2. Science Plan
10-12-06

A. What is the scientific vision for the Institute?

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, ONR, NSF and NASA. 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 were described briefly in Section 1 and are described in more detail below in Section 2E. It will be seen that research described under the first bullet of the Vision Statement is represented by CIOSS Themes 1, 2 and 4 (sensors, products and data analysis). Research described under the second bullet (modeling) is represented by CIOSS Theme 3, and activities under the third bullet (above) are represented by CIOSS Theme 5, outreach.

B. How is the CIOSS Mission Related to the NOAA Strategic Plan

The CIOSS goals are presented in the next section. The first CIOSS goal is to, “foster and provide a focus for research related to NOAA’s mission responsibilities and strategic objectives…” Given that CIOSS research is selected based on mutual interests with NOAA, it is not surprising that most CIOSS projects address one or more of the Mission Goals in NOAA’s strategic planning documents.

- **Ecosystems: Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through an Ecosystem Approach to Management –** Studies of ocean color provide the ability to monitor distributions of phytoplankton and make estimates of primary production. This production forms the base of the marine food chain. Estimating wind mixing, SST and other environmental conditions also allows an estimate of the areas where certain species will be favored, forming likely habitats for Harmful Algal Blooms (HABs), etc. Although limited to the lowest trophic levels, such estimates in the optically complex coastal ocean and river plumes will provide data needed to constrain the ecosystem components of the coastal ocean models. Most of these studies are still in their development phases and thus in need of considerable resources to make progress. For this reason, approximately 40% of Year-3 Non-Administrative (Research and Outreach) funding goes into aspects of Ecosystems research. The Coastal Ocean Application and Science Team (COAST) activities for HES-CW GOES-R Risk Reduction account for much of this funding, even more so starting in Year-4. Because of this, statistics for Year-4 are given both with the COAST project included and excluded. This is true also in Section 4, Table 4.1 and the Year-4 pie charts. In Year-4 with COAST included, 61% of Non-Administrative funding covers Ecosystems research. This drops to 20% of the funding if COAST is excluded.

- **Weather and Water: Serve Society's Needs for Weather and Water Information -** Many of CIOSS' activities in its first four themes address the need for improved information about surface winds (weather) and environmental conditions over and within the upper ocean (water). Among these activities, a major focus is on new or improved high-resolution fields in the coastal ocean, where the spatial scales of ocean features decrease and some forms of remote sensing (especially active and passive microwave sensors) are often "blanked out" over a region next to the coast (25-100km wide), due to contamination of the EMR signal by the nearby land. Since this is the region of primary interest to the IOOS coastal operational applications, research to improve these fields will have the direct effect of improving the operational use of oceanographic remote sensing products. Reducing the width of the satellite data gaps next to the coast will extend the fields of ocean SSH and geostrophic currents (from the altimeter) and vector winds (from active or passive microwave instruments) closer to the coast. Increasing the spatial and spectral resolution for ocean color will better resolve small patches of HABs and extend the data into the narrow arms of estuaries. Increasing the resolution for SST (combining the all-weather microwave and cloud-limited IR instruments) will better define the locations of ocean fronts associated with jets and plumes. Operational applications include shellfish and beach closures, search and rescue, fisheries management, designation of marine sanctuaries, etc. Approximately 36% of CIOSS' Year-3 funding for Non-Administrative activities has a primary focus on the Weather and Water Mission Goal. In Year-4, 27% of the funding is covered by the Weather and Water Mission goal if COAST is included; this increases to 56% if COAST is excluded.

- **Climate: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond –** One type of climate research investigates the processes involved in climate change, with the goal of incorporating more accurate representations of those processes in climate models. For this, long records are less important than accurate representations of the processes. An example of this type of research is the use of ocean color data in examining the processes involved in the ocean carbon cycle. Techniques that allow estimates of CO_2 concentrations and air-sea fluxes (from combinations of ocean color, SST, winds) are needed to understand the ocean's role in the global carbon cycle, especially in the coastal ocean. Often we don't even know the sign of CO_2 fluxes in coastal waters, due to the scarcity of in situ observations and large variations in fluxes over short time scales (several days) and spatial scales (10's of kilometers). Some of the CIOSS ocean color work has a focus on these concentrations and fluxes.

