Primary Production:

can we get there from
ocean optics and remote sensing?

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Participation in Observing-related Activities

- Participant in Ocean.US workshop, March 2002, that lead to report on “Building Consensus: Toward an Integrated and Sustained Ocean Observing System”
- National Science Foundation Advisory Committee on GeoSciences, 2000 - 2002
- National Science Foundation Advisory Committee on Environmental Research and Education (and chaired task group on sensors and observing systems), 2000 - 2002
- Co-chair ALPS workshop, April 2003, sponsored by NSF and ONR, on autonomous observing systems
- Participant WHOI workshop on Next Generation of Biological and Chemical Sensors, July 2003

Goal of NEOS, RARGOM, GOMOOS:

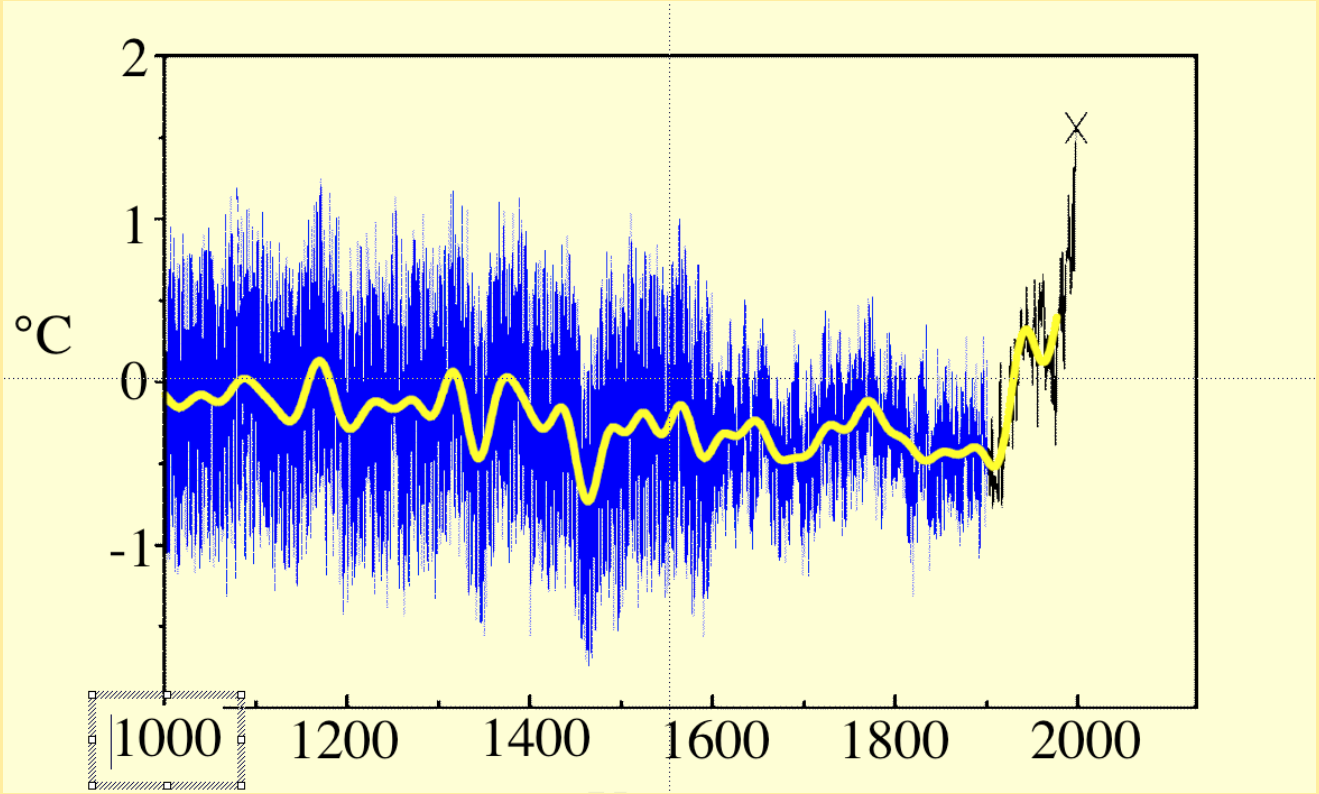
Continued development toward a sustained Ocean Observing System for Gulf of Maine

Charge today:

- What is the present status of long-term observations ?
- What we aren't measuring that we should be ?
- What are the gaps, opportunities, and links among researchers and institutions ?

Underlying Question:

how will changes in ocean temperature, circulation, and other physics affect primary productivity?



Northern Hemisphere Average Surface Temperature

From J. Runge'sRargom talk; plot from Mann et al. (1999) GRL 26:759-762

Fundamental question:

What do we want?

Biomass, P, from optics (satellites and moorings)

or

Rate of change, growth parameters, photosynthesis

What was the historical status of long-term observations of phytoplankton and primary productivity in the GOM?

Historical observations:

- ship-based
- individual investigator or multi-PI coordinated programs
- **not sustained**

What is the present status of long-term observations of phytoplankton and primary productivity in the GOM?

