The Cooperative Institute for Oceanographic Satellite Studies (CIOSS)
Initial Progress Report

February 11, 2004

INTRODUCTION

The Cooperative Institute for Oceanographic Satellite Studies (CIOSS) was established between NOAA and Oregon State University by a Memorandum of Agreement, signed on October 2, 2003 by OSU President Edward J. Ray and signed on December 23, 2003 by Under Secretary for Oceans and Atmosphere, U.S. Dept. of Commerce, VADM Conrad C. Lautenbacher. CIOSS was selected competitively from proposals submitted in response to a Request for Proposals posted in the Federal Register Notice (FRN, May 3, 2002, Volume 67, Number 86). Initial research collaborations are between the NOAA/NESDIS Office of Research and Applications (NESDIS/ORA) and OSU's College of Oceanic and Atmospheric Sciences (COAS). The primary purpose of CIOSS is to develop and maintain a center of excellence in satellite remote-sensing research and modeling of the ocean. To accomplish this, CIOSS combines the resources of a research-oriented university, NESDIS and other line offices of NOAA, and other Federal, State and private agencies. The research undertaken by CIOSS is relevant to understanding the Earth's oceans and atmosphere, with an emphasis on coastal regions, marine ecosystems and the living and non-living resources within these regions. This document is the **CIOSS Progress Report** for our initial activities in setting up the Institute. Before describing the work accomplished in **Year 1**, we review the goals, Research Themes and Tasks of CIOSS.

CIOSS GOALS

The "PROGRAM DESCRIPTION" section of the above Federal Register Notice specifies the general goal for the Institute: It should "explore new approaches for enhancing the use of present and future environmental satellites to meet the rapidly changing needs of the Nation's coastal and ocean regions." Presently, the "changing needs of the Nation's coastal and ocean regions" are being defined by the multi-agency efforts to create an Integrated Ocean Observing System (IOOS), with a strong presence in U.S. coastal waters. **The overarching goal of CIOSS research is to develop, improve and evaluate methods of ocean remote sensing and ocean-atmosphere modeling, building on strengths within the COAS (College of Oceanic and Atmospheric Sciences) and OSU faculty. Specific applications of CIOSS research include: 1) basic research into ocean and atmosphere dynamics; 2) contributions to ocean observing and modeling systems; and 3) evaluation of plans for future satellite systems and models. Although both coastal and open-ocean regions are included, a greater emphasis is placed on the broad-scale coastal ocean, another area of COAS strength. This cooperative institute provides an opportunity to consolidate the scientific expertise necessary for CIOSS research scientists to partner with NOAA colleagues in order to advance the Research Themes described below. Results from CIOSS projects are expected to contribute to the research thrusts of both NOAA and CIOSS.**

CIOSS ACTIVITIES AND RESEARCH THEMES

The FRN describes the three general activities expected of CIOSS. These are to:

(1) "Build an Institutional Infrastructure (Administrative Core)";
(2) "Expand Research in Satellite Ocean Remote Sensing, Satellite Data Management, and User Access Technologies (Research Component)"; and
(3) "Increase Recruitment and Outreach (Outreach Component)."

In the text below, we refer to these categories of activities as **Administration**, **Research**, and **Outreach, Education and Training**.

Administration consists of activities related to the CIOSS office and broader infrastructure, including internal and external governing boards, the relationships between CIOSS, COAS, OSU, NOAA/NESDIS/ORA and other academic, government and private institutions. Reports, proposals and ongoing communications between CIOSS and other institutions are administrative duties, as are the logistical arrangements for workshops and other CIOSS-related meetings.

Research is conducted within four **broad Research Themes and a fifth Integrated-Research Theme comprising Outreach, Education and Training**. The use of satellite data is implicit in each of these themes, as is the inclusion of evaluation and validation activities in the analyses. Collaborations between CIOSS researchers, colleagues in NOAA and other federal agencies are also included in each of these themes. For the most part, the fields of interest in CIOSS research are those in the upper-ocean and lower-atmosphere, although exceptions may occur. The geographic areas of initial interest are the broad-scale "coastal" regions of the U.S., starting with, but not limited to, the California Current System (CCS, within 500+ miles of the North American west coast). Research projects in other areas of the global ocean and atmosphere are not excluded from consideration. The Research Themes are:

- **Satellite Sensors and Techniques**: Development of satellite oceanography techniques and applications; evaluation of existing and proposed satellite sensors, algorithms, techniques and applications.
- **Ocean-Atmosphere Fields and Fluxes**: Development and evaluation of improved fields of physical parameters in the surface ocean (e.g., temperature, height, velocity, etc.), biological parameters (surface concentrations of pigments, optical properties, etc.), and surface fluxes (e.g., momentum, heat, fresh water), using remote sensing techniques.
- **Ocean-Atmosphere Models and Data-Assimilation**: Use of the satellite-derived fields to force and evaluate numerical models of the ocean and atmospheric circulation, including the use of the satellite-derived fields to "correct" ocean-atmosphere models through methods of data-assimilation, also known as inverse modeling.
- **Ocean-Atmosphere Analyses**: Dynamical analyses of data sets derived from satellites, models and/or in situ observations, in order to increase our basic understanding of the physical and biological processes in the ocean-atmosphere system, on a wide range of scales.

