Toward an integrated environmental information system in the Gulf of Maine

Philip Bogden, CEO
GoMOOS, Inc

GoMOOS

Integrating…in a Distributed Way

1. GoMOOS – User-Driven Nonprofit
   (Bridging the valley of death)
2. Toward a Regional Association
   (System of interoperable systems)
3. What makes you think it can happen?
   (Standards enable innovation)

GoMOOS

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GoMOOS

Operational Goals

To provide data and information that serve public and private sector needs to:

- Solve practical problems,
- Predict events, and
- Further understand natural systems…

…in the Gulf of Maine.

A Coastal Oceanic Analog of…

…the National Weather Service.

GoMOOS is Regional and Multisector

Serving all Gulf of Maine states and provinces:

Nova Scotia, New Brunswick, Maine,
New Hampshire, Massachusetts, on south…

Partners:

- Research Institutions
- Government Agencies
- Educational Institutions
- Private Industry
- Nonprofits

GoMOOS

User Needs

- Mariners – safety, rescue
- Shipping – safety & efficiency
- Mammals – endangered species assessment
- Aquaculture – site selection & water quality
- Lobster fishing – recruitment prediction
- Petroleum Industry – spill response
- Shellfishing – spat collection, site selection
- Military – national security, operations test bed
- Coastal Management – eutrophication
- Commercial & Sport Fishing – stock assessments
- Research – long-term observations, infrastructure

GoMOOS Members

Research/Education:

Bedford Institute of Oceanography (Canada)
Bigelow Laboratory for Ocean Science
Bowdoin College
Dalhousie University (Canada)
Maine Maritime Academy
Rutgers University
University of Maine
University of Massachusetts
University of New Hampshire
University of Rhode Island
Woods Hole Oceanographic Institution

Government:

Maine Dept. of Marine Resources
Maine Science & Technology Foundation
Maine State Planning Office
Massachusetts Coastal Zone Management
Massachusetts Water Resources Authority
Stellwagen Bank National Marine Sanctuary

Industry:

Bath Iron Works
James W. Sewall Company
Maine Lobstermen's Association
Portland Pipe Line Corporation
Satlantic, Inc. (Canada)
RD Instruments, Inc.

Marine Operations:

Atlantic Pilotage Authority (Canada)
Eastport Port Authority
Federal Marine Terminals (Canada)
Penobscot Bay & River Pilots Assoc.
Saint John Marine Pilots (Canada)
Saint John Port Authority (Canada)

Nonprofit:

Gulf of Maine Aquarium
Island Institute
New England Aquarium

GoMOOS

Technical Program

Real-time data acquisition:

Weather – surface winds, air temperature, visibility(fog), light flux, cloud conditions

Ocean conditions – current, waves, temperature, salinity

Water quality – dissolved oxygen, water clarity, turbidity, nutrients

Ocean biology – irradiance, algal biomass, productivity, community structure, acoustics (whales)

Modeling & Prediction: circulation & waves

Data & Information Management: adding value

Science Team

University of Maine

- **Neal Pettigrew (**Chief Scientist)**:** Buoys & Currents
- **David Townsend –** Nutrient measurements
- **Andrew Thomas –** Satellite remote sensing
- **Huijie Xue –** Circulation modeling
- **Lewis Incze –** Upper trophic levels

Bigelow Laboratory

- **Collin Roesler –** Phytoplankton and bio-optics

Woods Hole Oceanographic Institution

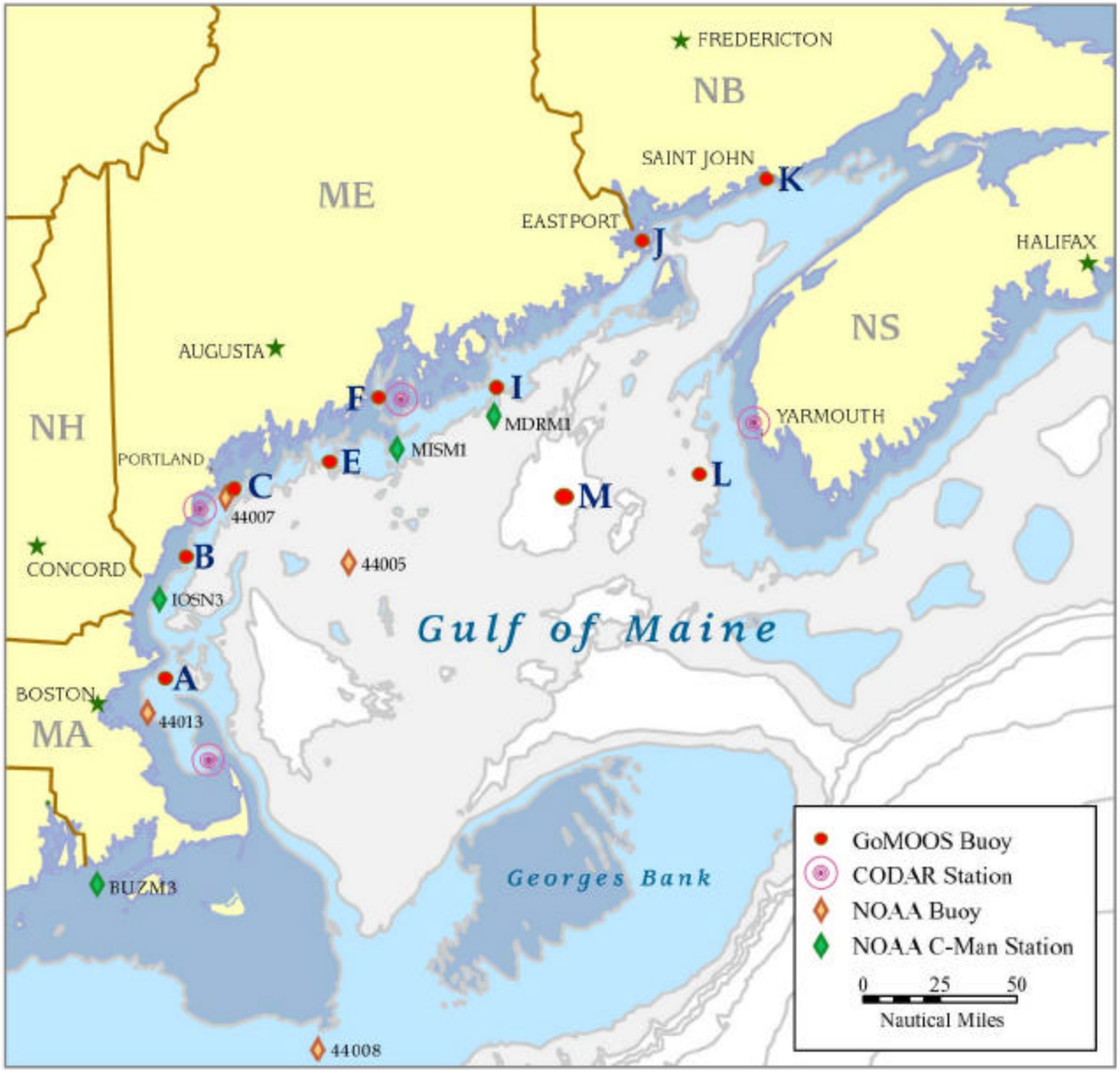
- **James Irish –** Wave measurements

Bedford Institute of Oceanography

- **Peter Smith –** Wave modeling & prediction
- **William Perrie –** Wave modeling & prediction

GoMOOS

GoMOOS Buoy Program



Mooring Team

"Have buoy, will travel"

University of Maine

Dr. Neal Pettigrew

John Wallinga

Linda Magnum

Robert Stessel

Woods Hole Oceanographic Inst

Dr. James Irish

Bigelow Laboratory

Dr. Collin Roesler

Dr. Andrew Barnard

GoMOOS

GoMOOS Shelf Buoy

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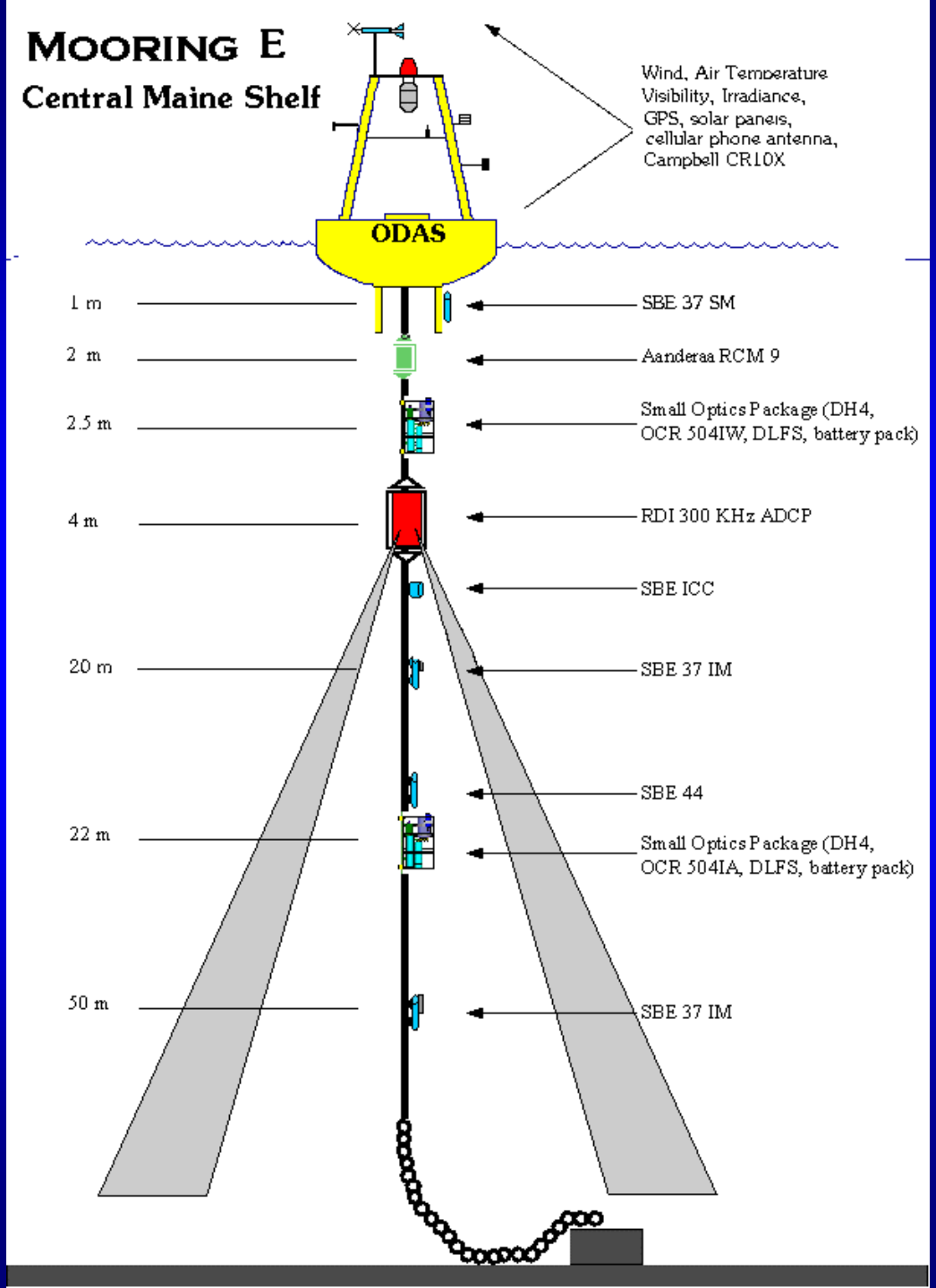
Real-Time, Modular Design



