## Adaptive Sampling and Prediction (ASAP)

**Planning Meeting
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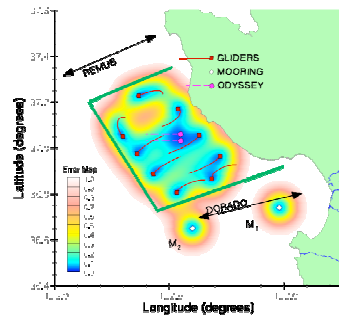
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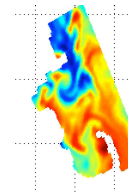

ASAP Program

Learn how to deploy, direct and utilize autonomous vehicles (and other mobile sensing platforms) most efficiently to sample the ocean, assimilate the data into numerical models in real or near-real time, and predict future conditions with minimal error.
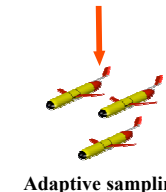
Ocean Model

Ocean Processes
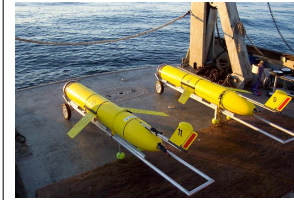
Model Prediction

Data Assimilation

Adaptive sampling

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Goals of ASAP Program

1. Demonstrate ability to provide adaptive sampling and evaluate benefits of adaptive sampling. Includes responding to
    a. changes in ocean dynamics
    b. model uncertainty/sensitivity
    c. changes in operations (e.g., a glider comes out of water)
    d. unanticipated challenges to sampling as desired (e.g., very strong currents)

2. Coordinate multiple assets to optimize sampling at the physical scales of interest.

3. Understand dynamics of 3D upwelling centers
    a. Focus on transitions, e.g., onset of upwelling, relaxation.
    b. Close the heat budget for a control volume with an eye on understanding the mixed layer dynamics in the upwelling center.
    c. Locate the temperature and salinity fronts and predict acoustic propagation.
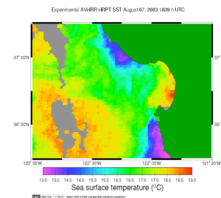
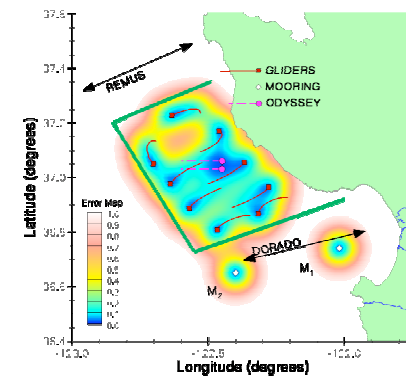Slide 3/16   **N.E. Leonard – ASAP Planning Meeting - Oct. 6-7, 2005**

Approach

1. Research that integrates components and develops interfaces.

2. Focus on automation and efficient computational aids to decision making.

3. Virtual pilot study in December 2005? Develop simulator.

4. Field experiment in August 2006.

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Slide 5

Glider Plan

Guidelines:
A. The sampling plans should be designed for data collection that
  a. Gives data that is understandable (in the oceanographic context) without a model.
  b. Provides a good map regardless of model.
  c. Yields good field + parameter estimates when combined with dynamical model.

B. Sampling plans should
  a. Be fully adaptive under operational constraints.
  b. Change in response to optimization of integration of coverage + sensitivity metrics.

C. Gliders operated as cooperative fleet: adaptation of 1 glider implies adaptation of all.

Optimal Coordinated Trajectory (OCT). A coordinated sampling pattern for the glider fleet that has been optimized with respect to the above objectives.

Coordination. Prescription of the relative location of all gliders (as a function of time).

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Slide 6

Glider Plan

Feedback to large changes and disturbances. Gross re-planning and re-direction. Adjustment of performance metric.

Feedback to switch to new OCT. Adaptation of collective motion pattern/behavior (to optimize metric + satisfy constraints).

Feedback to maintain OCT. Feedback at individual level that yields coordinated pattern (stable and robust to flow + other disturbances).