- **Outreach, Education and Training**: These include three broad Outreach Areas.
    - **Formal Education** includes activities designed to educate and train students (K-12, undergraduate and graduate students), researchers, resource managers and the general public in aspects of oceanography, the use of remotely-sensed data sets and numerical models, in order to learn more about the ocean. Short courses and workshops are included in this category.
    - **Informal Education** has the same goals as Formal Education, but takes place outside of the formal educational system. It may take many forms, including web-based material, presentations, forums, and exhibits at public science museums (sometimes referred to as "free-choice education").
    - **Data Access** includes activities that enhance the access of research scientists, students and educators, resource managers, and the general public to data sets derived from satellites and models, along with other information that aids in the interpretation of those data sets.

CIOSS TASKS

Cooperative and Joint Institutes typically divide their activities and projects into several "Tasks." Following the formats used in the other Cooperative Institutes, we define the following Tasks:

Task I: Provides administrative support for CIOSS, along with support for visiting scientists, limited-term postdoctoral research associates, graduate and undergraduate students and other limited-term support for collaborating research scientists; provides support for outreach activities.

Task II: Research in the CIOSS theme areas by CIOSS Fellows (university faculty and other research scientists who hold appointments in CIOSS) and those collaborating with CIOSS Fellows, whether funded by CIOSS or not.

Task III: Specific regional, national or international programs and projects that contribute to, and are in support of, the missions of NOAA, COAS and CIOSS. Examples include, but are not limited to: (a) Research regarding aspects of operational coastal and open-ocean observing systems, especially elements of those systems that include remote sensing and modeling (for example, a Pacific Northwest component of Ocean.US/IOOS or ORION; a project funded by the multi-agency initiative on Oceans and Human Health, etc.); and (b) Research that aids in the incorporation of mapping technologies (such as GIS) in the analyses of remotely sensed, modeling, and in situ coastal ocean data sets.

ACCOMPLISHMENTS DURING THE FIRST YEAR

The award Start Date is April 1, 2003. Funds for the administrative aspects of the proposal were received on 14 May 2003. Funds for the first year post-doctoral positions and the GIS work were received on 21 October 2003. The “Performance Period” for the first year post-doc and GIS research is June 1, 2003 – September 30, 2004. **Thus the overall period for the first year activities is April 1, 2003 – September 30, 2004**.

Activities funded by CIOSS during the first year fall under Tasks I and III. Research by CIOSS Fellows funded by other sources but directly related to CIOSS Research Themes fall under Task II.

Task I: Administration

The CIOSS office has been established within COAS at OSU. Dr. P. Ted Strub is the Director; Dr. Michael Freilich is the Deputy Director; and Janine Kobel is the Administrative Specialist working within this office.

Currently, there are 31 Fellows within CIOSS:
Drs. Mark Abbott, John Allen, John Barth, Eric Bayler, Andrew Bennett, Paul Chang, Dudley Chelton, Pablo Clemente-Colon, James Coakley, Gary Egbert, Steven Esbensen, Michael Freilich, Chris Goldfinger, James Good, Alexander Ignatov, Michael Kosro, Ricardo Letelier, Jon Luke, Eric Maloney, Laury Miller, Robert Miller, Michael Ondrusek, William Pichel, James Richman, Roger Samelson, Eric Skyllingstad, Yvette Spitz, Ted Strub, Peter Strutton, Michelle Wood, Dawn Wright. These include seven ORAD personnel (Bayler, Chang, Clemente-Colon, Ignatov, L. Miller, Ondrusek, and Pichel) Most of the other Fellows are presently COAS faculty members at OSU. The exceptions are Michelle Wood, who is a professor at the University of Oregon, Dawn Wright, who is in OSU Geosciences and Peter Strutton, who will join the COAS faculty within the next six months.

The Council of Fellows has been formed, consisting of Drs. Mark Abbott, Paul Chang, Dudley Chelton, Michael Freilich, Alexander Ignatov, Roger Samelson, with ex-officio (non-voting) members Ted Strub and Eric Bayler. Members may rotate on and off the Council of Fellows, as specified in the MOA. Additional members may be added by action of the Executive Board.

The Executive Board has been defined by the MOA, with Mark Abbott (Dean of COAS) as the chair.

Task I: Outreach, Education and Training

Outreach activity falls under Task I, above. Outreach activities have been initiated in the first two Outreach areas.

- Under the theme of **Formal Education**, a staff member within the SMILE program (Science and Math Investigative Learning Experience) is working with the CIOSS Administrative Specialist, CIOSS Fellows and a graduate student supervised by Dawn Wright to develop high school curriculum material, based on the CIOSS Research Themes. This material will be used in after-school “SMILE

Clubs" and in a year-end "High School Challenge," if funding continues. Twelve public school districts in Oregon are involved in this activity. In a second activity under Formal Education, a short workshop on the use of MODIS satellite data was conducted with partial CIOSS support (NASA provided the additional support).