Current status:

- ship-based, individual or multi-PI programs
- GOMOOS
  - * **satellite remote sensing of ocean color, etc.**
  - * **optical moorings**
- regional interest in moving toward sustained, long-term observations

GOMOOS satellite remote sensing

Andrew Thomas, University of Maine

Ocean color *

NASA's SeaWiFS (Sea-viewing Wide Field of View Sensor)
Near-surface phytoplankton biomass
Cloud-free conditions
Spatial resolution: 1.1 km
Frequency of images: ~ every other day; composites

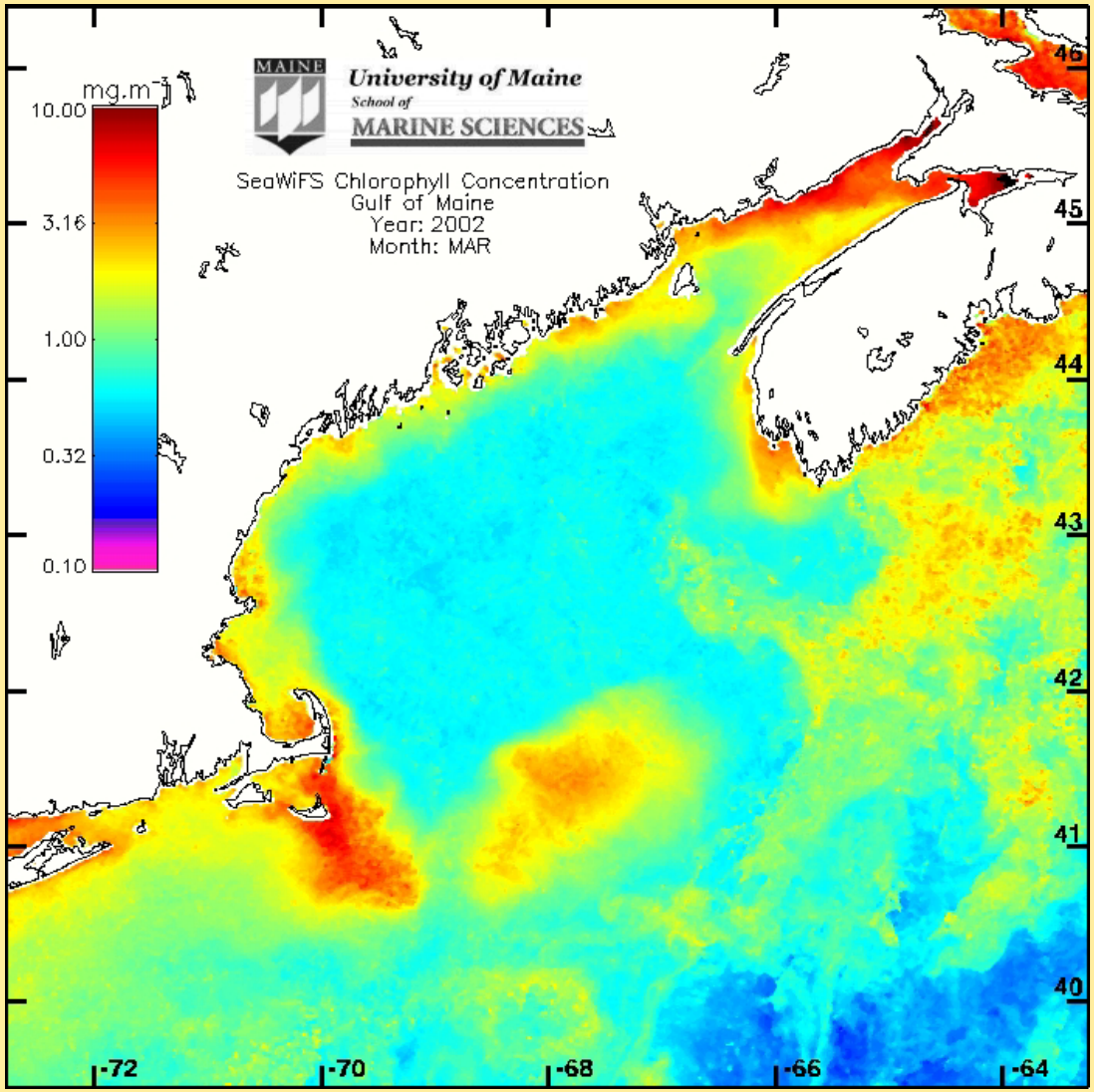
Sea surface temperature *

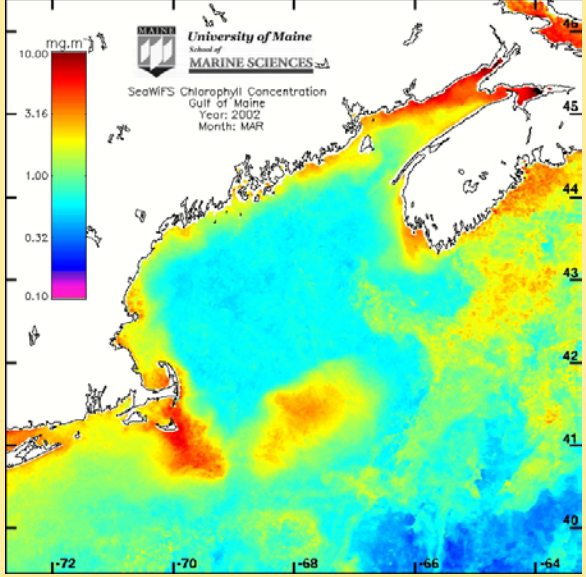
NOAA's AVHRR (Advanced Very High Resolution Radiometer)
Ocean surface temperatures
Cloud-free conditions
Spatial resolution: 1.1 km
Frequency of images: 4-6 per day

