# FIVE YEAR COOPERATIVE AGREEMENT

BETWEEN

OREGON STATE UNIVERSITY
COOPERATIVE INSTITUTE FOR OCEANOGRAPHIC SATELLITE STUDIES (CIOSS)

AND

THE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
(NOAA)

PERIOD OF PERFORMANCE

APRIL 1, 2008 – MARCH 31, 2013

COOPERATIVE AGREEMENT BUDGET

TOTAL CAP BUDGET $ 25,338,688

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# Cooperative Institute for Oceanographic Satellite Studies

# Five-Year Cooperative Agreement 2008-2013

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# April 1, 2008 – March 31, 2013

## Executive Summary

The Cooperative Institute for Oceanographic Satellite Studies (CIOSS) was established at Oregon State University (OSU) in 2003, creating a cooperative (Federal/Academic) center of excellence for research involving satellite remote sensing of the ocean and the air-sea interface. The primary collaborations are between research scientists in the NOAA/NESDIS Center for Satellite Applications and Research (STAR) and the OSU College of Oceanic and Atmospheric Sciences (COAS), although any collaborations between OSU and STAR personnel are covered by the Memorandum of Agreement.

After an extensive external review in October, 2006, CIOSS received the highest rating (Outstanding) and a recommendation for a second five-year period of funding. Conditions stated in the original Federal Register Notice and in the existing Memorandum of Agreement will continue. However, a new Five-Year Cooperative Agreement is needed. The present document constitutes the new Cooperative Agreement and presents a "Cap" Budget (not to be exceeded), along with a detailed 5-year Task I budget, requested as a multi-year grant.

The CIOSS mission is to enhance and improve the use of satellite remote sensing for oceanographic research, operational applications and education/outreach. CIOSS research projects address improvements in satellite sensors and the algorithms used to produce fields of geophysical variables, improvements in models that use the satellite fields, and analyses of combinations of satellite, model and *in situ* data sets. CIOSS outreach includes scientific outreach to members of the research community, and both formal and informal education. By accomplishing its goals, CIOSS helps NOAA to fulfill its leadership role for remote sensing and modeling in the future Integrated Ocean Observing System (IOOS), working closely with the NOAA CoastWatch program and IOOS Regional Associations to integrate remote sensing products into the overall observational system.

CIOSS research includes the primary variables measured in oceanographic remote sensing: SST (surface temperature), SSH (surface height), OVW (ocean vector winds), surface chlorophyll concentration (Chl) and other optical variables. One CIOSS focus is on global scales, working to create and analyze satellite-derived Climate Data Records to assess and detect climate variability and change. In the coastal ocean, CIOSS works to improve the quality and spatial resolution of satellite-derived fields, bringing the coverage closer to the coast. Because satellite sensors only detect the ocean' surface properties, the inclusion of *in situ* data is vital to understand oceanic processes. Models that assimilate these data provide a 3-D picture of the physical and biological fields and also help to fill gaps caused by clouds and the loss of satellite data next to the coast.

CIOSS research also addresses the design and evaluation of future sensors for OVW, SSH and ocean color. CIOSS scientists lead the Coastal Ocean Applications and Science Team (COAST), in which national experts in phytoplankton ecology, ocean color and optics help to design future bio-optical sensors and collect hyperspectral data sets in U.S. coastal regions. The initial COAST field work was conducted in Monterey Bay during September 2006. These data can be used to develop algorithms in coastal environments for all future color sensors. Similar field programs, planned for the East and Gulf Coasts, are presently on hold, due to the demanifestation of the HES-CW sensor on GOES-R. For OVW, individual research projects and workshops are

evaluating the capabilities of satellite wind sensors for both research and operational uses. CIOSS Fellows are also participating in the evaluation of new, high-resolution SSH sensors.

CIOSS workshops and short courses constitute outreach to the scientific community. Past examples include workshops and training for NWS forecasters in the use of scatterometer OVW fields; workshops to help NOAA design future color sensors; a short course in the use of satellite data for NOAA (NMFS and NOS) research scientists; and a workshop on data assimilation for coastal ocean models. A future workshop will examine methods of using altimeter data in coastal regions. CIOSS is involved in formal education through the Science and Math Interactive Learning Experiences (SMILE) high school program, which introduces high school students to oceanographic applications of remote sensing. Formal education also includes CIOSS support of undergraduate students in the COAS REU (Research Experiences for Undergraduates) program. CIOSS is engaged in informal education of the public through the development of interactive displays for science museums that highlight research in remote sensing of the ocean. The initial CIOSS project in informal education is a display on satellite remote sensing for the Public Wing of the Hatfield Marine Science Center (HMSC) in Newport, OR.

During its second five-year period, CIOSS plans to continue the administrative structure, research and outreach themes and activities that have been successfully developed in the first five years. The research and outreach directions and activities described above will continue into the beginning of the second five-year period. However, just as the program has evolved during the first five years, we expect this evolution to continue during the second five years.

Several factors will guide the evolution of the research program. Risk Reduction for GOES-R HES-CW has been terminated, eliminating the source for COAST funding. GLOBEC program funding is also ending and support from Research and Operations projects is uncertain. Thus, CIOSS is effectively starting over with its Core funding ($500K per year) as the only stable source of support. At the same time, however, the VIIRS sensor on POES will provide new color measurements that need algorithm development and cal/val activities. NOAA is also expected to take the lead on the new high-resolution scatterometer, while NASA takes the lead on a high-resolution altimeter. All of these instruments need “Risk Reduction” activities, providing opportunities for CIOSS proposals to NOAA and NASA. In a synergistic development, COAS has been awarded a grant from the NSF ORION (OOI) program to develop an array of coastal moorings off Newport, Oregon, and another off Washington. It is expected that the NOAA IOOS program will supplement these moorings with additional instruments or moorings. Thus, the infrastructure will exist to enhance CIOSS’ ability to propose cal/val and basic science activities in coastal waters, using the combination of enhanced in situ data, present and future satellite sensors and models. The experience gained during CIOSS’ first five years and the collaborations formed between CIOSS and NOAA will also increase the number of research opportunities and CIOSS’ ability to submit successful proposals that take advantage of those opportunities. Activities begun during the first five years in seeking funding beyond NESDIS (NOS, JCSDA, etc.) will continue and lead to a broader base of support. Thus, we anticipate vigorous growth in the CIOSS research program during the second five-year period.

We also expect an increase in Outreach and Education Activities. These include continued support for the SMILE program and proposals to extend the SMILE experience to the NOAA Office of Education; a continuation of support for REU students; and increased activity in helping to develop public displays for HMSC and other “science museums.” Short courses and workshops will also continue, as needed by various NOAA programs.

# I. BACKGROUND

## A. Introduction – CIOSS Establishment and Renewal

The Cooperative Institute for Oceanographic Satellite Studies (CIOSS) was established between the National Oceanic and Atmospheric Administration (NOAA) and Oregon State University (OSU) by a Memorandum of Agreement (MOA), signed on October 2, 2003 by OSU President Edward J. Ray on December 23, 2003 by Under Secretary for Oceans and Atmosphere, U.S. Department 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 OSU's College of Oceanic and Atmospheric Sciences (COAS, http://coas.oregonstate.edu/) and the Center for Satellite Applications and Research (STAR, http://www.orbit.nesdis.noaa.gov/star/ ), formerly the Office of Research and Applications (ORA), within NOAA's National Environmental Satellite, Data, and Information Service (NESDIS, http://www.nesdis.noaa.gov/). The creation of CIOSS recognizes the "mutual, evolving and long-term interest in cooperative research projects and operational programs" involving oceanographic issues, shared by OSU/COAS and NOAA. Further information about CIOSS, including the MOA, initial Five-Year Plan, annual and other reports can be found on its web site at http://cioss.coas.oregonstate.edu/. Information about OSU can be found at http://oregonstate.edu.

Following NOAA CI policy, as stated in the NOAA CI Policy Interim Handbook, CIOSS was thoroughly reviewed by External Review Teams (for Science Review and Administrative Review) during 17-19, October 2006. Both External Review Teams gave CIOSS an "Outstanding" evaluation and recommended its renewal for the "full term" (five additional years). The second five-year period covers April 1, 2008 – March 31, 2013. The review Briefing Book material can be found at http://cioss.coas.oregonstate.edu/CIOSS/review.html. Sections 1-3 and the first 7 pages of Section 4 (46 pages in all) provide a good overview of CIOSS during its first 4 years. The final reports of the Science and Administrative Review Panels can be found at the same URL under "Final Review Panel Reports."

The present document is the Five-Year Cooperative Agreement covering the second five-year period. Given the positive review, plans for next five years call for no radical changes from the present CIOSS structure, goals, or Research and Outreach Themes. The definitions of Tasks II and III are slightly changed to better match the present CI policy. Individual research and outreach projects will also continue to follow lines similar to those in recent years, with some modifications that constitute CIOSS' continued evolution, in response to NOAA opportunities and priorities, as well as to developments in other aspects of COAS research projects and staff. Thus, the first part of this new Five-Year Cooperative Agreement summarizes the present status of CIOSS but also indicates the directions expected for future administration, research and outreach activities.

## B. CIOSS Vision and Mission Statements

**Vision Statement:** CIOSS is a cooperative (federal-academic) center of excellence for research and education, which involves satellite remote sensing of the ocean and its air-sea interface, along with models of the ocean and overlying atmosphere. CIOSS provides a mechanism to bring together the resources of a research-oriented university (OSU), NESDIS and other NOAA line offices, with additional partners at other universities, government and

private agencies. With these partners, CIOSS conducts research of mutual interest to CIOSS/COAS and NOAA. This research helps NOAA to accomplish its Mission Goals and helps NESDIS to fulfill its role in providing the remote sensing component of the "national backbone" for the Integrated Ocean Observing System (IOOS), which includes operational and research components within NOAA. CIOSS also contributes to remote sensing aspects of NSF's ORION (Ocean Research Interactive Observatory Networks) program and performs research relevant to the earth-observing component of NASA and the ocean-modeling component of ONR.