Another type of climate research involves the direct observations needed to detect climate change, requiring longer records. The length of oceanographic satellite data sets are approximately 25 years for SST, 14 years for SSH, 9 years for ocean color (with possible comparisons to data from the less sensitive CZCS sensor, 25 years earlier) and 7 years for broad-swath OVW (QuikSCAT). Winds from the narrower-swath European scatterometers on the ERS satellites cover approximately 14 years, similar to the altimeter SSH record. The SST and SSH records are long enough, and have been used to document the details of interannual variability (El Niño and La Niña events, anomalous warm and cold conditions along the west coast, etc.). Ocean color and wind data have also recorded the onset of El Niño events (1997) and other unusual conditions, but are not yet long enough to define climate and changes in climate. Within the present CIOSS projects, GLOBEC is funding work that uses the longest satellite, in situ and model data sets to investigate the connection between the basin-scale circulation in the north Pacific and the mesoscale circulation in the California Current and the Gulf of Alaska. Other activities focus on techniques needed to detect climate change or the sensor and algorithm characteristics needed to form long, consistent "climate data records" (CDRs). CIOSS has held one workshop and will hold another on ocean color CDRs, to define their necessary characteristics. Other projects are comparing the OVW records from WindSat (a passive microwave sensor) with SeaWinds (an active scatterometer on the QuikSCAT satellite). One goal is to quantify the degree to which a change from the active to passive microwave sensors will compromise OVW CDRs that are constructed from the combination of the different types of sensors. CIOSS Fellows are also involved in discussions within NCDC that are defining NOAA's role in the formation of satellite CDRs. Approximately 24% of the Year-3 CIOSS funding for Non-Administrative tasks is for projects that address the Climate Mission Goal as their primary focus. In Year-4, 11% of the funding is covered by the Climate Mission goal if COAST is included; this increases to 23% if COAST is excluded.

- **Commerce and Transportation: Support the Nation's Commerce with Information for Safe, Efficient, and Environmentally Sound Transportation –** Although none of the present CIOSS projects have a specific focus on transportation, projects that increase our ability to observe and model the ocean circulation and improve measurements and forecasts of winds, weather and ocean conditions have obvious applications to marine transportation in helping vessels to avoid hazardous conditions, aid in search and rescue, plot courses that use the currents to reduce fuel consumption, etc. Table 3.1 identifies 15 projects or activities that involve ocean circulation or winds and have an impact on the Transportation NOAA Mission Goal, with budgets total approximately 34% of the Year-3 Non-Administrative funding. In Year-4 this figure is 24% with COAST included, 49% if COAST is excluded.

- **Mission Support: Provide Critical Support for NOAA's Mission –** Research areas for this Mission Goal include::
    - **New technologies for in situ and surface-based measurements**
    - **Advanced space-based sensor technology**
    - **High-performance computing, visualization and scientific information technology; and**
    - **Advanced observing platforms and systems.**

  The first CIOSS Theme is focused on sensors and algorithms and the second on the products derived from data produced by those sensors and algorithms, both examples of space-based sensor technology. Although not the primary focus of CIOSS, within COAS there is a long history of developing technology for in situ measurements of the ocean, with present expertise in multi-disciplinary ship-based measurements of: physics of circulation and mixing; chemistry and biology of the full water column; and geology, chemistry and biology of the ocean bottom. Technology is being developed for measurements of physics, chemistry and biology, using autonomous gliders and AUVs for unmanned vertical sections of the ocean. One group has a focus on working in the nearshore environment, consisting of water from the inter-tidal region out to approximately 15m depth. Another has a history of using new technology (time-lapse photography, sensors on jet skis and autonomous aircraft) to study currents and sediment transport in the very nearshore region, caused by the interaction of waves and nearshore topography. Applications for this group include beach erosion and deposition. Coastal radar technology is also being developed to measure surface currents within approximately 150km of the coast. The COAS strength in new technology for ocean observations is one of the reasons its faculty and staff are leaders in the IOOS observing system for the nations coastal waters.

COAS also has a history of high-performance computing using new techniques. A decade ago, this consisted of massively parallel computing. More recently, advances in operating systems have made it practical to cluster numbers of CPUs to achieve high performances. The modeling groups in CIOSS make use of this technology.

Finally, the next generation satellites include the consideration of new platforms, as well as configurations for multiple platforms. CIOSS Fellows are involved with plans for those systems through individual research and participation in working groups with a specific focus on new platforms and sensors.

Table 3.1 identifies 17 projects and activities that contribute to NOAA Mission Support, with budgets totaling approximately 46% of the Non-Administrative funding during Year-3. In Year 4 the figures are 64% with COAST included, 25% with COAST excluded.

Besides the above Strategic Mission Goals, NOAA states two more general goals:

- **Providing Organizational Excellence:** As a soft-money institute, COAS faculty must compete successfully for competitive research grants and publish in peer-reviewed journals. These factors keep the level of excellence and productivity at the highest level. CIOSS provides the connection between academic Fellows in CIOSS/COAS/OSU and other universities and Federal research partners at NOAA, which serves to keep NOAA research up to date and of high quality. Training and education at all levels is meant to provide competence in the workplace at NOAA and research groups which involve remote sensing of the ocean and its air-sea interface.