Winds

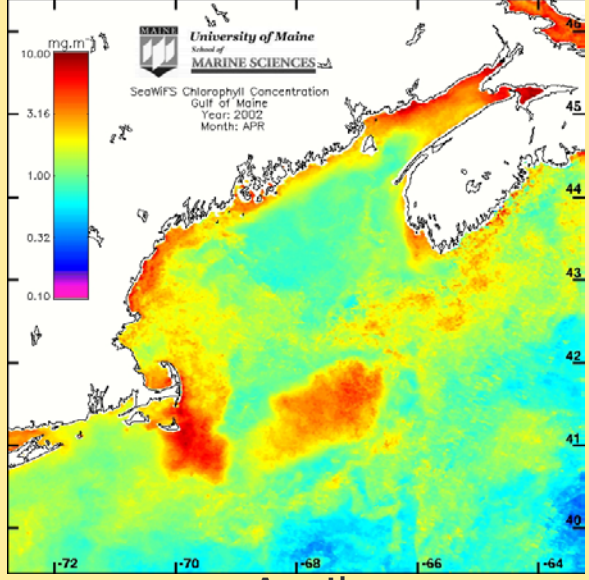
NASA's SeaWinds on QuikSCAT satellite
Speed and direction of near-surface winds
All weather conditions.
Spatial resolution: 0.25 degree
Coverage Frequency: twice a day

Ocean color from SeaWiFS





March



April

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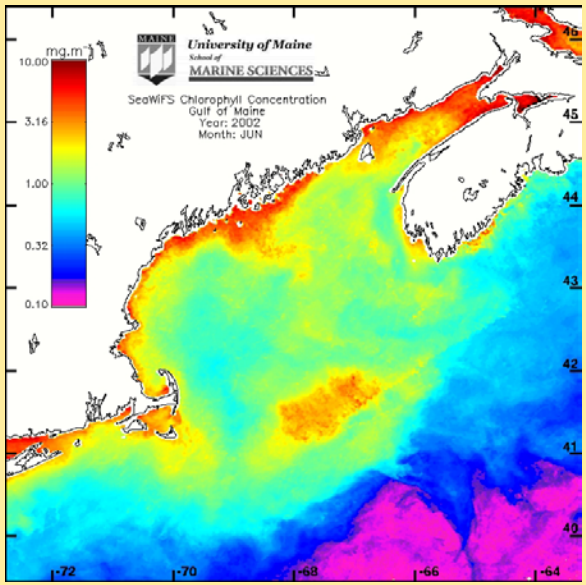
May



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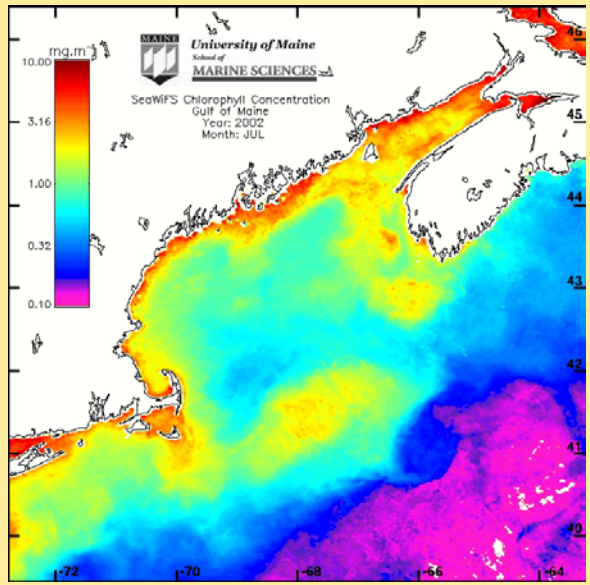
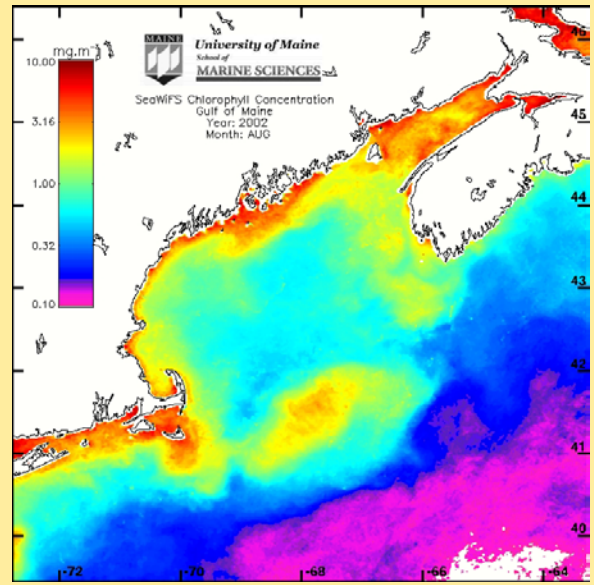
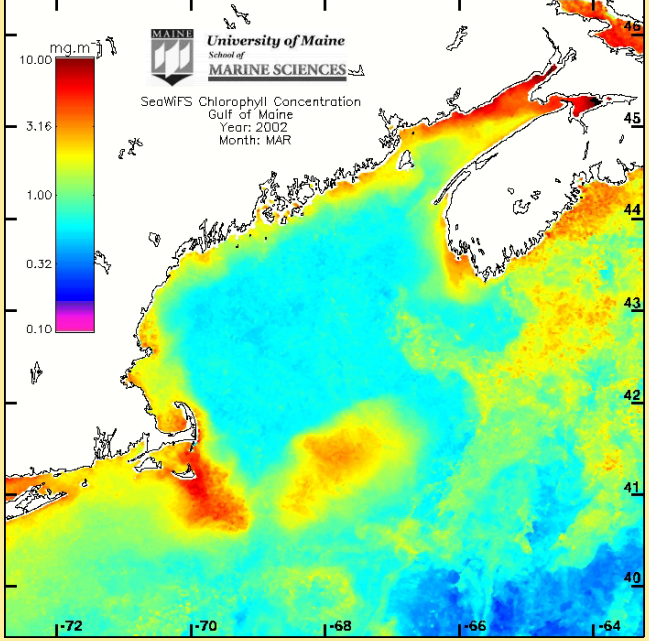


