The View from the COOLroom

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Coastal Ocean Observation Lab (COOL)

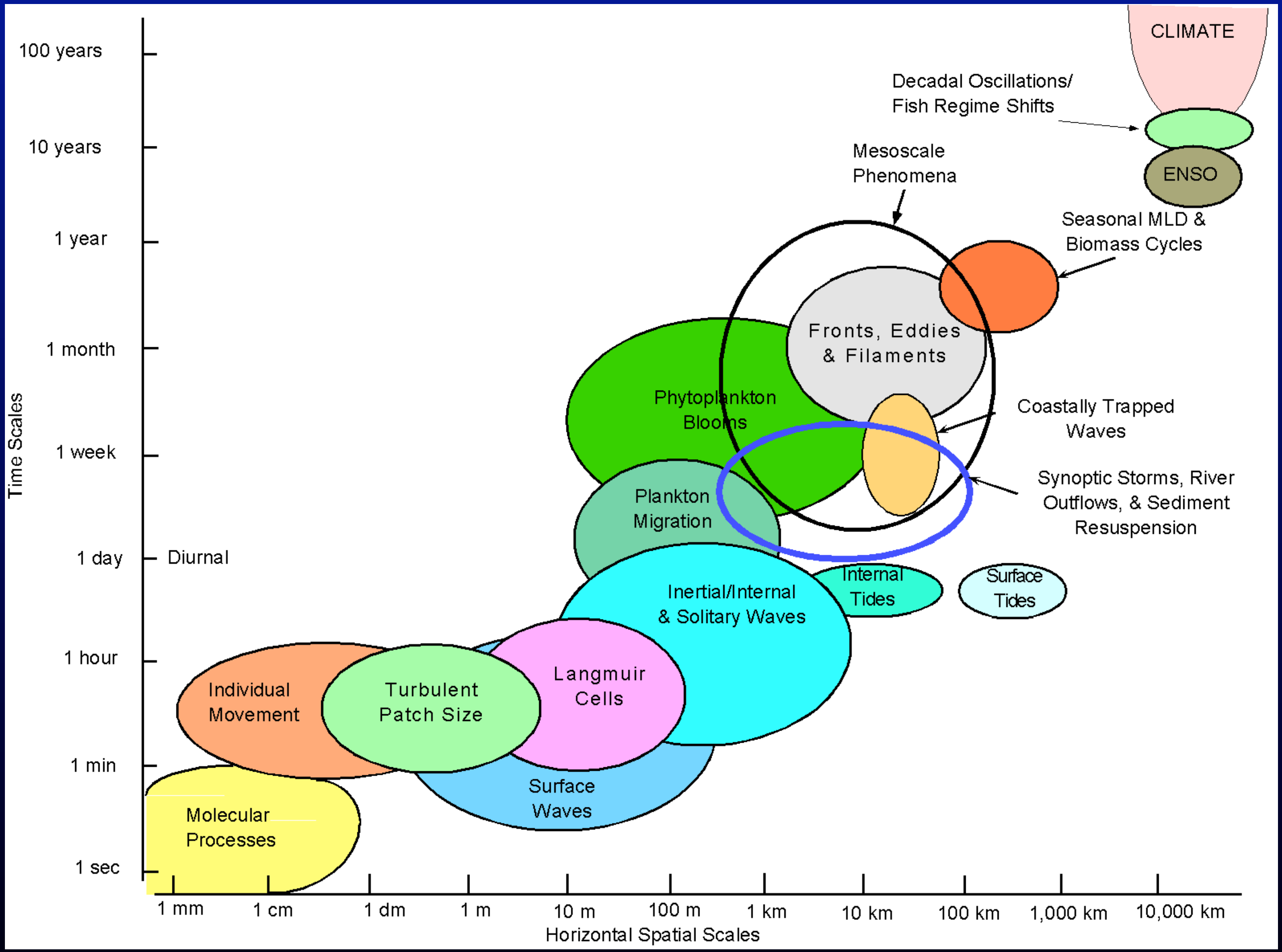
Research
http://marine.rutgers.edu/cool

Education
http://coolclassroom.org

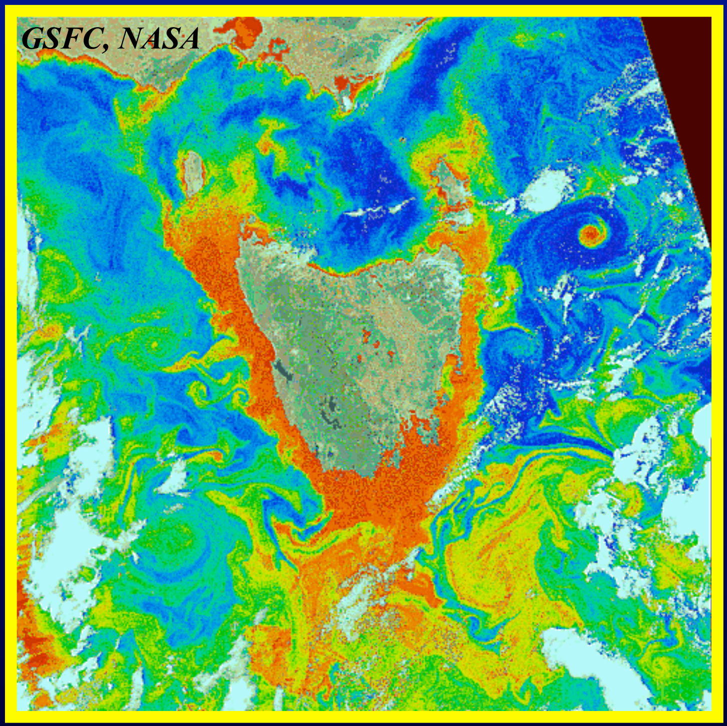
Public Outreach
http://www.thecoolroom.org

In Situ Research- 'The Early Years'

Processes Operate of Time and Space

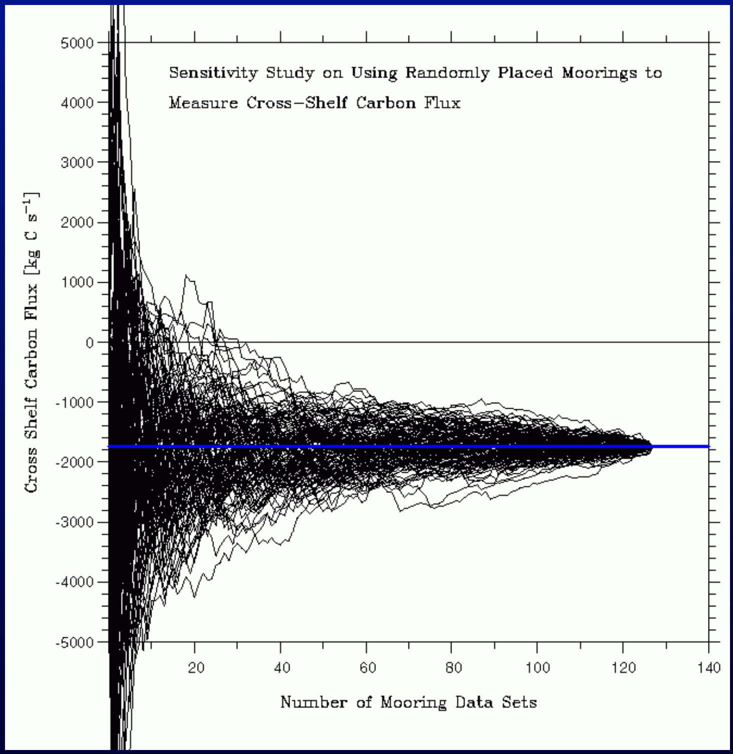


NATURAL VARIABILITY: Where do you put a mooring? Where do drive the ship? When should I be out there?



Color variability at multiple scales around Tasmania from CZCS image

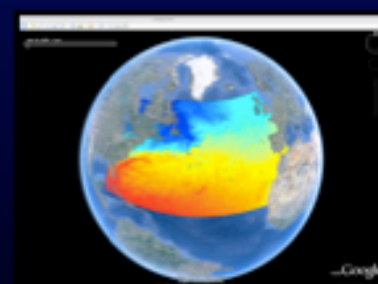
Causes? Strong winds, strong currents, bottom togography, etc.



Thanks Mossian (NASA) and Wilkins (Rutgers)

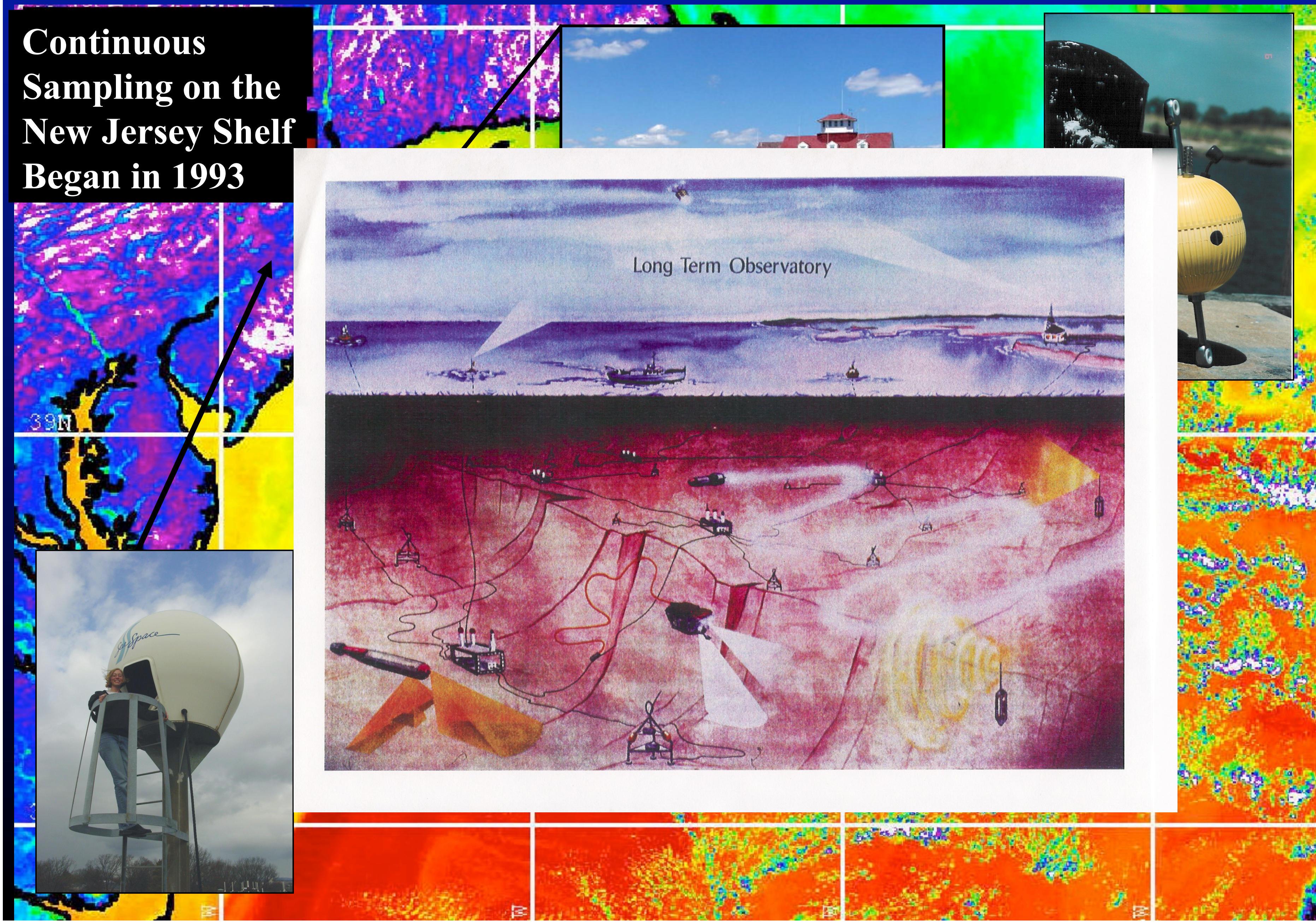
Technology will make life good

My Lab

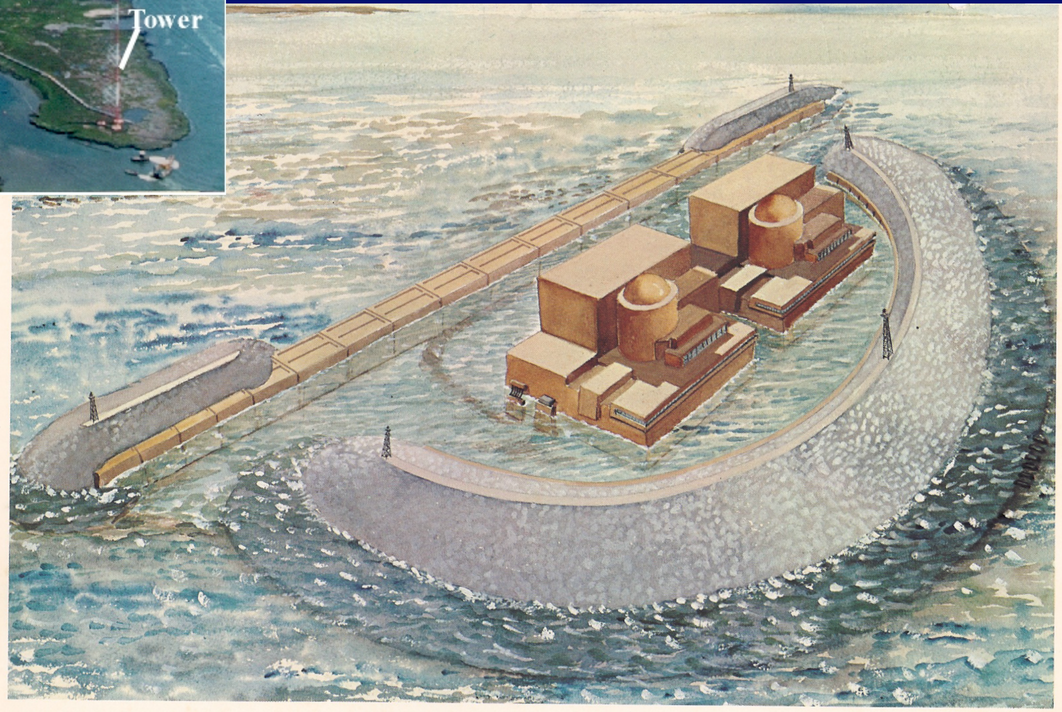


A Coastal Observatory : 1993

Continuous Sampling on the New Jersey Shelf Began in 1993



A field station & an environmental impact report

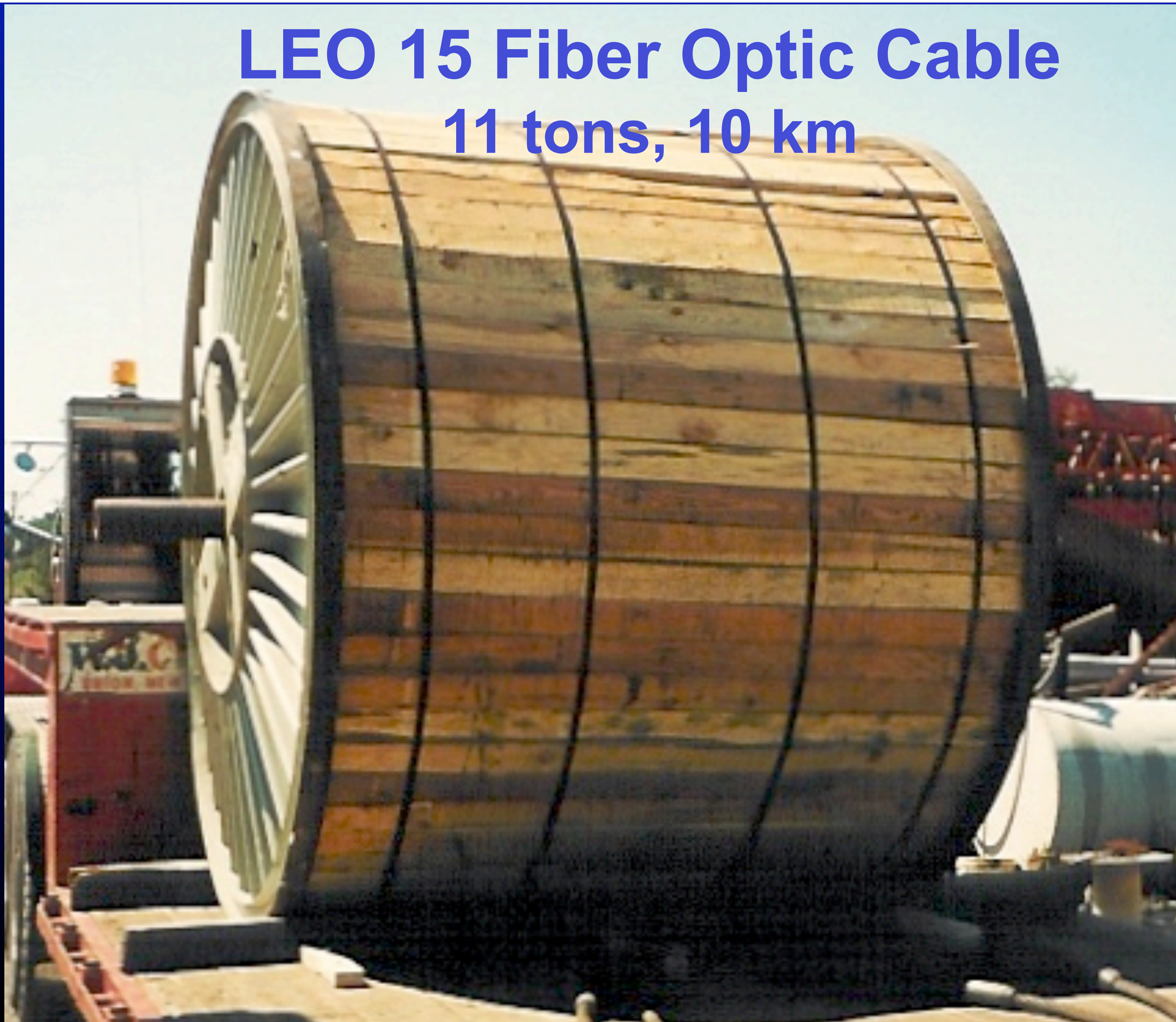


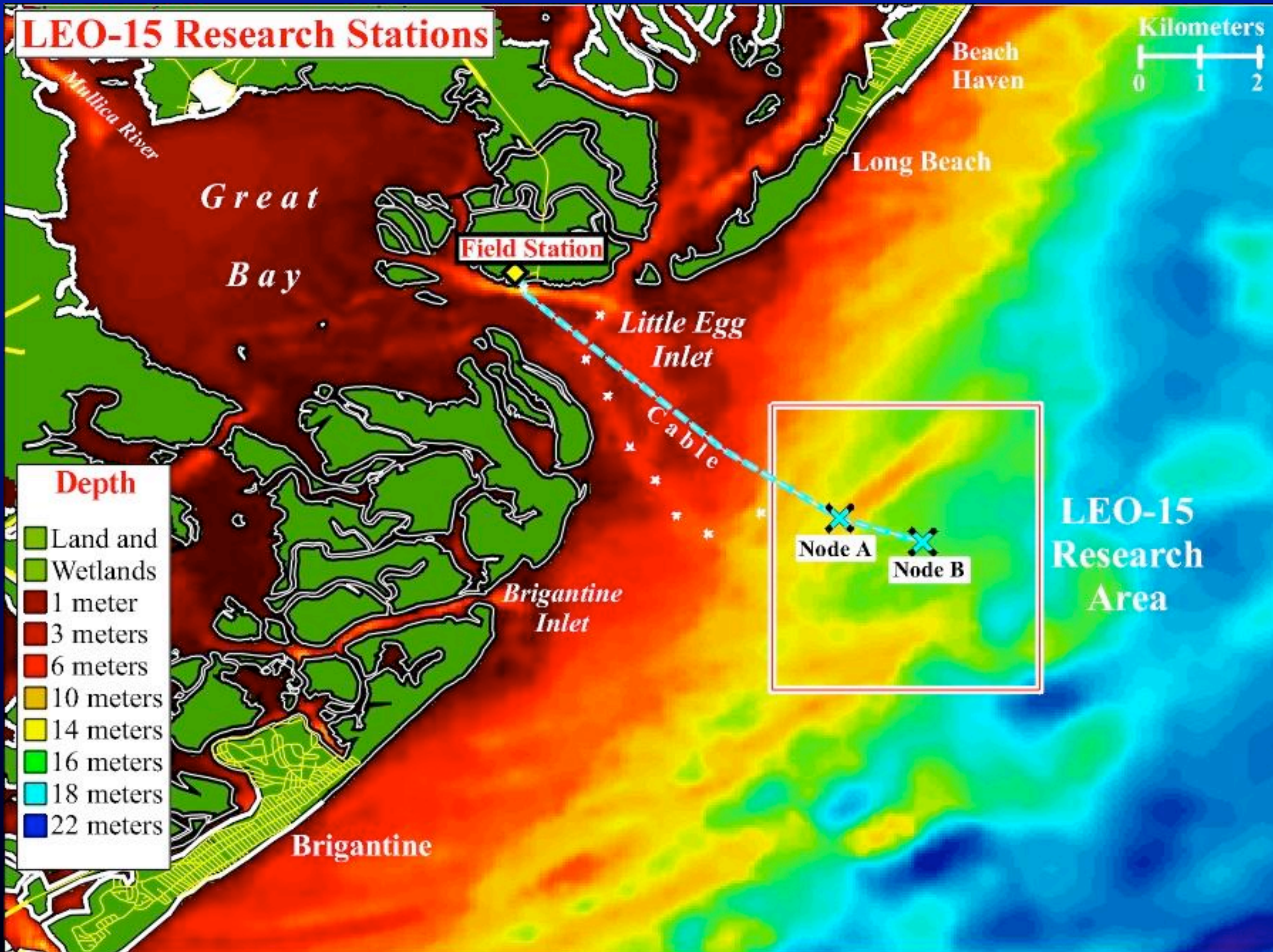
Atlantic Generating Station
Public Service Electric and Gas Company

Figure 1.1-1

LEO 15 Fiber Optic Cable

11 tons, 10 km




LEO-15 Research Stations
Mullica River
Great
Bay
Field Station
Little Egg
Inlet
Cable
Beach
Haven
Long Beach
Kilometers
0 1 2
Node A
Node B
LEO-15
Research
Area
Brigantine
Inlet
Brigantine
Depth
Land and
Wetlands
1 meter
3 meters
6 meters
10 meters
14 meters
16 meters
18 meters
22 meters

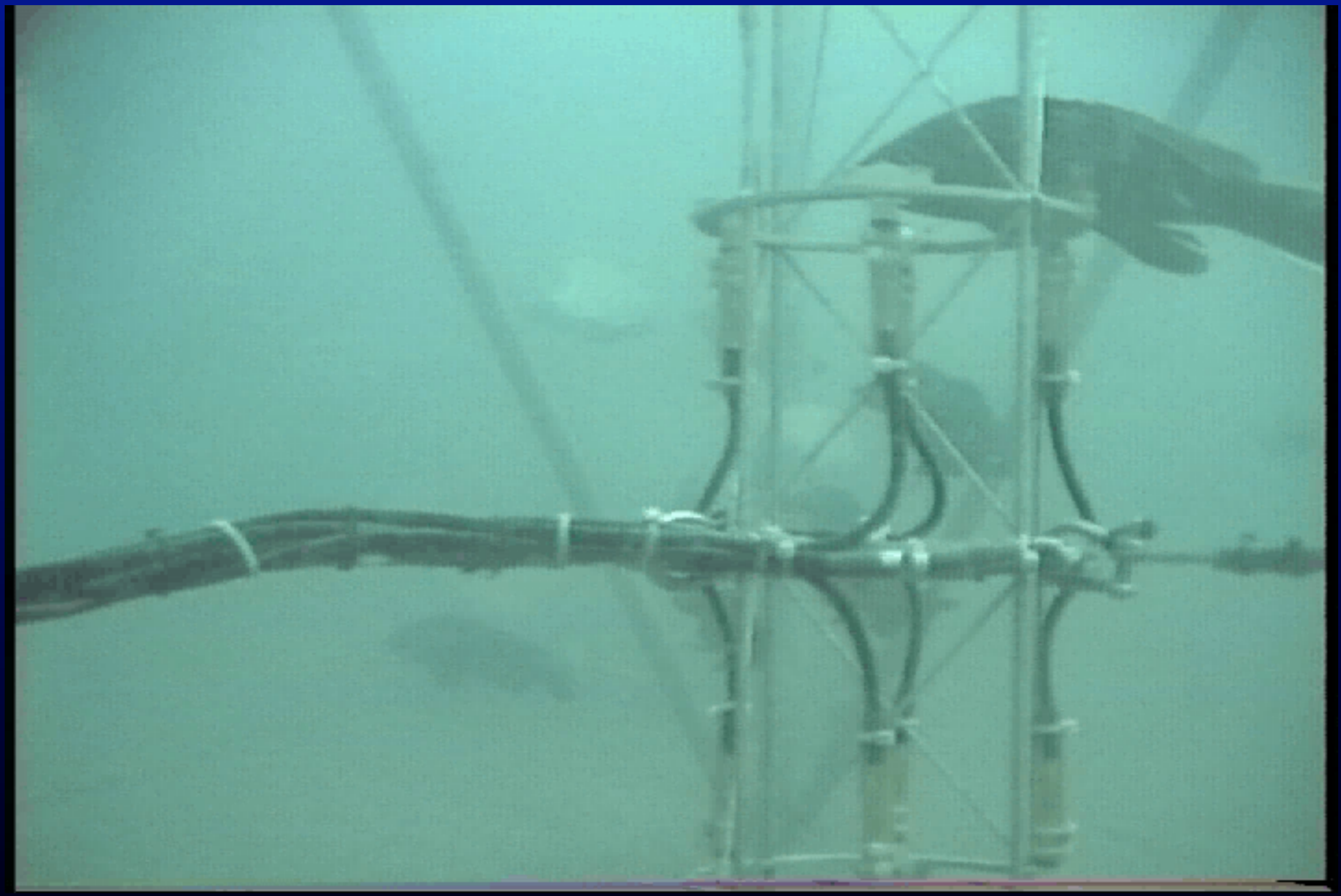
Sediment Transport Studies at LEO Site –early 1990's

Benthic Acoustic Stress Sensor (BASS) Tripod
Before and After Summer Deployment at LEO

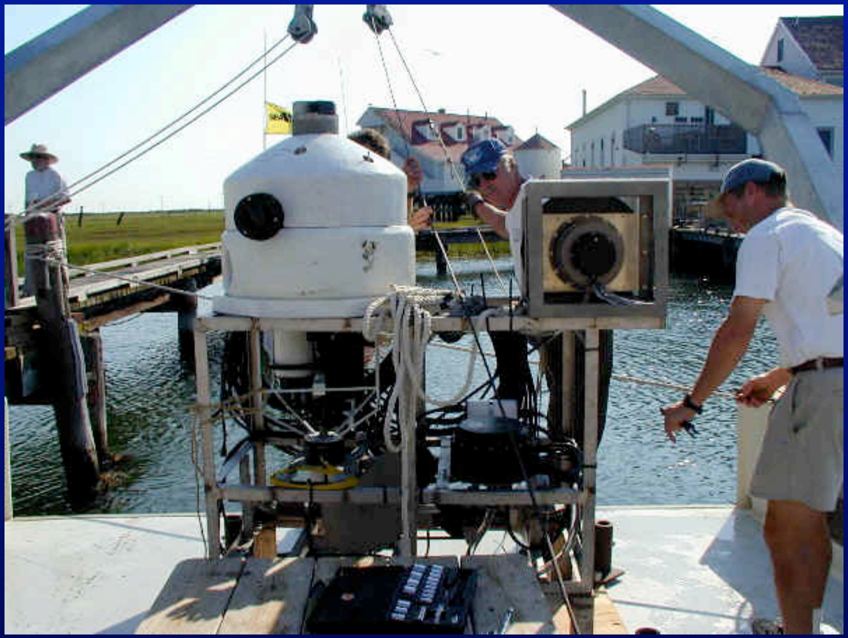
BASS Tripod
For LEO-15

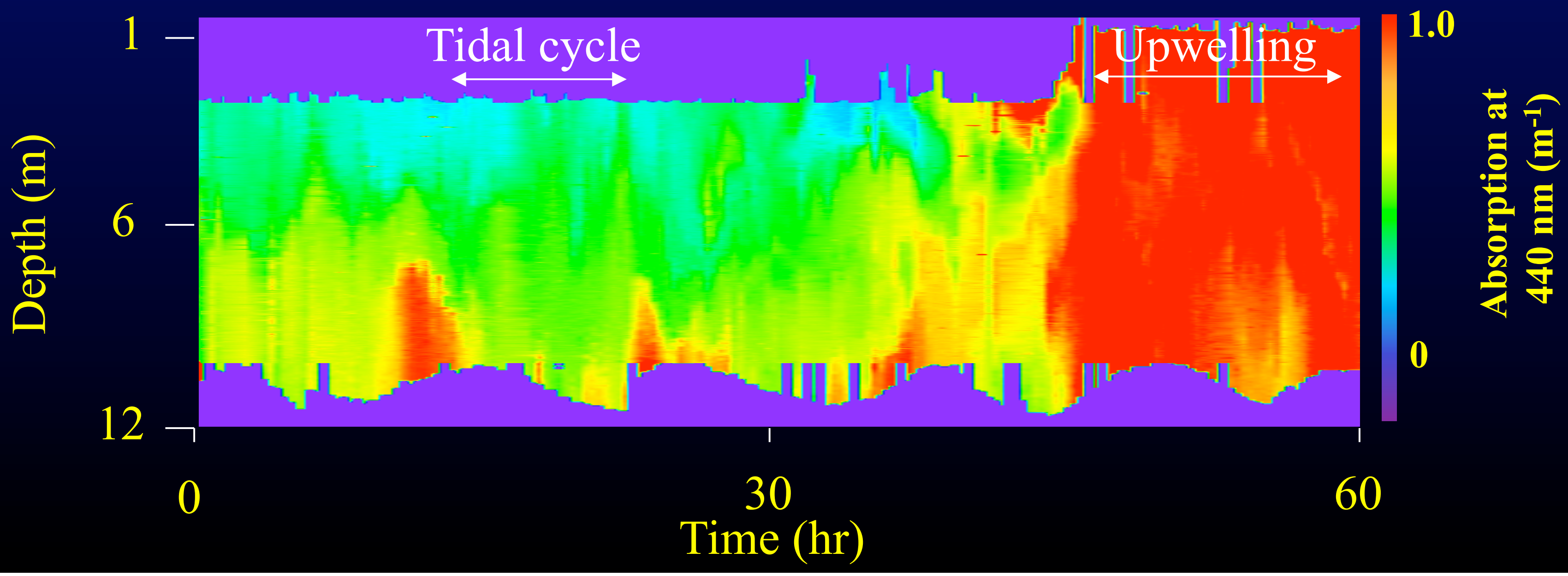
Late 1990’s

Lesson: The importance of having a continuous picture to the sea

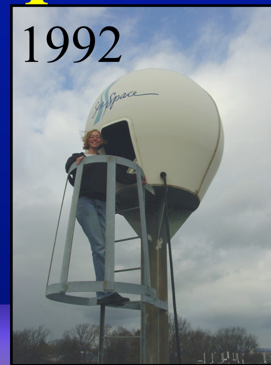


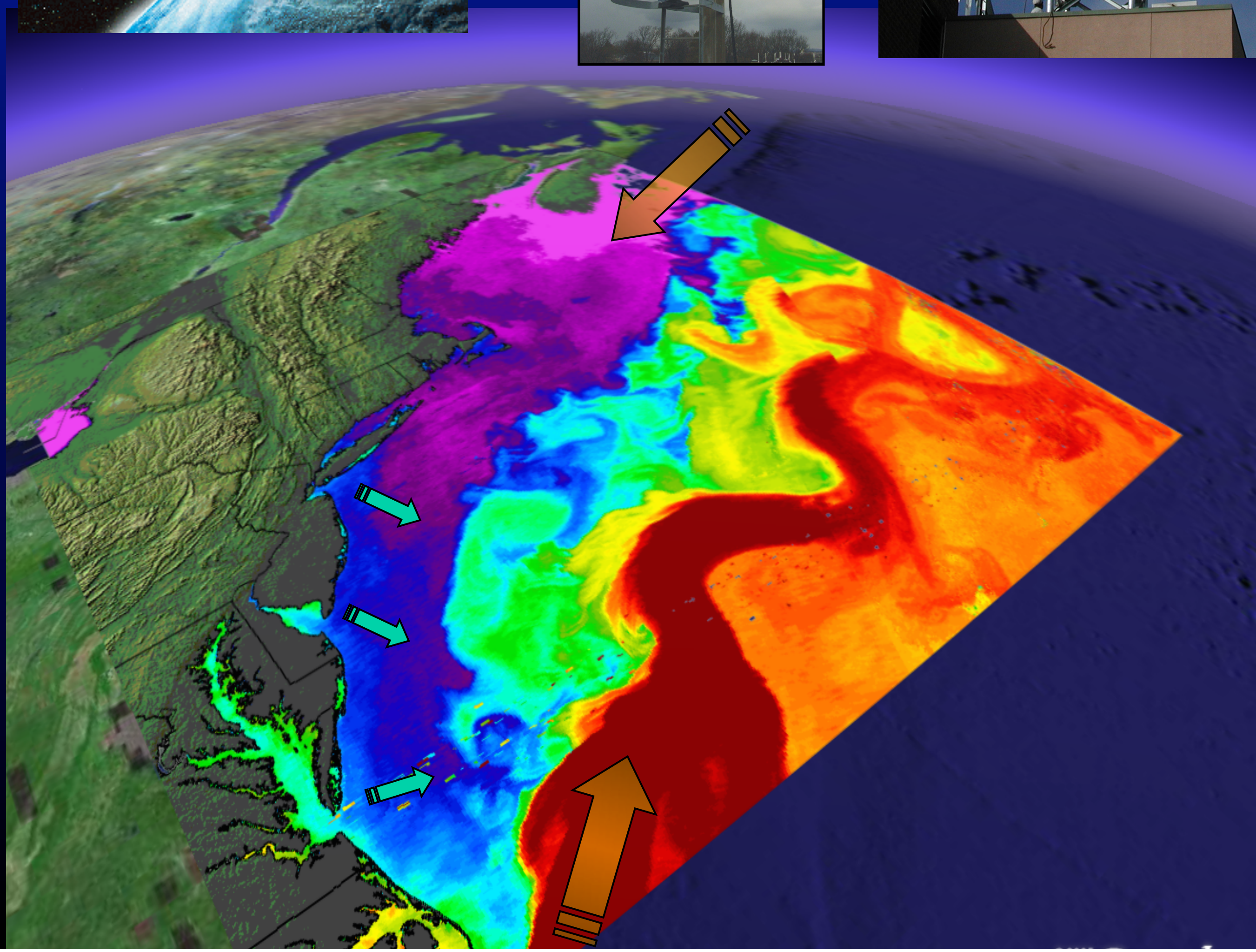
Optical profiler deployed on LEO-15 guest port

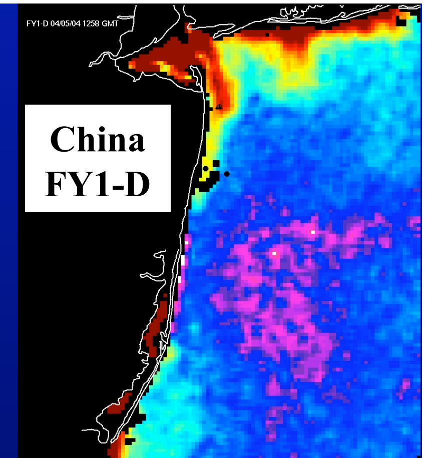


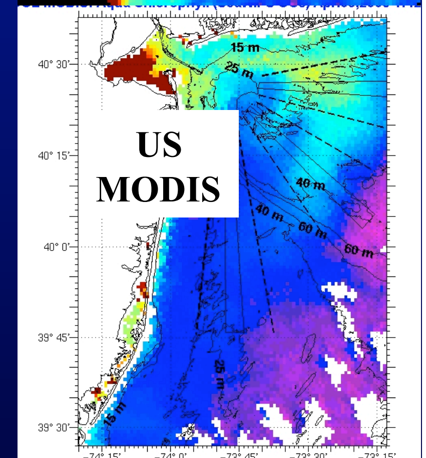


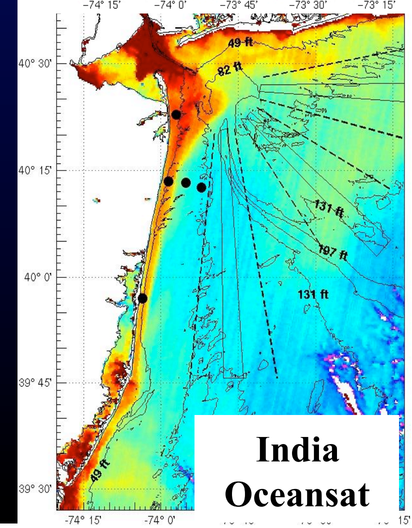
Satellite Data Acquisition Systems

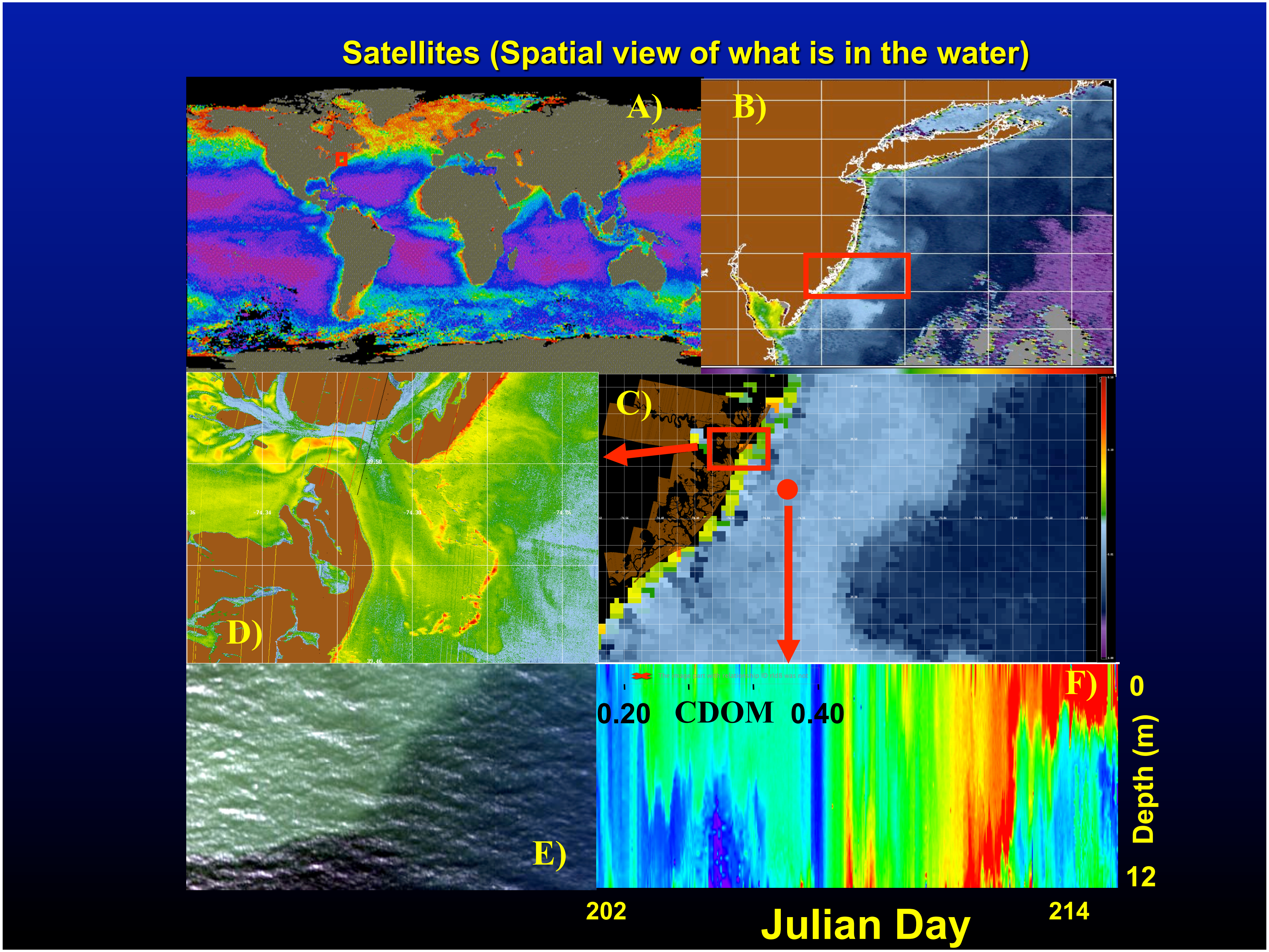




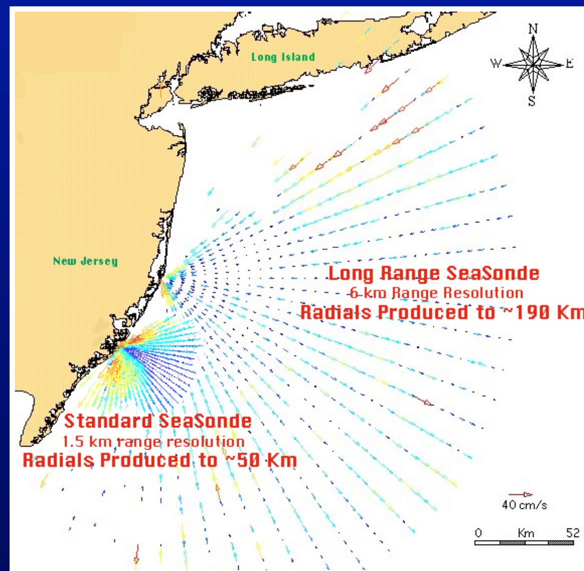


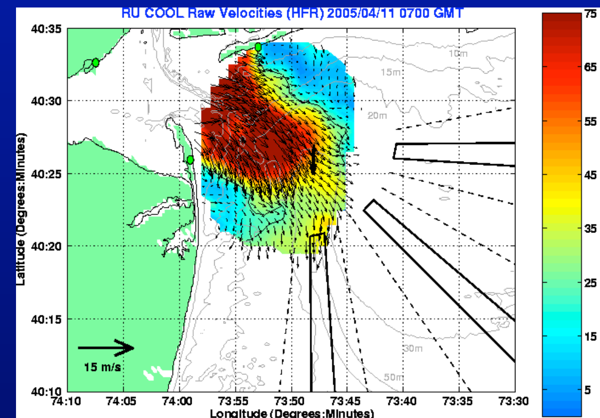





Satellites (Spatial view of what is in the water)
A)
B)
C)
D)
E)
F)
0.20
CDOM
0.40
0
Depth (m)
12
202
Julian Day
214

New Enabling Technologies – CODAR HF Radar

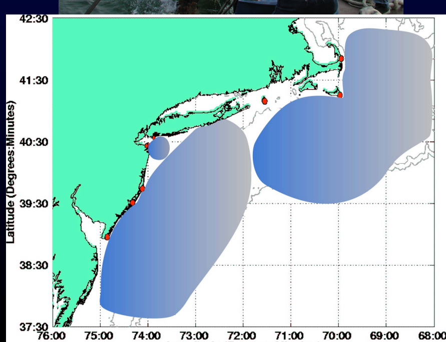


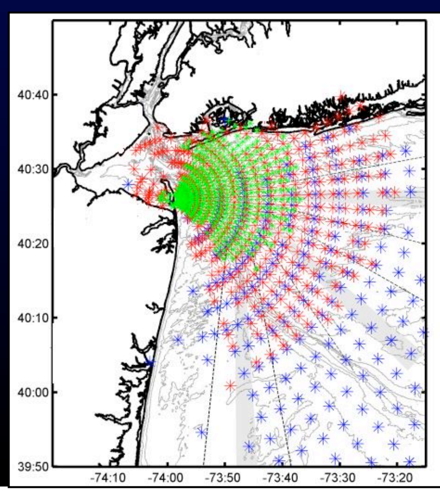


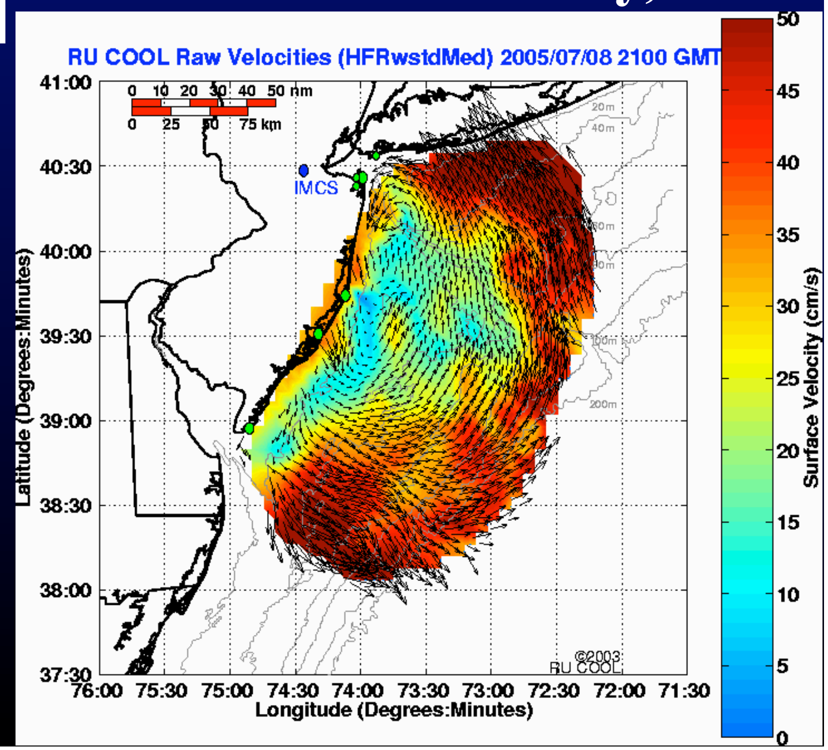
Hudson Plume – April, 2005

Summer Storm – July, 2005

Each Radar Measures Radial Component of the Surface Current

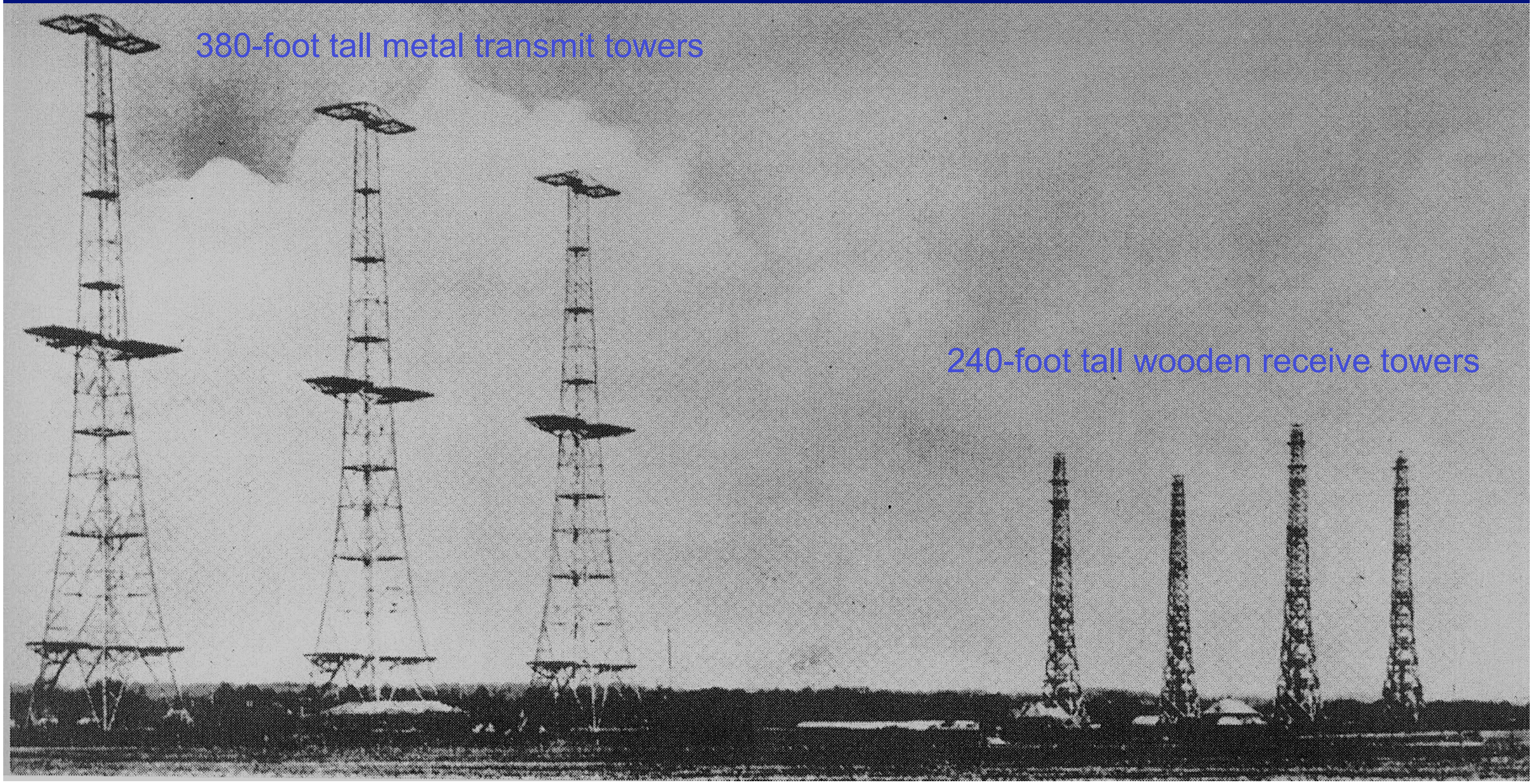






HF Radar -- Is It New Technology?

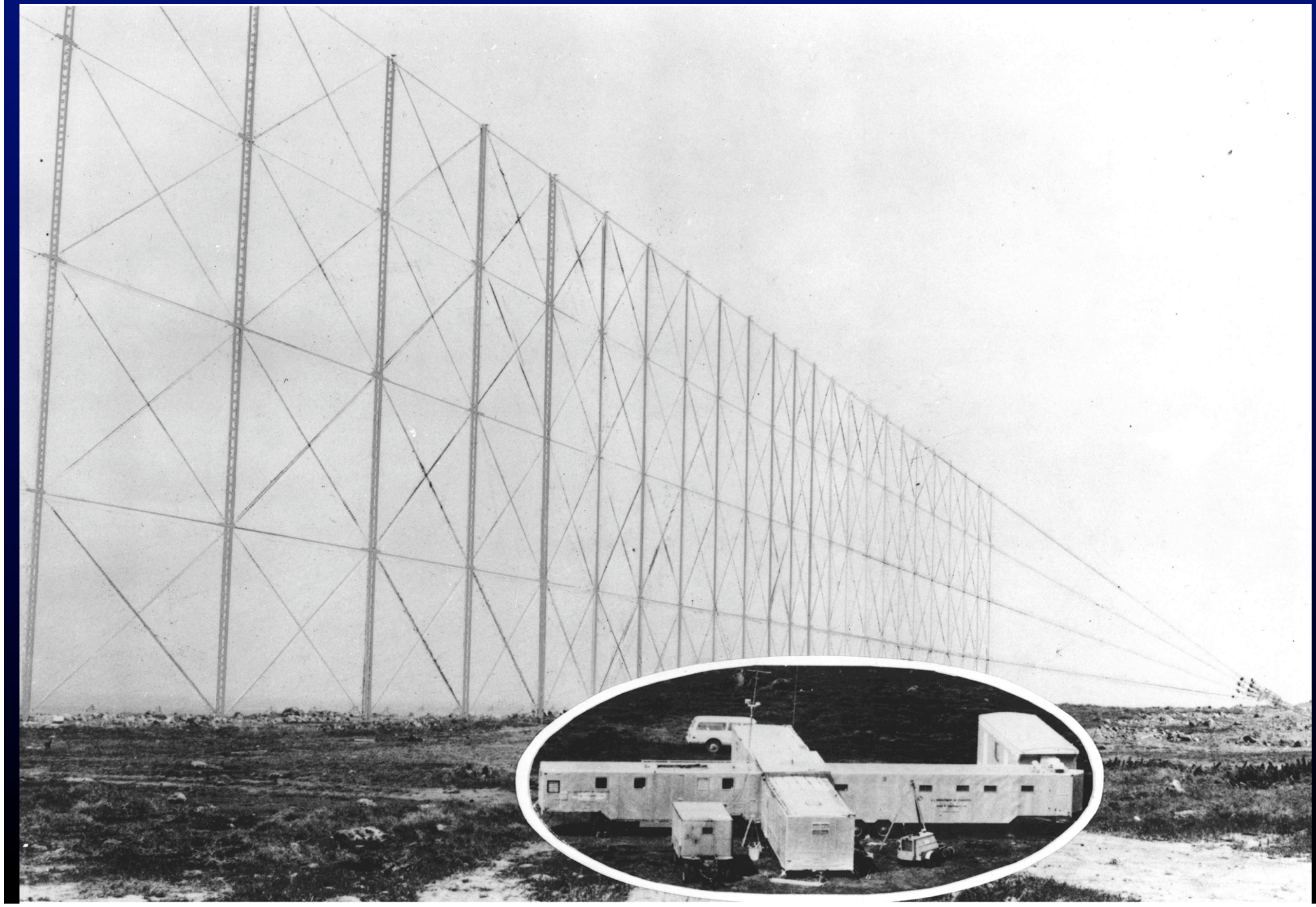
- British 25-MHz "Chain Home" built 1938 to detect German bombers
- "Bragg" sea echo from English Channel mistakenly labeled "jammer"
  - These systems preceded microwave radars by several years



★ The Beginnings ★

Large Phased Arrays on San Clemente Island, CA

- **Microwave vs. HF -- what's the difference?:** (about three orders of magnitude!)
- **Example: 500-m half-rhombic array built by DoC (Barrick) in 1972 -- SCI, CA**



But Why HF?

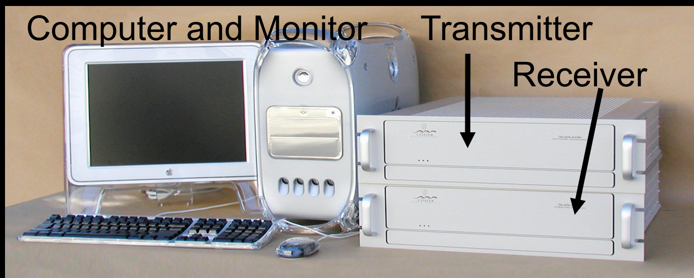
Beyond the horizon

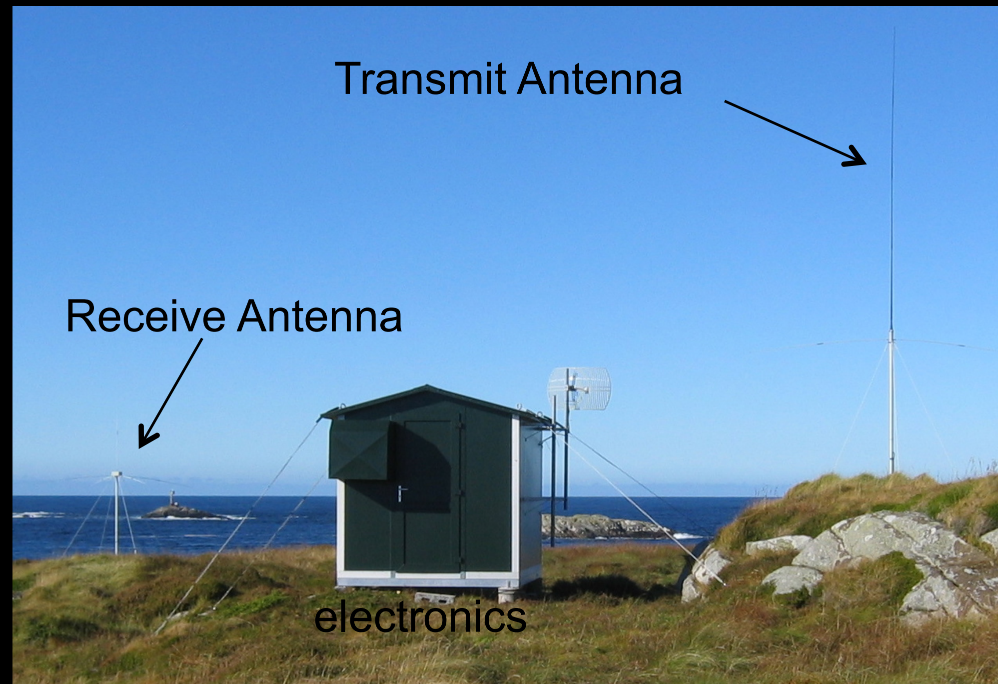
Scatter from water waves is simple

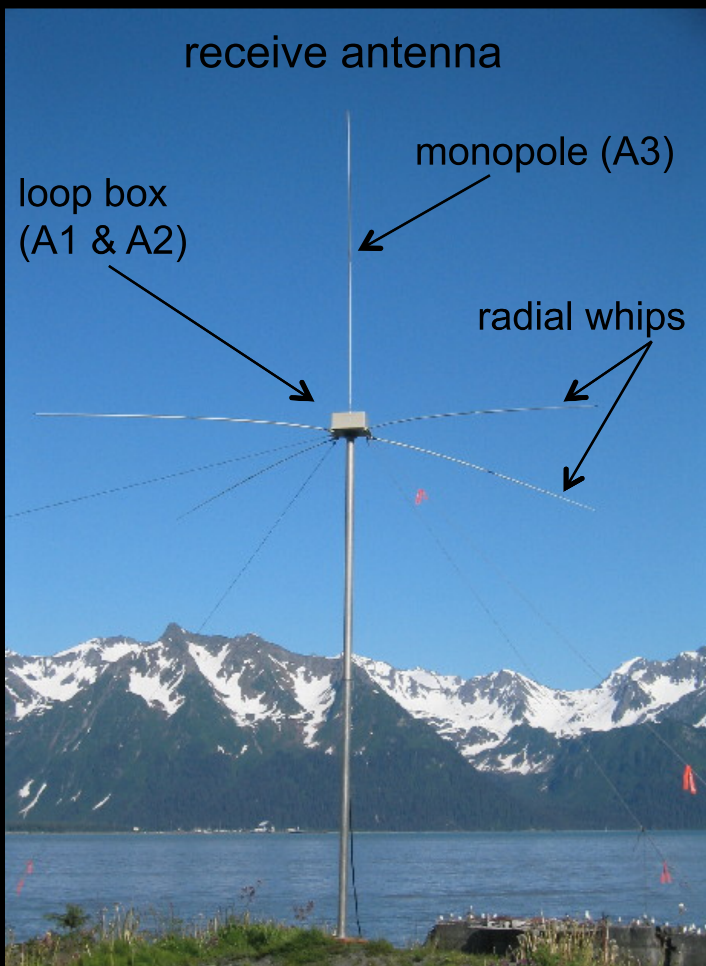
2 billion microwave radars exist

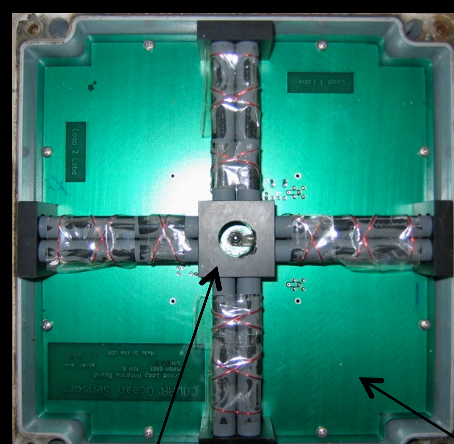
Only 350 HF radars exist in the world, 300 done by CODAR

HF radars not good for much except sea scatter & ships

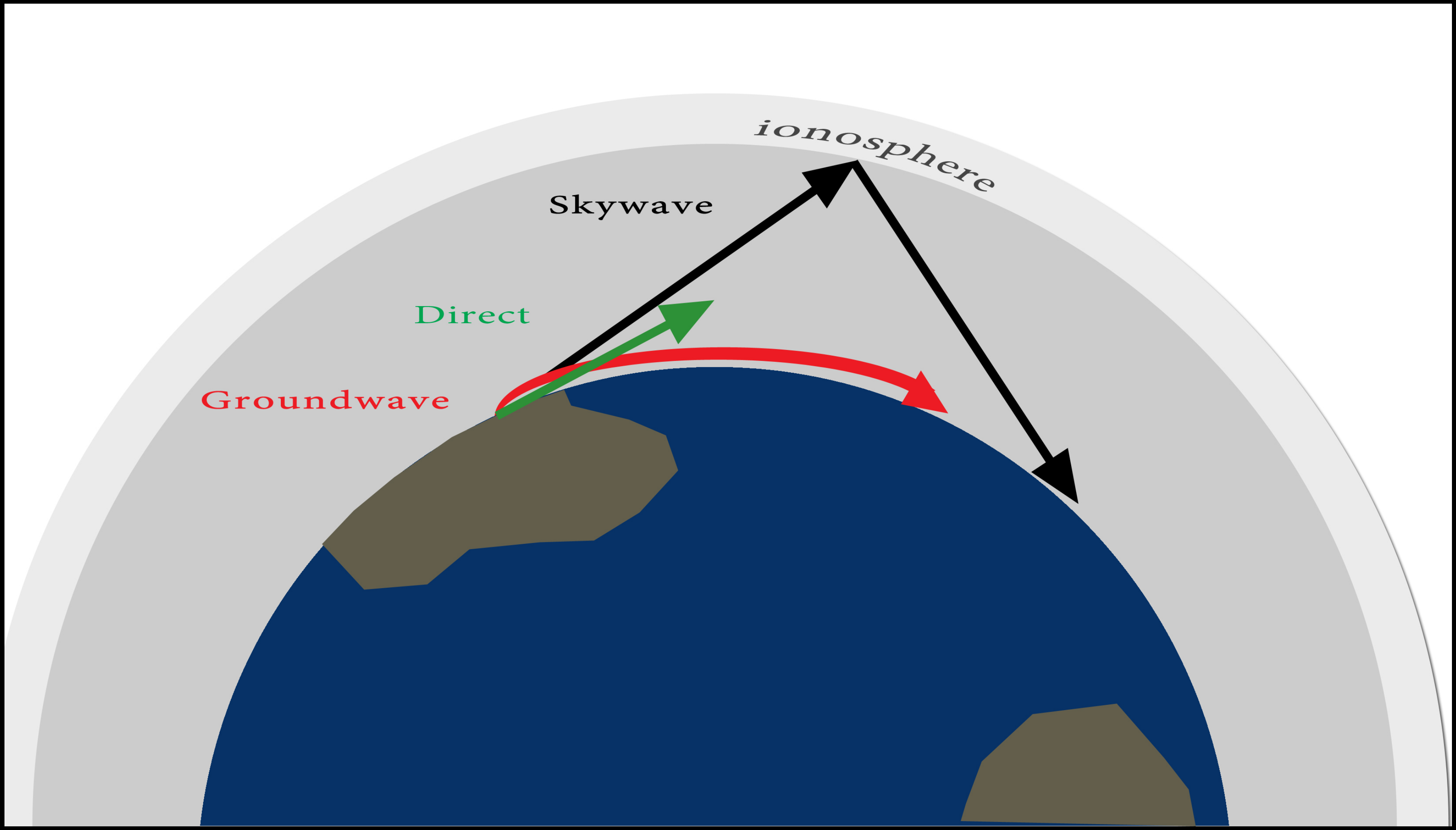

Computer and Monitor
Transmitter
Receiver


Transmit Antenna
Receive Antenna
electronics


receive antenna
monopole (A3)
loop box
(A1 & A2)
radial whips



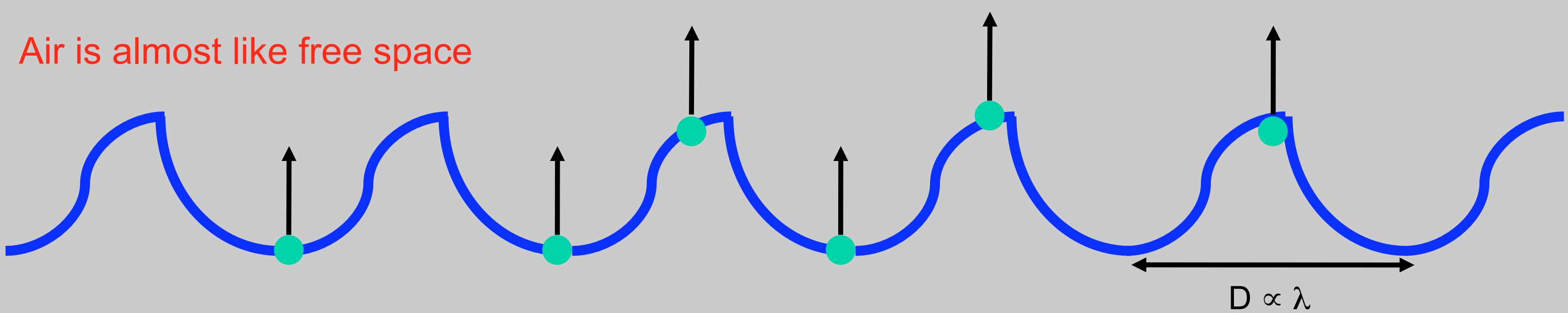
RF Modes of Propagation



Ground Wave Propagation & Depth of Measurement

- Requires interface between free space (air) and highly conductive medium (>8 ppt salinity sea water)
- Ocean surface exists as a free boundary allowing surface molecules freedom to conduct EM energy, much like a **<u>waveguide</u>**
- Allows **<u>vertically polarized</u>** EM energy to propagate w/ reduced energy loss for greater distances and beyond horizon
- Radar wave **<u>does not penetrate</u>** surface at all - depth of measurement comes from effective depth-averaged current "felt" by ocean wave
- 25 MHz measures to < .5 m, 5 MHz measures to 2 m deep