- Under the theme of **Informal Education**, discussions are underway between CIOSS and Jon Luke at the Hatfield Marine Science Center (HMSC) and Loren Johnson at the Oregon Museum of Science and Industry (OMSI) to explore the creation of public exhibits and video presentations. These would be based on the CIOSS/COAS Research Themes. This will require additional funding from a source not-yet identified.

Task I: Research by Post-Doctoral Researchers
Two post-doctoral research scientists are presently working on CIOSS projects. Four additional post-doc searches are in progress. This activity falls under Task I, above. One post-doc is working with Ricardo Letelier on ocean optics and satellite color data. CIOSS supports 50% of this effort, which contributes to the research themes of **Satellite Sensors and Techniques** and **Ocean-Atmosphere Fields and Fluxes**. A second post-doc is working with John Allen and Roger Samelson on the interpretation of model fields from the nested coastal model, run by John Kindle at NRL (one of the CIOSS partners). This contributes to the research theme of **Ocean-Atmosphere Models and Data Assimilation**. Results from these activities are presented in more detail below in the Research Appendix.

There are four searches for post-doctoral research scientists. John Allen, Gary Egbert and Robert Miller are interviewing candidates for a post-doctoral scientist who will develop techniques to assimilate satellite altimeter and surface radar data into nested coastal circulation models. This will contribute to the research theme on **Ocean-Atmosphere Models and Data-Assimilation**. Ted Strub and Michael Kosro are interviewing candidates for a post-doctoral scientist who will develop methods to combine coastal radar data with multiple satellite altimeter data sets in order to define the mesoscale variability in surface circulation off Oregon. This contributes to research themes of **Satellite Sensors and Techniques, Ocean-Atmosphere Fields and Fluxes** and **Ocean-Atmosphere Analyses**. James Coakley is interviewing candidates for a post-doctoral scientist who will use satellite data to estimate the surface heat fluxes caused by visible and infrared radiation (the research themes of **Satellite Sensors and Techniques** and on **Ocean-Atmosphere Fields and Fluxes)**. Mike Freilich is in the initial stages of a search for a post-doctoral scientist who will explore methods of increasing the resolution of surface wind fields, derived from satellite scatterometers. This will contribute to the research themes of **Satellite Sensors and Techniques** and **Ocean-Atmosphere Fields and Fluxes.**

Task II: Related Research

Research activities related to CIOSS themes, but funded by other sources, include the following five projects: (1) Two-dimensional (vertical and horizontal slices across the coastal ocean) coupled ocean-atmosphere models. Natalie Perlin, supervised by Eric Skyllingstad and Roger Samelson, with ONR support; Research Theme of **Ocean-Atmosphere Models and Data-Assimilation**; (2) Studies of global air-sea interaction using microwave SST and scatterometer winds. Dudley Chelton and Michael Freilich, with NASA support; Research Theme of **Satellite Fields and Fluxes** and **Ocean-Atmosphere Analyses**; (3) Studies of the seasonal and interannual variability in satellite altimeter SSH, satellite-derived winds, satellite-derived SST and surface pigment concentrations. Roberto Venegas, supervised by Ted Strub, with NSF support; Research Themes of **Satellite Fields and Fluxes** and **Ocean-Atmosphere Analyses**; and (4) Nested, coastal ocean models that assimilate current meter data. Alexandre Kurapov, supervised by John Allen, Gary Egbert and Robert Miller, with ONR support; Research Themes of **Ocean-Atmosphere Models and Data-Assimilation**). Results from these activities are presented in more detail below in the Research Appendix.

Task III: GIS and Mapping

Within the GIS component of research, work is beginning on the ocean bottom mapping project (Chris Goldfinger). This contributes to the research theme on **Ocean-Atmosphere Analyses**. Work has also begun on the incorporation of satellite data into the GIS project known as the Oregon Coastal Atlas (Dawn Wright at OSU, Tanya Haddad at Oregon's Ocean-Coastal Management Program). This is an interactive map, data and metadata portal for coastal managers, scientists and the general public. Satellite data are being added to the atlas database. This activity contributes to **Outreach** in the areas of **Informal Education** and **Data Access**. Results from these activities are presented in more detail below in the Research Appendix.

HIGHLIGHTS OF CIOSS ACTIVITIES

Administration Accomplishments and Progress

- The MOA was drafted, approved by NOAA and OSU lawyers and signed by the highest officials at OSU and NOAA. The MOA defines the overall scope of the research, administration and outreach. It defines the structure of governance (Fellows, Council of Fellows, Executive Board) and the procedures used to make decisions.
- Strub (Director of CIOSS) travelled to NESDIS/ORA HQ to meet with Eric Bayler on 28 March, 2003. The extended budget for the first 5 years (the "five-year cap") was developed during this visit.
- The CIOSS office was set up within COAS; the Administrative Assistant (Janine Kobel) was hired and started work in July, 2003.
- Strub attended the ORA CI Directors' Meeting in Madison Wisconsin during 1-2 May, 2003.
- CIOSS hosted the first site visit from members of ORA/ORAD during 13-14 May, 2003.