July



August

2002 SeaWiFS monthly composites



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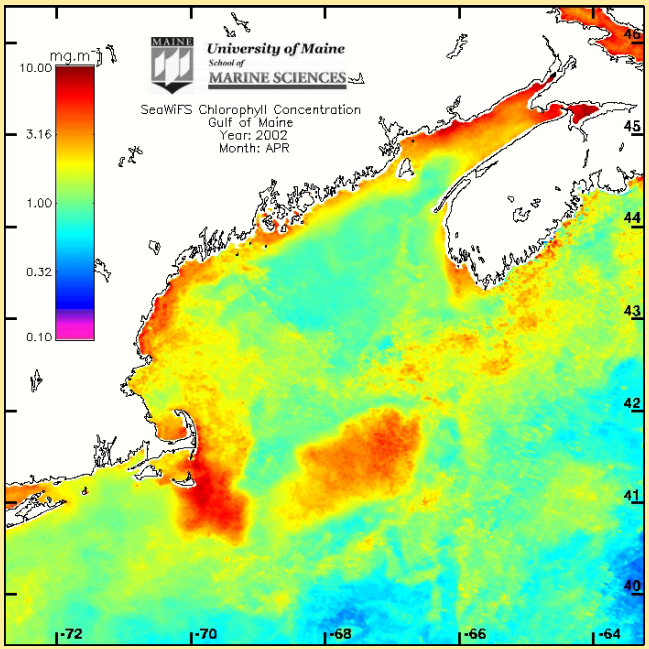

April

QuickTime™ and a TIFF (Uncompressed) decompressor are needed to see this picture.

2002

Phytoplankton Pigment

2003

QuickTime™ and a TIFF (Uncompressed) decompressor are needed to see this picture.

March

QuickTime™ and a TIFF (Uncompressed) decompressor are needed to see this picture.

QuickTime™ and a TIFF (Uncompressed) decompressor are needed to see this picture.

April

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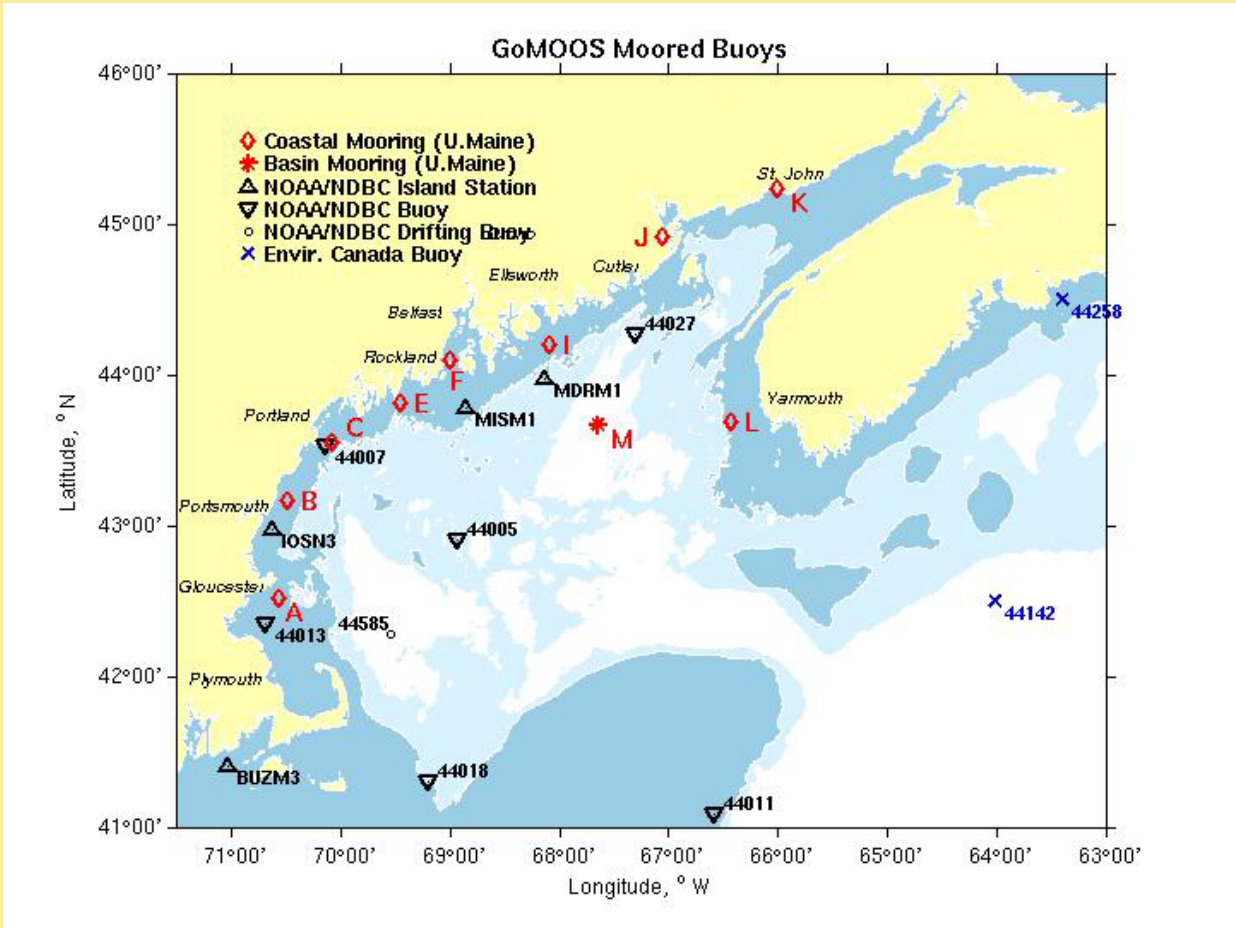
2002 **Sea Surface Temperature** 2003