Air is almost like free space

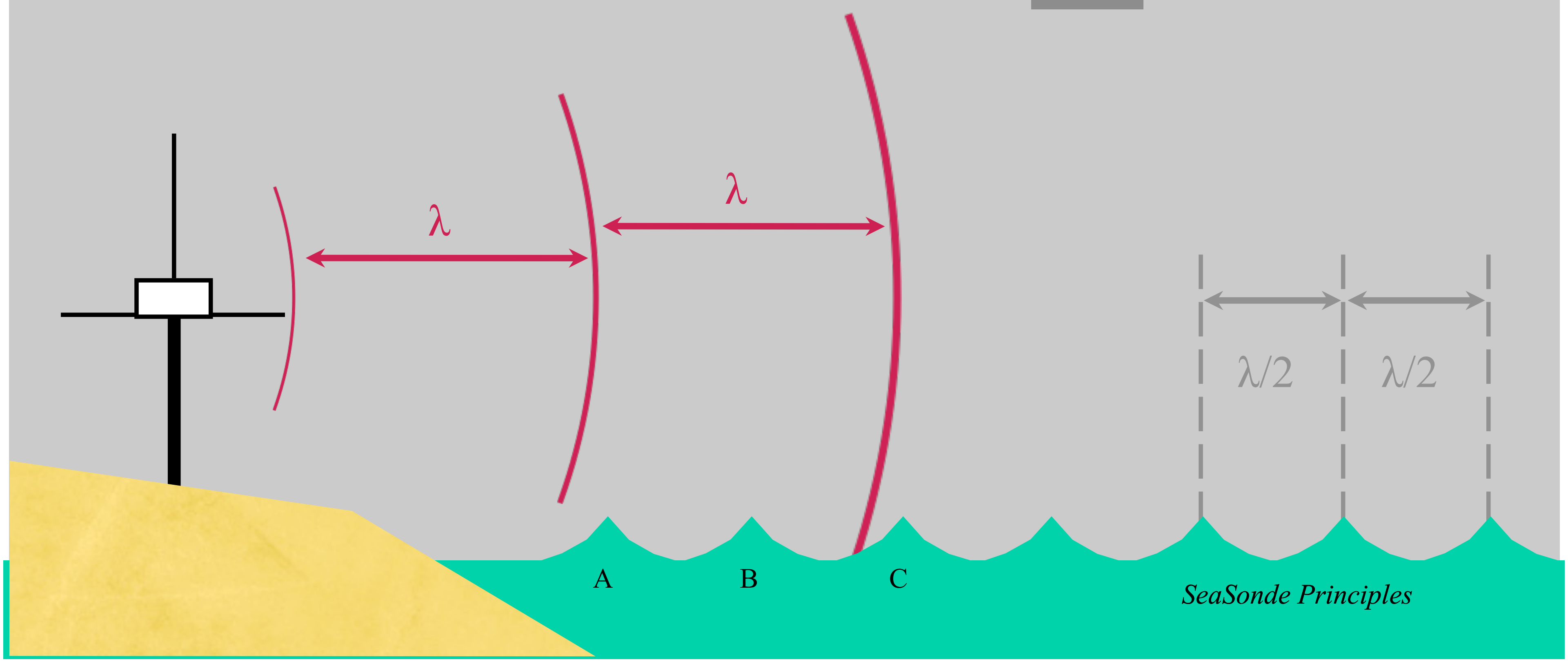


Depth of measurement is related to ocean wavelength
(Can be linear or logarithmic)

Seawater is conductive

Bragg Sea Echo

Freq mhz	λ meters	λ /2 meters	T seconds
5	60	30.0	4.4
13	23	11.5	2.7
25	12	6.0	2.0
42	7	3.6	1.5



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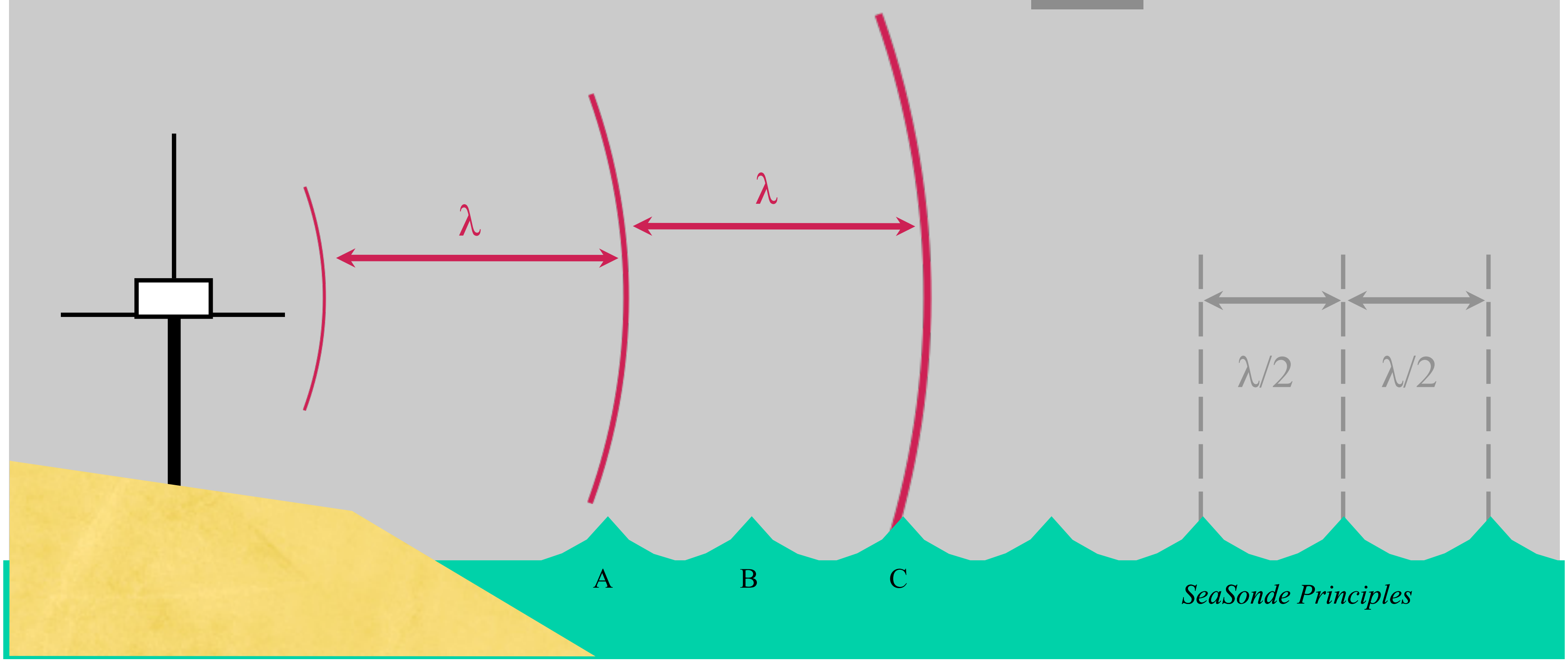

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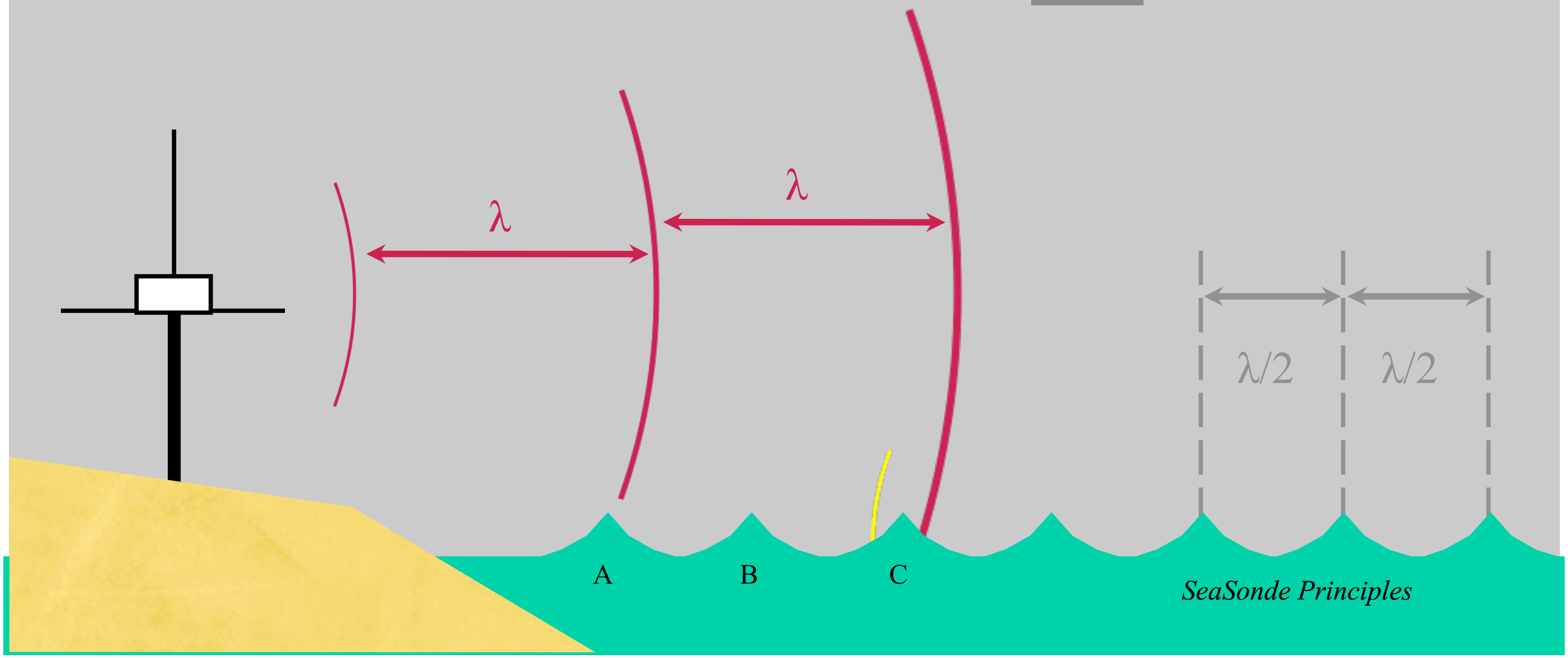

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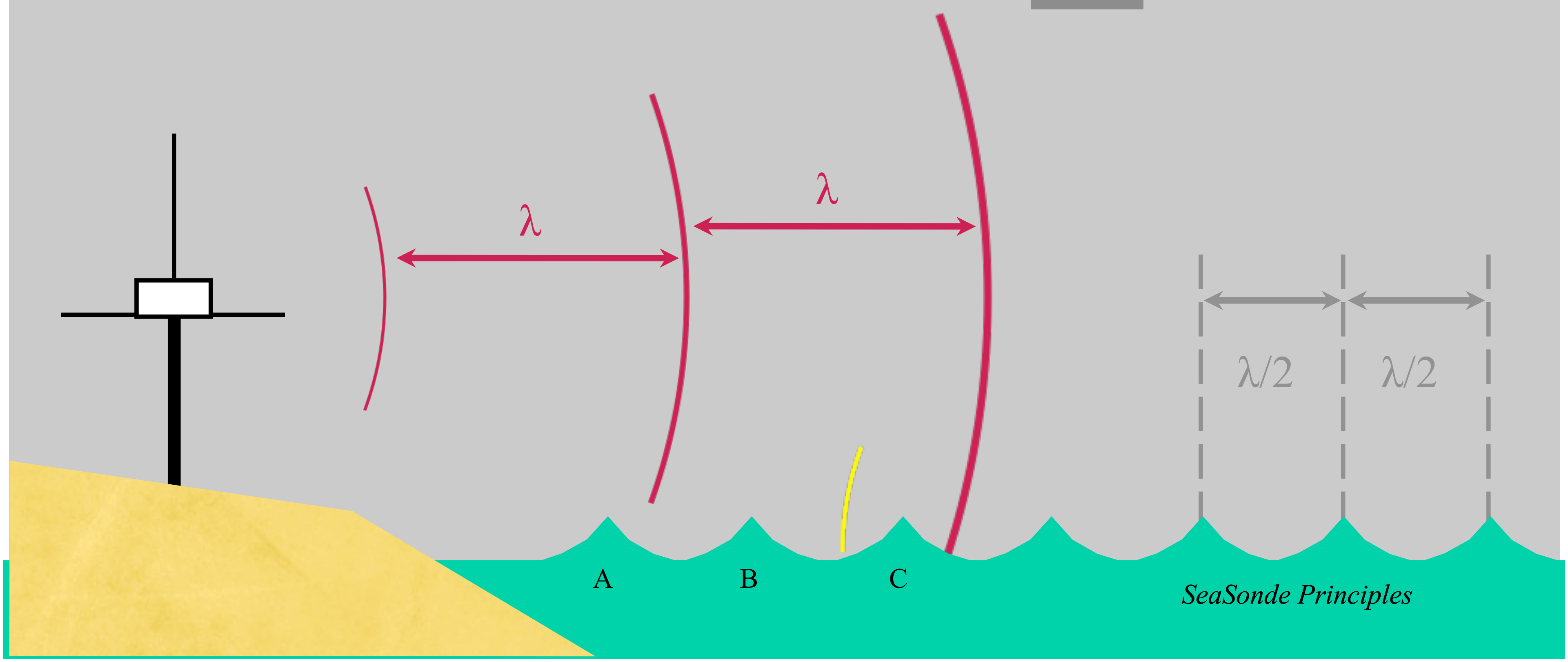

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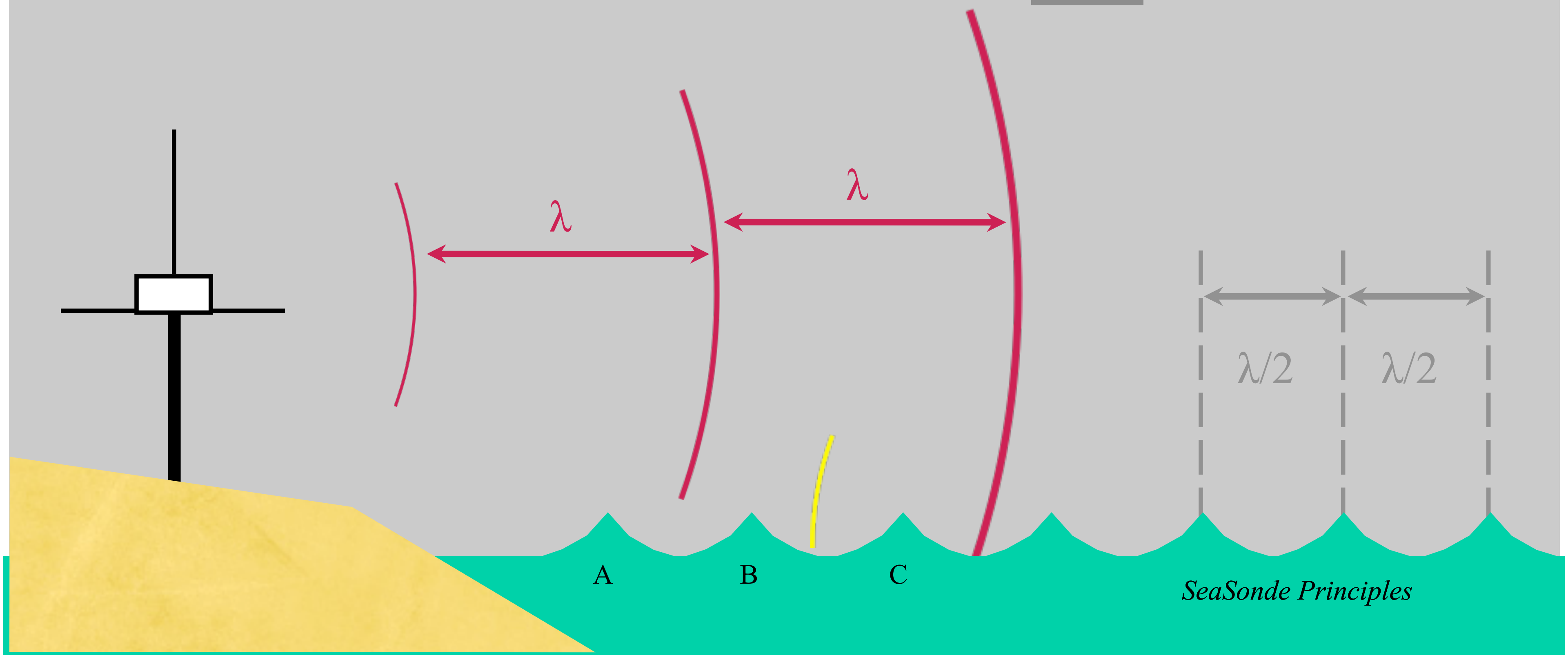

SeaSonde Principles

Bragg Sea Echo

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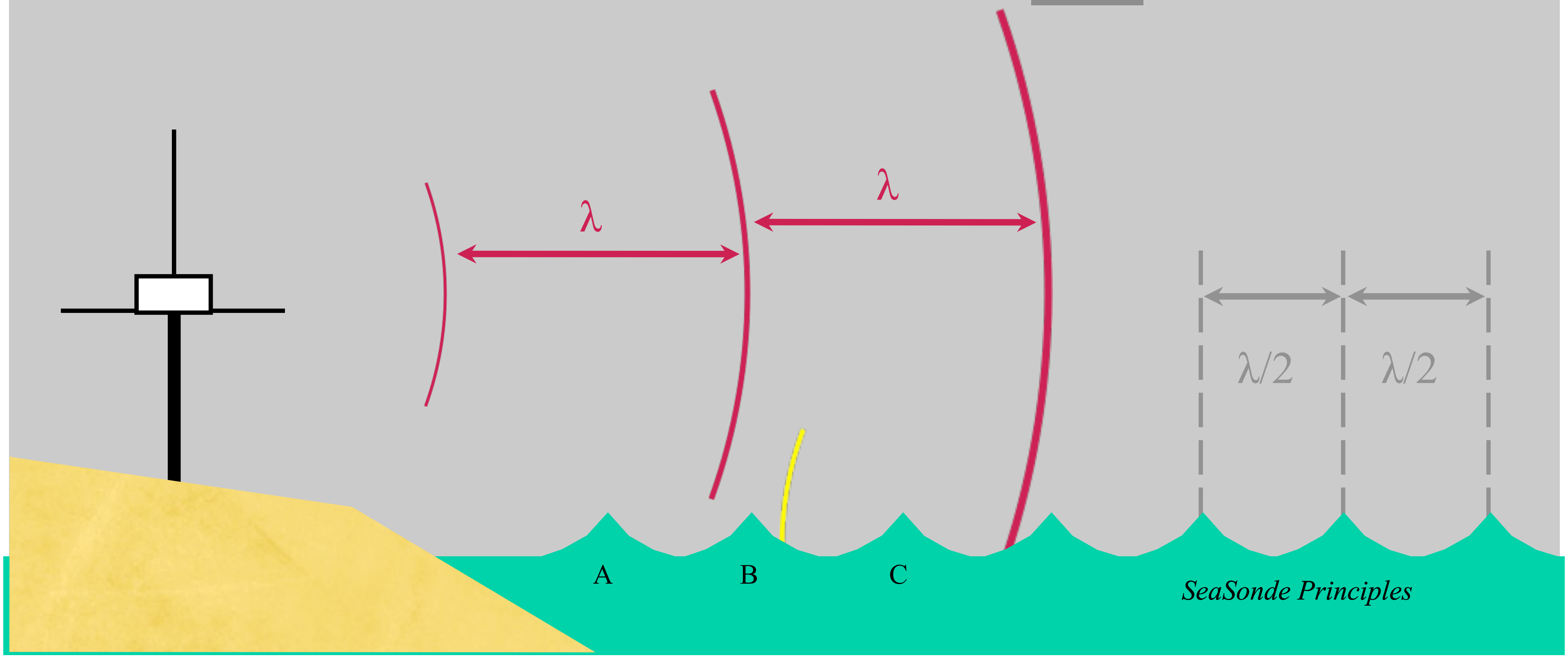

SeaSonde Principles

Bragg Sea Echo

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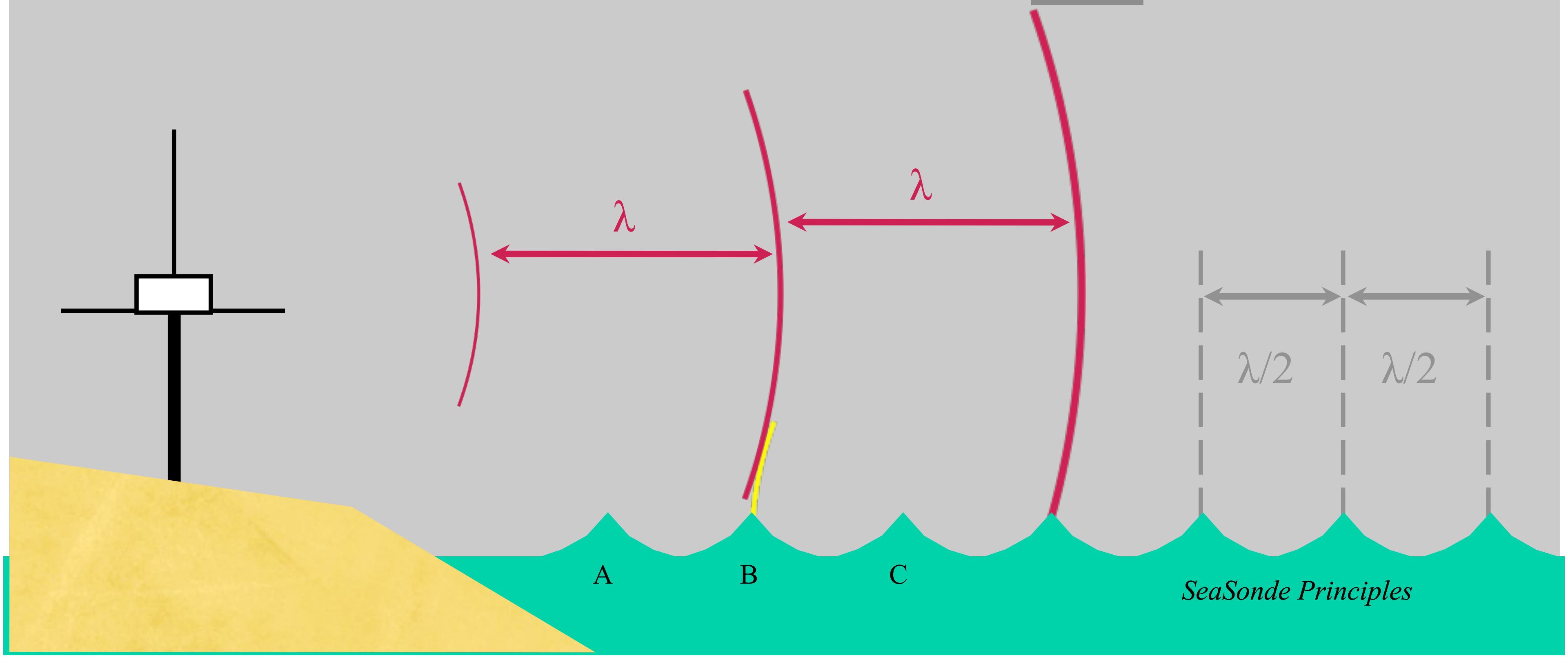

Bragg Sea Echo

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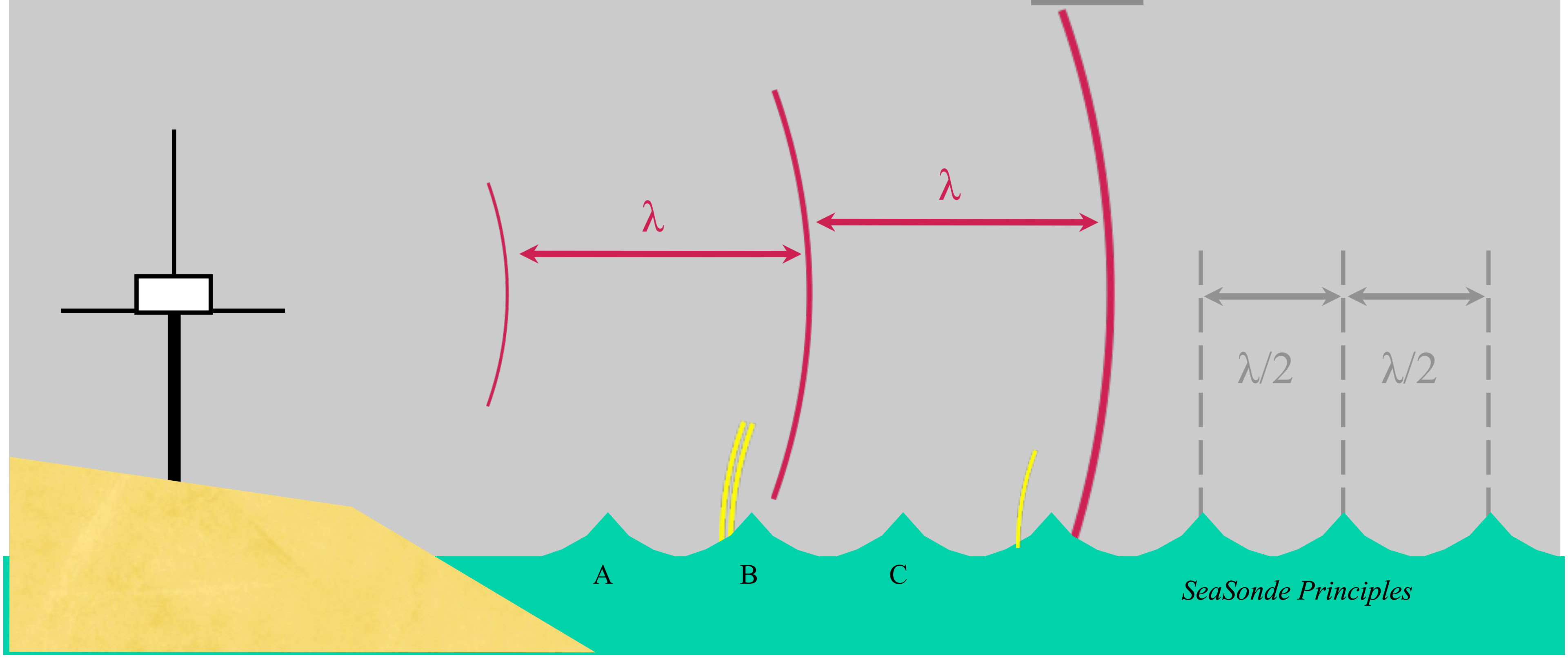
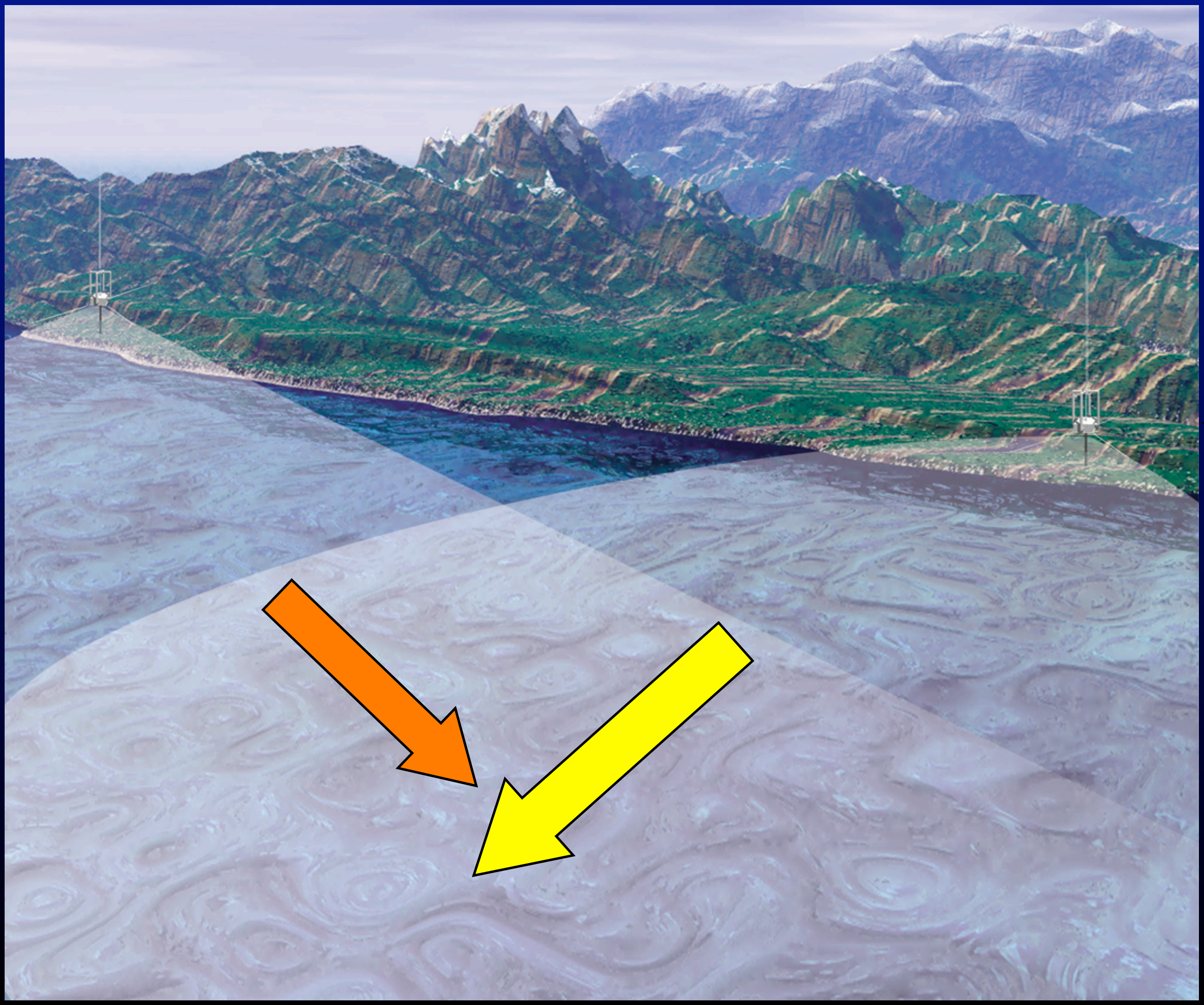


Two (or more) Sites Used to Produce Total Current Vector Maps from Single-Site Radials Where Coverages Overlap

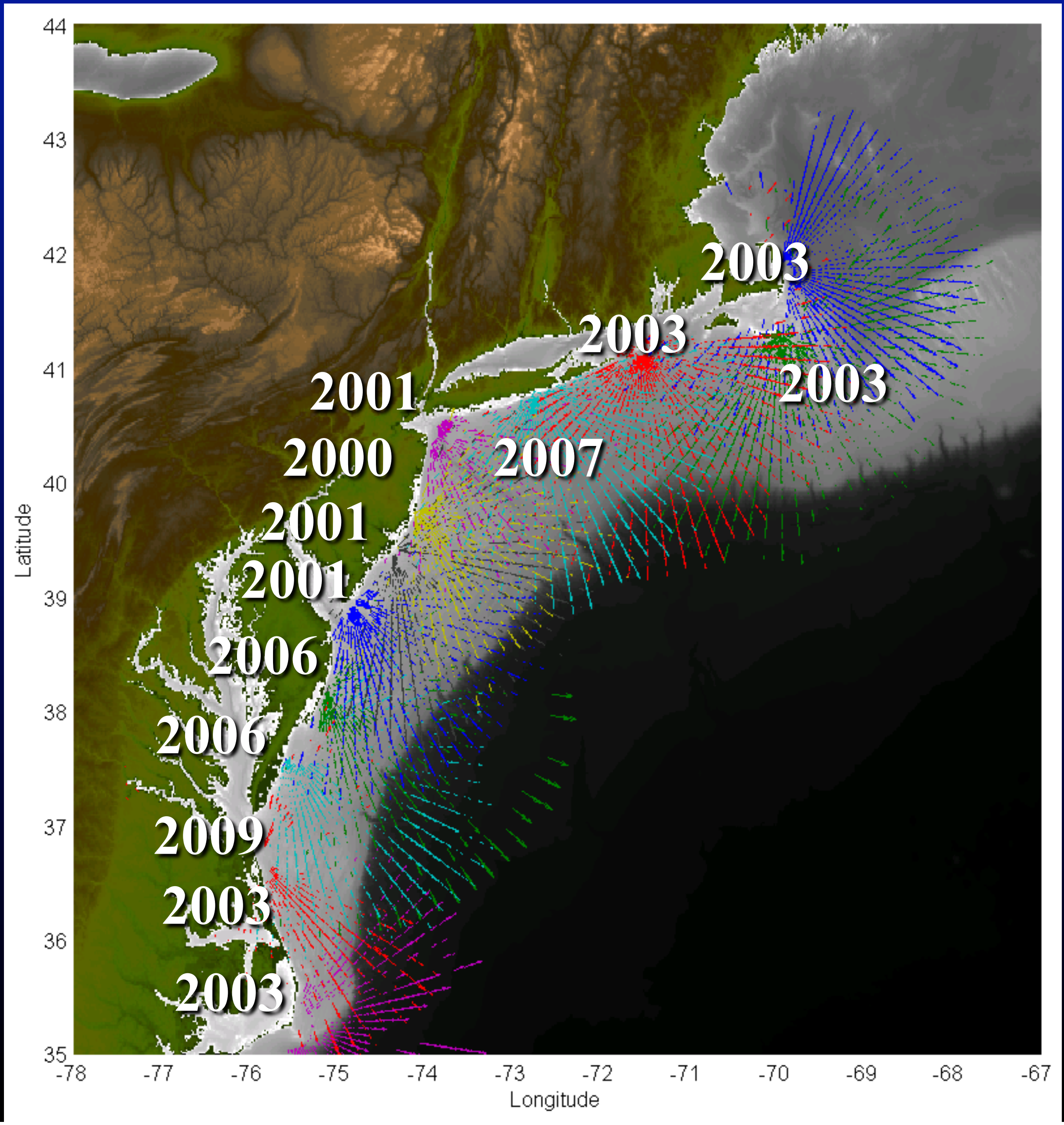


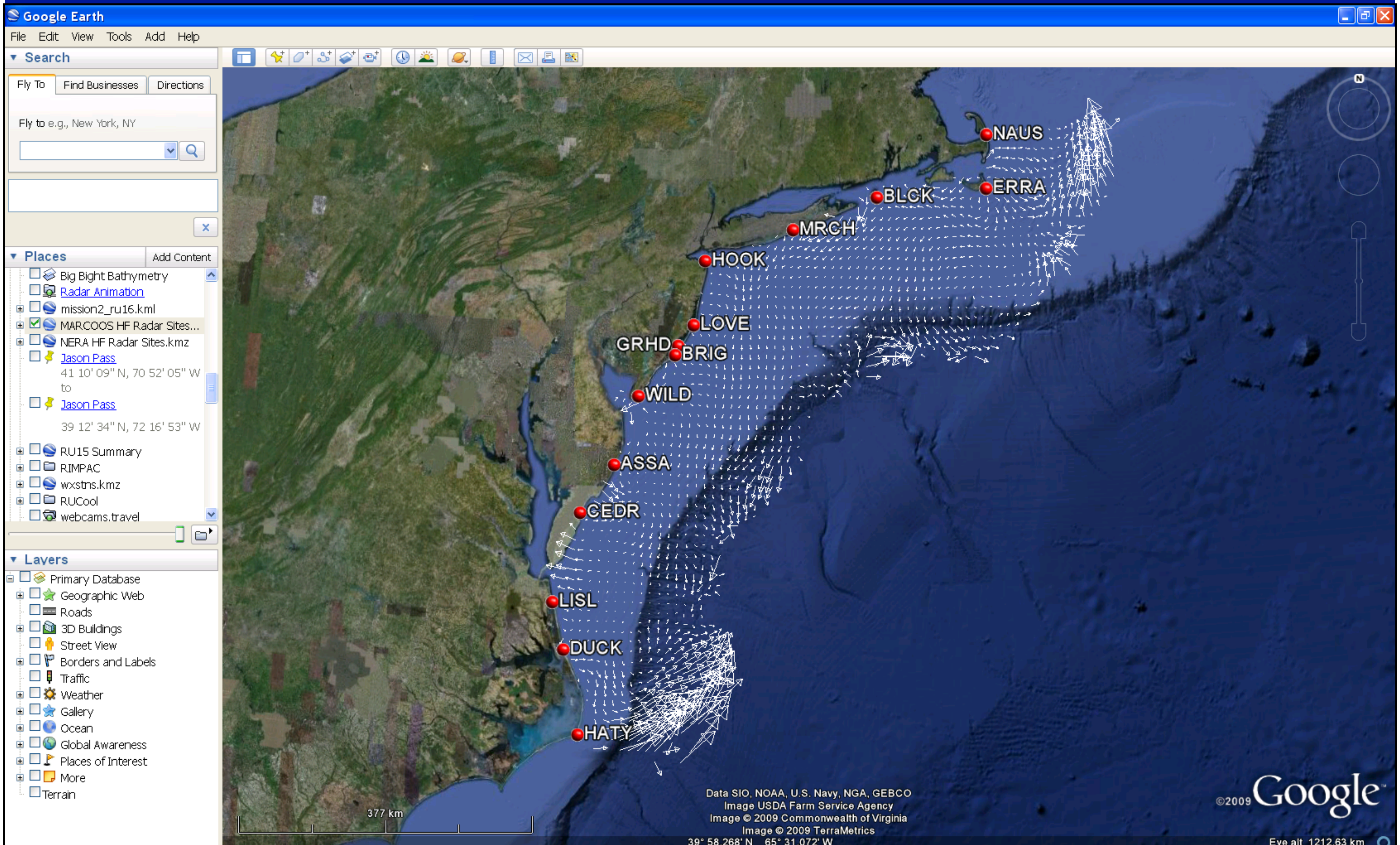
Angle of incidence
Greater than 15°
or less than 165°

LONG RANGE NETWORK

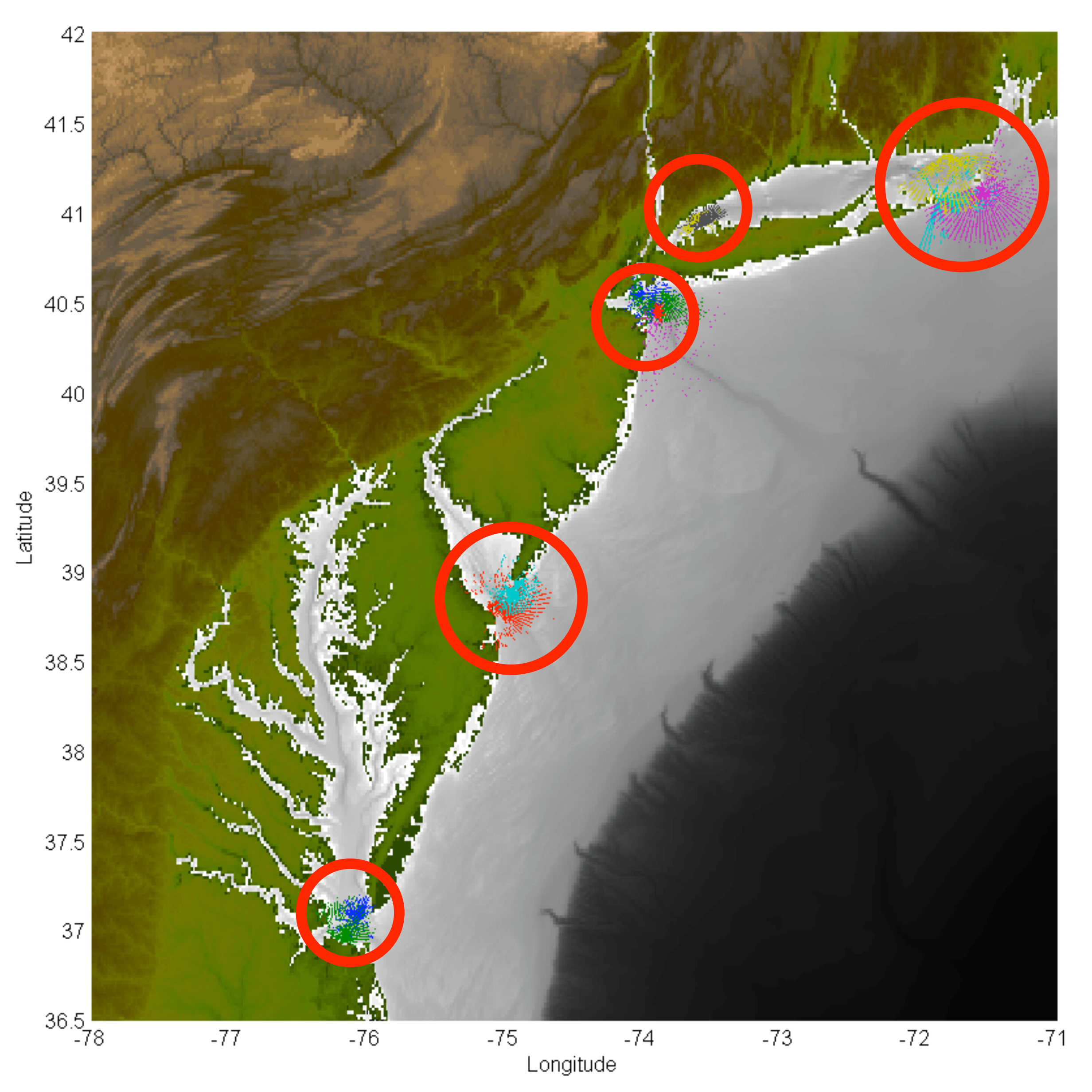
Rutgers Coastal Ocean Observation Lab

CENTER FOR COASTAL PHYSICAL OCEANOGRAPHY
OLD DOMINION UNIVERSITY




Google Earth
File Edit View Tools Add Help
Search
Fly To
Find Businesses
Directions
Fly to e.g., New York, NY
Places
Add Content
Big Bight Bathymetry
Radar Animation
mission2_ru16.kml
MARCOOS HF Radar Sites...
NERA HF Radar Sites.kmz
Jason Pass
41 10' 09" N, 70 52' 05" W
to
Jason Pass
39 12' 34" N, 72 16' 53" W
RU15 Summary
RIMPAC
wxstns.kmz
RUCool
webcams.travel
Layers
Primary Database
Geographic Web
Roads
3D Buildings
Street View
Borders and Labels
Traffic
Weather
Gallery
Ocean
Global Awareness
Places of Interest
More
Terrain
NAUS
ERRA
BLCK
MRCH
HOOK
LOVE
GRHD
BRIG
WILD
ASSA
CEDR
LISL
DUCK
HATY
377 km
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image USDA Farm Service Agency
Image © 2009 Commonwealth of Virginia
Image © 2009 TerraMetrics
39° 58.268' N 65° 31.072' W
©2009 Google
Eye alt 1212.63 km

Nested Standard Range Network



UCONN

UNIVERSITY OF Rhode Island

RUTGERS Coastal Ocean Observation Lab

University of Delaware 1743

CENTER FOR COASTAL PHYSICAL OCEANOGRAPHY

OLD DOMINION UNIVERSITY

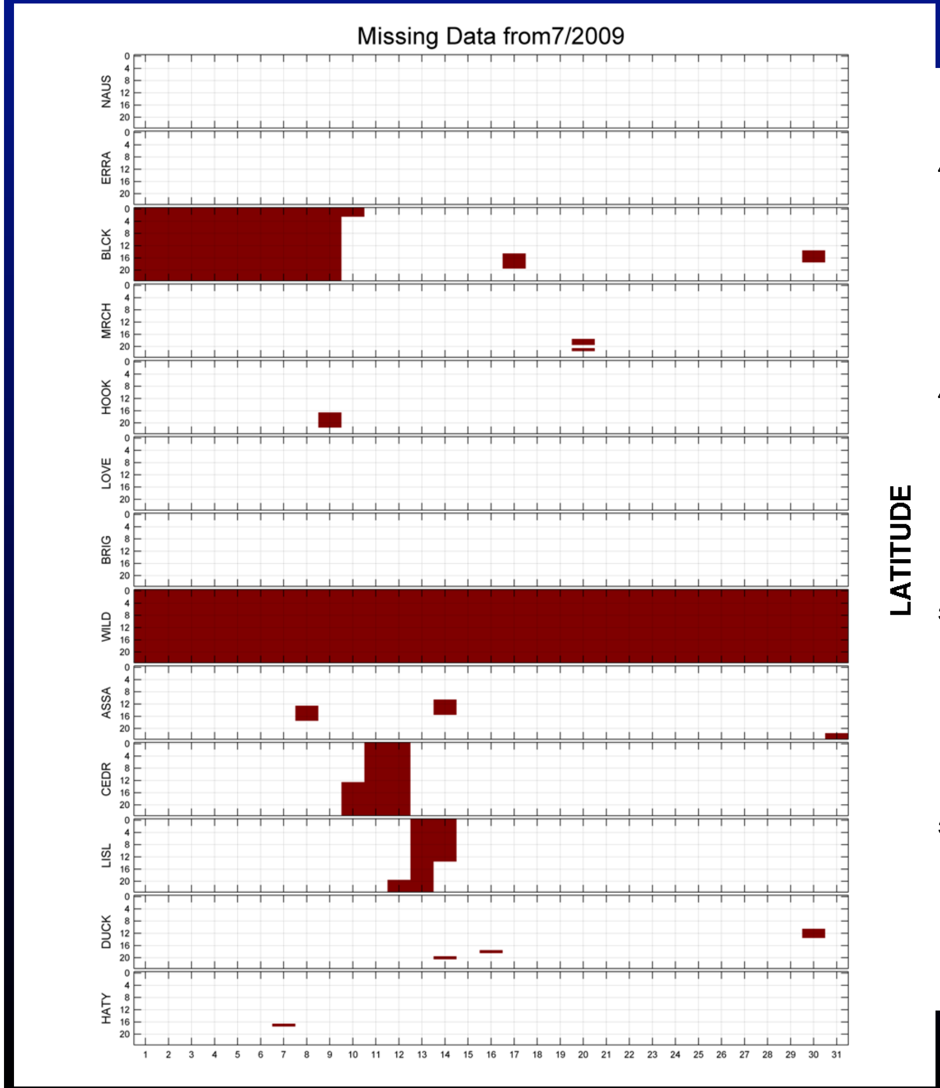

CEDAR ISLAND
2005


2009

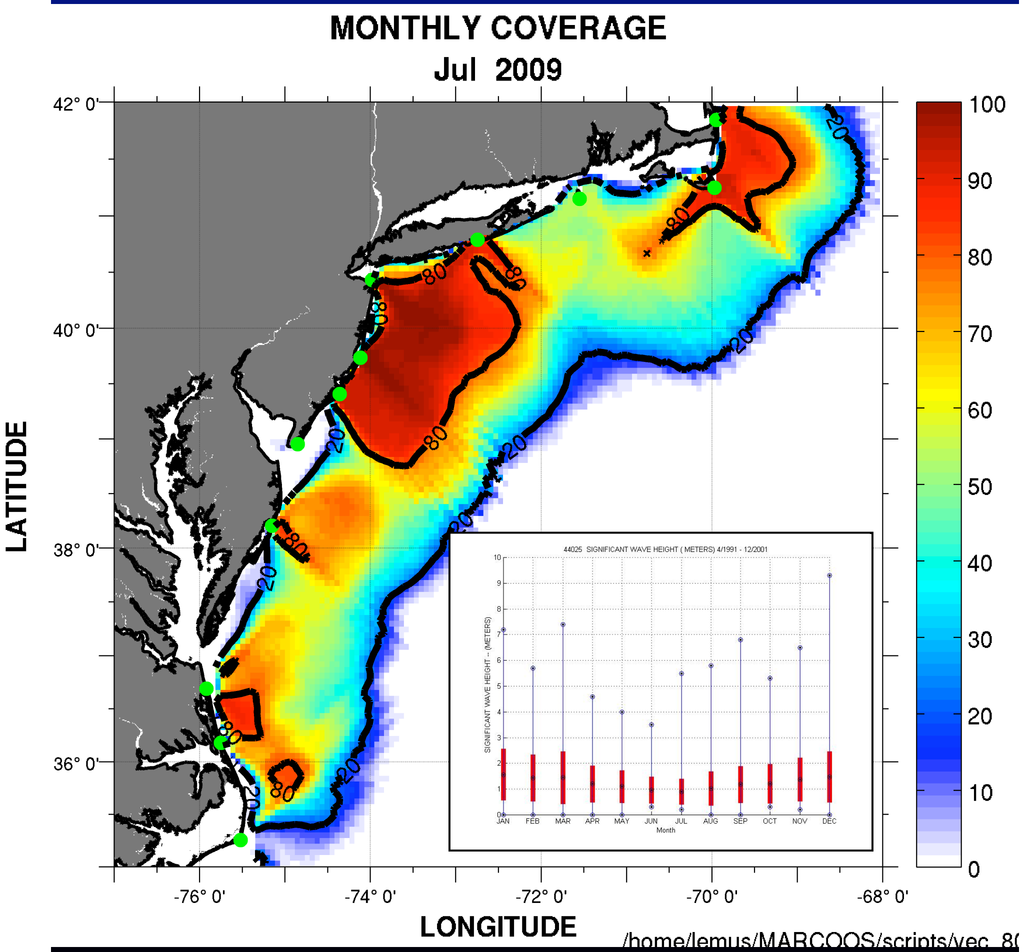

BLOCK ISLAND
2007


2009

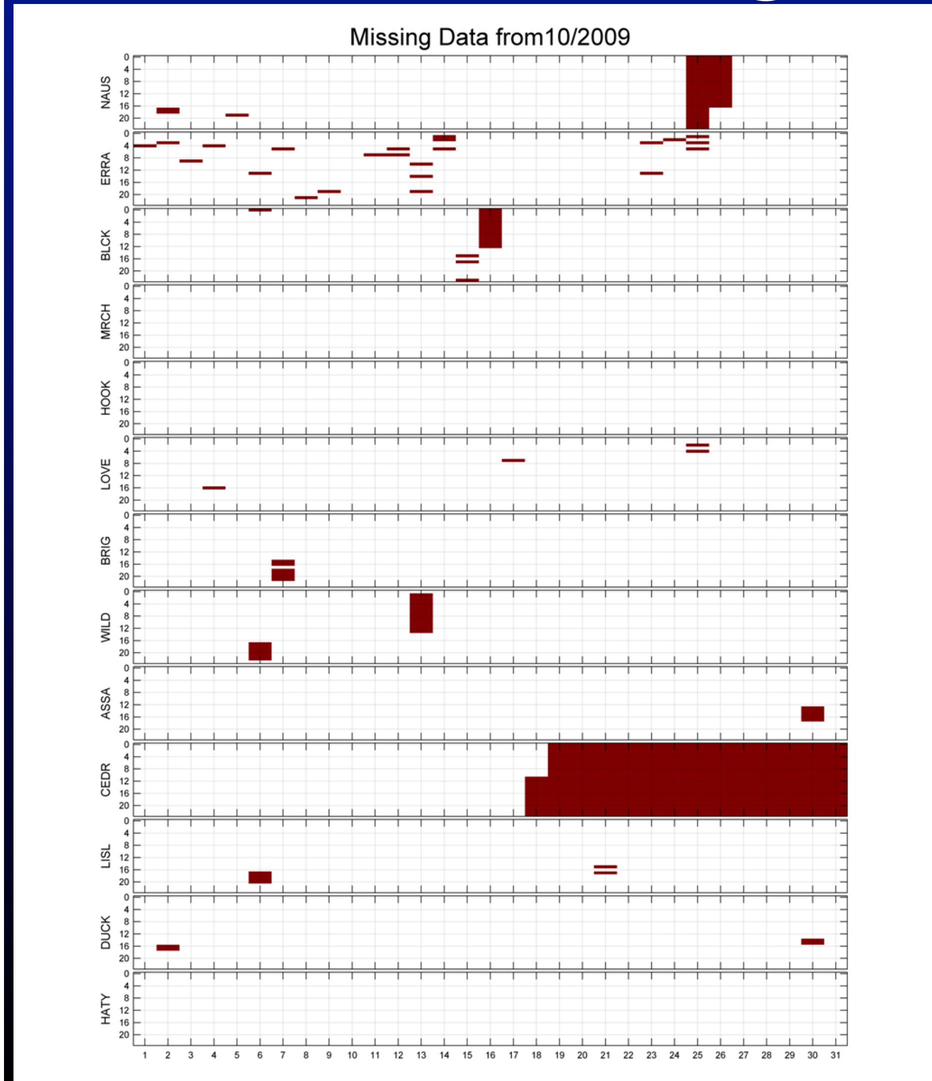
Radial Coverage



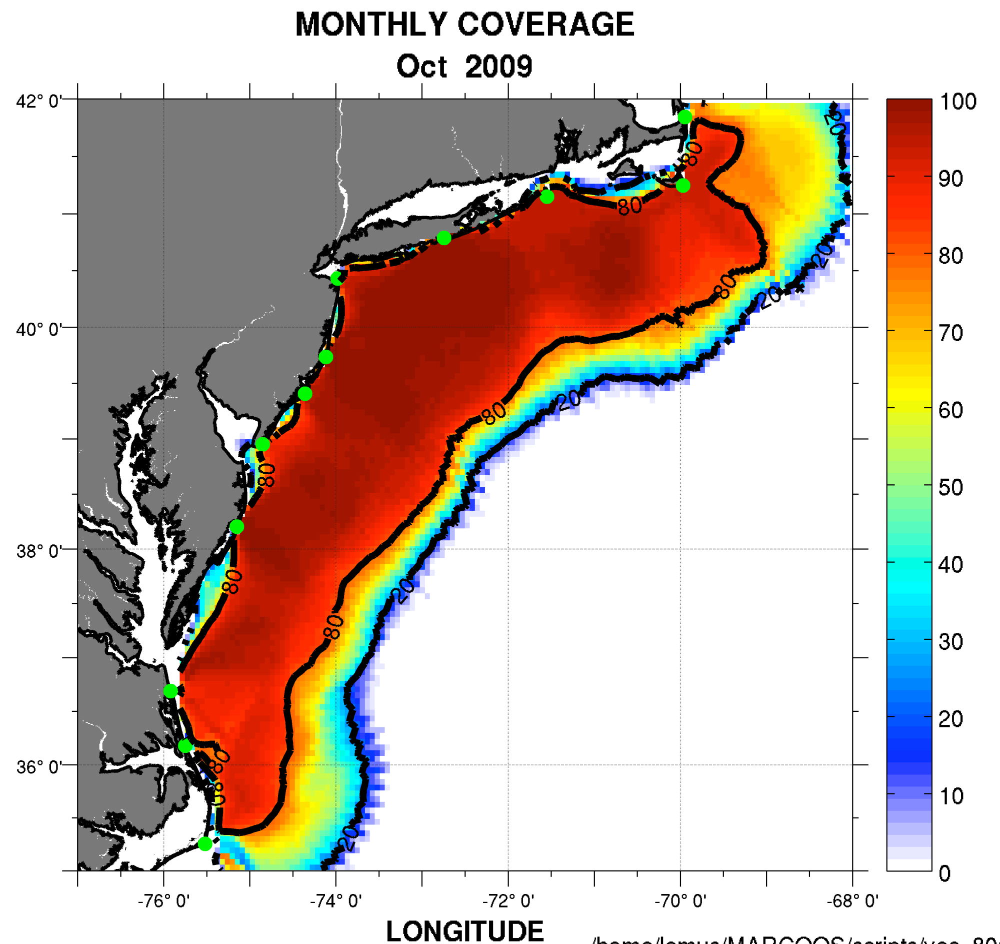
Total Coverage



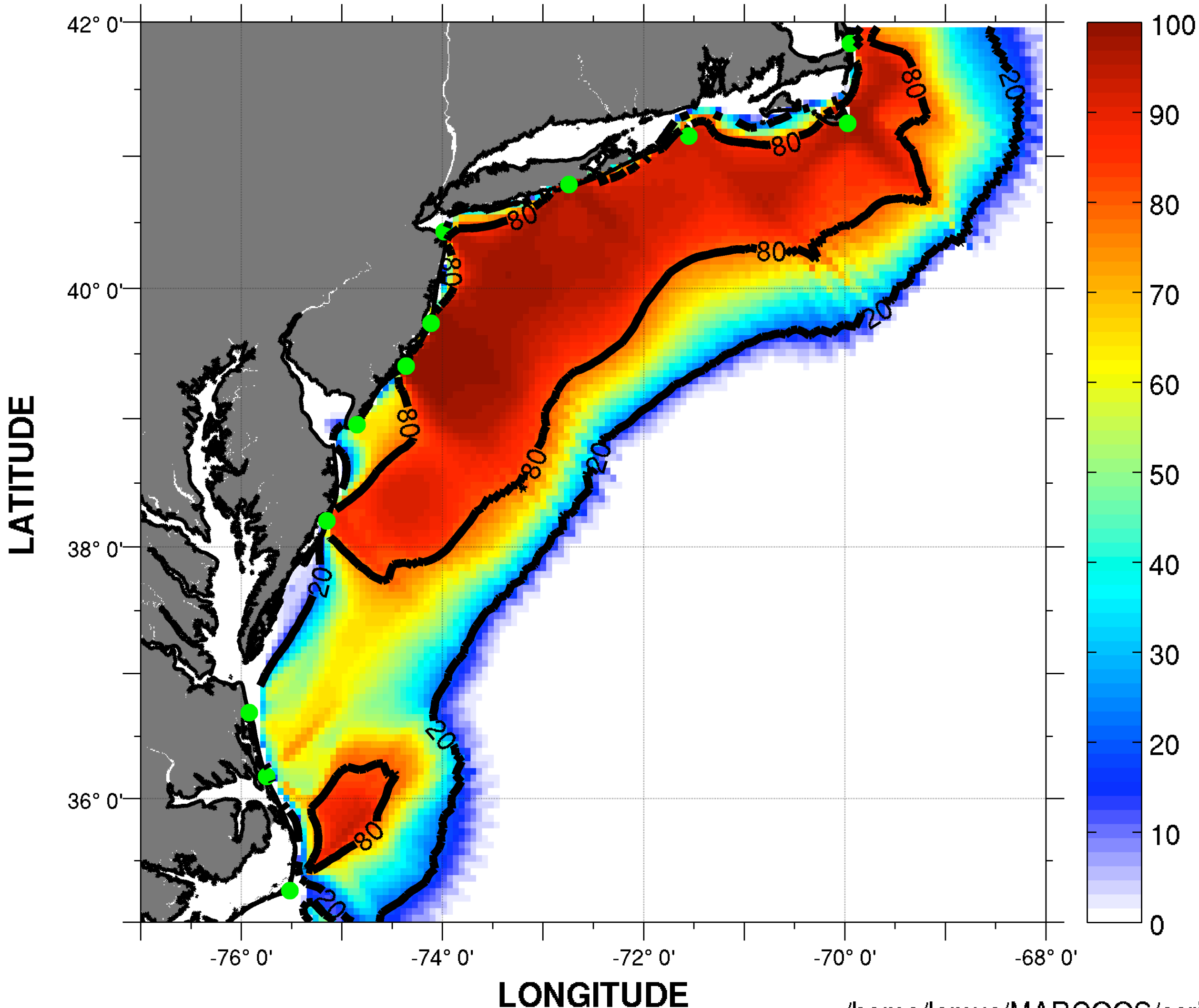
Radial Coverage



Total Coverage



2009
YEAR COVERAGE



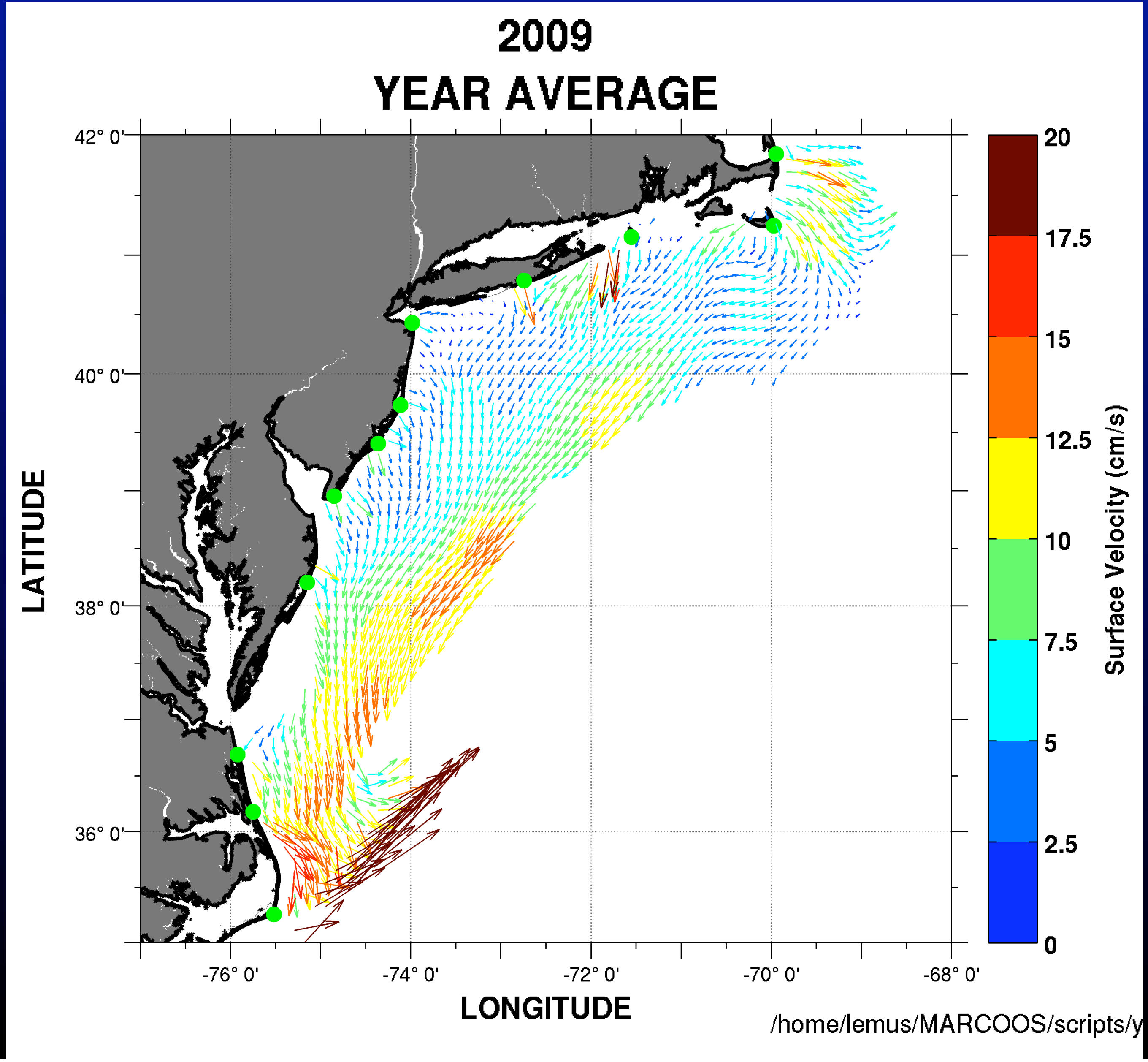
02/19/10

/home/lemus/MARCOOS/scripts/year_avg.m

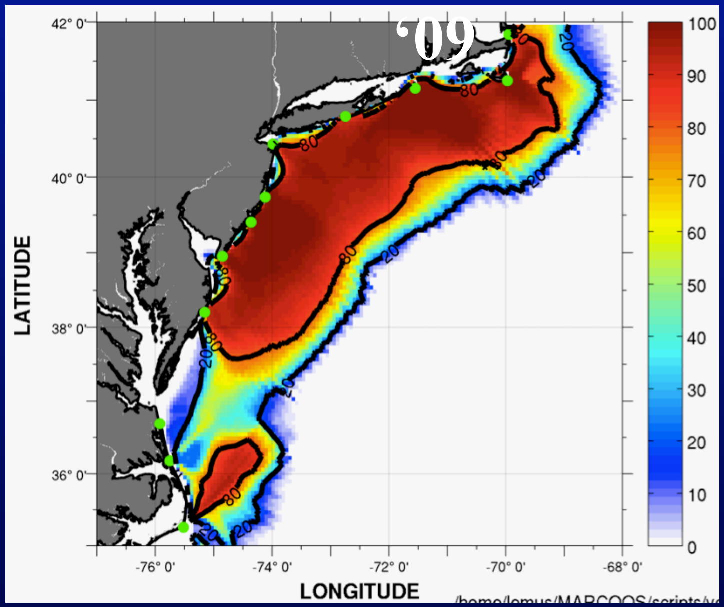
DEC 2008 to NOV 2009

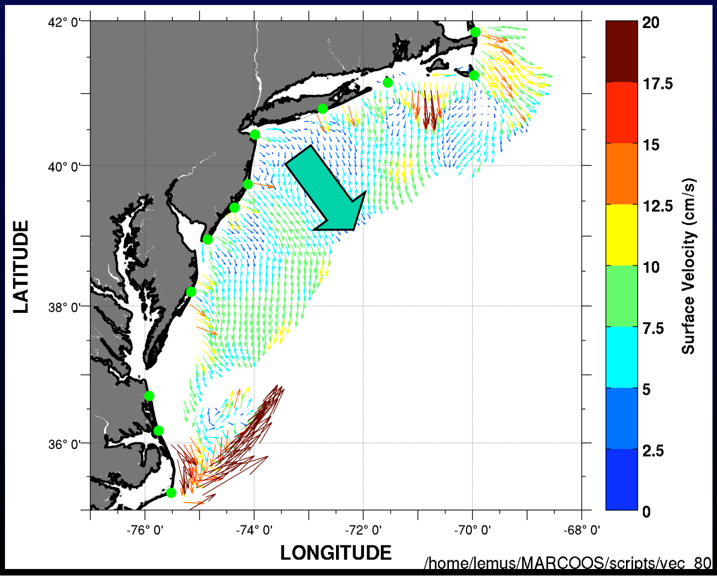
Every Other Vector Shown for Plotting Purposes

