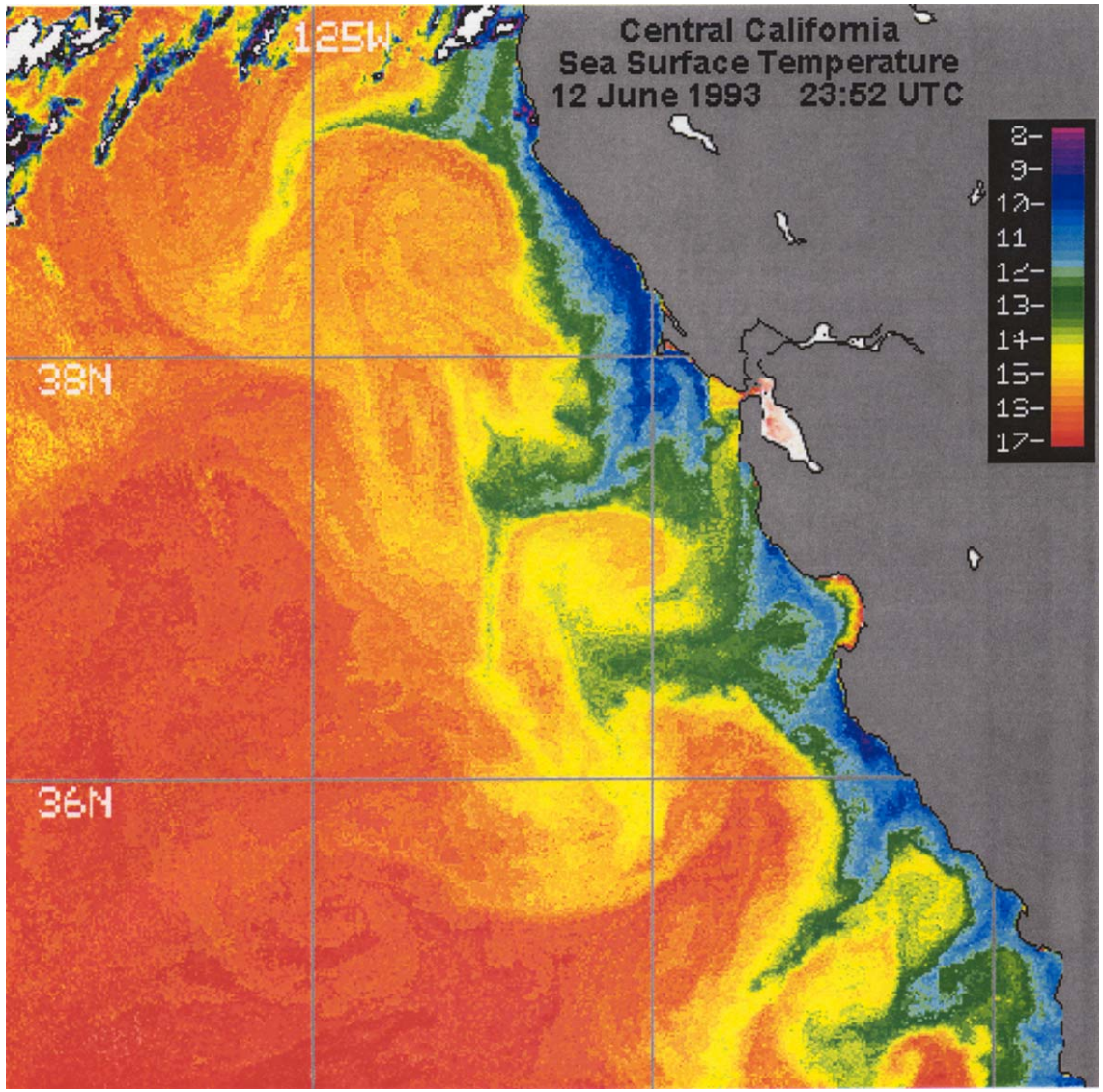
Harvard Ocean Prediction System (HOPS) Operational Forecasting and Adaptive Sampling

Wayne G. Leslie

13 November 2002


125W
38N
36N
Central California
Sea Surface Temperature
12 June 1993 23:52 UTC
8-
9-
10-
11
12-
13-
14-
15-
16-
17-

Real-time Operational Forecasting of Coupled Biological and Physical Fields

- **Define clear, obtainable objectives**
  - well-formulated objectives aid in focusing the forecasting effort
- **Characterize regional dynamics**
  - literature search
  - personal contacts with experts
  - determine previous modeling/forecasting experience
  - identify dominant variabilities and characteristics
  - evaluate expected magnitudes and sizes; relative importance of processes and scales; expected amplitudes, strength and size of features and their variabilities
- **Configure Ocean Observing and Prediction System**
  - identify modeling and data processing components
  - establish data needs and sampling
  - define model domains
  - calibrate the system