Many individual gliders.
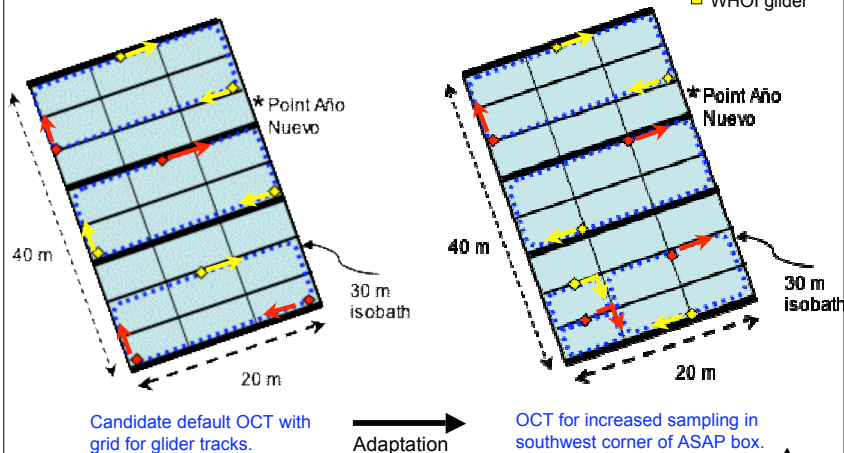
Other observations.

Models and model products

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Slide 7

Glider Plan

- ■ SIO glider
- ■ WHOI glider

Candidate default OCT with grid for glider tracks. → Adaptation → OCT for increased sampling in southwest corner of ASAP box.

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Slide 8

Glider Plan

Voting System

A web site will be created in which anyone from the team can propose a new area of the ASAP box for special sampling attention (ie propose a rectangle or rectangle from the candidate grid with corresponding time period of interest) and provide a justification for their proposal.

There will be a vote on-line. Each group has a vote. Rules for voting TBD. Justification for strong endorsements and rejections of proposals critical.

A minimum time interval between consecutive proposals will be imposed.

The goal is to implement important adaptation proposals and to be sure to try all the different reasons for adaptation (dynamics, sensitivity, …) over the course of the experiment.
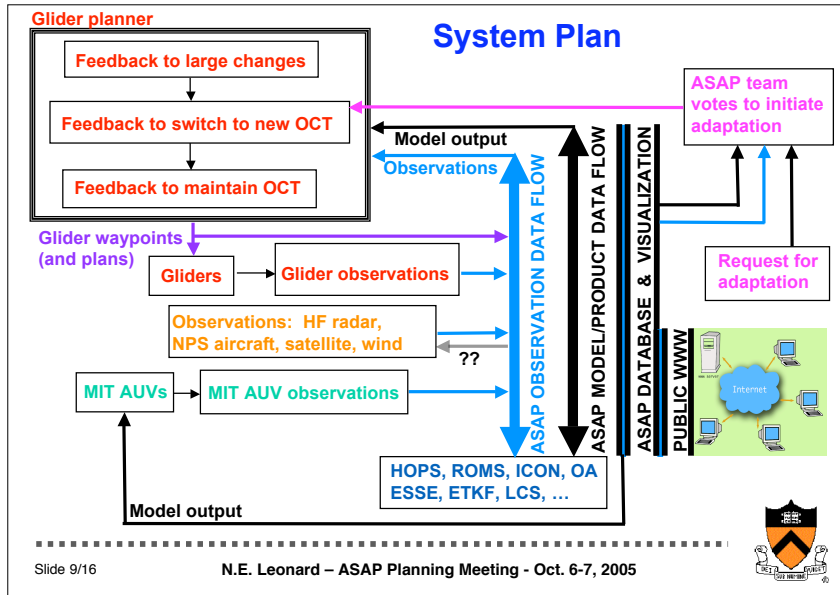
Physically possibility will be checked (e.g., can the gliders get to location in timely fashion).

Designated person will review all input and make final decision.

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Slide 9 — System Plan

Glider planner
- Feedback to large changes
- Feedback to switch to new OCT
- Feedback to maintain OCT

Glider waypoints (and plans)

Gliders → Glider observations

Observations: HF radar, NPS aircraft, satellite, wind ??

MIT AUVs → MIT AUV observations

Model output

ASAP team votes to initiate adaptation

Model output
Observations

Request for adaptation

HOPS, ROMS, ICON, OA ESSE, ETKF, LCS, …

ASAP OBSERVATION DATA FLOW — ASAP MODEL/PRODUCT DATA FLOW — ASAP DATABASE & VISUALIZATION — PUBLIC WWW — Internet

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Slide 10 — Virtual Pilot Study (VPS)

Why are we doing this?

(1) To address the goals set forth by ONR and by ASAP investigators (see Appendices) we are developing an observational infrastructure (the "system") that is robust, scalable, and sustainable. The system is not the goal, but our research goals require a working system.