Research

- CIOSS formed and held the first meeting (17 January, 2003) of the Council of Fellows to govern CIOSS research activity internally. The Council and the complete set of Fellows met several times during the year to discuss the developing CIOSS Research Activities.

- ORA requested that an additional research component be added, with Dawn Wright as PI and additional funding provided by ORA (27 May, 2003).
- Strub and Bayler developed the proposal for first year post-doc research projects. The final proposal was approved by NOAA on September 30, 2003.

Outreach and Education

- Staff members from the SMILE (Science and Math Investigative Learning Experiment) and NAMSS (Native Americans in Marine and Space Science) programs attended the site visit and exchanged program information and ideas with Fran Holt from NESDIS/ORA.
- During the same site visit, the ORA administrators and research scientists travelled to the Hafield Marine Science Center and became informed about further outreach opportunities and potential research collaborations.
- Discussions were initiated and continue at present with Jon Luke at HMSC and Loren Johnson at OMSI about possible public exhibits and video presentations that would highlight CIOSS/COAS research.
- CIOSS helped to host a workshop for MODIS users, providing administrative support prior to and during the workshop. The meeting was held 4-5 September, 2003.
- The first-year CIOSS outreach funds were used to support Dr. Melissa Feldberg, in the SMILE program, who is overseeing the development of high school curriculum material to be used at the 12 high schools affiliated with SMILE. Additional funding is being sought for the next two years of SMILE activities, in order to allow the materials to be used in the high school after school programs and in their year-end "High School Challenge."

RESEARCH APPENDIX:
DETAILS OF THE RESEARCH PROJECTS' ACCOMPLISHMENTS

Task I: Post-Doctoral Research Scientists

Paul Choboter – Post-Doc
Project Description – Models of the California Undercurrent

Postdoctoral Research Associate Paul Choboter has been working with John Allen and Roger Samelson to evaluate numerical models of coastal circulation. This is a necessary step before using those models to assimilate satellite and in situ data. This falls under the CIOSS theme of **Ocean-Atmosphere Models and Data-Assimilation.** Their general strategy has been to compare state-of-the-art numerical simulations with idealized analytical models. Besides testing the numerical models, the process also tests theoretical ideas. The COAS researchers have been collaborating with John Kindle of the Navy Reseach Laboratory (NRL) at the Stennis Space Center. Dr. Kindle has provided output from the Navy Coastal Ocean Model (NCOM) that NRL has been running to characterize the ocean off the west coast of the U.S. The initial process chosen for comparison is the poleward subsurface flow in the California Undercurrent (CUC). Although not designed specifically to simulate the CUC, these numerical models do contain a current resembling the CUC.

The observed poleward undercurrent over the continental slope along the west coast of the U.S. is a persistent feature that lies between the offshore core of the CCS and the surface coastal currents that are directly associated with wind-driven upwelling events over the continental shelf. It opposes the mean equatorward wind stress. Paul Choboter has identified an analog of the observed poleward undercurrent in the NRL NCOM model and has completed an analysis of the dynamics of this model undercurrent. Results indicate that the NCOM model undercurrent is geostrophic and approximately inertial (that is, the flow conserves the Bernoulli function, to first order), and suggest that it may be related to large-scale alongshore pressure gradients arising from the mean upwelling-favorable winds.

This initial examination is relevant to the modeling and satellite analyses in CIOSS for several reasons. First, poleward undercurrents are ubiquitous features of eastern boundary currents. As such, they pose a fundamental test of any model of eastern boundary currents. We cannot advance to models capable of assimilating satellite data, if the model dynamics are not validated. Present "tests" of different models often rely on patterns of surface features (SST, color and SSH) to "verify" their "realism," based on qualitative or statistical similarities between the mesoscale patterns produced by the models and the satellites. The undercurrent is a more subtle feature and thus, a more difficult test. Second, if the dynamics of poleward undercurrents depend on spatial and temporal variations in the surface wind stress and the alongshore surface pressure gradient, as our initial analyses suggest, satellite observations can be used to monitor both of these (pressure gradients represented by altimeter SSH fields, wind stress fields by scatterometers). Thus, if numerical models can reproduce the temporal variability of the undercurrent, we gain confidence in the model dynamics. The models can then be used to better characterize the dynamics and to establish the degree to which satellite observations of SSH and wind stress by altimeters and scatterometers could be used to monitor the temporal variability of the undercurrent strength (simulating the real sampling characteristics of the avaialable satellite fields). The CUC needs to be accurately represented in our model dynamics, since it plays a role in the seasonally evolving mesoscale circulation field and in the advection of plankton within the CCS.

Manuscript in preparation:

A New Solution of a Nonlinear Model of Upwelling
P. F. Choboter, R. M. Samelson, and J. S. Allen

Abstract:
A two-dimensional frictionless nonlinear model of coastal upwelling is reexamined. The model has been solved previously at steady state and as an initial-value problem. The existing solution to the initial-value problem is inconsistent with the steady-state solution, since the spinup solution develops shocks not present at steady state. A new solution to the spinup problem is presented that approaches the existing steady-state solution. The solution includes a surface equatorward jet and a poleward undercurrent with a maximum velocity near the coast.