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Synoptic Initialization

- **Generate gridded fields of state variables at synoptic strength**
  - synoptic structures are in place
  - structures are in near dynamical equilibrium
  - adjustment time is small in comparison to intended duration of forecast
- **Data sources**
  - climatology, historical data, historical synoptic data, feature models
- **Model initialization and re-initialization**
  - initialize with historical and synoptic data
  - re-initialize from start as data is acquired
  - model is kept current via re-initialization and assimilation
- **Assimilation of new data**
  - replaces historical data as new data is acquired
  - assimilate yesterday's data today for tomorrow's forecast
  - assimilate via time-dependent objective analysis
  - assimilate via dynamical model

Real-time Operational Forecasting Protocols (1)

- **Model Set-up and Procedures**
  - » Domain resolution, extent, levels, time step
  - » Use of nesting
  - » Forecast duration and frequency
  - » Define set of issued products
- **Data Issues**
  - » Availability
  - » Quality control and consistency
  - » Initialization methodology
  - » Assimilation parameters (e.g. ramping time and weights, influence in space and time)
  - » Forcing fields (resolution, reliability)

Real-time Operational Forecasting Protocols (2)

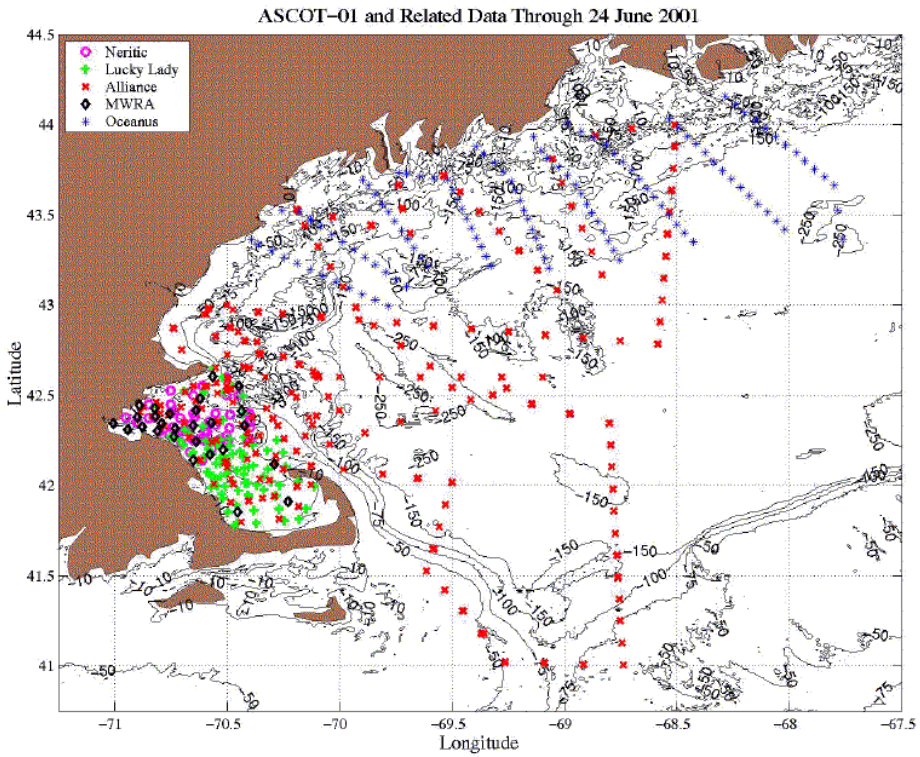
- **Constraints**
  - » Phenomena being forecast
    - – selection of relevant physics/biology
    - – spatial and temporal scales
  - » Data availability
  - » End User requirements
  - » Platform logistics
    - – *Under Direct Control*: dedicated ships, AUVs, gliders, etc.
    - – *Independent*: satellite, CODAR, established moorings, etc.
  - » Practical
    - – computational resources
    - – computational cost per model day
    - – optimal use of limited personnel
    - – forecast evaluation
    - – product preparation and dissemination

