oceanographic Institution (WHOI) at the Martha's Vineyard Coastal Observatory (MVCO) to 1) determine the rates and magnitude of biological influence on CO2 gas flux at the air-sea interface, 2) address the effective uses of ocean color satellite data for coastal CO2 flux inversion from space, and 3) assess the overall importance of coastal monitoring of the carbonate system within a climate observation context.

Co-Investigators: Wade McGillis (LDEO), Doug Vandemark (NASA), Scott Gallagher (WHOI), Joe Salisbury (UNH), and Ru Morrison (UNH)

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