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HF Radar Installation

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http://www.gomoos.org/codar/index.shtml?p=large

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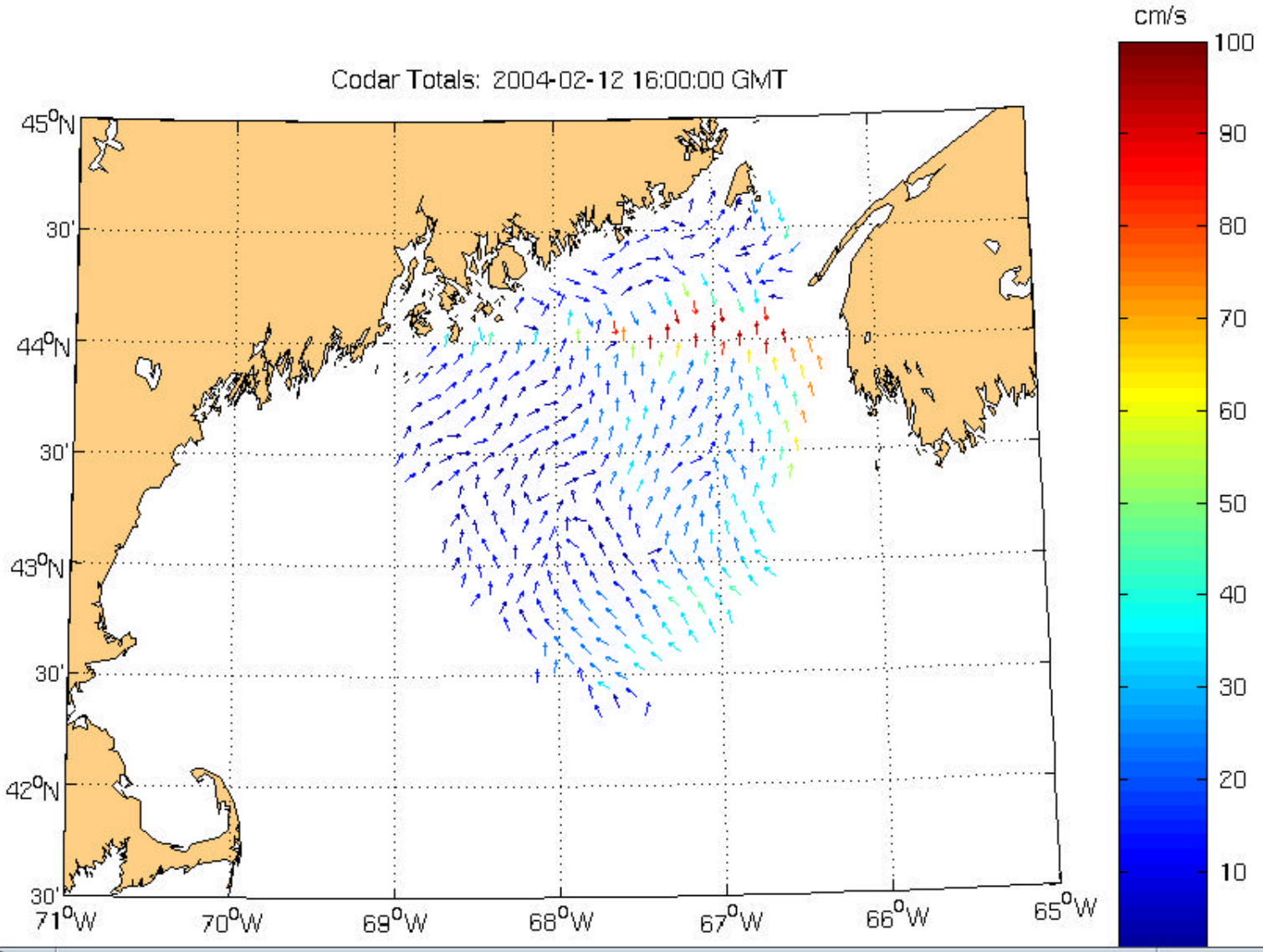

Done

Start Inbo... Welc... Micro... Welc... Welc... 97% 6:24 AM

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The System is Evolving

GoMOOS

Fisheries and Oceans Canada | Pêches et Océans Canada

ALLIANCE FOR COASTAL TECHNOLOGIES

Maine Dept. of Marine Resources
Mass. Division of Marine Fisheries
New Hampshire Fish & Game
U.S. Geological Survey

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http://dev.gomoos.org:8082/

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GULF OF MAINE OCEAN OBSERVING SYSTEM

GoMOOS

Up-to-date information on weather and oceanographic conditions in the Gulf of Maine

- Home
- About GoMOOS
- Graphing & download
- Latest data maps NEW!
- DODS data access
- Dial-A-Buoy
- About the Gulf of Maine
- North Atlantic Oscillation
- Ocean observing nationally
- ACT
- Contact GoMOOS
- Feedback

Current news

GoMOOS profiled by Wired News
(Nov 3, 2003) more...

GoMOOS is hiring
(Oct 22, 2003) more...

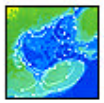
IOOS workshop report now available
(Oct 16, 2003) more...

Hourly Buoy Data

Buoys and Stations Collecting Weather and Ocean Data

Hourly information developed for marine operations includes wind, wave, visibility, air temperature, water temperatures at various depths, salinity and more. Real-time and historical data from GoMOOS and NOAA

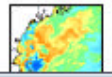
GO!



new

CODAR Surface Currents

Hourly measurements of large-scale sea surface currents.



new

Northern Shrimp

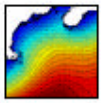
Explore northern shrimp fisheries information with this interactive mapping tool that brings together shrimp catch data with relevant environmental conditions.

Data Providers

- Maine Dept. of Marine Resources
- Northeast Fisheries Science Center

Atmospheric Conditions

Information about the latest weather conditions on the ocean includes wind, air temperature, visibility, and cloudiness index along with descriptions of the data.



new

Wave Forecasts

Predictions - up to 48 hours - of wave height and period.

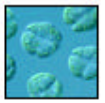
Weather Forecasts

Regional Weather

- Coastal Marine Forecasts
- Marine Prediction Center Atlantic Forecast
- Mount Washington

National and Canadian Weather

- Weather Channel.com
- WeatherUnderground.com
- The Weather Network



Ocean Biology Plant Life

Using light to measure chlorophyll, phytoplankton

Start Inbo... Micro... Welc... Welc... 97% 6:29 AM

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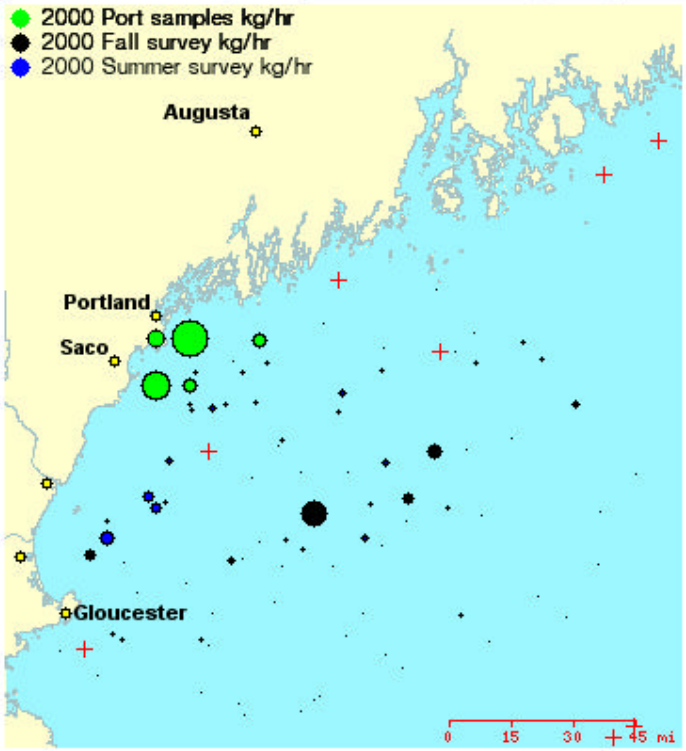
http://www.gomoos.org/shrimp/index.shtml

Search

GULF OF MAINE OCEAN OBSERVING SYSTEM

Interactive Map | Time Series Maps | Project Overview



Zoom to data area Zoom to full extent

Data | Tools | Layers | Download | Graphs | Legend

Method	Data	Year	Month or Week
Port samples	CPUE (kg/hr)	2000	All / All
Summer survey	CPUE (kg/hr)	2000	
Fall survey	CPUE (kg/hr)	2000	

Units: kg lbs

Query data

Click map symbol to view data.