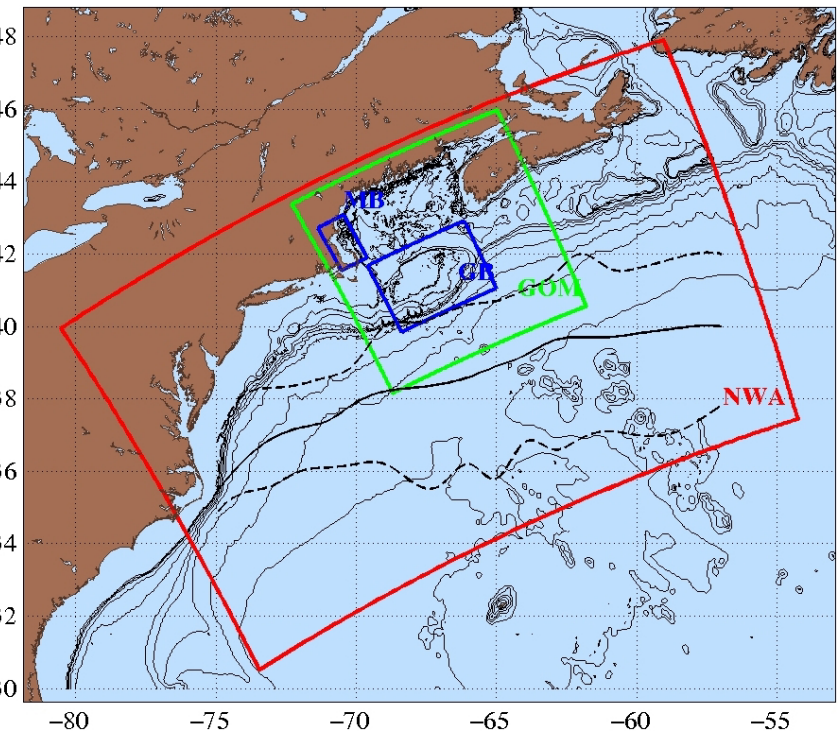
Comparison of Model Domain Computational Times

- **Nested – North West Atlantic (130x83x16), Gulf of Maine (131x144x16), Massachusetts Bay (53x90x16)**
  - 1.03 hours per model day
  - 7.21 hours per model week
- **Massachusetts Bay – standalone**
  - 4.73 minutes per model day
  - 0.55 hours per model week
- **ASCOT-02 Channel (149x114x20) – standalone**
  - 24.89 minutes per model day
  - 2.90 hours per model week

ASCOT-01 Data and Modeling Domains

6-26 June 2001





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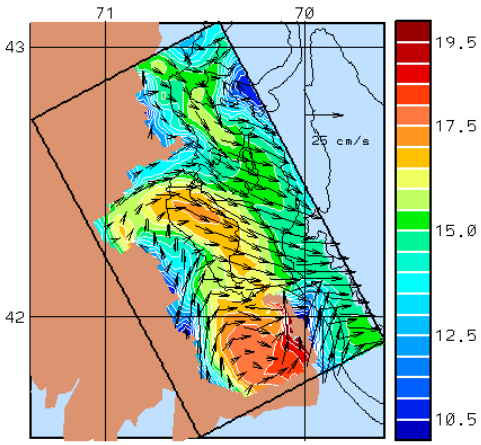
Real-time Operational Forecasting Protocols - ASCOT-01

- 3 telescoping, 2-way nested domains: Massachusetts Bay (MB), Gulf of Maine (GOM), North West Atlantic (NWA)
- Daily forecasts
- 4 day forecasts with restarts from previous forecasts
- Assimilate most recent *in situ* data
- Replace FNMOC forecasts with new analyses
- Products:
  - » *MB physics*: T, S, V at 2m, 10m and cross sections; skill metrics
  - » *MB biology*: Chl, Z, D at 5,10,15, 20m; Chl cross section; N, A at 15 and 20m
  - » *GOM physics*: T, S and V at 3m, 25m and cross sections

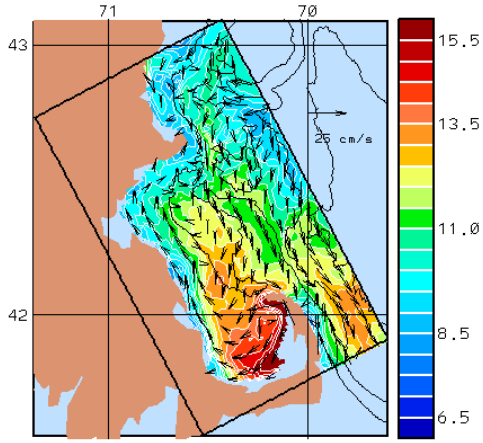
Nowcast Physical Products for 20 June 2001

Massachusetts Bay (Top) and Gulf of Maine (Bottom)