Ocean Sciences 2004, Portland talk:

Dynamical Forcing of the California Undercurrent
Choboter, P F; Allen, J S; Samelson, R M; and Kindle, J C

Abstract:
The California Undercurrent (CUC) is a subsurface current that flows poleward off the west coast of North America even though the surface wind stress and resulting surface currents are equatorward over a significant part of the domain for much of the year. Poleward undercurrents such as this have been observed along all the major eastern oceanic boundaries of the world, which suggests that the mechanism for their generation and maintenance may be a common one. Despite this, the dynamics of these currents are not well understood. In this work, the CUC is studied by analyzing numerical simulations from the Naval Research Laboratory's primitive equation Navy Coastal Ocean Model (NCOM). NCOM is configured for the California Current System domain with 30 sigma levels in the vertical and approximately 9 km horizontal resolution, in a region extending from 30 N to 49 N latitudes and from 135 W longitude to the U.S. west coast. Boundary conditions are obtained by one-way nesting within a global version of NCOM with 1/8 degree resolution and 40 vertical levels, and surface wind forcing is obtained from the Coupled Ocean-Atmosphere Mesoscale Prediction System (COAMPS) 10 m winds at 27 km resolution for the year 2001. The model contains features of a poleward undercurrent,

although with significant spatial and temporal variability. The dynamics of the CUC in NCOM are analyzed by diagnosing dynamical balances and comparing with simplified analytical models.

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Iain MacCallum – Post-Doc

Project Description – Remote Sensing of Optical Properties

Remote sensing measurements and recovery algorithms, such as those from the MODIS ocean color products, can be validated if the optical characteristics of the water column are known. Such optical characterization can be achieved using ship borne WetLabs AC9 attenuation and absorption measurements. These measurements have been made off the Oregon coast using two WetLabs AC9s running in parallel, one of which was equipped with a 0.2 micron filter to remove particulate matter. This arrangement makes it possible to separate the contribution of particulates from the contribution of soluble matter to the attenuation and absorption spectra. This falls under the CIOSS theme of **Satellite Sensors and Techniques** and **Ocean-Atmosphere Fields and Fluxes.**

Project Progress and Status

At present, the validation and analysis of remote sensing data has not yet begun. To date, a suite of algorithms and scripts have been developed to process data collected by WetLabs AC9 absorption and attenuation meters. These scripts and algorithms collate and validate AC9 data, and then perform various temperature, salinity and scattering corrections. Additional algorithms have been developed to process AC9 data collected using a Bluefin Autonomous Underwater Vehicle (AUV), and to merge this data with the AUV's navigational logs and data from other instruments in the payload (SeaBird CTD, Microsoar scalar turbulence meter, WetLabs ECO-VSF).

Once the in situ optical data set is assembled, coincident data from the MODIS sensors on both Terra and Aqua satellites will be collated. Data from the SeaWiFS sensor will also be collated for coincident analyses of all three satellites and in situ data. Using these data sets, methods will be developed to infer in situ particle size distributions from apparent optical properties such as the diffuse attenuation coefficient, which can be estimated from satellite color sensors. Data from the SeaWiFS and MODIS satellite sensors will be compared to *in situ* measurements of particle attenuation, particle size distribution and chlorophyll content. The proposed work will attempt to (1) relate satellite estimates of the coefficients of absorption, scattering, and chlorophyll concentrations to *in situ* measurements of particle size distribution (PSD), particle attenuation and chlorophyll concentrations; (2) relate particle size distributions to very coarse characteristics of phytoplankton species composition; and (3) characterize the spatial and temporal variability of phytoplankton distributions and characteristics in the large-scale coastal ocean off northern California and Oregon during the period when satellite coverage is available. These distributions will also be related to results of the other CIOSS investigations, namely the numerical models of coastal circulation and mesoscale circulation features determined from altimeter and coastal radar fields, the available PAR and the mesoscale surface wind stress fields.

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Task III: GIS and Mapping

Chris Goldfinger – Co-PI

Project Description and Status – Seafloor Mapping

A new graduate student, Andrew Lanier, has begun work on a substantial new multibeam bathymetric dataset acquired on the R/V Thomas Thompson in 2002. These data, acquired under NOAA Ocean Exploration funding, increase the high resolution multibeam holdings on the Oregon Margin by about 50%. The new data, acquired with a Simrad EM 300 system, are co-located with a previous deep towed SeaMARC 30 sidescan survey, allowing the new student to pursue a multi platform, multi-frequency approach to the analysis of seafloor habitats. These new data will be ground truthed with cores, submersible samples, video data, and towed camera data, as well as other remotely sensed data such as seismic reflection profiles. The integrated interpretation will in turn be integrated with the Oregon-Washington Regional Seafloor Habitat Database, which was released in it's initial version in November, 2003 (Goldfinger et al, 2003). The GIS database in ArcGIS format is now available on CD from the Active Tectonics/Seafloor Mapping Laboratory. This research falls under the CIOSS theme of **Ocean-Atmosphere Analyses.**

Under this project, we have taken on a new ArcGIS programmer, Paul Jessop, who has been working since October, 2003 on creating extensions to ARC specific to generating and updating the original Oregon-Washington Regional Seafloor Habitat Database and a companion product, a Confidence Assessment layer. This layer uses Baysian techniques to quantify the uncertainties in the Habitat Database so that further modeling efforts, presently underway, can use reasonable uncertainties when modeling the interrelationships between biologic data, fishing effort, and the habitat maps. The programming extensions allow nearly automated updating of the Confidence Assessment when new data are added to the Habitat Database, and also allow much faster additions of new data to the Database itself.