Temporal Coverage Greater than 50% Required for Plotting

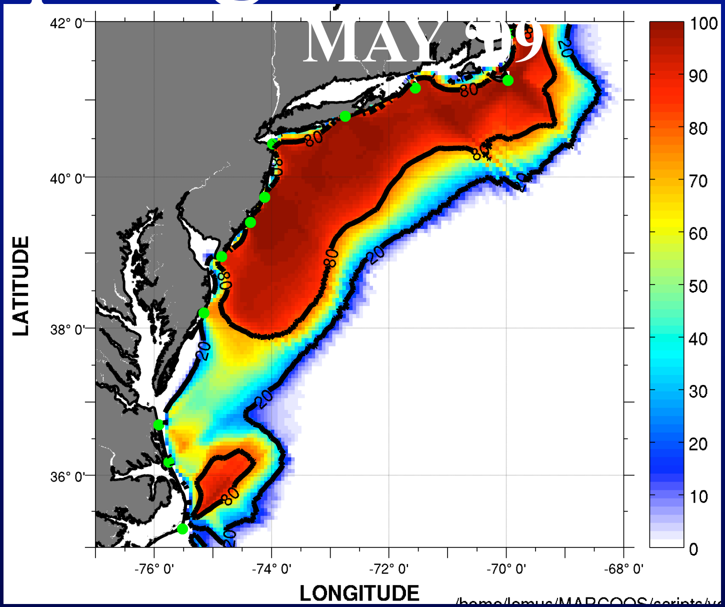


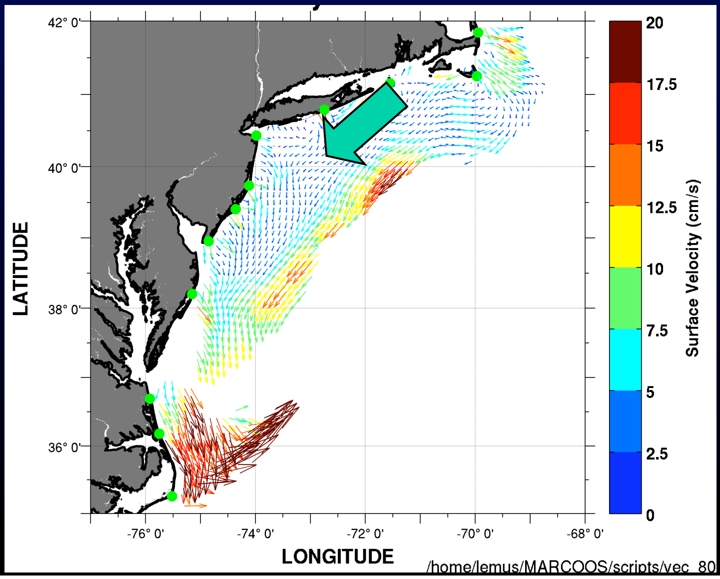
Winter DEC ’08 – FEB ’09



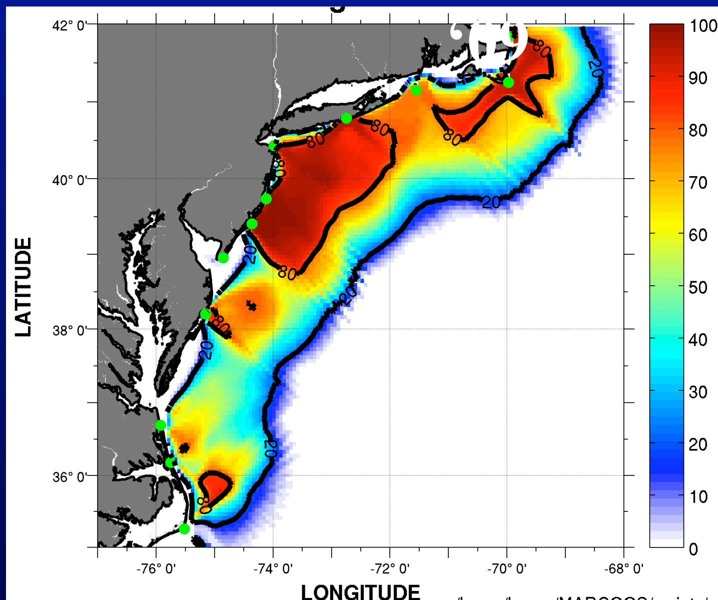


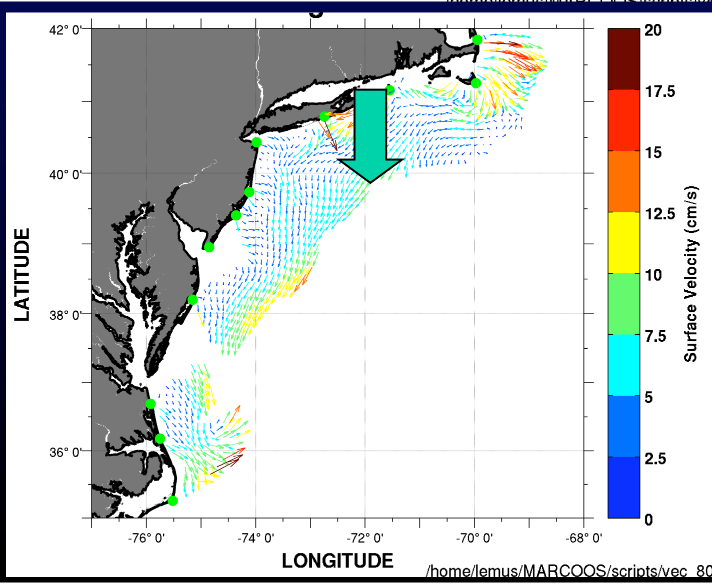
Spring MARCH ’09 – MAY ’09



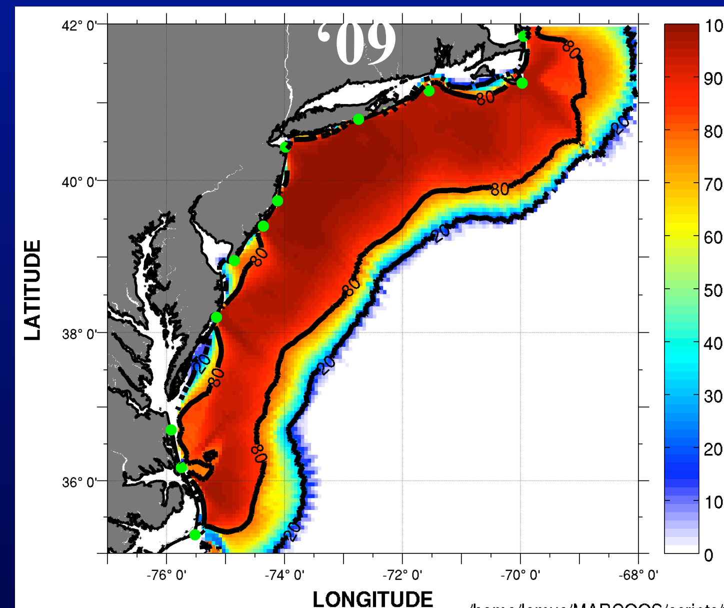


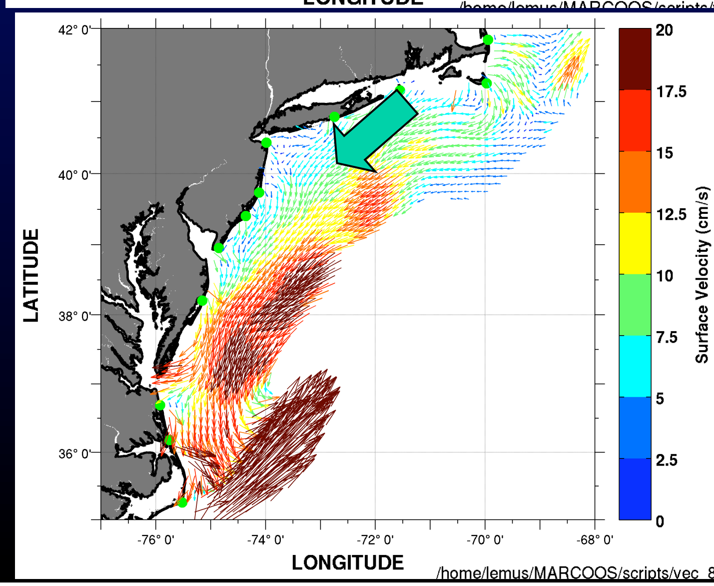
Summer JUNE '09 – AUG '09

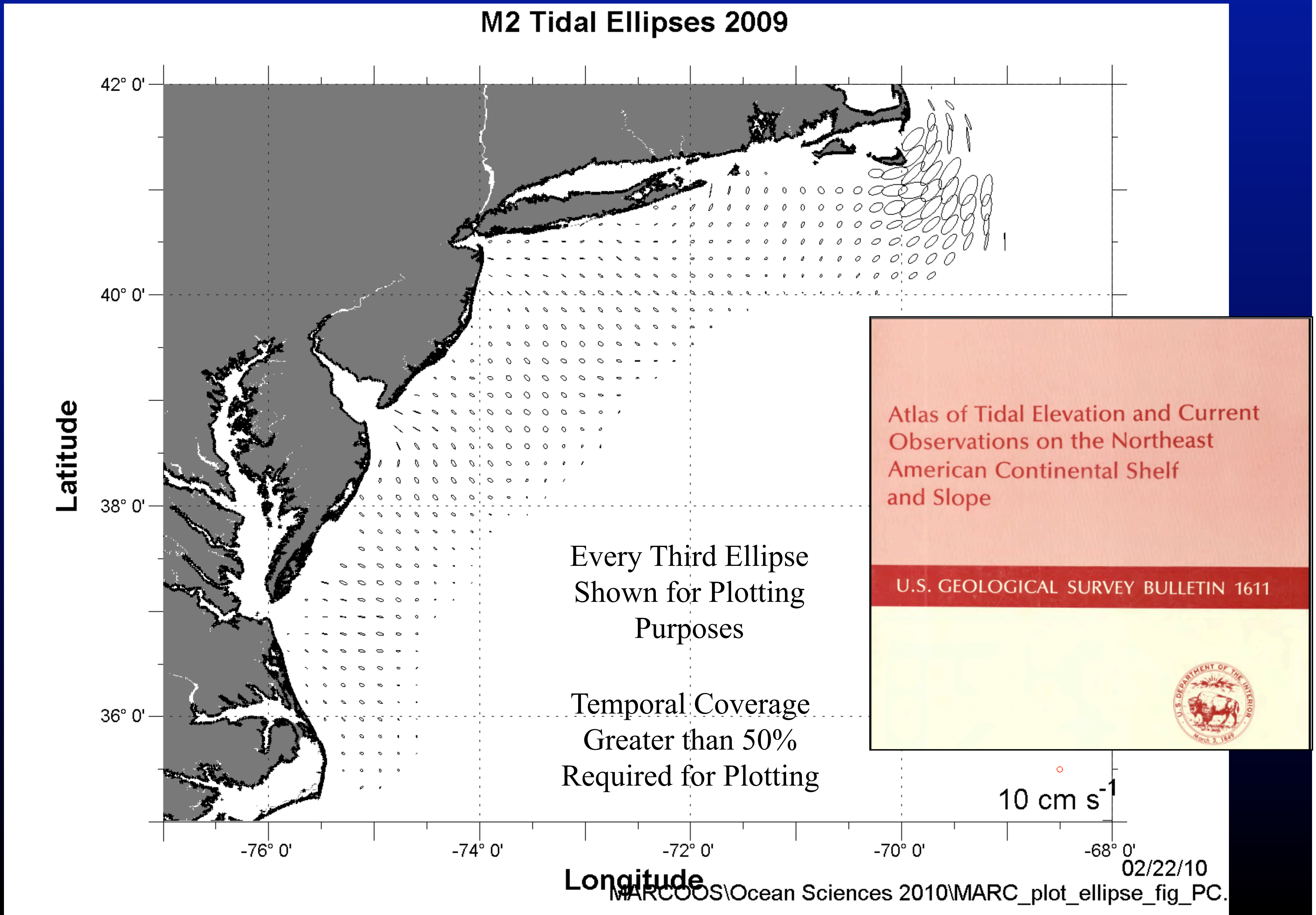




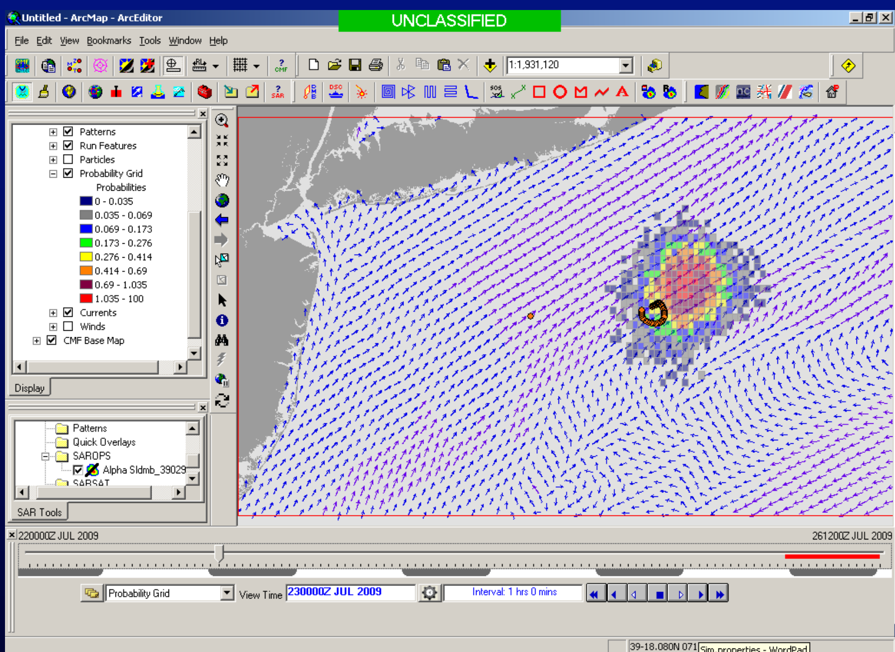
Fall SEPT '09 – NOV '09

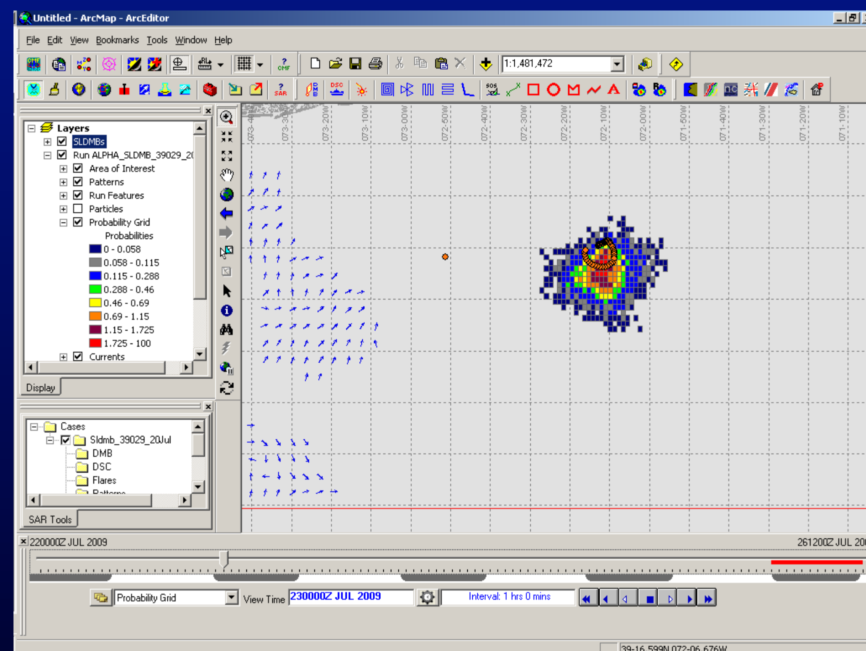





M2 Tidal Ellipses 2009
42° 0'
40° 0'
38° 0'
36° 0'
Latitude
-76° 0'
-74° 0'
-72° 0'
-70° 0'
-68° 0'
Longitude
Every Third Ellipse Shown for Plotting Purposes
Temporal Coverage Greater than 50% Required for Plotting
10 cm s-1
02/22/10
MARCOOS\Ocean Sciences 2010\MARC_plot_ellipse_fig_PC.
Atlas of Tidal Elevation and Current Observations on the Northeast American Continental Shelf and Slope
U.S. GEOLOGICAL SURVEY BULLETIN 1611

24 Hours Into Search





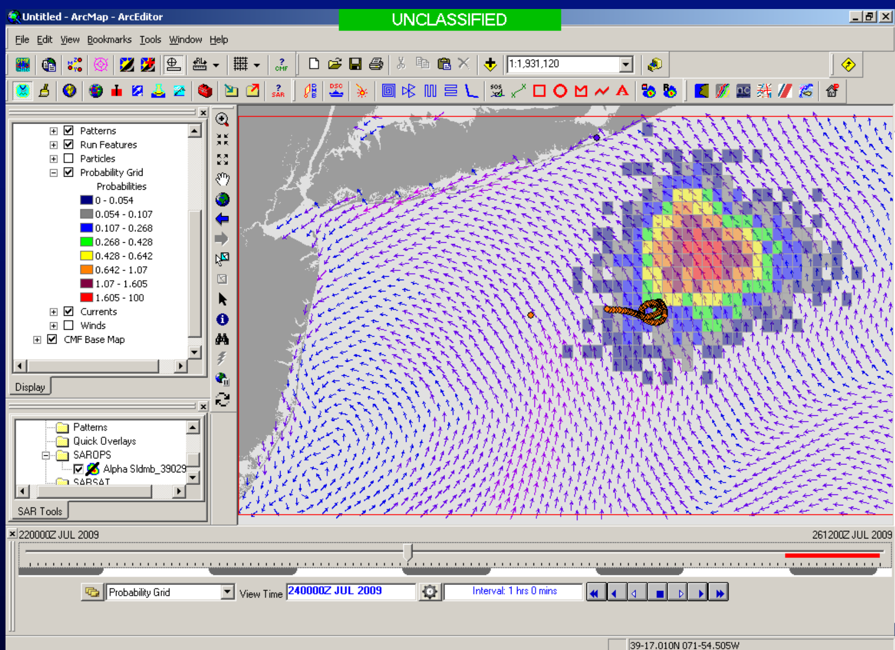
HYCOM

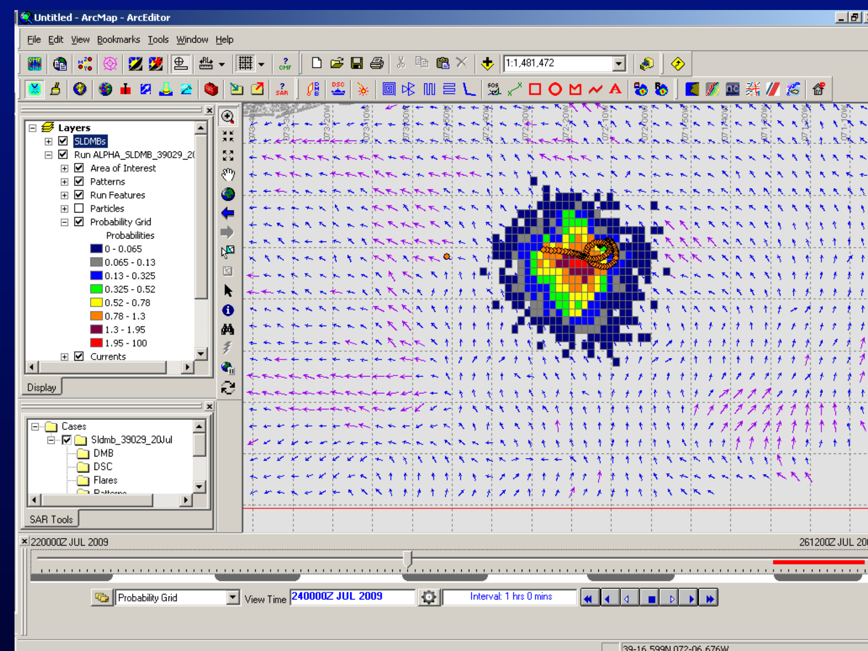
Low Confidence

HF Radar

High Confidence

48 Hours Into Search





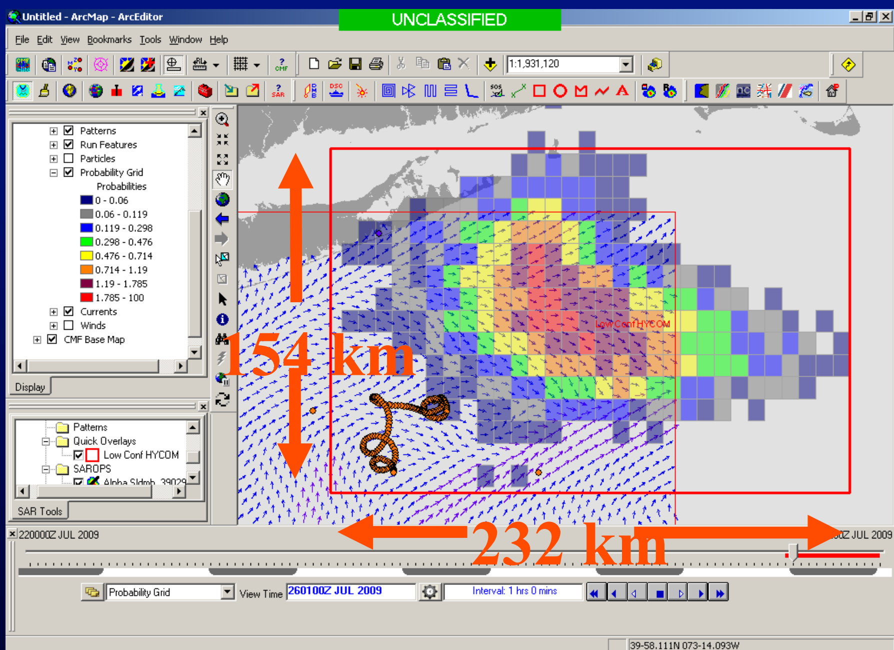
HYCOM

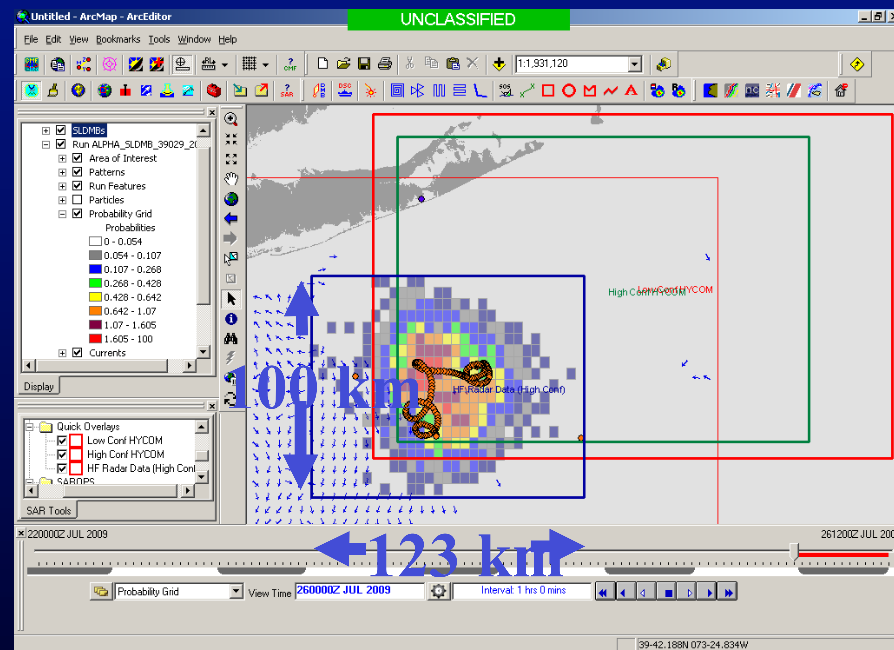
Low Confidence

HF Radar

High Confidence

Search Area After 96 Hours





HYCOM	HF Radar
36,000 km^2	12,000 km^2
10,500 nmi^2	3,500 nmi^2

What do the subsurface remote sensing platforms look like?

Large and medium-sized AUVs

Thanks to Gwynn Griff

Autosub
Southampton Oceanography Centre

Hugin
Kongsberg Simrad, Norway

Martin-600
Maridan, Denmark

Explorer family
ISE Research, Canada

Odyssey
Bluefin Robotics, USA

What will the subsurface remote sensing platforms look like?
AUVs do not need to be large …

Thanks to Gwynn Griff

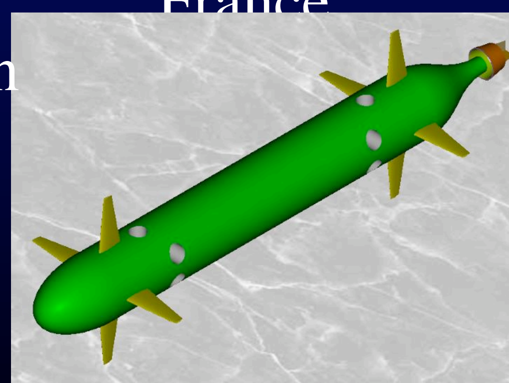
Slocum glider Rutgers

The Mauve AUV
France

Remus - a 1.8 m long AUV
Hydroid Inc., USA

Sea glider U. Washington
& APL, USA

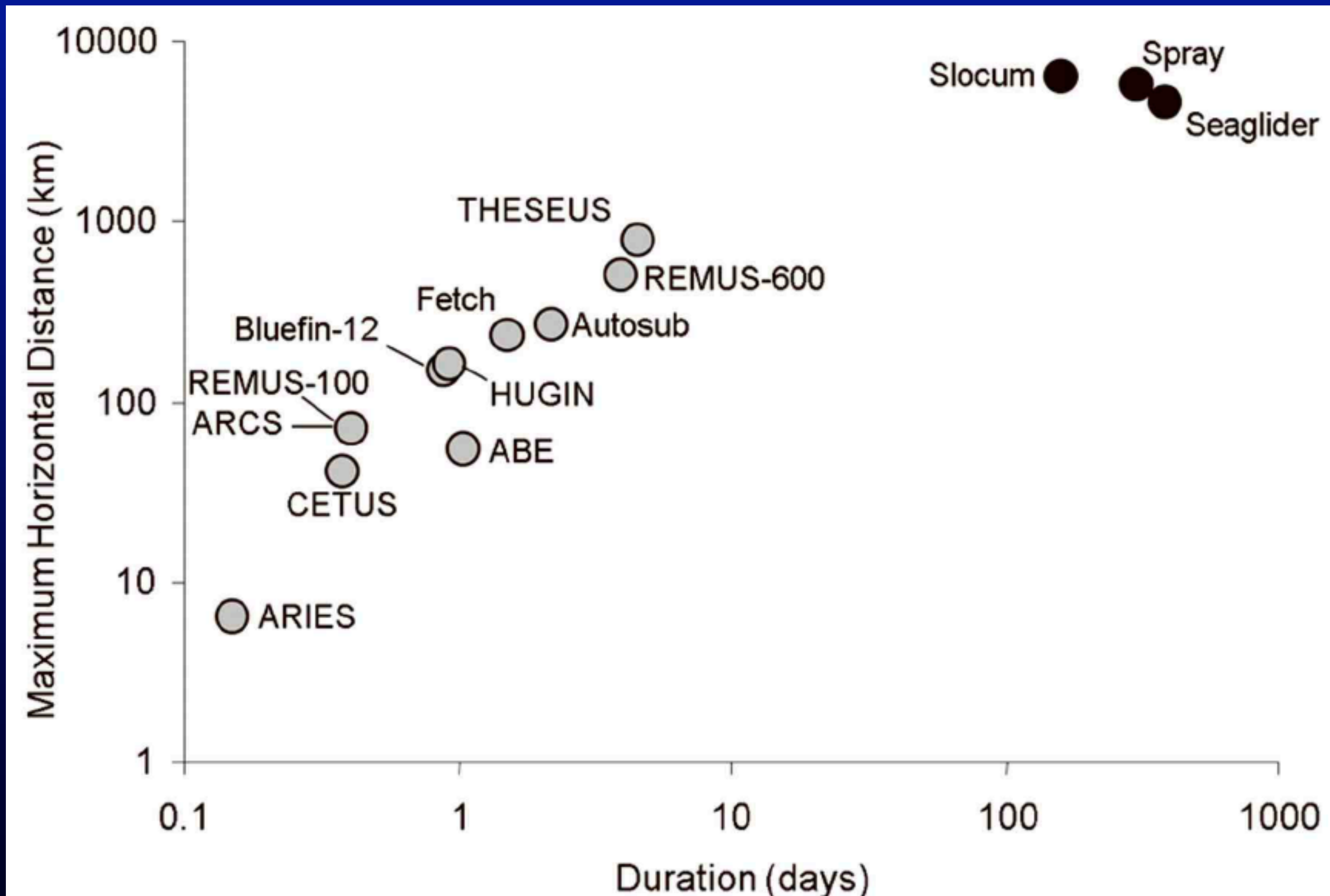
Spray glider, Scripps Inst.
Oceanography USA



C-Scout, IMD, Canada

Gavia - a one person AUV
Hafmynd, Iceland

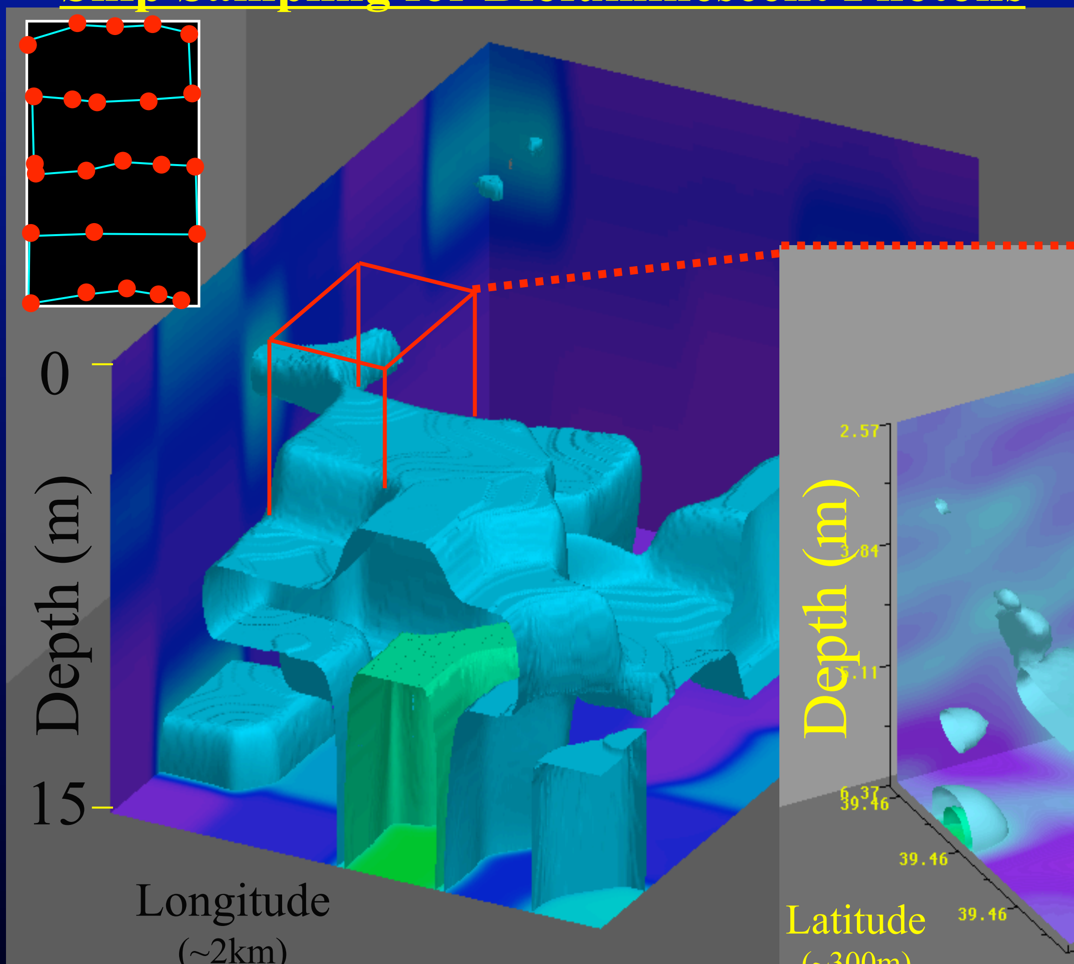
Range of space and time regions can be covered effectively.



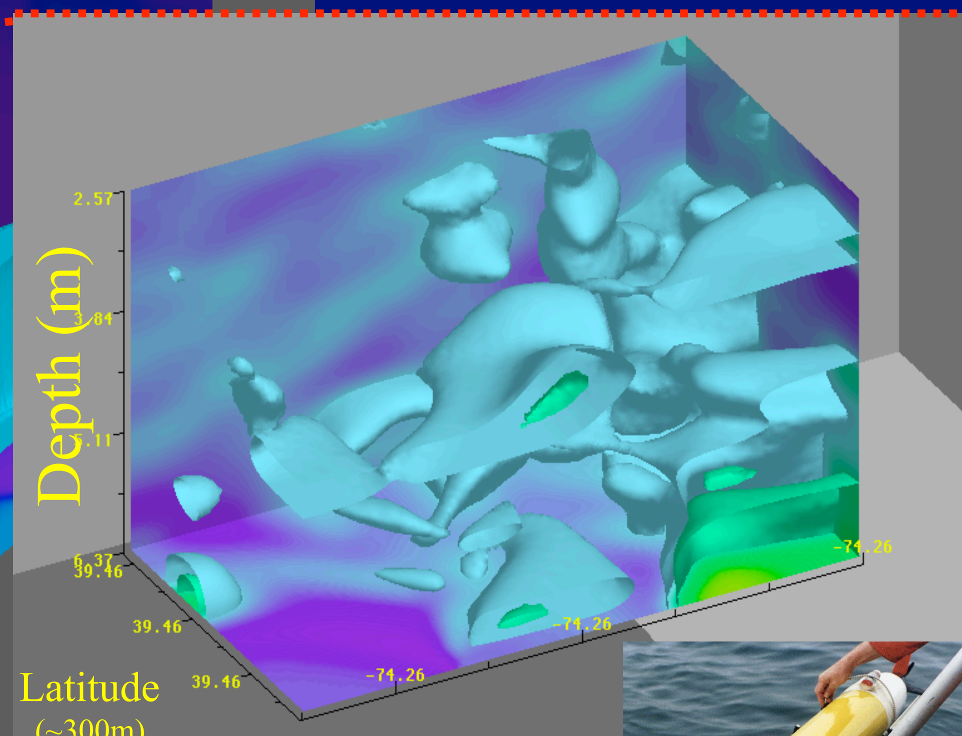
Moline & Schofield 2009 J. Atm Oce Tech

Oceans are complex and hard to sample: Small scale variability

Ship Sampling for Bioluminescent Photons

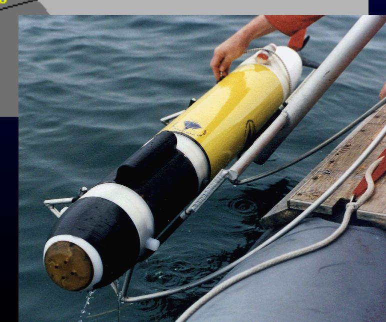


Robot Sampling for Bioluminescent Photons

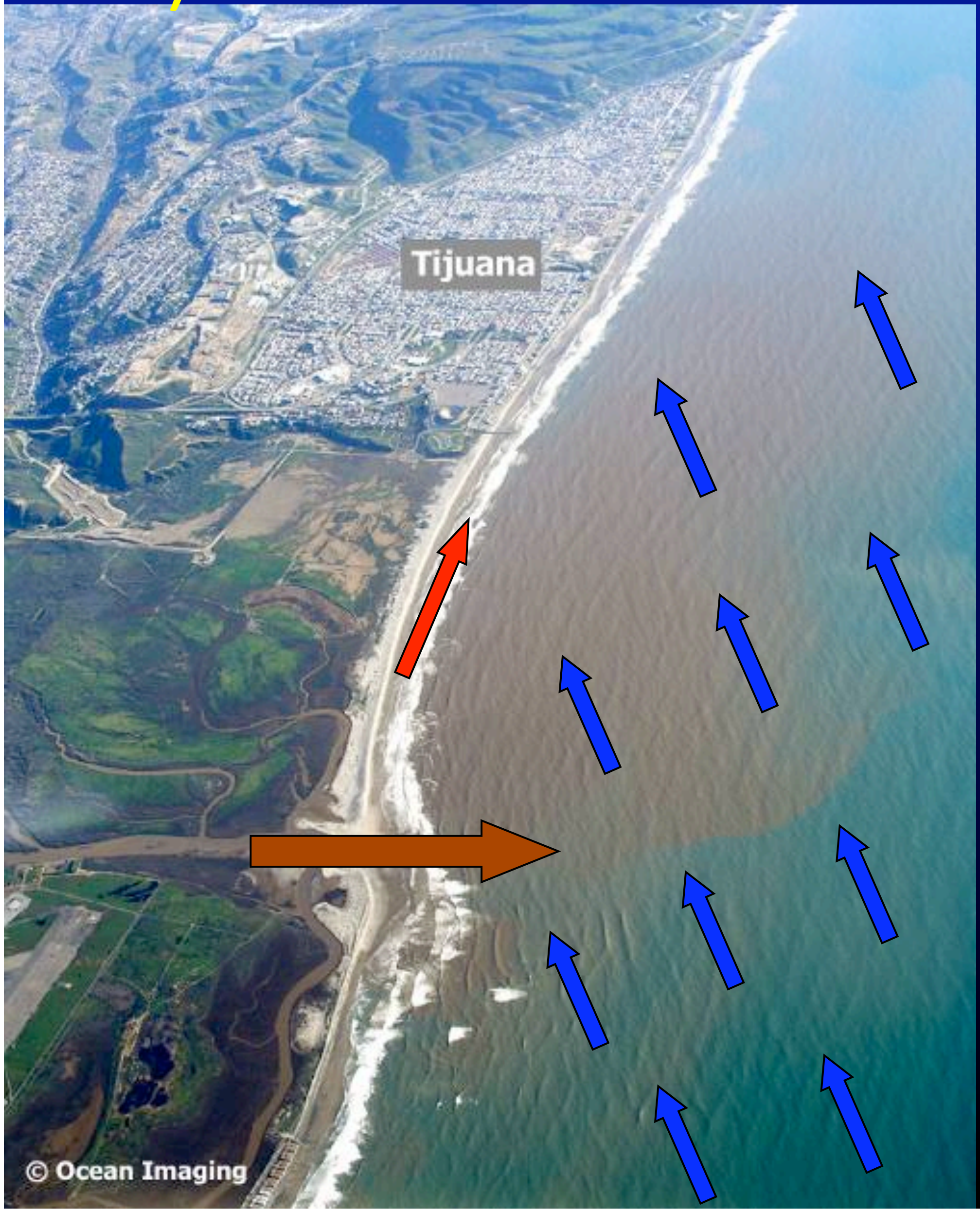


Thanks to Moline

1E10 bioluminscent photons/s   3E10 bioluminscent photons/s



2) Coastal Processes Study

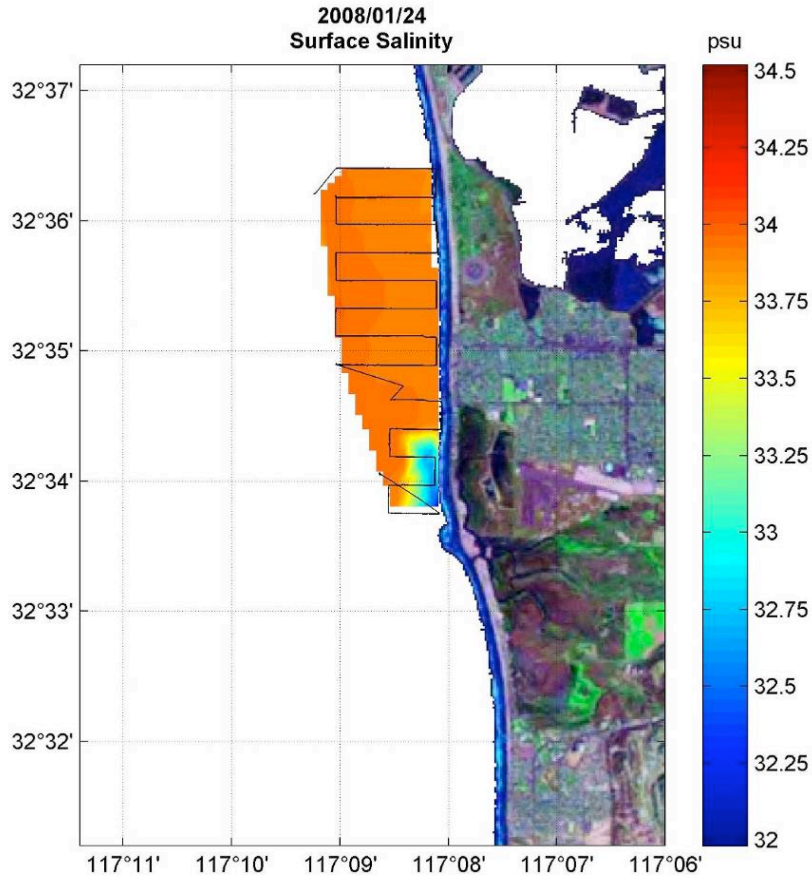


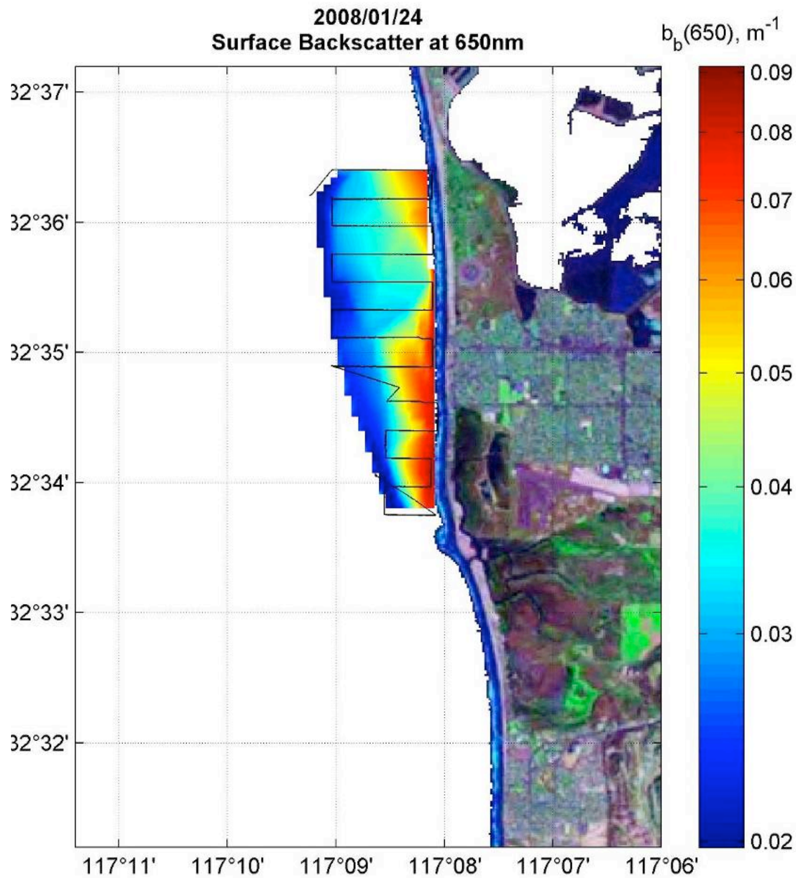
Scaling issues between:

- Discharge jet
- Offshore advection
- Surfzone mixing – wave driven transport

•DELFT 3D being used to test interplay between momentum of discharge jet, width of breaking and strength of wave driven currents in surf and width of surfzone, and offshore transport

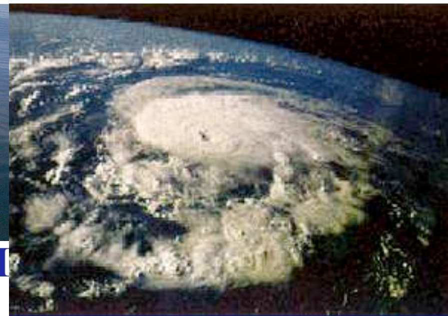
•Model runs showing

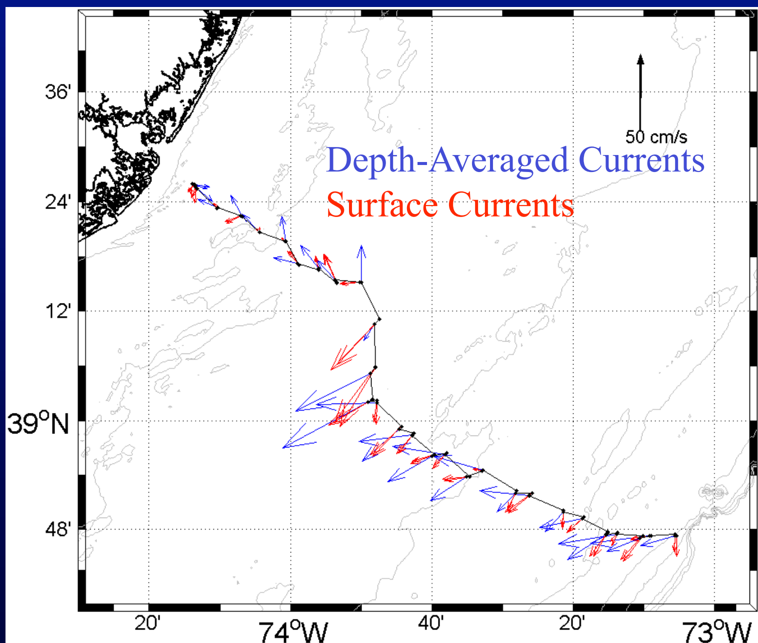


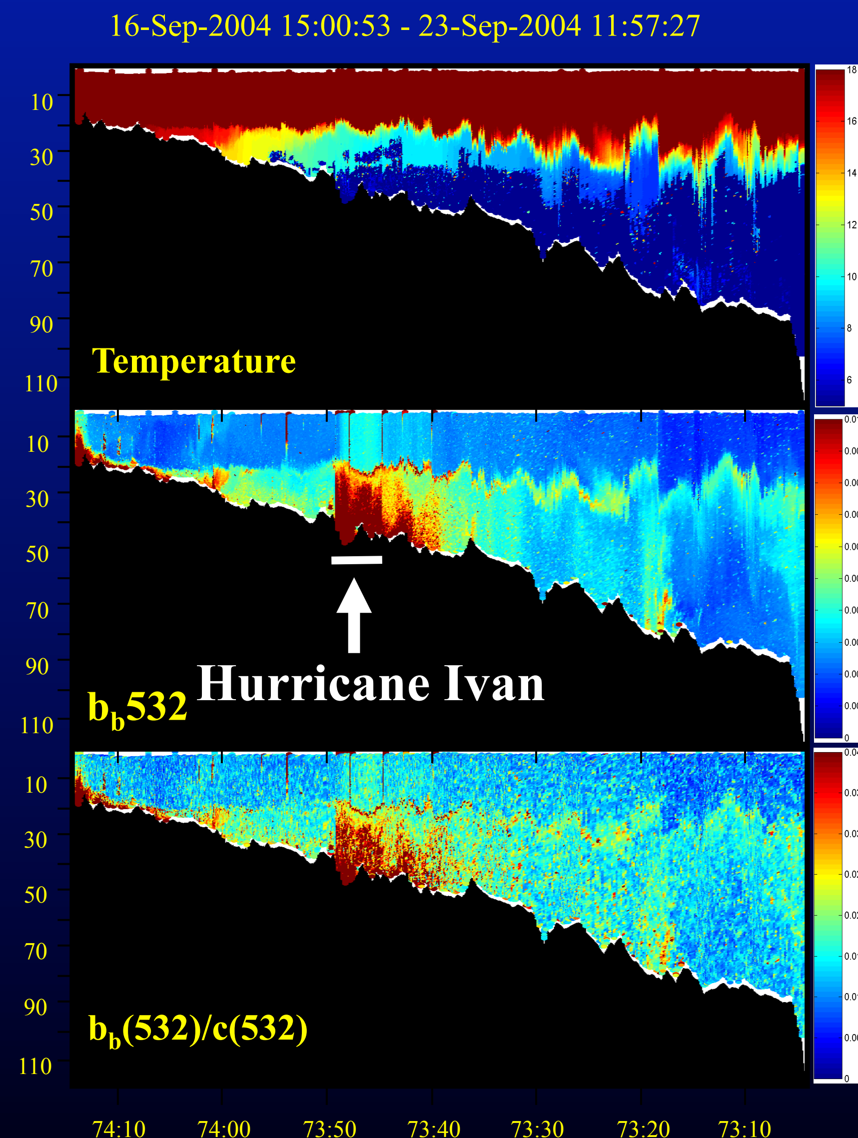


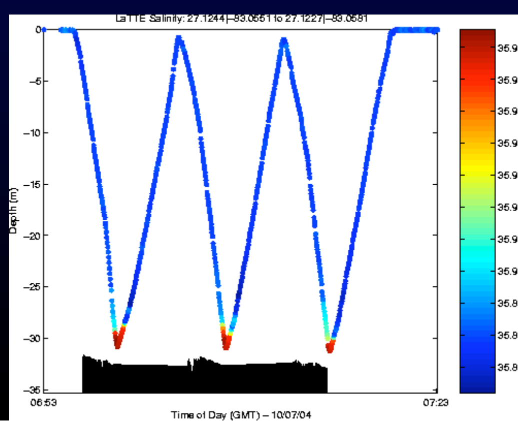
Example of mapping a freshwater plume out of the Tijuana River. Plume moving north. Salinity on left, optical scatter (turbidity) on right. Mapped with REMUS 100 – HF RADAR Surface currents used for mission planning.


WEBB RESEARCH
CORPORATION

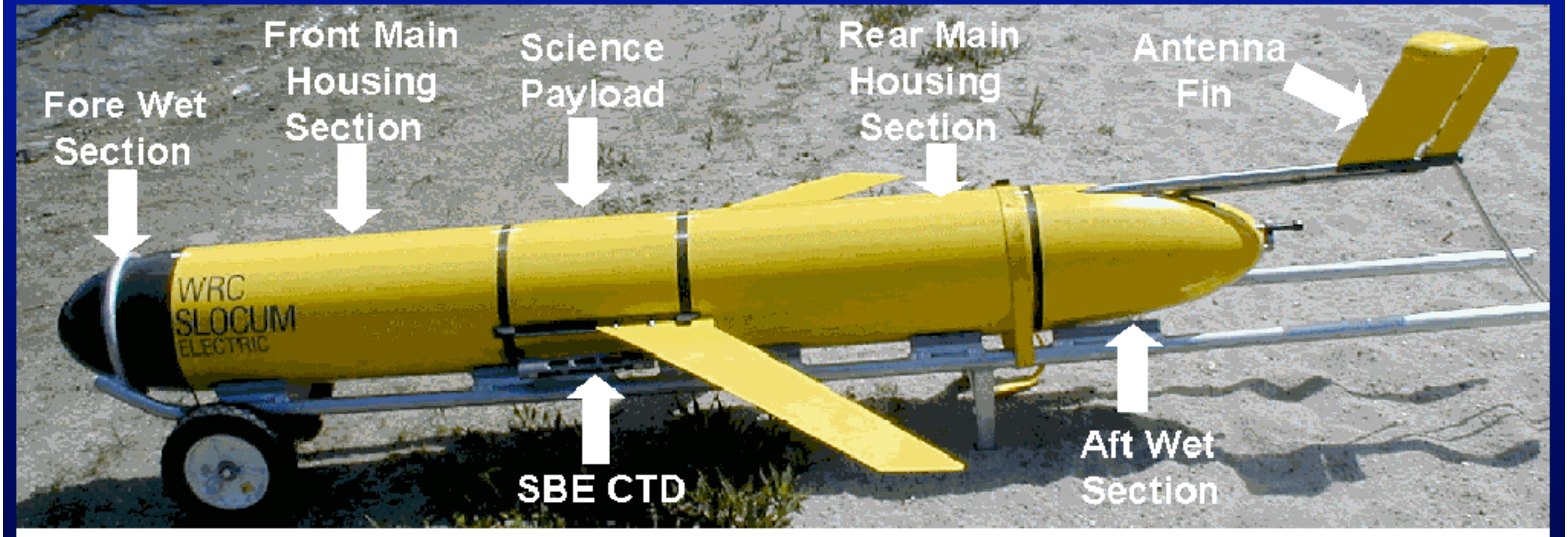



50 cm/s
Depth-Averaged Currents
Surface Currents
36'
24'
12'
39°N
48'
20'
74°W
40'
20'
73°W


16-Sep-2004 15:00:53 - 23-Sep-2004 11:57:27
Temperature
b_b532
Hurricane Ivan
b_b(532)/c(532)
74:10
74:00
73:50
73:40
73:30
73:20
73:10


LaTTE Salinity: 27.1244|−93.0551 to 27.1227|−93.0581
Depth (m)
Time of Day (GMT) – 10/07/04
06:53
07:23

Slocum Coastal Glider

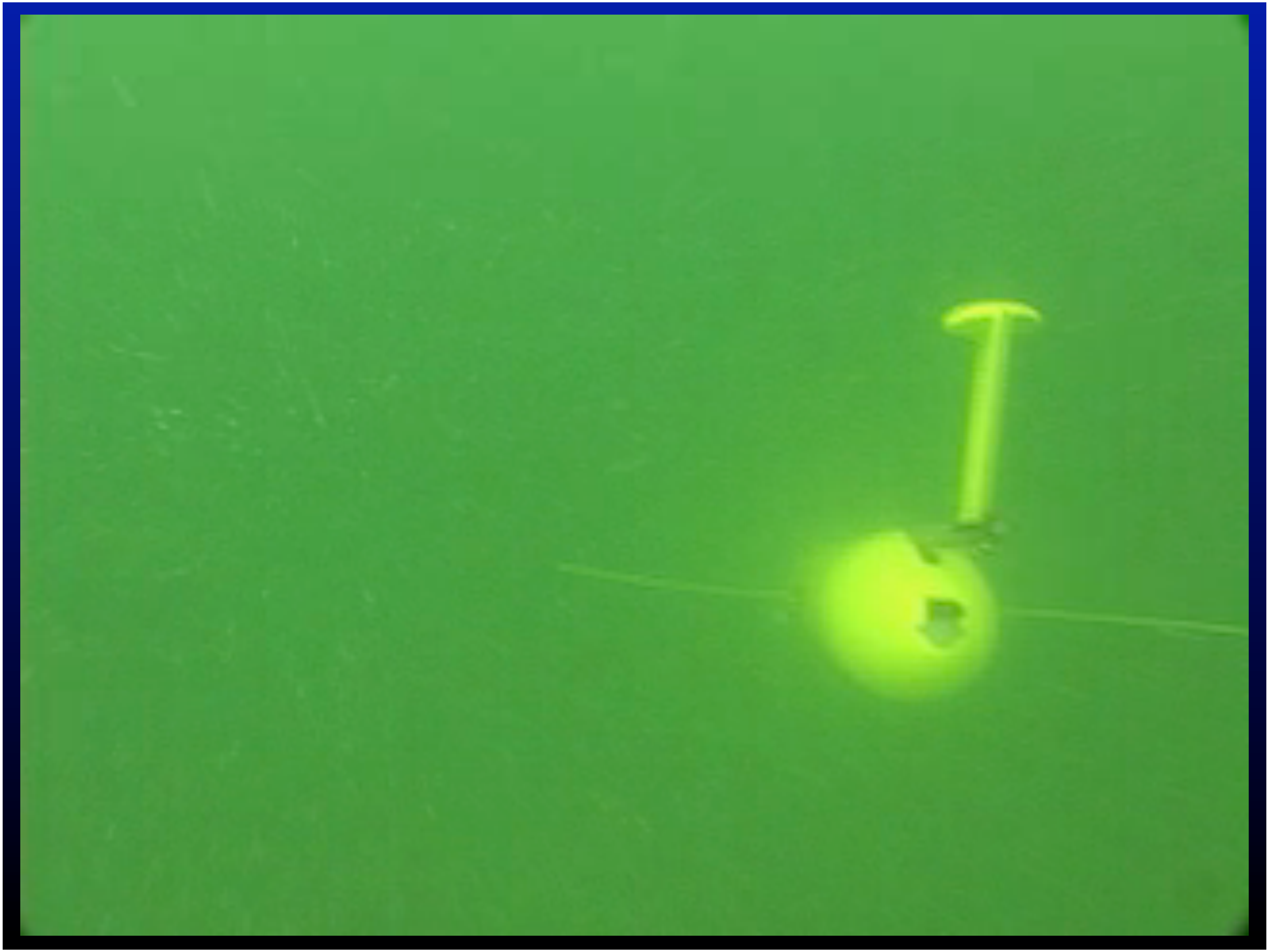


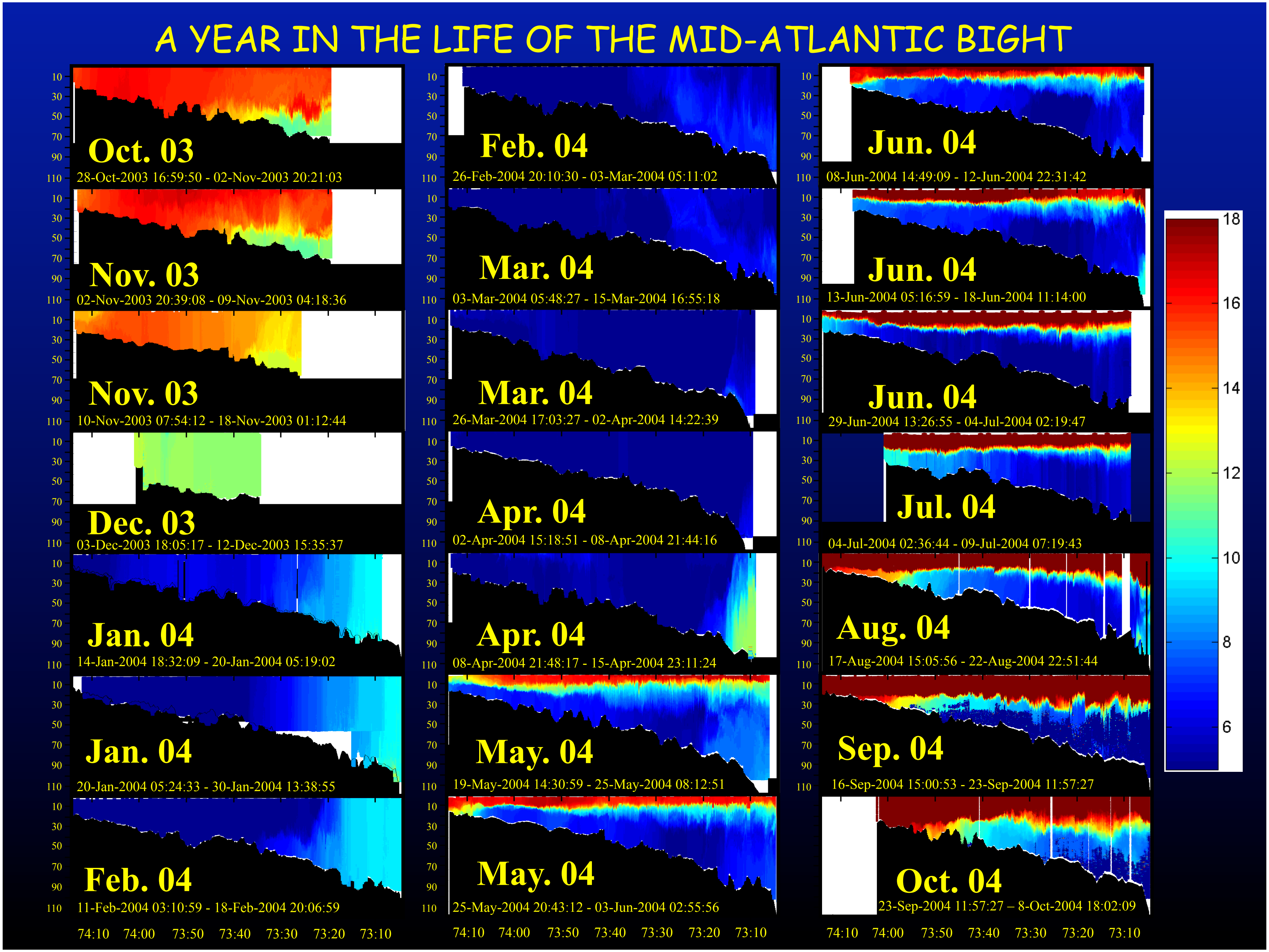
Glider Specs.

Length: 1.5 m Hull Diameter: 21.3 cm
Weight: 52 kg

Science Bay Specs.

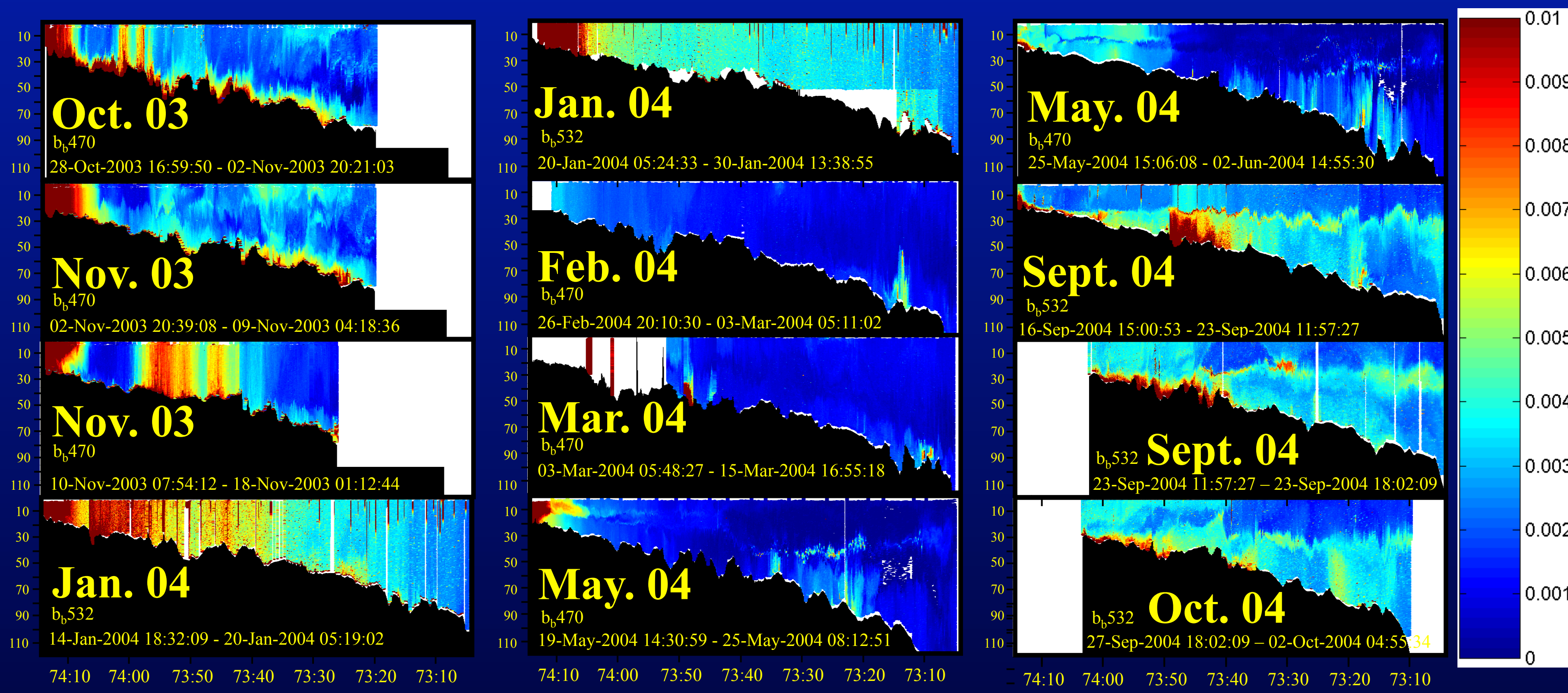
Length: 30 cm Diameter: 21.3 cm
Max. Payload Weight: 4 kg





A YEAR IN THE LIFE OF THE MID-ATLANTIC BIGHT
Oct. 03
28-Oct-2003 16:59:50 - 02-Nov-2003 20:21:03
Nov. 03
02-Nov-2003 20:39:08 - 09-Nov-2003 04:18:36
Nov. 03
10-Nov-2003 07:54:12 - 18-Nov-2003 01:12:44
Dec. 03
03-Dec-2003 18:05:17 - 12-Dec-2003 15:35:37
Jan. 04
14-Jan-2004 18:32:09 - 20-Jan-2004 05:19:02
Jan. 04
20-Jan-2004 05:24:33 - 30-Jan-2004 13:38:55
Feb. 04
11-Feb-2004 03:10:59 - 18-Feb-2004 20:06:59
Feb. 04
26-Feb-2004 20:10:30 - 03-Mar-2004 05:11:02
Mar. 04
03-Mar-2004 05:48:27 - 15-Mar-2004 16:55:18
Mar. 04
26-Mar-2004 17:03:27 - 02-Apr-2004 14:22:39
Apr. 04
02-Apr-2004 15:18:51 - 08-Apr-2004 21:44:16
Apr. 04
08-Apr-2004 21:48:17 - 15-Apr-2004 23:11:24
May. 04
19-May-2004 14:30:59 - 25-May-2004 08:12:51
May. 04
25-May-2004 20:43:12 - 03-Jun-2004 02:55:56
Jun. 04
08-Jun-2004 14:49:09 - 12-Jun-2004 22:31:42
Jun. 04
13-Jun-2004 05:16:59 - 18-Jun-2004 11:14:00
Jun. 04
29-Jun-2004 13:26:55 - 04-Jul-2004 02:19:47
Jul. 04
04-Jul-2004 02:36:44 - 09-Jul-2004 07:19:43
Aug. 04
17-Aug-2004 15:05:56 - 22-Aug-2004 22:51:44
Sep. 04
16-Sep-2004 15:00:53 - 23-Sep-2004 11:57:27
Oct. 04
23-Sep-2004 11:57:27 – 8-Oct-2004 18:02:09
10 30 50 70 90 110
74:10 74:00 73:50 73:40 73:30 73:20 73:10
18 16 14 12 10 8 6

NJSOS Endurance Line: Seasonal Cross-Shelf Optical Backscatter Transects



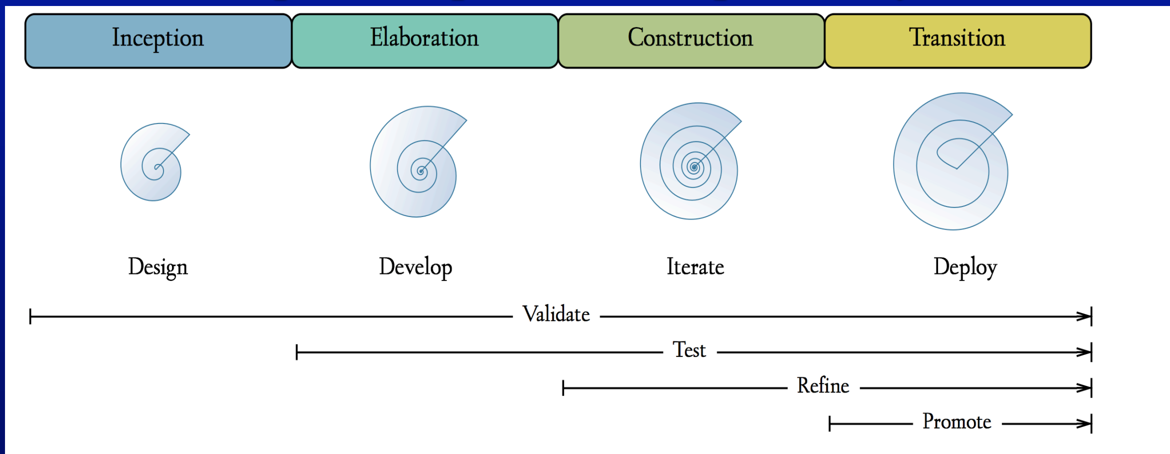
Science Findings

A) Storms lead to massive resuspension in the winter and early spring. After summer stratification storm induced mixing rarely mixes particles through the strong MAB pycnoclines, but lift material to the pynocline base.

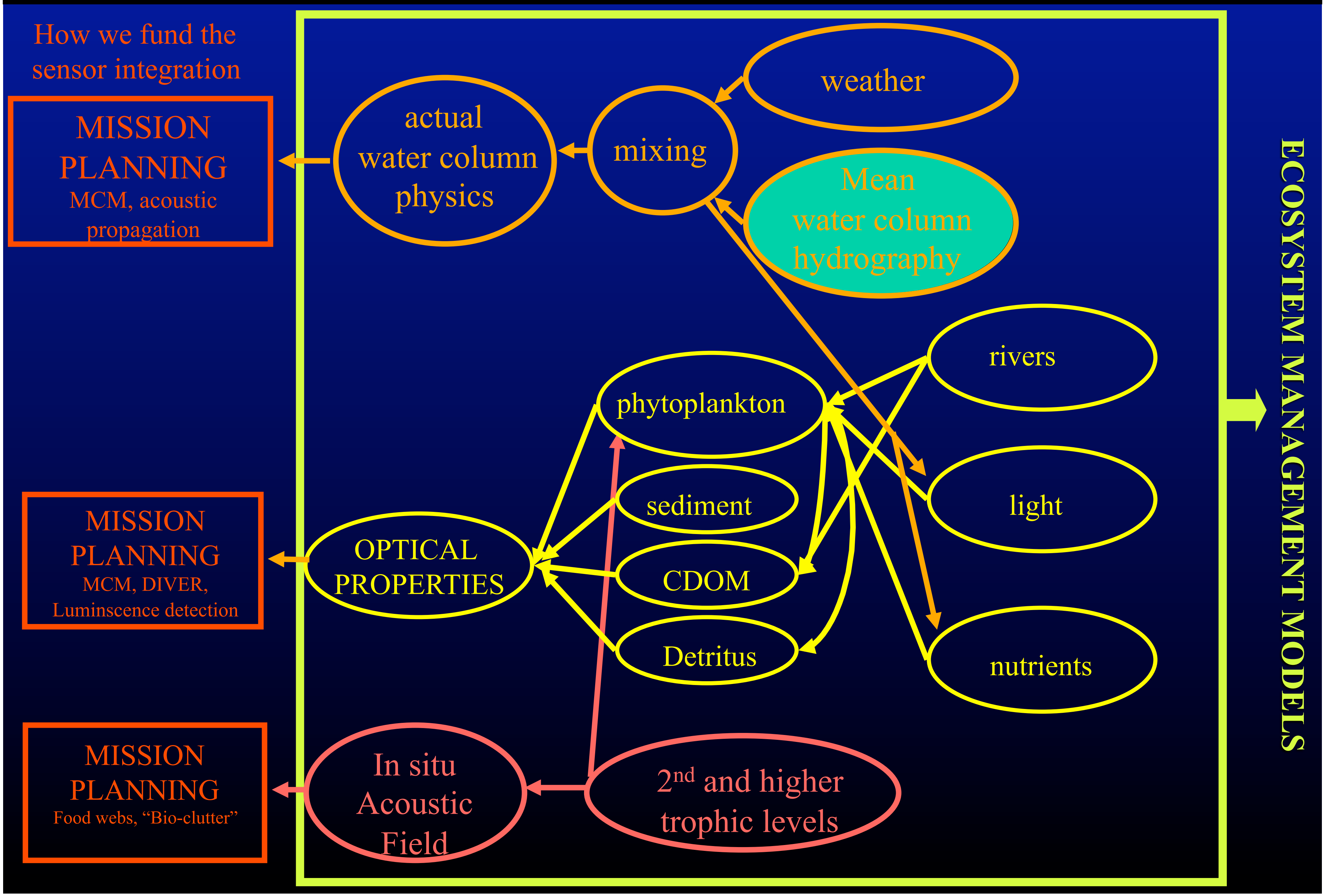
B) Particles accumulate in the cold pool and then are then advected back to shore in the summer.