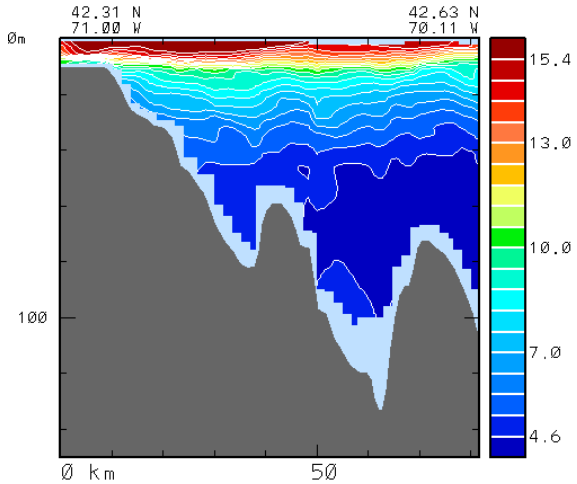
2m Temperature



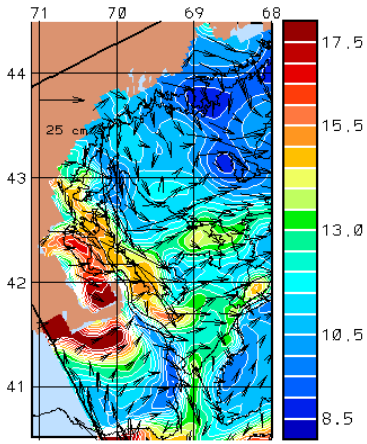
10m Temperature



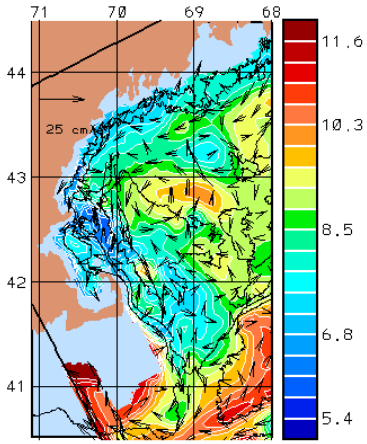
Temperature Section - Scituate



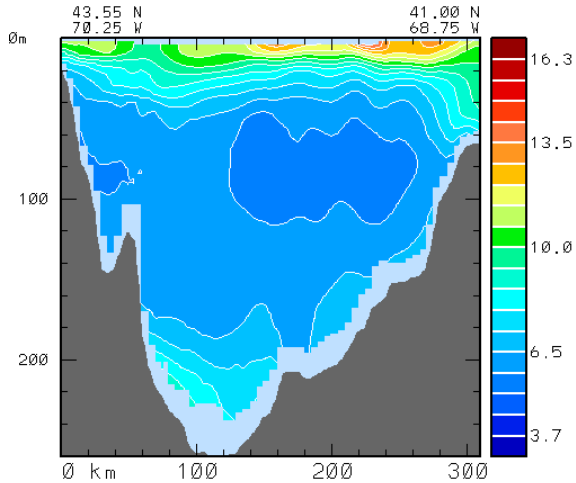
3m Temperature



25m Temperature



Temperature Section - Portland



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Elba time	Activity	Boston time
11:00	Transmit data of the night survey	05:00
	Final editing of input data	06:00
	Process data received overnight	09:00
	Plot and analyze completed forecast	10:00
	Grid data, prepare for assimilation into HOPS run	10:00
	Begin HOPS run	11:00
	Plan adaptive sampling tracks	12:00
19:00	Transmit forecast and sampling plan	13:00
20:00	Start CTD survey on Alliance	
	Apply CUPOM boundary conditions	16:00
	Continue HOPS forecast to completion	17:00
00:00	Replace CTD by XCTD and XBT	
04:00	Continue with CTD	
08:00	Survey ends close to Elba	
08:00	Process data of last night	
11:00	Transmit data of the night survey	05:00

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GOATS Operational Modeling: Logistics, Achievements, Issues

- **Data downloaded from GOATS web site upon start of working day or as it became available**
- **Distributed system:** data from Alliance via SACLANTCEN; meteorological forcings from FNMOC (Monterey, CA); HOPS modeling at Harvard; field and data transfer via internet
- **Approximately 8-10 hours from data receipt to available model product in stand-alone domain (16-18 hrs for nested domains)**
- **Products uploaded to GOATS web site at night EDT to be available in morning CET on Alliance**
- **Successfully issued 11 sets of products**
- **Model results accurately represented and forecast local conditions**
- **Provided adaptive sampling tracks daily**
- **Extremely challenging area topographically**