- **Setting Cross-Cutting Priorities:** NOAA includes these priorities:
  - **Developing, valuing and sustaining a world-class workforce**
  - **Integrating global environmental observations and data management**
  - **Ensuring sound, state-of-the-art research**
  - **Promoting environmental literacy**
  - **Leading international activities**

The CIOSS Themes and activities include all of the above priorities. CIOSS/COAS educational and training activities are designed to develop a world-class research workforce in remote sensing, modeling and observational techniques for all branches of oceanography and some aspects of atmospheric science. Integrated observations and data management will be carried out through CIOSS/COAS connections to the operational IOOS observing and modeling system, as well as the NSF ORION system of cabled observatories. Our partnership with the CoastWatch program covers some of the data management functions. Sound, state-of-the-art research is the foundation of CIOSS/COAS success in a competitive, soft-money environment. Work at the high-school level (through SMILE) and at public science museums with an oceanographic focus (such as HMSC) increases environmental literacy in oceanography and remote sensing research. Many of CIOSS Fellows' research projects involve collaborations within international remote-sensing teams, such as those established for altimetry (U.S., France and now many nations), scatterometry (U.S., Japan and Europe) and ocean color (U.S., Canada, Europe and India). Other international collaborations exist at the level of individual research projects.

C. What are the goals of CIOSS?

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:

- 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;
- Collaborate with NOAA research scientists in using satellite ocean remote sensing through: 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;
- 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
- 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.

The relationships between the CIOSS research activities and the NOAA Mission Goals is described in the preceding section (Section 2B). Collaborations between NOAA and CIOSS research scientists are summarized below under "Scientific Partnerships" (Section 3) and described in detail in the "Science Review" (Section 4) within individual project summaries, as well as within "Technology Transfer" (Section 5). The involvement of graduate students, post-docs and research scientists in joint research projects is also found in the Sections 3 ("Scientific Partnerships") and 4 ("Science Review"). The broader educational and training activities contained in the fourth bullet of the Mission Statement are described in Section 6 ("Education and Outreach").

D. What criteria are used internally to measure progress in accomplishing the CIOSS Mission?

The criteria used to judge progress in achieving the CIOSS goals are primarily those stated in the "Performance Measures" for Administration, Research and Outreach activities, found in the original CIOSS Five-Year Plan, with some modifications based on our experience since the writing of that document:

PERFORMANCE MEASURES

- The performance measures for CIOSS as an administrative unit include: evaluation and selection of proposed projects; the timely preparation of annual reports and 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; inform the oceanographic community on issues of importance to NOAA's oceanographic remote sensing plans and activities, communicating feedback from the community on those issues to NOAA and other agencies; plan and hold workshops, including those that evaluate present and future satellite systems; provide support for informal education; and develop or improve technologies that provide access to data for research scientists, managers and the public.

Methods used to assess the success of administration, research and outreach vary. Assessing the performance of the Administration in general and of the Administrative Specialist is the responsibility of the Director, who writes an annual performance report for the Administrative Specialist. For Outreach within the SMILE program, Ryan Collay calls periodic meetings of the CIOSS Director and Administrative Specialist with SMILE personnel, both to assess progress and to plan for the themes and activities of the SMILE high school program.

Means to assess the research performance have evolved over CIOSS' first four years. Reviews of individual scientists are conducted primarily at the College level by the Dean of COAS. Reviews of individual post-docs are conducted by their supervisor. At the CIOSS project level, each project must contribute a short annual progress report that becomes part of the CIOSS Annual Technical Report. The Year-3 Annual Technical Report is included as an appendix, but the individual project reports (some updated) from that Annual Report are also included in Section 4, the Science Review.

To facilitate in the review of the projects, during Year 4, CIOSS instituted an internal review process, consisting of presentations of project results during two half-day sessions, open to all of COAS. The general outcome of the Internal Review was positive, with statements that these two sessions were the best internal symposia held at COAS in some time. The Internal Review symposia will continue as an annual event and should, in principal, be connected to the internal proposal review process. The timing of making this connection of reviews and proposals is a problem, however, due to NOAA's inability to fund projects in a timely manner. Thus we are being asked to submit next year's annual Omnibus Proposal as early as October, but funding for projects that started last April are not arriving until the end of September. This makes it difficult to use a review of this year's progress as the basis for selection for next year. Never-the-less, we will continue to use the "symposium" format for assessment of annual progress (in addition to written progress reports) and expect that the details of this format will continue.

E. What is the CIOSS Task Structure and what are the major scientific CIOSS Themes?

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. Task II consists of research and additional outreach projects that are funded by NOAA/NESDIS. Task III includes additional research and outreach projects that are funded by agencies other than NOAA/NESDIS. These agencies include other NOAA Line Offices and any other Federal or non-Federal sources of funding.