GOMOOS Optical Moorings

Collin Roesler, Bigelow Labs



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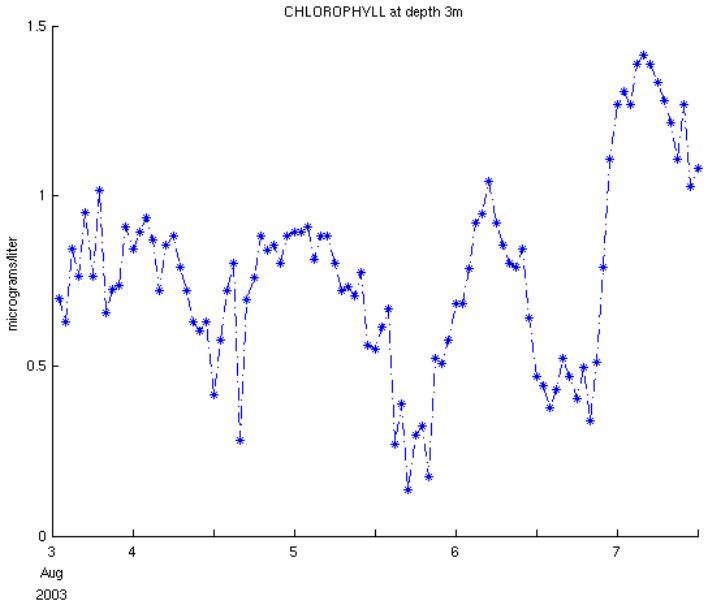
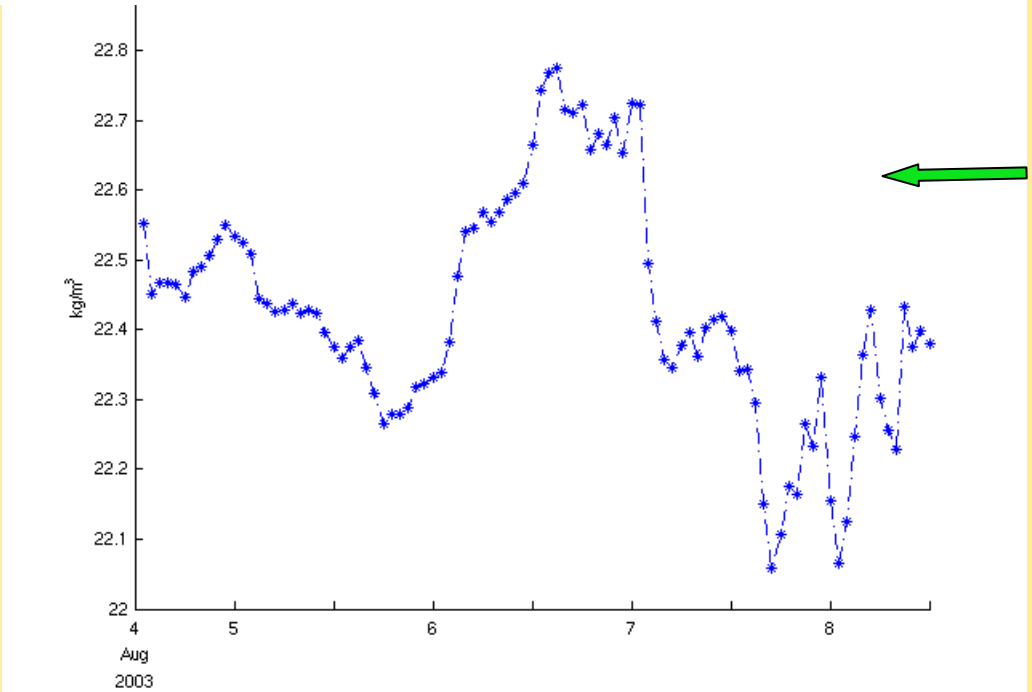
optics at B

