AOSN II System Goals and Performance Metrics

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The 2003 AOSN II field program depends on coordinated activities between groups that (1) make state estimates and forecasts using data-assimilating models, (2) that carry out physical observations from manned and unmanned vehicles, (3) that observe the ecosystem including the biota responsible for bioluminescence, and (4) that address ways to adapt the observing array in real-time to improve forecasting and to better define physical and biological processes occurring in the Monterey Bay region.

This document addresses the 2003/04 goals and objectives of the integrated system and how we will demonstrate success in achieving them. These objectives and metrics will serve as input to the control room as they make real-time adjustment of assets during the field trial and as guidance to ONR in evaluating future objectives and plans.

A. OPERATIONAL GOAL. Develop a capability to coordinate a diverse collection of manned and unmanned observing platforms within the context of data-assimilating models to form a powerful and efficient observing system that makes ocean forecasts on a defined schedule, adapts the observational array to its own findings, is easily relocated and potentially sustainable.

Objective A1 (operations). Exercise effective operational control over a collection of models and platforms to provide data and forecasts on a regular schedule, make operating decisions in an effective and efficient fashion, and respond to a full range of environmental variability and operational contingencies.

Strategy. A central control room will be established at MBARI. They will monitor the full system and direct queries for information needed in the control process to the appropriate groups. The information in the control room will be made available to all off-site participants in near-real-time. The control room will seek guidance from all participants but will be responsible for re-allocation of resources to deal with environmental and operational contingencies.

The control room should, before the experiment, have available the constraints that asset owners place on the degree to which the mission of these assets can be managed. Operators of observational platforms have the final say on any changes of mission or operations of that asset.

Metric. The operation center will maintain a log describing how the schedules for providing data and forecasts are met, which operating decisions were made, when and why, and how unplanned problems were dealt with. Operational effectiveness will be judged qualitatively from this story of the field trial.

Objective A2 (data flow). Provide every participant access within hours to all field data and a selected set of model products. Initial field data should have undergone enough quality control that it always improves the information content (i.e. it is useful). Data quality improvements should be made to update data throughout the field program. All versions of data, and a comprehensive sampling of all model runs will be archived.

Strategy. A centralized system will collect data/products, make them available through the web, and will archive all versions of data. Originators (observing elements or modeling groups) will be primarily responsible for quality control of their own data/products. To assist in improving QC procedures, users will inform the control room of expected data/product-quality issues. The control room will solicit information and/or corrective action from data originators.

Metric. Data and its arrival times will be recorded at the central distribution site along with times and nature of questions about data quality. After the experiment, state estimates of the entire experiment can be used to measure the fraction of each observing system's data that is useful by a statistical measure of probable sampling error and modeling error.

Objective A3 (tools for operations). Anticipate the tools that are necessary for effective control and provide them. The tools must be flexible enough to be effective over the limits of foreseeable environmental variability, model performance, and failures of observational platforms or systems.

Strategy. In the initial trial emphasis will be placed on providing the control room and off-site participants with the tools to visualize enough model products, up-to-date data sets and operational data. In addition to data/product-availability needed to satisfy the Data Flow objective above, effort should be placed on identifying visualization products made available by data/product originators over the web, obtaining tools from originators to run at MBARI and to obtaining general-purpose tools that can be adapted to respond to new needs as the control room begins to operate.

Metric. Success is determined by how rapidly and effectively the Control Room Staff is able to function. They should log when unforeseen needs for new tools are identified and how long it takes to satisfy them. Control Room Staff will critique the tools after the trial.

Objective A4 (system design). Determine which observing platforms, models and management structures are efficient within the observing-prediction-analysis system.

Strategy. Because the program consists of advocates for particular components, some outside body like reviewers of a future proposal will be needed to evaluate effectiveness of different efforts in AOSN II. Program activities will focus on gathering information to serve as the basis for future decisions.

Metric 1. Each component will present a report of its successes and difficulties in field-trial report or workshop. Presentations by collective teams (i.e. modeling, control room, etc.) evaluating success in achieving stated goals will be encouraged, but cooperation in comparing components may difficult to achieve, so primary reliance should be on judgment by reviewers outside the program.

Metric 2. A proposal for a second field effort similar in scope and goal to the 2003, will be prepared in which the reasons for selecting particular components will be given. The soundness of this design in the eyes of outsider reviewers will be the primary measure of success

Objective A5 (sustainability). Determine what resources, platforms, models and operational management are needed to build a sustainable data-adaptive observing system.

Strategy. In this first field trial, the primary activity with respect to sustainability will be learning what would be needed to field a sustainable system.