2000 annual Port sampling by 10-minute square

- 132 - 192 kg/hr
- 193 - 252 kg/hr
- 253 - 312 kg/hr

2000 Summer survey

- 0 kg/hr
- 1 - 353 kg/hr
- 354 - 706 kg/hr
- 707 - 1058 kg/hr

2000 Fall survey

- 0 kg/hr
- 1 - 50 kg/hr
- 51 - 100 kg/hr
- 101 - 149 kg/hr

GoMOOS - P.O. Box 4919 - Portland, ME 04112-4919 - 207.773.0423 - fax: 207.773.8672 - info@gomoos.org

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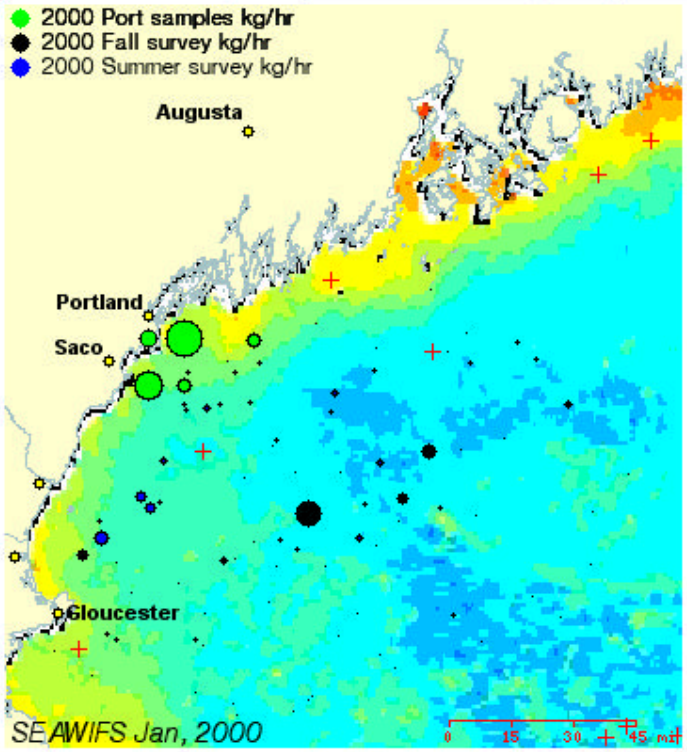

Zoom to data area Zoom to full extent

Data | Tools | Layers | Download | Graphs | Legend

Layers

- [ ] Shaded relief
- [ ] Bathymetry (background)
- [ ] GOM Surficial geology
- [ ] Coastal Surficial geology
- [ ] Bathymetry (contours)
- [ ] Lat/Lon lines
- [ ] Summer survey strata
- [ ] Fall survey strata
- [ ] Statistical areas
- [ ] 10 min. squares

Satellite composites

- [x] Ocean color (monthly) 2000 Jan
- [ ] SST (monthly) 2003 Jan

Models

- [ ] Bottom temp. 2003 Jan

Climatology

- [ ] Temperature Jan -Depth-
- [ ] Salinity Jan -Depth-

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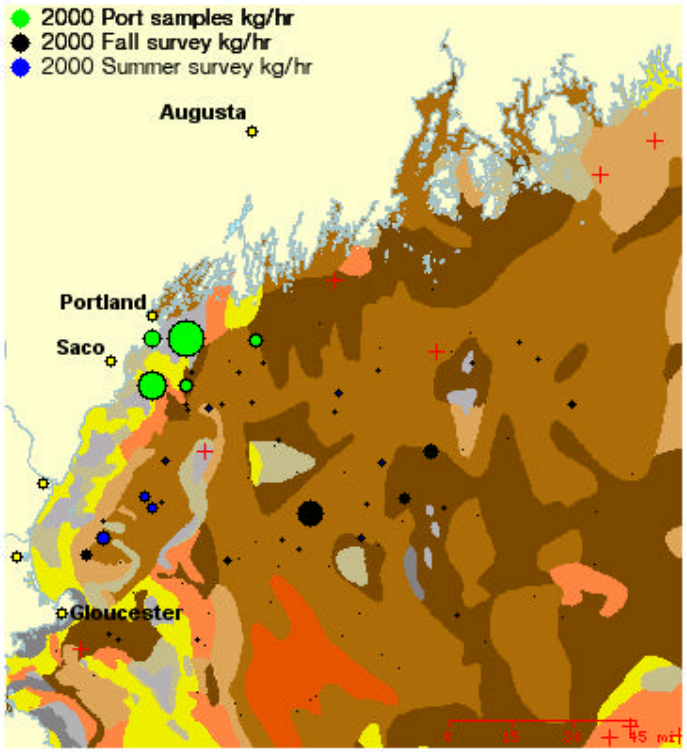

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Map Legends - Mozilla

Map Legends

2000 annual Port sampling by 10-minute square

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Layer Legend

- Bedrock
- Gravel
- Gravel-sand
- Sand
- Clay-silt/sand
- Sand-clay/silt
- Clay
- Sand-silt/clay
- Sand/silt/clay

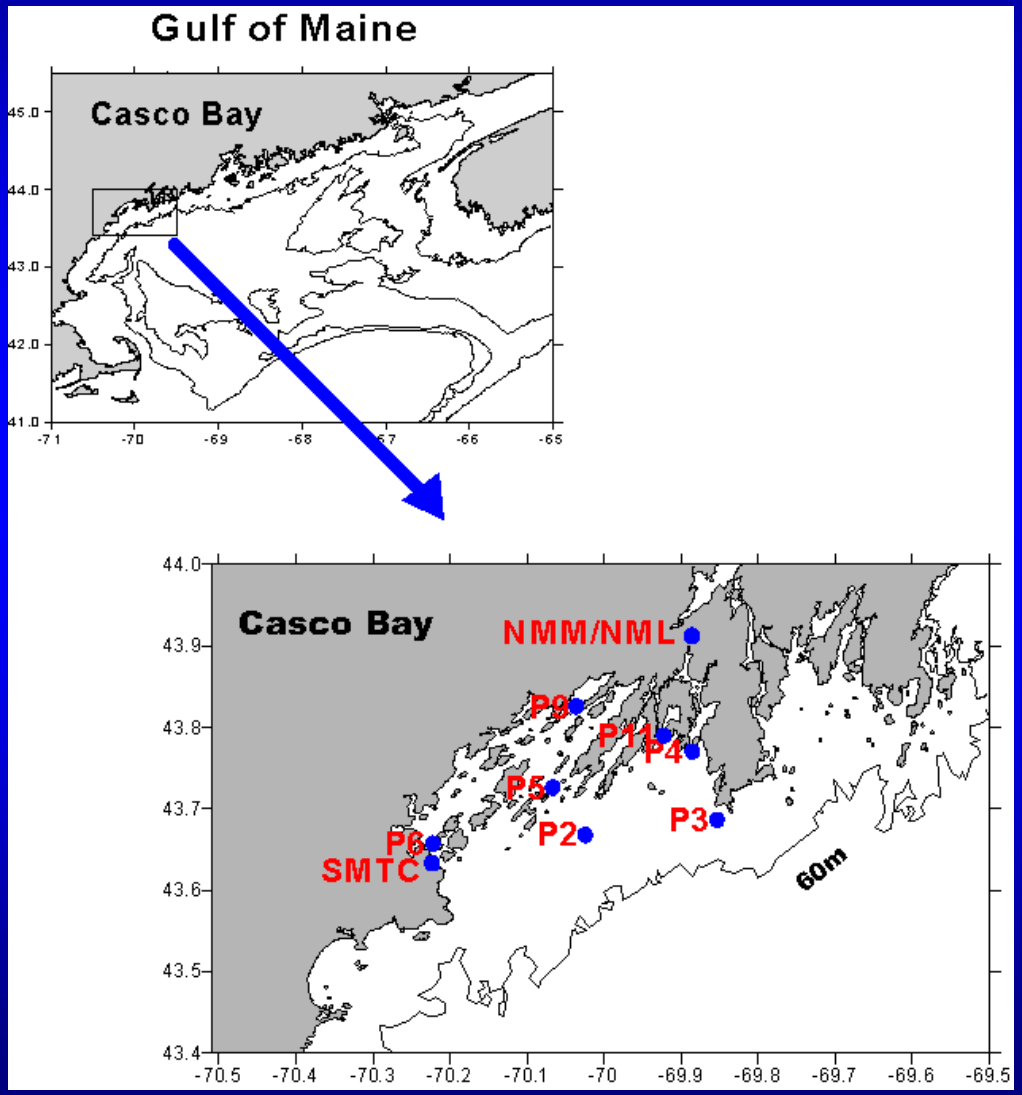
Close this window

The System is Evolving

Nutrient Monitoring

Dave Townsend
(Univ. of Maine)
&
Friends of Casco Bay

(…& EPA?)



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Standards Enable Innovation

- WWW → HTTP & HTML

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Standards Enable Innovation

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- Climate Modeling → OPeNDAP/DODS & CF
- Census of Marine Life → DiGIR & Darwin Core
- EPA → HTTP & (XML + Data Schema)
- Coastal IOOS → OPeNDAP + ???
- Web GIS → HTTP & (XML + OGC Services)

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http://www2.dmsolutions.ca/msapps/ioos2-beta/ Search

Home Bookmarks GoMOOS NPR+ Grid :: Centre for Ma...