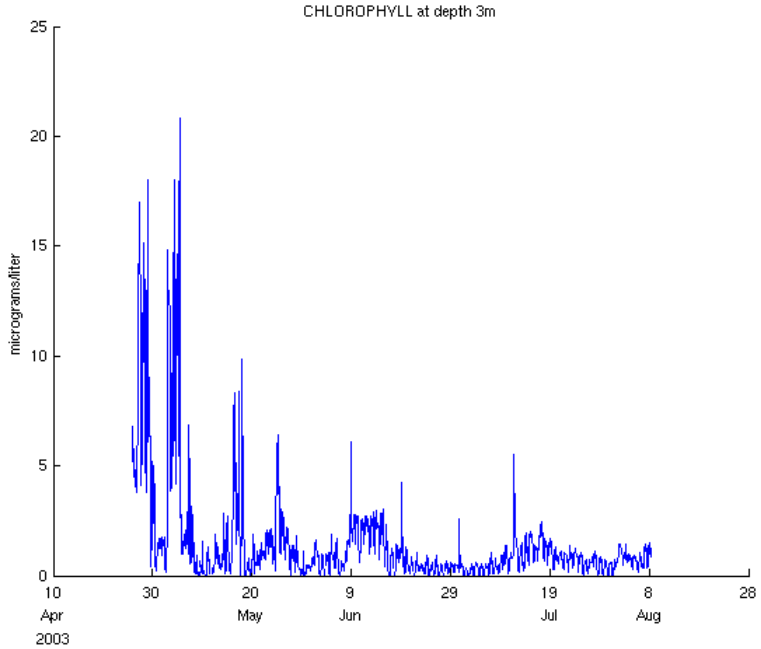


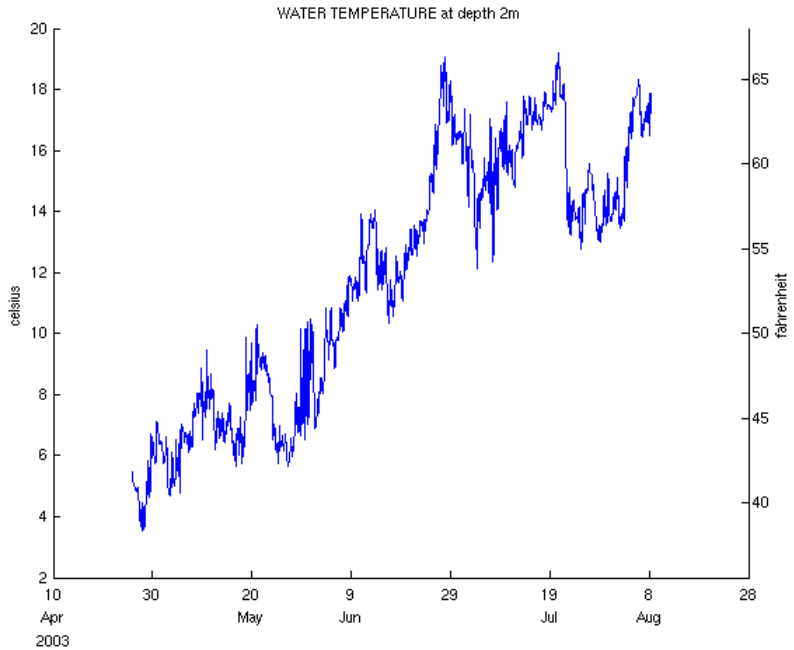


Buoy B,
August 2003

← Chlorophyll, 3 m

← Temperature, 2m



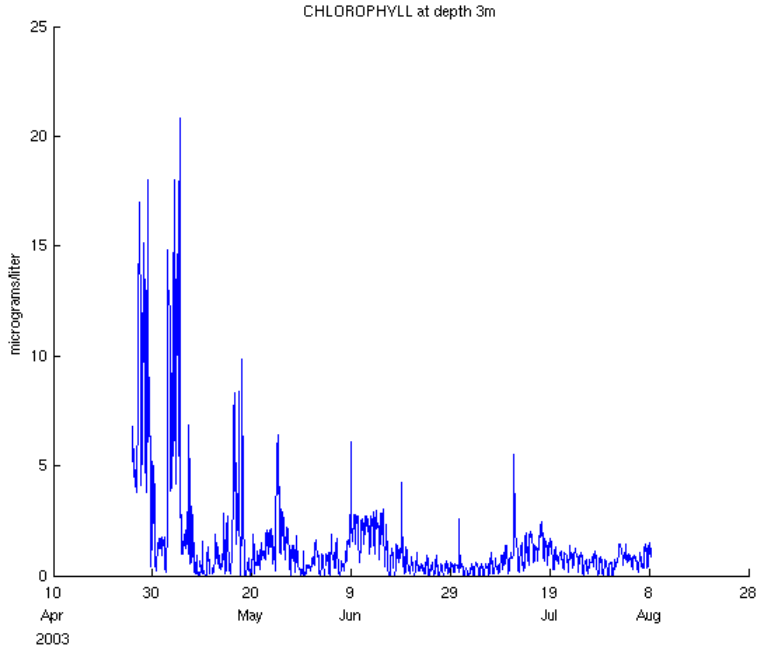


Buoy B, 2003 record

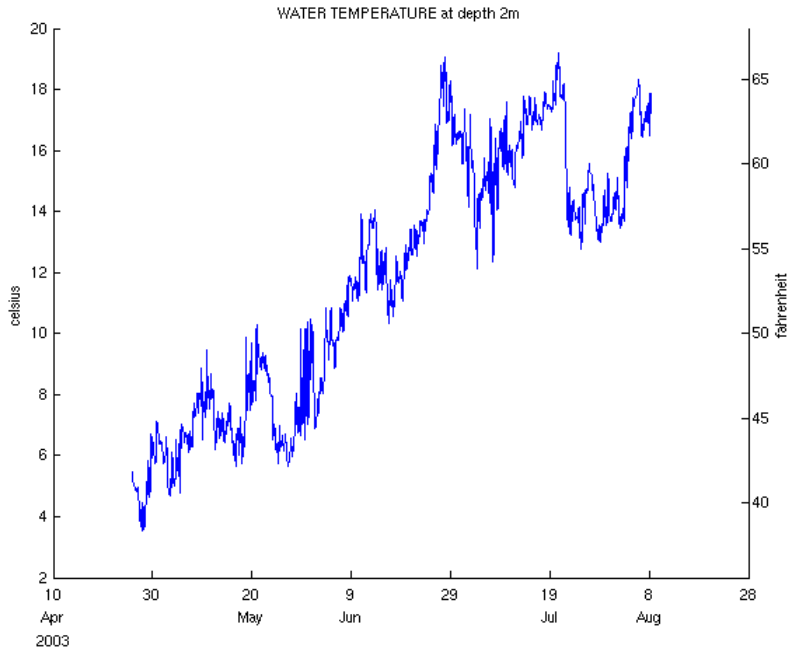
Chlorophyll, 3 m

Temperature, 2m

Buoy B, 2003 record

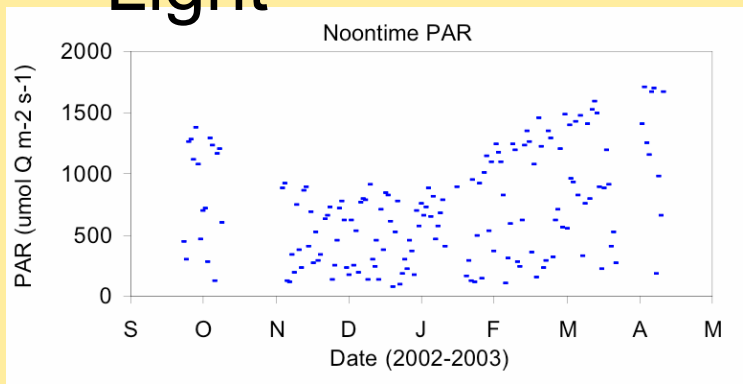


Chlorophyll, 3 m



Temperature, 2m

Light



What's missing?