CIOSS contributes to the development of ocean observing and modeling systems, along with public understanding of those systems, through:

- Research that helps to develop and improve our understanding of, and operational products related to, the upper ocean and air-sea interface. It does this by using data from present and past satellites and by helping to plan future satellite sensors;
- Research that helps to incorporate and assimilate those products and understanding into ocean and atmosphere circulation models; and
- Education and training in the same topics, reaching a wide range of "audiences" in formal education (K-16 education, graduate school, ongoing professional training) and informal education (public outreach).

CIOSS Research Themes are described below in Section II. It will be seen that research described under the first bullet of the Vision Statement (above) is represented by CIOSS Themes 1, 2 and 4 (sensors, fields and data analysis). Research described under the second bullet is represented by CIOSS Theme 3 (modeling and data assimilation), and activities under the third bullet are represented by CIOSS Theme 5, outreach and education.

**CIOSS Mission, Goals and Objectives:** The CIOSS mission is to enhance and improve the use of satellite remote sensing for oceanographic research, operational applications and education/outreach. To do this, CIOSS has the following broad goals and objectives:

- To foster and provide a focus for research related to NOAA's mission responsibilities and strategic objectives in the coastal and open ocean, emphasizing those aspects of oceanography and air-sea interaction that utilize satellite data, along with models of oceanic and atmospheric circulation;
- To collaborate with NOAA research scientists in using satellite ocean remote sensing through: basic research; evaluation, validation, and improvement of data products from existing and planned instruments; development of new multi-sensor products, models, and assimilation techniques; and investigation and creation of new approaches for satellite data production, distribution, and management;
- To improve the effectiveness of graduate-level education and expand the scientific training and research experiences available to graduate students, postdoctoral fellows and scientists from NOAA and other governmental laboratories and facilities; and
- To educate and train research scientists, students, policy makers and the public to use, and appreciate the use of, satellite data in research that improves our understanding of the ocean and overlying atmosphere.

### C. Using CIOSS Strengths; Focus on Ocean Margins and Climate

CIOSS has been established within COAS at OSU to make use of the extensive and broad-ranging expertise of COAS faculty in satellite remote sensing, in situ data collection, data analysis, modeling and data assimilation. CIOSS supports research that enhances the ability of NOAA/NESDIS to accomplish its mission, while also training scientists in the use of remotely sensed data. Leveraging specific COAS strengths, a major focus is on the large-scale continental margins of the U.S., with applications to other ocean margins of the world. The general focus on continental margins is aligned with the present national priority to create an Integrated Ocean Observing System (IOOS) for the "coastal" ocean, interpreting the word "coastal" in a broad sense. Within that focus, a region that serves CIOSS as a "test bed" for satellite technique development, modeling and data analysis is the California Current, along the U.S. west coast. This is a region where many CIOSS Fellows collaborate in multi-institutional field programs and in the establishment of long-term observational networks, providing a wealth of field data with which to test remote sensing and modeling methods and to validate products. The NSF ORION (Ocean Research Interactive Observatory Networks) program will also locate its "endurance array" off Oregon and Washington, providing even more synergistic observational data sets with which to supplement and compare satellite fields.

CIOSS also has an interest in research and data sets that address the larger (global) scales of climate variability and change. Most available satellite-derived data sets are now available over periods long enough (10+ years) to analyze and quantify interannual variability. The longest data sets (SST, 20+ years; SSH, 15 years) can begin to look at decadal changes and long-term trends (as demonstrated by SSH estimates of global sea level rise). CIOSS will continue its activities in helping to create consistent long-term satellite data sets (Climate Data Records, CDR's), which offer the best hope to characterize changes in global ocean surface characteristics.

## II. CIOSS RESEARCH AND OUTREACH THEMES

The following five themes are of mutual interest to NOAA and OSU.

- **Theme 1: Satellite Sensors and Techniques**: Evaluation of existing and proposed satellite sensors, algorithms, and measurement techniques.

- **Theme 2: Ocean-Atmosphere Fields and Fluxes**: Development, evaluation and analysis of improved fields of physical and biological parameters in the upper ocean, and of surface parameters and fluxes at the air-sea interface, using combinations of remote sensing, in situ data and modeling.

- **Theme 3: Ocean-Atmosphere Models and Data Assimilation**: Use of satellite-derived fields to force and evaluate numerical models of the oceanic and atmospheric circulation, including the assimilation of those fields into models using methods of inverse modeling. For some applications, the ocean models include components of marine ecosystems.

- **Theme 4: Ocean-Atmosphere Analyses**: Dynamical and statistical analyses of data sets derived from satellites, models and in situ instruments, in order to increase our

understanding of the physical, chemical, biological, geological and societal processes that affect and are affected by the ocean-atmosphere system.

- **Theme 5: Outreach**: We include three broad Outreach areas, each to be related to CIOSS research and its results.

    - **Formal Education** of students (K-12, undergraduate and graduate students), other scientists, resource managers and the general public in aspects of oceanography, surface meteorology and the use of remotely sensed data sets and numerical models. Short courses and training workshops are included in this category, as are workshops designed to develop or evaluate present and planned sensors and techniques.

    - **Informal Education** of the same groups in the same subjects, but in contexts outside of the formal educational system, short courses and workshops. This may take the form of web-based material, presentations, forums, and exhibits at public science museums.

    - **Data Access** includes activities that enhance the use of data sets derived from satellites and models by research scientists, students, educators, resource managers and the general public.

## III. CIOSS TASK STRUCTURE

For budgetary and administrative purposes, CIOSS uses a simple structure to partition activities into three "tasks," as do most of the NOAA CIs. Task I involves NOAA/NESDIS's basic support for the administration and general operations of CIOSS, including outreach, using core funding. Tasks II and III consist of research and additional outreach projects, differentiated by the degree of collaboration with NOAA personnel.

**Task I: CIOSS Core Office Administration and Outreach**
Provides general administrative support for CIOSS research and core outreach activities (all Themes). Task I includes but is not limited to the following activities:

- **a.** General operation of CIOSS, including providing salaries for the Administrative Program Specialist, Director, Deputy Director and other administrative staff members;
- **b.** Necessary funding for domestic and international travel for the Director and other CIOSS staff, Fellows and participants in CIOSS workshops;
- **c.** Publication of the annual and other reports, newsletters, articles, brochures, etc.;
- **d.** Outreach activities supported by the annual core funding from STAR/SOCD, primarily the organization of workshops and short courses, sponsored or hosted by CIOSS. CIOSS may also help to organize workshops sponsored by other agencies, on topics included in the CIOSS Research Themes.

**Task II: CIOSS Research and Additional Outreach, in Close Collaboration with NOAA Personnel**
Provides support for research projects consistent with CIOSS' Research and Outreach Themes, if the projects involve substantial collaborations with NOAA colleagues; these

include support for outreach beyond that covered in Task I, when NOAA personnel are involved. Details of these projects are developed in each proposal, as specific opportunities are identified.

**Task III: CIOSS Research and Additional Outreach, with Minimal Collaborations with NOAA Personnel**
Provides support for research projects in CIOSS' Research and Outreach Themes, similar to those in Task II, in which collaboration with and participation by NOAA personnel are not substantial. Details of these projects are also developed in each proposal, as specific opportunities are identified.

# IV. PERFORMANCE MEASURES

The performance measures for CIOSS as an administrative unit include: the timely preparation of annual reports, omnibus and other proposals; the efficient coordination of workshops sponsored by CIOSS and affiliated organizations, along with reports resulting from those workshops; organization of meetings of CIOSS Fellows and their colleagues; organization of meetings of advisory boards; preparations for formal and informal reviews of CIOSS by NOAA and outside agencies, as needed.

Research performance is primarily measured by the quality and quantity of publications resulting from research projects in the CIOSS Research Themes, and through presentations of results at professional meetings. The presentations and publications may be authored by CIOSS Fellows alone or jointly with their collaborators and students. These are the standard research performance measures used by Federal agencies that fund research.

Performance measures for outreach consist of demonstrated success in carrying out: programs that provide training for students in K-20, resource managers and the public; activities that support informal education; planning and execution of workshops, including those that evaluate present and future satellite systems; and activities that develop or improve technologies that provide access to data for research scientists, managers and the public.

## *Descriptions of Administration, Research and Outreach*

No major changes are planned for the structure and activities of CIOSS Administration, Research or Outreach during the second five-year period. Thus, the descriptions of the activities and projects for each of these components during the first five-year period are summarized below, followed by a discussion of how these might evolve from their present state over the next five years.

# V. CIOSS ADMINISTRATION

## A. General Administration Activities

CIOSS administration consists of activities related to the CIOSS office and broader infrastructure, internal and external governing boards, and the relationships between CIOSS, COAS, OSU, NOAA/NESDIS/STAR, other NOAA components, 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, short courses and other CIOSS-related meetings.

## B. Relation of CIOSS to COAS

CIOSS is physically and administratively housed within COAS at OSU. COAS was recently ranked sixth in the amount of research funding distributed by the Oceans Division of the National Science Foundation from 2002-2005.

Over 92 percent of COAS' annual expenditures derive from competitive Federal grants and contracts; the College brings in more than 30 percent of the total OSU annual grant funding. Given its dependence on Federal funding, the College has developed strong accounting and grant support services (independent of the main University system) to administer the COAS budget (~$26M per year). While CIOSS has its own operating budget and controls its own expenditures and operations, the COAS business office resources are provided to CIOSS as a voluntary contribution. The COAS office handles all travel accounting, bookkeeping, and grant and personnel management. COAS benefits from the COAS administrative and computational resources. COAS fosters multi-disciplinary interactions by minimizing organizational barriers (e.g., COAS does not have traditional discipline-based departmental structures).