C) Particle distributions are best described by haloclines on the MAB

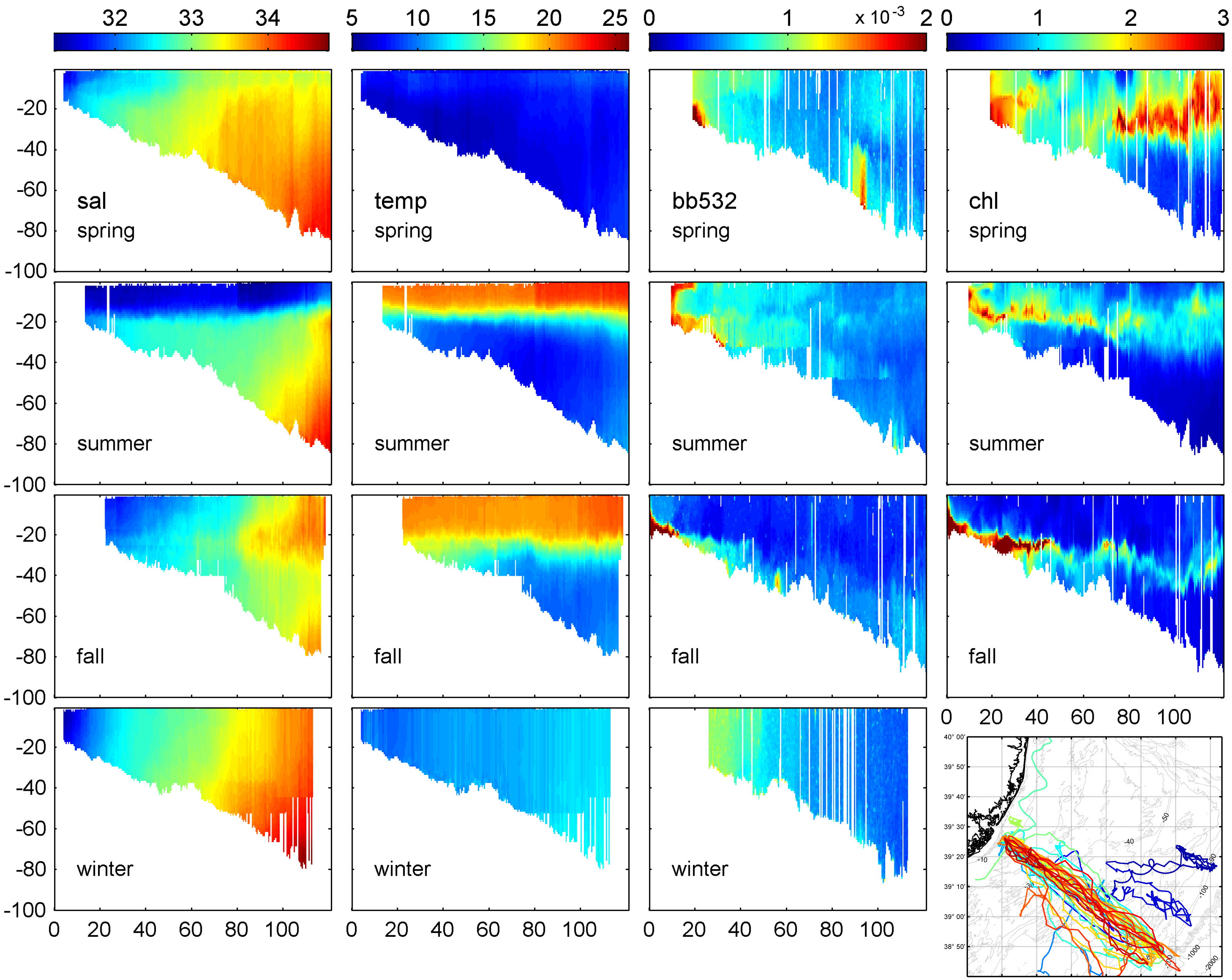
Rutgers, Webb Research, and Instrument Companies Spiral Development Cycle



Gliders will be used to assist numerous applied mission planning and simultaneously provide the first subsurface network capable of enabling ecosystem management



Seasonal climatologies (from 42 missions)



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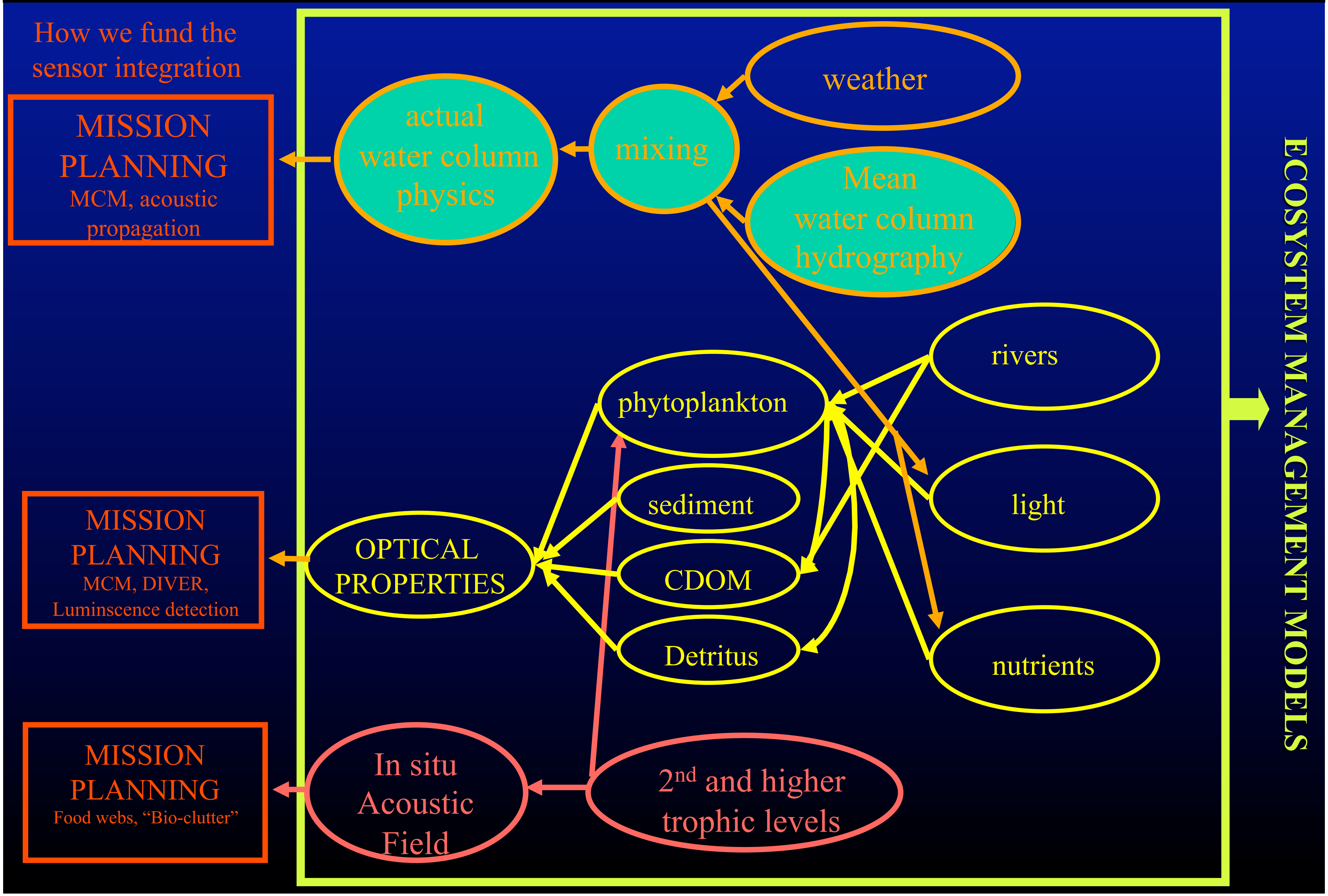
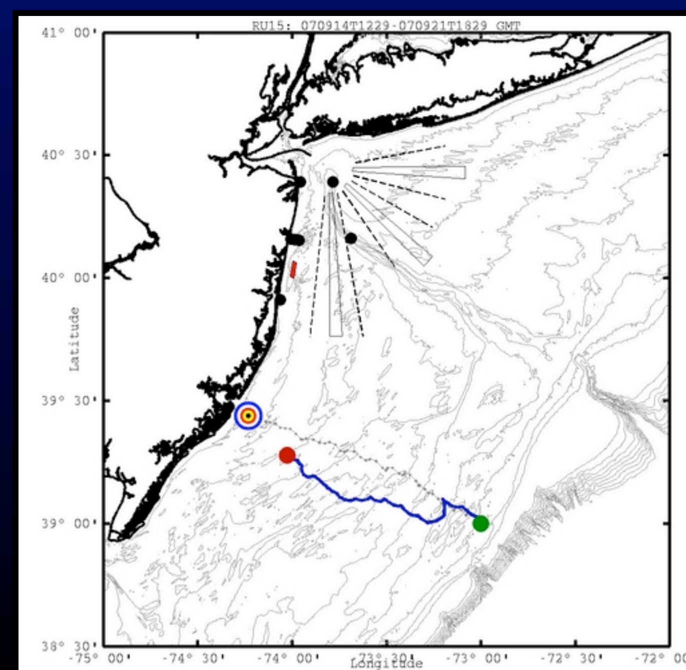


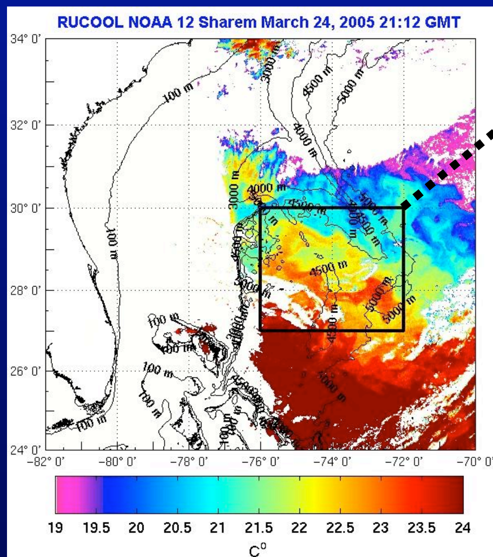
External Modular Sensors

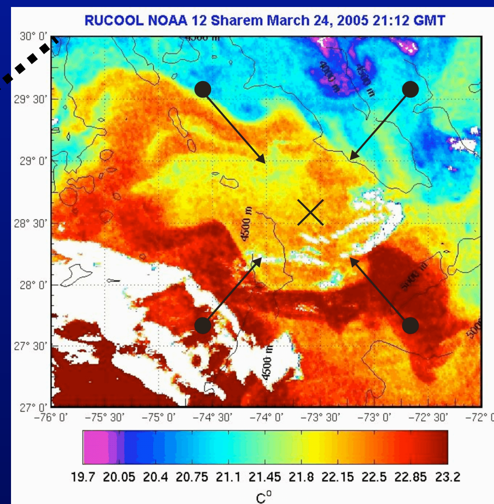
Oregon State University Collaboration

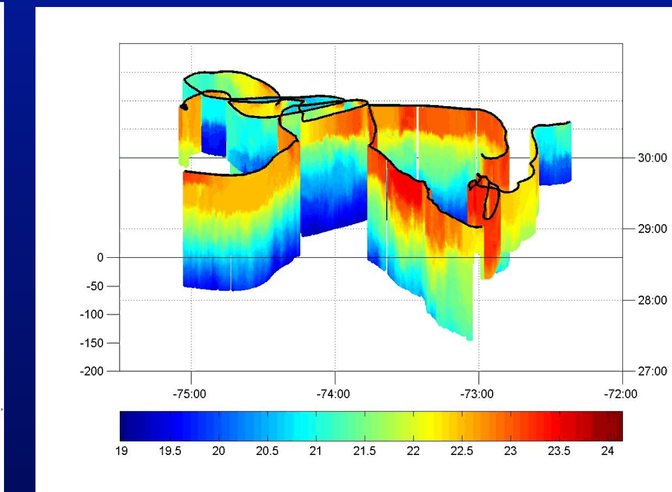
ChiPod attached to glider for 1 and 18 day missions

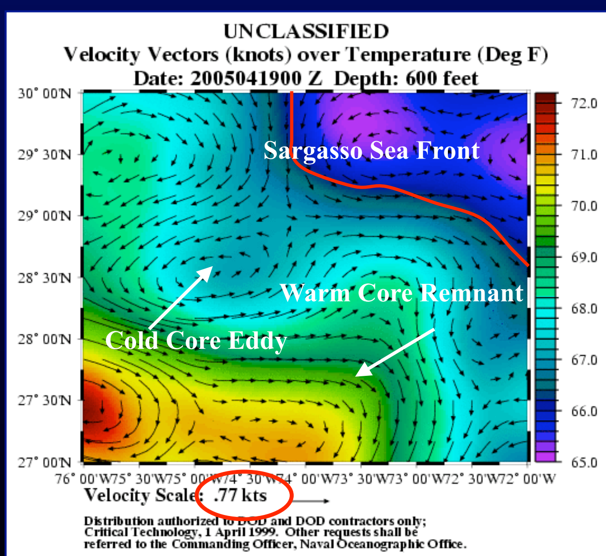


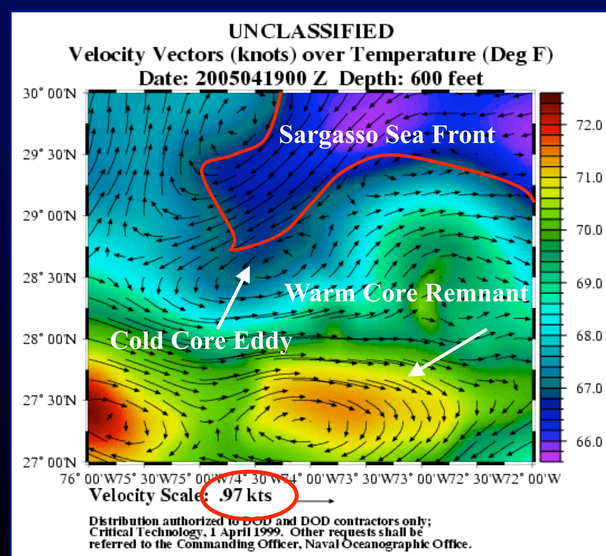
The ability to map space persistently at sea is key: Here 4 gliders changed Naval tactics during a submarine war game 64 times in 1 month.

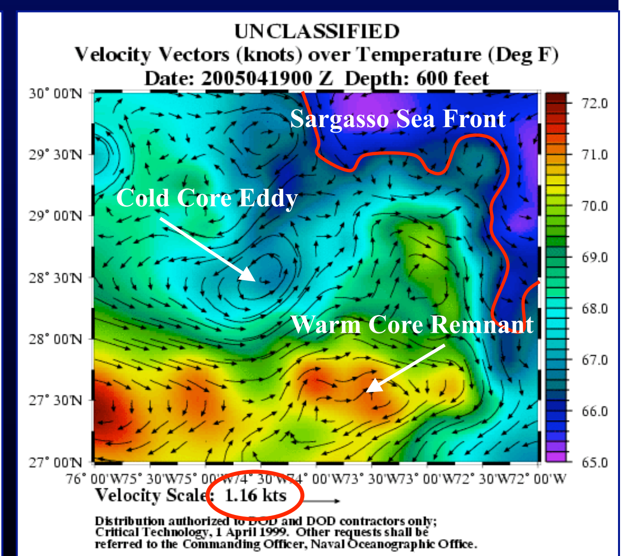




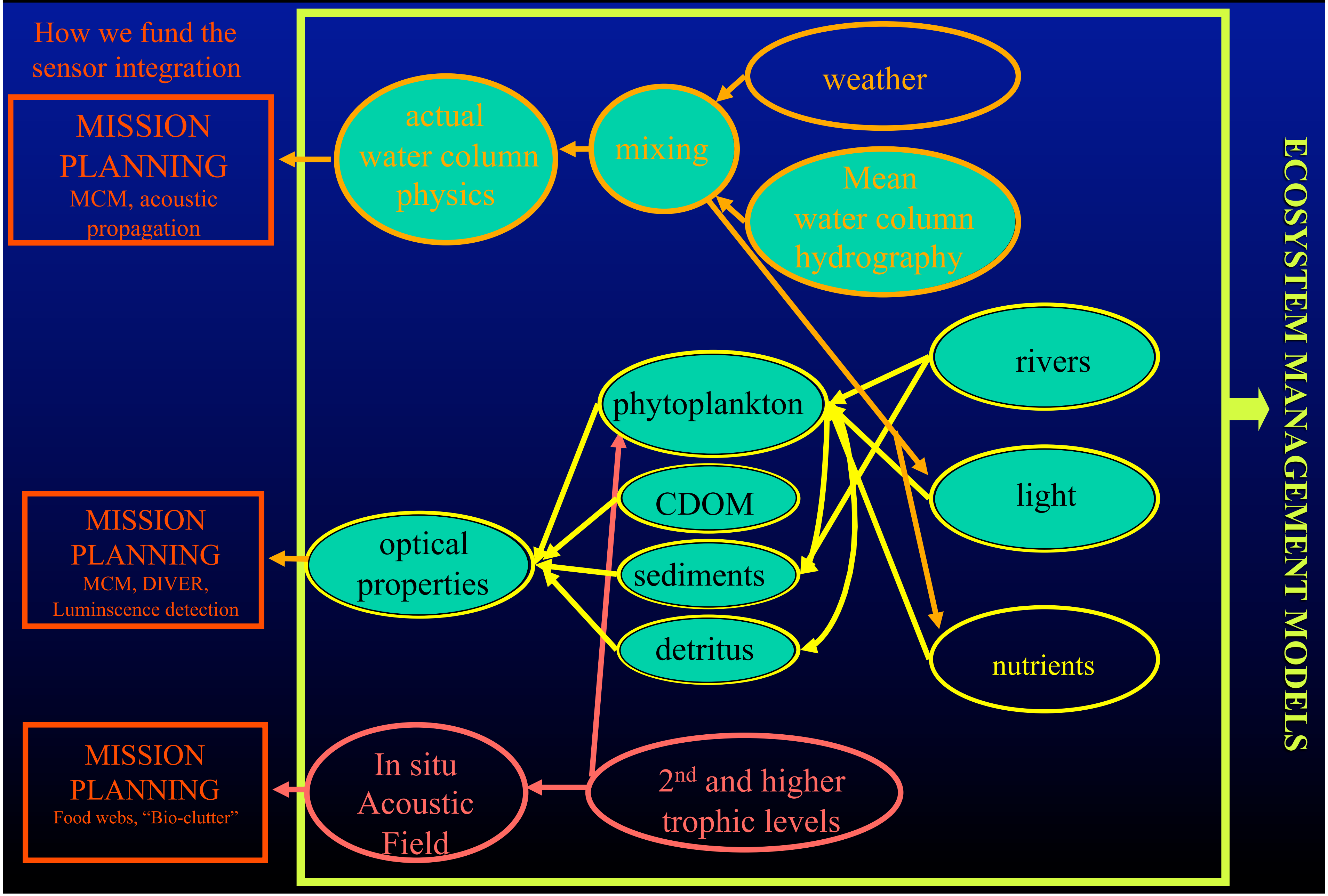






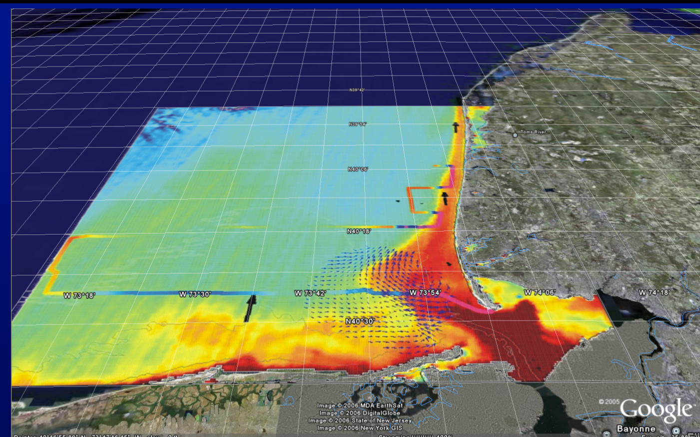


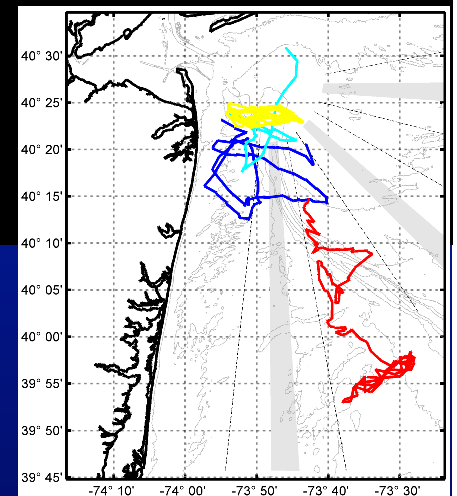
Gliders will be used to assist numerous applied mission planning and simultaneously provide the first subsurface network capable of enabling ecosystem management

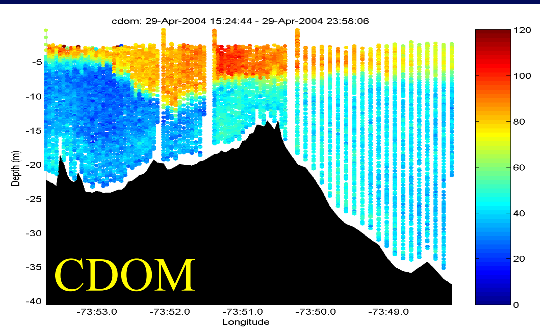


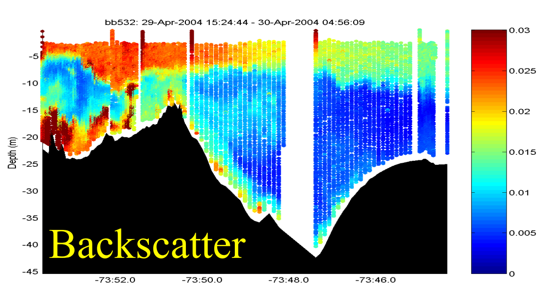
RIVERS

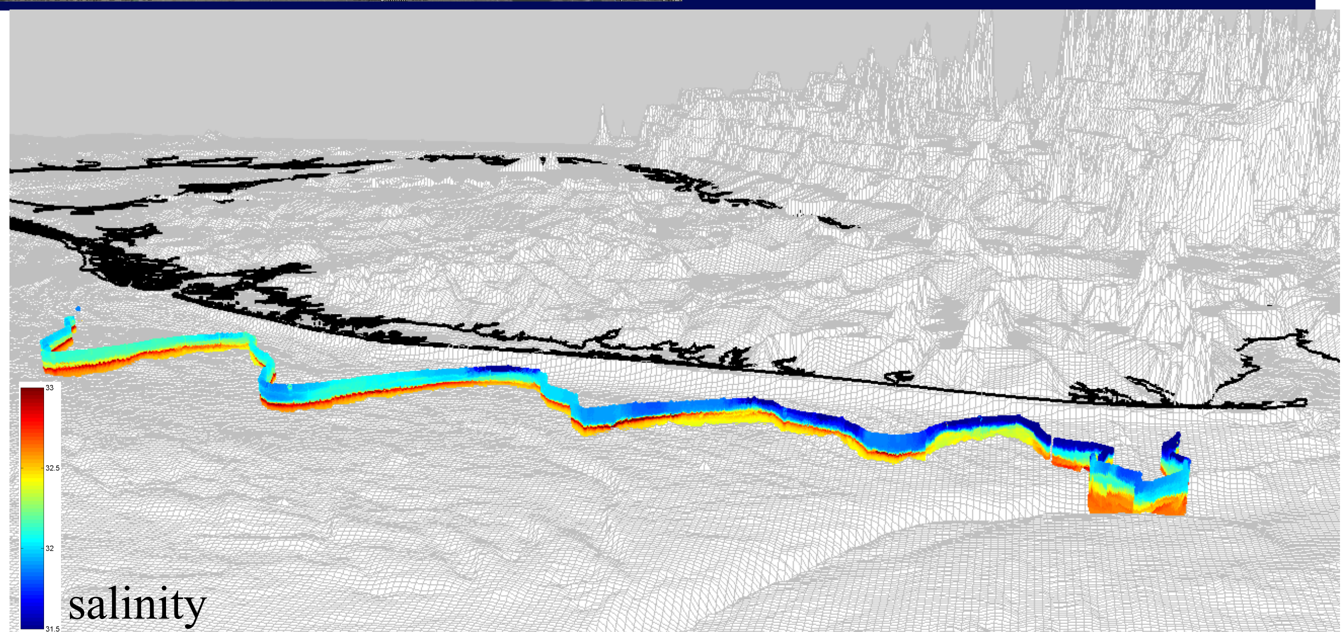
NSF's LaTTE - Under transports and transformations of Hudson River Plume



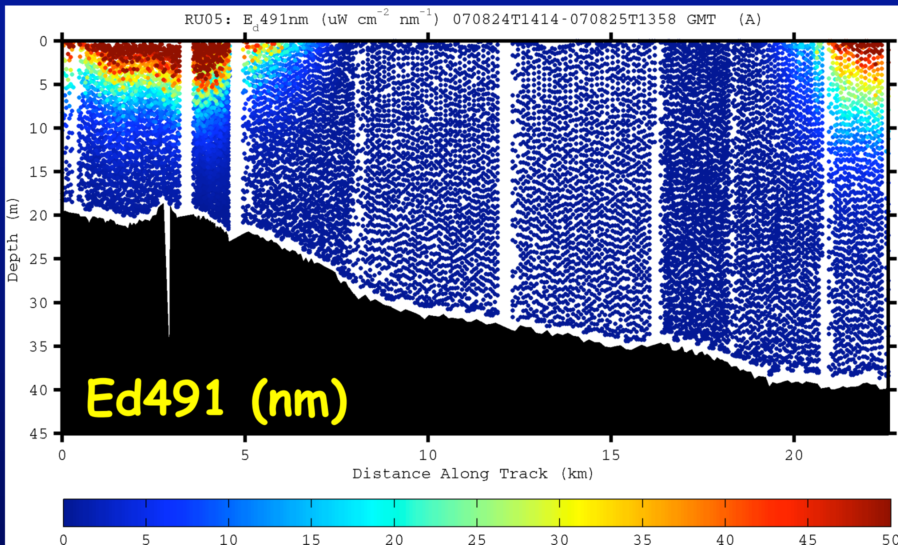


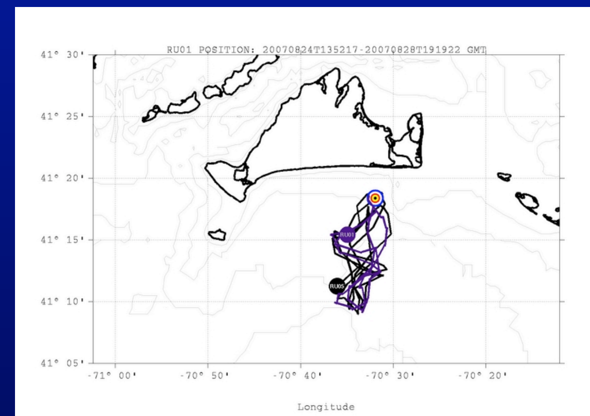


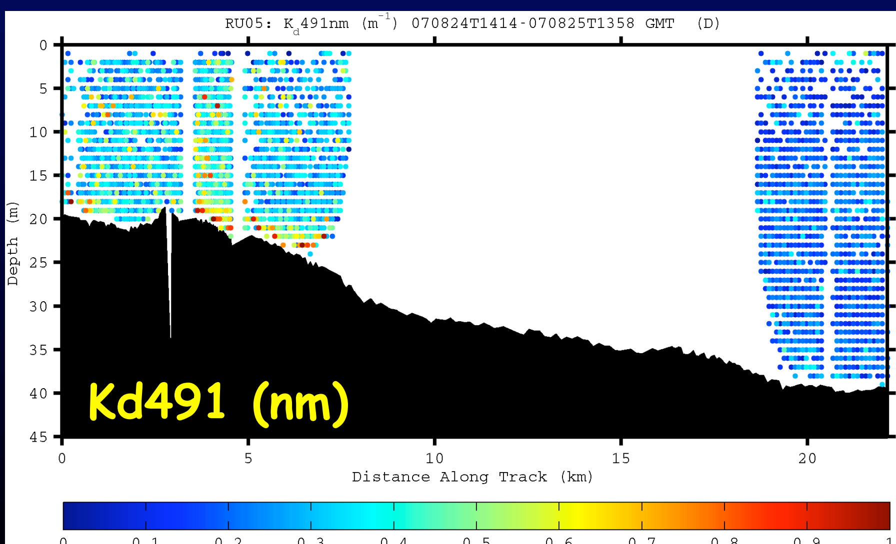




Light: ONR's OASIS experiments at Martha's Vineyard (spectral downwelling irradiance, and the apparent optical properties)

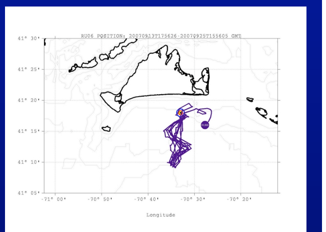




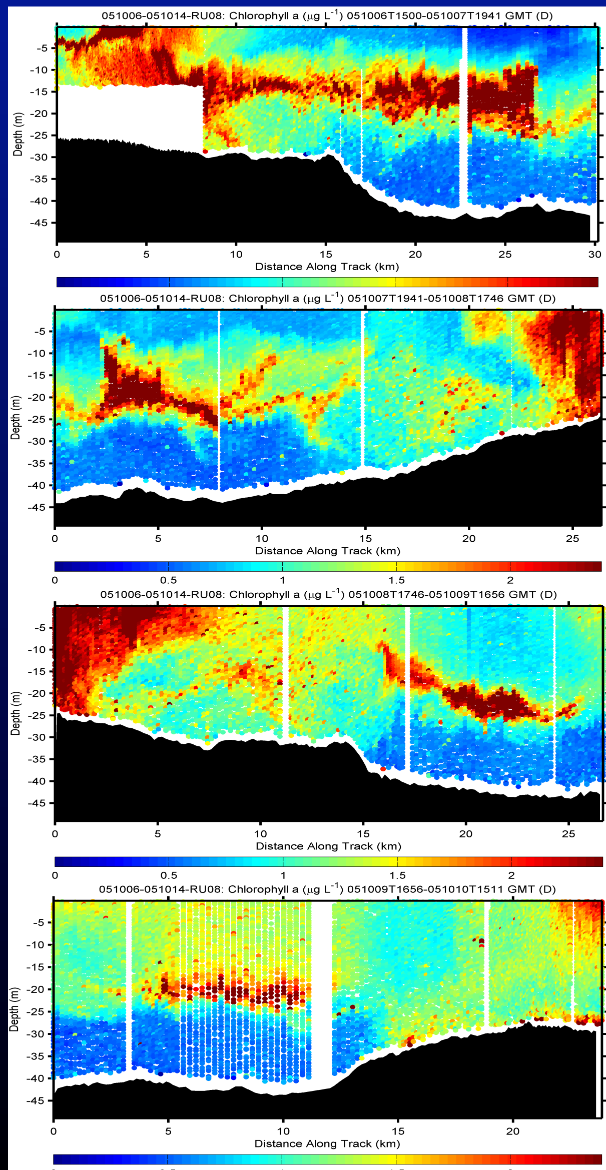


Phytoplankton: ONR's HyCODE & OASIS and NSF's EcoHAB programs (bulk phytoplankton and phytoplankton composition)

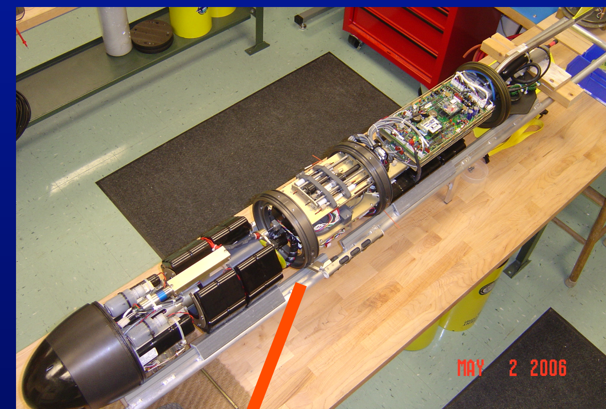
Phytoplankton biomass

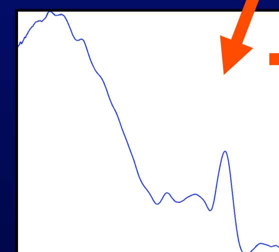


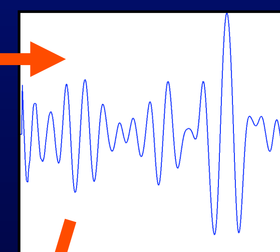
Phtyoplankton response To passage of Nor'Easter storm

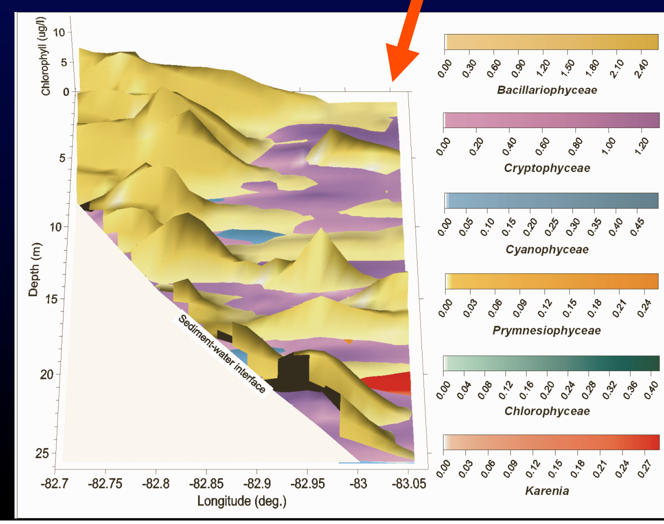


Phytoplankton communities

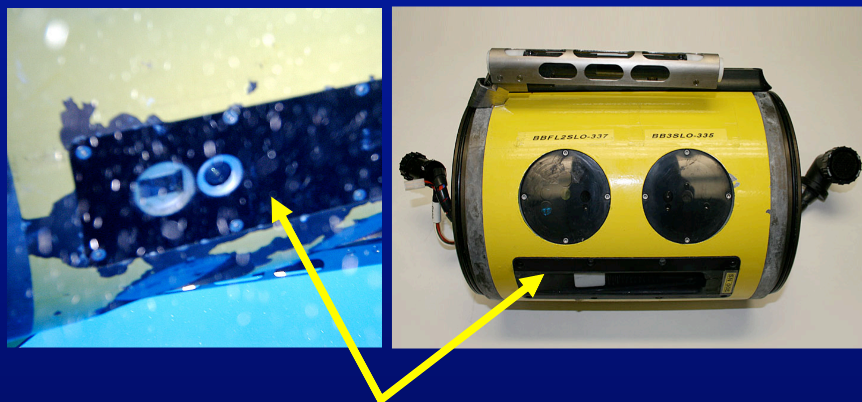


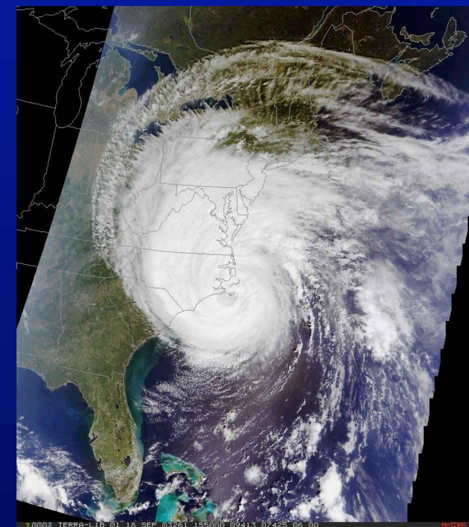


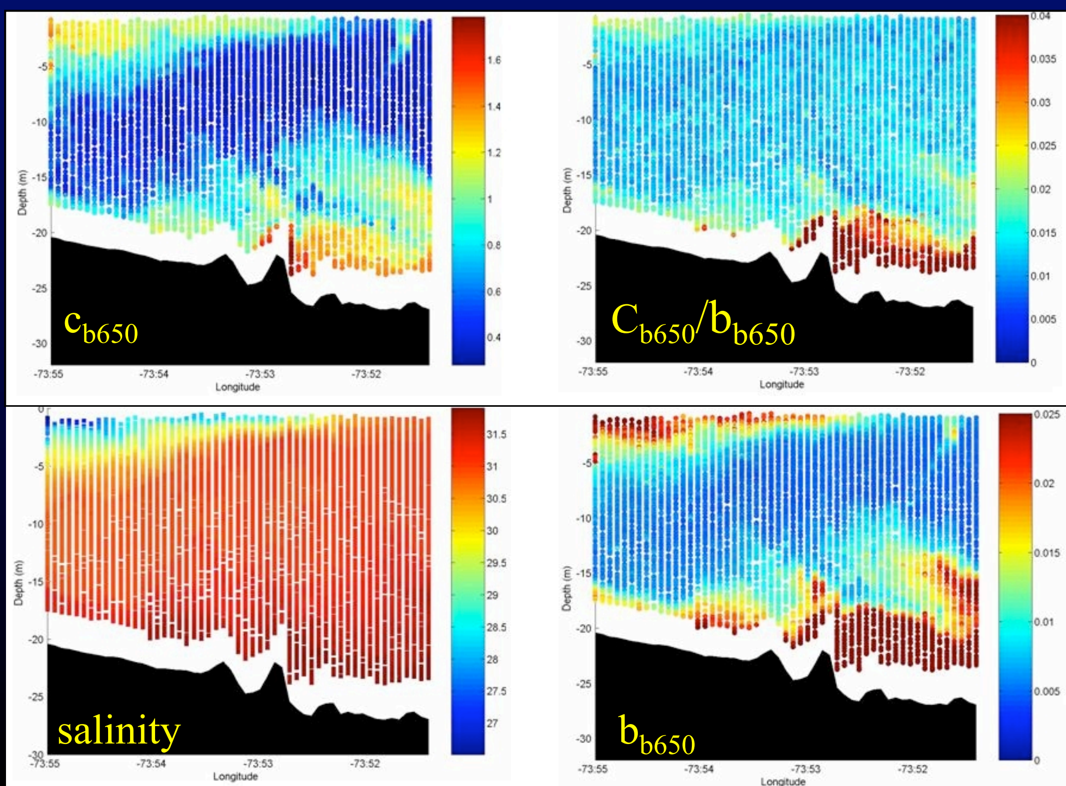




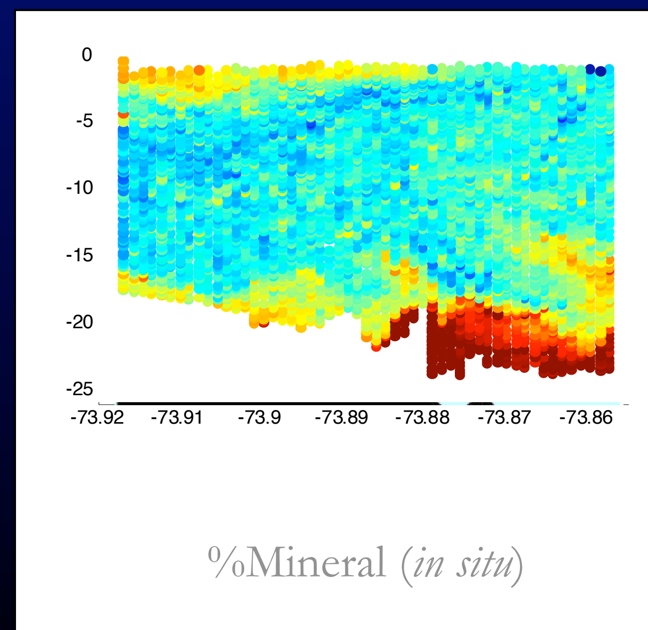
Sediment: ONR's OASIS and MIREM programs focused on refining understanding of nepheloid layers and importance of storms



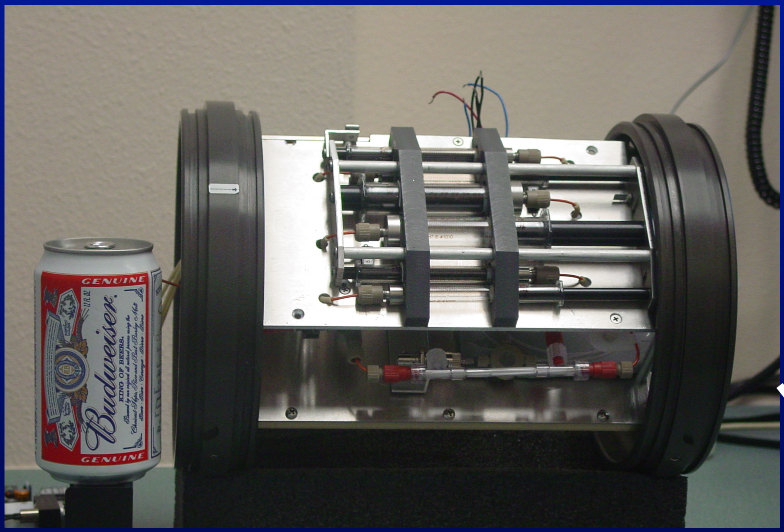


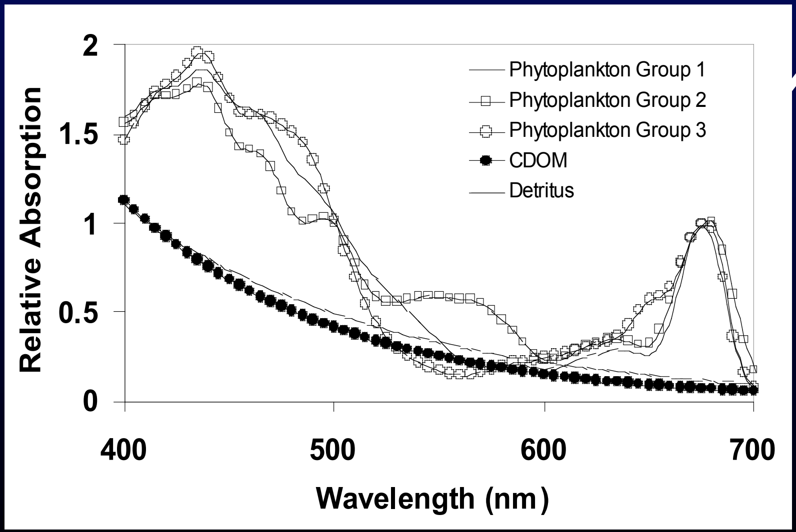


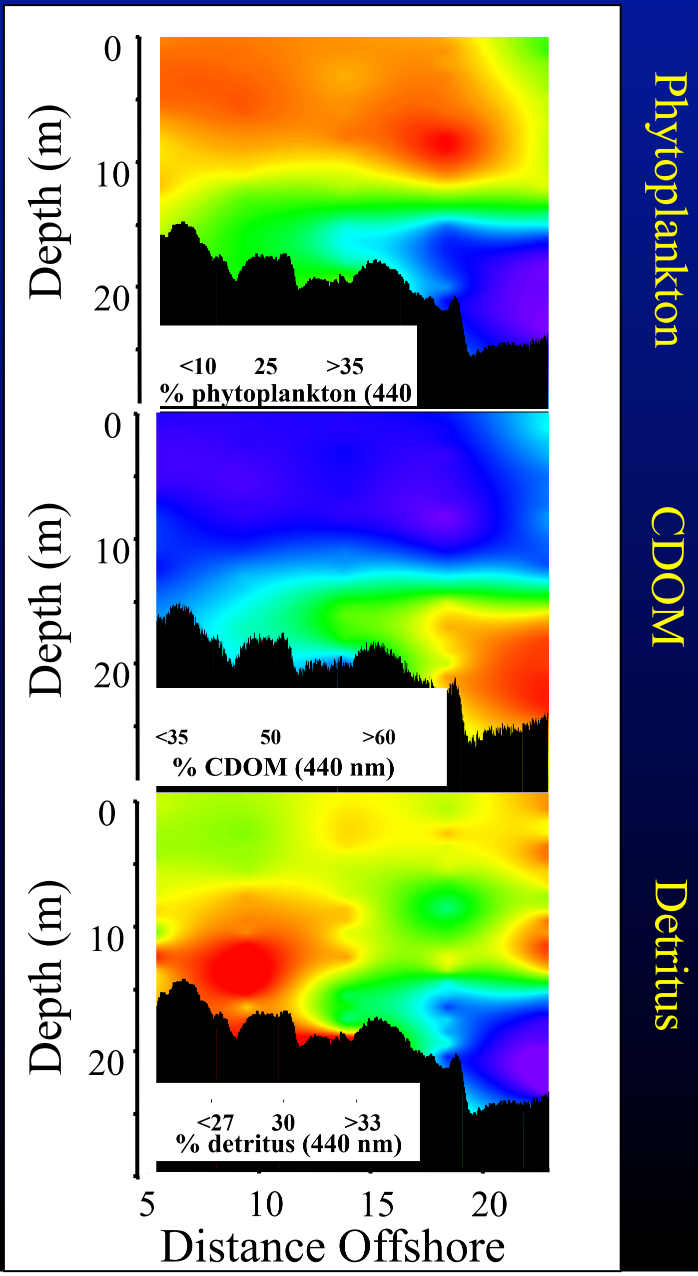
Empirical algorithms



Detritus: With the availability of hyperspectral absorption invert the detrital optical load using techniques developed for ac-9 (ONR HyCODE)



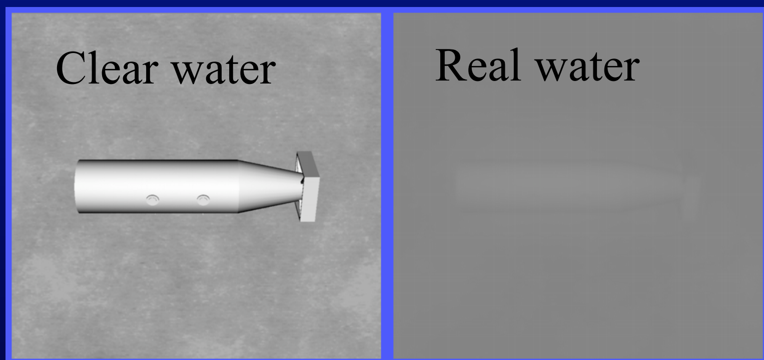




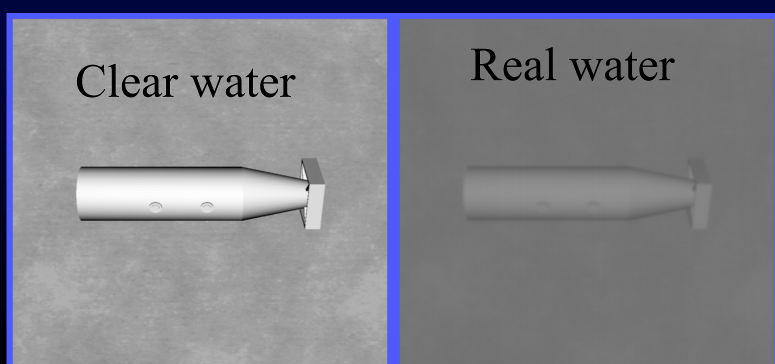
ONR MIREM experiments: The combination of optical parameters can be used to define optically-based mission planning models

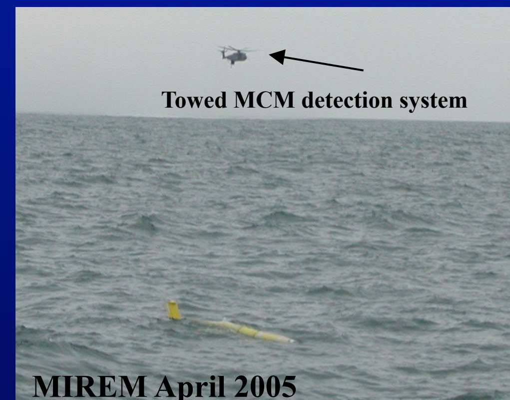
The Problem: What can you see?
Helicopter or diver….

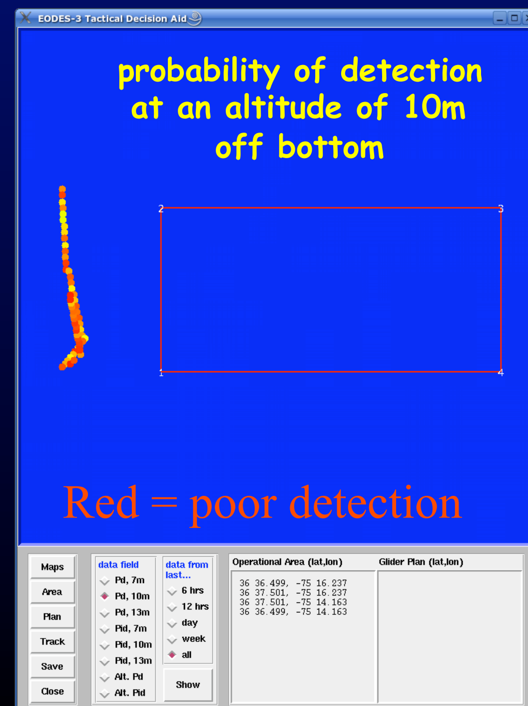
April 24, 2005

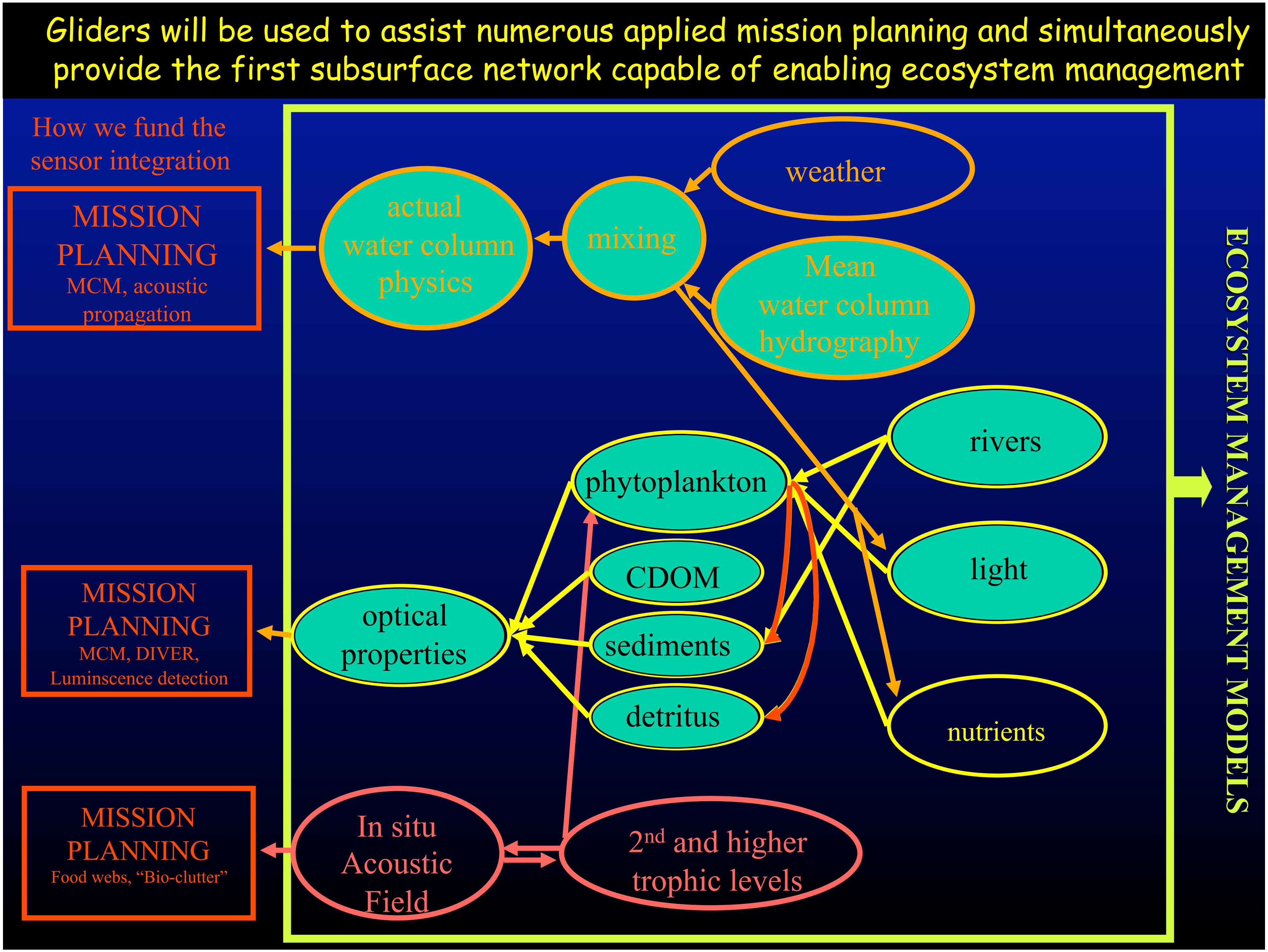


April 26, 2005





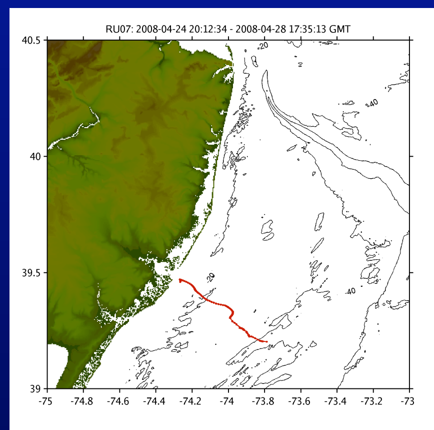


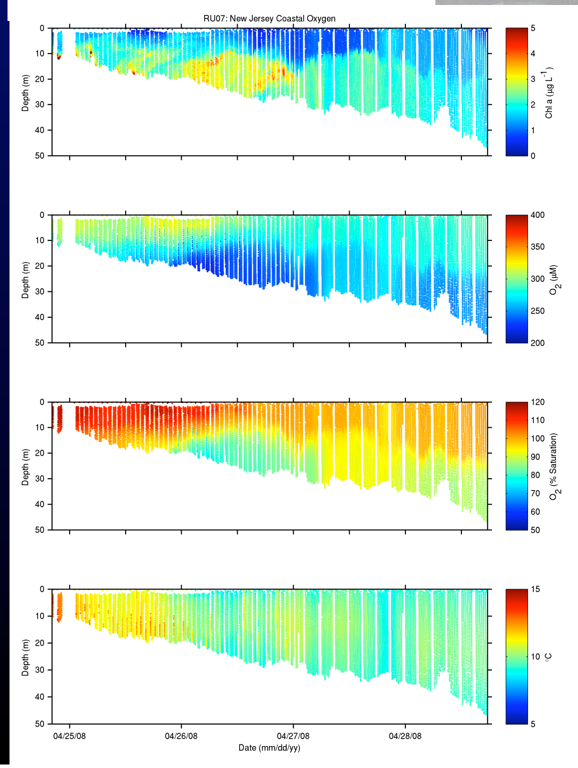


Gliders will be used to assist numerous applied mission planning and simultaneously provide the first subsurface network capable of enabling ecosystem management
How we fund the sensor integration
MISSION PLANNING
MCM, acoustic propagation
MISSION PLANNING
MCM, DIVER, Luminscence detection
MISSION PLANNING
Food webs, "Bio-clutter"
actual water column physics
mixing
weather
Mean water column hydrography
rivers
phytoplankton
light
CDOM
optical properties
sediments
detritus
nutrients
In situ Acoustic Field
2nd and higher trophic levels
ECOSYSTEM MANAGEMENT MODELS

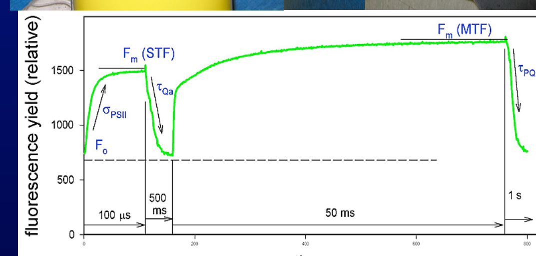
NOAA OE & NJ DEP: The production of CDOM & detritus tightly coupled to phytoplankton growth; therefore there is need to measure growth and metabolism.

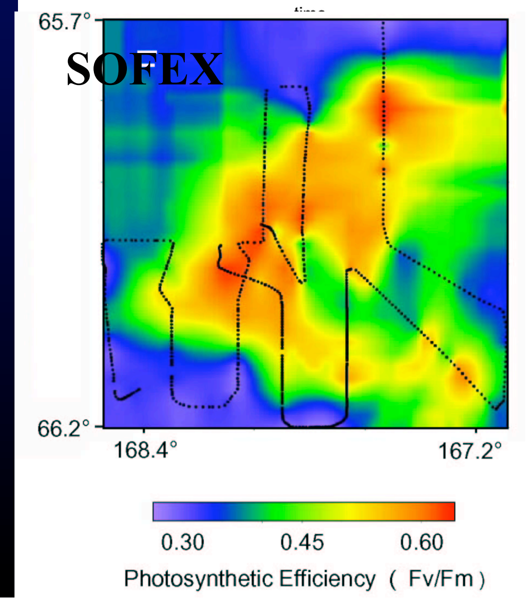
Oxygen



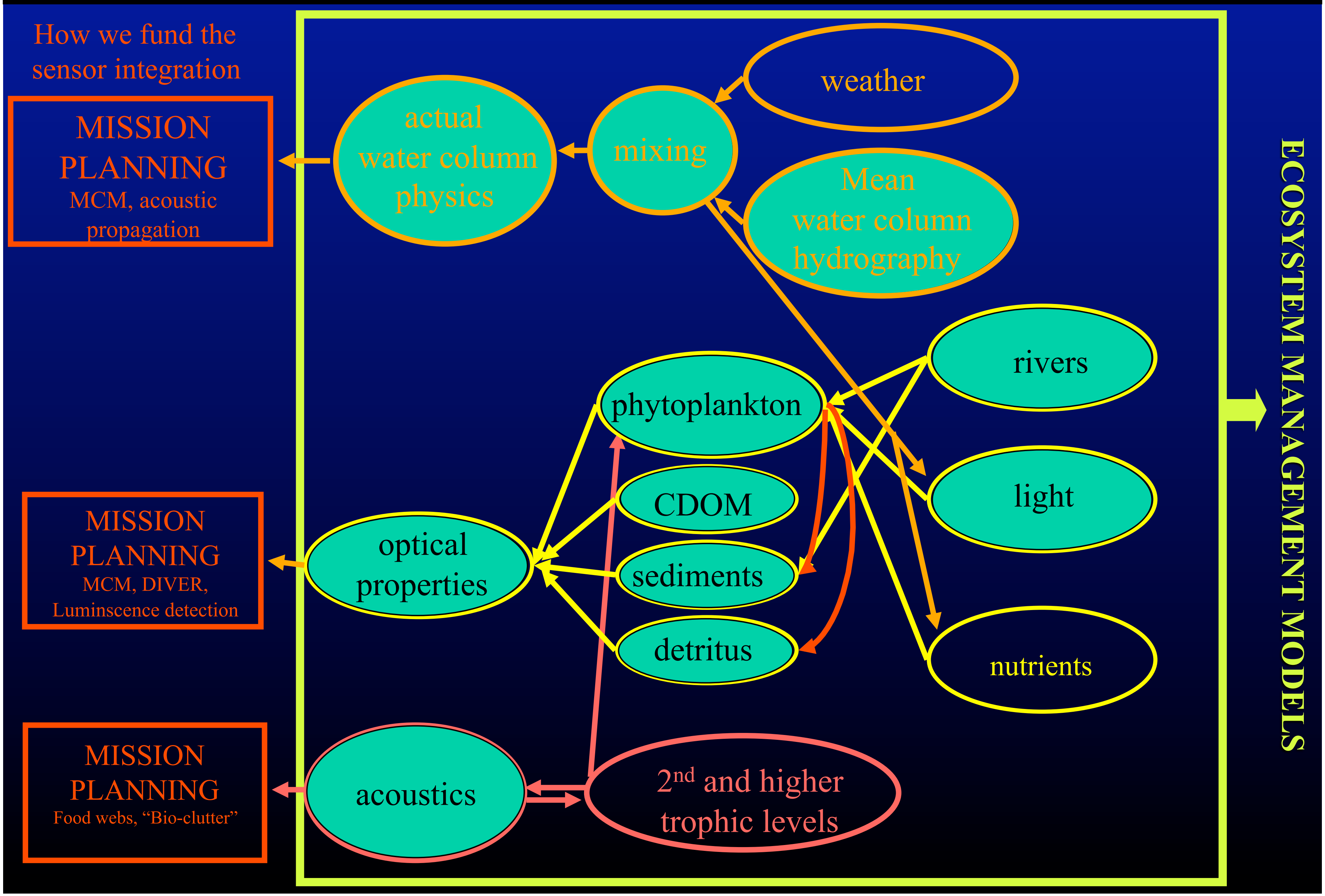


Phytoplankton health



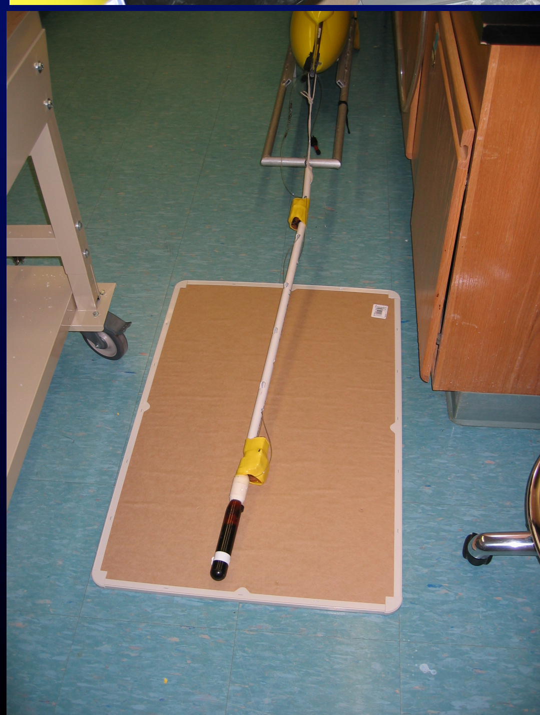


Gliders will be used to assist numerous applied mission planning and simultaneously provide the first subsurface network capable of enabling ecosystem management



Proposed location but vibrations from glider contaminated acoustic signals

- June ’06 URI visits Rutgers with hydrophone
- August ’06 Hydrophone attached to glider for 15 minute segment
- Sept. ’06 Hydrophone attached to glider for 14 day mission
- April ’07 URI visits Rutgers for two days of experiments to test beam forming capability



Final configuration with hydrophone towed behind glider with no rigid connection between the two

Future focus areas will be on recording marine sounds with specific focus on higher trophic levels.