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, as they are added to the CIOSS office;
- **b.** Necessary funding for domestic and international travel for the Director and CIOSS staff;
- **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 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, Funded by NOAA/NESDIS

Provides support for research projects in CIOSS' Research Themes; provides support for outreach beyond that covered in Task I (additional workshops and short courses, formal and informal education, improvement of data access). Task II includes all activities funded by NESDIS offices, except those included in Task I (core administration and outreach). These include projects funded by STAR/SOCD through the annual omnibus proposal, along with other projects funded by NESDIS, through proposals addressed to specific funding opportunities. Details of these projects are developed in each proposal.

Task III: CIOSS Research and Outreach, Funded by Agencies other than NOAA/NESDIS
Provides support for research projects in CIOSS' Research Themes and outreach projects, similar to those in Task II, when funded by agencies outside of NOAA/NESDIS. Details of these projects will be developed in each proposal, as specific opportunities are identified.

CIOSS Themes: The following five themes of mutual interest to NOAA and OSU are stated in the Five-Year Plan and are being pursued during the initial five years. The wording from the Five-Year plan has been changed slightly, based on ongoing experience in our research activities.

- **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 using methods of inverse modeling. For some applications, the ocean models will 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.

1. How were the CIOSS Themes identified?

As described in the Overview (Section 1) and repeated here, the CIOSS Themes follow naturally from the CIOSS Vision Statement (Section 2A) and Mission Goals (Section 2C). The simplest summary of the CIOSS vision/mission is that it will enhance and improve the use of satellite remote sensing for oceanographic research, operational applications and education/outreach. To do this, CIOSS activities must start with research needed to plan and evaluate satellite *sensors* and algorithms, in order to ensure that the best "level 0" data are collected (**Theme 1: Satellite Sensors and Techniques**). Basic data derived from the sensors using the lowest-level algorithms must then be converted into higher level *products* needed to obtain the information needed for research, applications and outreach. These usually take the form of 2-D fields of geophysical parameters at the air-sea interface, sometimes representing fluxes (of momentum, heat, gases) between the ocean and atmosphere (**Theme 2: Ocean-Atmosphere Fields and Fluxes**). The fields and fluxes represent both driving forces for the ocean (wind stress, heat and fresh water fluxes) and its response (circulation and biological). One use of the flux fields is to force numerical *models* of ocean circulation and ecosystem response. The fields of state parameters (SST, SSH, chlorophyll-a concentrations) allow an evaluation of the models, which give a more complete view of the changing 3-D fields in the ocean than possible with any type of observations. The state variables may also be assimilated into the models to constrain the unknown or poorly represented processes (**Theme 3: Ocean-Atmosphere Models and Data Assimilation**). To better understand the physical and biological processes in the upper ocean, *analyses* of combinations of satellite data, model output and in situ data allow us to test hypotheses regarding those processes (**Theme 4: Ocean-Atmosphere Analyses**). This may lead to an iteration of the research cycle, resulting in improved sensors and models. Even the most basic research is not conducted in a vacuum and research funded by NOAA has an even greater need to connect to societal benefits. This requires communication of the research results and "education" in the broadest sense. **Theme 5: Outreach** thus consists of *formal and informal education* at all levels. This prepares students for careers in remote sensing (at NOAA or elsewhere), increases the "environmental literacy" in the public, and develops an appreciation for science in general, in a very tangible form.

2. How have they evolved (over the last decade)?

Given its short 4-year history, the CIOSS Themes have not changed substantially during its first 4 years, although there have been refinements in how we assign specific projects to the first two themes. The original wording did not distinguish clearly between the "techniques" included in Theme 1 and the "methods" needed to create improved fields in Theme 2. We now assign research on sensors, sensor design and the lowest level algorithms and parameters (usually some form of radiances or brightness temperatures) to Theme 1, with methods of producing geophysical fields from those lower level data considered to be covered in Theme 2. There is also some overlap between Themes 2 and 4 (analyses in general), which we have clarified somewhat in considering Theme 4 to involve the study of physical and biological processes, using the products from Theme 2 (and data from models and in situ observations). These are minor refinements, rather than major changes. Considering the future, however, we do not envision changes in the five Themes as presently expressed above, given their broad nature. We do expect the mix of projects addressing each Theme to evolve, in response to the changing emphases and needs of NOAA and other funding agencies engaged in remote sensing of the ocean and air-sea interface.