## C. CIOSS Organizational Structure

A simplified picture of the CIOSS organizational structure is presented below in Figure 1, in which the blue-shaded boxes represent elements of CIOSS and the white boxes represent the organizations and people with whom CIOSS interacts most closely. Not shown are the organizational structures for NOAA and its components – Ingrid Guch and Kent Hughes are located in STAR (http://www.orbit.nesdis.noaa.gov/star/star_orgchart.php ), which is directed by Al Powell; STAR is part of NESDIS, a NOAA line office led by Mary Kicza (http://www.nesdis.noaa.gov/About/nesdis_org.html); VADM Conrad Lautenbacher is the overall Administrator of NOAA (http://www.pco.noaa.gov/org/NOAA_Organization.htm). The figure also does not show the larger structure within OSU – the Director of CIOSS is appointed by the Dean of COAS (Mark Abbott, http://coas.oregonstate.edu/), who is, in turn, appointed by the President of OSU (Edward Ray, http://oregonstate.edu). The CIOSS MoA is signed by VADM Lautenbacher and OSU President Ray, demonstrating that it encompasses collaborations between personnel within NOAA and OSU at all levels.

## D. CIOSS Staff

To minimize administrative costs, CIOSS presently has only two administrative positions: the Director (Ted Strub) and Administrative Specialist (Amy Vandehey). The Director interacts with the program managers within NESDIS/STAR, primarily the Cooperative Research Program (CoRP) Chief (Ingrid Guch), the Satellite Oceanography and Climate Division (SOCD) Chief (Kent Hughes, Acting) and the Director of STAR (Al Powell). The Administrative Specialist interacts with the CoRP Chief and the STAR Program Support

Specialist for grants (Patty Mayo). Within COAS, the CIOSS Director and Administrative Specialist interact with a COAS Grants Accountant (Linn Bright), who has been assigned to help CIOSS interact with the OSU Office of Sponsored Research. A third administrative position, Deputy Director, was originally proposed and nominally occupied by Dr. Michael Freilich during CIOSS' first 3 years. Dr. Freilich's duties as Associate Dean of COAS, however, left little time for CIOSS activities and he took no salary as CIOSS Deputy Director. Since Dr. Freilich's move to NASA, this position has been vacant.

The Director of the Institute is responsible for overall leadership, coordination, planning and priority setting. This includes development of mechanisms to facilitate cooperative research between Fellows of CIOSS, NOAA, and other institutions. The Director is responsible for submitting an annual report and omnibus proposal for the next year (including administration, research and outreach). The Director is also responsible for seeking additional opportunities for funding and proposals by Fellows and their colleagues, for encouraging and facilitating such proposals, and for coordinating such proposals within the overall CIOSS program. These proposals include outreach, as well as research. Other duties are described in the MOA. The Administrative Program Specialist provides logistical support for operation of the office, oversees personnel matters, conducts budget reviews and projections, prepares reports and proposals, and provides logistical support for workshops and short courses.

CIOSS Organizational Chart

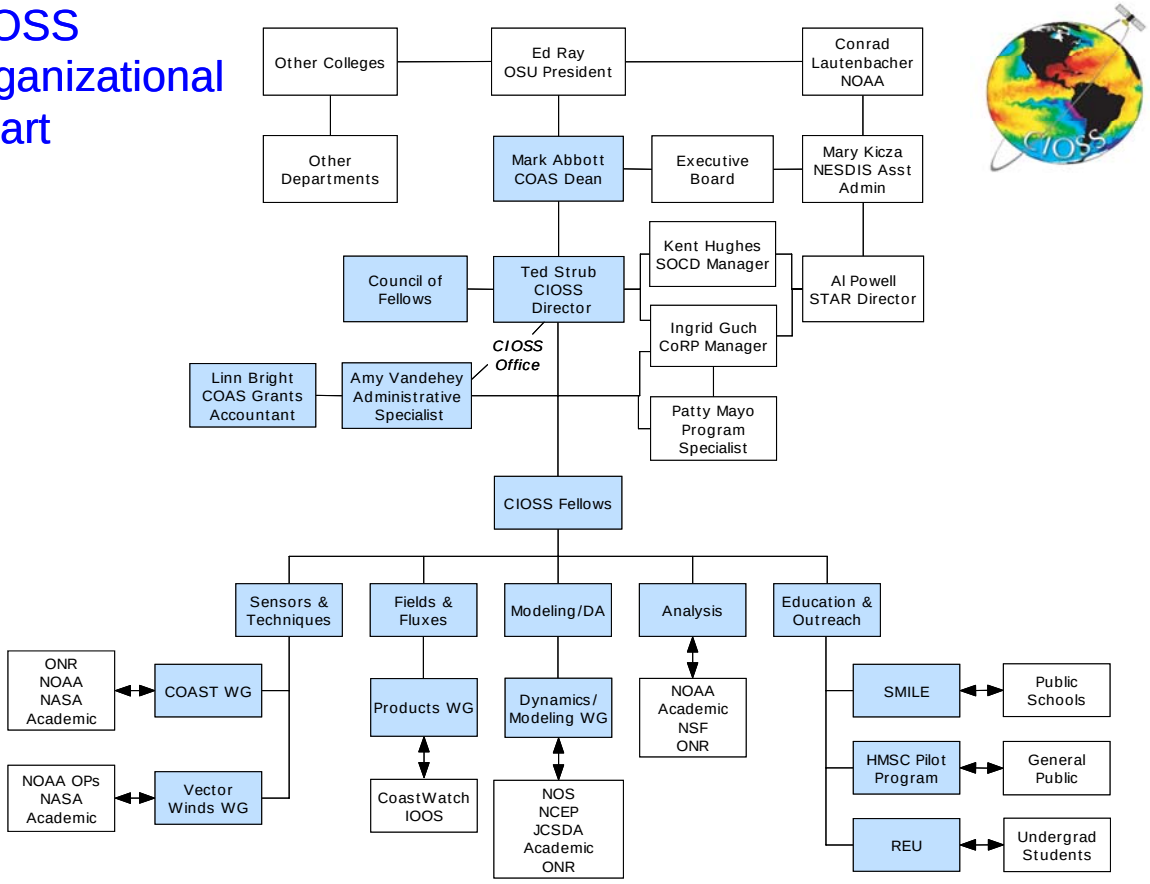


**Figure 1. CIOSS Organizational Structure. Elements of CIOSS and COAS are in blue. Elements in white are those with which CIOSS interacts most closely. CIOSS is housed within the College of Oceanic and Atmospheric Sciences at OSU, whose complete structures are not shown.**

## E. CIOSS Fellows, Council of Fellows and Executive Board

There are presently (September, 2007) 32 CIOSS Fellows: twenty-two at OSU, one at the University of Oregon, one at the NOAA CoastWatch West Coast Node in Pacific Grove, CA, and eight at NOAA/STAR/SOCD. A Council of Fellows (with COAS and SOCD members) advises the Director when issues arise. Most of the interactions between the Director and Council members are carried out through individual discussions (in person, over the telephone) and e-mails, with periodic in-person and teleconference meetings. An external Executive Board also advises both NOAA and CIOSS administrators. The duties and appointment procedures for the Fellows, Council of Fellows and Executive Board are described in more detail in the MOA, which can be found on the CIOSS web page (http://cioss.coas.oregonstate.edu/CIOSS/archive.html ) under "Reports and Publications / Archived Reports." Present membership lists are found on the CIOSS web site, under "Personnel" (top bar) (http://cioss.coas.oregonstate.edu/CIOSS/ ).

## F. Proposal and Reporting Procedures

The procedure by which internal proposals are solicited and chosen by CIOSS (for support by the annual core funding) is described in detail in the "Year 4 Annual Progress Report", pages 8-9; this is found under "Archived Reports" at the URL given above. Briefly, the STAR/SOCD program managers provide some guidance as to their priorities and the Council of Fellows issues an annual call for internal proposals. These become part of the "Annual Omnibus Proposal." The Council of Fellows acts as the Review Panel, evaluating and selecting proposed projects, with suggested modifications. After any revisions needed to address review comments, the proposal is sent to the STAR Program Specialist, who makes any final modifications needed and submits the proposal to the NOAA Grants Management Division (GMD). Other proposals may be written in response to announcements in the Federal Register or internal NOAA announcements of research opportunities. These are also sent to the STAR Program Managers for comments and to the Program Specialist, who submits them to the GMD.

When funding is approved by GMD and released to OSU, it is handled by personnel in the OSU Business Affairs Office, in the Office of Post-Award Administration (OPAA), who interact with the COAS Grants Accountant (Linn Bright). PI's receive quarterly (or monthly, if requested) budget summaries from the COAS Grants Accountant. OPAA personnel assure compliance with all regulations and submit *Semi-Annual Financial Reports* to NOAA for all NOAA grants at OSU, including CIOSS. The PI's submit annual technical Progress Reports to CIOSS for each project, which become part of the CIOSS *Annual Technical Progress Report.* This document is submitted to NOAA within 90 days after the CIOSS anniversary date (April 1).

## G. Future Administration Plans

Although no major changes are planned, the organization chart has been modified to show the elimination of the Deputy Director position for the present. This represents our recognition that neither we nor NOAA have found a way to support this position at more than a nominal level. In lieu of this position, the Director will request 5 months of salary from NOAA and 1 month of salary from COAS, reflecting a more realistic level of support to match time spent on CIOSS administration. During the second five-year period, however, we will be looking for an opportunity to find an eventual successor to the Director's position. If a candidate can be identified, that person will become Deputy Director. When the time is appropriate, the Deputy Director and present Director will trade jobs.

Another slight change is that the REU program, which has been funded out of the Administration support (Task I), will move to Task II, along with the SMILE program.

Figure 2 (in the next section) shows a break-down of CIOSS' annual budgets for the first five years and an estimate for the next five years. The bottom color (purple or dark blue) represents the Administration budget, which continues to grow through inflation during the second five-year period. The second segment from the bottom (violet) represents the Core Outreach and Education budget. This expands to include the REU program in Year 4, although the REU program was technically funded through Administration during years 4 and 5. The third segment (light blue) represents Core Research, funded by the part of the Core funding ($500K) that is not taken up by Administration and Core Outreach and Education. Funding for Core Research shrinks in the second five-year period, as Administrative costs increase.