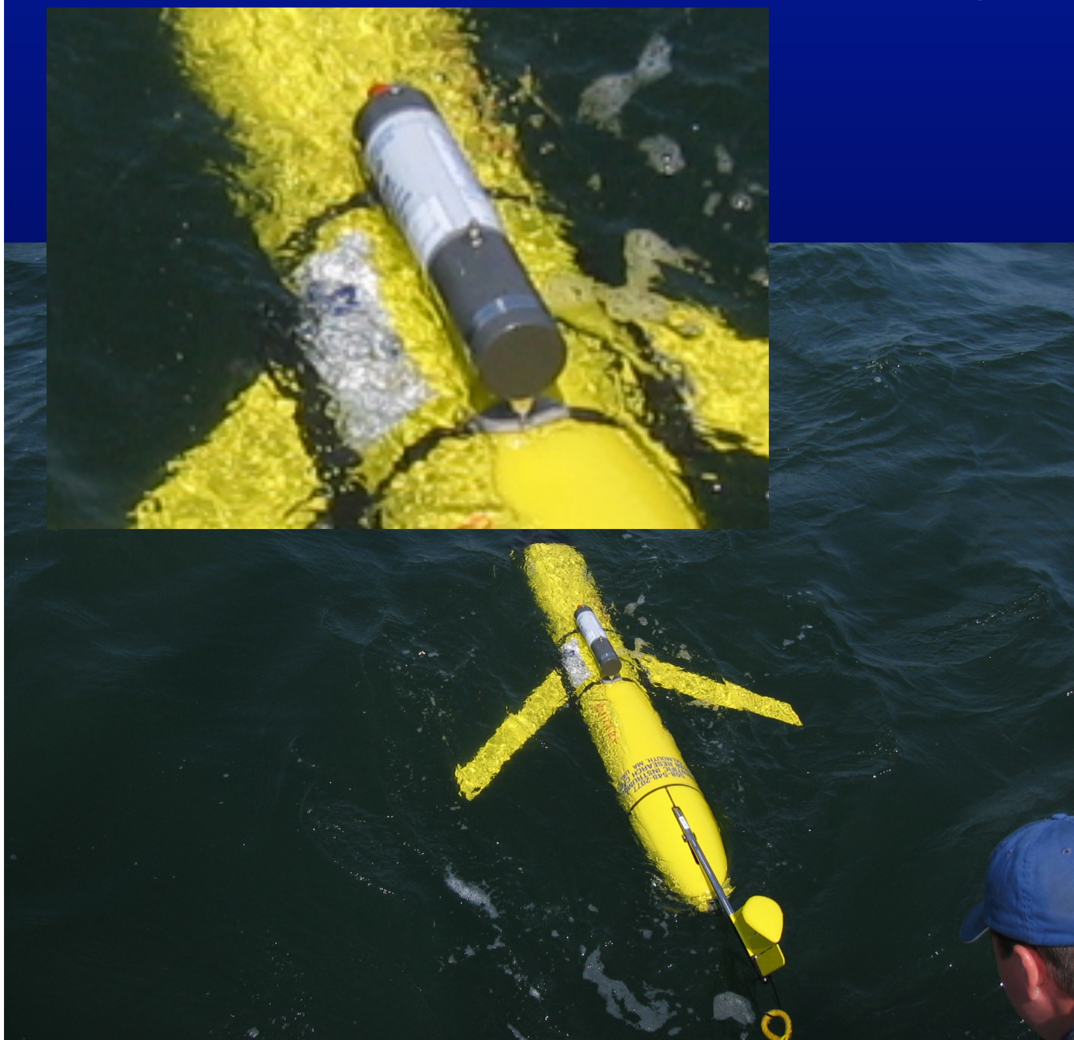
UNIVERSITY OF Rhode Island

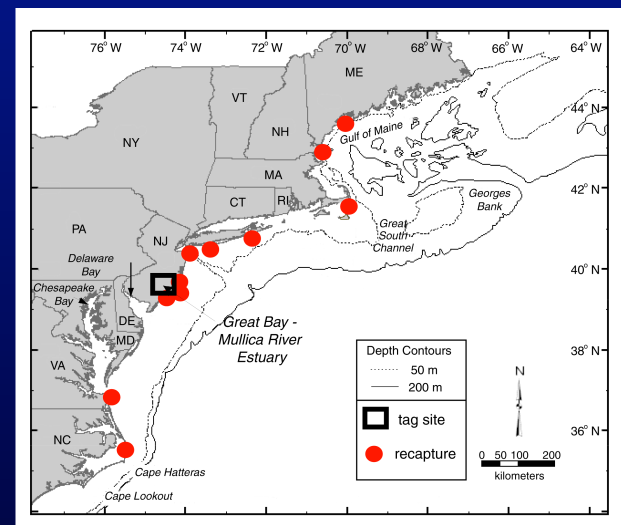
RUTGERS MARINE & COASTAL SCIENCES

External Modular Sensors

NOAA National Marine Fisheries Service (NMFS) Collaboration

Vemco "Fish Finder" Attached to glider for 1 and 12 day missions





160 Acoustic pings from transmitter over 2 hour period

Currently gliders are being outfitted with RDI Explorer ADCP, focus on currents, bottom tracking and zooplankton

1) The sensor

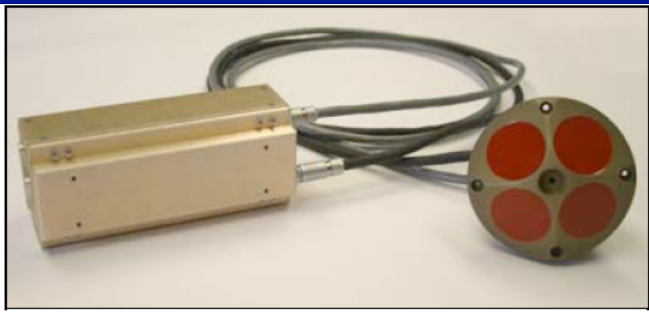
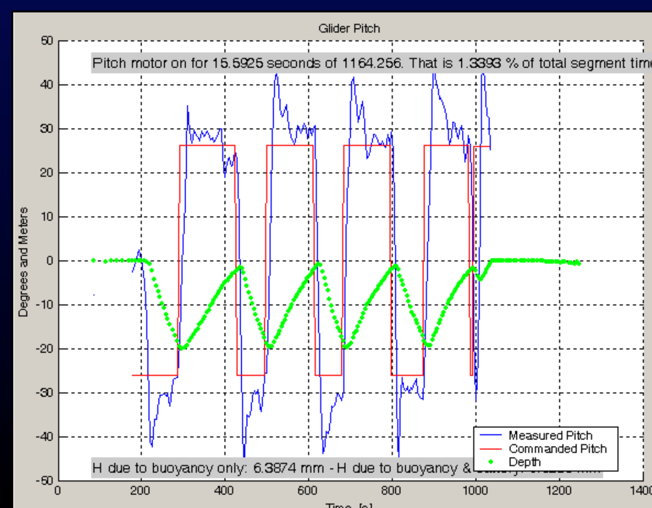


Figure 1: TRDI Explorer DVL

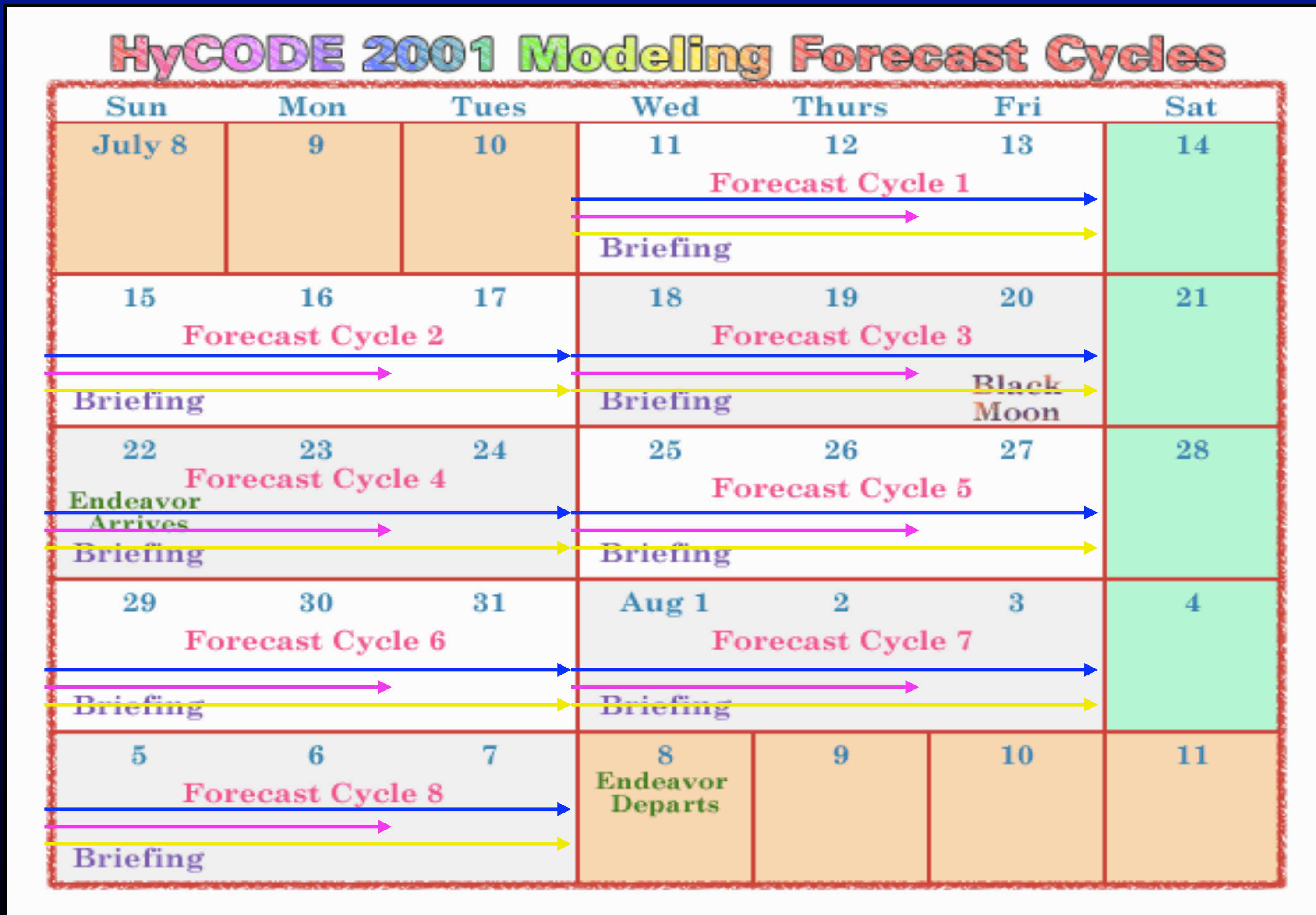
Bottom Tracking	Phased Array	Piston
Maximum Altitude[1]	75m	65m
Minimum Altitude	0.5m	
Velocity Range[2]	± 5m/s	
Long Term Accuracy	± 0.4% ± 0.2cm/s	
Precision[3] @ 1 m/s	± 1.2cm/s	
Resolution	0.1cm/s (default), 0.01mm/s (selectable)	
Ping Rate	7Hz Typical	
Water Profiling		
Maximum Range[1]	30m	20m
Minimum Range	0.7m	
Velocity Range[2]	± 5m/s	
Long Term Accuracy	± 0.75% ± 0.2 m/s	
Precision[3] @ 1 m/s	± 6cm/s	
Resolution	0.1cm/s	
Ping Rate	7Hz Typical	
Acoustic		
Sound Pressure Level	213dB re 1uPa@1m	205dB re 1uPa@1m
1-Way Beam Width (Typical)	2.4°	3.3°
Center Frequency	614.4kHz	
Number of Beams	4	
Beam Angle	30°	
Environmental		
Maximum Operating Depth	100 m	300 m
Operating Temperature	-5°C to 40°C	
Storage Temperature	-25°C to 60°C	
Vibration & Shock (transport)	IEC 60721-3-2, 2nd Ed, 1997-3	
Vibration (operational)	IEC 60945, 4th Ed, 2002-8	

2) Expanded glider payload capacity

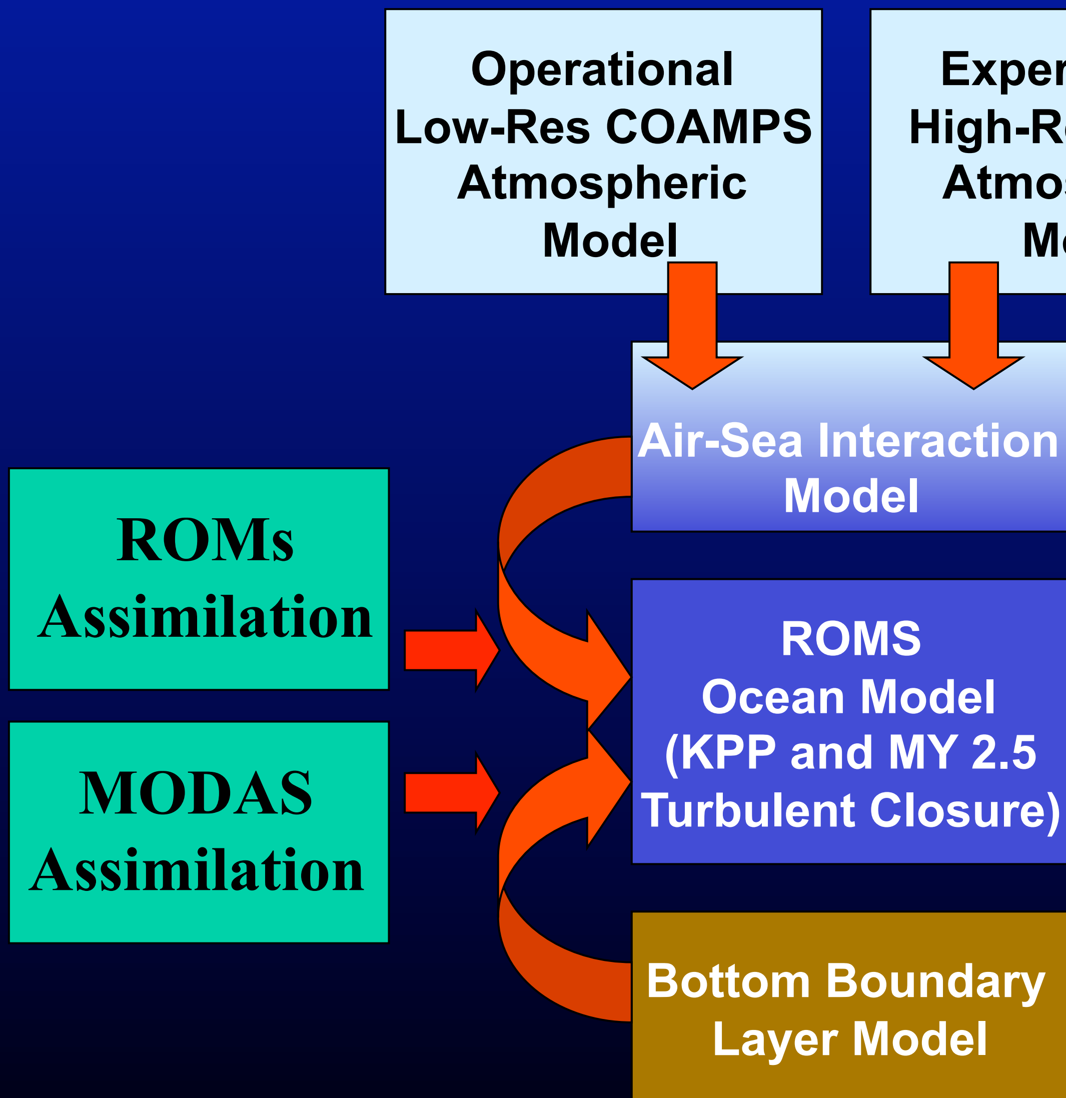
320 Alkaline C-cells versus 230

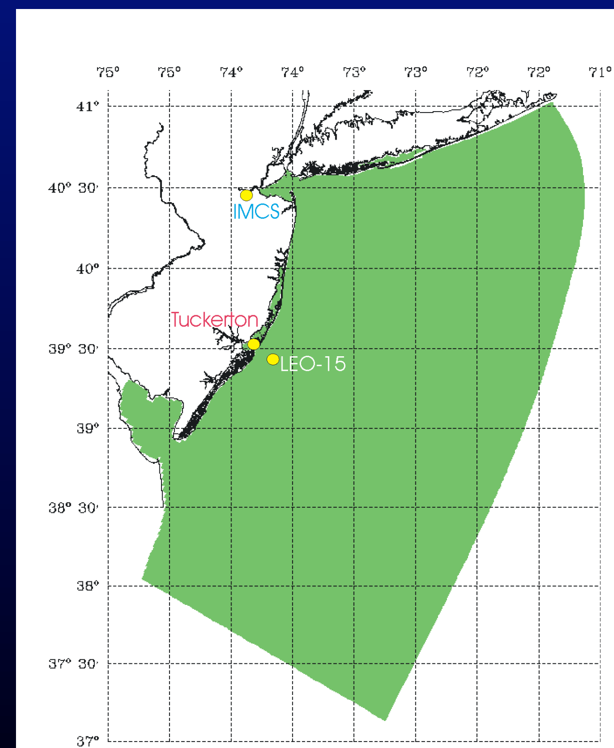


Month Long Experimental Effort

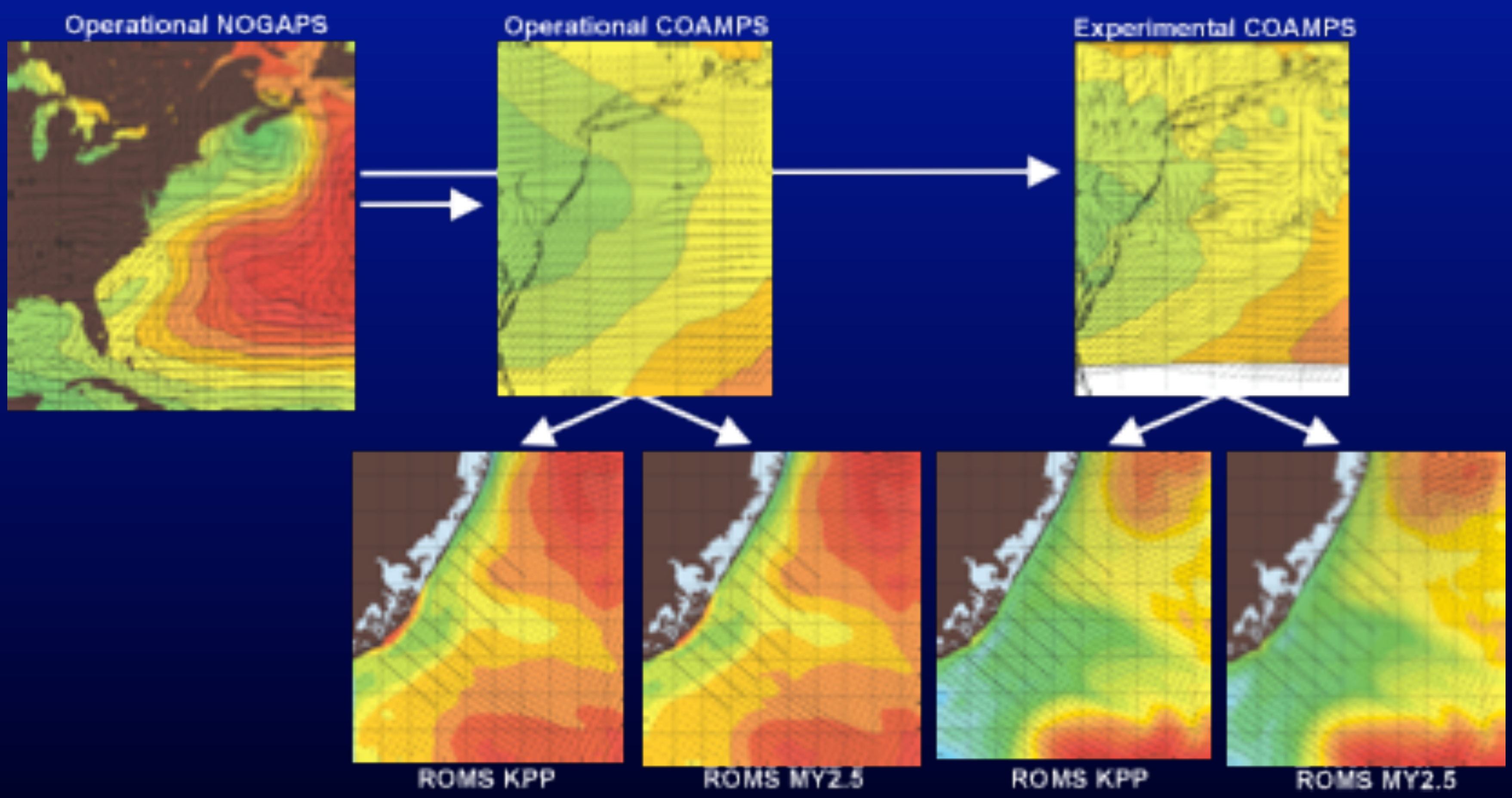


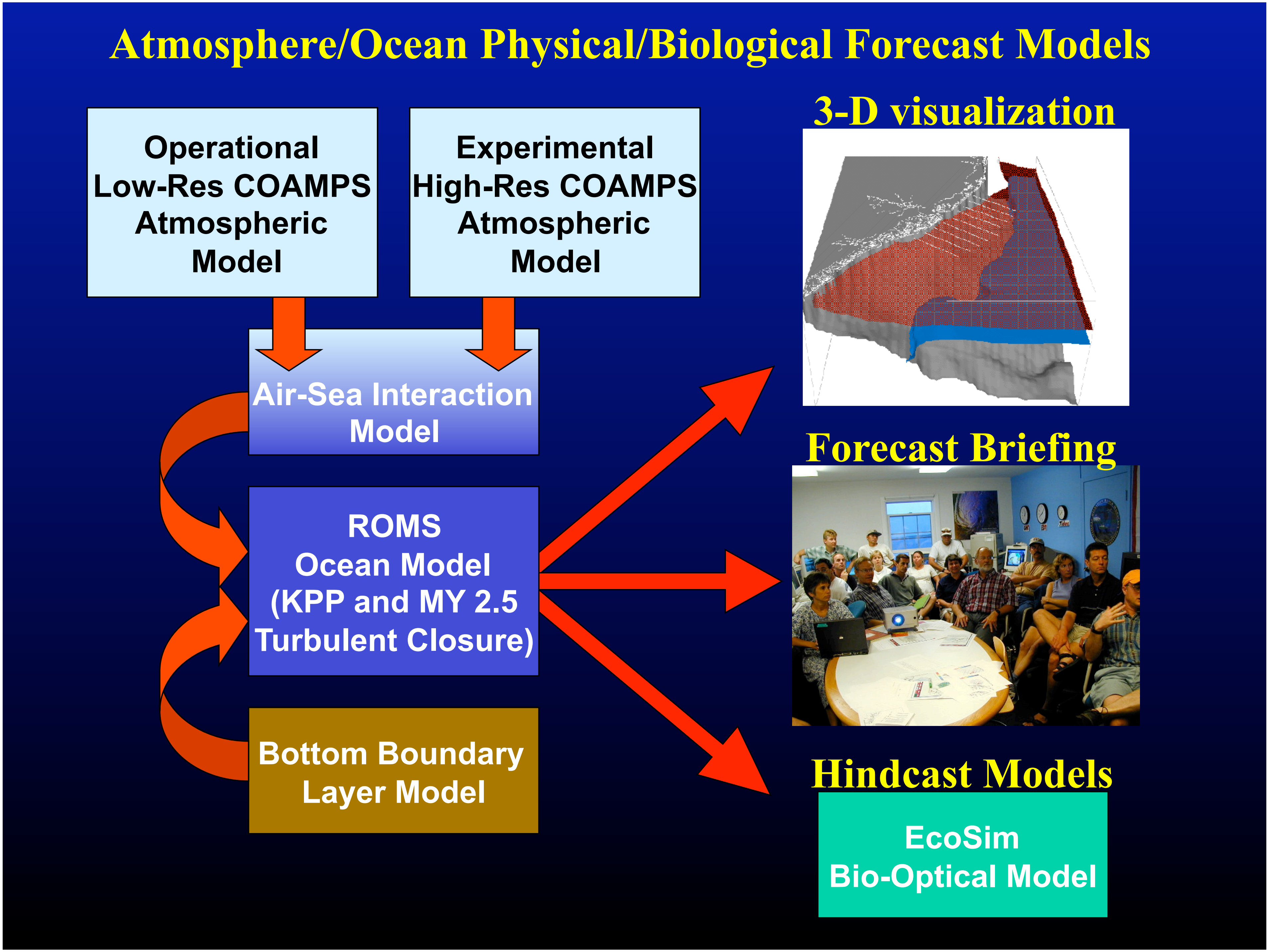
Atmosphere/Ocean Physical/Biological Forecast Models

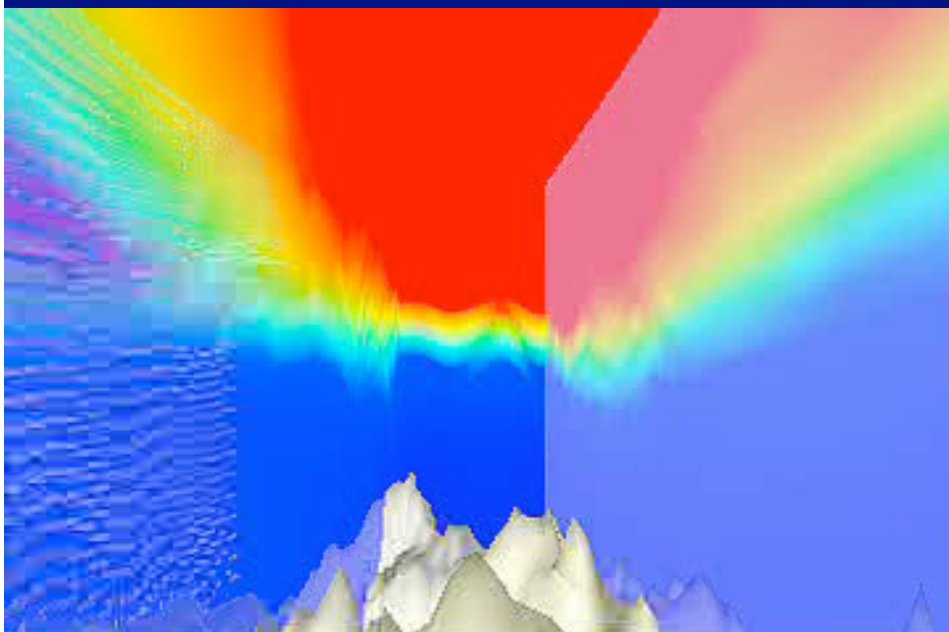


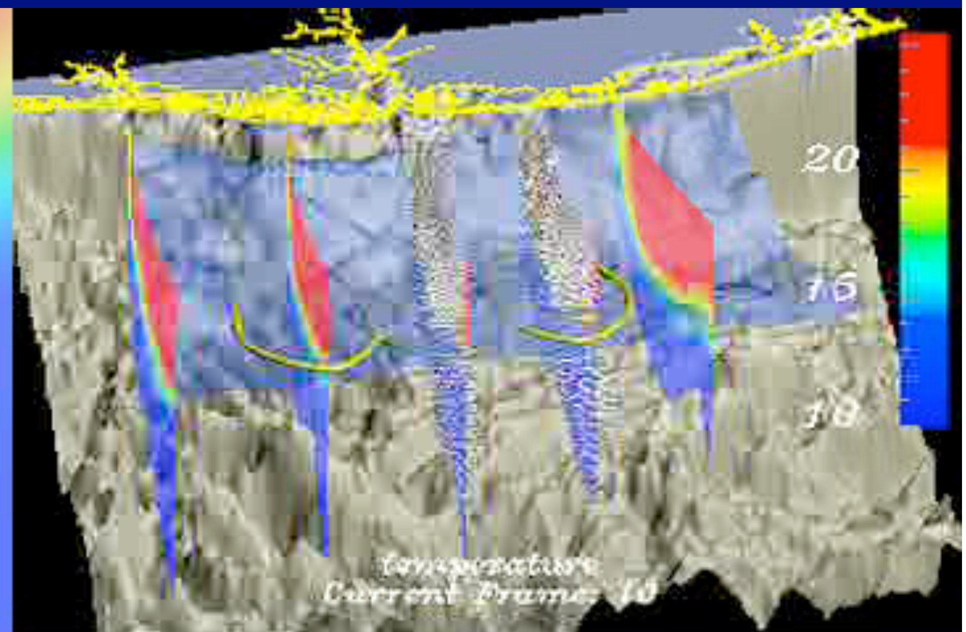


2001 Real-time Ensemble Forecasts




Atmosphere/Ocean Physical/Biological Forecast Models
Operational Low-Res COAMPS Atmospheric Model
Experimental High-Res COAMPS Atmospheric Model
Air-Sea Interaction Model
ROMS Ocean Model (KPP and MY 2.5 Turbulent Closure)
Bottom Boundary Layer Model
3-D visualization
Forecast Briefing
Hindcast Models
EcoSim Bio-Optical Model

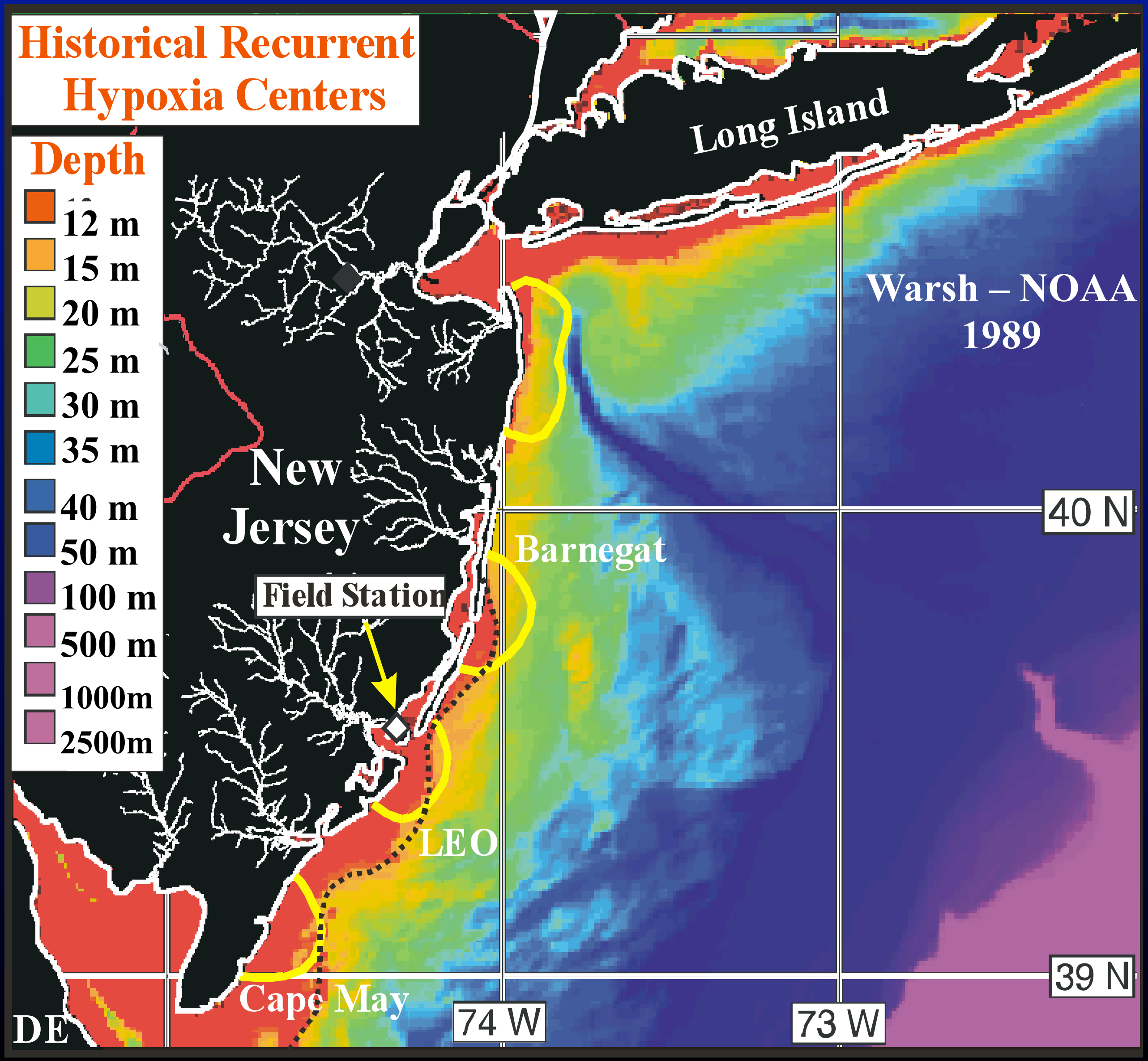


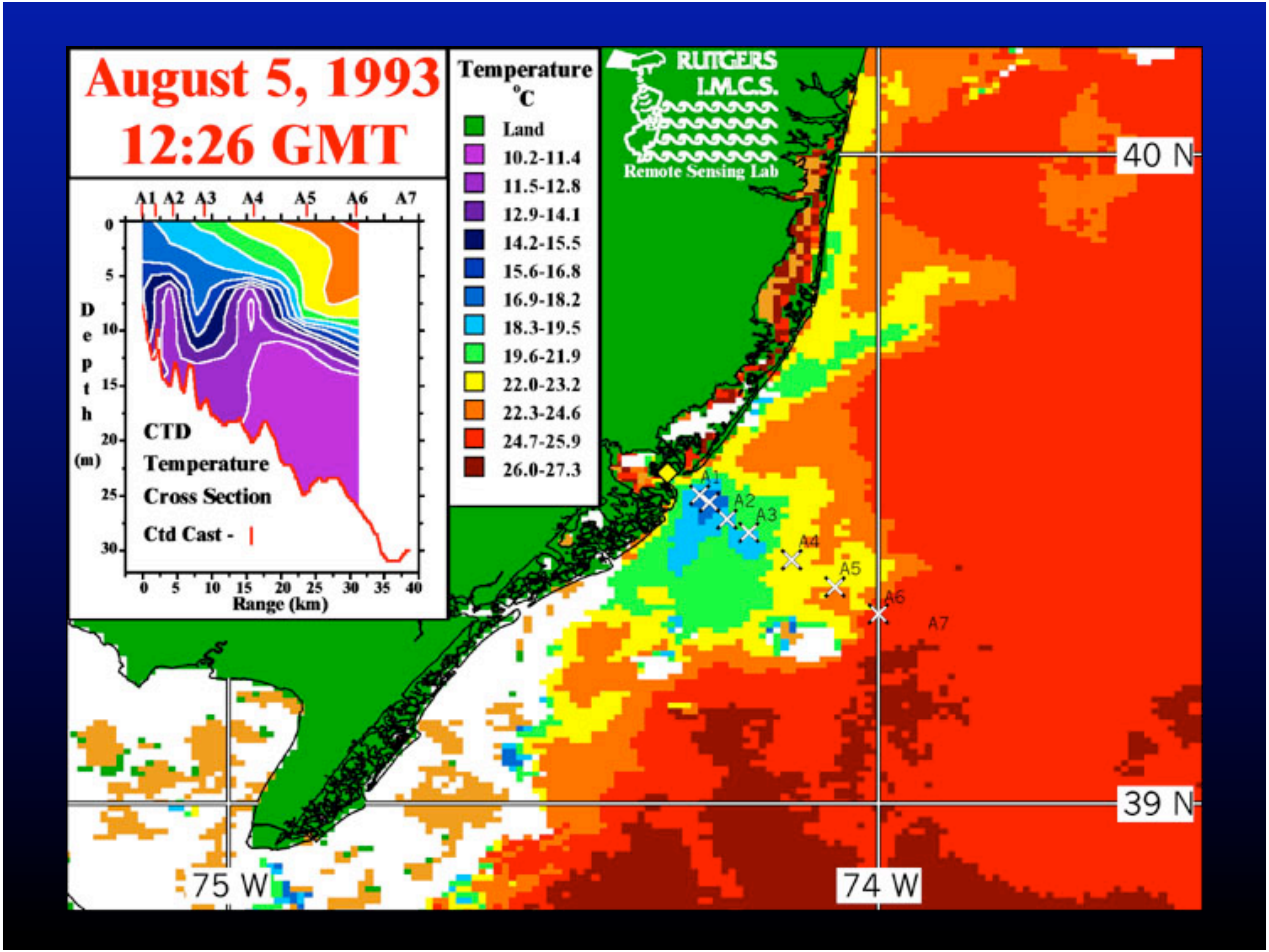


20
15
10
temperature
Current Frame: 10

How well can we sample a 20 by 20 kilometer box in the ocean?

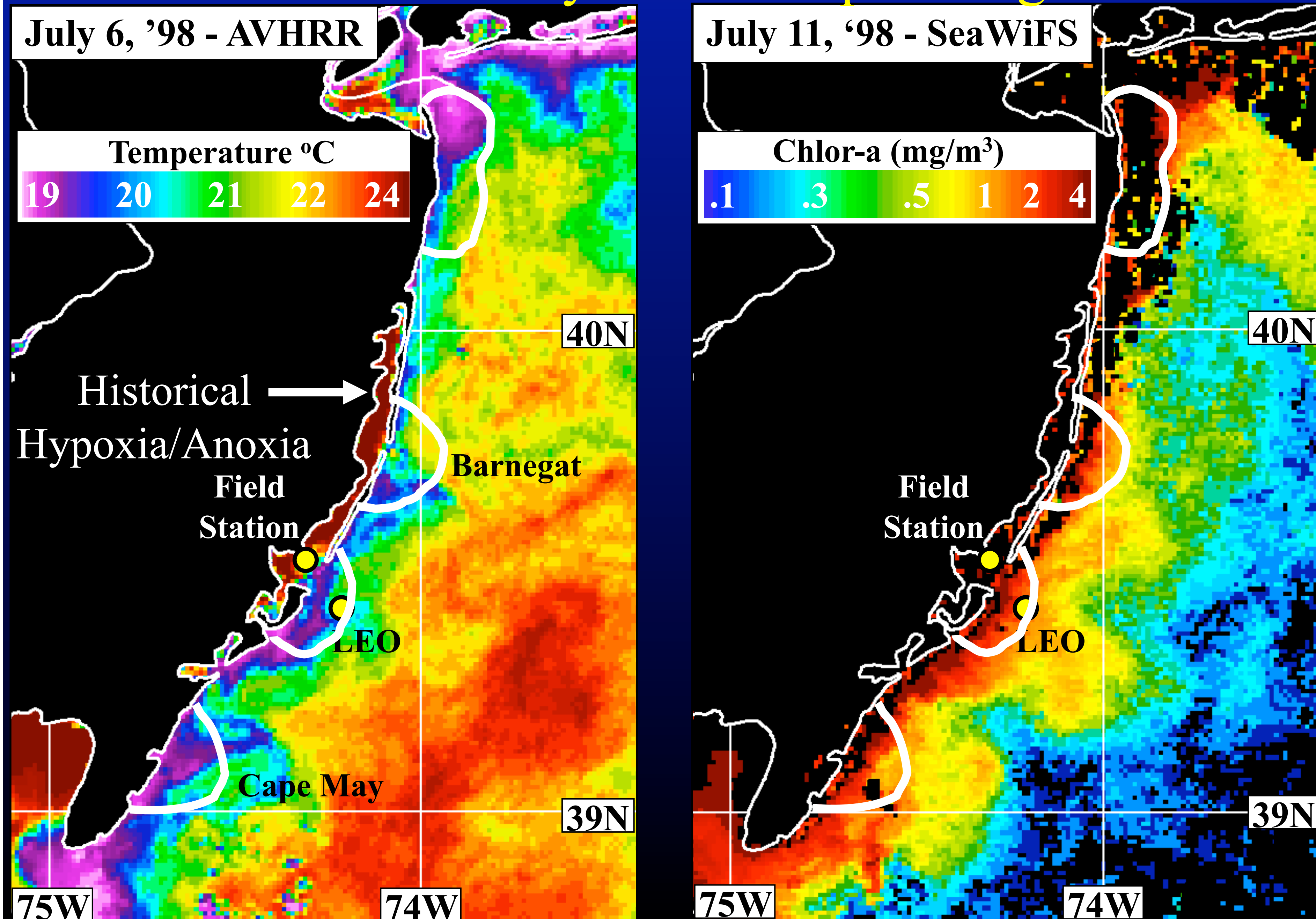
Hypoxia/Anoxia & Bottom Bathymetry

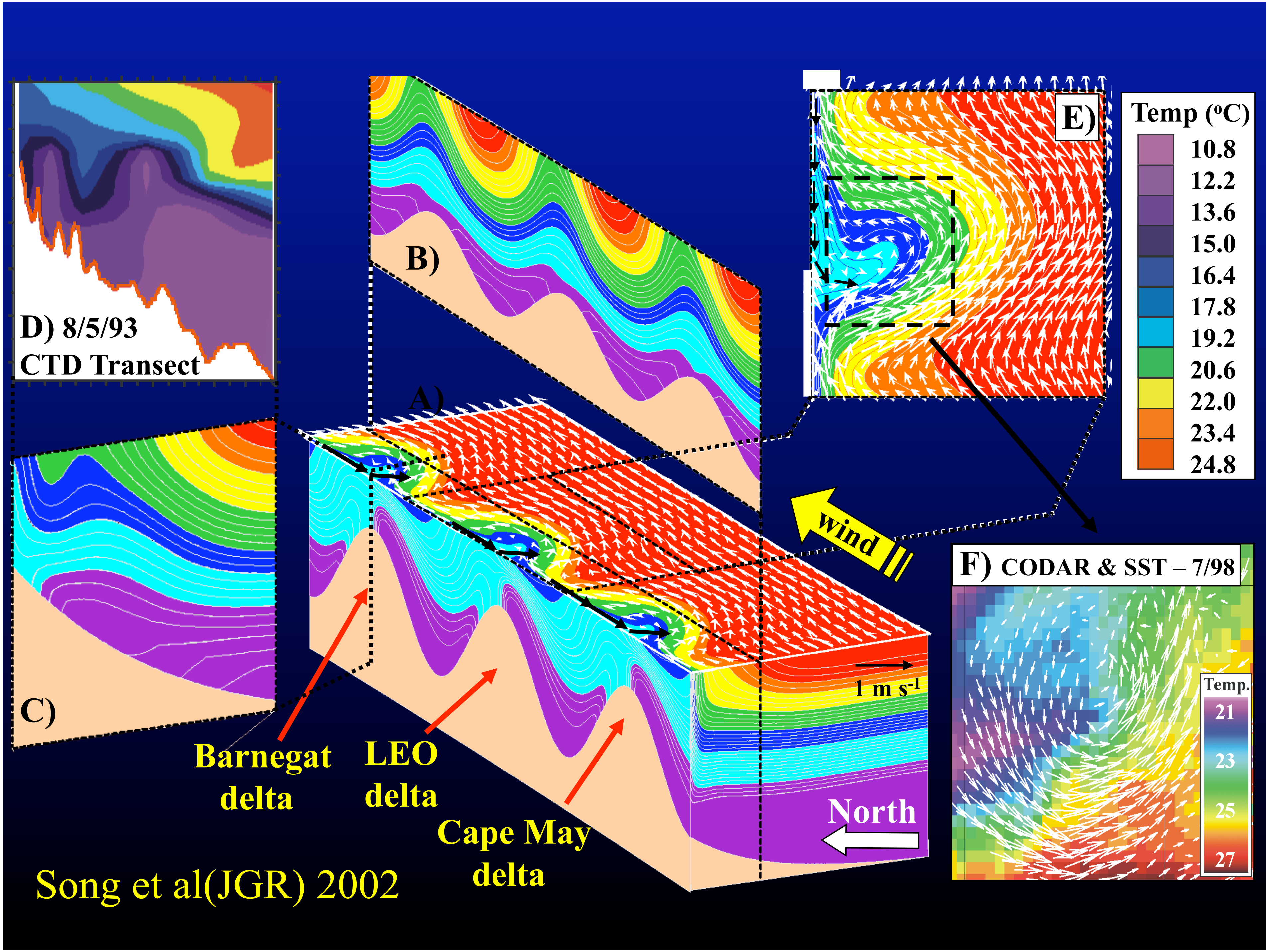




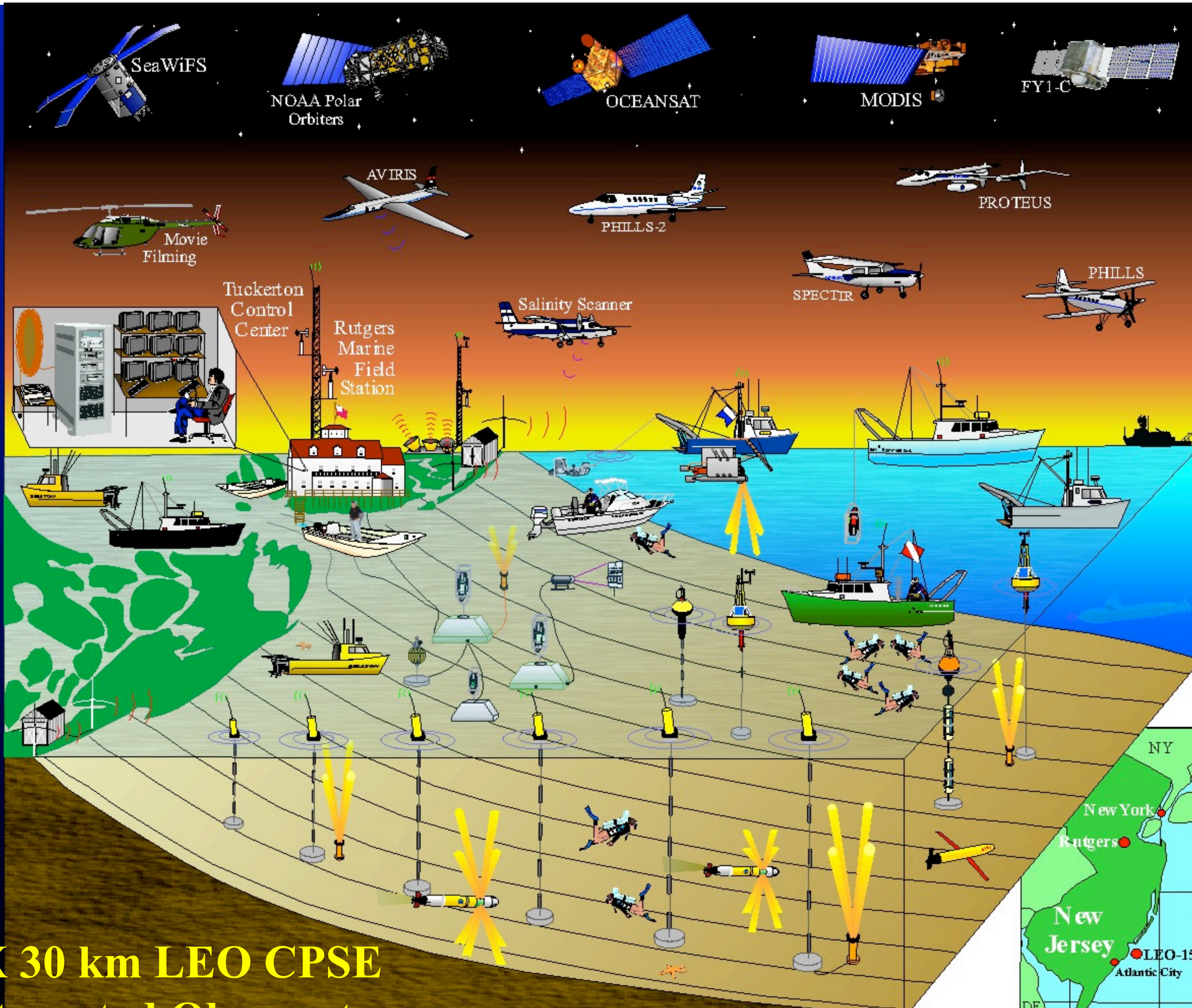
August 5, 1993
12:26 GMT
Temperature °C
Land
10.2-11.4
11.5-12.8
12.9-14.1
14.2-15.5
15.6-16.8
16.9-18.2
18.3-19.5
19.6-21.9
22.0-23.2
22.3-24.6
24.7-25.9
26.0-27.3
RUTGERS I.M.C.S.
Remote Sensing Lab
A1 A2 A3 A4 A5 A6 A7
Depth (m)
0 5 10 15 20 25 30
CTD Temperature Cross Section
Ctd Cast -
0 5 10 15 20 25 30 35 40
Range (km)
40 N
39 N
75 W
74 W

New Jersey Coastal Upwelling





D) 8/5/93
CTD Transect
B)
A)
C)
E)
Temp (°C)
10.8
12.2
13.6
15.0
16.4
17.8
19.2
20.6
22.0
23.4
24.8
wind
1 m s-1
F) CODAR & SST – 7/98
Temp.
21
23
25
27
Barnegat delta
LEO delta
Cape May delta
North
Song et al(JGR) 2002

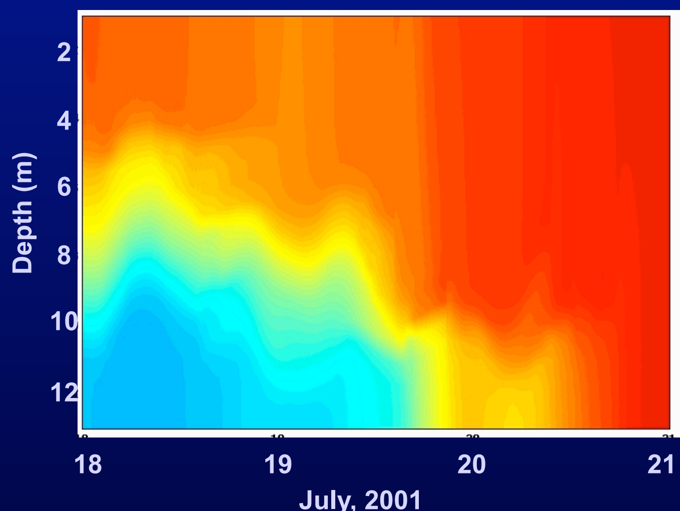


30 X 30 km LEO CPSE
An Integrated Observatory

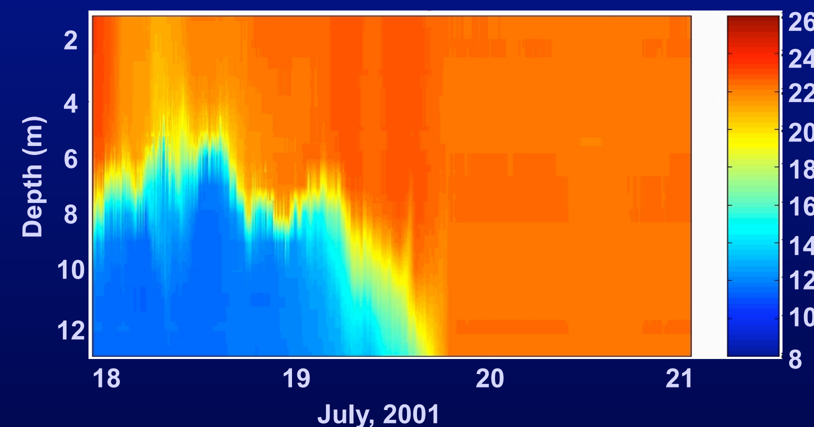
Forecast
Real-Time Ensemble Validation

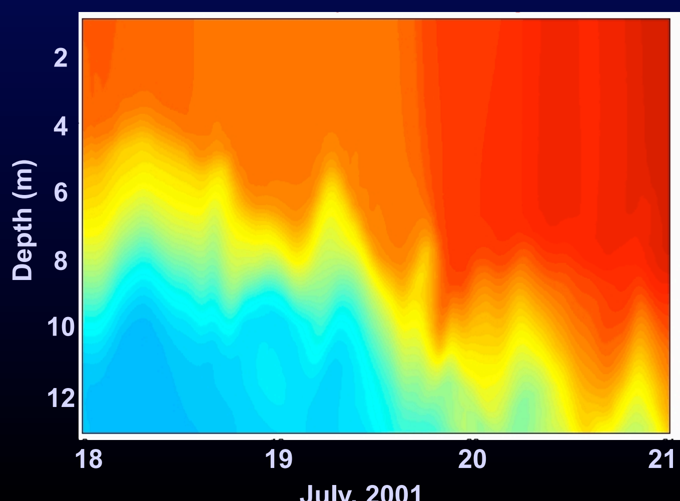
HR COAMPS / ROMS

Thermistor



KPP

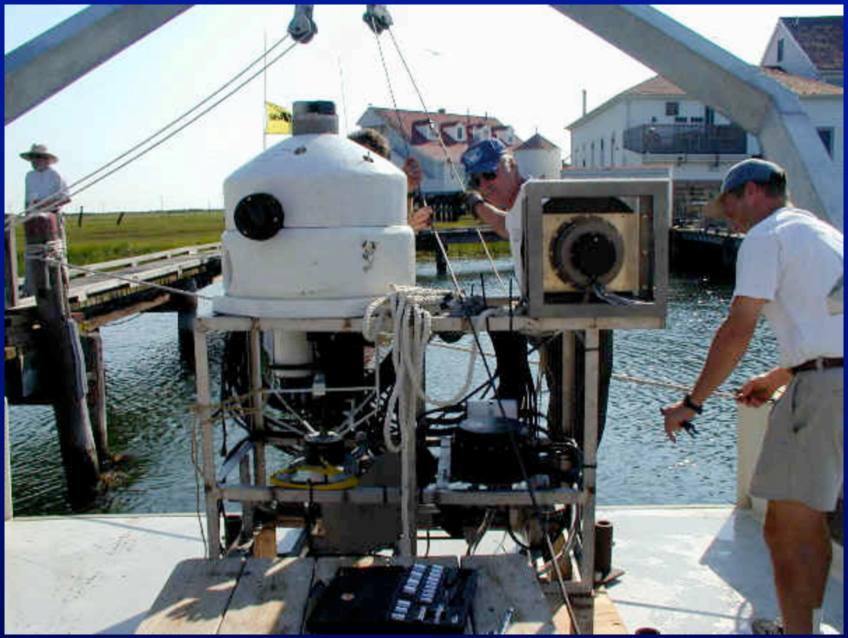


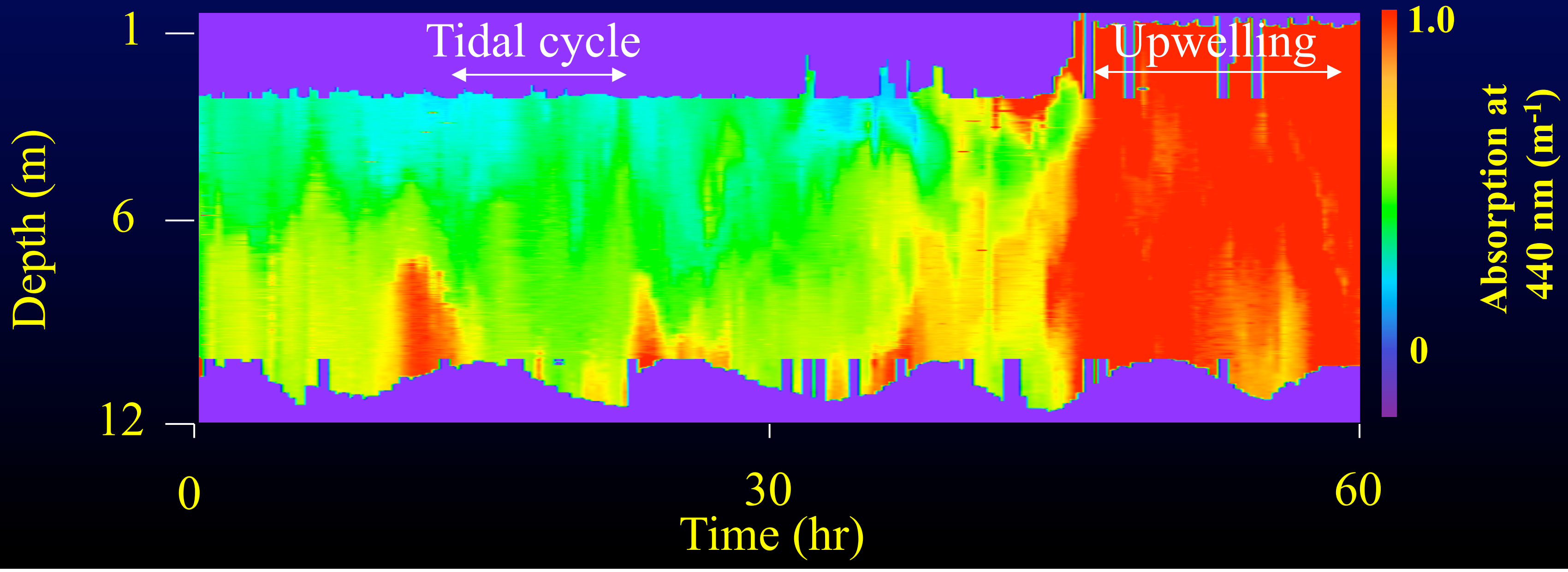


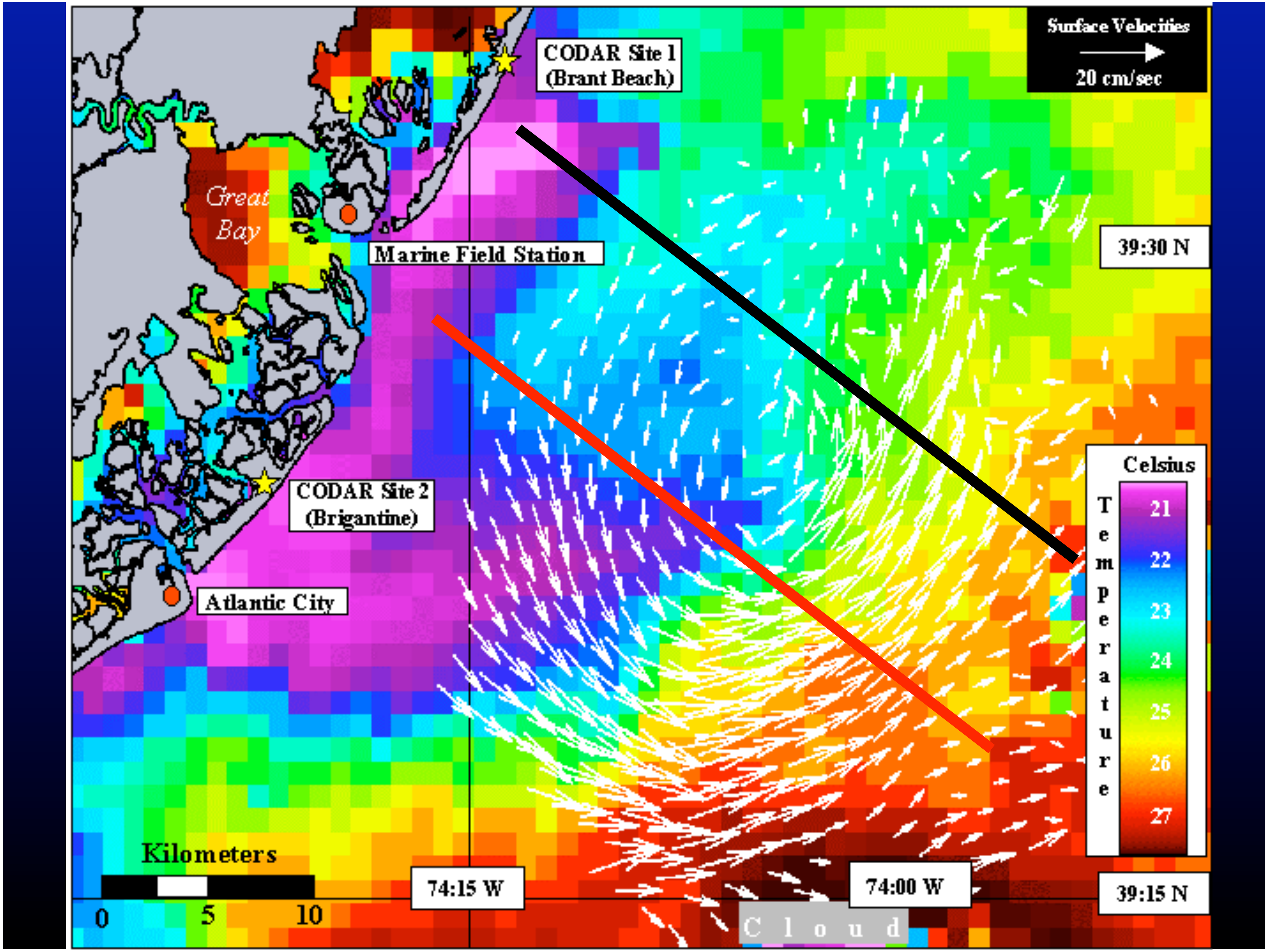
MY2.5

-In an observationally rich environment, ensemble forecasts can be compared to real-time data to assess which model is closer to reality and try to understand why.

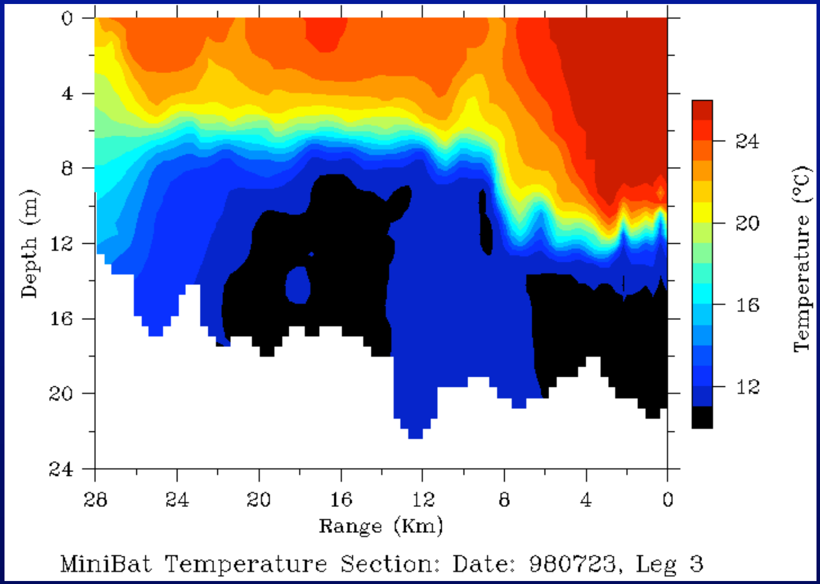
Optical profiler deployed on LEO-15 guest port

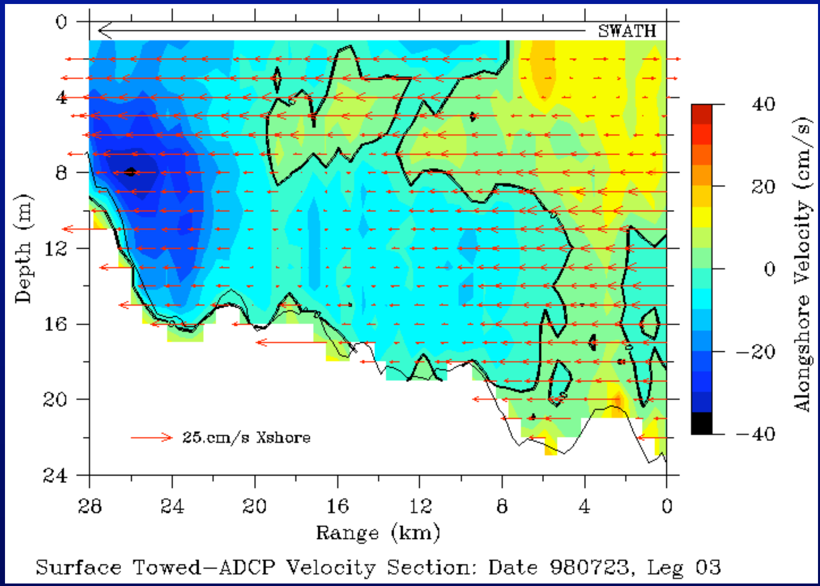


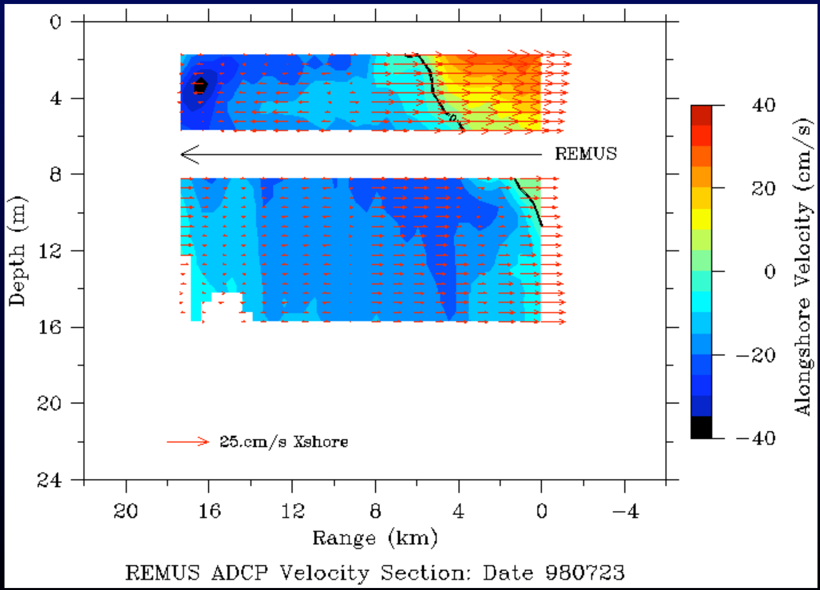


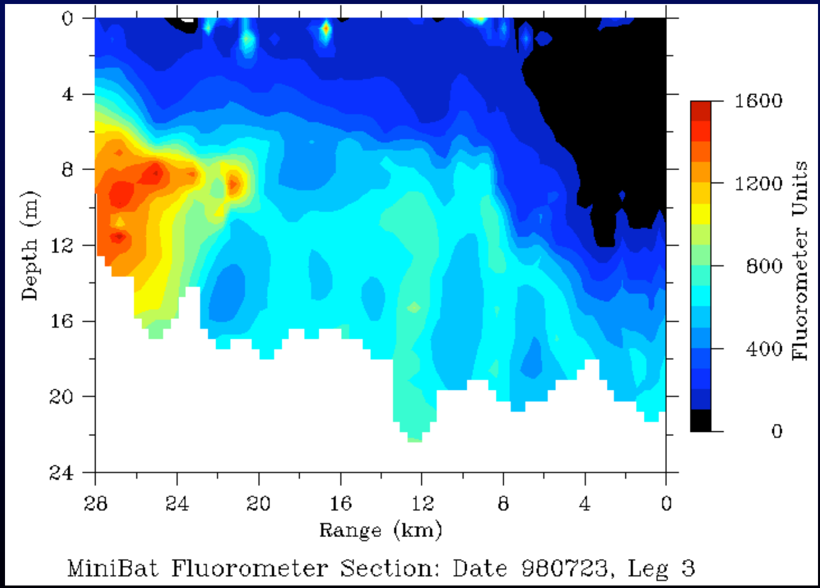

Surface Velocities
20 cm/sec
CODAR Site 1
(Brant Beach)
Great
Bay
Marine Field Station
39:30 N
CODAR Site 2
(Brigantine)
Atlantic City
Celsius
Temperature
21
22
23
24
25
26
27
Kilometers
0
5
10
74:15 W
74:00 W
39:15 N
Cloud