Also in part under this project, the COAS GIS laboratory has been upgraded with new hardware (Freilich) and current software, with additional auxiliary software for data manipulation and visualization.

A new part-time support person is now available to both assist in hardware/software maintenance and upgrades, and act as a resource for GIS applications in the lab. In coming months, we plan to add new 3D volume visualization capability so that water column data can be visualized and manipulated together with seafloor bathymetry, backscatter and habitat data, as well as sea surface satellite data. We are presently beginning to integrate new water column hydroacoustic data acquired simultaneously with multibeam data as a test of this system.

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Dawn Wright – PI
Project Description and Status – GIS Mapping of the Coastal Ocean

The research conducted in this project falls under the CIOSS themes of **Ocean-Amosphere Analyses** and **Outreach.**

GIS Component:
We are searching for oceanographic satellite data appropriate for covering specific areas and time periods of interest and coastal management questions for the Oregon Coastal Zone, Territorial Sea and adjacent stewardship areas for incorporation into the Oregon Coastal Atlas (OCA, http://www.coastalatlas.net). Our current challenge is that we are finding data that have been collected for the understanding of mesoscale ocean processes (10's to 100's of km) while many coastal resource management issues, such as coastal hazards occur at the km to m scale. By early March we will have collected summary information regarding storage size, cost, refresh frequency and availability of oceanographic satellite data for specified areas and time periods of interest. We have started with acquisition of Landsat data, as well assea surface temperature data derived from SeaWifs and AVHRR, which can be used in conjunction with sediment transport, historic buoy wave, and climate model information that are normally used in performing hazards risk analysis. In the spring, work will commence on converting these data sets to geotiffs or GIS-style grids that the MapServer software within OCA can read, while enhancing the "Ocean Areas" section of the OCA web site by expanding its capacity to retrieve and serve these data sets to clients. The "Ocean Areas" interface will be redesigned and tested throughout the summer. By then we should also have an educational module in place targeted at Territorial Sea and ocean area managers dealing specifically with the range of specific types of oceanographic satellite data available to decision makers, These data are planned for incorporation in to the Oregon Coastal Atlas.

Outreach:
A Geosciences doctoral student, Michele Punke, was hired for fall term to work with SMILE coordinator Melissa Feldberg on the development of GIS- and remote sensing-related educational materials for use in SMILE activities (e.g, SMILE Clubs and workshop sessions for SMILE K-12 teachers). They have outlined the structure of a year-long program for students and teachers leading up to a final "challenge project" ("Mapping and Understanding Oil Spills with Satellite Data) to take place at the end of an academic year. Michele had applied for another fellowship that was much more in line with her dissertation research, the funding for which was approved in late 2003. OSU Geosciences Master's student Peter Bower was selected to replace Michele and will continue work on the project for the remainder of the grant. He is currently "crossing over" with Michele, and collecting resources and data sets that will be incorporated into the educational program and challenge project.

A Geosciences undergraduate, John Robinson (African-American), has confirmed his availability and enthusiasm for the summer internship at NOAA CSC. Judith Vergun will assist Wright in identifying two students from the NAMSS program, one to be the second summer intern going to NOAA CSC, and the second to work in Wright's lab over the summer (along with an undergraduate McNair scholar, also to be determined).

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Task II: CIOSS-Related Research at COAS
NOTE: These projects are carried out by CIOSS Fellows, but with funding that does not come through CIOSS.

Drs. Eric Skyllingstad and Roger Samelson – Co-PI's

Project Description - COAMPS Simulations of the Coastal Atmosphere-Ocean
With ONR funding, we are conducting and analyzing COAMPS mesoscale atmospheric model simulations of the response of the coastal lower atmosphere to sea surface temperature (SST) varia-tions. In FY03, we completed a collaborative study with L. Mahrt (COAS/OSU) of boundary layer development in offshore flow of warm air over cool water. In FY04-FY05, we will couple COAMPS to a coastal ocean circulation model, and use the coupled model to study the response of the coastal lower atmosphere to SST variations associated with coastal upwelling. The research will be coordinated with and supplemented by related research conducted with NSF/CoOP support and through the the recently formed NOAA-OSU Cooperative Institute for Oceanographic Satellite Studies. This research falls under the theme of **Ocean-Atmosphere Models and Data Assimilation.**

Natalie Perlin has been hired for this postdoctoral position with the ONR funding.