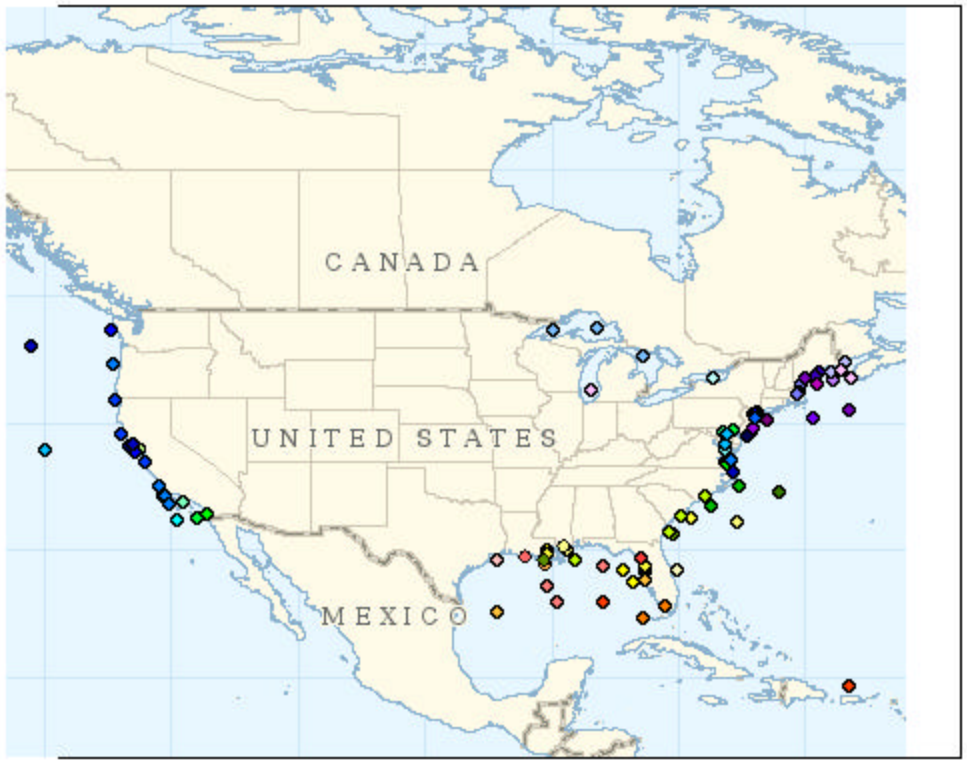
IOOS OGC Compliant Web Map Service
Prototype Wind and SST Observations

Zoom to: North America

Filter by Time and Date

Date: May 6 2004

Time: 6:00:00 Time Zone: -04



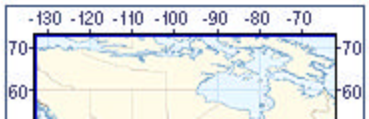
0 560 1120 1680 2240 2800 mi

Legend

Show layers by: Apply

- GoMOOS
  - Sea Surface Temperature
  - Wind Barbs
  - Deep Sea Temperature
- SEA-COOS
  - Sea Surface Temperature
  - Wind Barbs
- NYHOS (Stevens Institute)
  - Sea Surface Temperature
- Wavcis (LSU)
  - Sea Surface Temperature
- NOAA CSC
  - Sea Surface Temperature
  - CoastWatch AVHRR SST
- UNH COOA
  - Latest COOA - MODIS SST
- Base Layers
  - Base Layers
  - Bathymetry Contours
  - SST Color Ramp

• Key to reading map symbols



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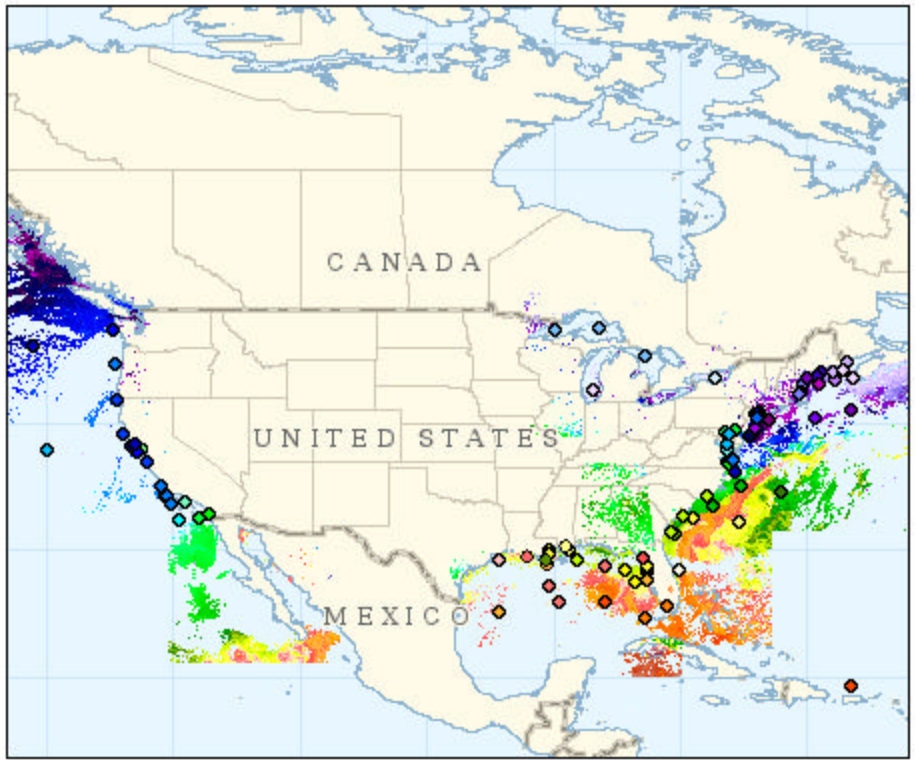

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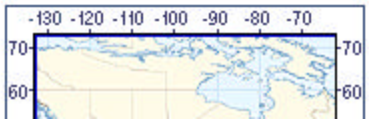
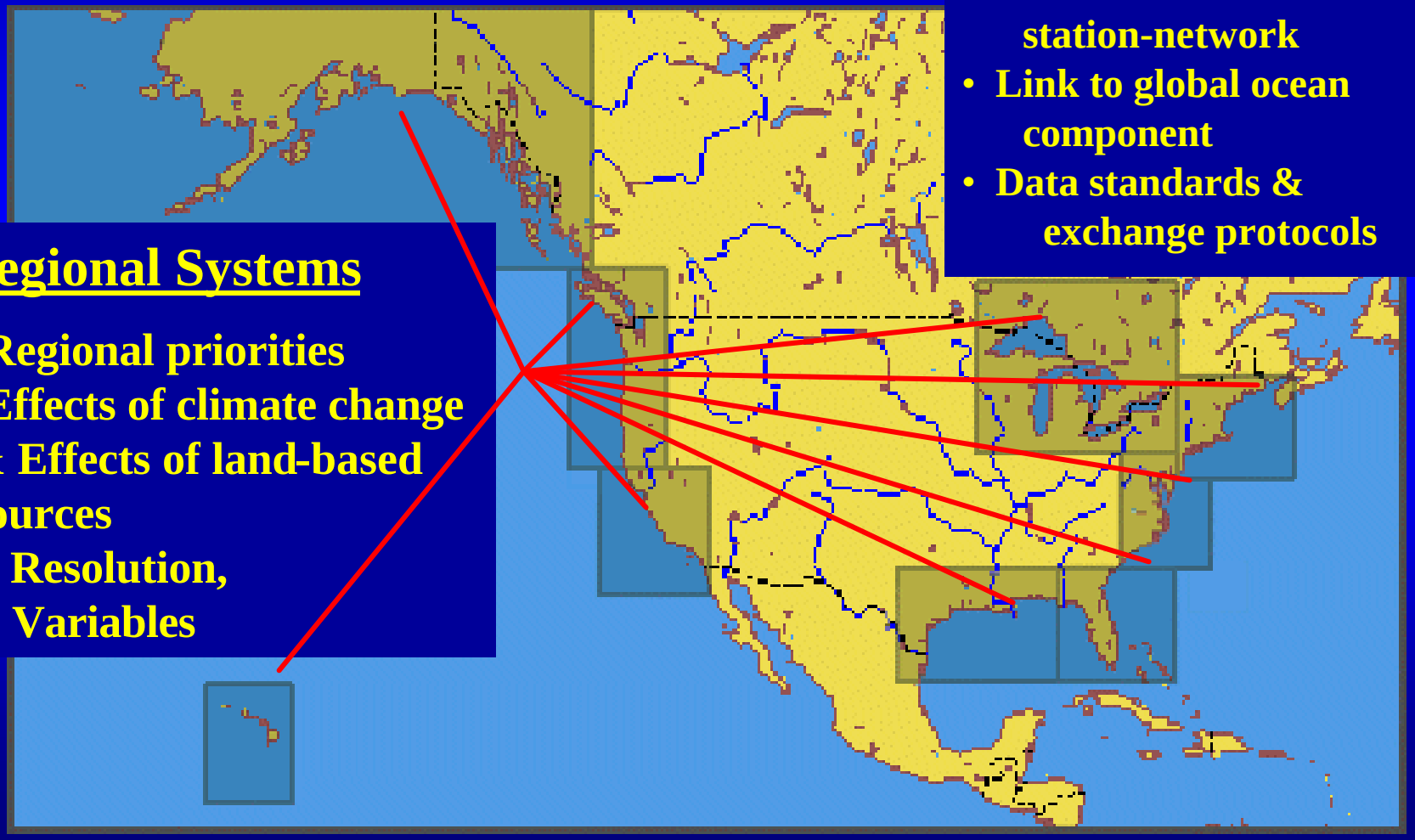


National Federation of Regional Systems

National Backbone

- Satellite remote sensing
- In situ sensing reference & sentinel station-network
- Link to global ocean component
- Data standards & exchange protocols



Regional Systems

- Regional priorities
- Effects of climate change & Effects of land-based sources
- - Resolution,
- - Variables

GoMOOS

Integrating…in a Distributed Way

1. GoMOOS – User-Driven
   (Research → Operations → Research)
2. Toward a Regional Association
   (Cultural & technical challenges)
3. What makes you think it can happen?
   (A: Demos are here. …EPA?)

