AOSN 2 Program Research Objectives

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This document brings the hypotheses and scientific objectives developed by the AOSN II working groups into a single document, outlining (a) a set of objectives for the 2003 experiment and (b) longer term objectives for the program. The assumption is that the 2003 field program will be the first of a series of field programs. This document outlines the research objectives in order to carry out the program defined in the AOSN Charter document.

Key objectives of the field program of 2003 are to demonstrate:

1) the ability to generate ocean predictions with an integrated observing and modeling system on a defined schedule.
2) predictive capability (a) qualitatively, by identifying and locating oceanographic features correctly and (b) quantitatively, by RMS error of field variables and anomaly pattern coefficients that beat persistence.
3) adaptive sampling on a daily time scale involving measurements on the sub-regional scale to support forecast error reduction, and on an multi-hourly time scale involving autonomous feedback control laws, real-time control of observational data, and coordinated movement of multiple gliders.
4) Observation of ecosystem response on scales which allow us to understand linkages with physical processes

Long-term engineering development objectives for the program revolve around (a) developing a clear understanding of the dependence of overall predictive system performance on the performance of individual components, and (b) improving system performance. Functionality of the system is outlined in the AOSN System Document.

Thus the 2003 field program will provide a foundation of experience to both; (a) refine system design and design a field program that better quantifies system performance, and (b) understand physical and interdisciplinary dynamical processes that will allow more definitive predictive skill experiments in the next step.

Overall Numerical Modeling Working Group Objectives

- to achieve realistic and accurate simulations (fields and error estimates) of the physical dynamics and aspects of the coupled biological dynamics of the region

- to carry out OSSEs for the effective design of the dynamical and predictive skill experiment
- to intercompare a set of dynamical models differing in details of numerics, sub-grid-scale, etc.
- to forecast in real-time and to identify and provide on a daily basis features and sub-regions to be adaptively sampled, based on a list of scientific and technical objectives
- to develop an effective method for an integrated interpretation of multiple real-time model systems, including the possibility of combined ensembles
- to integrate numerical forecast models effectively and powerfully into an overall integrated system

Overall Adaptive Sampling Work Group Objectives

- to provide automatic, adaptive waypoint generation using feedback control.
- to compensate for errors in forecast using feedback of observational data more frequently than ocean model updates.
- to guide glider network gradient climbing for feature tracking using cooperative feedback control strategies.
- to use cooperative feedback control strategies to adaptively guide vehicle network formations and sampling patterns to resolve length and time scales in observational fields.
- to improve current estimates and glider position estimates using glider dynamic models. This will improve the quality of the collected data, notably measurements by gliders of the flow.
- to improve control and navigation of gliders by making use of glider dynamic models. More faithful execution of commanded glider trajectories and waypoints, with possible improvements in glider speed, range, and tracking of fronts, will allow for higher fidelity data collected.
- to compute TFP (thermal front parameter) fronts from temperature data using Lagrangian Coherent Structures (LCS).
- to improve navigational capabilities using LCS structures.
- to predict the temporal movement of LCS's for about one day, based on previous LCS computations.
- to test the accuracy of the model predicted data by comparing LCS structures predicted from past data with LCS structures computed from forecast or hindcast. This will determine good strategies for computing LCS.

Overall Interdisciplinary Dynamical Objectives

I. Physical dynamics, structure and variabilities

1. onset of upwelling (e.g. Has the forecast upwelling occurred? Does the plume emanating from Point Ano Nuevo bifurcate?)
2. upwelling steady state (e.g. Was a quasi-steady state achieved? When?)
3. relaxation event (e.g. When does the standing meander of the California Current relax? What are the consequences?)
4. Monterey Bay circulation and variability (e.g. What determines the sense of the circulation in Monterey Bay?)
5. advective exchanges of water and material between Monterey Bay and California Current System (CCS) (e.g. What are the location and sources of external exchanges during upwelling?, relaxation?)

6. interaction of buoyancy flow-through forcing (CCS) with wind-driven forcing (e.g. Local – what are the interactive effects within the Bay? Large scale – what are the external effects that influence the Bay?)
7. the effect of atmospheric coastal jet forcing and small scale wind curl on upwelling and downwelling
8. role of intense sub-mesoscale, mesoscale filamentation and eddying in the dynamics of CCS and its impact on the CCS/Monterey Bay interaction
9. mixing processes in Monterey Bay (e.g. What are the dominant horizontal and vertical mixing scales in the upwelling front? What are their importance?)
10. interaction of the deep canyon with the upper ocean and euphotic zone (e.g. Are deep canyon effects important in the euphotic zone and, if so, when?)

II. Ecosystem dynamics, structure and variabilities

1. determine relative importance of nutrients and micronutrients in controlling the amount of primary productivity within the upwelling plume
2. identify source-water seed populations controlling the biological community structure, including bioluminescence constituents.
3. trace time evolution of biological assemblages in relation to specific water mass properties, including age.
4. detect and discriminate effect of upwelling and subduction processes on the distribution and total amount of primary production
5. minimal biogeochemical ecosystem model appropriate for overall balances of coupled bio-physical dynamics for differing circumstances throughout experiment, e.g. difference between upwelling and relaxation regimes

Motivation and Rationale for Adaptive Sampling

II. Evaluating and optimizing predictive capability and predictive skill – daily adaptive sampling

1. to achieve and maintain a realistic description of the features of the synoptic circulation (currents, eddies, etc.) over the entire domain of interest and duration of experiment
2. to control and improve RMS errors and PCC metrics evaluated in real-time (e.g. Are the errors occurring attributable to structure or phase errors? Why are model RMS errors largest at the mouth of the Bay?)
3. to optimize overall dynamical accuracy by sampling sub-regions of intense vorticity/energy/enstrophy (“dynamical hot spots”) (e.g. How do dynamical events relate to forecast errors?)
4. to sample sub-regions so as to reduce errors predicted by ESSE and/or simplified error models (e.g. Are forecasted errors accurate?)

IV. Feedback control of adaptive sampling – multi-hourly adaptive sampling

1. demonstrate automatic, adaptive waypoint generation.
2. compensate for errors in forecast through feedback of observational data in control loop operating faster than ocean model prediction cycle. Cooperative feedback control strategies can guide glider gradient climbing for feature tracking.

3. Cooperative feedback control strategies for gliders in a network resolve length and time scales in observational fields.
4. The use of LCS (Lagrangian Coherent Structures) improves the navigation of gliders and the detection of fronts.

Relevant Documents:

- AOSN Charter Document
- Adaptive Sampling and Forecasting Plans, Leonard and Robinson, January 2, 2003.
- AOSN System Document (In production)