(2) The purpose of the VPS is to test the system in its entirety. The fundamental purpose of a pilot experiment (whether "real" or "virtual") is to shake out the wrinkles in an experimental plan so that time and resources are used most efficiently during the actual field program.

(3) The VPS is "virtual" only in the sense that no observing hardware will be placed in the field. Asset movement and profile data will be simulated. All other aspects of the system will be utilized in the same manner as if we were engaged in a field operation.

(4) Specific research questions are secondary to refining the operation of the complete system. Individual elements of the observing system can be conveniently tested in isolation before or after the VPS.

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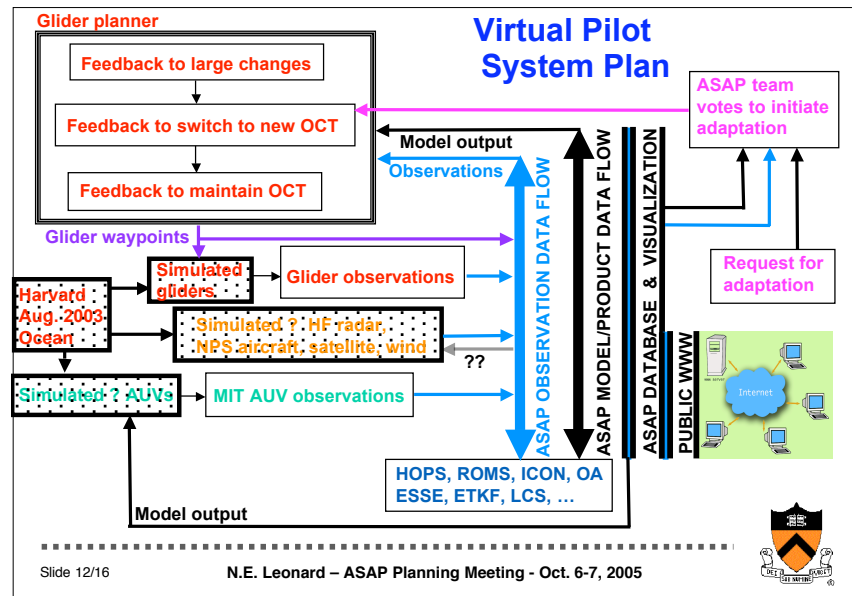
Slide 11 — Virtual Pilot Study (VPS)

What is real, what is virtual

Real	Virtual
Control system	Observing hardware
Data flow	Ocean (replay 2003?)
Predictive models	

Measures of success

(1) All elements of the system operate smoothly together and with minimal human involvement.

(2) An external observer should not be able to tell that this pilot study was "virtual." Although we are simulating both the ocean and the ocean observing hardware, all of the data and control interfaces (internal and external) should appear and behave exactly as they will during the field experiment.

(3) The VPS should help us identify potential problem areas that need correction before Summer 2006 field work begins. All groups should walk away from the VPS with a very clear idea of the work that remains to be done.

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Slide 12 — Virtual Pilot System Plan

Glider planner
- Feedback to large changes
- Feedback to switch to new OCT
- Feedback to maintain OCT

Glider waypoints

Harvard Aug. 2003 Ocean

Simulated gliders → Glider observations

Simulated ? HF radar, NPS aircraft, satellite, wind ??

Simulated ? AUVs → MIT AUV observations

Model output
Observations

ASAP team votes to initiate adaptation

Request for adaptation

HOPS, ROMS, ICON, OA ESSE, ETKF, LCS, …

Model output

ASAP OBSERVATION DATA FLOW — ASAP MODEL/PRODUCT DATA FLOW — ASAP DATABASE & VISUALIZATION — PUBLIC WWW — Internet

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Virtual Pilot Study (VPS) -- To be resolved

Schedule for VPS?

What period of Harvard Aug 2003 ocean should we use?

How much of the system plan do we anticipate that we can test in the VPS?

Are there developments not yet reflected in system plan that we need to add?

Are there critical pieces not getting attention? Who will do these?

Where do we need additional effort in integration of methodologies?

Where are the interfaces not yet complete?

How might preliminary results of OSSE's help us hone our plan?

What remains to do to make data flow?

What are remaining open questions that we should consider as a team?

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Goals of Meeting

Discuss and resolve issues and questions for VPS.

Address new ideas and developments for VPS.

Finalize VPS plans.

Assign remaining action items to be completed in advance of VPS.

Determine action items to be initiated in parallel with VPS.

Discuss and resolve issues related to ASAP '06 logistics.

Discuss and resolve issues related to larger MB '06 multi-project integration (Curtin).

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