GoMOOS

Thank You

Ocean Observing Systems
-- The GoMOOS Prototype --

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   (Demos are here – EPA…?)

Basic Science (old paradigm)

Exercise: Justify the infrastructure ($) needed to enable testable hypotheses for all of:

a) North Atlantic Oscillation
b) Wind-Driven Circulation
c) Bio-physical coupled models

Correct answer must address two points:

- *NSF can't afford it.*
- *Congress needs a cost/benefit analysis.*

User-Driven Science (new paradigm)

a. North Atlantic Oscillation…

Fisherman: "That NAO index looks like my revenues over the last 20 years."

b. Wind-Driven Circulation…

Headline: "USCG improves search & rescue, saving $30M in one year."

c. Bio-physical coupled models…

Headline: "HAB warning saves lives!"

This System Must Operate 24/7!

Maritime Shipping Industry

3,500 transits/yr
50 million tons

202,000 transit hrs
$43 million ops.

1% time savings
= $500,000/yr

Commercial Fishing Industry

Time and safety

Average value per fishing day = $4.1M

"…I check for the official gale warnings, then go to the [GoMOOS] web site to see if the wind is actually blowing now. I can get a day's work in…"
--Scalloper from Stonington, Me.

Connecting Fisheries to the Physical Environment

Climate change

Stock assessment

-- chlorophyll/productivity

-- circulation

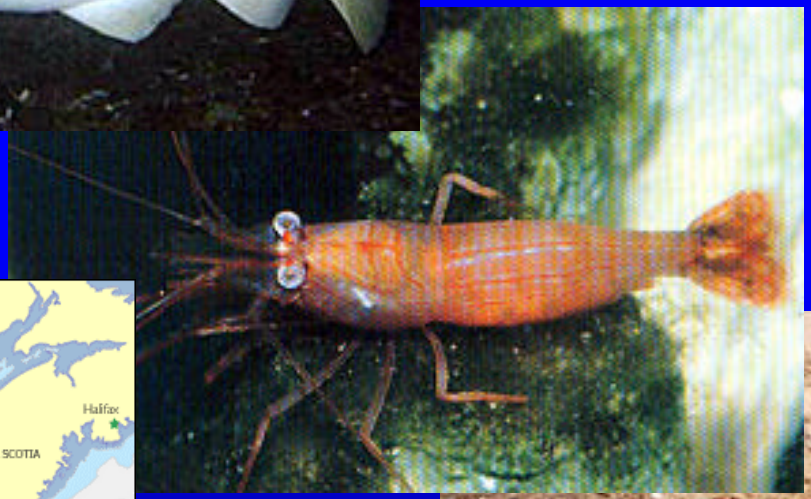
Aquaculture siting

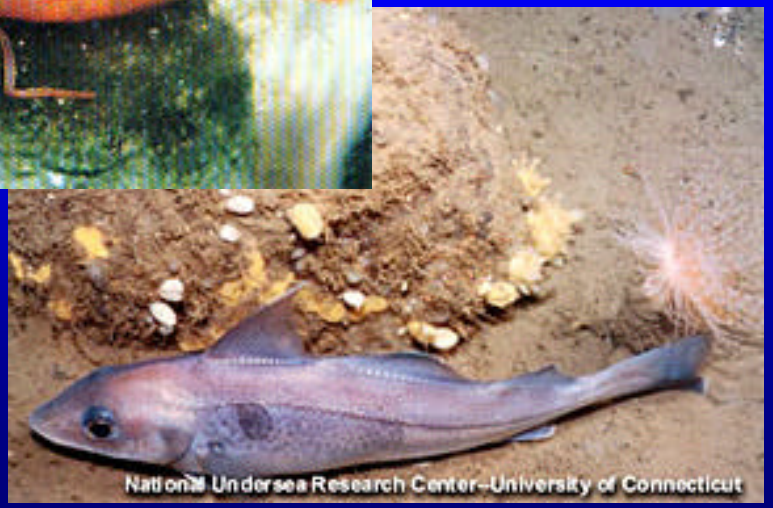
-- dissolved oxygen

-- salinity

-- sea surface temp.

-- currents





Oil Spills: Contingency Planning, Prevention, and Recovery

Julie N –
180,000-gal. spill,
Portland Harbor
September 1996

Real-time
- -- Wind
- -- Waves
- -- Currents
- -- Predictive models

Search & Rescue

U. S. Coast Guard:

2nd largest user of GoMOOS web site

6000 missions/yr
500 saved lives
28 lives lost/yr

4% success after 2 hours,
1% increase in effectiveness = 6 more lives saved per year

24/7 User Need For HF Radar:

Coast Guard Search & Rescue

Wastewater Management

New Boston Harbor Sewage Outfall

- Boundary conditions
  for nutrients & currents
- Dissolved oxygen

Helps meet costly
monitoring requirements

New Frontiers for Resource Management: Biological Observations

Alexandrium tamarence:
Agent of paralytic shellfish poisoning (red tide)

Experimental technologies

Future: Red Tide predictive index

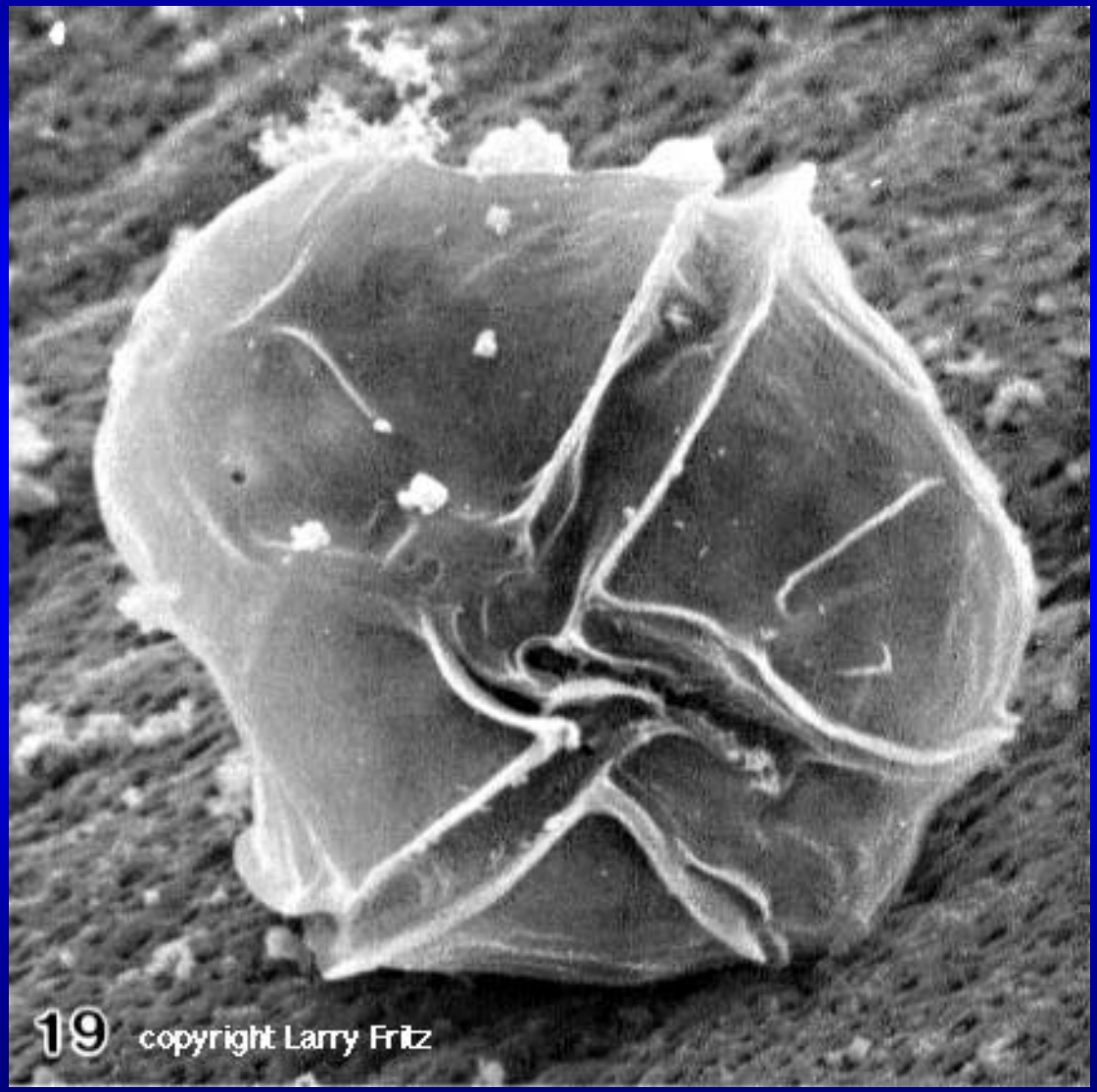


Photo credit: Larry Fritz

GoMOOS

Cost-Effective System for Research and Operations

- The system must produce long-term research-quality data.
- The system must operate 24/7 to accommodate user needs.
- No individual user can afford to pay for the entire system.
- The U.S. national system will be a federation of linked regional systems.

GoMOOS

Estimated Annual Benefit
Potential for 5 Sectors

1. Search and rescue (lives saved)
2. Oil spill mitigation
3. Efficiencies in commercial fisheries
4. Recreational fishing days
5. Maritime transportation – vessel operating costs

$33+ million per year

Source: Kite-Powell and Colgan, 2001, for NOAA

GoMOOS

Estimated Annual Costs
For a Regional Ocean Observing System

Capitalization (over 3 years): +/- $12M

- 10 – 13 buoy locations
- 4 CODAR units
- Data management system

Operation & Maintenance: +/- $4 M/yr

…Conservative cost-benefit ratio = 1:10.