Metric. Based on results from the 2003 field trial, each activity (control room, modeling, etc.) will provide an estimate of what it would take to make their component sustainable in the future. These assessments will be used to design and propose additional observing exercises in which parts may be sustained. The adequacy of the information for this system design will be the first measure of our ability to anticipate the needed for a sustainable system.

B. PREDICTION GOAL. Provide skillful daily forecasts of physical and biological variables in the Monterey Bay region up to 5 days with longer experimental outlooks.

Objective B1 (inner grid prediction). Demonstrate quantitatively accurate forecasts of Bay-scale patterns of temperature, salinity, velocity within an approximately 100 km by 100 km region between Pt. Ano Nuevo and Pt. Sur.

Metric 1. Compare predictions and observations within the region of concern. RMS misfit of T, S, $\mathbf{U}_H$, SST will be compared with expected sampling error on model's scale and with observed variability over the region of interest. Model-data pattern correlations will be compared with the sampling error in measuring it.

Metric 2. Carry out subjective retrospective comparisons of forecasts of a day with (a) subsequent now-casts for the same day and (b) trained-observer analyses of that day based on observations. The primary aim will be to develop general descriptions of the phenomena that are predictable and those that are not.

Daily forecasts must be stored at approximately 1-hour time resolution out to maximum forecast range to match observation times.

Observations should preserve spatial structure down to model resolution scales, which are O(0.5 km).

Main observations for comparison are

CODAR – $\mathbf{U}_{SURF}$.	Moorings & Vert. profiler – $\mathbf{U}$, T, S profiles
Pt. Sur surveys – T, S profiles	Gliders – T & S profiles, $\int \mathbf{U}\, dz$
AUVs – T,S at depth	NPS Aircraft & NOAA Sat – SST
P3 AXBTs – T profiles	ADCPs – post experiment $\mathbf{U}$ profiles

Objective B2 (feature forecasts). Forecast position and characteristics of discovered small-scale dynamical features like eddies, fronts, and upwelling plumes.

Metric. Compare model-data misfits of positions and characteristics with variability in model and possibly in data.

Model forecasts at 1-hour intervals should be adequate. Inclusion of color in models might increase robustness of comparison.

Main observations for comparison will be

NPS Aircraft & NOAA Sat – SST, Color	CODAR – $\mathbf{U}_{SURF}$.
Pt. Sur surveys – T, S transects	Gliders – T, S, $\int \mathbf{U}\, dz$ transects
AUVs – T,S at depth	P3 AXBTs – T stations (?)

Objective B3 (unmodeled physics). Test the ability of model-based analyses to describe the synoptic- and event-scales of the inner-grid region to determine if there are unmodeled or poorly modeled processes.

Strategy. The question of whether the ocean includes unmodeled, or inaccurately modeled, processes can ultimately be determined only through careful comparison of observations with output from models that have assimilated the best possible specification data. After the experiment, the team will try to develop a model-based state-estimate of the full experimental period (as D1 below) and compare it with individual data sets to determine if there are specific aspects of the model that are unsatisfactory and, if so, what model changes could improve them.

Metric. Participants will develop hypotheses about the causes of consistent model-data disagreements. These will be used to motivate model experiments that attempt to identify and repair inadequacies. Success will be determined by how much model changes lead to improvement of model-based state estimates.

C. ADAPTIVE SAMPLING GOAL. Use data-adaptive real-time control of observing assets to improve the utility of the observing array.

Objective C1 (control of glider groups). Show that groups of gliders can be controlled as coherent sub-arrays using hourly data from the group.

Strategy. Some potential sampling strategies depend on operating gliders as groups to measure properties (gradients, integrals) that cannot be determined by single gliders. Algorithms are needed to control such groups in the face of variability (internal waves, fronts, etc.) that will not be predicted by models. A class of control algorithms that do not depend on detailed estimates of the velocity field will be used to control glider groups.

Metric. Quantitative characteristics of the group will be defined (center of mass, dispersion, angular velocity, etc.) and the limits to which these can be controlled will be established through a series of multi-glider missions. Attempts will be made to re-configure (e.g. dilate, rotate) the group in response to observational data.

Objective C2 (glider-group adaptive sampling). Use cooperative groups of gliders, driven by their own hourly data, to efficiently locate and sample features of interest.

Strategy. An important element of a sampling network is the ability to find and describe special features in the ocean (fronts, eddies, filaments, etc.). Features may be hard to locate with preplanned arrays because of inadequate resolution. Glider groups will be tasked to find, follow and describe features identified in other data or in model outputs. They will use group measurements of gradients and other measures of spatial variation to do this.

Metric 1. The success rate in finding features not well identified by model forecasts, and the efficiency of feature search, will be used to assess adequacy of the operating strategy. Comparison will be made with plausible pre-planned strategies.