What has evolved more during CIOSS' first 4 years is our approach to how we address the CIOSS Themes. Our initial approach, as described in the original proposal that was funded by NESDIS, was to use the entire core research funding amount to hire post-doctoral research fellows who were assigned specific projects within one of the first four Research Themes. This strategy was based on our need at the time to entrain early-career scientists into remote sensing research at COAS, along with the emphasis on mentoring and training in the original NOAA call for proposals that lead to the formation of CIOSS. To accomplish this, we solicited "post-doc proposals" in the CIOSS Theme areas and selected six of those to fund, based on reviews by both the CIOSS Council of Fellows and our NOAA program manager (Eric Bayler), who involved his "branch chiefs" in the review, as well. During the first two years, however, we found that the attraction and hiring of post-docs was an uncertain and lengthy process, resulting in the hiring of post-docs with a wide range of capabilities and likelihoods for success. This is in comparison to the existing personnel within CIOSS/COAS, who are extremely capable of accomplishing specific research goals. Thus, in its third year, CIOSS began a process of soliciting proposals from its Fellows for more traditional projects, focused on specific research topics within the first four Research Themes, which could be accomplished by support for PIs, technicians, post-docs and students. Priorities for specific topics were provided by our NOAA program manager and the evaluation of the proposals was again accomplished using a review by the local Council of Fellows members and a review by Eric Bayler and his staff. This approach is producing more timely results and was repeated in developing our omnibus proposal for Year-4.

The most development or evolution in CIOSS research has been in the projects that fall outside of our Core Projects. The best example is found in the Risk Reduction activities for the future GOES-R satellite series. Prior to the inception of CIOSS, there were existing collaborations between COAS and NOAA research scientists within the ocean color community. During the first year of CIOSS, one of the Core post-doc projects consisted of efforts to collocate in situ measurements of chlorophyll-a pigment concentrations and satellite measurements from the SeaWiFS and MODIS sensors, which could be used to develop, evaluate and improve future ocean color algorithms. At the same time, discussions between CIOSS and NESDIS led to a proposal to establish a multi-institutional team of ocean color experts (with Federal, Academic and Private Industry representatives) that would establish the technical requirements for a future hyperspectral or multi-spectral color sensor for the GOES-R geostationary satellites (nominally to fly in 2012). This sensor would provide observations of biological parameters in U.S. coastal waters, with repeated observations during each day, allowing the examination of the diurnal cycle from space for the first time. A proposal was funded to form the team – the Coastal Ocean Applications and Science Team (COAST) – and to begin the process of providing the necessary specifications, writing documents and brochures to build support for the instrument within the ocean color community, and planning the collection of field data that will allow the development of algorithms necessary for the new sensor. These planning activities continued during Year-3, while a comprehensive proposal was written for the much more expensive field program, involving research scientists from half a dozen universities, NOAA and NRL laboratories. Three locations were chosen for field work during a sequence of three years, representing the west coast (Monterey Bay), the east coast (an unspecified location in the New York or Mid-Atlantic Bights) and the Gulf Coast (location to be determined). The proposal period could only extend until the end of the present CIOSS 5-year cooperative agreement and so covers the first two field years. The proposal was approved and field-work began in early September 2006 in Monterey Bay.

The COAST illustrates the development of a major program within CIOSS, designed to meet specific NOAA objectives, while also representing basic research of mutual interest to NOAA, CIOSS and a variety of universities and federal laboratories. It will ultimately make use of the data collated in the first "post-doc" project, as well as the new data collected by the program's field work. There are a number of other projects within CIOSS (some CORE and some supplemental) that are complementary to the COAST efforts, including efforts to help define Climate Data Records for ocean color sensors (two workshops, one already held), to help in evaluate design changes in the "MOBY-2" buoy that will be used for vicarious calibration of new ocean color sensors (one workshop), a project to use existing hyperspectral (Hyperion) satellite data to prepare for the new sensor, and a related project using satellite and field data to investigate harmful algal blooms off Oregon.

We hope that the COAST project will serve as an example for development of other topical research areas, which are underway but have not grown to the same scope as COAST. As we did for ocean color, we are using Core funding to support pilot projects that we hope will grow. One research area with similarities to that of ocean color has a focus on ocean vector winds (OVW). Existing collaborations between COAS and NOAA OVW research scientists have been strengthened within the CIOSS framework. Collaborative projects have now been funded with both Core support and additional "Research and Operations" funding from NOAA that are evaluating and combining the scatterometer and passive microwave (WindSat) OVW data, as well as refining algorithms that produce OVW fields with the higher spatial resolution that is needed for work in the coastal ocean. Two workshops have brought together marine forecasters from NOAA that are knowledgeable about the operational requirements for OVW products, with research scientists (NOAA and academic) that are knowledgeable about the sensor and wind field characteristics. Of all the parameters under study at CIOSS, the future of OVW sensors is the most in jeopardy. We hope that the results of these workshops will be used in the rescoping of the NPOESS CMIS wind sensor and that these research and outreach efforts will continue to be supported by NOAA.