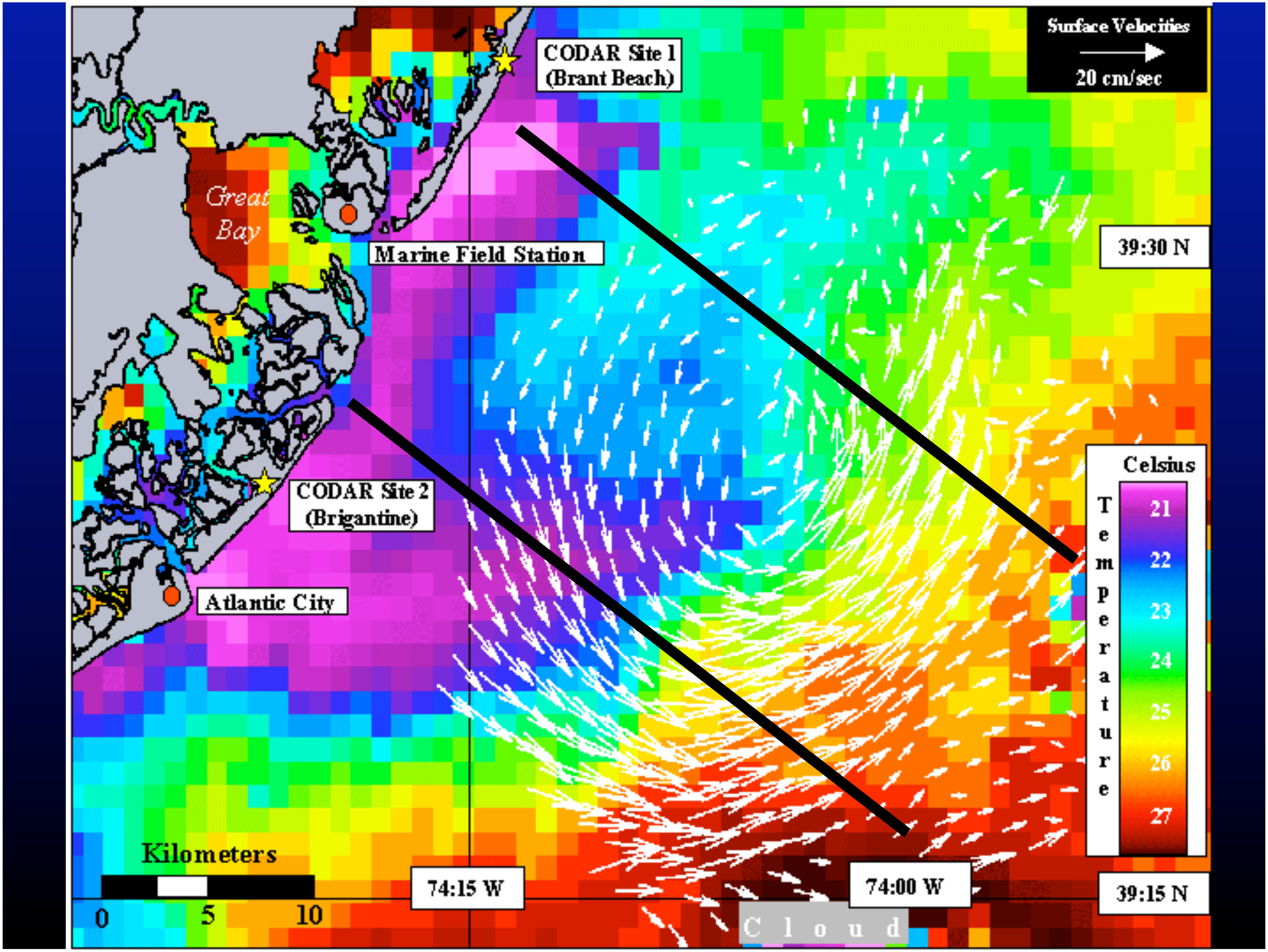
Shipboard surveys





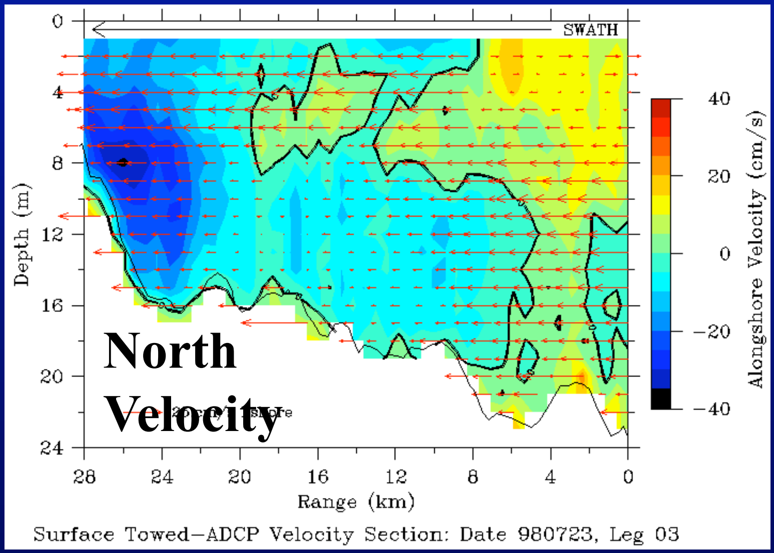


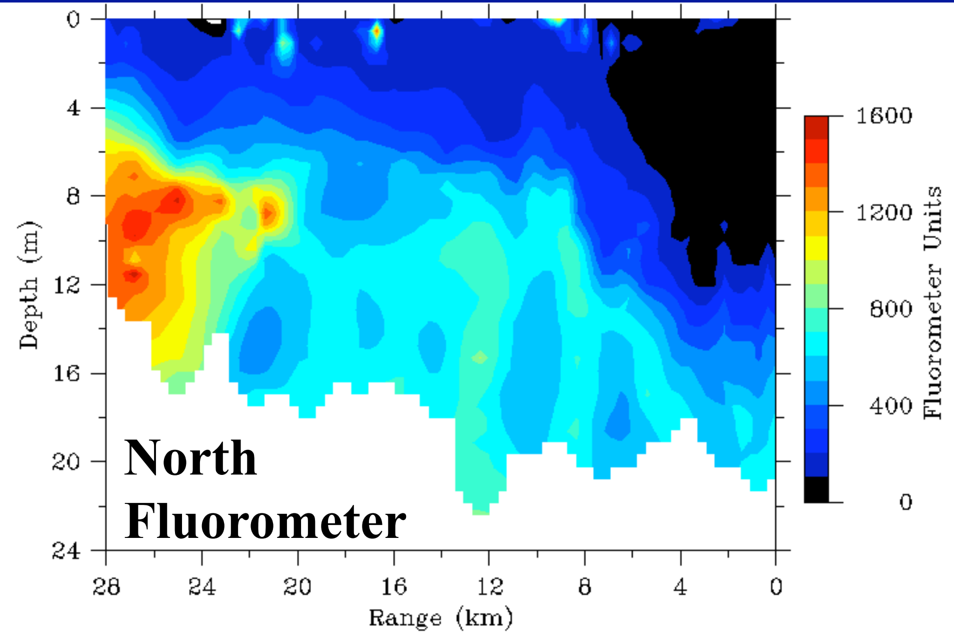


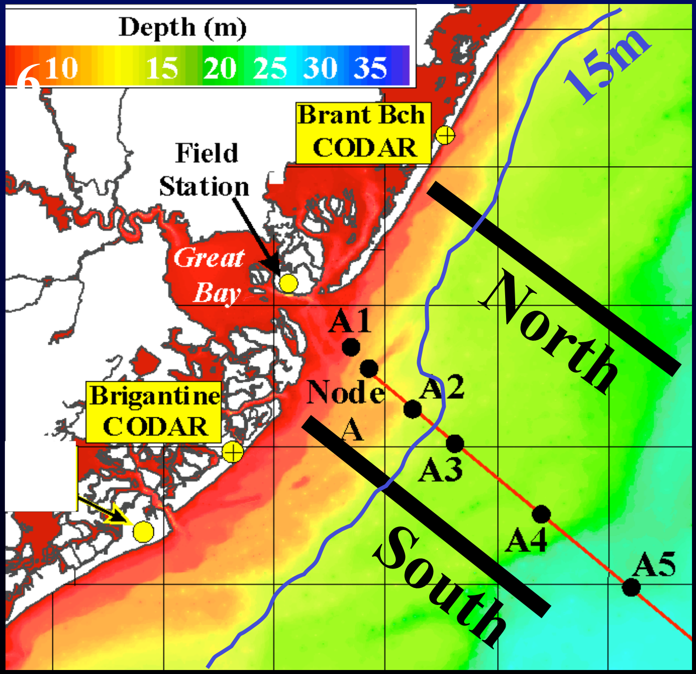


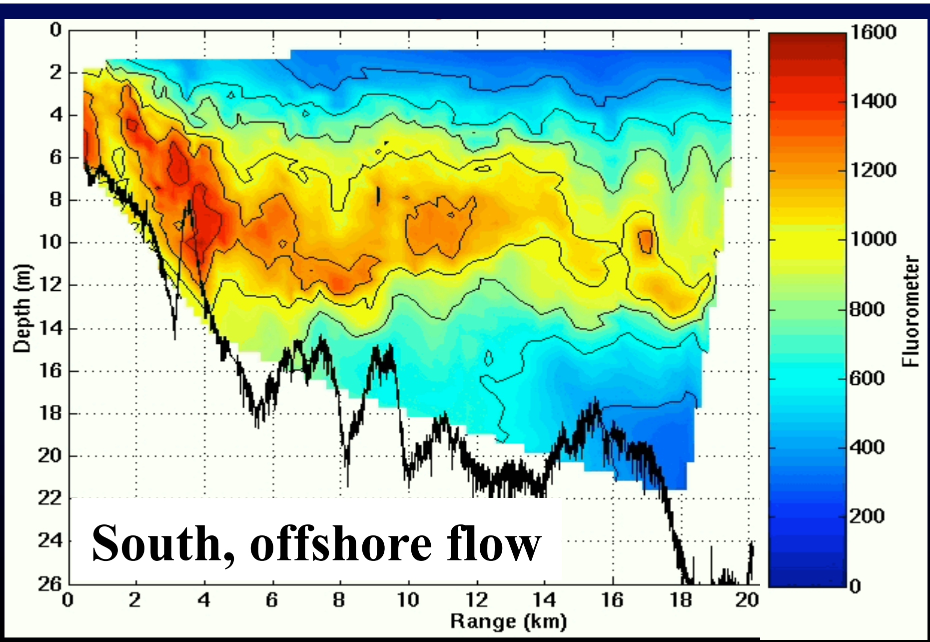
CODAR Site 1 (Brant Beach)
Surface Velocities
20 cm/sec
Great Bay
Marine Field Station
39:30 N
CODAR Site 2 (Brigantine)
Atlantic City
Celsius
Temperature
21
22
23
24
25
26
27
Kilometers
0
5
10
74:15 W
74:00 W
39:15 N
Cloud

Adaptive Sampling of Resolved Scales- Shipboard & AUV surveys

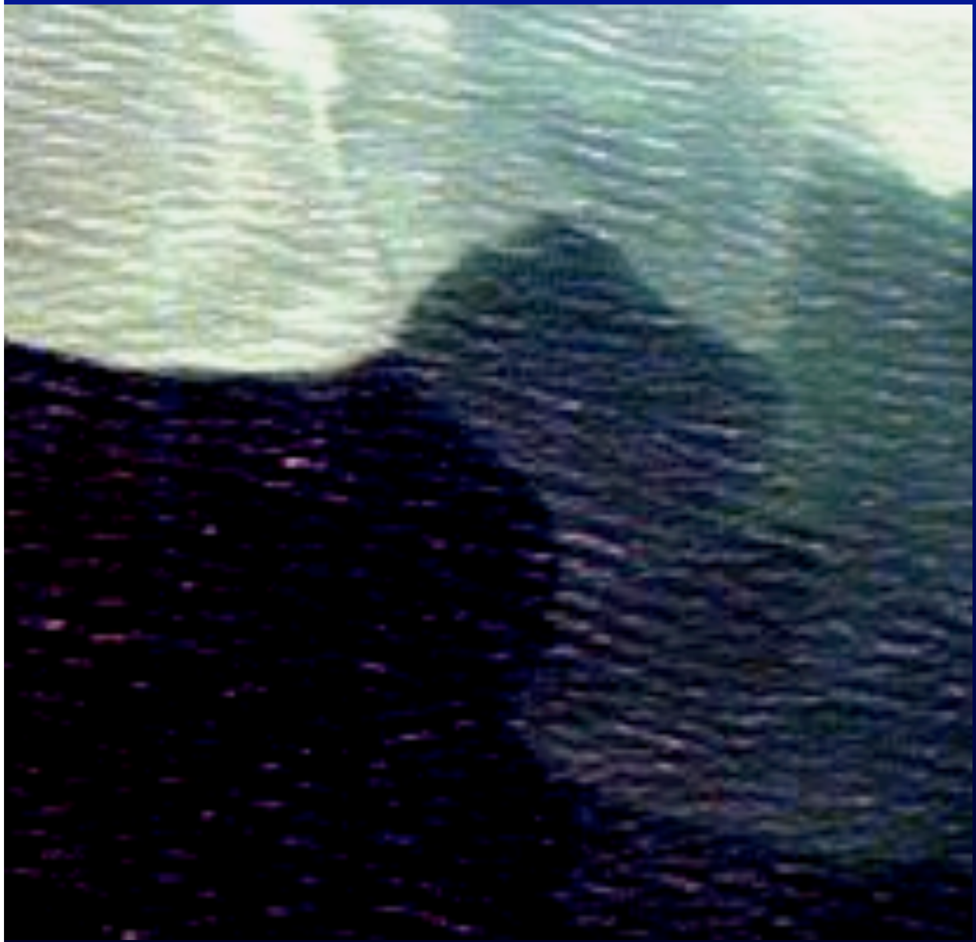


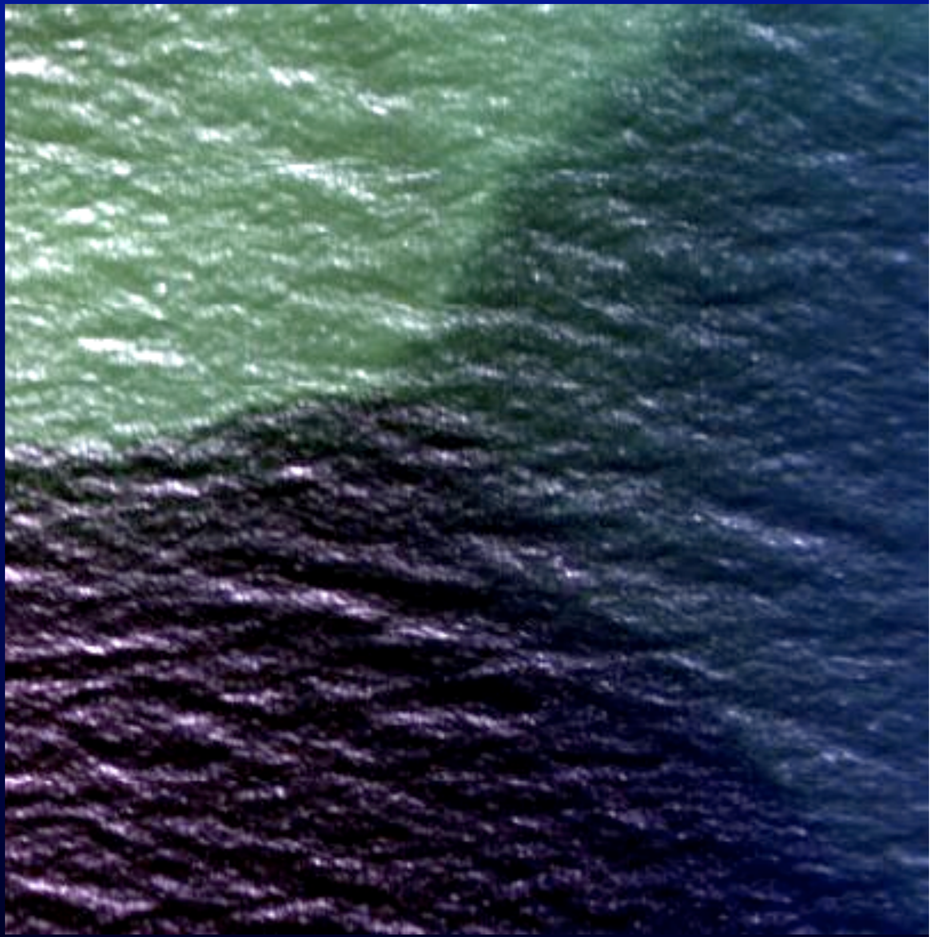


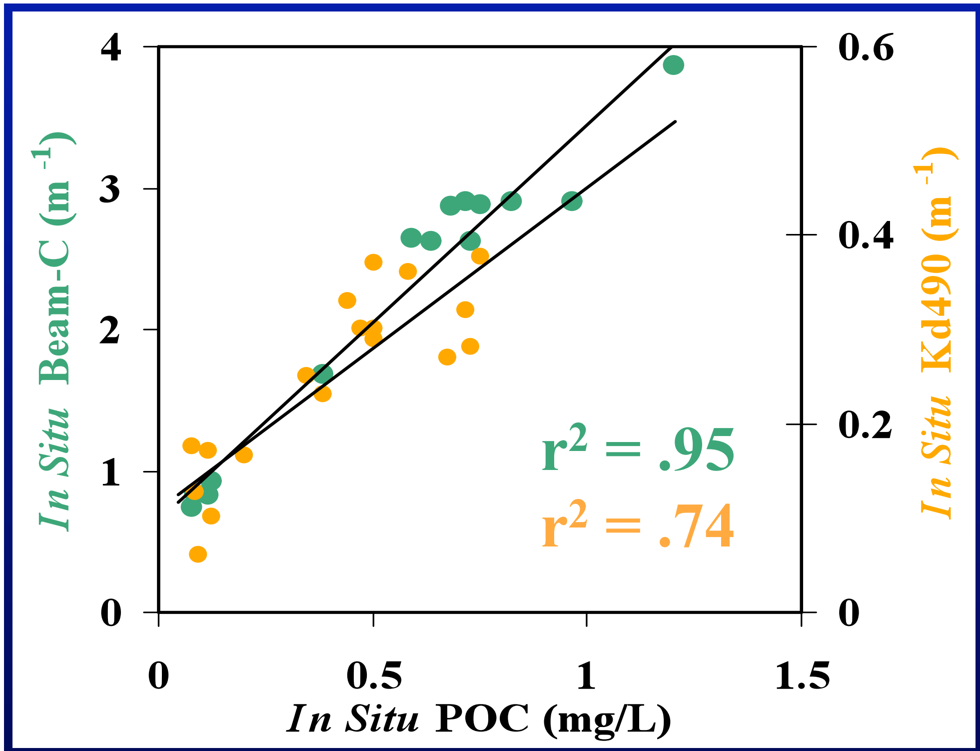




That Pristine Blue NJ Water







POC represents potentially
182 µmol oxygen/kg
Upwelling can account
For spatially distribution
of recurrent upwelling eddies

-Where does the POC come from?

What is the annual particle dynamics for the shelf itself?

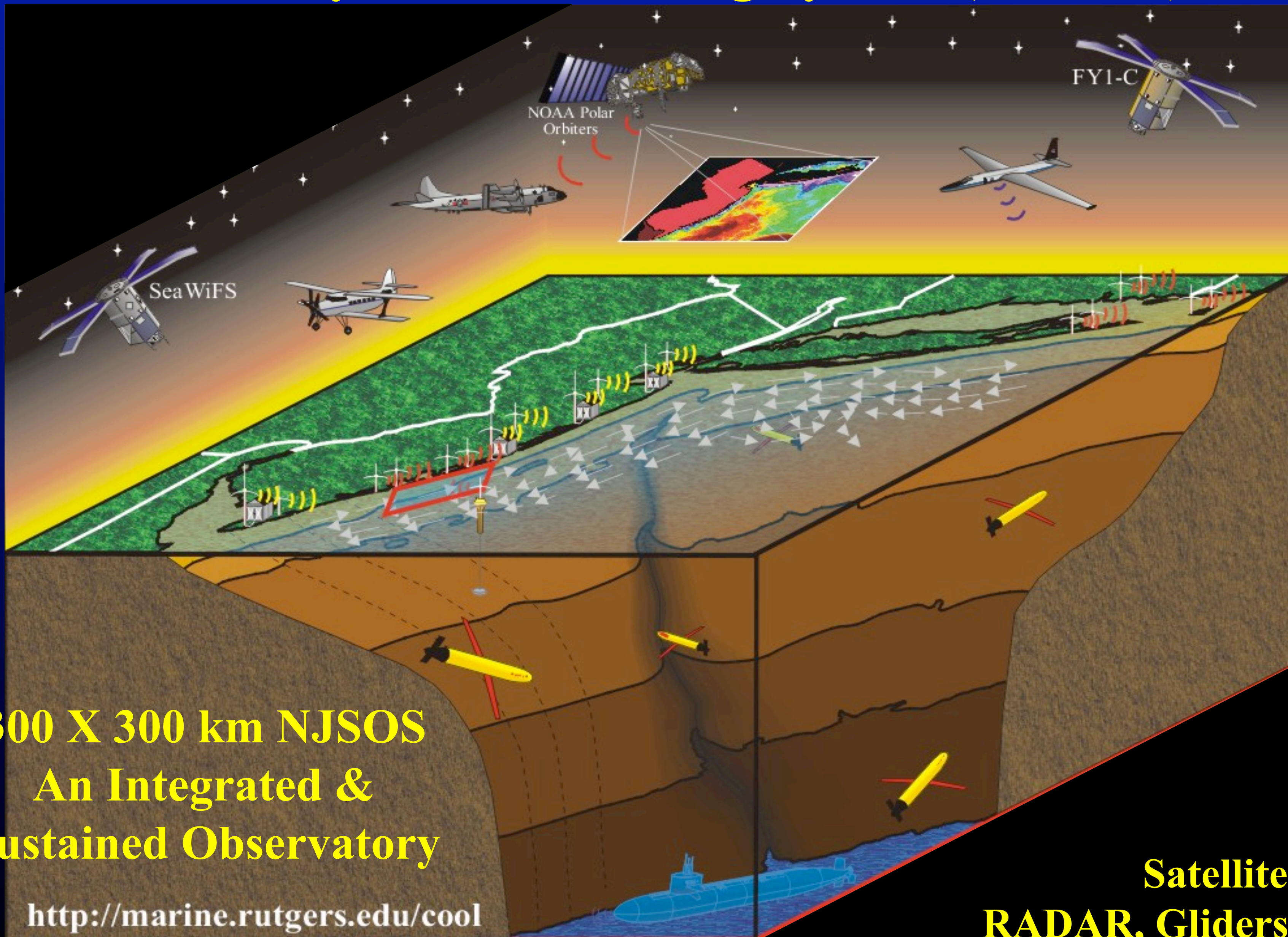
How important is are rivers in the loading of material?

-What regulates "big upwelling years"

The big upwelling years seem to follow colder winters

is it the size and extent of the Mid-Atlantic cold pool?

New Jersey Shelf Observing System (NJ-SOS)



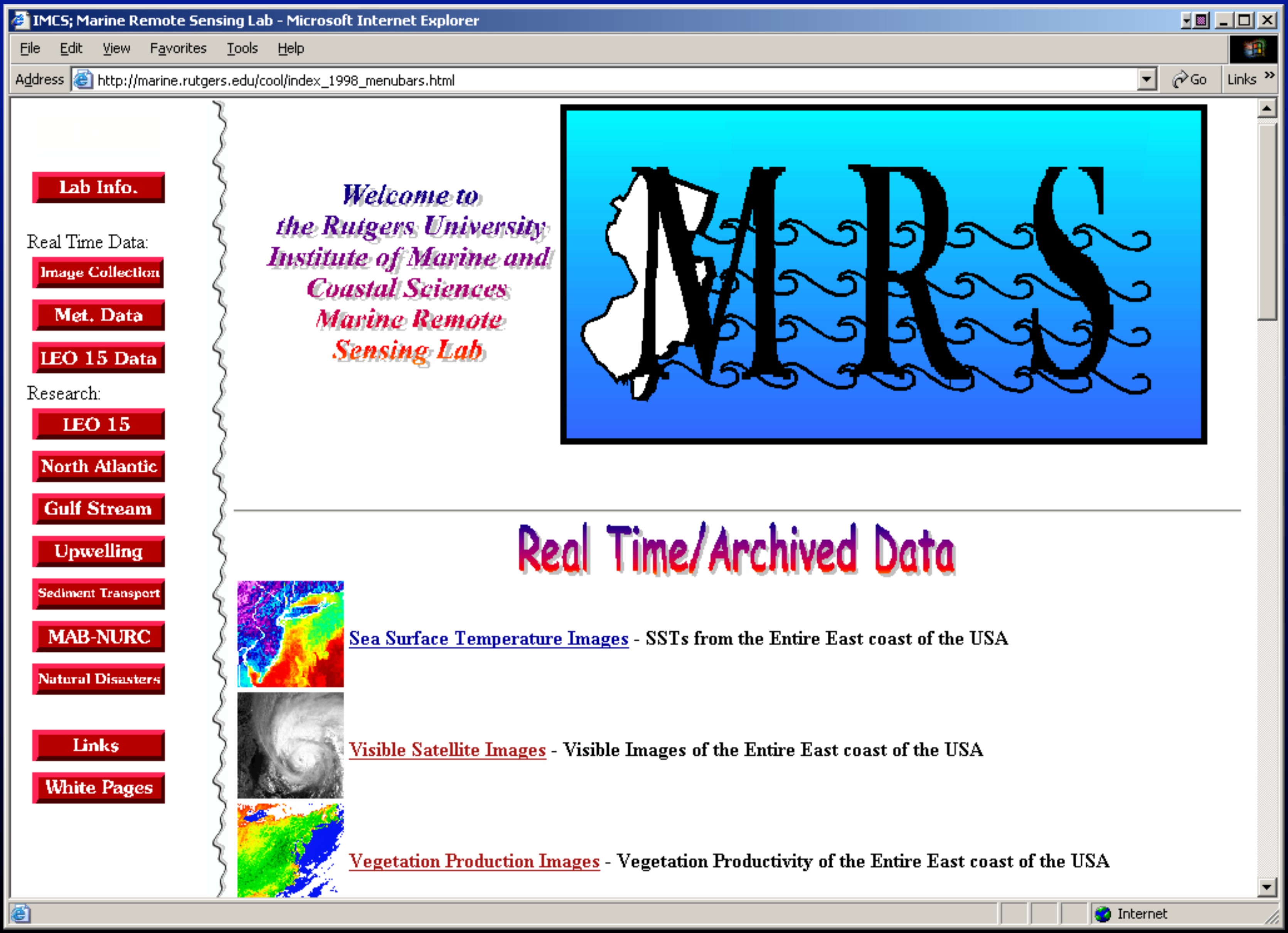
300 X 300 km NJSOS
An Integrated &
Sustained Observatory

http://marine.rutgers.edu/cool

Satellites,
RADAR, Gliders

Where we do go from here?

Marine Remote Sensing Webpage : Starting 1994
(We weren't even "COOL" yet!)



How do we archive and distribute the data?

Initial data distribution

- Duck Field Research Facility model.

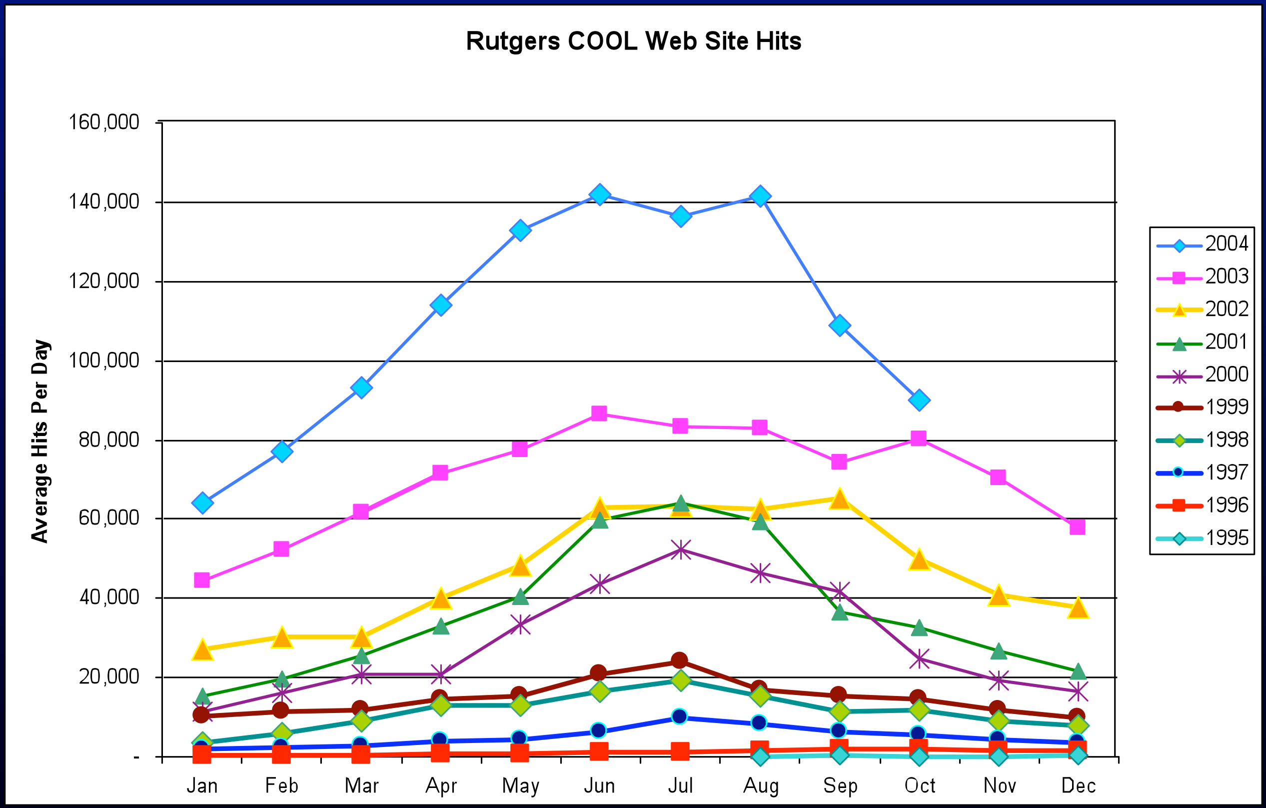
- Monthly reports summarizing the data on an FTP site.

A new approach to data distribution

- Keith Bedford (Ohio State University) approached us with a concept known as the "world wide web".

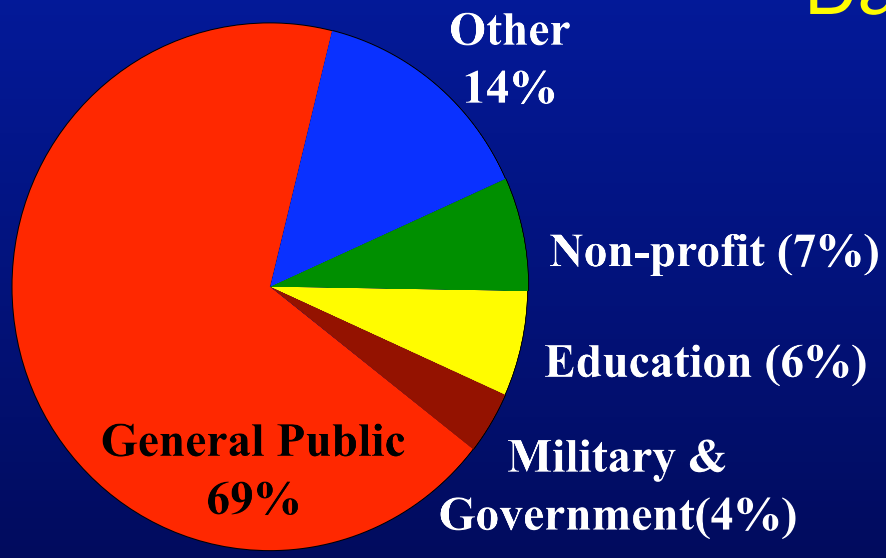
- He claimed he could get 30 hits a month!

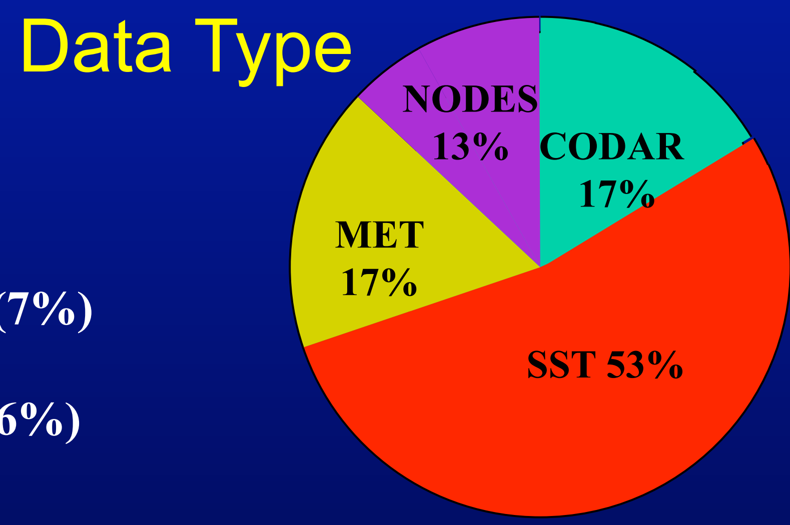
OUTREACH

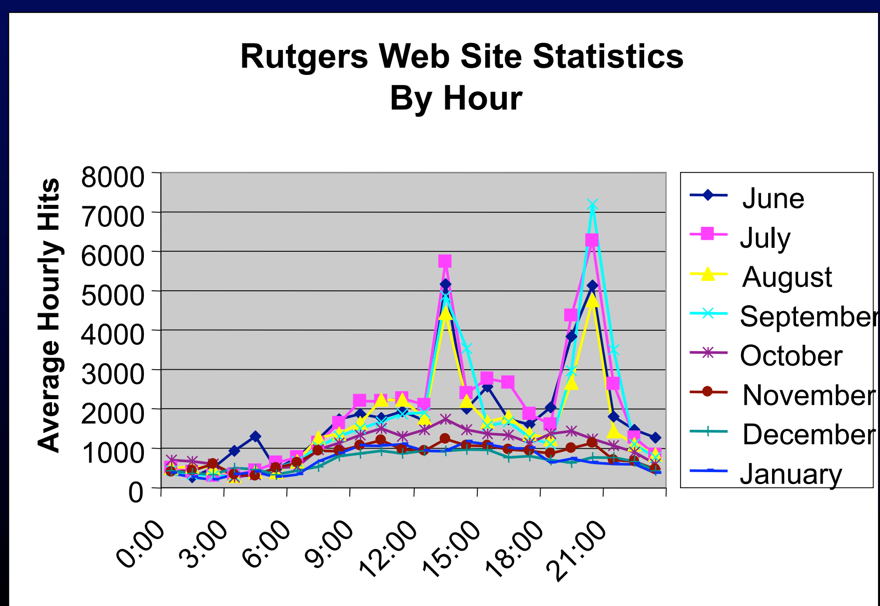


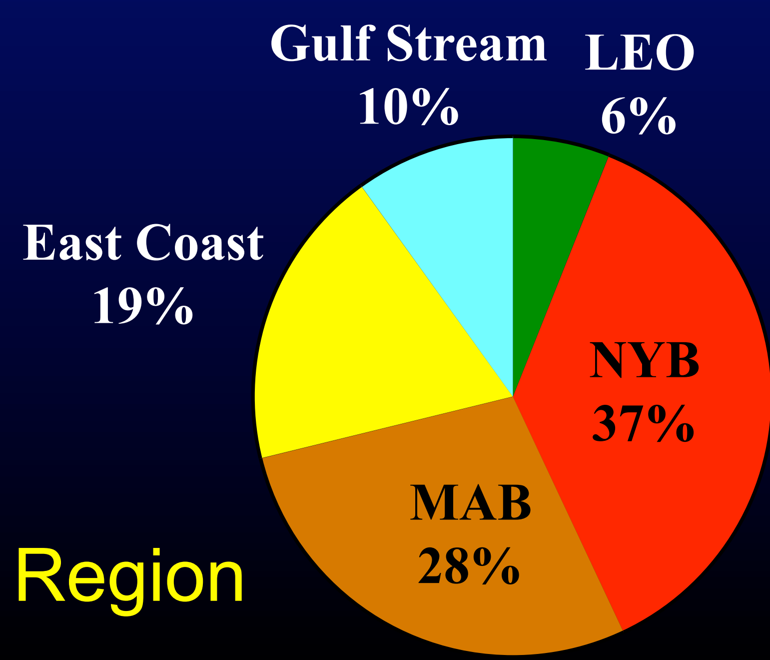
Rutgers COOL Web Site Hits
Average Hits Per Day
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
-
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
2004
2003
2002
2001
2000
1999
1998
1997
1996
1995

Rutgers Web Site Statistics



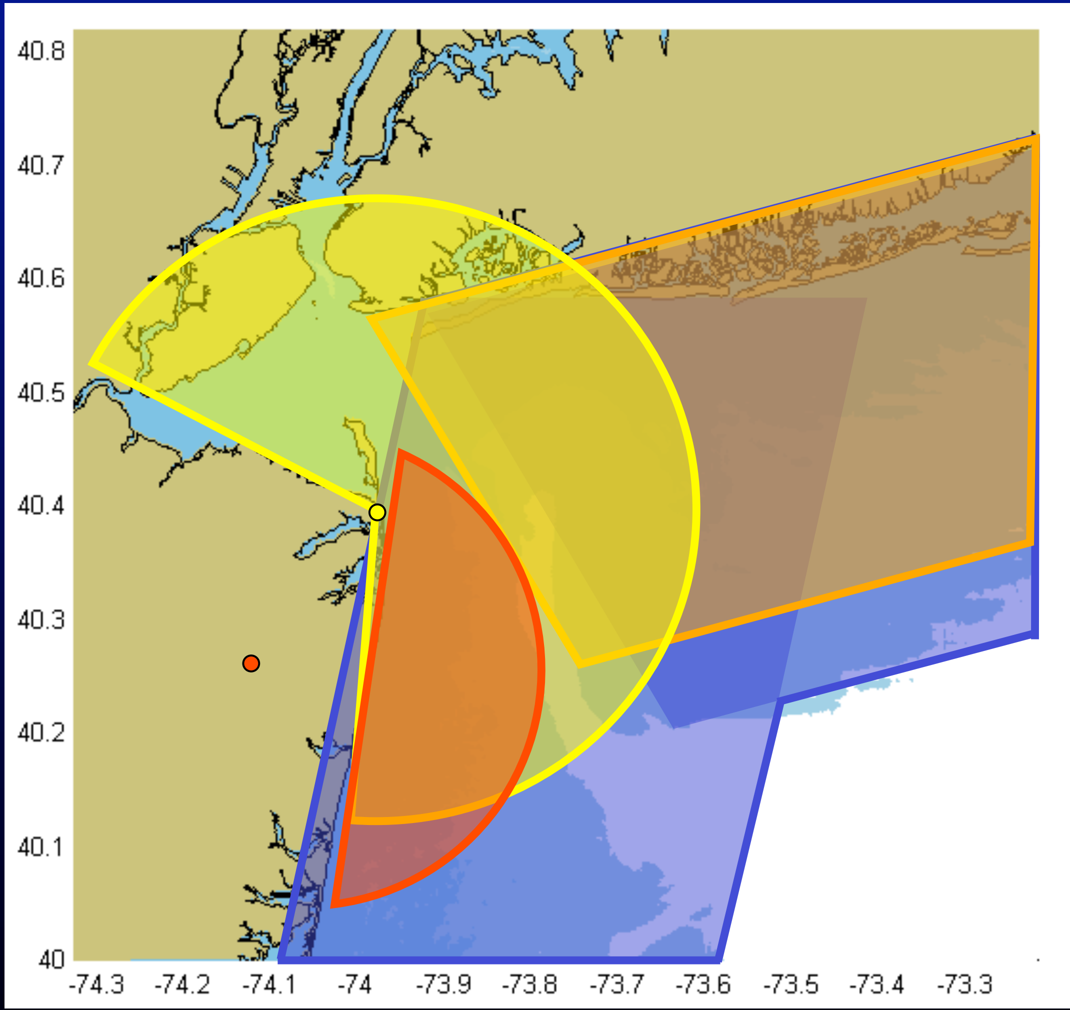


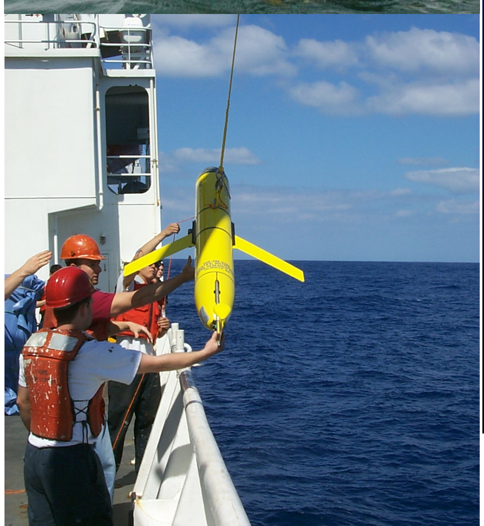




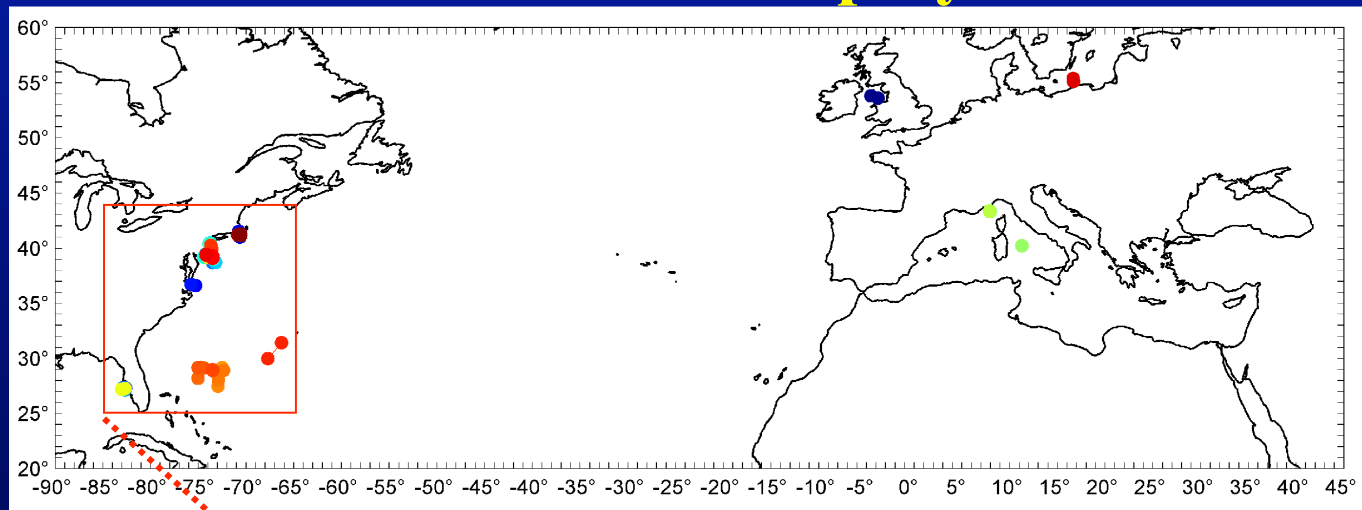
Ship-to-Shore Communications

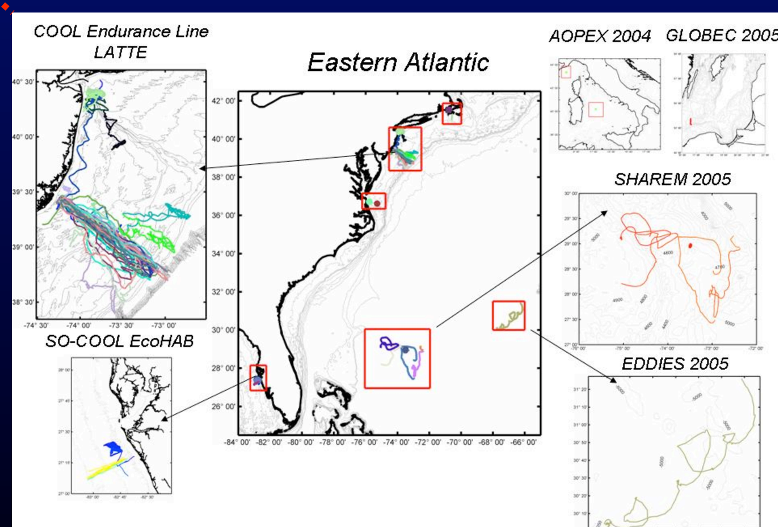
- **AirNet Communications Wireless Broadband** (~1.5 Mbps, coverage 7 miles offshore from Sandy Hook)
- **Verizon National Access** (~100 kbps, coverage up to 20+ miles off Long Island, less for New Jersey)
- **Freewave Radio Modems** (~80 kbps, coverage for a 18 mile radius centered at Sea Bright Fire Department)
- **Verizon Quick2Net** (14.4 kbps, coverage up to 20+ miles off both New Jersey and Long Island)
- **Iridium Satellite** (2,400 bps, global coverage, data and voice)





Global Glider Deployments

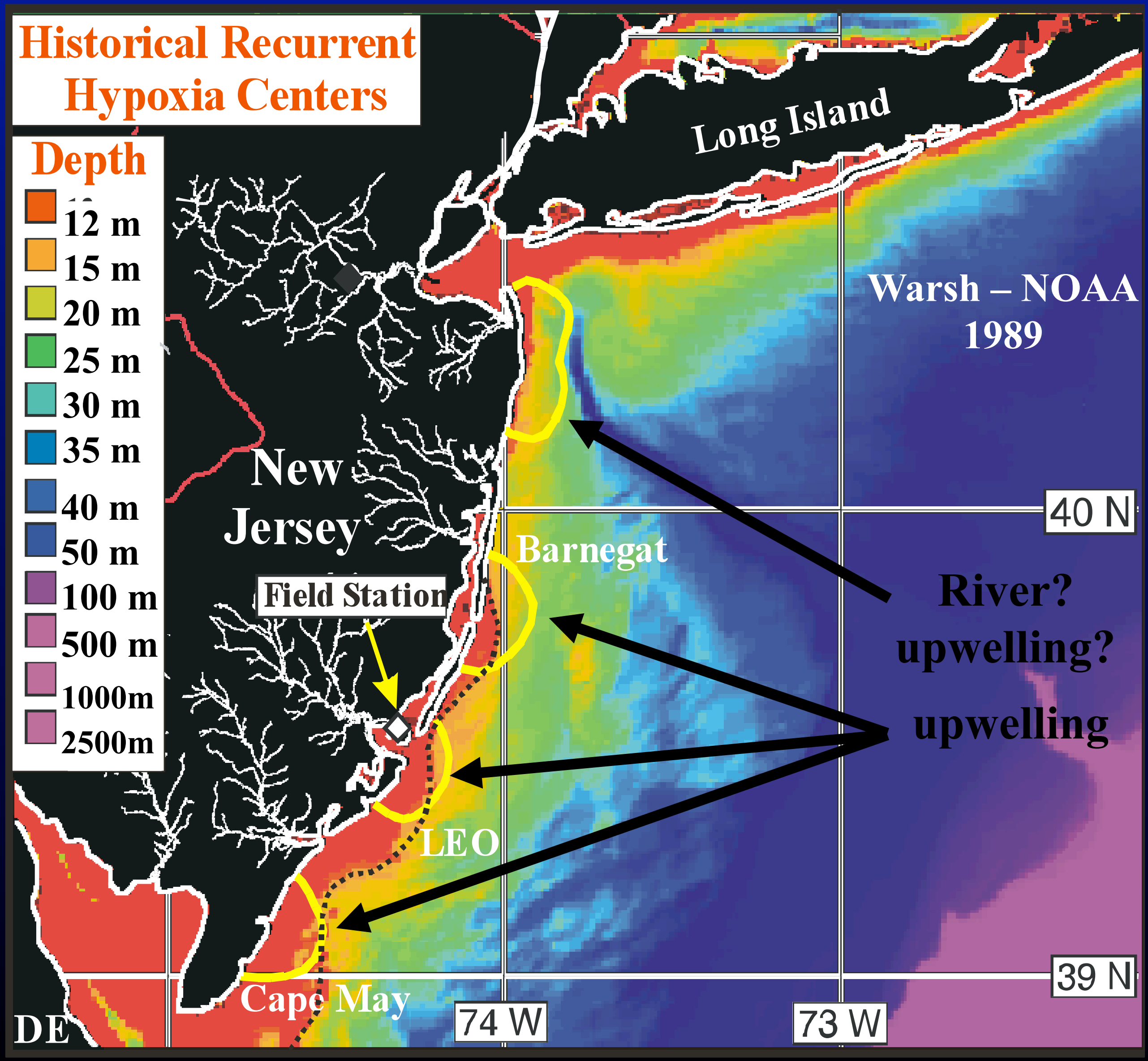


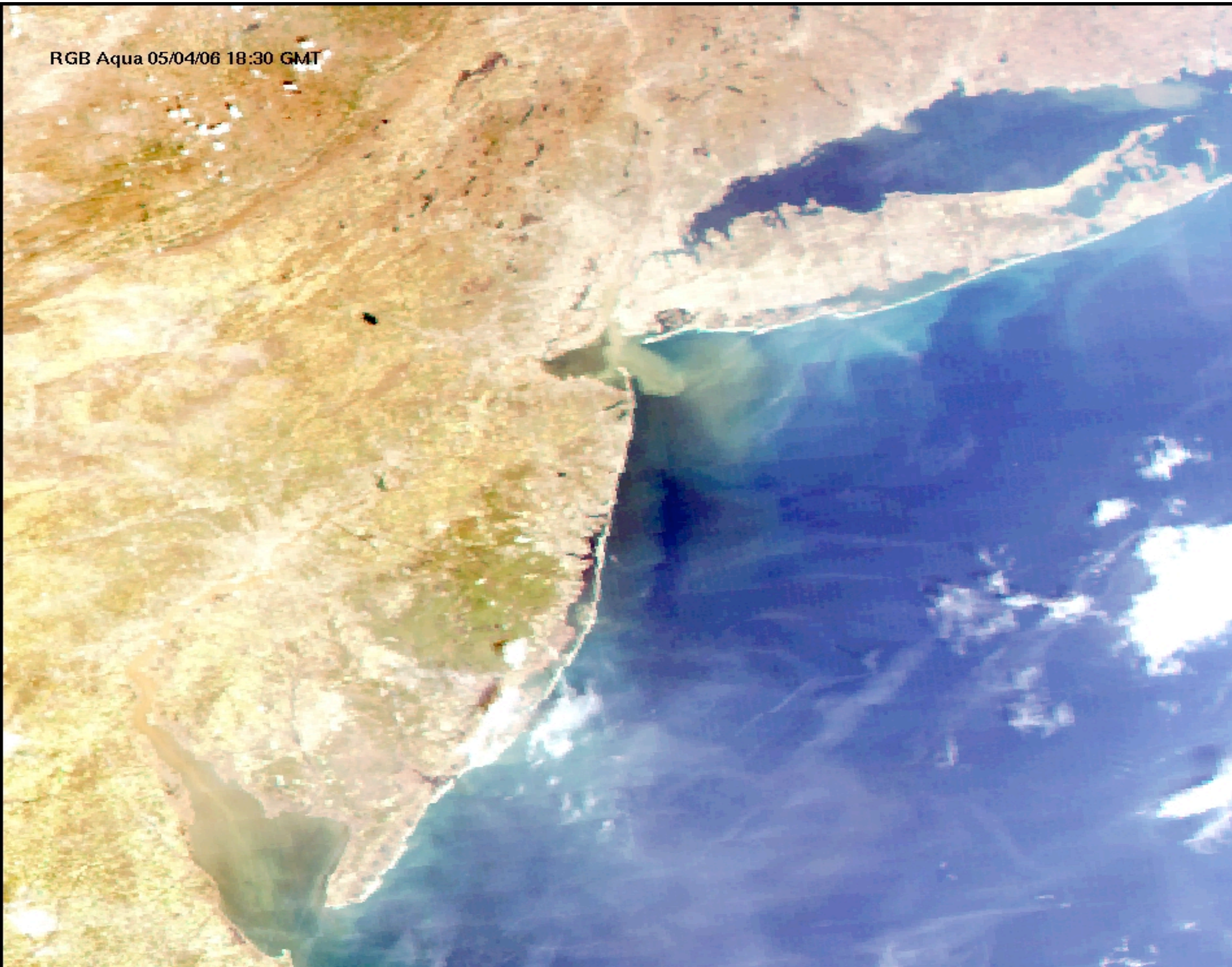


Glider Stats Since Oct. 03

KILOMETERS FLOWN: 15041
CALENDAR DAYS: 504
GLIDER DAYS: 704

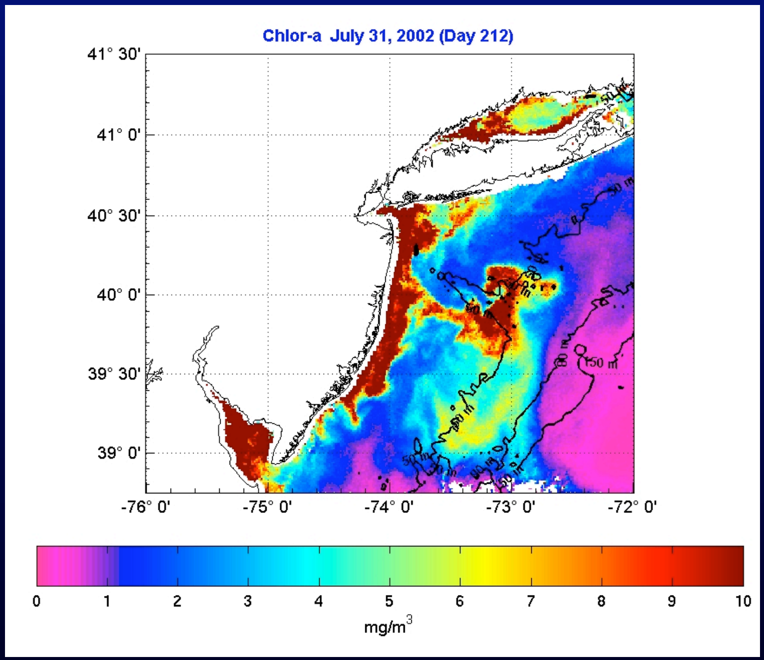
Hypoxia/Anoxia & Bottom Bathymetry

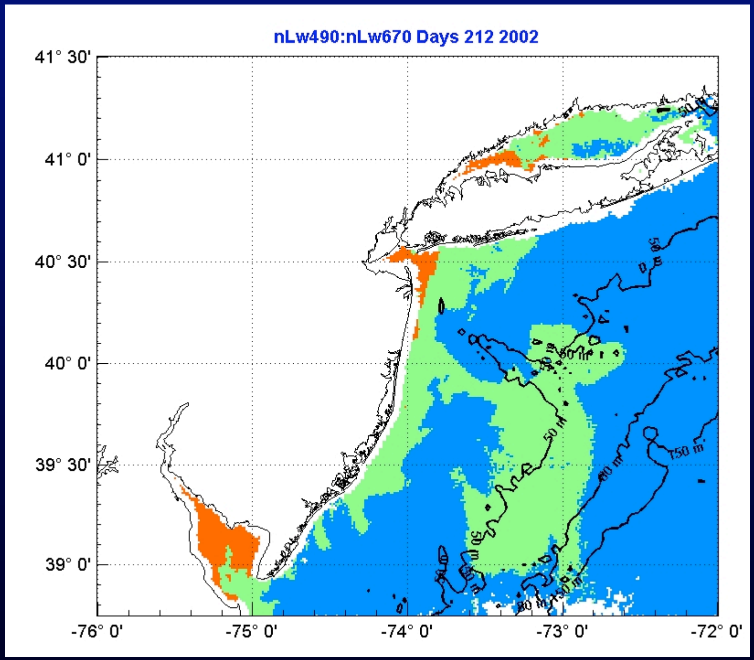



RGB Aqua 05/04/06 18:30 GMT

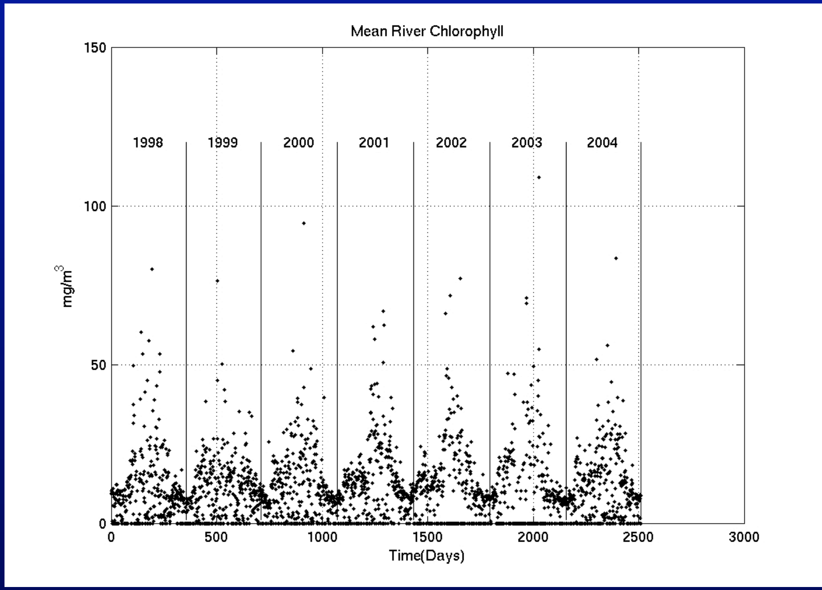
RIVERS ARE IMPORTANT TO THE OVERALL SHELF BUDGET OF CARBON AND BIOLOGICAL PRODUCTIVITY

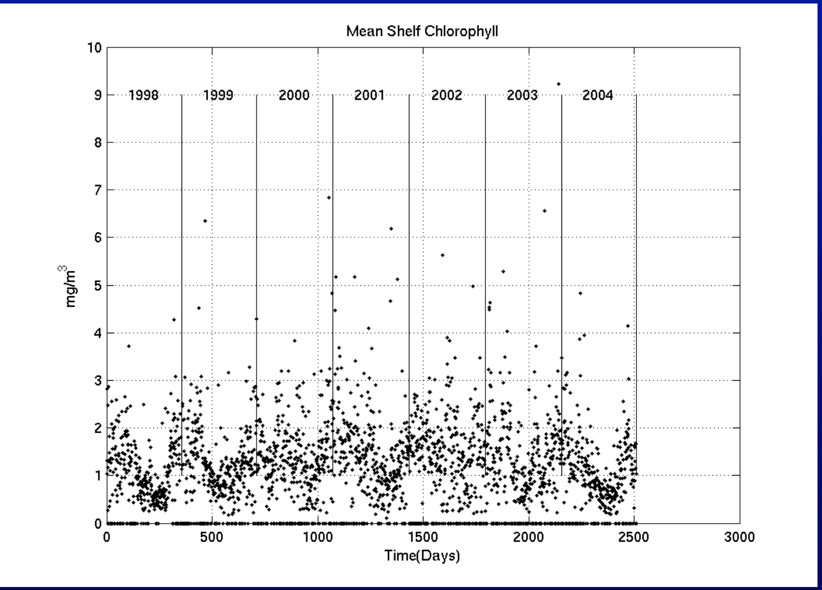
HOW DO WE DISCRIMINATE RIVERS?

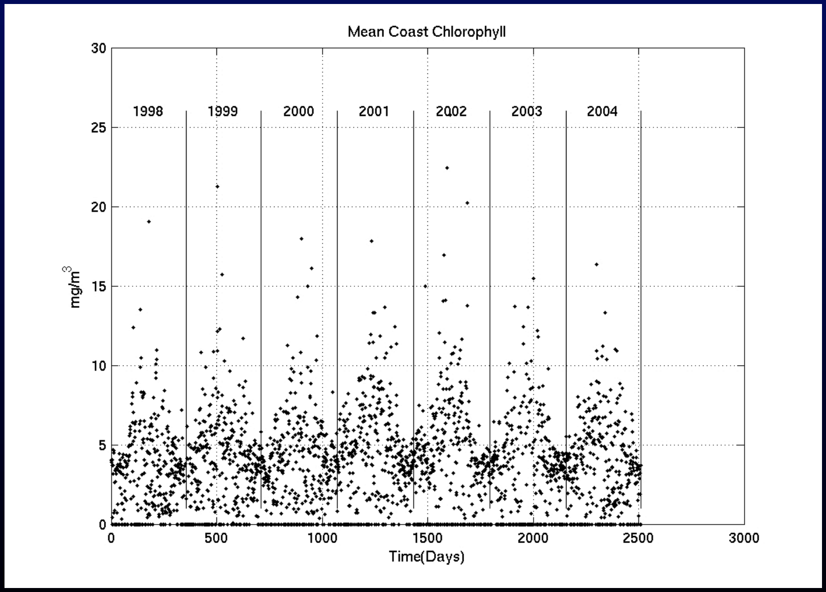


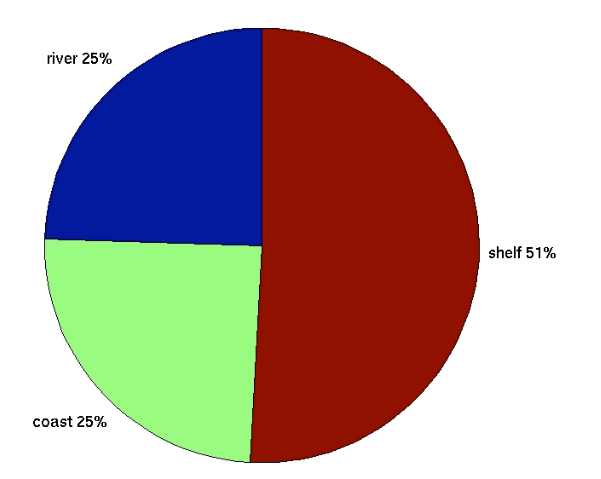


ANNUAL CHLOROPHYLL A FOR THE MAB

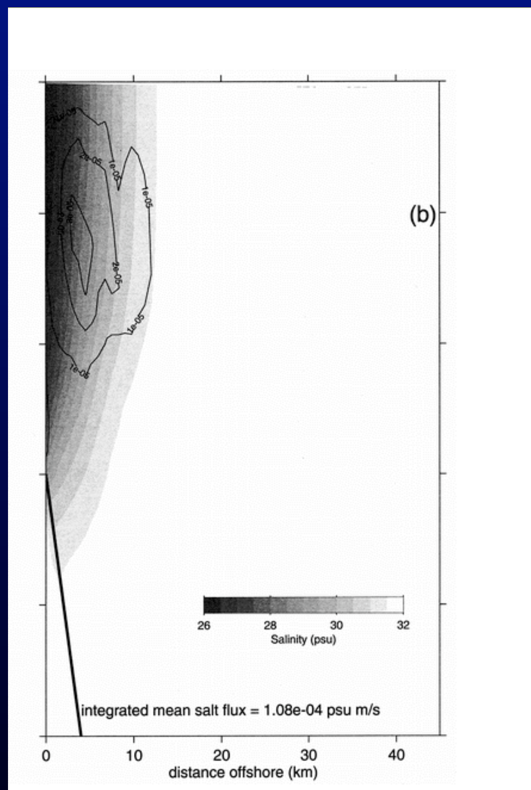
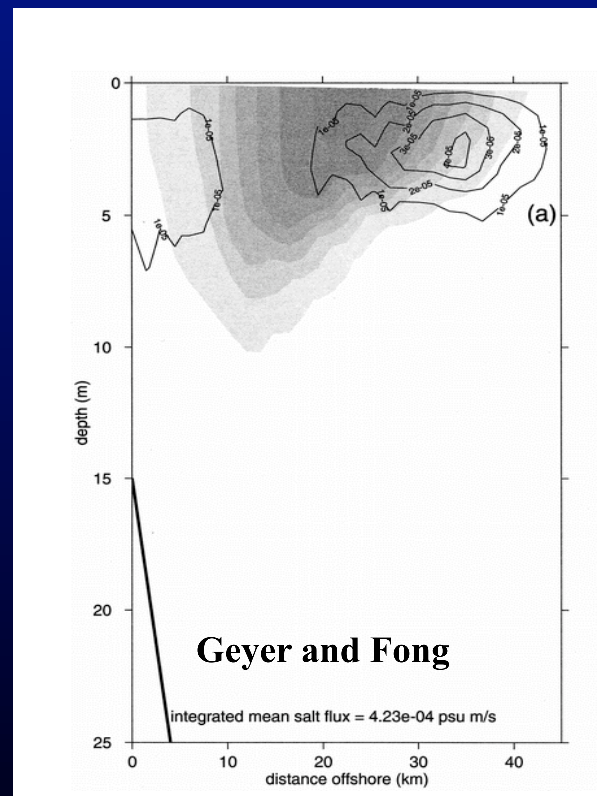




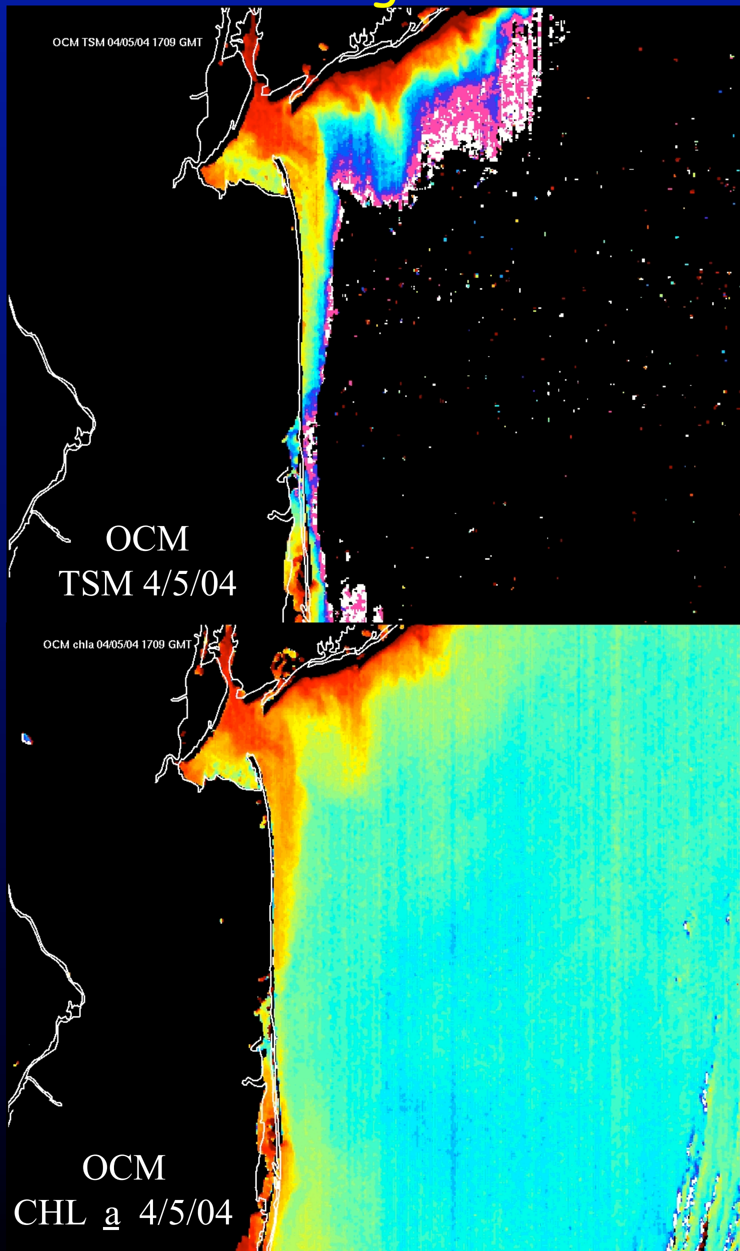




Science focus Land-Ocean: How does the dynamics in the physical oceanography influence the transport and transformation of the particulate and dissolved matter in coastal buoyant plumes?