Lessons Learned So Far…

1. Useful information is Critical
   - Data **?** Information. The path is **not** obvious.
   - Users must be engaged – we're market driven.
2. Operational needs (24/7) are strenuous!
   - Just ask the scientists involved in the system.
   - The model is new to researchers, and evolving.
3. Research & Operations must be linked!
   - System must be based on sound science.
   - Real-time QA/QC can't wait for peer review.

If GoMOOS were a car…?

…Honda Insight, Volvo, Chrysler

Ocean Observing Systems
-- The GoMOOS Prototype --

1. GoMOOS Overview
2. User-Driven Nonprofit
   (Governance with Accountability)
3. Economic Reality
   (Bridging the Valley of Death)
4. National Scene & Ocean.US
   (Governance at the National Level)

A Revolution Is Approaching In Coastal Ocean Science.

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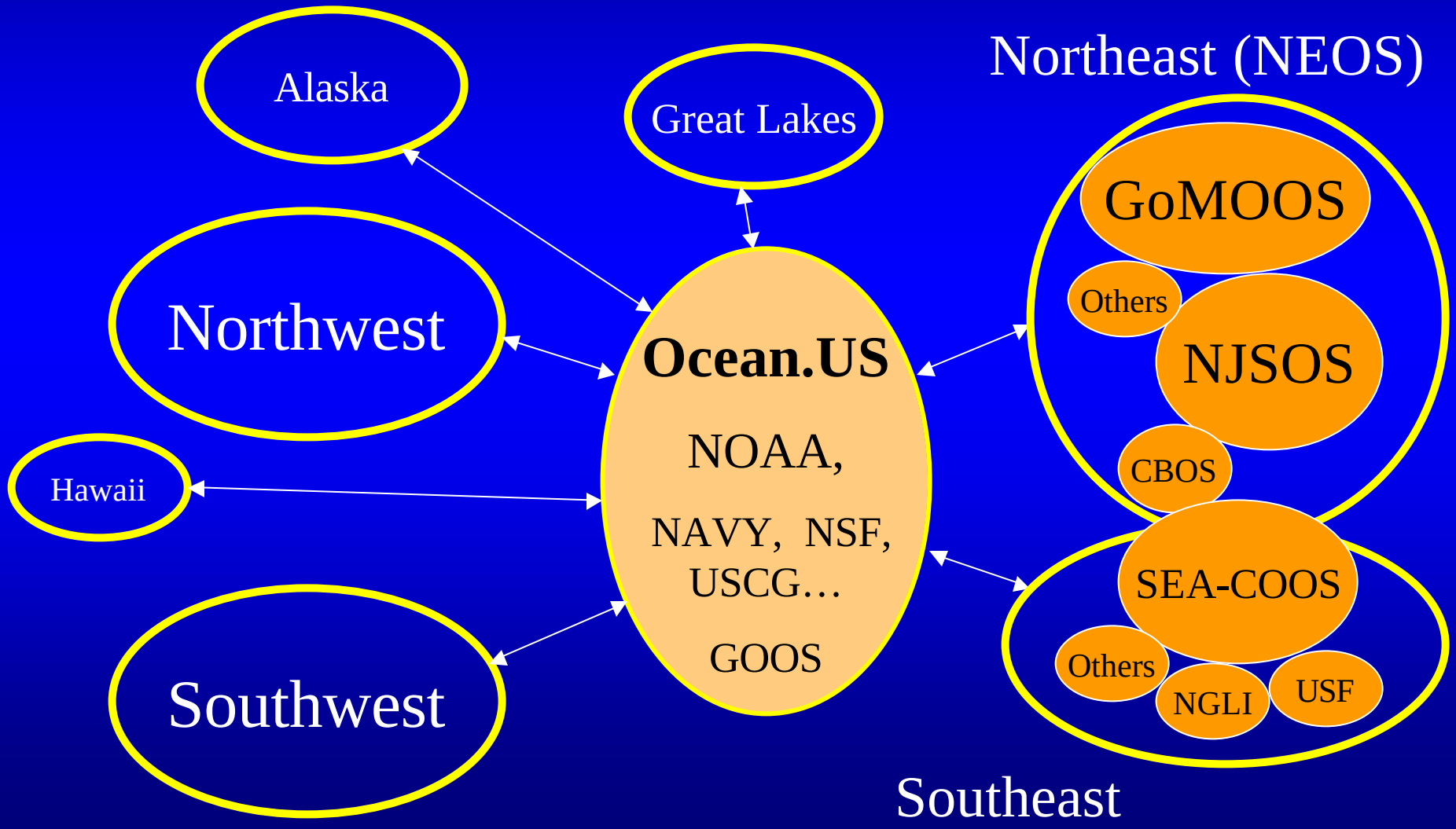
Is GoMOOS a Regional Prototype?

- Congress is discussing legislation that will establish the agency framework for a national coastal ocean observing system.
- The U. S. Ocean Commission on Ocean Policy is making the recommendation.
- Ocean.US, under the auspices of NOPP and the NORLC, is preparing the plan.

Present Status of National OOS

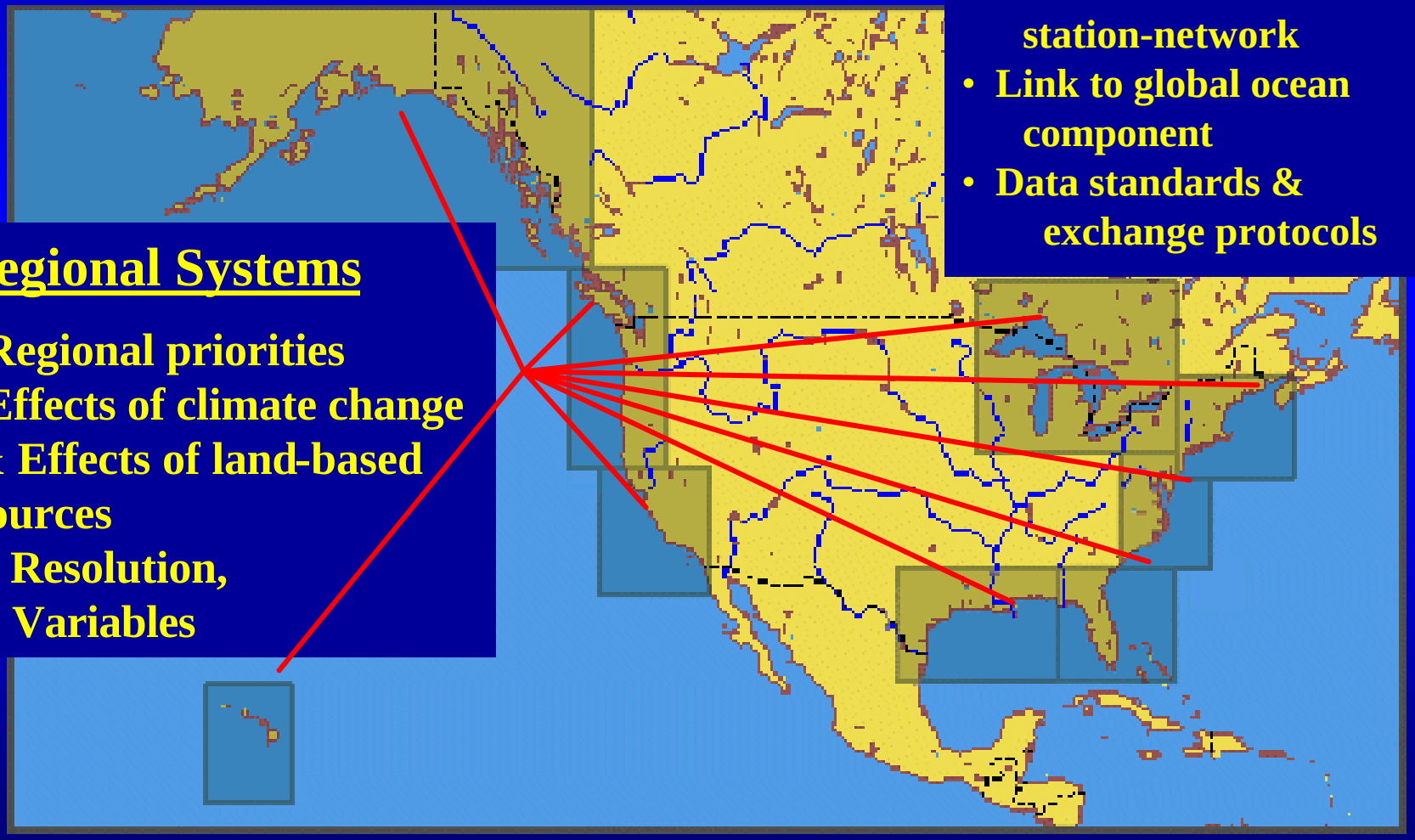
Notional & National Federation of Coastal Regional Systems



National Federation of Regional Systems

National Backbone

- Satellite remote sensing
- In situ sensing reference & sentinel station-network
- Link to global ocean component
- Data standards & exchange protocols



Regional Systems

- Regional priorities
- Effects of climate change & Effects of land-based sources
- - Resolution,
- - Variables

Why GoMOOS, Inc?

GoMOOS provides a single voice to:

- Link research & operations
  - Leverage local infrastructure via partnerships
  - Work efficiently with operational agencies
- Provide governance with accountability
  - Respond to subregional user needs
  - Respond quickly & remain innovative
- Justify long-term funding
  - Engage local constituencies
  - Provide a multipurpose utility, based on sound science, to support research and the public good

Up-to-date information on weather and oceanographic conditions in the Gulf of Maine

www.GoMOOS.org

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Updates – March 2004

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- Northern Shrimp Tool is on line

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- OpenIOOS.org is on line

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Standards Enable Innovation

- WWW → HTTP & HTML

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- Climate Modeling → CF + OPeNDAP

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- IOOS → ??? + OPeNDAP
- OGC → XML + Web Services

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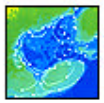

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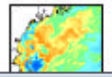

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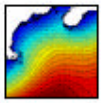

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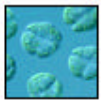

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Using light to measure chlorophyll, phytoplankton

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CODAR Sea Surface Currents

Gulf of Maine | Project Overview

Photo: Karl Schlenker

CODAR transmitting antenna located on the coast of Maine.