A third example of a research field that is being pioneered at CIOSS and that we hope to expand is provided by the efforts in coastal ocean modeling and data assimilation. In this case, the pre-existing collaborations were between COAS coastal modelers, other academics and federal research scientists at both NOAA and NRL. The collaboration with NRL modelers is through past and present NOPP projects. The collaboration with NOAA modelers is within the context of the U.S. GLOBEC project in the NE Pacific (NEP). Two of the initial CIOSS "post-doc" projects supported modeling and model analysis. One involved analysis of the NRL model to look at the dynamics of the poleward California Current undercurrent. The goal of that effort was to determine if altimeters could monitor the strength of the undercurrent. The second (ongoing) project involves the assimilation of both altimeter (SSH) and coastal radar (surface velocity) data into coastal circulation models. Within the U.S. GLOBEC NEP project, there was also a call for coastal circulation models. The funding from CIOSS was used to leverage a successful proposal to support a post-doc to do the model and data-assimilation development, with partial funding from both CIOSS and GLOBEC. At the same time, a NOPP proposal was submitted and funded to nest coastal models within the Navy's (NRL's) models, providing additional resources for the nesting activities. In addition, GLOBEC is funding "ecosystem" modeling at COAS for both the lowest trophic levels (NPZ = nutrients, phytoplankton and zooplankton) and at higher levels (IBMs = Individual Based Models of zooplankton and fish), which are nested within the physical circulation models. The GLOBEC funding (from NOS) is sent through CIOSS for logistical reasons. In addition to the CIOSS/GLOBEC funded modeling projects, CIOSS is supporting or partially supporting two other modeling pilot projects. In one, winds from weather forecast models are being used to force a coastal model extending several days into the future. This represents a pilot coastal ocean forecast system. In the second, a truly coupled atmosphere-ocean model is being developed in a coastal domain, with both CIOSS and NRL funding.

This hierarchy of nested physical and biophysical coastal models at CIOSS/COAS provides us with a concentrated level of effort and expertise that is exceptional within the U.S. modeling community. Making use of their leadership in the field, CIOSS is hosting a workshop for the leading coastal modelers and data assimilation experts in the nation, to be held in April 2007. With few exceptions, the invitations have been enthusiastically accepted and we envision a workshop that will define the present state of the art in coastal modeling and data assimilation. Those invited include representatives from NOS and NRL, where we expect the responsibility for coastal modeling to reside within the IOOS system. Part of our motivation in laying the framework for this modeling development is the possibility that NOS or other NOAA offices such as the Joint Center for Satellite Data Assimilation (JCSDA) might establish a more formal team at CIOSS for coastal model development, similar to the COAST project. If this were to happen, then support from NOS for the continuation of the present Core modeling projects would free funds for new pilot projects.

In addition to the development and growth of projects within the four Research Themes, activities within the Outreach Theme (Theme 5) have also evolved. During our first year, we explored the creation of a public display at the Oregon Museum of Science and Industry (OMSI) in Portland, Oregon. CIOSS Fellows had previously worked with OMSI to create a display centered on remote sensing of El Niño effects in the Pacific Ocean. For CIOSS, however, OMSI requested a level of support ($100K-$250K) beyond what CIOSS had available. At that time, CIOSS began discussions with the Director of the Hatfield Marine Science Center’s (HMSC) Public Wing, which is run by Oregon Sea Grant. These discussions remained at a relatively low level until Year-3, when a graduate student (Molly Phipps) entered the new “Informal Education” program at OSU, which is a joint program between Sea Grant and OSU. CIOSS agreed to help fund her PhD research project, which is to evaluate methods used in public displays, using the HMSC Public Wing as a laboratory. This work is underway and we hope for a final pilot display within a year.

The other major educational activity under the Outreach theme is our support for the High School component of the SMILE program. During CIOSS’ Year-1, funds from our Core Administration component were redirected to provide initial support for SMILE to develop science modules (“club activities”) for the after-school SMILE clubs, which meet weekly. The activities had themes of oceanography, remote sensing and mapping. During Year-2, a separate proposal to NOAA provided support to continue this work. During the school year, the activities developed during Year-1 were used and the culminating 2-day “High School Challenge” focused on an oil-spill scenario, in which teams of high school students devised solutions to a developing spill. During Year-3, support for SMILE was provided as one of the individual funded projects and a new set of activities and High School Challenge scenario (centered on fisheries management) were developed and used. During This activity is being continued during Year-4, with additional support from a newly funded NSF Science and Technology Center (STC) project. The STC project is a collaboration between COAS, the

Oregon Health and Science University (OHSU) and the University of Washington, with some of the same people involved as in the NANOOS IOOS Regional Association (including CIOSS Fellows). The goal of the STC support is to broaden the geographic coverage of SMILE and develop educational modules with a coastal oceanography theme. Thus, as with the Research Themes, a small amount of initial and continuing support has evolved into a larger program (using the existing SMILE structure) that is educating high school students in topics related to oceanography and the uses of remote sensing in oceanographic research and operations.