# VI. CIOSS RESEARCH

## A. The Overarching Research Goal

The overarching goal of CIOSS research is to develop, evaluate, improve and use satellite ocean remote sensing data and methods, in order to increase our understanding of the ocean and lower atmosphere. This goal encompasses the mutual research interests of OSU/COAS/CIOSS, NOAA/NESDIS and other NOAA line offices in: 1) Basic research in oceanic, coastal and air-sea dynamics, using satellite ocean remote sensing data and methods, along with in situ data and model output fields; 2) Contributions to ocean observing through the evaluation of present and planned satellite systems; 3) Contributions to environmental modeling, in particular through data assimilation and model validation; and 4) Applications of this basic research in satellite remote sensing and modeling to marine ecosystems and the management of living and non-living resources within the coastal and open ocean. Although both coastal and open-ocean regions are addressed, greater emphasis is placed on basic research and applications within the broad-scale coastal regions.

## B. Past and Present Research (Themes 1-4)

As for Administration, no radical changes are planned in the continued evolution of the CIOSS Research program. Thus, although the present document is a plan for the next five years, the activities of the past five years represent the trajectory upon which the research program is expected to continue, with some modifications noted below.

CIOSS expects to enhance collaborations with NESDIS' Satellite Oceanography and Climatology Division (SOCD) on topics of mutual interest. These topics are all related to CIOSS Research Themes as well as the SOCD mission and include, but are not limited to:

* Climate Data Record definition, creation and maintenance
* Ocean Color cal/val, product development and utilization
* Evaluation and access to non-US sources of satellite ocean color data
* Ocean Surface Vector Winds - mission planning, science and utilization
* Altimetry - mission planning, science and utilization
* CIOSS/SOCD collaborations to support IOOS
* Outreach - working to establish direct and productive connections to NOAA educational resources

* CoastWatch - working to improve ties between CoastWatch and the evolving OceanWatch
* VIIRS - helping to ensure it is successful for ocean color

The five CIOSS Themes are depicted as colored boxes in the lower part of Figure 1. Under the first three Themes are found colored boxes representing working groups that were formed to help coordinate activities in those Research Themes. Individual projects under those themes are not shown in the figure. The white boxes at the bottom represent the outside agencies with which the projects or working groups interact. The working group histories and activities are presented in more detail in Appendix A (below), as are the individual projects under each Theme. More complete descriptions of the individual projects are found in the CIOSS "Year-4 Annual Progress Report" at the CIOSS web site under Archived Reports (http://cioss.coas.oregonstate.edu/CIOSS/archive.html) and in Section 4 ("Science Review") of the External Review Briefing Book (http://cioss.coas.oregonstate.edu/CIOSS/review.html).

**Theme 1, "Sensors and Techniques":** This primarily includes work that helps to design and evaluate future sensors.

**Ocean Color**: The greatest effort under this Theme has been expended by the COAST team members, in preparation for the HES-CW sensor on the next generation of geostationary satellites (GOES-R). Before this sensor was decommissioned, COAST held four workshops in which they designed the specifications for the CW sensor and planned three field experiments to collect hyperspectral data over the west coast (Monterey Bay), the east coast (NY Bight) and the Gulf Coast (unspecified). Data collected during the first field season over Monterey Bay have been processed and discussed at a fifth COAST workshop in July 2007. An anticipated 5-6 papers will come out of that workshop, describing initial analyses. After the decommissioning of the sensor, however, funding for COAST was cut and the other data sets and analyses have been shelved. It is hoped that funding will be restored in the future, since the data sets and analyses will help to develop algorithms for any future color sensor (VIIRS or others).

A subset of the COAST team members took part in an "Analysis of Alternatives" exercise, to help NOAA define alternative strategies that could accomplish the goals of the HES-CW sensor. Other CIOSS activities that address future and past color sensors include the analysis of hyperspectral data from the past Hyperion sensor, looking at inherent spatial fields in the color fields at scales smaller than can be address by 1-km sampling; workshops to define the requirements needed to produce ocean color Climate Data Records (CDR's); and workshops to define future in situ measurements needed for cal/val activities for future ocean color sensors.

**Ocean Vector Winds (OVW)**: CIOSS Fellows have also helped to define future sensors for OVW, through analysis of WindSat passive microwave data. This technology was planned for the future CMIS sensor, now decommissioned, and may be the choice for a replacement sensor (compared to active radar scatterometers). New scatterometer techniques have also been proposed, using an interferometric radar scatterometer that may resolve ocean vector winds to 2-5 km, with no gap next to the coast (the "XOVWM" sensor). The Decadal Survey gave responsibility for this sensor to NOAA, although it is expected that NASA will help to develop the sensor. CIOSS Fellows Dudley Chelton and Ted Strub are providing examples of science issues that could be addressed with such a sensor in the coastal ocean.

**Sea Surface Height (SSH)**: Future altimeter missions may also make use of an interferometer technique to derive high resolution SSH (the "SWOT" sensor), with ~1km resolution and no coastal gap. CIOSS Fellows Dudley Chelton and Ted Strub are also helping in this effort. Strub and his research team are working with Laury Miller and colleagues at NESDIS/SOCD to investigate ways to get around some of the altimeter corrections that will still pose a problem close to the coast. Strub and Miller plan to hold a workshop in early 2008 to bring together those who are working on this problem, forming collaborations that will make progress on these corrections, preparing for the new sensor.

**Theme 2, "Fields and Fluxes"**: Under this Theme, new techniques are used to construct improved fields of surface ocean variables and air-sea fluxes.

**Ocean color**: Work on Harmful Algal Blooms is focusing on identifying the surface ocean characteristics that define preferred "habitat" for HAB's. This is especially difficult on the west coast, where the species responsible for the blooms cannot be identified by present sensors (and are not always toxic). In two projects, CIOSS Fellows Peter Strutton and Michelle Wood are addressing this problem.

**OVW**: CIOSS Fellow Dudley Chelton and student Craig Risien have produced global wind climatologies from QuikSCAT data with 0.25º resolution. One is a graphical (wind rose) climatology and the other is digital climatology of various wind and wind stress variables. Both climatology web pages and manuscripts describing them are available on the CIOSS web page, http://cioss.coas.oregonstate.edu/CIOSS/ under the link to "Climatology of Global Ocean Winds". For coastal studies, Barry Vanhoff (CIOSS) is developing a coastal land mask for use with 12.5 km scatterometer data, which reduces the width of the data gap next to the coast.

**SSH**: CIOSS post-doc Martin Saraceno has submitted a manuscript describing the combination of coastal tide gauge SSH with traditional global (AVISO) SSH fields to create SSH fields that better represent the along-shore surface currents in the region within 40 km of the coast, where standard altimeter fields are based mostly on extrapolation and poorly represent the SSH and alongshore current fields. In a related project, CIOSS Fellow Ted Strub is substituting less restrictive correction terms to along-track data to resolve changes in SSH within 20-25 km of the coast. The along-track data will eventually be combined with the tide gauge and standard SSH fields to resolve the position of coastal jets within that 40 km coastal region.

**Multi-Sensor Fields**: Using the technique developed by Saraceno (above), CIOSS Fellows Jack Barth and Ted Strub are developing fields of coincident SSH, SST, OVW and Chlorophyll-a pigment concentrations along the U.S. West Coast. The OVW data will come from the analyses of Vanhoff (above), while SST and Chlorophyll-a will come from NOAA Pathfinder and NASA/Goddard archived data, respectively. These fields will be useful in studies such as described by Venegas et al. (below).

**Theme 3, "Models and Data Assimilation"**: New modeling techniques or applications of existing techniques are explored in this Theme.

**Coastal Modeling, Forecasts and Data Assimilation (DA)**: CIOSS Fellows Alexandre Kurapov and John Allen (and others) are developing methods of nesting coastal models within larger regional and basin scale models to provide high resolution fields of water properties and currents. Methods of assimilating data from both altimeters (SSH) and coastal HF radars (surface currents) are being developed in the same project. In a related project, Kurapov and colleagues are using the NWS high resolution atmospheric forecast model winds and surface fluxes to drive a simplified coastal model, spinning up with past winds and using forecast winds to forecast the coastal ocean currents two days into the future. The fields are available at http://www-hce.coas.oregonstate.edu/~orcoss/SSCforecast.html. The plan is to incorporate improvements and DA into the forecast model when they are judged ready in the research models (Kurapov and Allen, above). U.S. GLOBEC is providing 1/3 of the funding for the research modeling. Another coastal modeling effort is being directed by CIOSS Fellows Roger Samelson and Eric Skyllingstad, using a coupled ocean-atmosphere model to investigate the interactions of the two fluid systems in a coastal domain. Future coastal ocean models will need to be coupled with the atmosphere but much needs to be done to understand the coupled systems. ONR is funding 75% of this effort.

**Zooplankton (and Phytoplankton) Modeling**: With U.S. GLOBEC funding (directed through CIOSS), Hal Batchelder is using Lagrangian, "individual based modeling" techniques to track hundreds of thousand of zooplankton that move through an Eulerian (fixed grid) model that includes nutrients, phytoplankton and zooplankton (NPZ). The NPZ modeling is also funded by U.S. GLOBEC, not through CIOSS. Thus, the only ecosystem components of the CIOSS modeling efforts are funded entirely by sources outside of CIOSS.

**Basin-Scale Models and DA Estimates of Error Fields**: CIOSS Fellow Robert Miller has been funded to work with colleagues at the JCSDA in using methods of inverse modeling to estimate error fields in basin-scale ocean models. This effort is just beginning and will extend two years into the second five-year period.

**Theme 4, "Oceanic and Atmospheric Data Analysis"**: New modeling techniques or applications of existing techniques are explored in this Theme.