CODAR or Coastal Ocean Dynamics Application Radar

- Is a land-based high-frequency radar system
- Makes long-range measurements of sea surface currents
- Measures sea surface currents independent of fog or cloud cover
- Can measure currents for areas where two or more stations overlap

View map of Gulf of Maine CODAR stations

Uses of CODAR sea surface current measurements

- Provides real-time information to assist with search and rescue operations
- Predicting oil and hazardous material spill movement
- Safe and efficient navigation and marine operations
- Monitoring large ocean currents that transport lobster and other larvae around the Gulf
- Education

Links to learn more about CODAR

The Physical Oceanography Group at the University of Maine

The COOL Room CODAR tutorial

CODAR Ocean Sensors, Inc.

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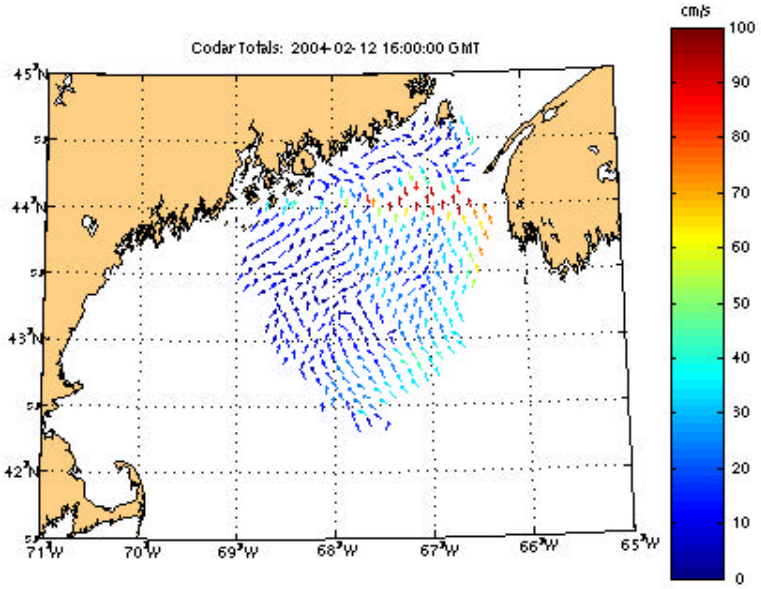

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Large version

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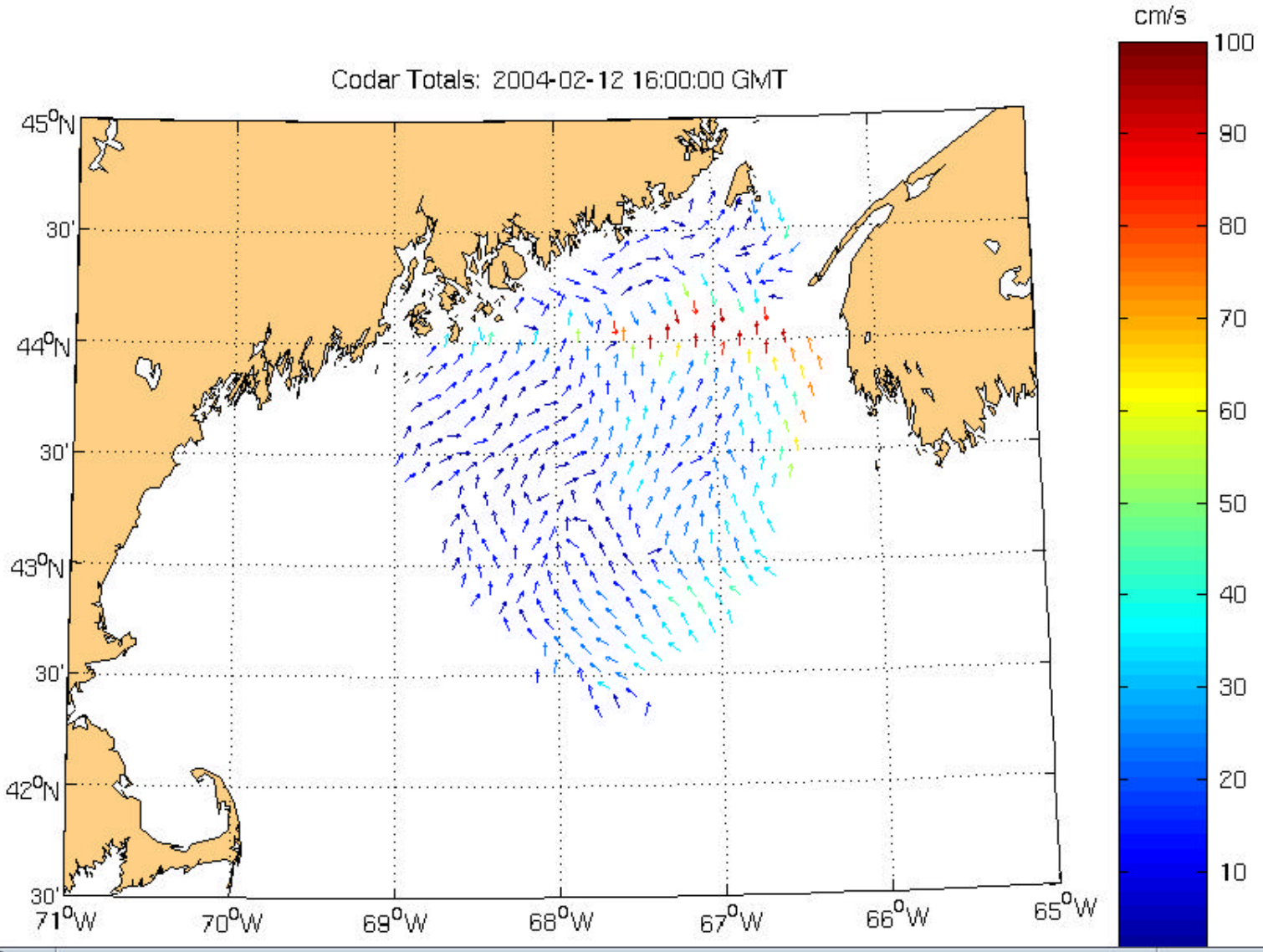

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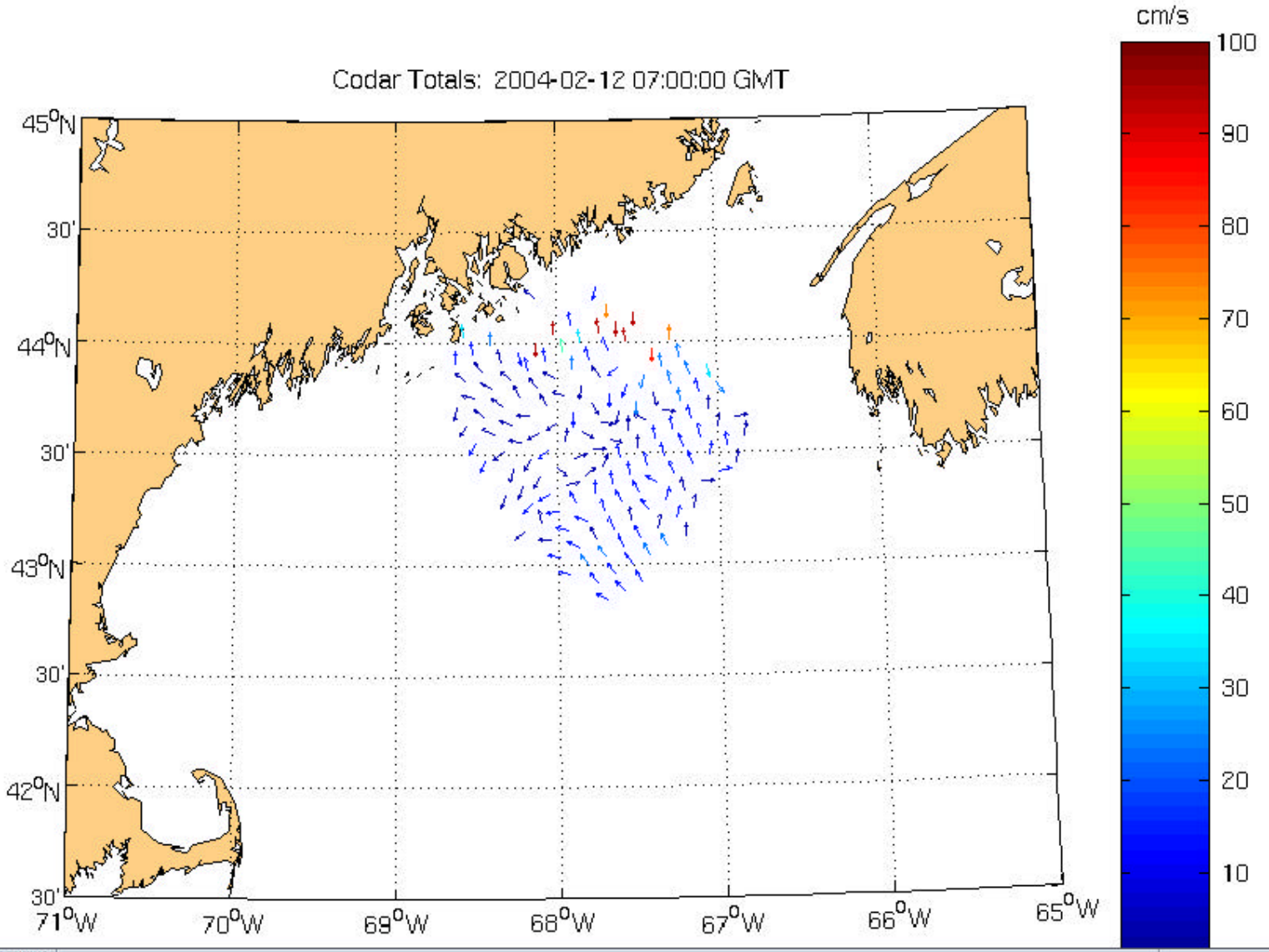