The original call for proposals that established CIOSS expressed the expectation that the new CI would grow, with additional NOAA funding, to reach approximately $1M per year by the end of the 5 years. Although we (at COAS) were confident in our ability to attract additional research funding, the exact manner in which that would happen within a new NOAA Cooperative Institute could not be envisioned when the proposal was made. For instance, we were unaware of the type of Risk Reduction efforts undertaken by NESDIS for future satellites. That activity is presently providing the largest source of additional support for CIOSS (in COAST). The above examples provide specific models of the way in which we expect CIOSS to continue to evolve during the second five-year period. As a metric, the total for CIOSS proposals for Year-3 was $2.1M and for Year-4 is $3.3M, compared to the original goal of $1M per year by Year-5.

3. Which themes/sub-themes are near completion?

As should be evident from the material presented above, none of the broad CIOSS Themes are intended to be "completed" during the lifetime of CIOSS, in the sense that they need to be eliminated. Individual projects within each theme have been completed and others will be completed at various times. Several examples illustrate the manner in which we expect projects to be completed, while leaving a history of collaborations that expands the CIOSS research domain.

- During years 1-2, the post-doc project of MacCallum assembled a collocated set of satellite and in situ ocean color measurements. The initial project is completed and the data set is available for algorithm development in the COAST project.
- During Year-1, the NOAA Coastal Services Center in Charleston, SC, funded Geographical Information System (GIS) work for members of the OSU Geosciences Department through CIOSS. This effort resulted in the use of IKONOS 1-m data for mapping coastlines. It also provided partial support for the collection of subsurface, high-resolution bottom topography data, which have been placed into GIS map formats by the Oregon Sea Grant program. Although there are no coastline or bottom topography mapping efforts in CIOSS at this time, this initial GIS project provides a basis for future collaborations in mapping projects.
- A second post-doc project (Choboter) from years 1-2 consisted of the analysis of the NRL model fields to study the poleward undercurrent in the California Current. The analysis is nearly complete but has been placed on the "back-burner", due to the departure of the post-doc. There are plans to complete this work, but this experience illustrates the risk of placing the responsibility for specific projects solely with post-docs, for whom a priority is to move on to a more permanent position, when an opportunity becomes available.
- Another of the initial post-doc projects (Guo) has just been completed (August 2006). In this project, methods of making estimates of surface short-wave and long-wave radiation from AVHRR data were developed and evaluated. A paper describing this

work is being completed, making the results available to the community. After completing his post-doc, Guang Guo moved to work for I.M. System Group, Inc. (IMSG). IMSG is a contracting company that provides scientific and technical support to NOAA on GOES and other satellite projects.

- A final example of the successful completion of a research project is provided by the Year-3 effort to analyze infrared measurements of SST from the GOES-10 geostationary satellite to map surface SST fronts in the California Current. This work was carried out by Renato Castelao, a student of CIOSS Fellow Jack Barth, in collaboration with Tim Mavor in NOAA/STAR/SOCD. This work consisted of analysis of SST fields provided by Mavor and resulted in two peer-reviewed publications (also part of a PhD dissertation), which will both publicize the availability of the data sets and demonstrate their utility. This project, along with the post-doc project of Guo, represents the model for successful "stand-alone" projects. Castelao has recently started work as a post-doc at Rutgers University. CIOSS Fellow Dudley Chelton is analyzing the GOES-10 SST data in collaboration with Castelao to investigate SST influences on wind stress over the California Current System

These projects represent examples of the way in which completed individual projects may provide an immediate basis for new projects, may end with publications that disseminate the results or may be placed aside for future continuations.

4. What are the emerging theme areas? Why?
5. Are any changes in program emphasis being considered for the next cycle?
These questions are related and are addressed together.

As stated above, the five basic CIOSS Themes are not expected to change. They cover most projects that we presently envision. Projects within these Themes do evolve, resulting in changing emphases within and between the Themes. We expect that several factors will play a major role in the evolution of CIOSS projects.

The first is the ongoing rescoping of the NOAA NPOESS suite of satellite sensors, which will require continued efforts on Theme 1 (Sensors and Techniques). CIOSS Fellows are helping to write a joint NOAA-NASA white paper that is meant to evaluate the impacts of the changes in NPOESS sensors that resulted from the Nunn-McCurdy recertification process. Thus, while our initial efforts with respect to sensors concentrated on Risk Reduction for the GOES-R HES-CW color sensor and evaluation of ocean vector wind fields produced by the WindSat passive microwave sensor, it is likely that we will expand our research to include the NPOESS VIIRS sensor (for ocean color and temperature) and the "CMIS-Lite" replacement for the CMIS (OVW) sensor.