**SST**: CIOSS Fellow Jack Barth and graduate student Renato Castelao (CIOSS) worked with Tim Mavor (NESDIS/SOCD) to analyze SST frontal distributions in the coastal ocean, preferred habitat for some fish species. Two papers resulted from this work, which helped to validate products available from CoastWatch.

**SST-Winds**: Fellow Dudley Chelton and post-doc Qing-Tao Song are using ECMWF wind fields to investigate the mechanism whereby the SST influences the surface winds, extending that analysis to winds higher in the atmosphere. The results of this study may help to point the way for improvements in the boundary layer formulations in atmospheric forecast models.

**Long-Range HF Radar Error Analysis**: Fellow Mike Kosro is analyzing error characteristics of the long-range HF radar surface current fields. This is a necessary step before the assimilation of the radar fields into coastal models is possible (Kurapov and Allen, above).

**Latitudinal Variability in the Northern California Current**: GLOBEC is funding Fellows Mike Kosro and Ricardo Letelier to use coastal radar, moored current meters, ship and satellite data to look at variability north and south of Cape Blanco, Oregon. The currents from these mooring have been quite useful in validating the alongshore currents derived from combinations of tide gauge and altimeter data (Saraceno, above).

**Basin – Boundary Interactions**: GLOBEC is funding Fellow Ted Strub and colleagues at other institutions to determine the response of the mesoscale fields in the California Current to variability in the N. Pacific basin-scale circulation. Strub is using satellite SSH.

**Mesoscale Energy Variability**: With GLOBEC funding, graduate student Julie Keister is using wavelet analysis to quantify annual and interannual variability in the eddy kinetic energy found in the mesoscale circulation fields in the California Current. She is relating this to the basin- and boundary-scale circulation fields determined in the project of Strub (previous project). A manuscript describing the results has been accepted by JGR-OCEANS. She will further relate this to the biological data collected in the GLOBEC project during 2000 and 2002 in her Thesis.

**Multi-Sensor Climatologies and Interannual Variability**: Roberto Venegas was supported by GLOBEC and CIOSS to develop the climatology of SST, Chlorophyll-a concentrations, SSH and OVW in the northern California Current. The multi-sensor data set is similar to that under construction by Barth and Strub (above) over the entire California Current. After subtracting the seasonal climatology the interannual variability reveals El Niño and La Niña events, along with the influence of other basin-scale changes in circulation, not related directly to ENSO conditions. A manuscript describing the Venegas results is in press at JGR-Oceans.

## C. Future Research Plans

CIOSS will continue to stress its present Research Themes, which essentially include activities that:
(1) Prepare for future satellite sensors and algorithms – color, winds, surface height and SST
(2) Improve the fields derived from present sensors – SST, color, winds, surface height
(3) Improve models for prediction, data assimilation and coupling of the ocean and atmosphere
(4) Analyze combinations of satellite, model and in situ data to examine ocean fronts, air-sea interaction, connections between basin-scale and regional circulation, climatologies etc.

**Projections of Funding for CIOSS Themes and NOAA Strategic Goals for the Next Five Years – The Cap Budget:**

Through consultation with CIOSS Program Managers (Ingrid Guch and Kent Hughes, NESDIS/STAR), the “cap” or “ceiling” budget for CIOSS during its next five years has been set at $5,000K per year, or $25,000K over the five years. The five year total is the legal limit which CIOSS cannot exceed over the next five years, without NOAA approval. To project the proportion of this total that will be budgeted for each CIOSS Theme or each NOAA Strategic Goal, we have used the percentages from the actual CIOSS budgets for projects during years 3 and 4 of the first five years. These years represent the years with the greatest research expansion for CIOSS, which might be expected to be similar to a future period with expanded research activities that approach the $5,000K per year maximum. The projects during these years can be found, along with their funding and associated CIOSS Themes and

NOAA goals in Table 4.1 (pg 12) of the External Review Briefing book, Section 4: "Science Review" (http://cioss.coas.oregonstate.edu/CIOSS/review.html).

Using this approach, the annual $5,000K is projected to be divided into the following NOAA Strategic Goals:
Ecosystems: 48.7% = $2,435K
Weather and Water: 28.0% = $1,400K
Climate: 14.5% = $725K
Mission Support: 8.8% = $440K
Transportation: 0% = $0K

Similarly, the projected percentages and amounts in each of the CIOSS Themes are:
1. Satellite Sensors and Techniques: 40.6% = $2,030
2. Ocean-Atmosphere Fields and Fluxes: 15.9% = $795K
3. Ocean-Atmosphere Models and DA: 14.0% = $700K
4. Ocean-Atmosphere Analyses: 13.7% = $685K
5. Outreach: 6.8% = $340K

**Projections of Funding for CIOSS Themes and NOAA Strategic Goals for the Next Five Years – From Known Sources:**
In Figure 2, we present the breakdown of funding during the first five years for various known sources of support, along with projections for the second five years for these same sources. Core Research represents small projects chosen each year for funding out of the core $500K, as described above. This shrinks as Administration and Core Outreach and Education grow. The CIOSS budget, however, extends above $500K during the first five-year period due to: (1) (light blue-green) Miscellaneous projects (one-year special projects, such as GIS funding during the first year, the analysis of Hyperion data and HES advisory support during the third year, AOA and Ground System Support during the fifth year); (2) (yellow) Research and Operations funding for various projects during years 3-5; (3) (orange) Risk Reduction (for HES-CW, data collection, algorithm development, workshops, etc.); and (4) (pink) Other Program funds (GLOBEC and JCSDA).

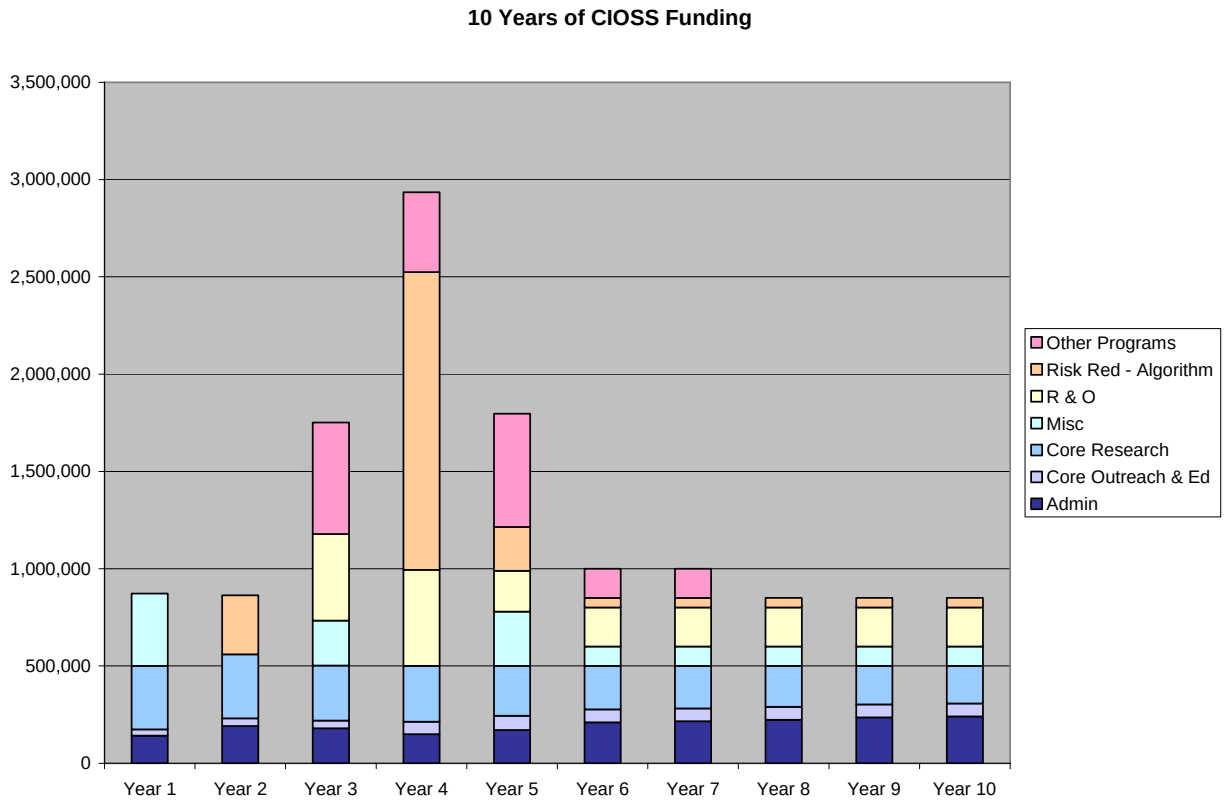


**Figure 2. CIOSS funding in several sources (see color chart) during CIOSS' first five-year period (actual) and projected for CIOSS' second five-year period (estimated) from the same sources. See text.**

During the second five-year period, we have projected funding from these same known sources of funding. Core costs ($500K per year) are divided into Administrative Costs (from our Task I proposed budget, below), Core Outreach and Education ($42,400 for SMILE and $24,000 for REU) and Core Research (the remainder). Increases in Administrative costs cause Core Research to shrink from approximately $224K in Year-6 to $193K in Year 10. The only other known funding is for the JCSDA project of Miller and Richman (~$150K per year during years 6 and 7). GLOBEC and the present COAST (Risk Reduction) funding end after Year-5. The JCSDA project of Miller and Richman (Other Programs) will end after Year-7.

In projecting amounts from known sources of funding for the second five-year period, we are assuming that Research and Operations projects will continue at approximately $200K per year, that Workshops (to develop improved algorithms, surface fields, model techniques, etc.) will continue at $50K per year and that Miscellaneous projects will be funded at $100K per year. Even these nominal amounts will require ongoing efforts and continued communication between CIOSS personnel and various NOAA program managers. In addition, we expect opportunities for new funding to arise, as they did during the first five-year period. Some of these are described below.