Project Status
CIOSS-related manuscript submissions:

Scatterometer and model wind and wind stress in the Oregon-California coastal zone.
Perlin, N., R. M. Samelson, and D. B. Chelton, Monthly Weather Review, submitted.
Abstract:
QuikSCAT/Seawinds satellite scatterometer measurements of surface wind stress are analyzed and compared with several different atmospheric model products, from an operational model and two high-resolution nested models, during two summer periods, June through September 2000 and 2001, in the coastal region west of Oregon and California. The mean summer wind stress has a southward component over the entire region in both years. Orographic intensifications of both the mean and fluctuating wind stress occur near Cape Blanco, Cape Mendocino, and Point Arena. Substantial differences between the model products are found for the mean, variable, and diurnal wind stress fields. Temporal correlations with the QuikSCAT observations are highest for the operational models, and are not improved by either nested model. The highest resolution nested model degrades the temporal correlations due to incoherent high-

frequency (0.5-2 cpd) fluctuations. The QuikSCAT data reveal surprisingly strong diurnal fluctuations that extend offshore 150 km or more with magnitudes that are a significant fraction of the mean wind stress. Wind stress curl fields from QuikSCAT and the models show local cyclonic and anticyclonic maxima associated with the orographic wind intensification around the capes. The present results are consistent with the hypothesis of a wind-driven mechanism for coastal jet separation and cold water plume and anticyclonic eddy formation in the California Current System south of Cape Blanco.

A numerical modeling study of warm offshore flow over cool water.
Skyllingstad, E., R. Samelson, L. Mahrt, and P. Barbour, Monthly Weather Review, submitted.
Abstract:
Internal boundary layer development in offshore flow of warm air over cool water is studied numerically, using a two-dimensional, high-resolution mesoscale model with a turbulent kinetic energy closure scheme, and a three-dimensional large-eddy simulation (LES) model that explicitly resolves the largest turbulent scales. The results are compared with aircraft observations of mean and turbulent fields made at Duck, NC. The decoupling of the weakly-convective boundary layer from the surface, as it is advected offshore, and the formation of an internal boundary layer over the cool water, provide a severe test of the turbulence closure schemes. Two sets of experiments are performed, the first examining the transition from a rough surface having the same temperature as the ambient lower atmosphere, to a smooth ocean surface that is 5 ^oC cooler. The second experiment introduces a 4 km strip along the coastline having surface temperature 5 ^oC warmer than the ambient atmosphere, mimicking the barrier island geography of the Duck site. In the first experiment, we find that the mesoscale model overpredicts turbulent intensity in the upper half of the boundary layer, forcing a deeper boundary layer. Both the mesoscale and LES models produce only a small change in the boundary layer shear and tend to decrease the momentum flux near the surface much more rapidly than the observations. Results from the second experiment are more in line with the observed momentum and turbulence structure, but still have a reduced momentum flux in the lower boundary layer in comparison with the observations. We find that turbulence in the LES model generated by convection over the heated land surface is stronger than in the mesoscale model, and tends to persist offshore for greater distances because of greater shear in the upper boundary layer winds. Analysis of the mesoscale turbulence closure suggests that better estimation of the turbulence mixing length could lead to improvements in the parameterized turbulence profiles.

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Dudley Chelton and Michael Freilch – Co-PI's

Project Description and Status – Ocean-Atmosphere Interaction
Scatterometer data are being used, in combination with other satellite data, to investigate a wide range of ocean-atmosphere interactions. Examples include the effects of wind-jets that are created by gaps in the mountains of Central America and changes in the surface wind stress caused by SST signals associated with equatorial Tropical Instability Waves.

The latter work has been extended to a global study of SST-induced changes in the surface wind stress, published in Science in January 2004. The abstract for that paper is included below. This work is funded by NASA and falls under the themes of **Satellite Fields and Fluxes** and **Ocean-Atmosphere Analyses**

Paper appearing in Science, January, 2004

Satellite Measurements Reveal Persistent Small-Scale Features in Ocean Winds
Dudley B. Chelton, Michael G. Schlax, Michael H. Freilich, Ralph F. Milliff

Four-year averages of 25-km resolution measurements of near-surface wind speed and direction over the global ocean from the QuikSCAT satellite radar scatterometer reveal the existence of surprisingly persistent small-scale features in the dynamically and thermodynamically important curl and divergence of the wind stress. Air-sea interaction over sea-surface temperature fronts throughout the world ocean is evident in both fields, as are the influences of islands and coastal mountains. Ocean currents such as the Gulf Stream generate distinctive patterns in the curl field. These previously unresolved features have important implications for oceanographic and air-sea interaction research.
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Ted Strub (PI) and Roberto Venegas (Graduate Student)

Project Description and Status – Statistical Analysis of Satellite Fields in the Pacific Northwest
As part of the U.S. GLOBEC NEP project, we are examining the structure of the circulation in the California Current along the Pacific Northwest, using several types of satellite data. The post-doc we are trying to hire to look at combined altimeter and coastal radar data will continue this work, at higher spatial resolutions than our present altimeter analyses. So our present work lays the foundation for the work that will be done under CIOSS. This research falls under **Satellite Fields and Fluxes** and **Ocean-Atmosphere Analyses).**

The abstract for the presentation at the upcoming GLOBEC Science Investigators meeting is below.