Satellites:

MODIS and other ocean color images

-- more coverage of satellite biomass

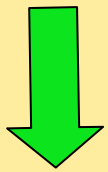
sea surface temperature through clouds (microwave)

-- more information on forcing

altimetry ?

Moorings:

optics and nutrients on all moorings w/ synoptic physics



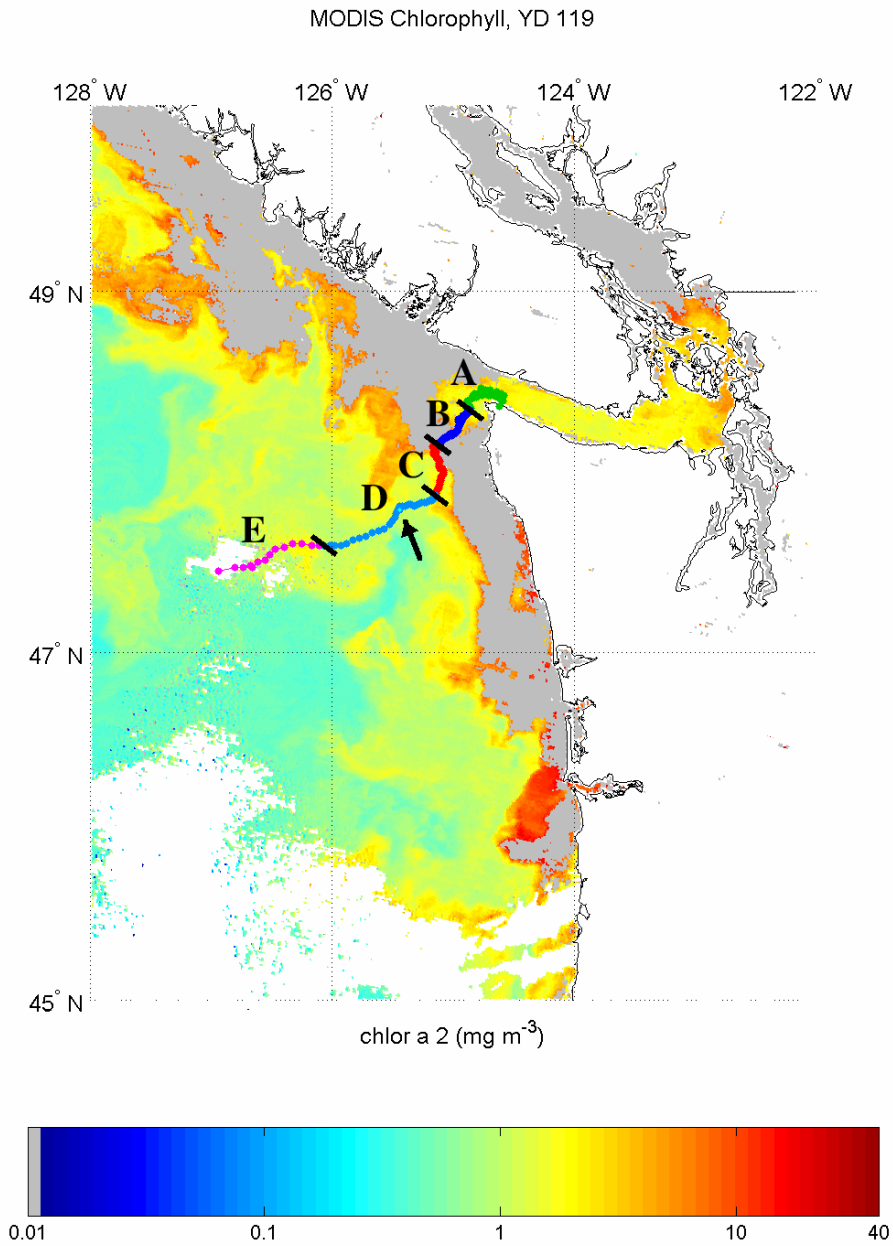
Rationale: better coverage of biomass and physical forcings