**Miscellaneous Projects**

One project in this category is the "Ground Systems" funding, which is presently being used to transition the high resolution scatterometer land mask to NOAA/NESDIS (Paul Chang's real-time system). If this becomes an annually available funding of $50K or more, it will provide at least half of what we have assumed for the second five-year period ($100K per year). Other projects in this category have arisen due to special circumstances. We assume that this will continue to occur.

**Research and Operations**
This is another unpredictable category. Since its inception during CIOSS' third year, CIOSS has received over $200K per year for various projects. We include this number in our projections, with no guarantee of its continuation.

**Risk Reduction, Algorithm Development, Workshops**
This category represents a large addition to the CIOSS budget, supporting the coordination of the COAST team and its activities, along with a number of workshops and other activities related to Ocean Color sensors. With the elimination of the HES-CW sensor from the GOES-R platforms, Risk Reduction funding for the HES-CW sensor came to an end. The COAST project received some funding during Year-5 to complete initial data processing and analyses of the "first" field program in Monterey Bay in September 2006.

These data are available for algorithm development for any color sensor, including VIIRS and other ocean color sensors proposed for future missions. Likewise, the data sets that were planned to be collected along the U.S. East Coast and Gulf Coast could be used in the same way, allowing algorithms to be developed and tested in different types of water along different U.S. coasts. If STAR becomes the center for algorithm development and testing within NOAA/NESDIS, we anticipate a renewed effort in (and support for) Risk Reduction for ocean color sensors and hope that COAST activities be revived.

Similarly, new high-resolution scatterometers and altimeters are being planned for the future, with NOAA being given the lead for the high-resolution Ocean Vector Wind sensor. These will need Risk Reduction efforts, algorithm development and workshops to coordinate these activities and CIOSS will propose some of this work. Thus, although we have assumed support of only $50K per year for workshops, we hope to play a significant role in Risk Reduction for several projects that will raise the funding above this level.

One development that may aid in increasing CIOSS' role in future Risk Reduction is the fact that COAS has been awarded a significant grant to help design, fabricate and deploy a set of moorings off Oregon and Washington. Under the NSF ORION (OOI) program, COAS successfully partnered with WHOI and SIO to take responsibility for the coastal "Endurance Array", which (as presently designed) will consist of a linear array of moorings off Newport Oregon, with another off central Washington. With current meters, optics, nutrients and meteorological sensors on most of these moorings, they will provide platforms from which to ground truth and develop algorithms for coastal ocean currents (from altimeters and scatterometers), ocean color and winds. In addition to this NSF funding and activity, support has also been awarded from the NOAA IOOS program to the Regional Association in the Pacific Northwest (NANOOS), for components of observing systems off Oregon and Washington. These observations will augment the OOI arrays, with more of an operational focus. Making use of the resources provided by both of these programs, sensors needed for algorithm development and cal/val activities for satellite sensors can be deployed on the

existing or nearby moorings at a cost below that needed at a site without this activity, infrastructure and expertise. CIOSS will make use of these opportunities, as they arise.

**Other Programs**

NOAA funding for investigators in the U.S. GLOBEC program has increased CIOSS budgets during years 3-5. While this is ending, a proposal has been funded through CIOSS for a data assimilation project at the JCSDA. This will extend through Year-7. During the second five-year period, we will continue to try to find additional sources of funding outside of NESDIS/STAR for CIOSS projects. In particular, we have been in communication with coastal modelers in NOS (Frank Aikman) and JCSDA (Eric Bayler) in an effort to find or create opportunities to support some of the projects that are presently supported by Core Research. Another of the modeling projects (coupled models, Samelson and Skyllingstad) are preparing a proposal to ONR to continue to cover most of the support for that project (ONR has supported it at 75% in the past). With regard to the present NASA call for proposals (ROSES), Ted Strub will be proposing to extend the work of CIOSS post-doc Martin Saraceno in applying altimeter SSH fields to regions closer to the coast than traditionally attempted. Dudley Chelton will propose to the same call to continue the work he has been doing on ocean eddies and horizontal eddy heat fluxes. Although proposals to NASA and other agencies outside of NOAA will not formally be submitted through CIOSS, they will contribute to the overall research program in ocean remote sensing at COAS and CIOSS.
A project has been approved in the NOAA MERHAB program, with CIOSS Fellows Peter Strutton and Michelle Wood as PI's. In theory, this proposal could have been submitted through CIOSS. However, the end of the first five-year period presents a source of confusion for projects that would span this nominal end-date, even if we know that we will request a no-cost extension. This problem limited the COAST multi-year proposal to two years, instead of the original three year plan. It also posed problems for the recently funded JCSDA project of Miller and Richman, which has been approved but is now funded for only one year, instead of the intended three. Thus, present NOAA CI policies related to end dates for the five-year funding period create problems with the submission of proposals to multi-year programs within NOAA, which deter PI's from submitting those proposals through CIOSS.

# VII. CIOSS OUTREACH AND EDUCATION

## A. General Outreach and Education

The CIOSS outreach program consists of activities that link research methods and results to a broader community of students, scientists, resource managers and the general public. These activities increase the benefits from the research by making its data, methods and conclusions more widely accessible. At the same time, outreach activities increase public awareness of the value of the research and of the roles of NOAA and academic scientists in conducting the research. The overall goal of outreach is to give the research a "broader impact" on a wider community. Because outreach is directly related to CIOSS research, it is included as a research theme.

## B. Approach to Outreach and Education

The primary aims of CIOSS outreach are: to educate new practitioners and users (research and non-research) of ocean remote sensing products; increase the awareness and appreciation of the uses of remote sensing among the general public; evaluate new sensors and products and inform the community of those results; and improve methods of making data accessible

to scientists, managers and the general public. The mentoring of postdocs and new faculty is another aspect of outreach that occurs as a natural consequence of the CIOSS research strategy. Examples of the type of activities that we envision are:

1. Conduct workshops and short courses that serve several purposes: (a) Train professional research scientists and graduate students in methods of satellite remote sensing and modeling; (b) Evaluate present and future satellite sensors and techniques, providing guidance to NOAA/NESDIS as it moves toward the NPOESS era (examples given under "Research," above).

2. Support programs in the public schools that introduce concepts of satellite remote sensing, oceanography and mapping in general. Besides introducing these concepts, the goal is to nurture the ability in, and appreciation of, science and math in the general public.

3. Explore the establishment of interactive displays of CIOSS and related activities at science museums, such as the Hatfield Marine Science Center (HMSC) and the Oregon Museum of Science and Industry (OMSI).

4. Develop or collaborate with others who have existing web pages that provide both data links and tutorial activities at levels from high school to graduate school.

5. Collaborate with existing programs (NOAA, State and non-governmental) that interact with potential non-scientific users of ocean remote sensing. These uses can both benefit from existing operational products and can provide critical guidance on the needs of the commercial ocean industry for new products.

## C. Past and Present Outreach and Education (Theme 5)

The two main activities for outreach and education are the support for the SMILE program and a low level effort to create a pilot display at the HMSC which highlights ocean remote sensing. These activities are described in detail in the External Review Briefing Book, "Education and Outreach" (Section 6) - http://cioss.coas.oregonstate.edu/CIOSS/review.html.
The total SMILE program is described at http://smile.oregonstate.edu/ and PowerPoint files showing the program and high school challenge can be found on the CIOSS web page under "Outreach and Education" http://cioss.coas.oregonstate.edu/CIOSS/outreach.html. Other activities include workshops and short courses, some of which are included above and others of which are summarized below (see also the beginning of the "Education and Outreach" section, reference above).

**SMILE**: CIOSS has supported the development of materials for the High School component of the SMILE program since CIOSS' first year. The materials were first used in CIOSS' second year. The SMILE program is an after school "club" activity, designed to motivate students to graduate from high school and attend college in a field of science, math or education. It targets districts with population with a high proportion of those groups under-represented in university attendance, especially in fields of science and math. CIOSS has provided partial support for the SMILE high school program and helped them to develop material that stresses remote sensing and oceanography. Their annual culminating event is a day and a half "High School Challenge", bringing students from all SMILE districts (12) to

OSU for a scenario-based problem-solving session. See the links above for more information.

**HMSC Pilot Display:** The original idea was to create a display that highlights ocean remote sensing and oceanography in general at the HMSC. A pilot display has been partially designed by Molly Phipps, a student in the OSU Informal Education Program. Another student is in the process of taking over the project. The format for the pilot display is an interactive "kiosk". Other possible plans and formats involve 3-D projection systems, allowing the viewer to "fly" through 3-D fields under the ocean off Oregon, where the actual data are from GLOBEC research cruises. See the Appendix (below) and the External Review Briefing Book, "Education and Outreach" (Section 6) for more details - http://cioss.coas.oregonstate.edu/CIOSS/review.html.

**Workshops and Short Courses**:
In addition to workshops already described under each Theme (above), the following have been held:
**Remote Sensing Short Course for NMFS and NOS Scientists:** This 3-day, hands on course has been held twice in Corvallis, with initial material taught by CIOSS Fellows and hands-on GIS computer exercises taught by CoastWatch and NMFS personnel.
**Forecast Use of OVW's**: Ralf Milliff and Peter Stamus have visited operational forecast offices and instructed the forecasters in the use of QuikSCAT OVW data, also surveying the forecasters to determine the impact of the OVW data on the forecasts. A manuscript will be submitted to "Weather and Forecasting." They are now installing software at selected forecast offices to make the data available.
**Marine Forecast Training**: Mike Freilich has participated in training courses for marine forecasters in each of the first four years of CIOSS. He will not participate while at NASA.
**Climate and CCS Ecosystems Workshop**: This workshop was held at Scripps at the request of Chet Koblinsky (NOAA/Climate) and Steve Murawski (NMFS). Experts in the California Current (CCS) presented information on the need for ecosystem observations and information on different observing system and modeling capabilities that could address these needs. A report written after the workshop presented a plan for a future observing and modeling system for the CCS; the report was forwarded to Koblinsky and Murawski to use in planning new NOAA initiatives in the CCS.