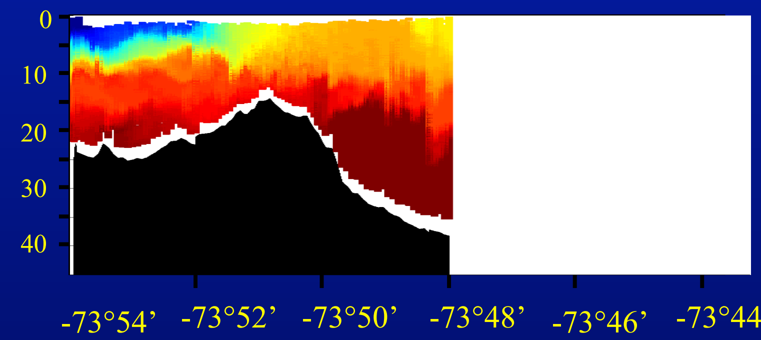
Downwelling	Upwelling
	
Southern flowing turbid plume	Eastern offshore flowing shallow turbid plume

Downwelling condition



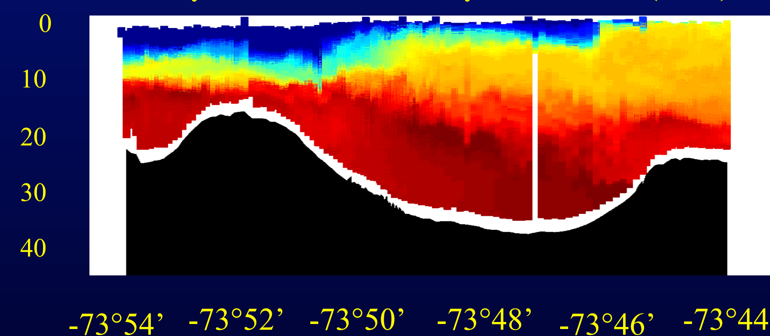
Downwelling condition

05-May-2004 11:33:11 - 06-May-2004 01:14:01 (GMT)



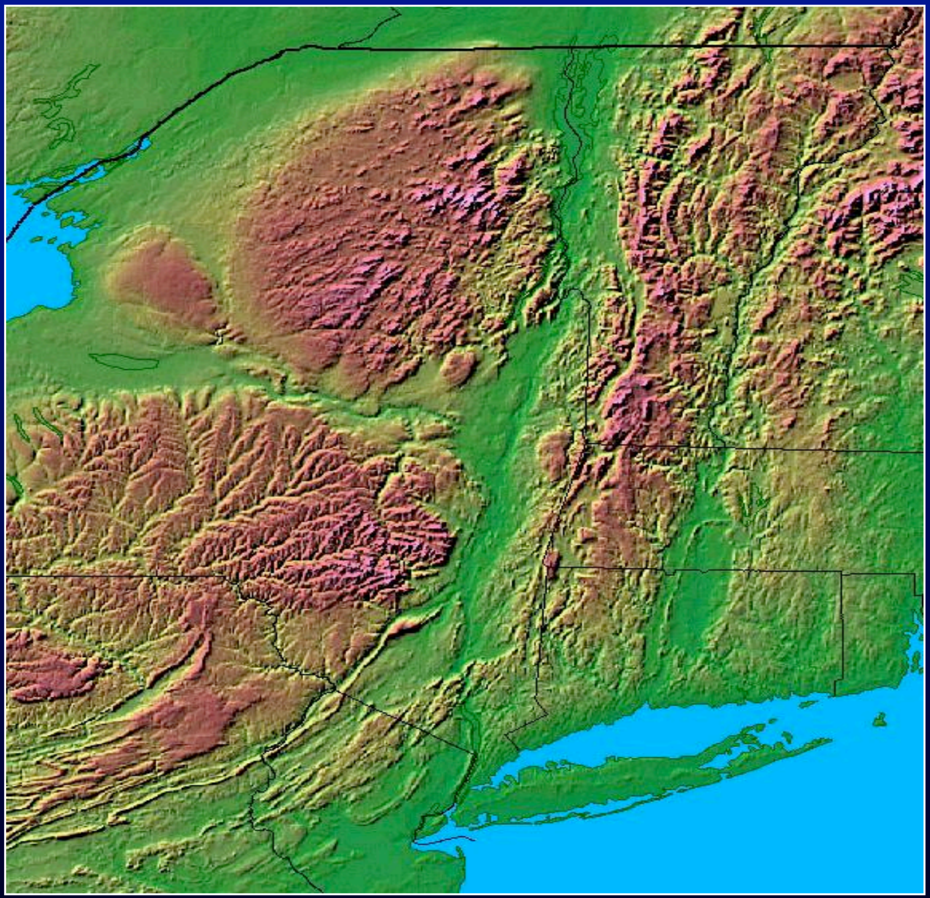
Upwelling condition

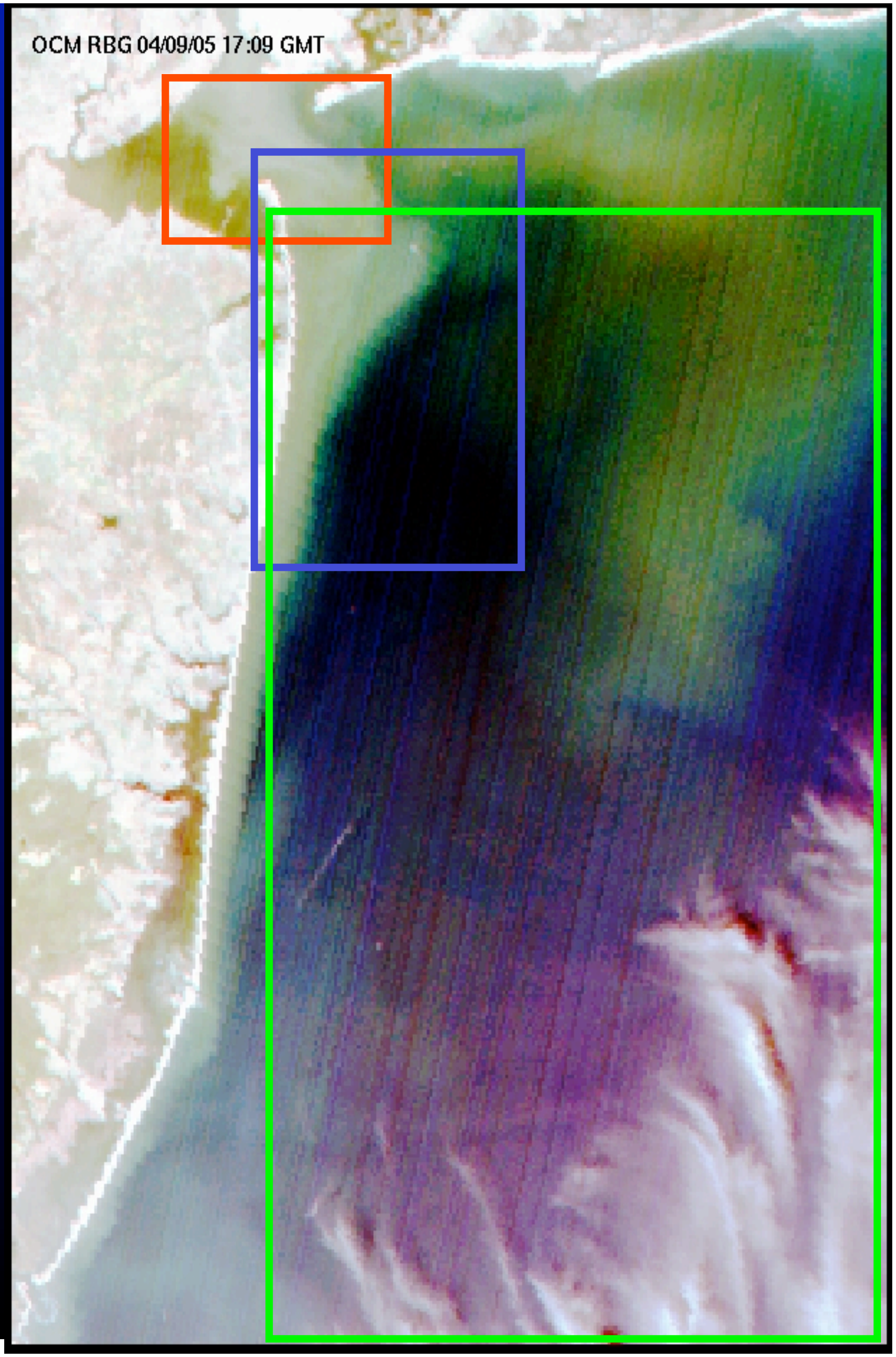
11-May-2004 23:06:28 - 12-May-2004 19:32:29 (GMT)



The Geyer-Fong plume dynamic appears to hold HOWEVER……

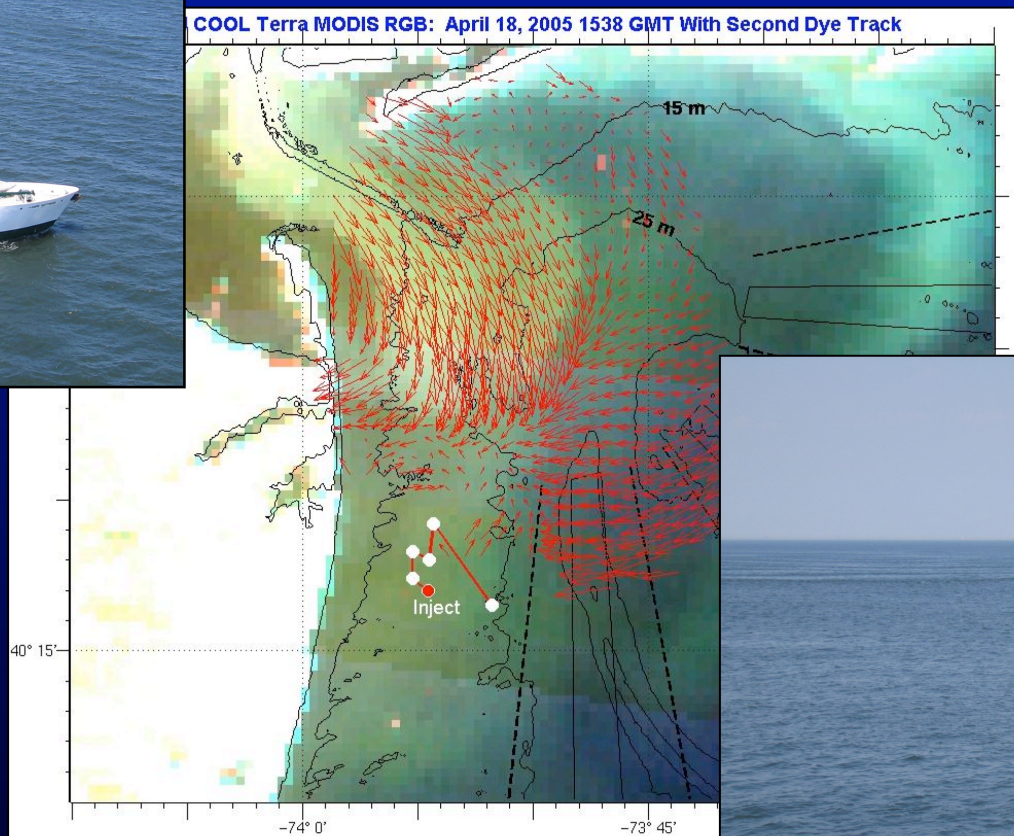
CARBON IS PROVIDED TO THE SHELF FROM NURMEROUS RIVERS FED BY BIG WATERSHEDS

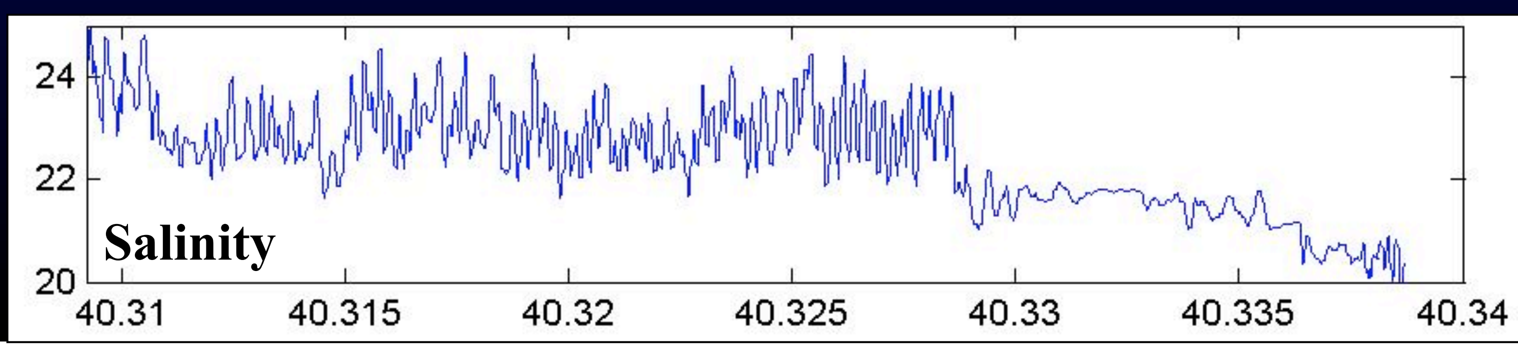


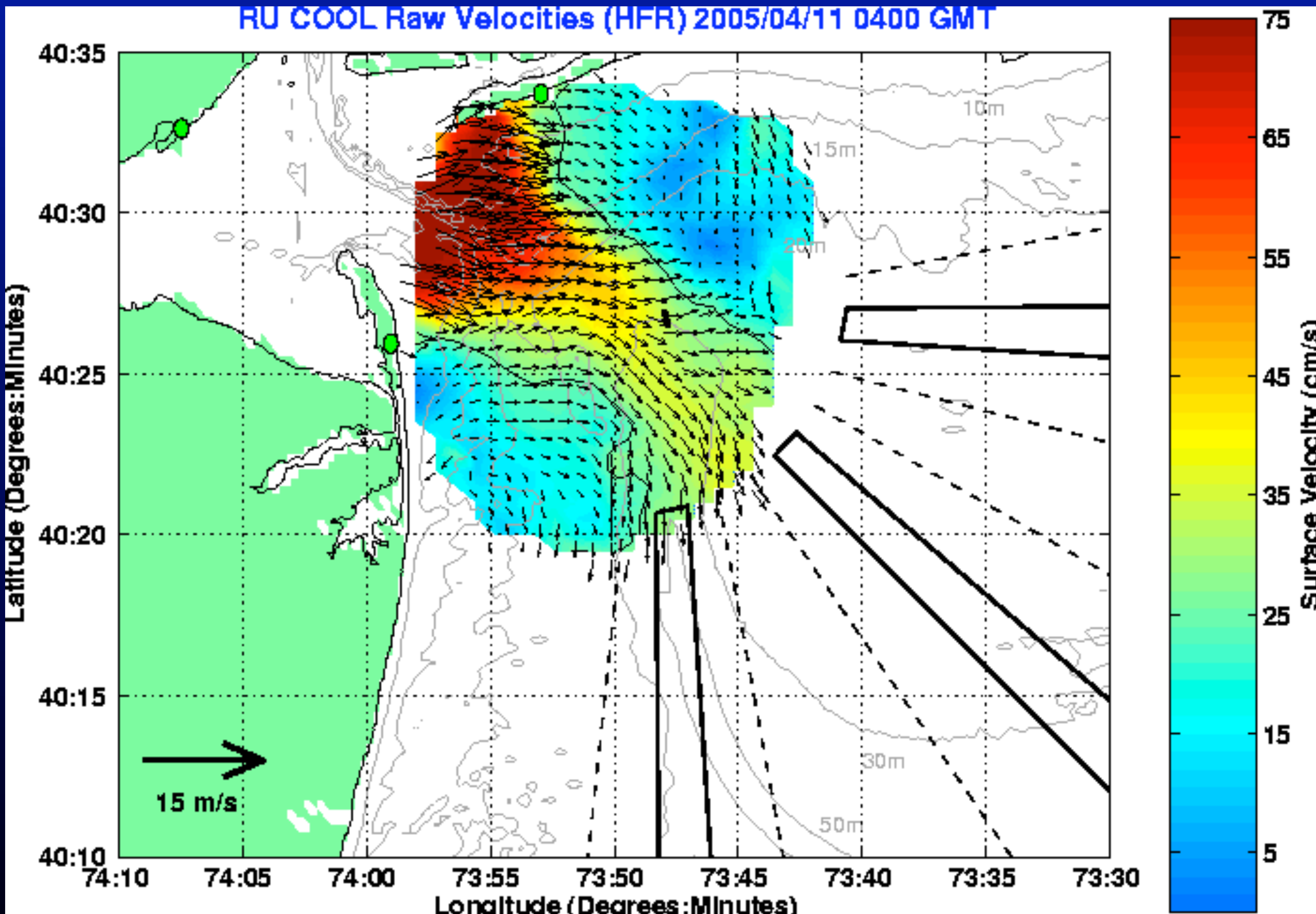


- Estuary Exit
- Near-Shore
- Shelf

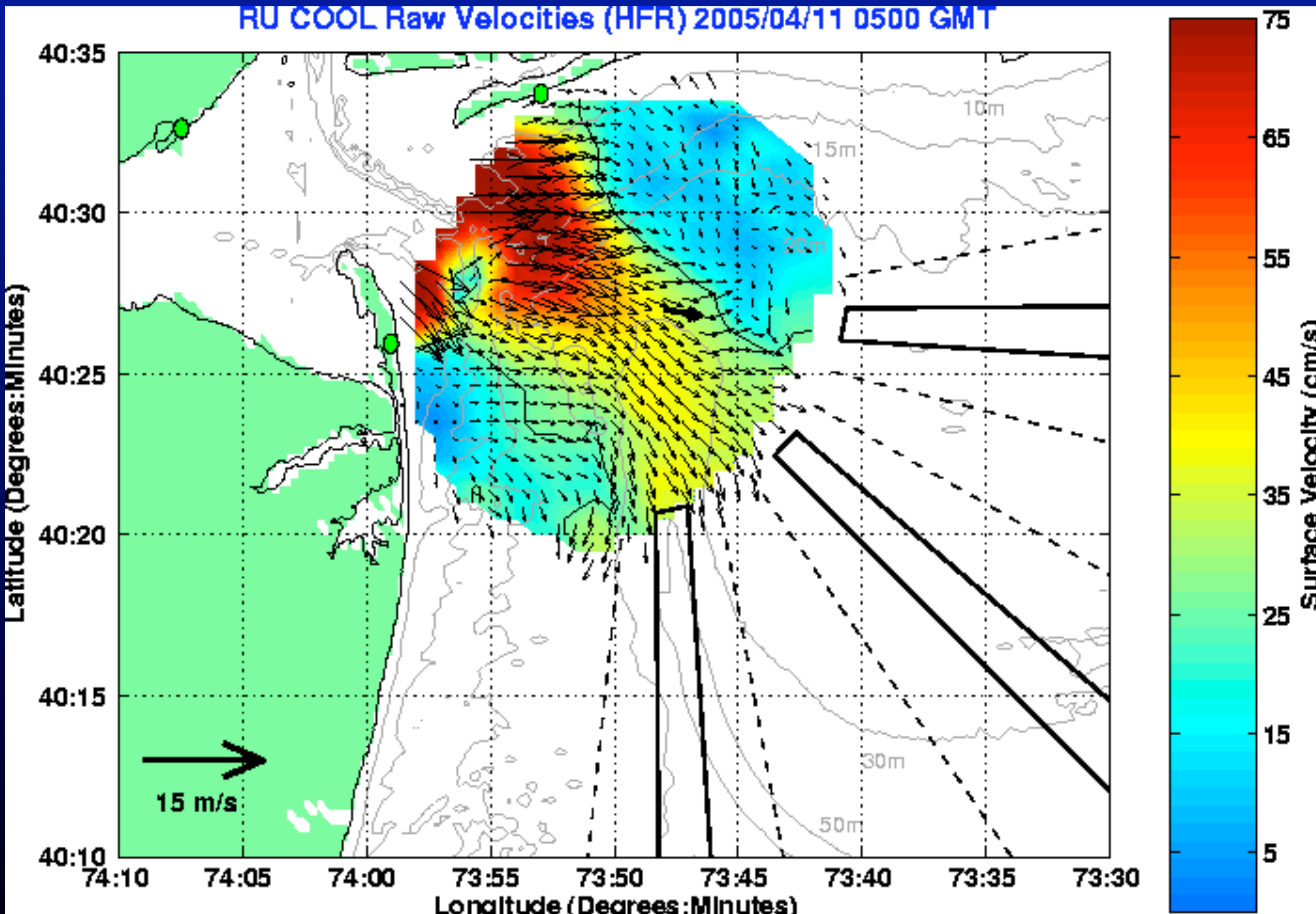
Input of organic matter is pulsed to coastal system as floods and punctuated tidal squirts. Example, a tidal bore as it flows past the R/V Cape Hatteras



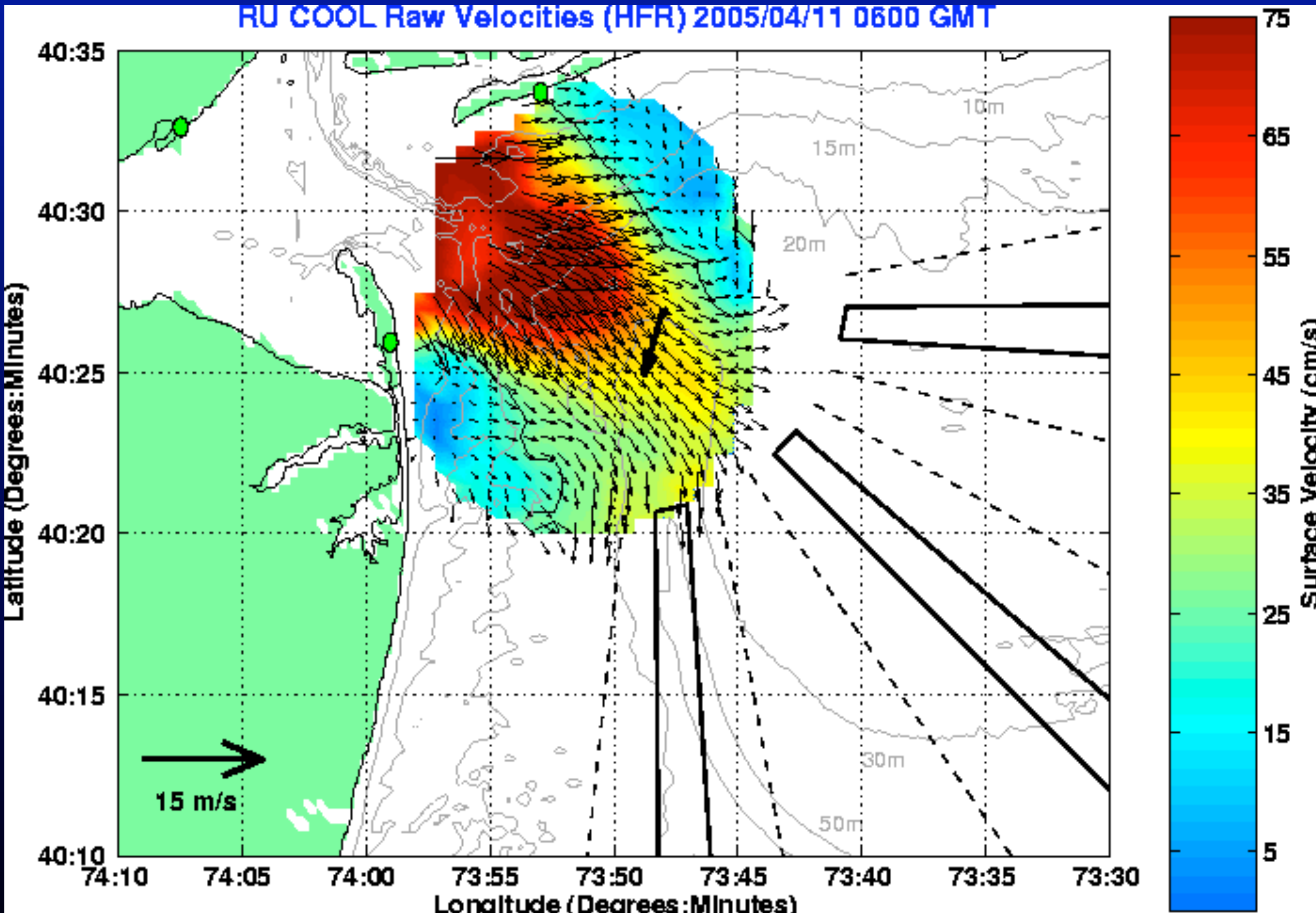




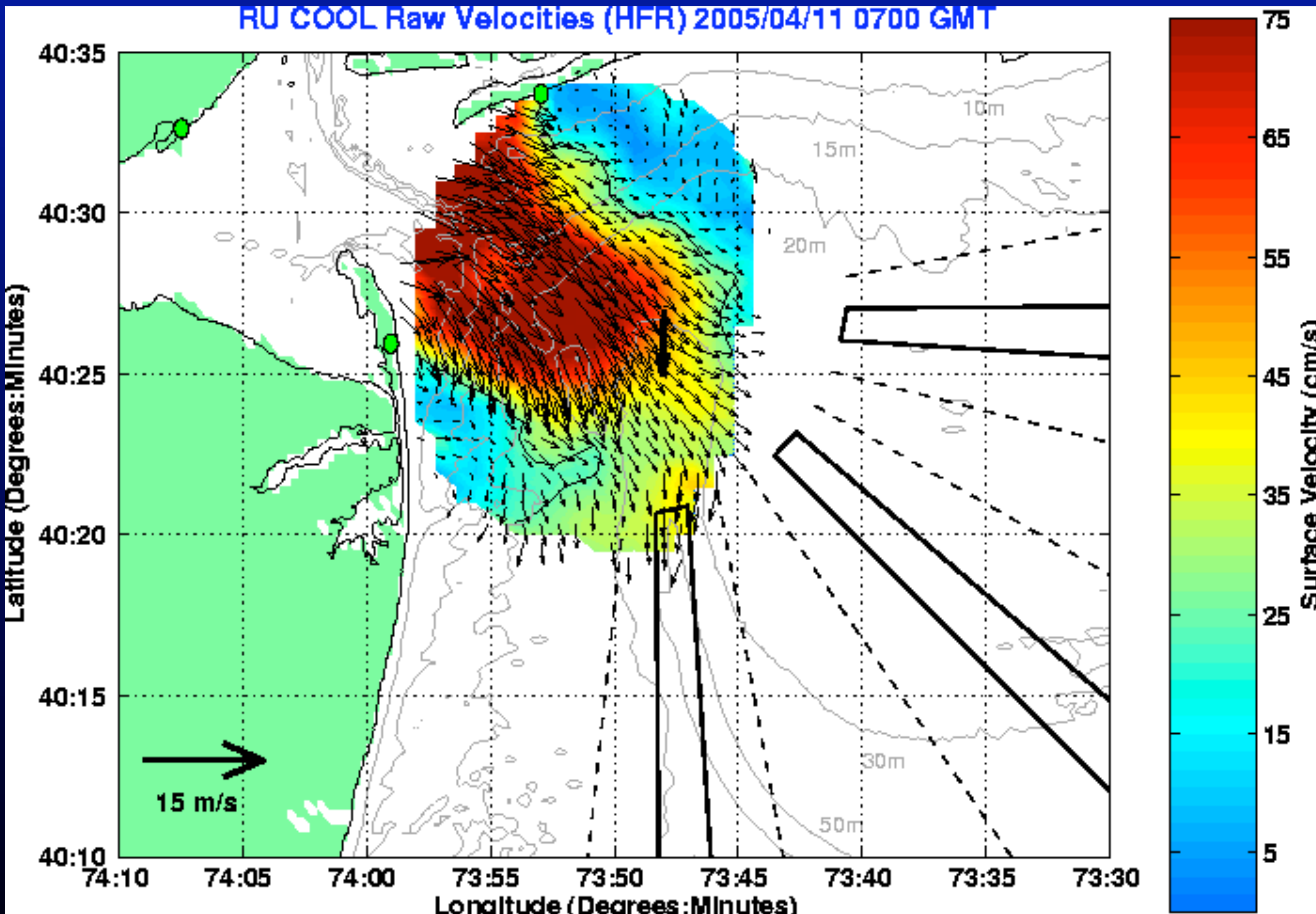
Wind data from NOAA NDBC station at Ambrose Light



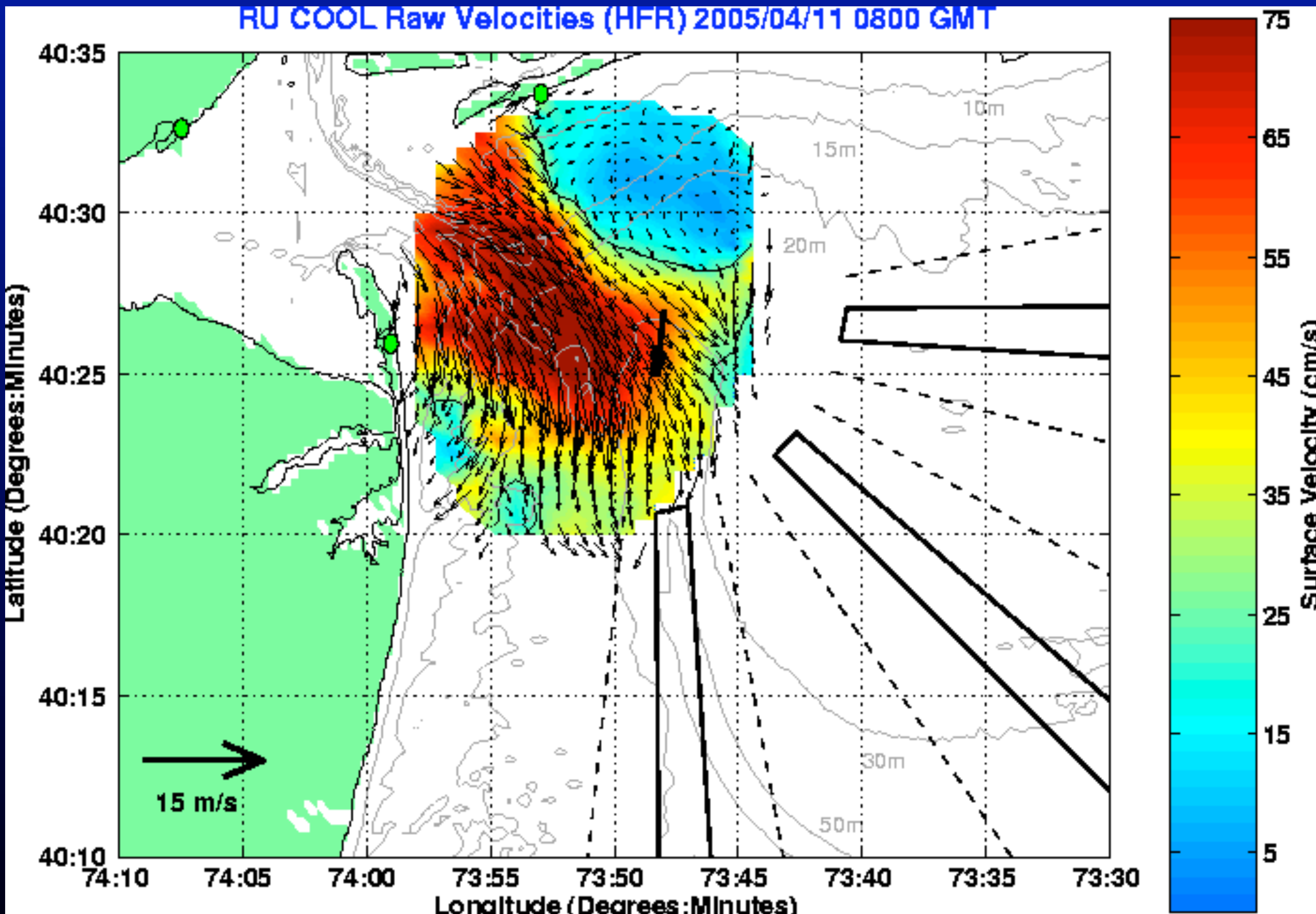
Wind data from NOAA NDBC station at Ambrose Light



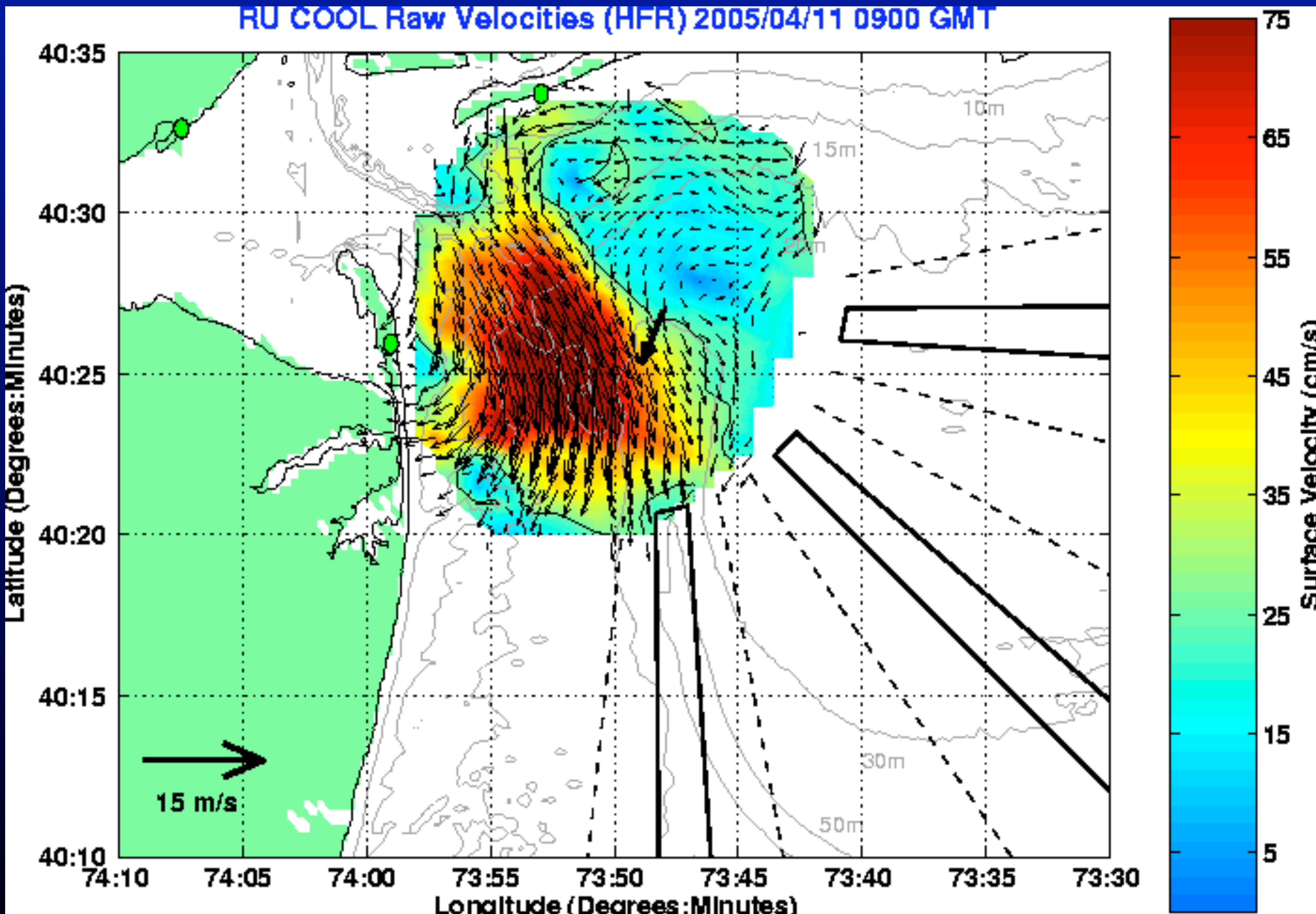
Wind data from NOAA NDBC station at Ambrose Light



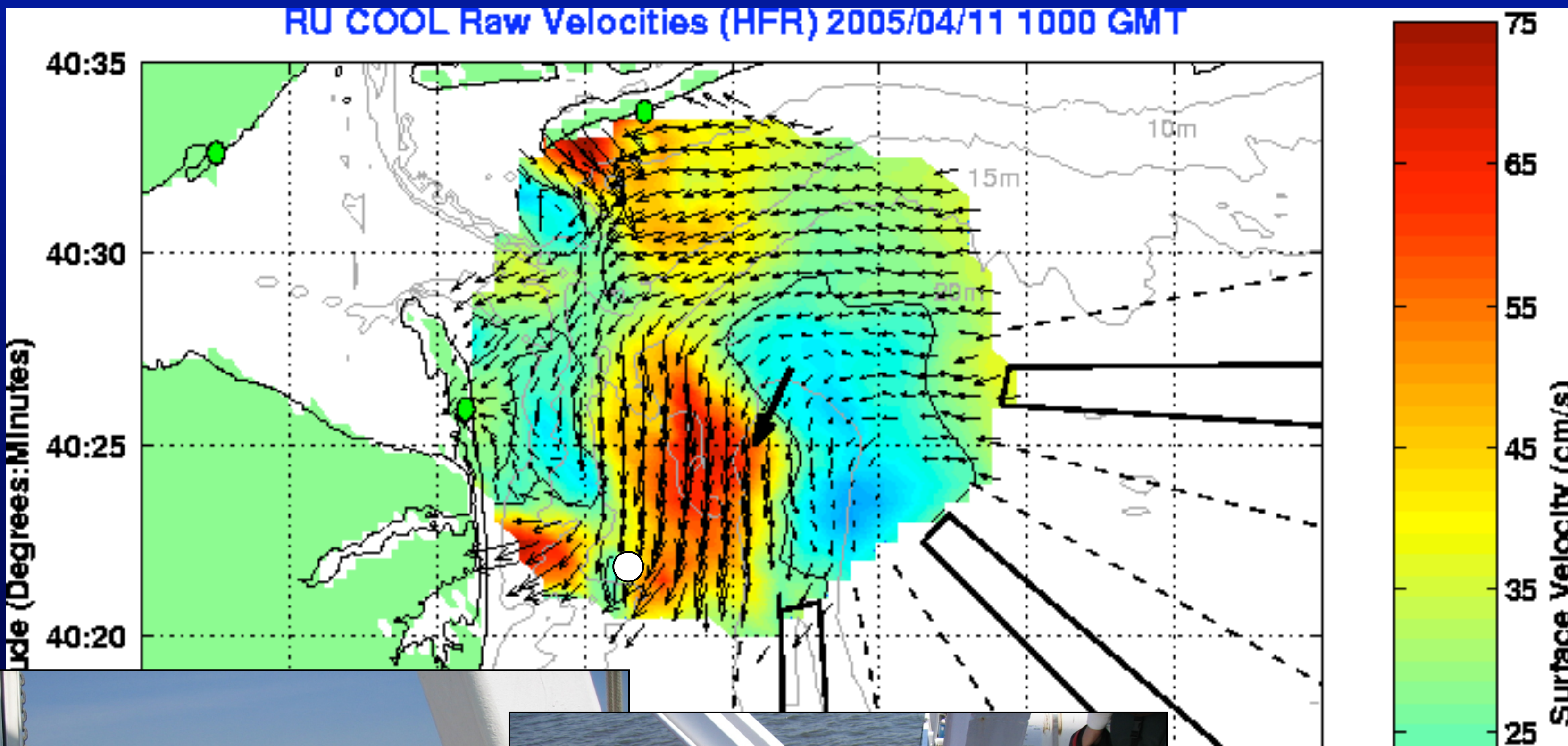
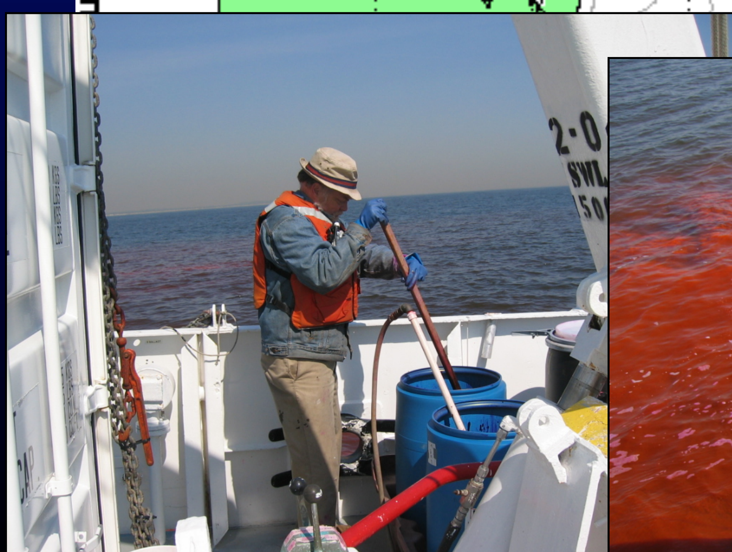
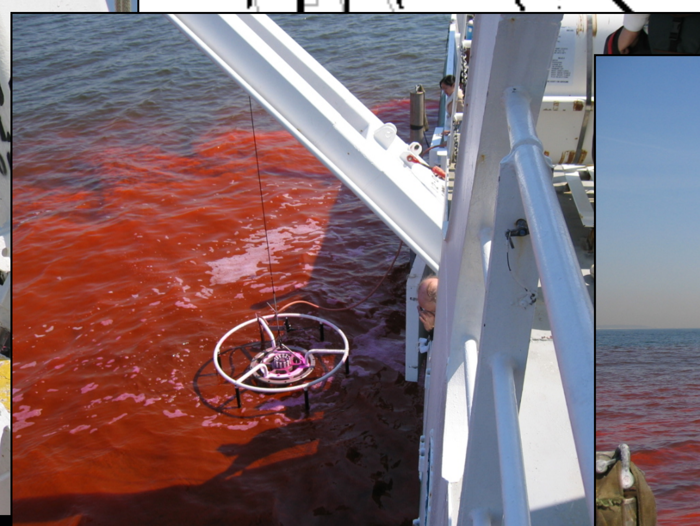
Wind data from NOAA NDBC station at Ambrose Light

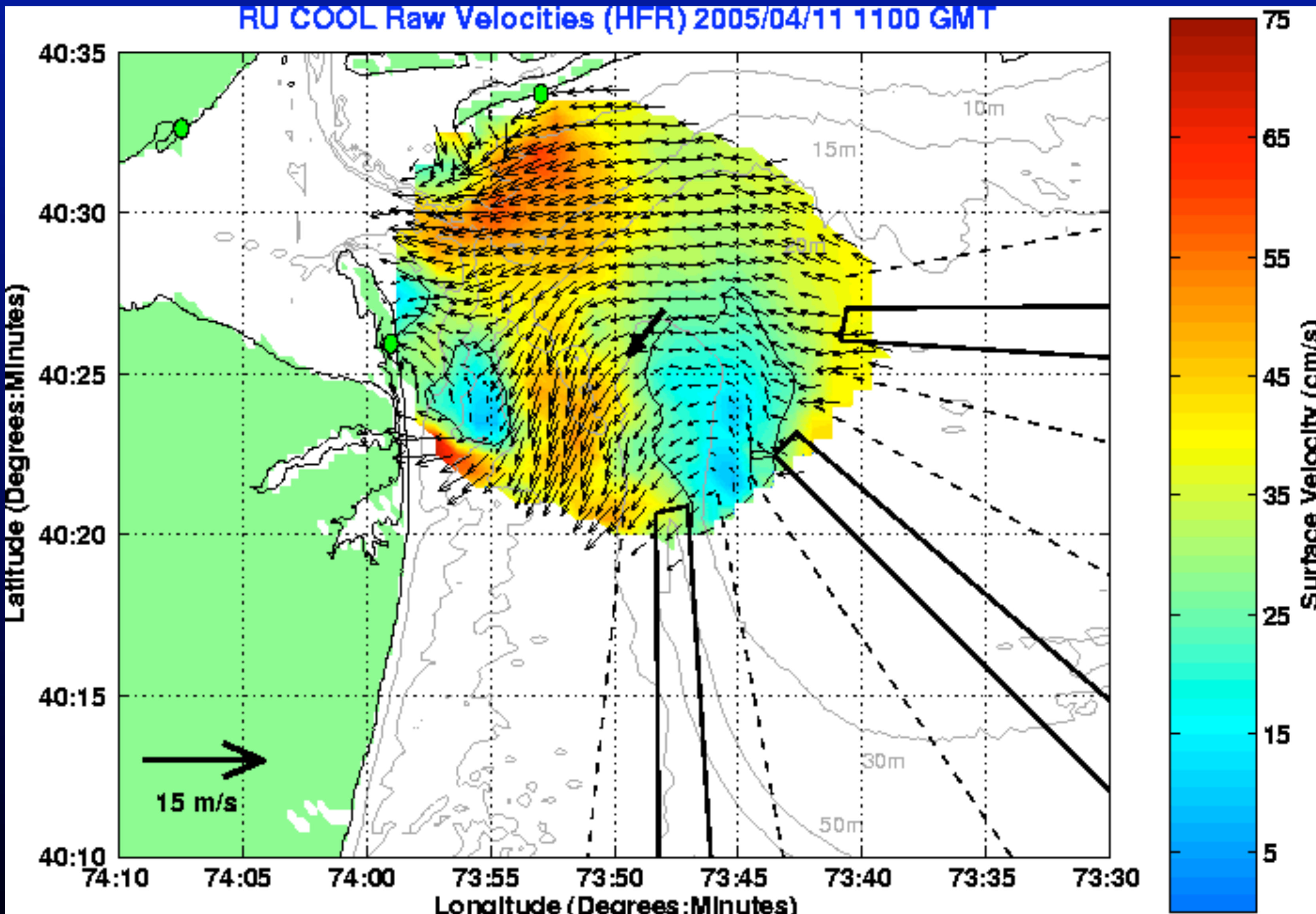


Wind data from NOAA NDBC station at Ambrose Light

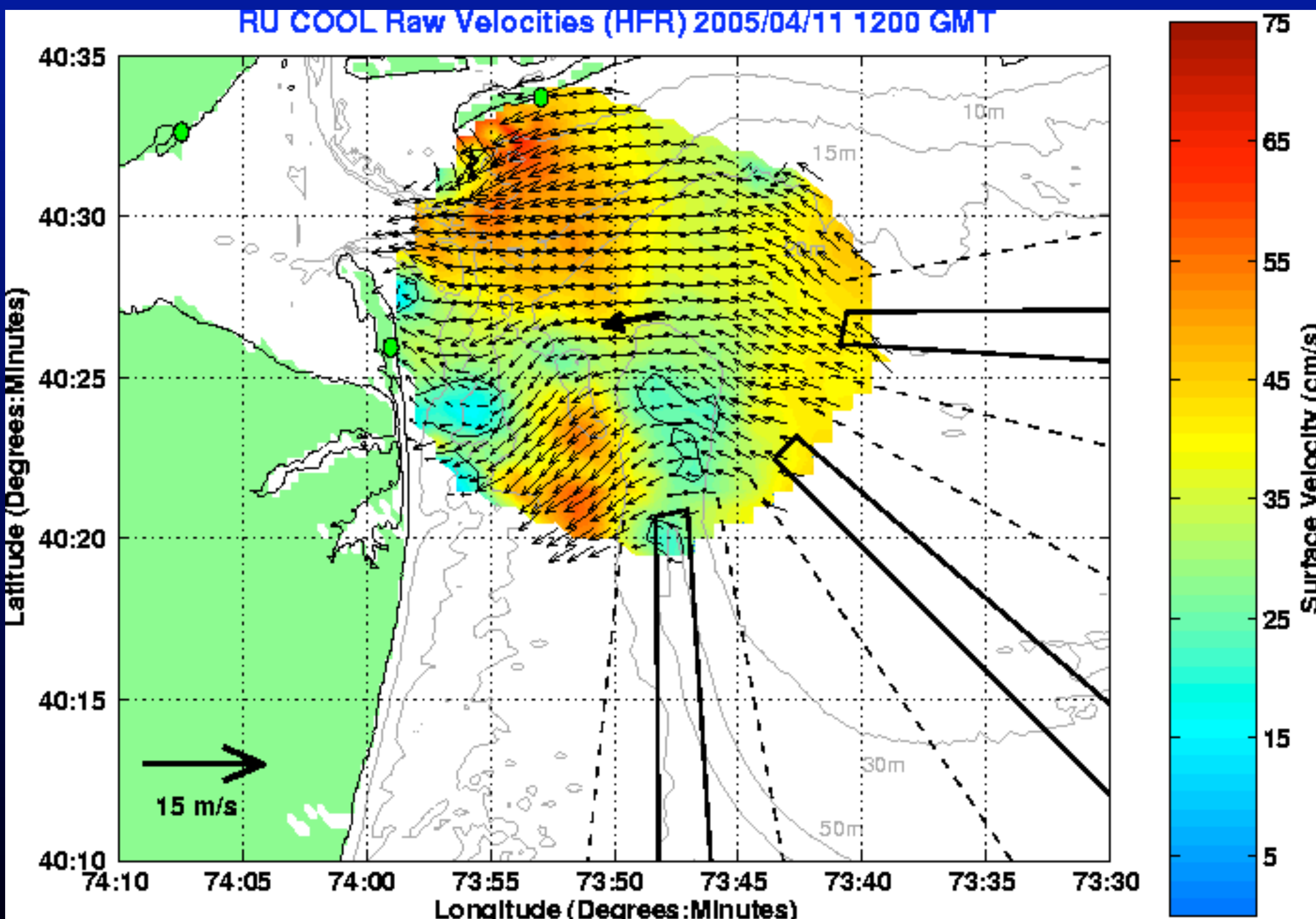


Wind data from NOAA NDBC station at Ambrose Light

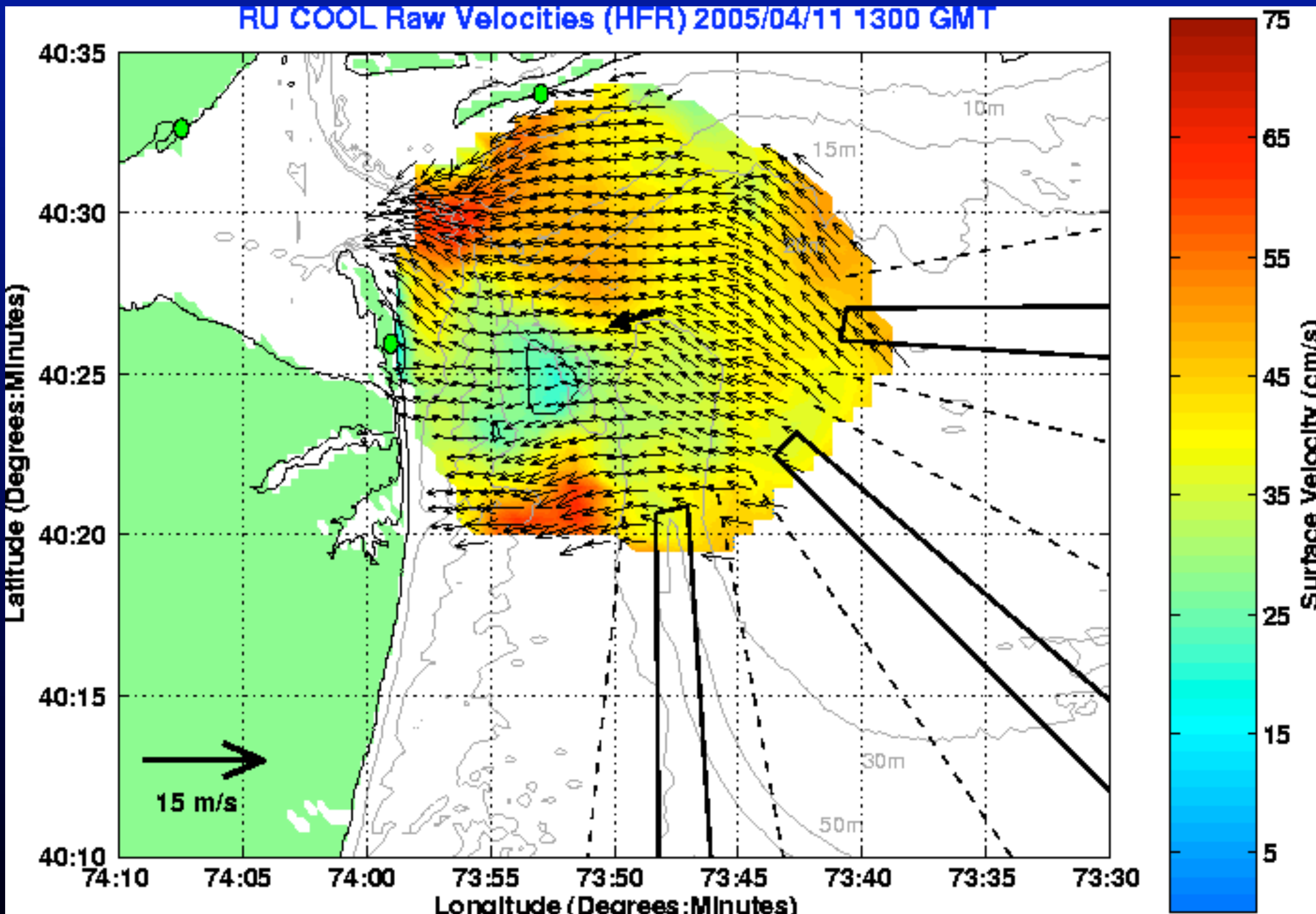

RU COOL Raw Velocities (HFR) 2005/04/11 1000 GMT
40:35
40:30
40:25
40:20
ude (Degrees:Minutes)
10m
15m
75
65
55
45
35
25
Surface Velocity (cm/s)



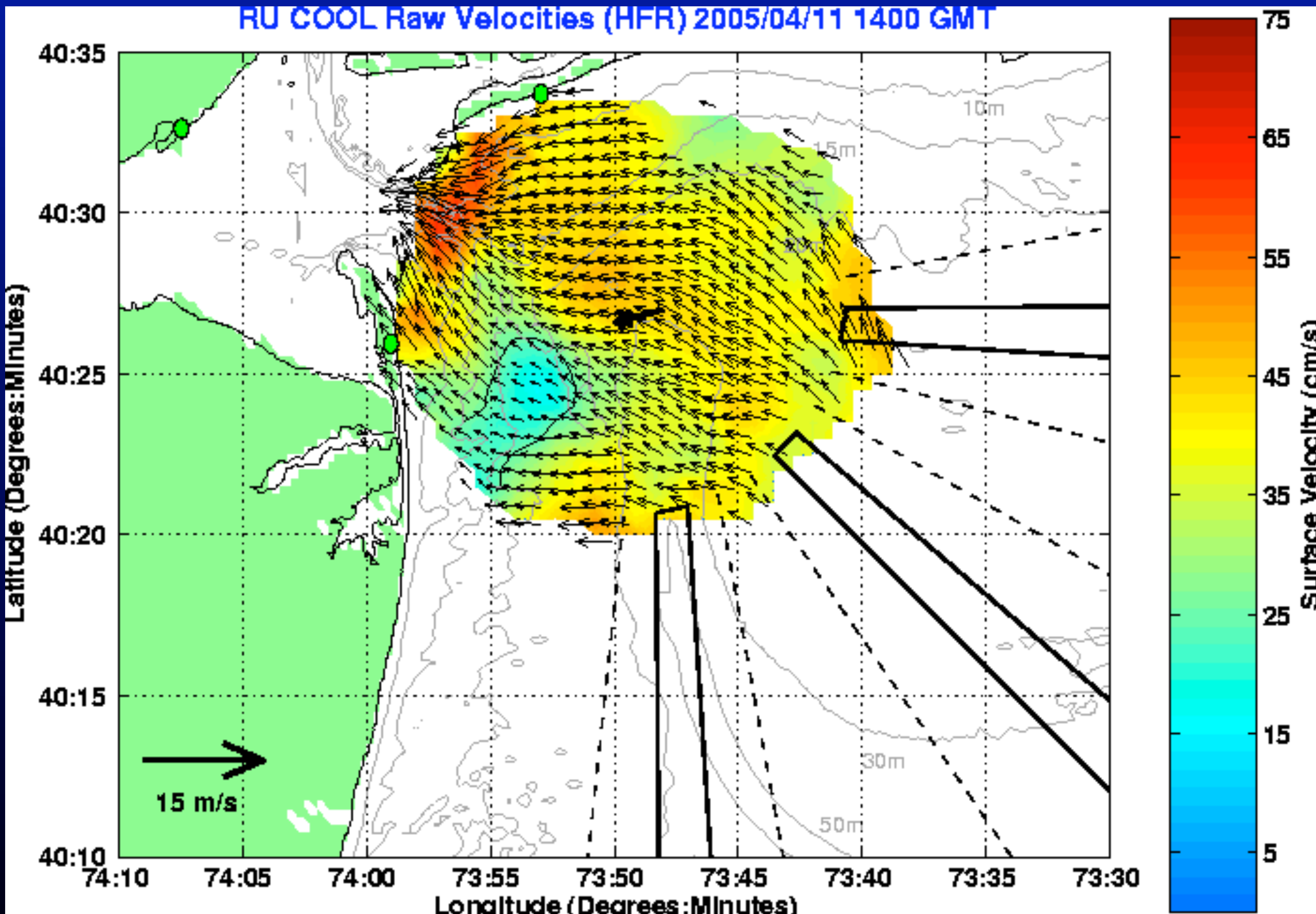
Wind data from NOAA NDBC station at Ambrose Light



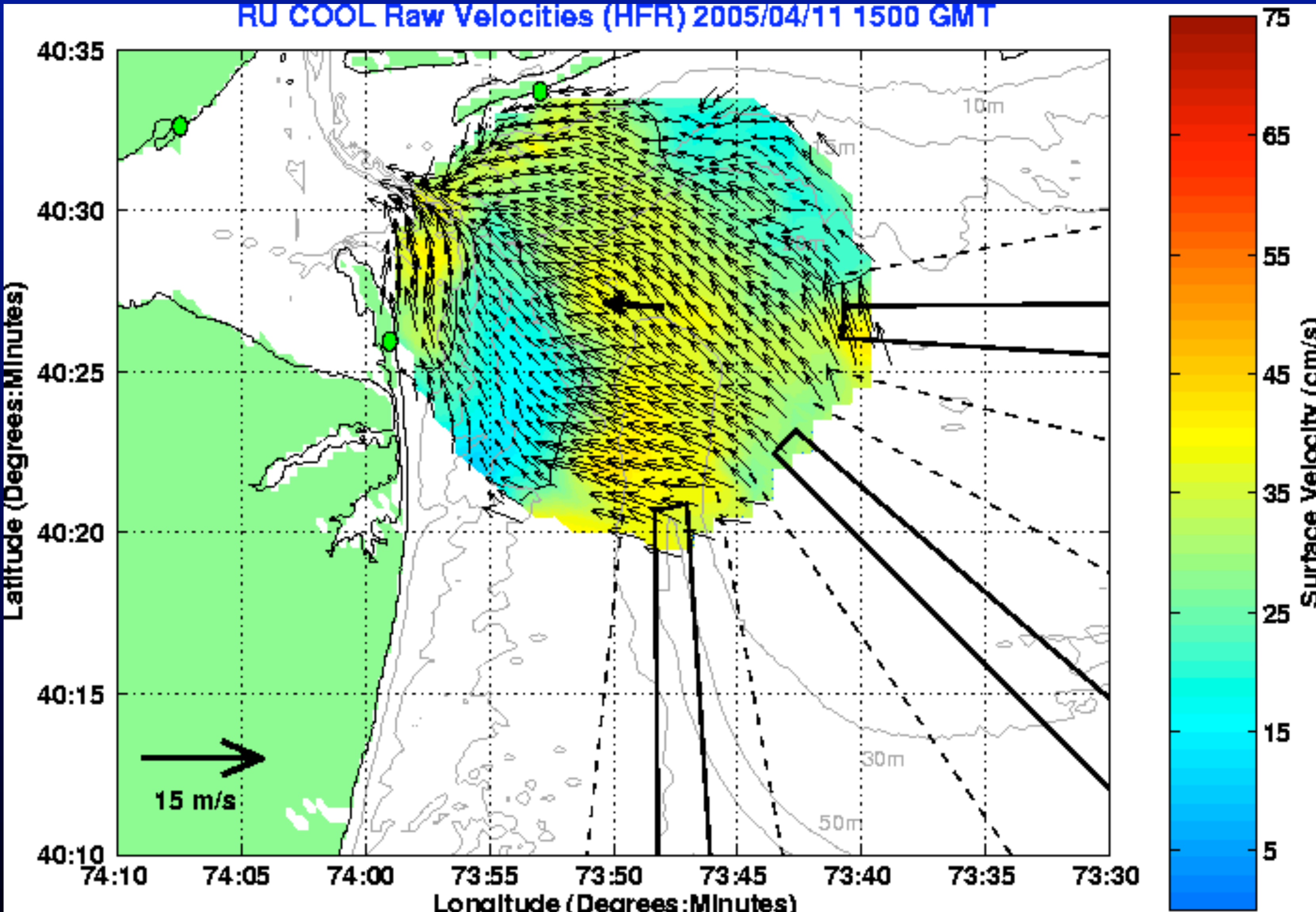
Wind data from NOAA NDBC station at Ambrose Light



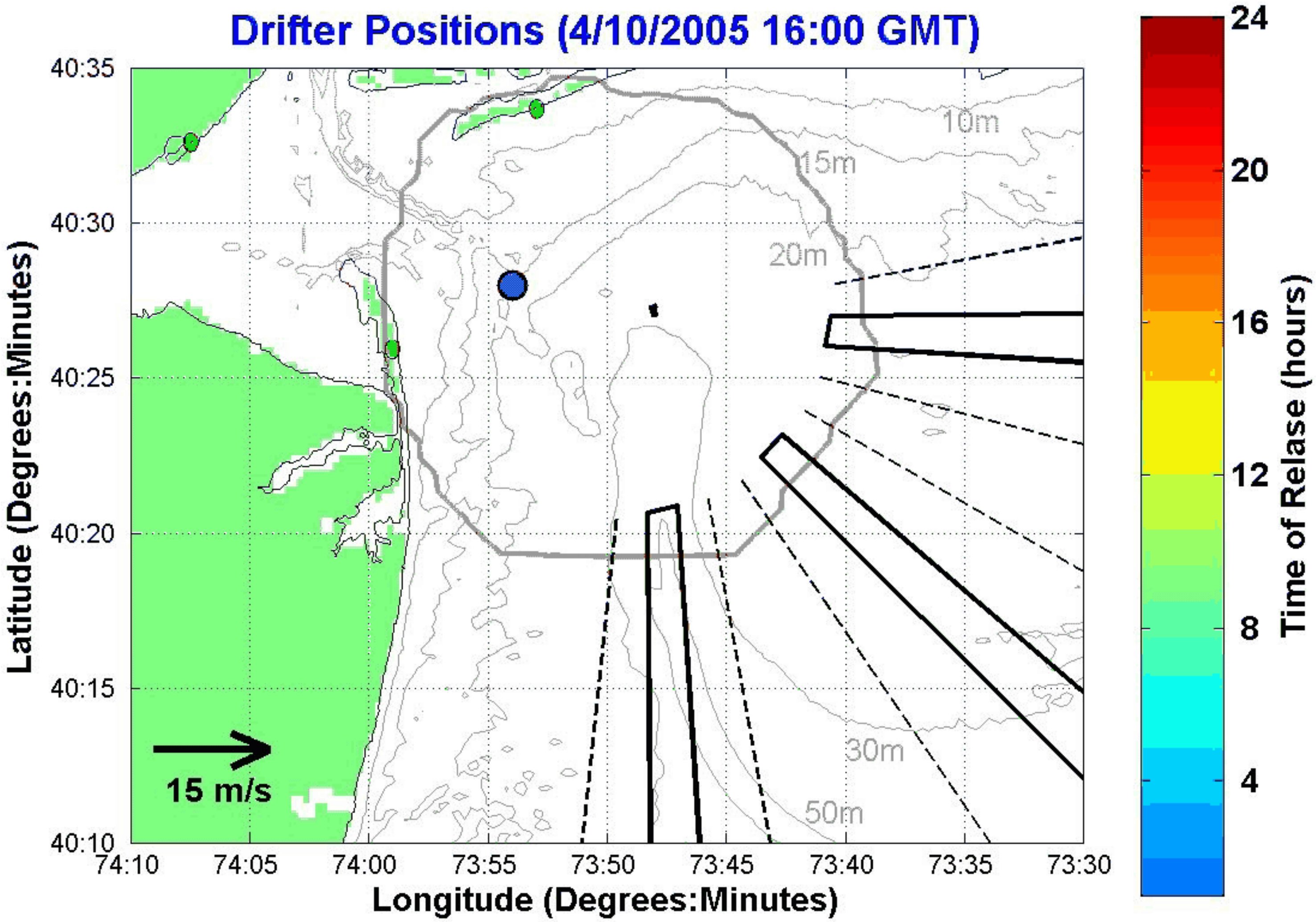
Wind data from NOAA NDBC station at Ambrose Light



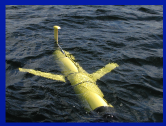
Wind data from NOAA NDBC station at Ambrose Light



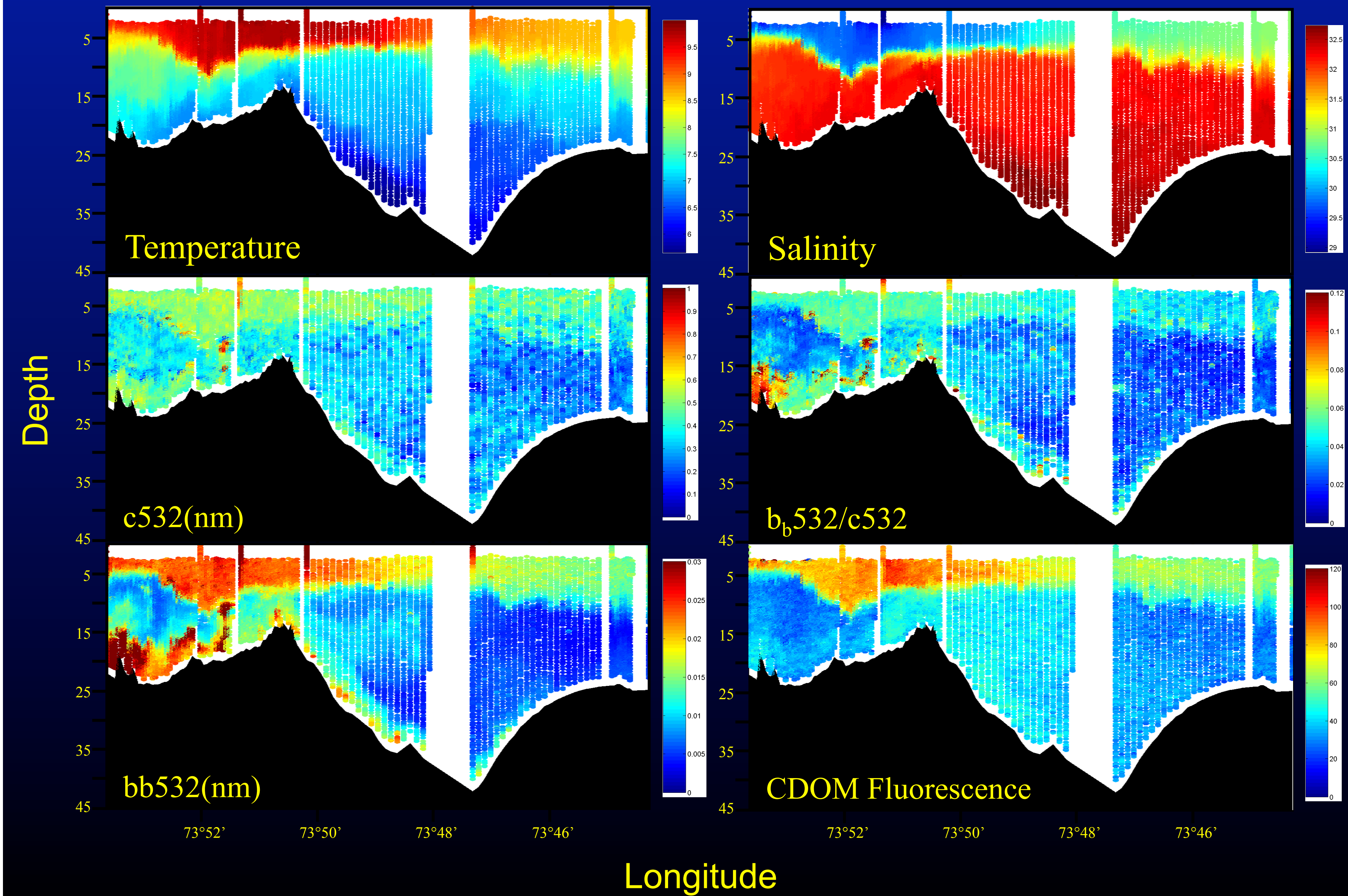
Wind data from NOAA NDBC station at Ambrose Light



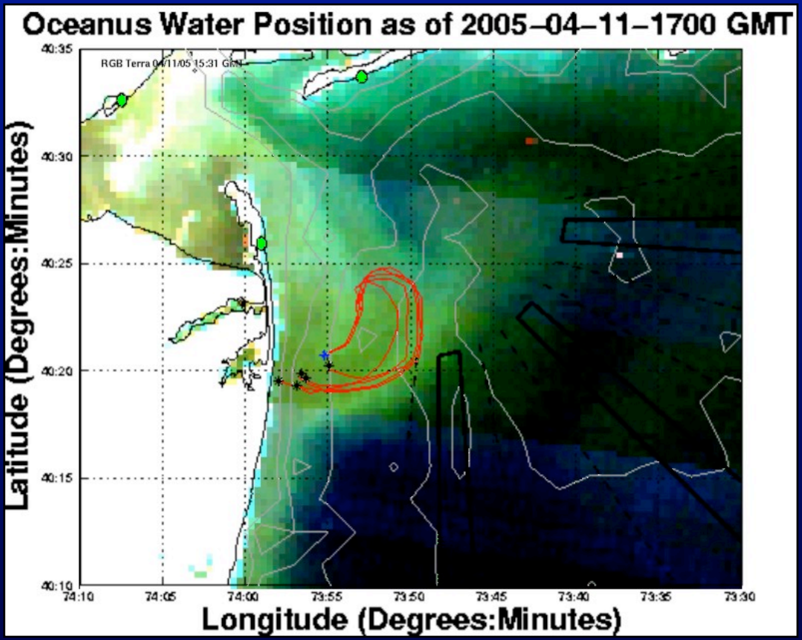
Drifter Positions (4/10/2005 16:00 GMT)
40:35
40:30
40:25
40:20
40:15
40:10
Latitude (Degrees:Minutes)
74:10
74:05
74:00
73:55
73:50
73:45
73:40
73:35
73:30
Longitude (Degrees:Minutes)
10m
15m
20m
30m
50m
15 m/s
24
20
16
12
8
4
Time of Relase (hours)