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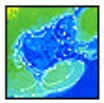

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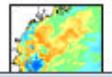

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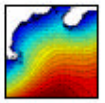

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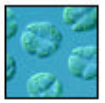

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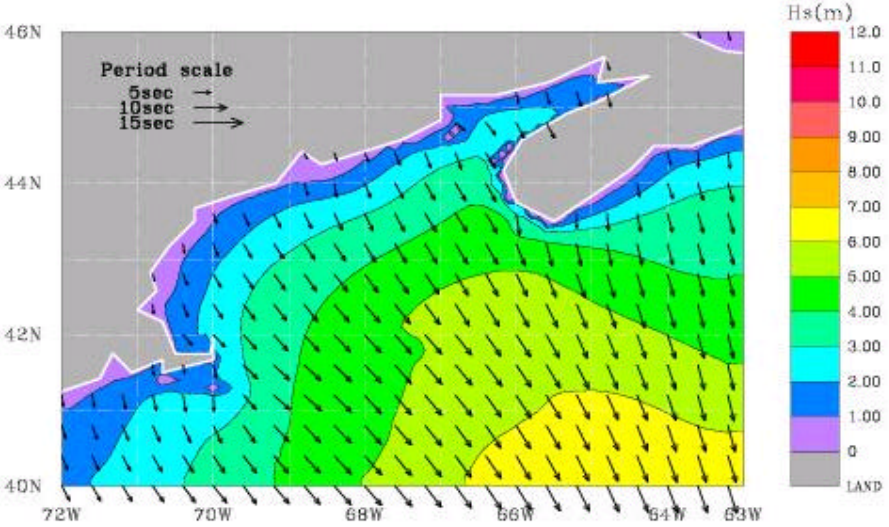
Gulf of Maine Wave Forecast

WARNING: These coastal wave forecasts are experimental and should NOT be relied upon as a primary source of wave forecast information. Significant errors in predicting coastal wave heights and the timing of storm events are known to occur.

Gulf of Maine | East Coast | North Atlantic

SIG. WAVE HEIGHTS (CONTOURS), WAVE DIRECTIONS (DIR. OF VECTORS), WAVE PERIODS (LENGTH OF VECTORS) AT 2004020900



Time is in EST

02/08 7:00 PM EST	02/09 1:00 AM EST	02/09 7:00 AM EST	02/09 1:00 PM EST	02/09 7:00 PM EST	02/10 1:00 AM EST	02/10 7:00 AM EST	02/10 1:00 PM EST	02/10 7:00 PM EST

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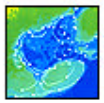

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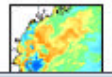

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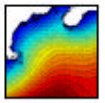

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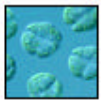

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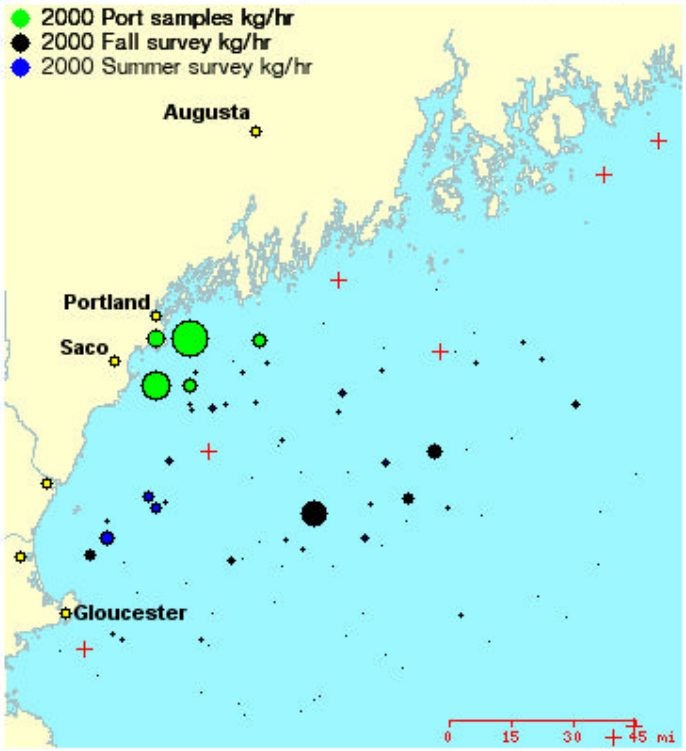
Interactive Map | Time Series Maps | Project Overview



Zoom to data area Zoom to full extent

Data | Tools | Layers | Download | Graphs | Legend

Method	Data	Year	Month or Week
Port samples	CPUE (kg/hr)	2000	All / All
Summer survey	CPUE (kg/hr)	2000	
Fall survey	CPUE (kg/hr)	2000	

Units: kg lbs

Query data

Click map symbol to view data.

2000 annual Port sampling by 10-minute square

- 132 - 192 kg/hr
- 193 - 252 kg/hr
- 253 - 312 kg/hr

2000 Summer survey

- 0 kg/hr
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- 354 - 706 kg/hr
- 707 - 1058 kg/hr

2000 Fall survey

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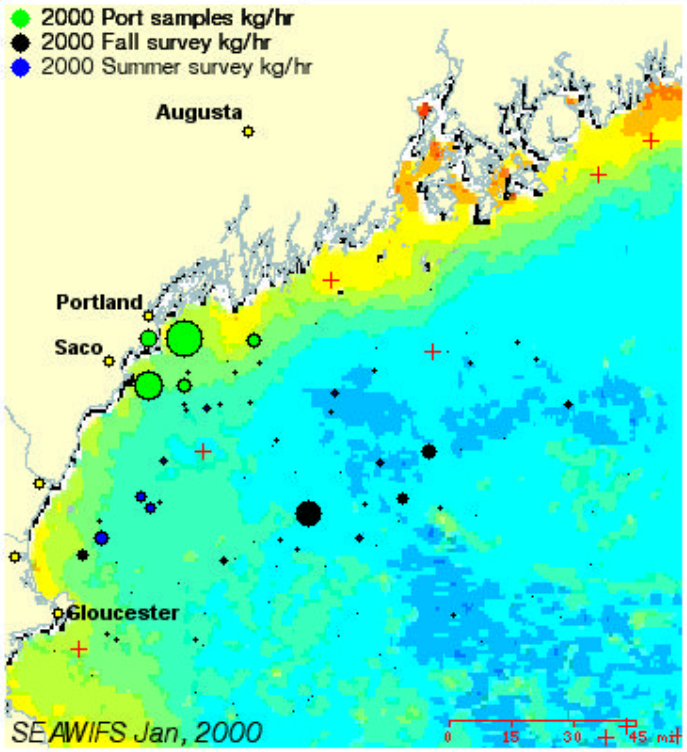

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Layers

- [ ] Shaded relief
- [ ] Bathymetry (background)
- [ ] GOM Surficial geology
- [ ] Coastal Surficial geology
- [ ] Bathymetry (contours)
- [ ] Lat/Lon lines
- [ ] Summer survey strata
- [ ] Fall survey strata
- [ ] Statistical areas
- [ ] 10 min. squares

Satellite composites

- [x] Ocean color (monthly) 2000 Jan
- [ ] SST (monthly) 2003 Jan

Models

- [ ] Bottom temp. 2003 Jan

Climatology

- [ ] Temperature Jan -Depth-
- [ ] Salinity Jan -Depth-

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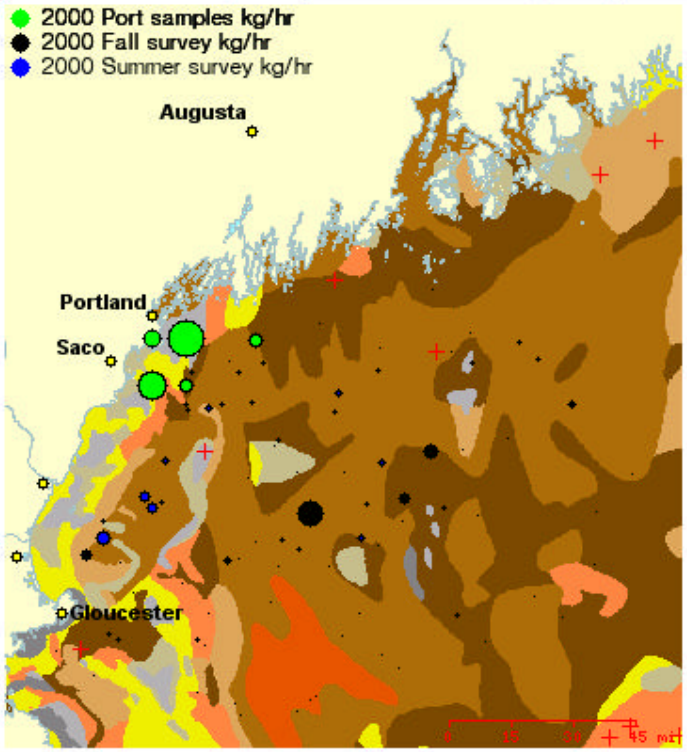

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Map Legends - Mozilla

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Layer Legend

- Bedrock
- Gravel
- Gravel-sand
- Sand
- Clay-silt/sand
- Sand-clay/silt
- Clay
- Sand-silt/clay
- Sand/silt/clay

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Ocean Observing Systems
-- The GoMOOS Prototype --

1. GoMOOS – User-Driven Nonprofit
   (Bridging the valley of death)
2. Toward a Regional Association
   (System of interoperable systems)
3. What makes you think it can happen?
   (Standards enable innovation)