## D. Future Outreach and Education Plans

The CIOSS Outreach and Education efforts during the second five-year period will continue the present activities in (1) workshops and short courses; (2) support for the OSU SMILE program; (3) support for REU students; and (4) development of displays for science museums that highlight research in remote sensing and oceanography.

**Workshops and Short Courses**
If (when) there is demand, we will repeat the short course in ocean remote sensing for personnel in NMFS, NOS, and other NOAA and state offices. This has been held twice, in collaboration with personnel from the CoastWatch and NMFS lab in Pacific Grove, California (Dave Foley and Cara Wilson).

Eric Bayler (JCSDA) has suggested that CIOSS could host a short course (~2 weeks) in coastal modeling and data assimilation. Our modelers are considering such a course in summer, 2008.

Ingrid Guch (NESDIS/STAR/CoRP) is leading an effort to create "modules" that can be used at each CI in courses on remote sensing for undergraduate and/or graduate students. These would be available over the web. The idea is that there would be video (the equivalent of the power point slides and other graphics that a lecturer would show during the lecture) and also live audio from the remote lecturer. Initially, we will use the capabilities of the "VISIT" web site for initial trial lectures. Ted Strub will present a test remote lecture during his present (Fall 2007) graduate course on Ocean Remote Sensing. Subsequently, more complete guest lectures and modules will be prepared for general use using the same technology. Ultimately, complete courses may be developed.

Workshops will be held, as requested by NOAA. At present, we are planning a workshop in the use of altimeter data in coastal regions, closer to the coast than traditionally expected. In collaboration with Laury Miller in STAR/SOCD, we plan to hold this workshop early in 2008. Ted Strub is the lead at CIOSS. Several other workshops have been requested, concerning cal/val activities for ocean color sensors. Curt Davis is the lead on these. We assume that the opportunity to host other workshops will occur during the next five-year period.

**SMILE**

We have discussed with the NOAA Office of Education (Marlene Kaplan and Carrie MacDougal) ways in which the OSU SMILE program could be expanded to other states, as recommended by the External Review Panel. This essentially involves moving the graduate student who coordinates the SMILE High School program to the NOAA Office of Education as an intern after graduation from OSU. The intern would bring to NOAA the experience of the SMILE program and work to implement "SMILE-like" programs elsewhere. Those in the OEd have suggested proposals to the Environmental Literacy program, when a new call for proposals to that program is issued. Although they did not know when such a call would be issued, this remains a good possibility over the next five years. If (in this process) support for the SMILE program could be moved outside of the CIOSS Core funding, there would be more support for Core Research. The same would be true if the REU program could be moved out of the Core budget. If NOAA were to institute an REU program of its own, this might be possible.

**REU Students**

NSF has renewed (for three years) the COAS/HMSC REU program, with support for 10 undergraduate students to work at HMSC and 5 students to work at COAS. During summer 2007, CIOSS supported an additional four students at COAS. CIOSS has funds in Year-5 for five additional REU students and plans to continue this support. The existence of the NSF program provides infrastructure that allows CIOSS to support the additional REU students at minimal cost and effort. CIOSS plans to continue this as long as the NSF program continues, although it would free Core funds if another source of support within NOAA could be found.

**HMSC Displays**

We have also discussed proposals to fund displays at HMSC. A low level effort has been underway for several years, carried out by a graduate student at OSU; this will produce a single "kiosk" prototype display. There is presently a NOAA call for proposals for "spherical displays" in science museums, for which we will partner with those in OSU Informal Education, HMSC and with the NOAA Environmental Visualization Program (EVP). These

displays involve the visualization of global satellite fields, for which CIOSS could provide data sets. We are also interested in displays of real-time and historical regional data sets, both satellite surface fields and in situ data, collected by research vessels, that would take the visitor to a 3-D field world of subsurface physics (currents, temperatures, salinity), chemistry (nutrients) and biology (plankton, fish, marine mammals and sea birds). Such data sets have been collected during specific field program (GLOBEC, NSF-CoOP, etc.) and exist within COAS data archives. Efforts by those in the NOAA/STAR EVP could help with the technical expertise to convert the satellite imagery and field data from COAS into displays for HMSC, with faculty in the Informal Education Department at OSU providing the design for the interactive elements.

## VIII. PROJECT PARTNERS

The CIOSS-NOAA MOA names a broad range of potential partner institutions in NOAA line offices, other federal and state governments and academic institutions. New formal partners can be added at the suggestion of the Council of Fellows. Although COAS and NOAA/NESDIS are the lead partners, all parts of OSU and all parts of NOAA are included in the MOA, since it is signed at the highest level of both OSU and NOAA. The MOA, however, lists specific offices within NOAA as the most likely partners.

In practice, the MOA neither mandates that the partners listed in the MOA must participate as partners in projects nor prohibits others from participation. Thus, during the first five years of CIOSS activity, projects have involved many of those named in the MOA and others, who were natural partners in the research. Section 3 of the External Review Briefing Book provides details on the partners involved in each project. See the section titled “Scientific Partnerships” at http://cioss.coas.oregonstate.edu/CIOSS/review.html.

Actual partners in CIOSS projects and those with whom we are discussing future projects include:

NOAA/NESDIS: STAR, STAR/SOCD, NCDC (National Climatic Data Center) and CoastWatch

NOAA/OAR (the Office of Oceanic and Atmospheric Research): CPO (Climate Program Office), CO-OPS (Center for Operational Ocean Products and Services), GFDL (Geophysical Fluid Dynamics Laboratory), AOML (Atlantic Oceanographic and Meteorological Laboratory) and PMEL (Pacific Marine Environmental Laboratory).

NOAA/NMFS (National Marine Fisheries Service): the NWFSC (Northwest Fisheries Science Center), SWFSC (Southwest Fisheries Science Center) and ERD (Environmental Research Division).

NOAA/NOS (National Ocean Service): CSCOR (Center for Sponsored Coastal Ocean Research), NOPP (National Ocean Partnership Program), MMA (Marine Modeling and Analysis), ORR (Office of Response and Restoration – HazMat) and the CSC (Coastal Service Center).

NOAA/NWS (National Weather Service): NCEP (National Centers for Environmental Prediction), TPC/NHC (Tropical Prediction Center/National Hurricane Center), and various Weather Forecast Offices.

NOAA/Sea Grant, *Oregon Sea Grant

NOAA/OPPI (Office of Program Planning and Integration)

NOAA Office of Education

JCSDA (Joint Center for Satellite Data Assimilation – NOAA/NASA/NRL)

U. S. Coast Guard

ONR/NRL: *Stennis and Monterey Labs

NASA/EOS: Physical and Biological Oceanography, NASA/Goddard, NASA/CERES, NASA/JPL

NIST (National Institute for Science and Technology)

State of Oregon: *Oregon Coastal Management Program (OCMP) and Department of Agriculture (HAB monitoring)

HMSC (Hatfield Marine Science Center)

ECMWF (European Center for Medium-Range Weather Forecasting)

Academic Institutions: *UCLA, UCSC, UCSB, *Rutgers, U. Maine, Old Dominion U., U. Hawaii, Florida Environmental Research Institute, U. Maryland, U. New Hampshire, MIT, U. Connecticut, U. Maryland/Horn Point Lab, U. Delaware, U. Southern Mississippi, Woods Hole Oceanographic Institute, Scripps Institute of Oceanography, U. Miami, Louisiana State U., U. Oregon, Oregon State University/SMILE, Brigham Young U., Central Florida U.

Private Institutes: Ocean Imaging, Inc., Remote Sensing Solutions, OCENS INC, North West Research Associates

The "*" indicates the five partner institutions that provided letters of support for the initial proposal.

# IX. MILESTONES/OUTCOMES

## A. First Five Years

Below we list the "milestones" from the Cooperative Agreement for the first five years. All have been met or exceeded, except as noted (*in italics*)

**Administration**

- Within the **first year**: The Council of Fellows and Executive Board will be defined and the Council will begin regular meetings; An Administrative Program Specialist will be hired using OSU procedures; The MOA between NOAA/NESDIS and OSU will be drafted and finalized; The initial research projects will be proposed to NOAA/NESDIS; and The positions within the chosen projects will be announced and the hiring process continued until the positions are filled.
- Within the **first two years:** The annual procedures will be established for evaluating progress, setting priorities for future directions, proposing each new year's research activities to NOAA/NESDIS, and identifying new opportunities for CIOSS resources with other federal or state funds; Besides regular meetings of the Fellows, Council of Fellows, and Executive Board, there will be visits of ORAD (SOCD) personnel to CIOSS and of CIOSS personnel to ORAD (SOCD). Visits between CIOSS personnel

and other cooperative institutes or NOAA/NESDIS offices will also be used to increase opportunities for collaborations.