Interannual and seasonal variability of satellite-derived chlorophyll pigment, sea surface height, temperature and wind stress in the northern California Current System. R.M. Venegas, P.T. Strub, E. Beier

The monthly seasonal climatology and interannual variability are examined in satellite-derived fields of surface chlorophyll pigment (CHL) concentration, sea surface height (SSH), sea surface temperature (SST) and wind-stress (TAU) in the northern California Current System between 1997 and 2003. The CHL concentrations in the study area show highest values (more than 5 mg/m**3) next to the coast, especially north of the Columbia River, decreasing in the offshore direction. We note that some of the apparently high

chlorophyll concentrations may be due to other dissolved substances in the discharge from the Columbia River and the estuaries north of it, which are not be distinguished from cholorophyll pigments by the global SeaWiFS algorithms used to process this data.

The long-term mean dynamic topography comes from the Levitus hydrographic climatology and decreases next to the coast south of the Columbia River, especially south of Cape Blanco. This pattern is roughly consistent with the temporal mean of the scatterometer wind stress field, which is downwelling-favorable north of the Columbia River and upwelling favorable in the south, strongest south of Cape Blanco. This split between climatological upwelling and downwelling is farther north than previous climatologies suggest, but may be affected by the particular 4-year period of scatterometer winds. SST values are also coldest next to the coast south of the Columbia River; the width of the cold coastal band increases as one moves farther south. North of the Columbia River, there is a narrow band of colder water next to the coast, but also a general meridional cooling trend as one moves to the north, caused by the latitudinal gradient in surface heating.

Harmonic analyses define the monthly seasonal patterns. From approximately March through October, SSH and SST decrease and CHL concentrations increase next to the coast south of 44.5ºN. The regions around Heceta Bank (44.0º - 44.5ºN) and around Cape Blanco are particularly prominent in summer (see July-August). The Heceta Bank region is higher in CHL concentrations from February through November. In individual images (not shown), filaments of high CHL concentrations extend more than 200km offshore, occurring more often offshore of the Columbia River, Heceta Bank and in the area surrounding Cape Blanco. Downwelling-favorable winds during October through February, create a band of high SSH next to the coast, resulting in the poleward "Davidson Current" during winter. During this period, fields of SST and CHL concentrations become more homogeneous, but CHL concentrations are still higher in a narrow band next to the coast. It is during this time that the Columbia River plume flows northward, allowing dissolved colored material in the plume to produce the appearance of high CHL concentrations in a narrow band next to the coast. This winter signal combines with the summer CHL concentrations to produce the pattern seen in the temporal mean.

Removing the harmonic seasonal cycles leaves the interannual variability, as summarized by the first 3 EOF's. El Niño conditions (1997-1998, low CHL concentrations, high SSH and SST) and La Niña conditions (1998-1999, high CHL concentrations, low SSH and SST) are observed in the first (and somethimes second) modes of the EOF's. Maximum anomalies in CHL concentrations occurs at inshore locations north of the Columbia River during much of 1998-2000 and at inshore locations south of the Columbia Riven during spring and early summer of 2001-2003 (second EOF). Higher levels of CHL concentrations occurred along most of Pacific Northwest during 2002 (first and third mode), attributed to an intrusion of subarctic water.
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Alexandre L. Kurapov, J. S. Allen and G. D. Egbert – Co-PI's

Project Description and Status:
Using data collected during recent field programs off the Oregon coast, nested coastal ocean circulation models are being used to assimilate various types of in situ data, in order to determine the quantitative impact of the assimilation. This research falls under the theme of **Ocean-Atmosphere Models and Data-Assimilation**. A manuscript has been submitted and another is undergoing internal review before submission.

Paper submitted to JGR-Oceans:
Distant effect of assimilation of moored ADP currents into a model of coastal wind-driven circulation off Oregon.
Alexandre L. Kurapov, J. S. Allen, G. D. Egbert, R. N. Miller, P. M. Kosro, M. Levine, and T. Boyd.
Abstract
An optimal interpolation (OI) sequential algorithm is implemented for a three-dimensional primitive equation model to assimilate current measurements from acoustic Doppler profilers (ADPs) moored on the Oregon shelf as a part of the Coastal Ocean Advances in Shelf Transport (COAST) upwelling experiment (May-August 2001). A stationary estimate of the forecast error covariance required by the OI is computed based on the error covariance in the model solution not constrained by data assimilation. Lagged model error covariances are used to account for the effect of previously assimilated data. The forecast error covariance has a shorter alongshore spatial scale than the model error covariance unconstrained by the data, as an effect of propagating dynamical modes. Assimilation of currents from one or two of the moorings located on the path of the upwelling jet helps to improve the model-data rms error and correlation at the mooring sites located at an alongshore distance of 90~km, south or north from the assimilation sites. The coastal jet is deflected offshore over Heceta Bank and assimilation of data from an inner-shelf mooring in the jet separation zone does not help to improve prediction in the far field. Larger improvements are obtained for the first part of the study period (yeardays 146-190). In the second part (days 190-237), the geometry of our limited area model possibly limits prediction accuracy. In numerical experiments involving assimilation of data from only one mooring, the actual and expected rms error improvements are compared providing a consistency test for the forecast error covariance.