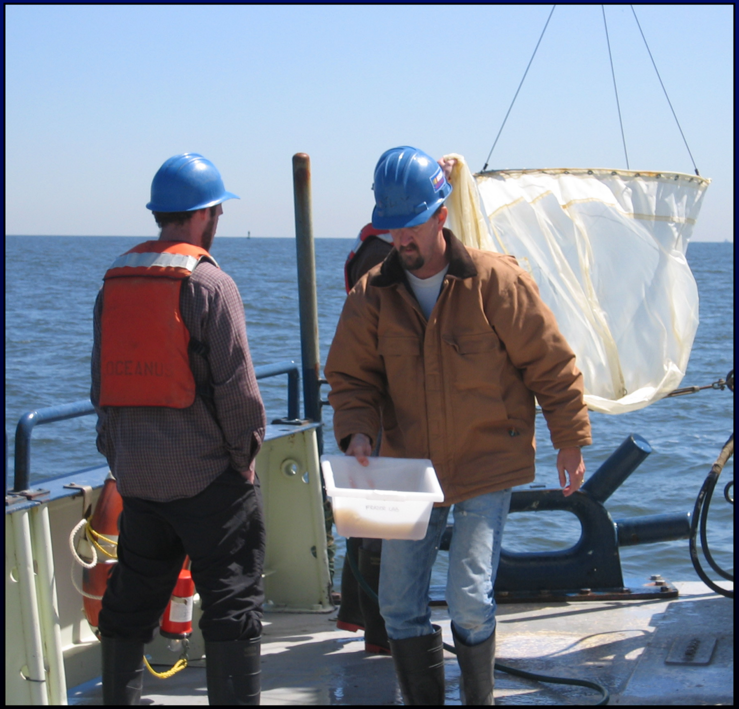


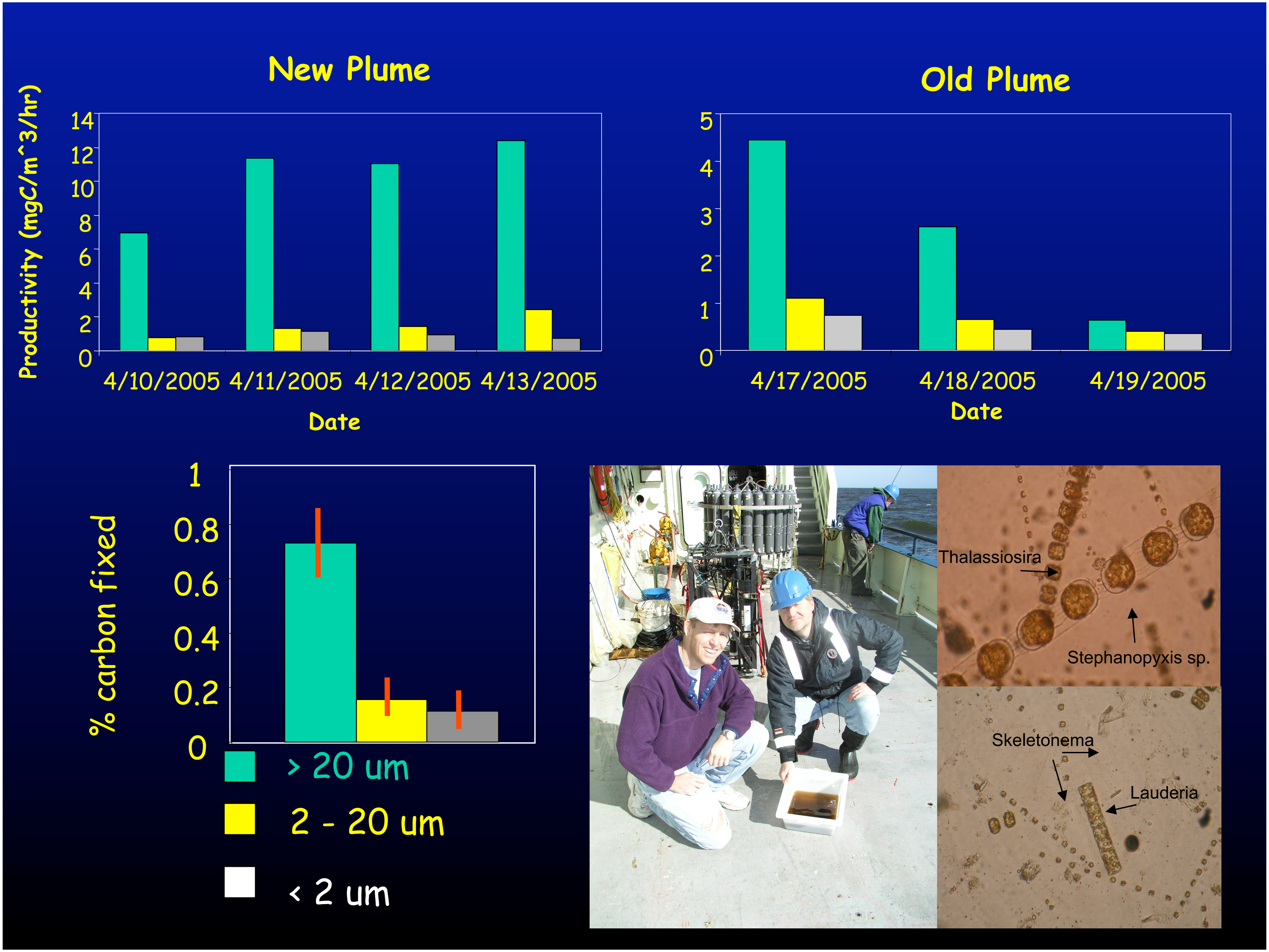
WHAT FLOWS OUT? PARTICLES AND DISSOLVED ORGANIC MATTER



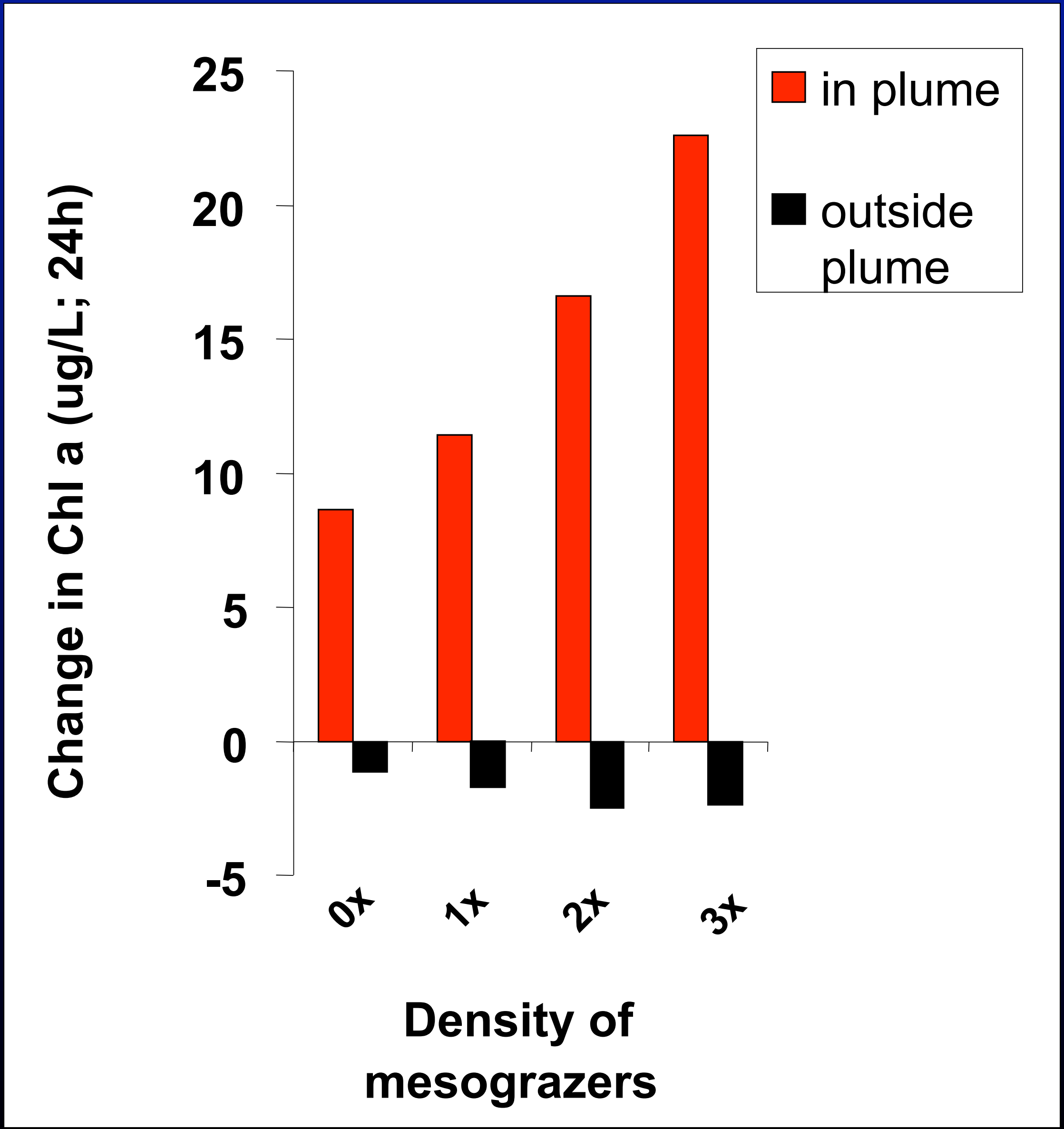
The Nearshore Recirculation: A Remineralization Incubator (known to locals as the Frazer eddy)





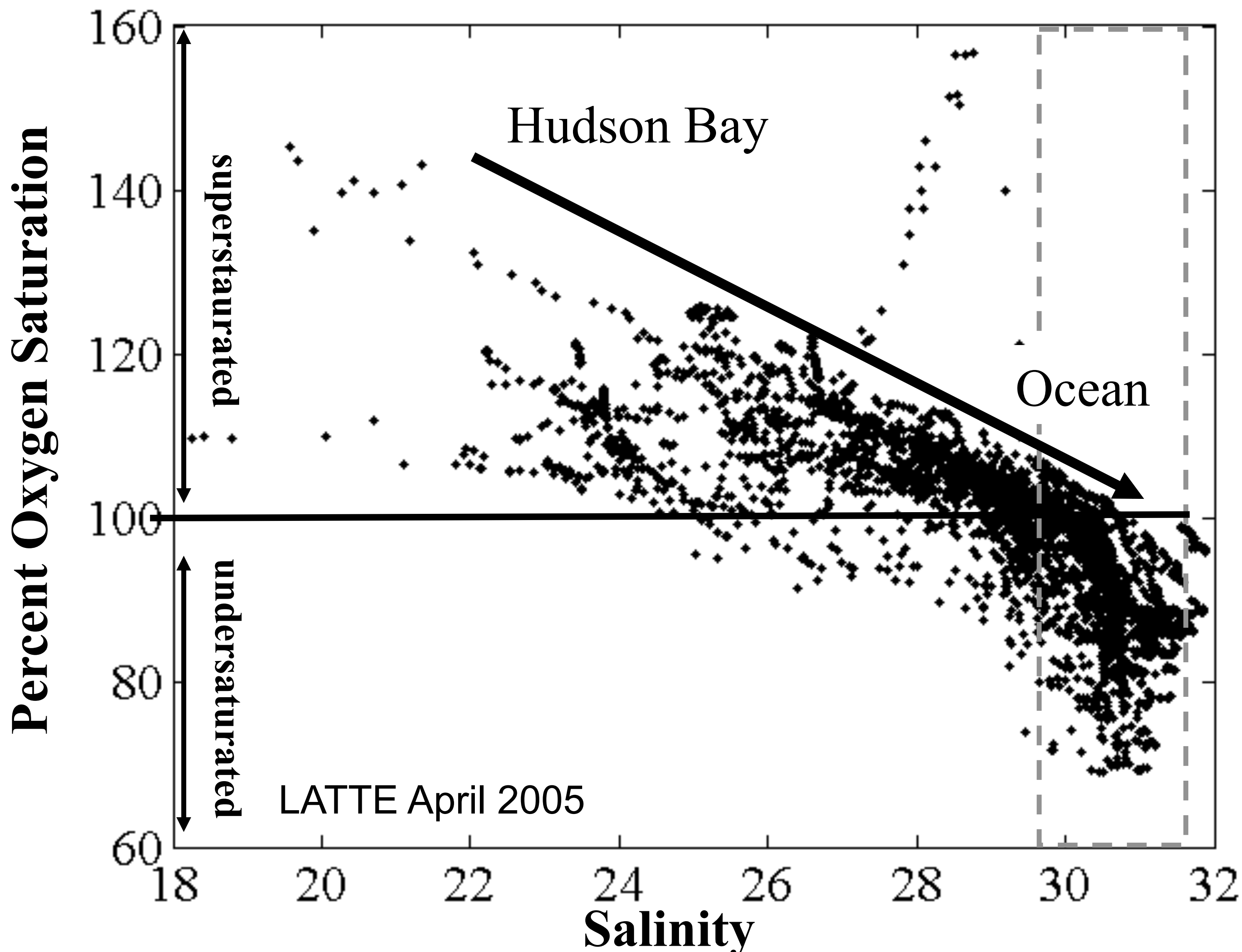


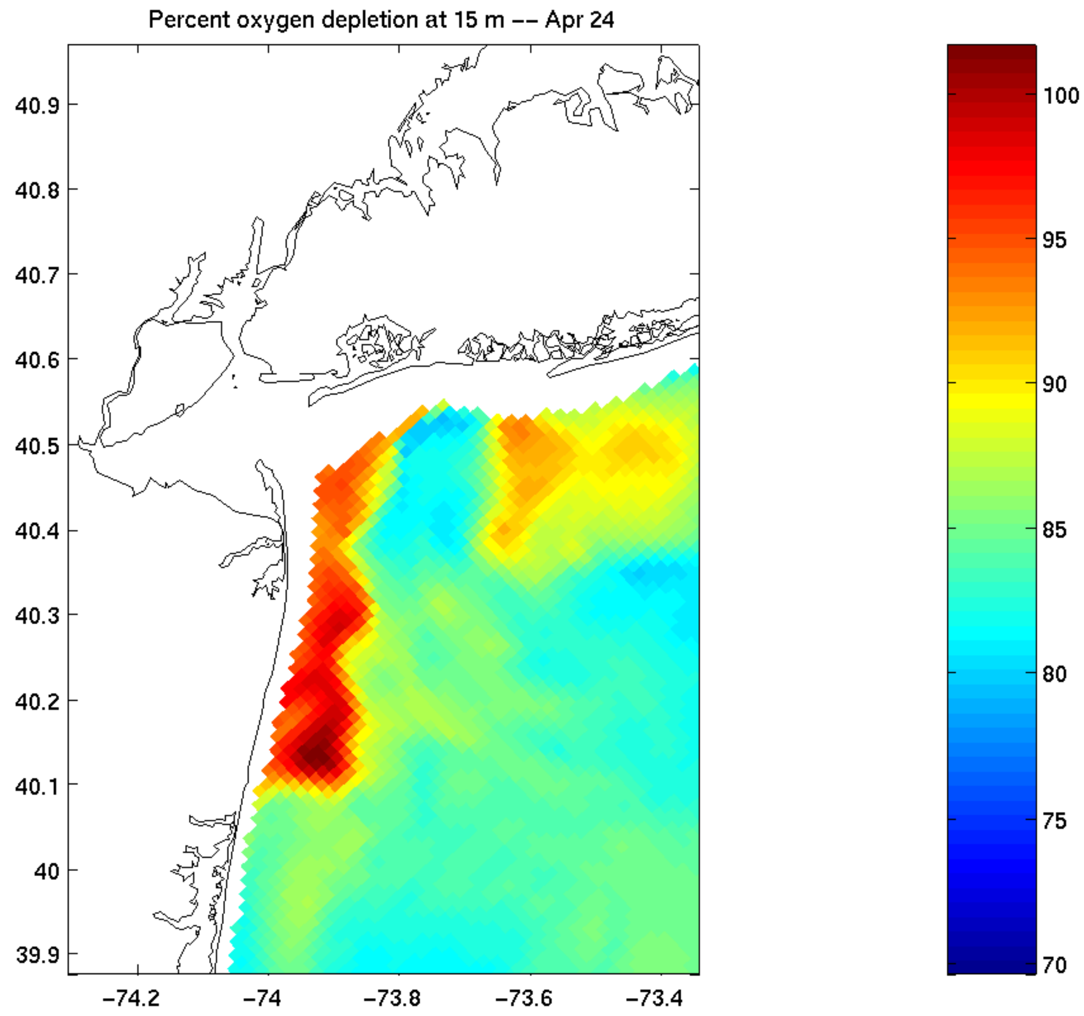
New Plume
Productivity (mgC/m^3/hr)
0
2
4
6
8
10
12
14
4/10/2005
4/11/2005
4/12/2005
4/13/2005
Date
Old Plume
0
1
2
3
4
5
4/17/2005
4/18/2005
4/19/2005
Date
% carbon fixed
0
0.2
0.4
0.6
0.8
1
> 20 um
2 - 20 um
< 2 um
Thalassiosira
Stephanopyxis sp.
Skeletonema
Lauderia



Grazing rates
in Hudson river plume

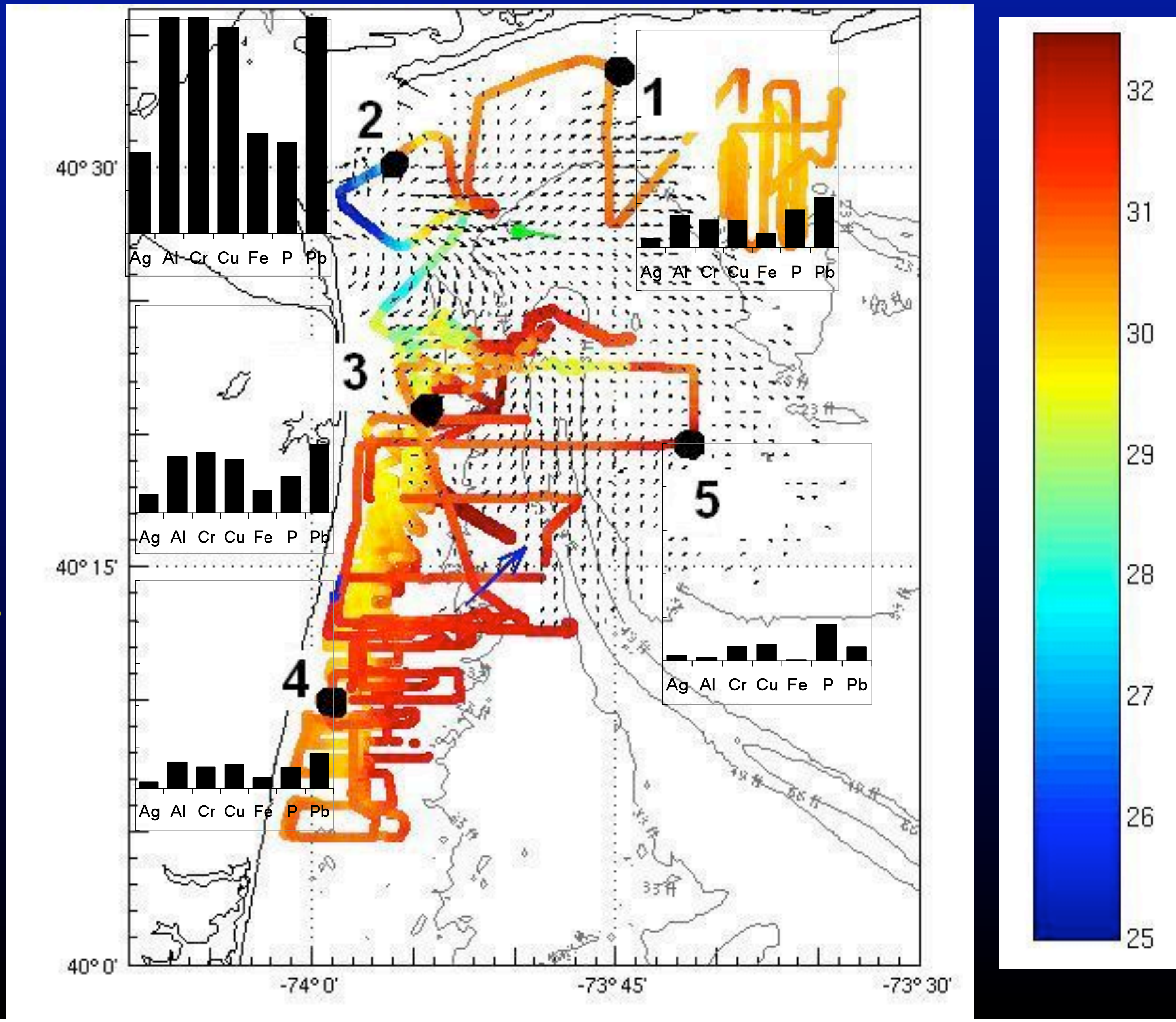
You can't eat things bigger
then your head


Percent Oxygen Saturation
160
140
120
100
80
60
superstaurated
undersaturated
Hudson Bay
Ocean
LATTE April 2005
18
20
22
24
26
28
30
32
Salinity

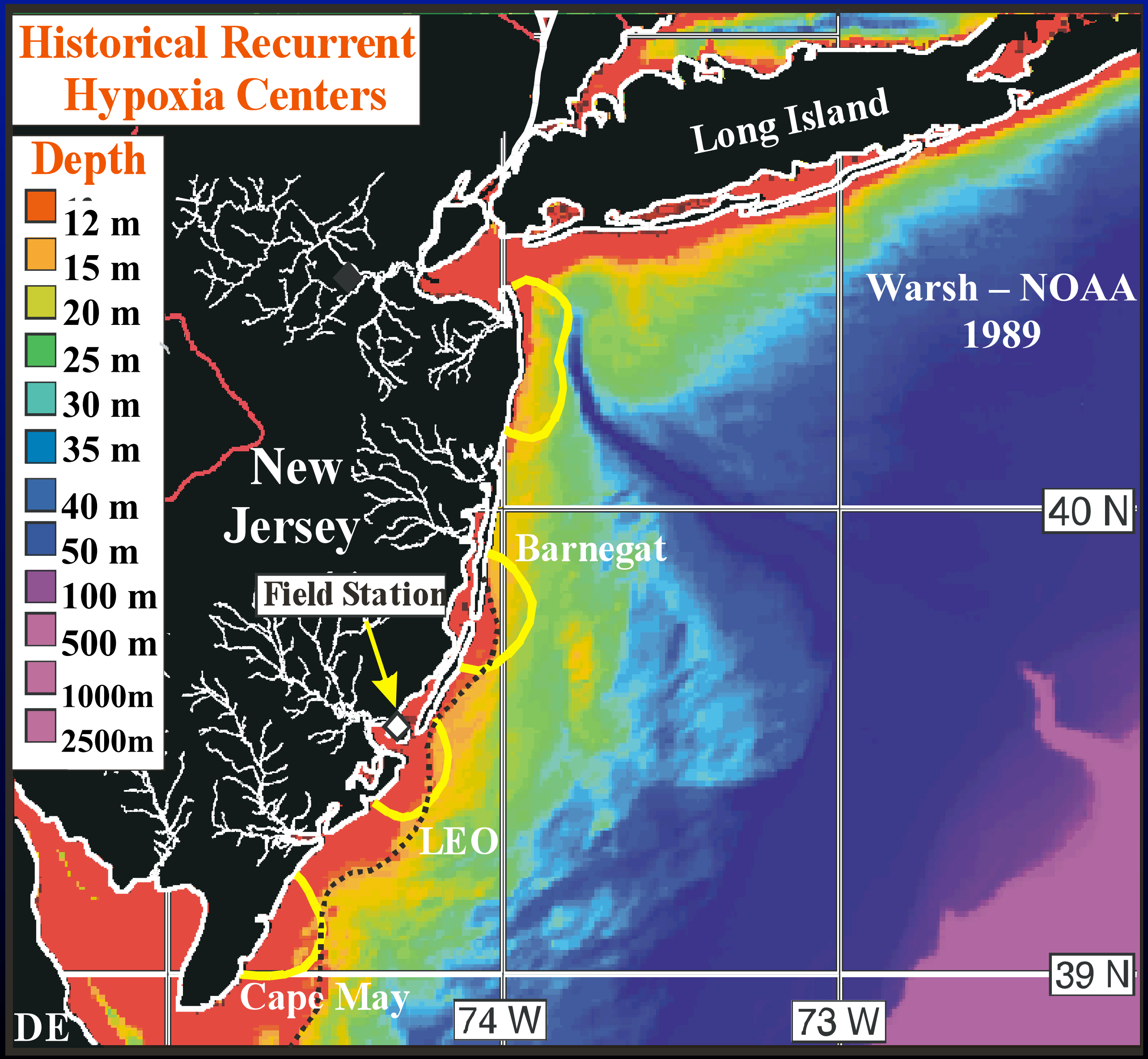

Percent oxygen depletion at 15 m -- Apr 24
40.9
40.8
40.7
40.6
40.5
40.4
40.3
40.2
40.1
40
39.9
-74.2
-74
-73.8
-73.6
-73.4
100
95
90
85
80
75
70

>20 µm particulate trace metals and phosphorus - Ag, Al, Cr, Cu, Fe, P, Pb

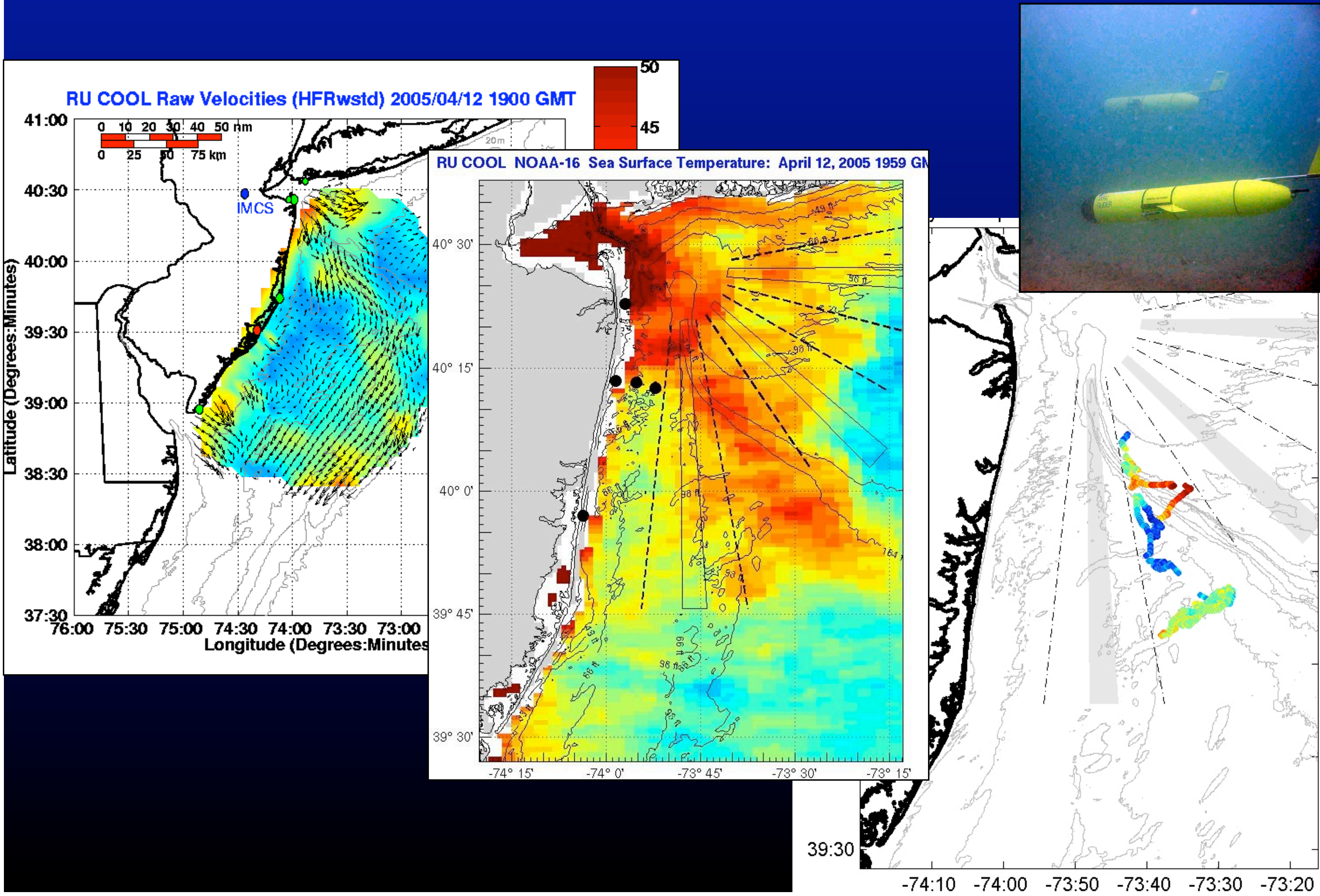
50 ng L^{-1}
(Al, Fe, P µg L^{-1};
Ag x 10, Al x 5, P x 10)



Hypoxia/Anoxia & Bottom Bathymetry



Freshwater Plume Moves Out Across the Shelf: Hudson Shelf Valley



LaTTE 2005 --Post Injection 2 – Final shipboard survey
After luring the Cape Hatteras offshore.

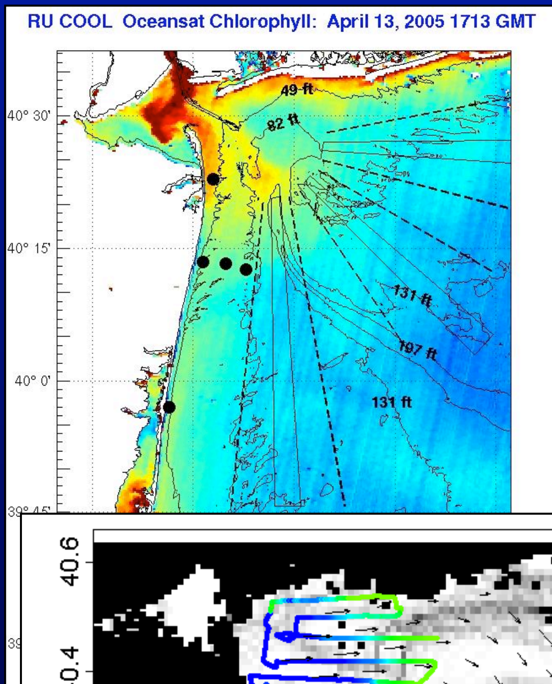
"The survey began on the 'Highway'. We were near the glider when it surfaced. We saw currents ripping southward in a 10 m thick layer of freshwater along the highway -- perhaps the most significant freshwater transport we saw all week."

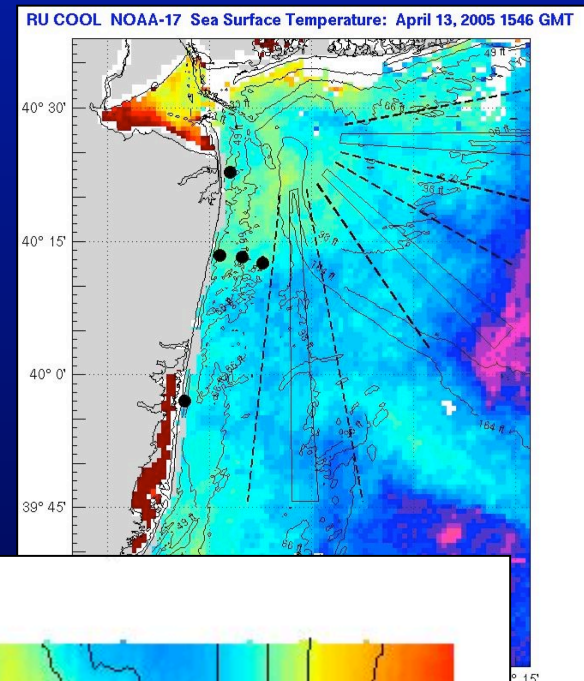
"Perhaps the most perplexing to me is 'the Highway' and why there has been a lack of a strong coastally trapped flow this week."

--- Bob Chant aboard the Cape Hatteras, April 21, 2005

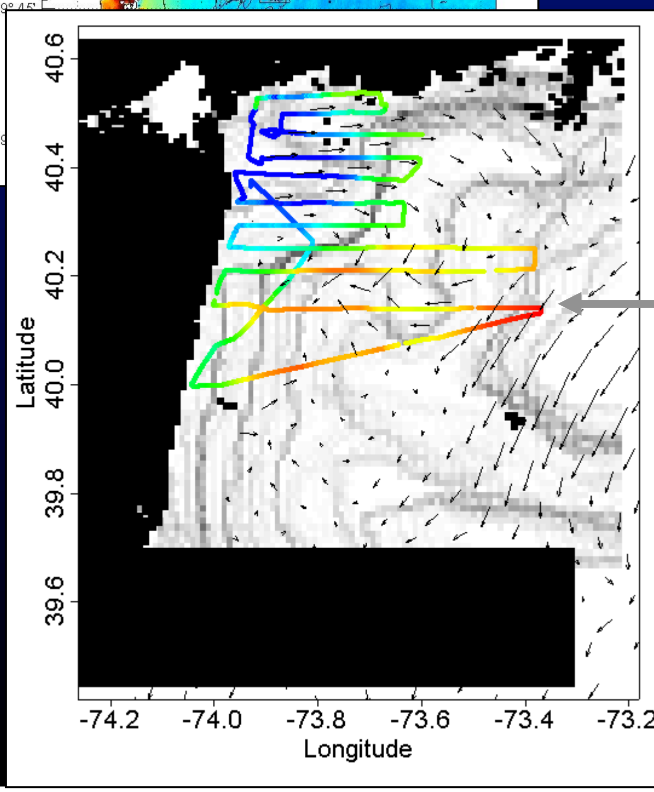
Freshwater Plume Moves Out Across the Shelf: Water Mass Boundaries

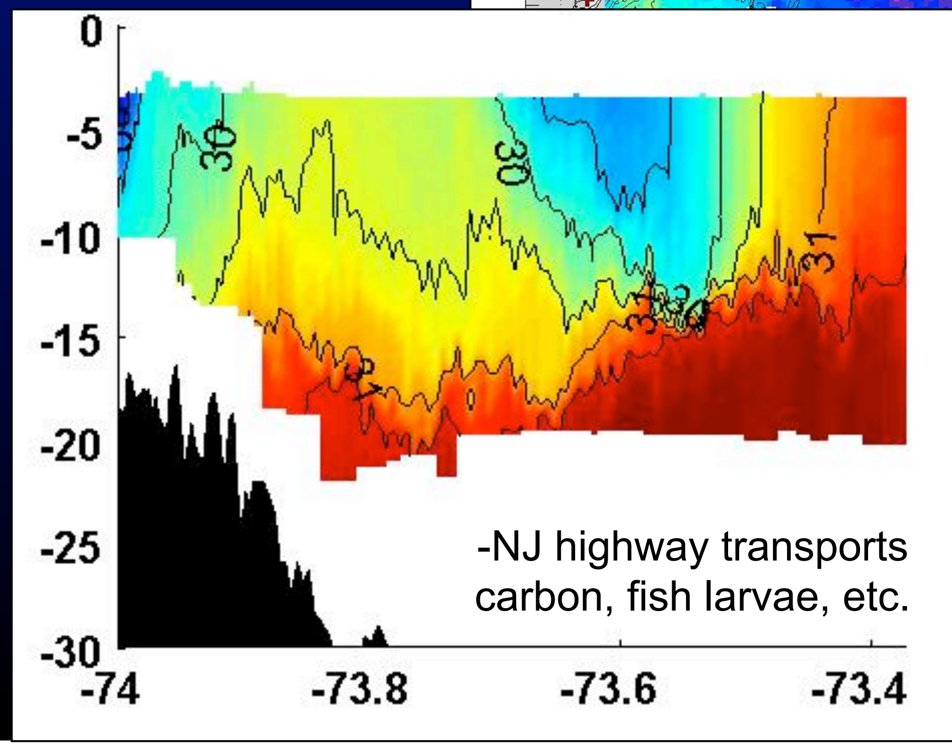
(Oliver et al., 2004)

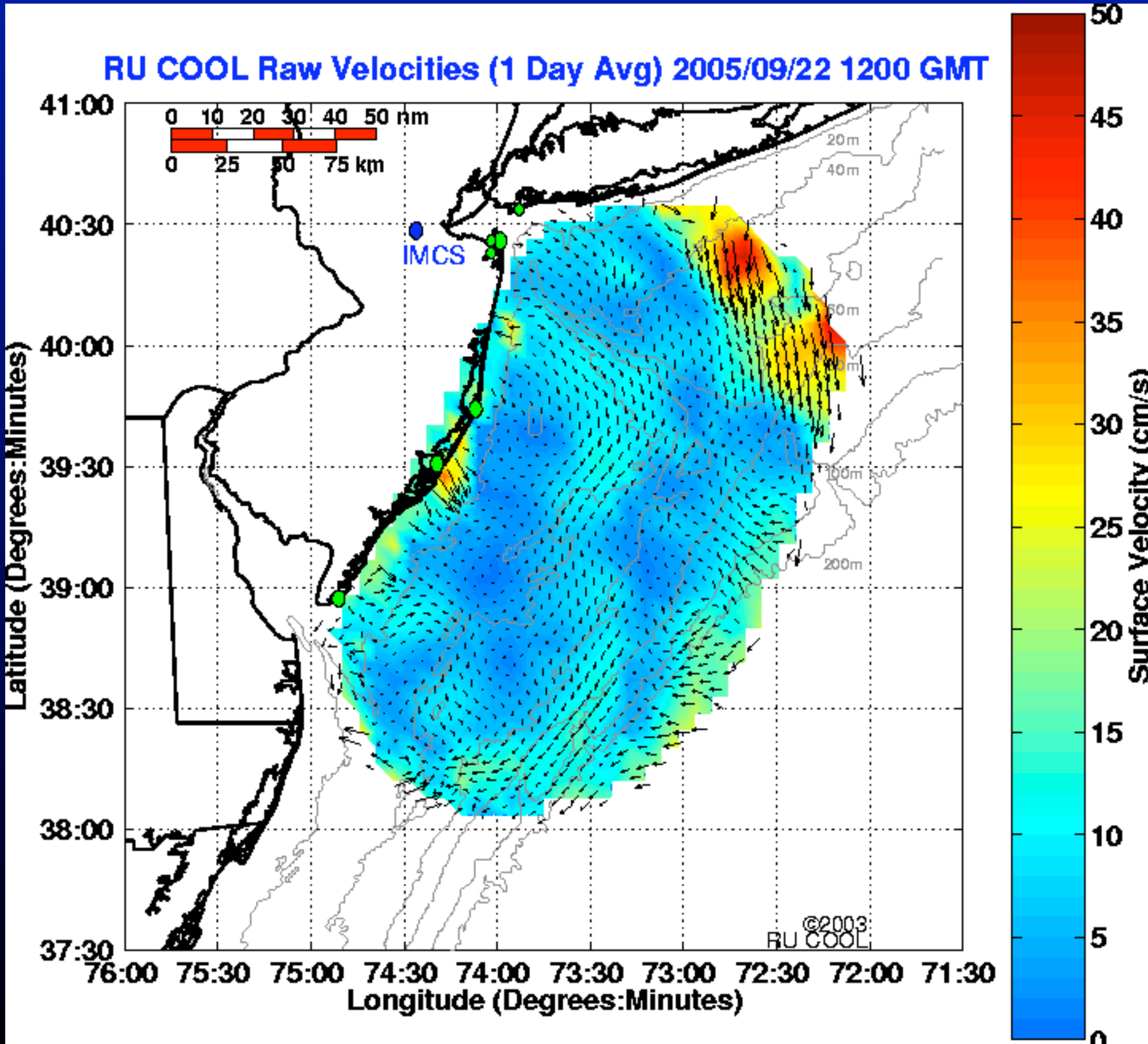




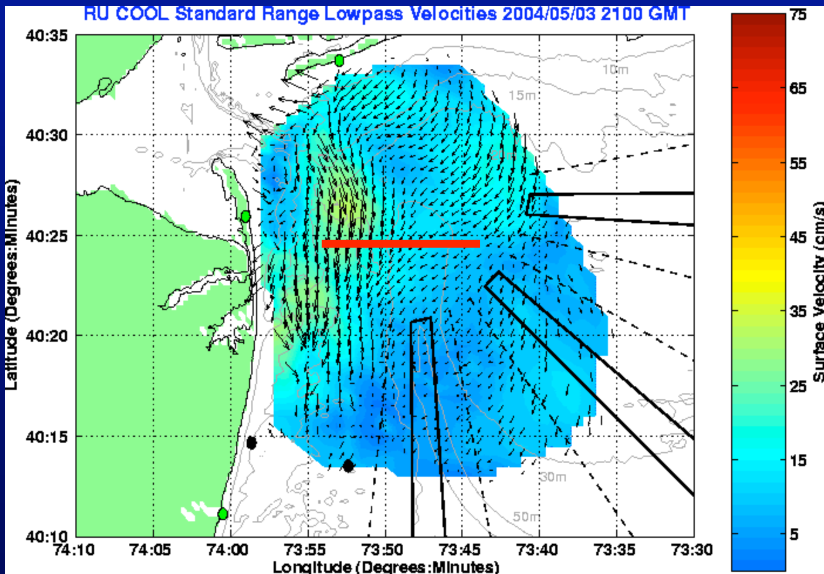
April 13, 2005

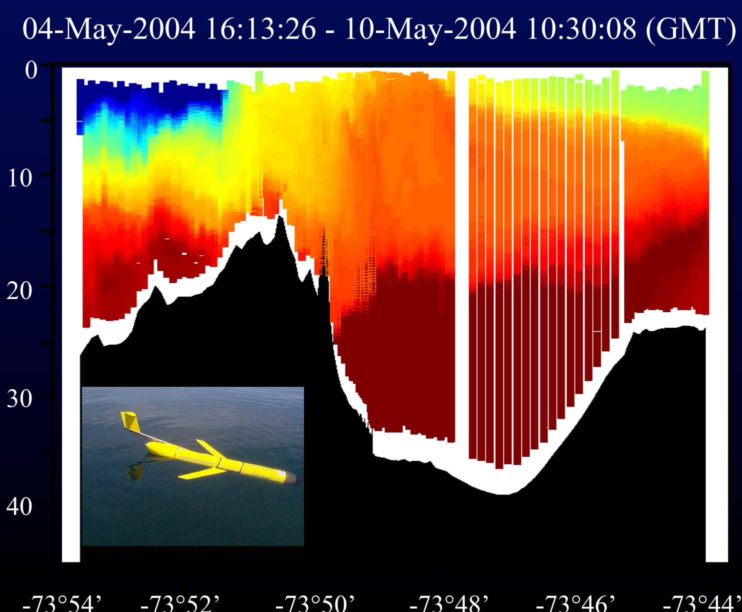


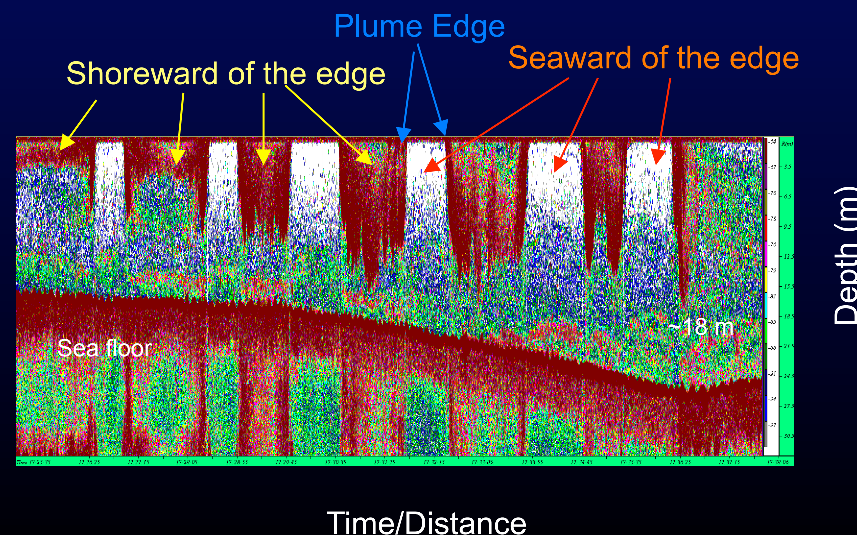




RU COOL Raw Velocities (1 Day Avg) 2005/09/22 1200 GMT
0 10 20 30 40 50 nm
0 25 50 75 km
IMCS
20m
40m
60m
100m
200m
41:00
40:30
40:00
39:30
39:00
38:30
38:00
37:30
76:00 75:30 75:00 74:30 74:00 73:30 73:00 72:30 72:00 71:30
Longitude (Degrees:Minutes)
Latitude (Degrees:Minutes)
©2003 RU COOL
Surface Velocity (cm/s)
0 5 10 15 20 25 30 35 40 45 50

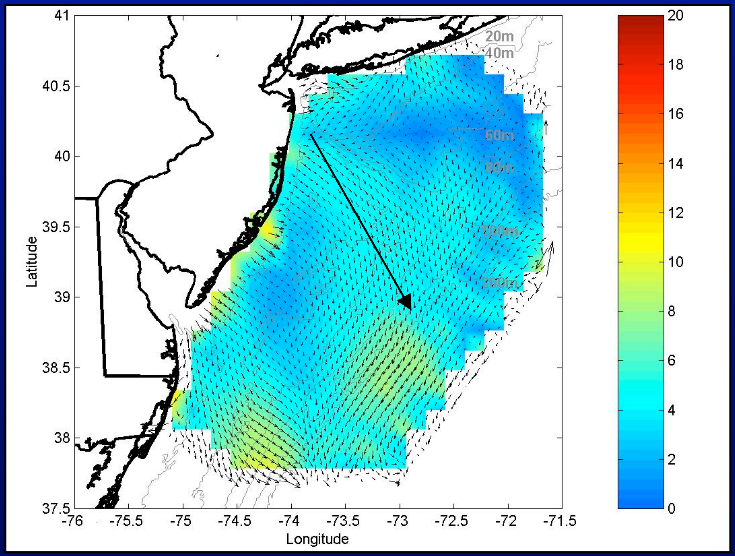

RU COOL Standard Range Lowpass Velocities 2004/05/03 2100 GMT
Latitude (Degrees:Minutes)
40:35
40:30
40:25
40:20
40:15
40:10
74:10
74:05
74:00
73:55
73:50
73:45
73:40
73:35
73:30
Longitude (Degrees:Minutes)
10m
15m
30m
50m
Surface Velocity (cm/s)
75
65
55
45
35
25
15
5


04-May-2004 16:13:26 - 10-May-2004 10:30:08 (GMT)
0
10
20
30
40
-73°54'
-73°52'
-73°50'
-73°48'
-73°46'
-73°44'

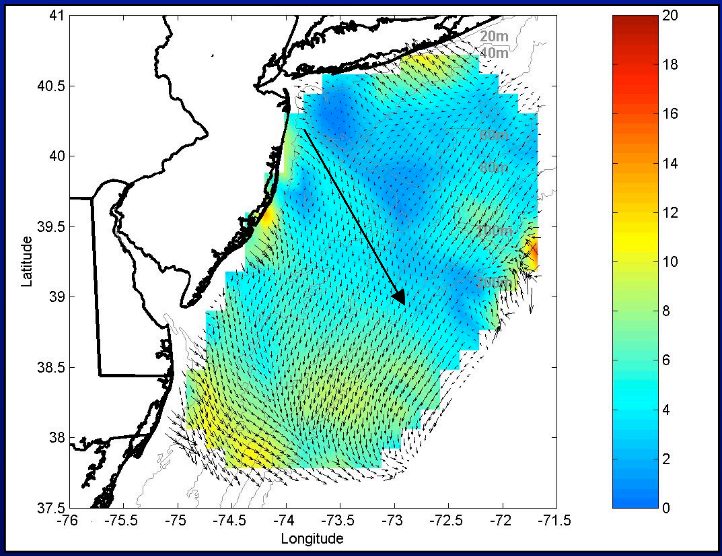

Plume Edge
Shoreward of the edge
Seaward of the edge
Sea floor
~18 m
Depth (m)
Time/Distance

Seasonal Climatologies

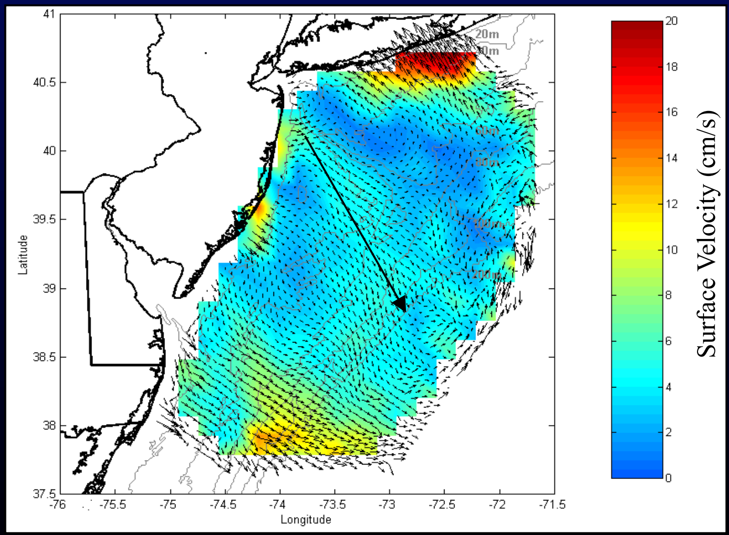
Annual mean 2002



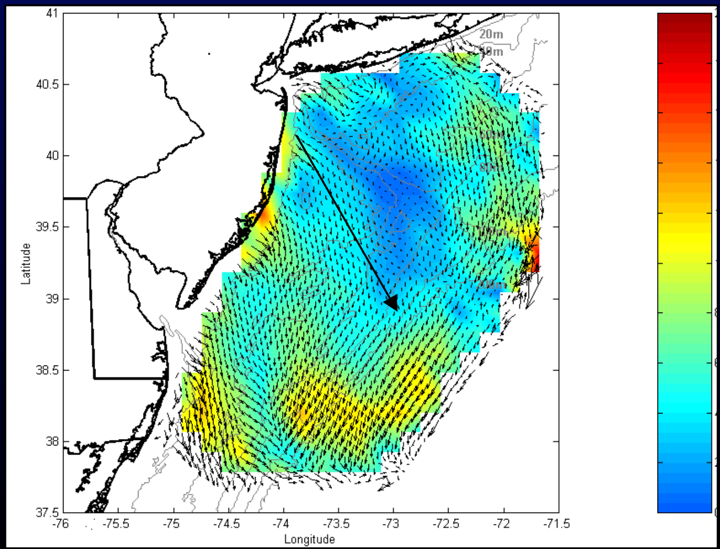
Annual mean 2003

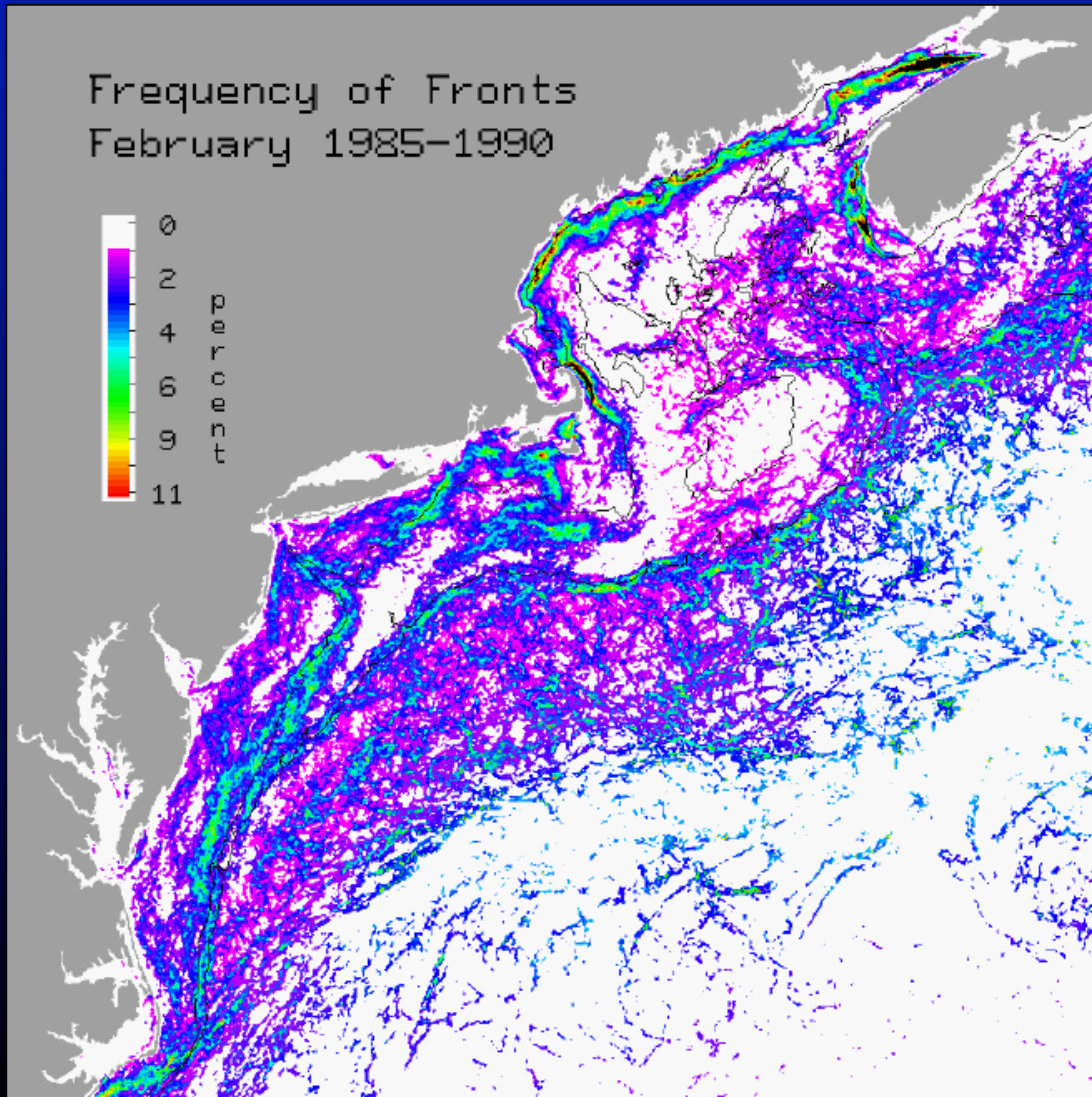


Summer mean 2002-2003

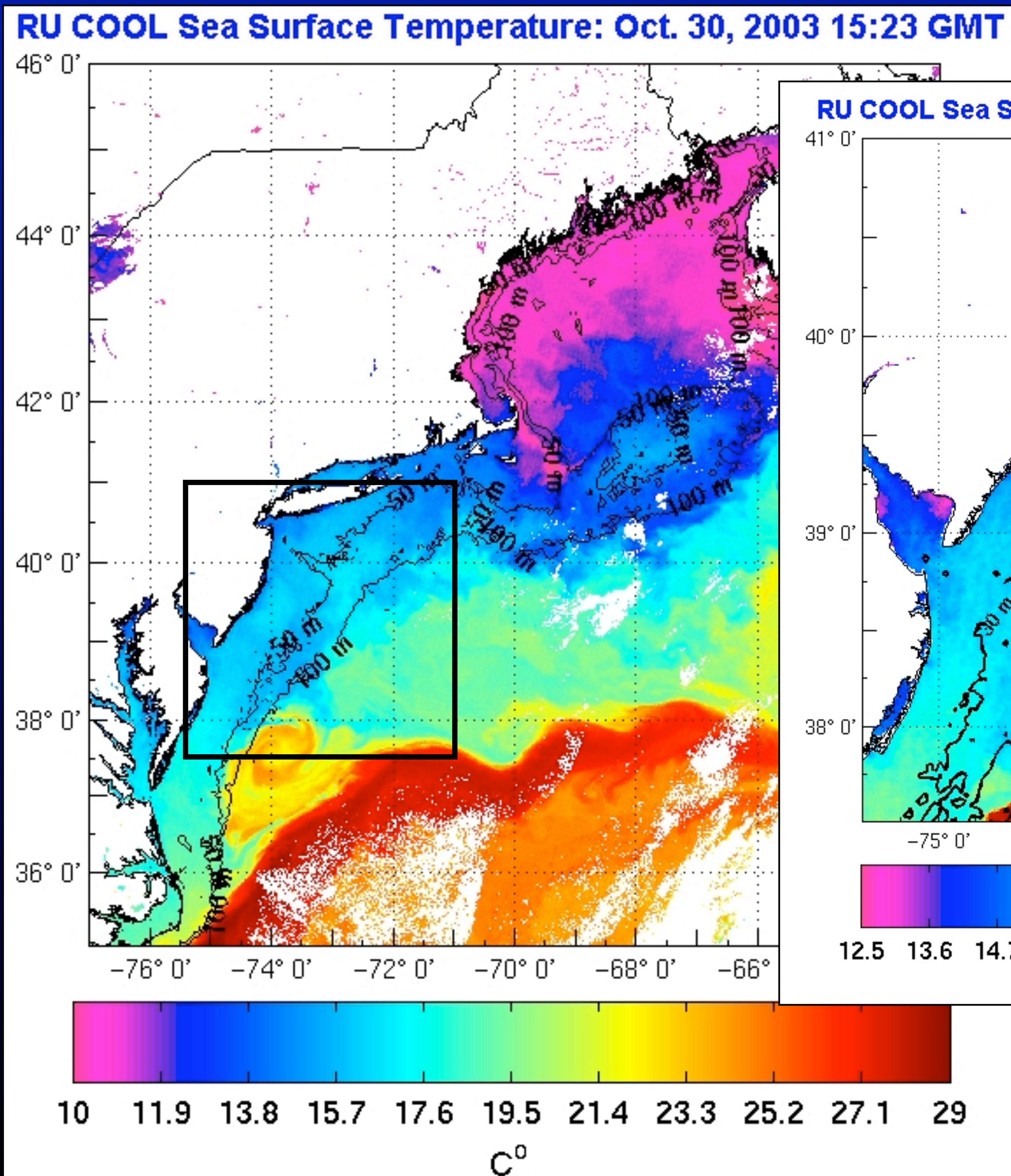


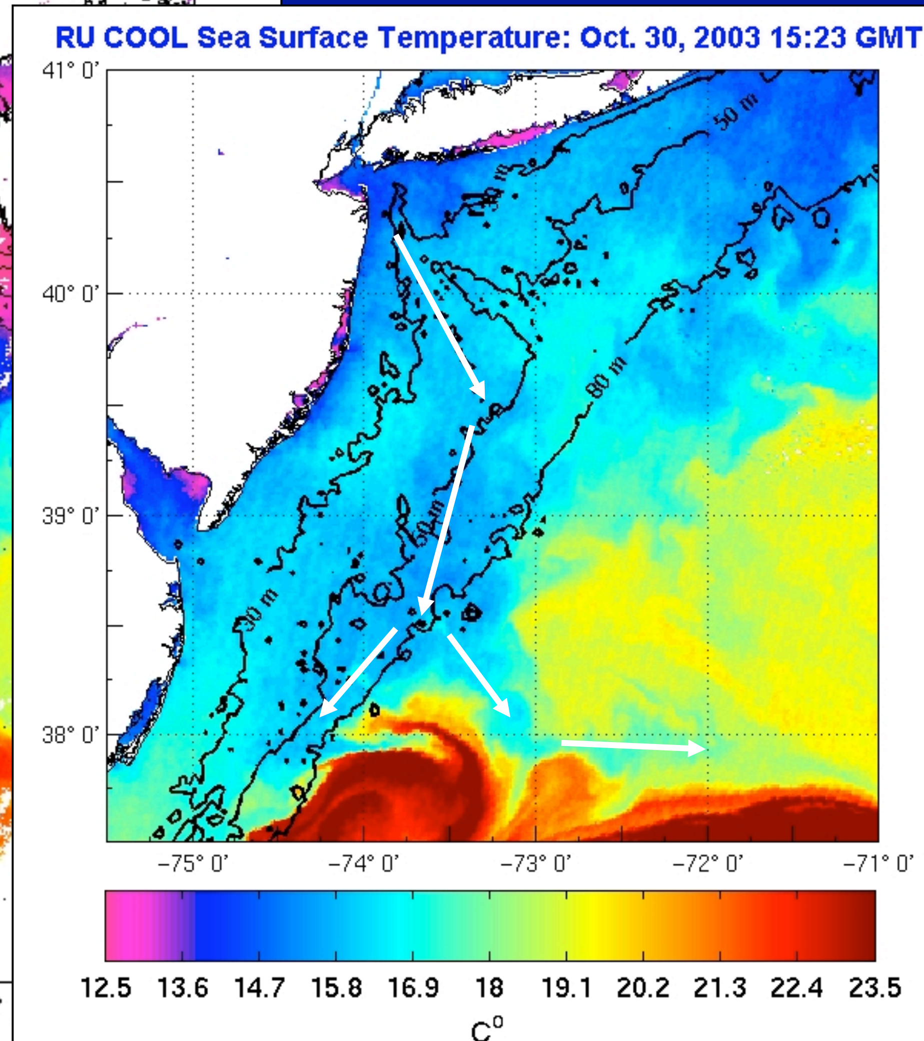
Winter mean 2002-2003





Thanks to
Dave Ulman


RU COOL Sea Surface Temperature: Oct. 30, 2003 15:23 GMT
46° 0'
44° 0'
42° 0'
40° 0'
38° 0'
36° 0'
−76° 0'
−74° 0'
−72° 0'
−70° 0'
−68° 0'
−66°
50 m
100 m
10
11.9
13.8
15.7
17.6
19.5
21.4
23.3
25.2
27.1
29
C°

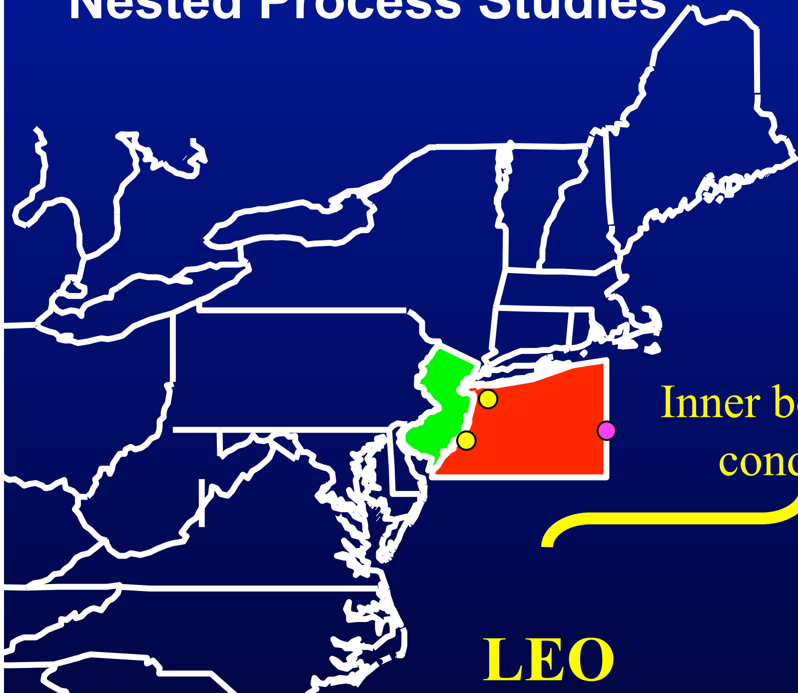

RU COOL Sea Surface Temperature: Oct. 30, 2003 15:23 GMT
41° 0'
40° 0'
39° 0'
38° 0'
−75° 0'
−74° 0'
−73° 0'
−72° 0'
−71° 0'
50 m
80 m
12.5
13.6
14.7
15.8
16.9
18
19.1
20.2
21.3
22.4
23.5
C°

Rutgers Coastal Observatory

Provide a Long-term Shelf-Wide Context for High Resolution Nested Process Studies

Coastal Ocean Observation Lab

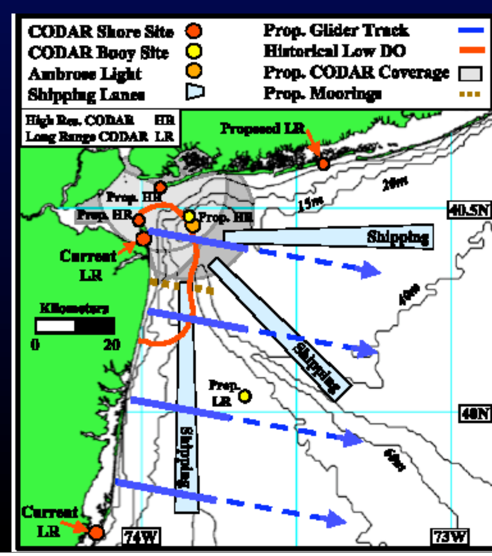
Operations Center



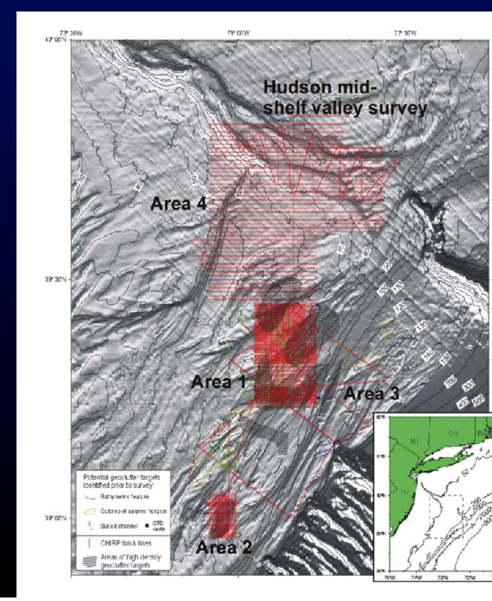
Outer boundary condition

LEO

LaTTE

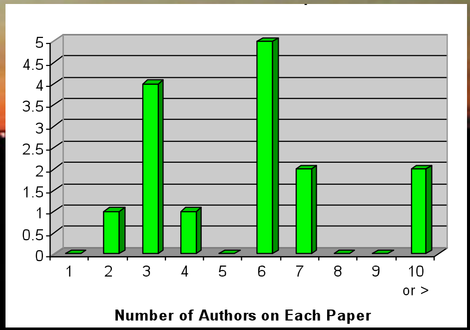


SW06



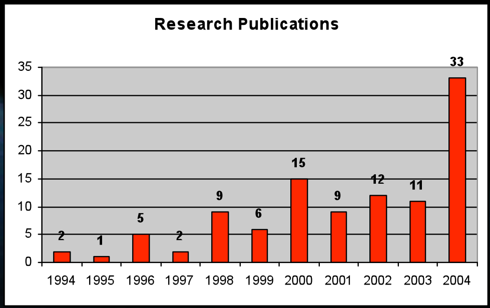
Dawn in the age of observatories

"I walk into our control room, with its panoply of views of the sea. There are the updated global pictures from the remote sensors on satellites, there the evolving maps of subsurface variables, there the charts that show the position and status of all our Slocum scientific platforms, and I am satisfied that we are looking at the ocean more intensely and more deeply than anyone anywhere else." **Henry Stommel**



Lessons learned:

1) It takes years to build an integrated observing network, good plan is to set aside ~ 5 yrs.
2) Pay-off is worth it, however waiting for maturation can be slow,
3) Pay-off is discovering unexpected things
4) Pay-off is going to sea EVERY day



THANK YOU