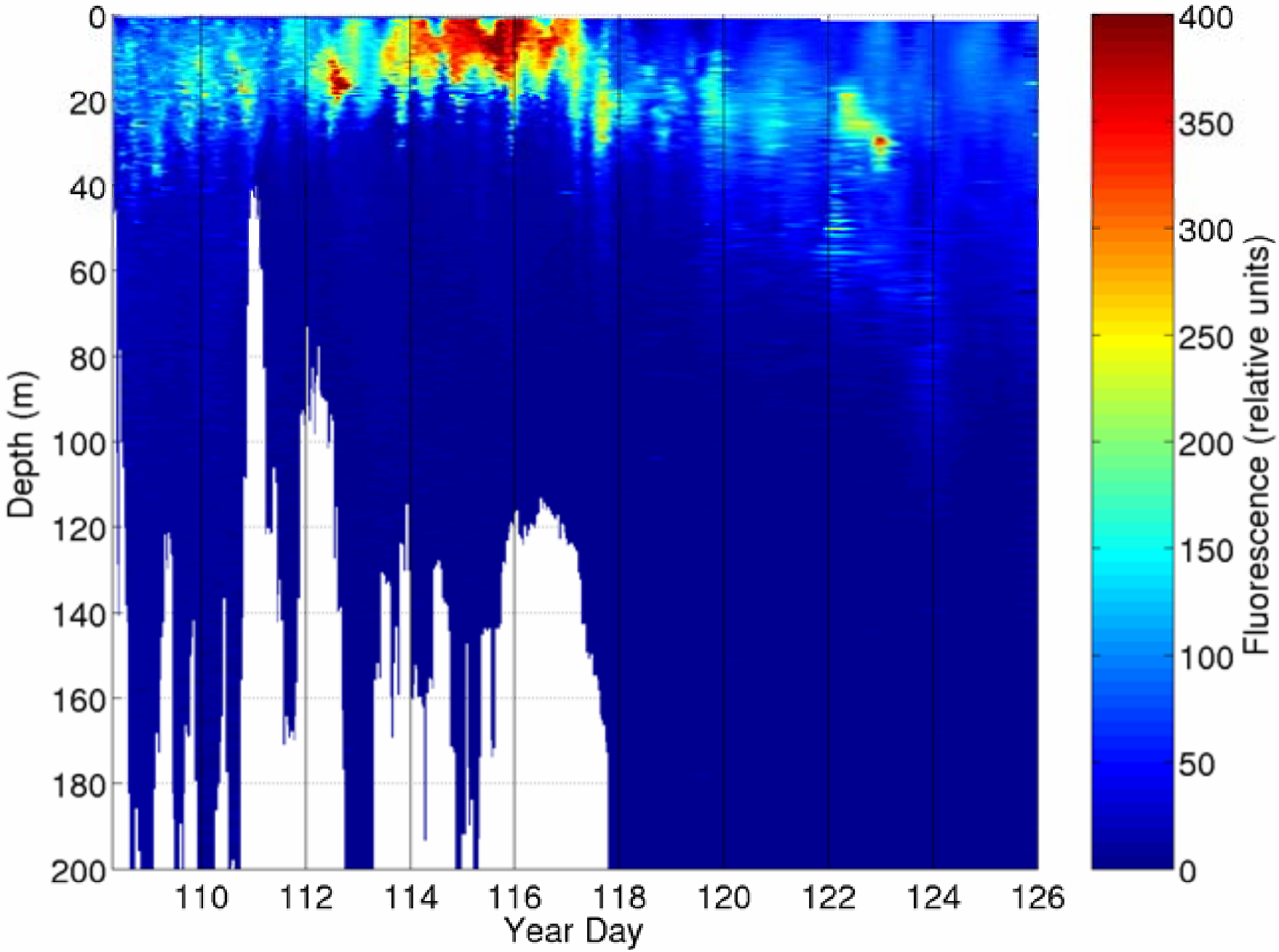
What's still missing?

Satellites and Moorings:

pretty good coverage of biomass

Still lack spatial interpolation and depth


MODIS Chlorophyll, YD 119
128° W
126° W
124° W
122° W
49° N
47° N
45° N
A
B
C
D
E
chlor a 2 (mg m-3)
0.01
0.1
1
10
40


Fluorescence, Washington Coast April-May 2002
Depth (m)
0
20
40
60
80
100
120
140
160
180
200
110
112
114
116
118
120
122
124
126
Year Day
400
350
300
250
200
150
100
50
0
Fluorescence (relative units)

What's still missing?

Satellites and Moorings:

pretty good coverage of biomass

AUVs:

better spatial and depth

Rate parameters for dP/dt:

$$dP = P\ (\text{gain} - \text{loss}) / dt$$

P from optics (satellites and moorings)

gain from photosynthesis and growth

loss from grazing or sinking

NB: advection ignored here for simplicity

Need physiological parameters

Primary production

$PS = a * E * \Phi$

where

- PS = primary production
- a = absorption (~ from phytoplankton biomass)
- E = irradiance
- Φ = **quantum efficiency (moles photons absorbed to moles carbon)**

Loss

Mortality from grazing

Need physiological parameters

How to get them?

Systematic ship-based programs to build up a library of physiological parameters.

Species - still can’t get them from space

Recommendations

- Cooperation - divide the work & conquer
- Analysis of uncertainty - what areas and where need more observing resources
- AUVs for spatial and depth
- Ship surveys for physiological parameters (photosynthesis and grazing)
- Fishing fleet - like Sea Keepers