- By the end of the **fourth year**: A more formal review of CIOSS will be held (as specified in the FRN), to allow evaluation of progress by all interested parties. In the **fifth year**, a renewal proposal for an additional 5-year period will be prepared and submitted by CIOSS in collaboration with NOAA/NESDIS (*Note: This is the present document).*
- A specific expectation expressed in the FRN is to leverage core support in order to increase the funding for CIOSS activities to a level of **approximately $1M by the end of the first 5 years.**

**Research**

- The specific research projects funded with core support in each year will be determined by proposals from CIOSS Fellows for projects in CIOSS Research Themes and ORAD (SOCD) priorities. These proposals will be evaluated and presented to NOAA/ORAD (SOCD) in the annual omnibus proposal.
- **In years 1 and 2**: One obvious milestone is the hiring of postdoctoral fellows or starting faculty for the initial projects (*Note: Some of the post-docs were hired in the second year but did not arrive until the third year).*
- **In year 2 and each following year**: Another milestone is the successful submission of additional proposals to both NOAA/NESDIS (Task II) and other NOAA agencies (Task III).
- **In year 3**: The CIOSS omnibus proposal will begin to emphasize more directed research projects using all CIOSS resources, rather than support only for projects involving the hiring of new post-docs.
- **By year 3**: The success of CIOSS will depend on the establishment of collaborations between the CIOSS Fellows in COAS and our counterparts in NOAA/NESDIS and other branches of NOAA. By year 3 we would hope to have one or more NOAA/NESDIS personnel visit CIOSS for extended periods (months to years) in order to enhance collaborations. *Note: Bringing NOAA personnel to CIOSS (Corvallis) for extended periods (6-months to several years) has not been possible, due to changes in NOAA CI policy.*

**Outreach**

- **In each year**: CIOSS will sponsor workshops/short courses on topics in remote sensing and/or coastal modeling/data assimilation. These may be primarily for training or for working groups to evaluate satellites, sensors and techniques in remote sensing and modeling.
- **In year 1 and beyond**: A web site will be established for communications and to inform the public.
- **In year 1 and beyond**: CIOSS will work with SMILE or another appropriate group to develop curricular materials with an oceanography/remote sensing focus, for use in public schools at the high school level.
- **In year 2 and beyond**: The material developed above will be implemented at the high school level.
- **In year 1 and beyond**: Opportunities will be explored to establish displays of NESDIS/CIOSS science results at public science museums. The two such museums with whom we have had the most contact are HMSC (Newport) and OMSI

(Portland). *Note: Progress on this goal has been slow, although we are continuing to work with those in the OSU Informal Education Program and Sea Grant to plan a display at HMSC.*

## B. Second Five Years

The "milestones" for the second five-year period are more open-ended, lacking the specific initial milestones that could be foreseen in establishing the CI during its first five years.

**Administration**

- **In each year**: The specific research projects funded with core support in each year will be determined by proposals from CIOSS Fellows for projects in CIOSS Research Themes and ORAD (SOCD) priorities. These proposals will be evaluated and presented to NOAA/ORAD (SOCD) in the annual omnibus proposal.
- **In each year:** Additional proposal will be submitted, based on NOAA external or internal RFP's.
- **During the five-year period**: The total CIOSS budget for the 5-year period will average $1M per year or more.
- **During the fourth year** of this period: CIOSS/COAS will recompete to continue as the ocean remote sensing CI in NESDIS.

**Research**

- **In each year**: The specific research projects funded with core support in each year will be determined by proposals from CIOSS Fellows for projects in CIOSS Research Themes and STAR/SOCD priorities. These proposals will be evaluated and presented to NOAA/STAR/SOCD in the annual omnibus proposal.
- **By the end of year-1**: An active program of scientific exchanges between NOAA and CIOSS personnel will be established to help increase their interactions.
- **During the five-year period**: CIOSS personnel will play active roles in the development of new OVW, SSH and color sensors.
- **During the five-year period**: There will be a continued emphasis on creating improved satellite fields, with emphasis on the coastal ocean. This will include reducing the gap between the coast and the offshore data found in traditional global OVW and SSH fields, as well as improvements in products derived from ocean color sensors in the coastal ocean.
- **During the five-year period**: The present focus on air-sea interactions will continue, in both coastal and open ocean domains.
- **During years 3-5**: The observational systems in the IOOS and ORION programs are expected to be put in place over the next five years. CIOSS will use these systems in to establish its capability to develop and validate algorithms and satellite products, with an emphasis on coastal color, OVW and SSH fields.
- **During the five-year period**: Additional sources of funding will be sought for some of the modeling projects, through the JCSDA, NOS, OAR or other NOAA programs.
- **During the five-year period**: Modeling activities will continue to stress pilot prediction systems for coastal circulation, data assimilation in high resolution coastal domains and coupled air-sea models of the same domains.
- **By the end of the five-year period**: Modeling activities will include NPZ ecosystem components and individual based models for some species of phytoplankton and zooplankton**.**

**Outreach**

- **In each year**: CIOSS will sponsor workshops/short courses on topics in remote sensing and/or coastal modeling/data assimilation. These may be primarily for training or for working groups to evaluate satellites, sensors and techniques in remote sensing and modeling.
- **During the five-year period**: CIOSS will continue its support of the SMILE program and its efforts to help NOAA create an expanded system of "SMILE-like" programs at the national level.
- **During the five-year period**: CIOSS will establish public displays at HMSC, the Oregon Aquarium or other venues that help to educate the public on issues concerning oceanography and ocean remote sensing.
- **During the five-year period**: CIOSS will work with NOAA to establish graduate programs that involve time spent at NOAA labs.

## X. SUMMARY

In summary, the continued presence of CIOSS at COAS allows a partnership of NOAA/NESDIS research scientists with colleagues in an academic research institution with a broad range of shared interests and expertise in satellite ocean remote sensing and modeling. The additional strengths in observational and theoretical studies of the coastal ocean increase the capabilities for evaluation and improvement of the satellite techniques and products, by comparison with in situ measurements, model and idealized theoretical results. The emphasis of collaborations between NOAA/NESDIS and COAS research scientists in CIOSS will continue to be studies of the coastal ocean margins, although the open, large-scale ocean will also continue to be examined. This is especially relevant in helping NOAA/NESDIS to move into its natural role as leader in providing satellite data as part of oceanic and coastal observing systems (Integrated Ocean Observing System, IOOS; the Ocean Research Interactive Observatory Networks, ORION; and Global Earth Observing System of Systems, GEOSS), which is a national priority over the next decade. These observing systems will invariably be integrated with data assimilative ocean-atmosphere models, an area where CIOSS Fellows are also leaders and will continue to work. Equally important, CIOSS Fellows will play a critical role in evaluating present and future satellite sensors, to help NESDIS take on its major responsibility for running and improving the NPOESS and GOES satellite sensors and techniques. Within the context of this research, outreach and education for scientists, managers and the general public will continue as one of five major themes and activities.

# XI. List of Acronyms

## Acronyms in CIOSS Five-Year Plan

| | |
|---|---|
| AGU | American Geophysical Union |
| ASLO | American Society of Limnology and Oceanography |
| CCS | California Current System |
| CI | Cooperative Institute |
| CIMSS | Cooperative Institute for Meteorological Satellite Studies |
| CIOSS | Cooperative Institute for Oceanographic Satellite Studies |
| COAS | College of Oceanic and Atmospheric Sciences |
| COAST | Coastal Ocean Applications and Science Team |
| CoOP | Coastal Ocean Processes |
| CoOP COAST | Coastal Ocean Processes – Coastal Ocean Advances in Shelf Transport (Oregon) |
| CoOP WEST | Coastal Ocean Processes – Wind Events In Shelf Transport (N. California) |
| CWI | Coastal Waters Imager |
| DoD | Department of Defense |
| ECOHAB | Ecology and Oceanography of Harmful Algal Blooms |
| FRN | Federal Register Notice |
| GEOSS | Global Earth Observing System of Systems |
| GIS | Geographic Information Systems |
| GLOBEC | Global Ocean Ecosystems Dynamics program |
| GODAE | Global Ocean Data Assimilation Experiment |
| GOES | Geostationary Operational Environmental Satellites |
| GOES-R | Geostationary Operational Environmental Satellites – next generation of GOES (~2012) |
| GOES-R3 | GOES-R Risk Reduction |
| HES | Hyperspectral Environmental Suite |
| HES-CW | Hyperspectral Environmental Suite – Coastal Waters Imager |
| HMSC | Hatfield Marine Science Center |
| IOM | Inverse Ocean Modeling |
| IOOS | Integrated Ocean Observing System |
| IR | Infrared |
| ITR | Information Technology Research |
| JPO | Journal of Physical Oceanography |
| MOA | Memorandum of Agreement |
| MODIS | MODerate resolution Imaging Spectroradiometer |
| MTDC | Modified Total Direct Cost |
| NASA | National Aeronautics and Space Administration |
| NCDC | National Climatic Data Center |
| NCEP | National Centers for Environmental Prediction |
| NESDIS | National Environmental Satellite, Data and Information Service |

| | |
|---|---|
| NGDC | National Geophysical Data Center |
| NMFS | National Marine Fisheries Service |
| NOAA | National Oceanographic and Atmospheric Administration |
| NODC | National Oceanographic Data Center |
| NOPP | National Ocean Partnership Program |
| NOS | National Ocean Service |
| NPOESS | National Polar-orbiting Operational Environmental Satellite Systems |
| NRL | Naval Research Laboratory |
| NSF | National Science Foundation |
| NWFSC | Northwest Fisheries Science Center |
| NWS | National Weather Service |
| OAR | Office of Oceanic and Atmospheric Research |
| OCMP | Oregon Coastal Management Program |
| OCS | Ocean Climate Service |
| OGP | Office of Global Programs |
| OHH | Oceans and Human Health |
| OMSI | Oregon Museum of Science and Industry |
| ONR | Office of Naval Research |
| OPPI | Office of Program Planning and Integration |
| ORA | Office of Research and Applications |
| ORAD | Oceanographic Research Applications Division |
| ORION | Ocean Research Interactive Observatory Networks |
| OSU | Oregon State University |
| PAR | Photosynthetically Active Radiation |
| PFEL | Pacific Fisheries Environmental Laboratory |
| PMEL | Pacific Marine Environmental Laboratory |
| QuikSCAT | SeaWinds Scatterometer on the QuikSCAT platform |
| SAR | Synthetic Aperture Radar |
| SeaWiFS | Sea-viewing Wide Field-of-view Sensor – Color Sensor |
| SF424 | Standard Form 424 |
| SMILE | Science and Math Investigative Learning Experiences |
| SSH | Sea Surface Height |
| SST | Sea Surface Temperature |
| STAR | Center for Satellite Applications & Research |
| SWFSC | Southwest Fisheries Science Center |
| TOA | Top Of the Atmosphere |
| TOS | The Oceanography Society |
| UCLA | University of California Los Angeles |