Metric 2. The description of features gained from glider groups will be subjectively contrasted with what would have been known without them to assess the utility of glider-group descriptions. Objective assessments will compare improvements of state estimates and predictions made with and without the glider-group data. Inside OSSEs, the utility of descriptions gained using controlled glider-groups will be contrasted with descriptions that could be obtained from (a) pre-planned arrays based on the same initial information and (b) groups controlled with various algorithms.

Objective C3 (adaptation to describe features). Use daily model predictions of important events and features to change the sampling array in order to improve state estimates of the field.

Strategy. Objective B3 and D1 depend on combining data into a dynamically consistent and accurate model-based state estimate of how the region evolved during the field trial. This state estimate should include important features that might vary too rapidly to be well described by a fixed sampling array. Model forecasts will be used direct assets to such features so that they can be well measured and, hence, well represented in the state estimate.

Metric. Using the observations from the “fixed” observational array as a foundation, the improvement to the utility of state estimate resulting from event-directed assets will be determined. Criteria for measuring the “utility” of state estimates will be developed.

Objective C4 (adaptation for prediction). Use the sensitivities of daily model prediction skill to adjust the observing array in order to improve prediction skill.

Strategy. Procedures for real-time identification of model sensitivities to particular data are not yet well enough tested for reliable asset allocation. The primary strategy for testing adaptation for prediction skill will be to well sample the field in 2003 and test adaptation-for-skill in the analysis phase using data-denial experiments. Because observing assets are marginal for well sampling the entire 100 km x 100 km inner model grid, focus will be in a roughly 30 km offshore by 75 km alongshore box with its northeast corner near Ano Nuevo.

Metric 1. The prediction-skill sensitivity of the HOPS and ROMS models will be compared to see if this sensitivity is robust enough to use in adapting the sampling array.

Metric 2. Based on data from a reduced data set, the improvement in prediction skill resulting by making available all data will be forecast. This will be compared with the prediction skill achieved when the withheld data are reinstated.

Objective C5 (Lagrangian Coherent Structures). Determine the utility of Lagrangian Coherent Structures (LCS) predictions in controlling gliders.

Strategy. Lagrangian coherent structures are characterizations of velocity fields that can be computed for each model forecast. It is hypothesized that knowledge of these structures can be used to improve control algorithms for gliders. Of particular interest is the use of LCS to develop efficient waypoint sequences to move gliders rapidly.

Metric. Compare transit times for gliders to reach a specific point using piecewise-straight strategies (taking currents into account) with a strategy informed by LCS.

Metric. Using all observed temperature data, compare in hindcast the use of groups of gliders as well as LCS for locating fronts with the identified "hot spots" as predicted by HOPS/ROMS.

D. INTERDISCIPLINARY DYNAMICS GOAL. Understand the dynamical processes that determine the variability of physical and biological variability in the region.

Objective D1 (state estimates). Use data-assimilating models to produce post-experiment, dynamically consistent, state estimates of physical fields that are consistent with observations. Use these fields to study the physical processes in the region.

Metric. Modeling groups will produce post-experiment state estimates for the experimental period. Data-model misfit will be compared with the sampling errors separating measurements from fields on the scales resolved by the model to judge the accuracy of the state estimate.

Objective D2 (physical-biological). Understand key physical processes of potential importance to prediction of physical and biological fields.

Strategy. The Monterey Bay area supports a number of energetic processes that must be well handled before models can predict important fields well. Examples are the onset of Pt. Ano Nuevo upwelling, the response to wind relaxation, advective exchanges between Monterey Bay and the California Current, responses to the coastal jet and small-scale wind-stress curl, property responses to mesoscale eddies and filamentation, and interaction of Canyon bathymetry with euphotic zone properties. Combinations of various data sets and model state-estimates will be examined to see if, where and why models fail to describe the observations.

Metric 1. Model descriptions of these processes will be compared with observations in an attempt to draw out descriptions of process dynamics. In the case of model-data disagreements, model sensitivity to parameterizations and uncertain forcing fields will be explored to produce hypotheses for causes of model-data disagreements.

Metric 2. Some understanding will be in the form of discoveries whose importance will be judged by the impact they have on the thinking of the physical and biological communities.

Objective D3 (plankton dynamics). Increase understanding of the physical and biological processes determining variability of planktonic populations.

Metric 1. Use maps of species abundance or secondary properties like bioluminescence and fluoresence in conjunction with advection fields from data-assimilating state estimates and analyses of Lagrangian Coherent Structures to infer rates of change following a water parcel. Evaluate system success from the coherence and degree of plausibility of the implied rates of change.

Metric 2. Compare spatial-temporal variability of populations and bio-indicators with physical processes inferred from model state estimate and from direct interpretation of observations. Evaluate system success from degree to which plausible conceptual models can explain variability.