On a broader scale, CIOSS Fellows Dudley Chelton and Michael Freilich led the efforts that resulted in a community letter to the NRC Decadal Survey Steering Committee, signed by 753 U.S. and international research scientists. This committee is writing a report that will set priorities for the development and deployment of new NASA research satellite sensors over the next several decades. The community letter summarized the need for sensors used by oceanographers for research and operations, providing material that had been previously omitted from the draft Decadal Survey Report. We expect the issues regarding future satellite sensors, as presently represented by the plans for NPOESS rescoping and by the Decadal Survey Report, to continue for the foreseeable future. CIOSS will continue to play a leading role in research, planning and community outreach activities that promote the best instruments for oceanographic satellite studies.

The second factor that will shape CIOSS' emphasis is the continued development of coastal and basin-scale ocean observing systems. These are represented by the multi-agency IOOS operational system(s) and by the research-oriented systems planned by NSF in the ORION (Ocean Research Initiative Observatory Networks) program. Especially within the IOOS system, CIOSS will continue to work with CoastWatch and the closest of the west coast IOOS Regional Associations (NANOOS and PaCOOS) to define, evaluate and improve remote sensing products that are useful within the context of these operational systems. CIOSS will continue its research in CIOSS Theme 2 (Fields and Fluxes) and to transition that research to operations, using CoastWatch as the present outlet for products. CIOSS will continue outreach (CIOSS Theme 5) that includes those products in educational materials (such as SMILE) and science museums (such as HMSC). CIOSS will also continue to help define what the future observing systems should be. As an example of that type of community outreach, CIOSS is co-sponsoring (with the JIMAR CI at Scripps) a workshop on the effects of climate variability/change on California Current ecosystems (November 14-16, 2006).

An integral part of the planned observing network is a system of nested models of the basin-scale and coastal ocean, including ecosystem components. This suggests an expanded emphasis on CIOSS Theme 3 (Models and Data Assimilation). In September 2005 at a meeting of the CIOSS Working Group on Dynamics and Modeling, Frank Aikman (NOS) and John Allen discussed the possibility of forming a separate CI at COAS for coastal modeling. Present NOAA policy makes the establishment of a new CI at OSU unlikely. Moreover, a new CI is unnecessary, since the CIOSS MoA is between OSU and NOAA at the highest levels and encompasses modeling activities in Theme 3. Thus, an extended modeling team can be coordinated within CIOSS, led by CIOSS modelers. The structure of that team remains to be defined. It might start as a smaller, focused effort within CIOSS, expanding to include participants from many universities, federal labs and private consulting firms, similar to the team formed for the COAST project. Research by members of this team, communicated by regular workshops, could be transitioned to operational models at NOS, NRL or elsewhere. This is one area where real expansion and increased emphasis may occur during the second five-year period. The coastal modeling and data assimilation workshop scheduled for April 2007 will provide a venue to discuss this development further.

The only CIOSS Theme not mentioned above is Theme 4 – Ocean and Atmosphere Analyses. This is a broad theme, which could encompass most of what is included in the more focused Themes 1-3. We use this theme to concentrate on research that focuses on processes, using any data sets (satellite, in situ, model output) that can be used to improve our understanding of those processes. This improved understanding feeds back into the improvement of the sensors, products and models in Themes 1-3. The expansion and contraction of projects in Theme 4 depends on the availability of funding for specific projects.

6. What projects would CIOSS stop or start, given level funding or increases/decreases of 10%?

Funding for CIOSS consists of a Core amount of $500K per year. This was written into the Announcement in the FRN, as was the requirement that no more than half of that can be used for Task I, administration and Core Outreach. The non-administrative part of this Core funding is used for Task II, Core Research and Additional Outreach. As explained above in describing the evolution of our approach to research, Core Research funds in years 1-2 were used to fully or partially fund post-docs, working on the first projects chosen to address CIOSS Themes. The Council of Fellows served as an initial review panel, followed by a review at NESDIS/STAR/SOCD by Eric Bayler and his Branch Chiefs. Starting in Year-3, these funds were used to fund specific individual projects, selected from proposals submitted to the CIOSS Council of Fellows. These were again reviewed in a two-step process by the CIOSS Council and by NESDIS/STAR/SOCD. This procedure was followed again in Year-4 and will continue to be used in the future, assuming level funding. If Core funding decreases, we will first attempt to decrease the funds used for administration, while protecting the salary of the CIOSS Administrative Specialist who runs the office. Without a full-time person in this position, CIOSS could not function. If the funding for Core Research decreases, the number of projects funded will decrease, but the present procedure for selecting the projects to fund will continue.

If the Core funding increases, the Council of Fellows will consider the options available, working with our NOAA Program Managers. An example of this occurred in Year-3, when an additional $100K was made available in Core Research funds, with an associated list of priorities from our Program Manager, Eric Bayler. The result was to increase the available funding for the Year-3 proposals, noting the priorities expressed by NOAA for the extra funding. The top priority for the extra funding was for research that made use of existing hyperspectral data and the additional research project chosen did exactly that. This fit nicely into the COAST project, which includes the possibility that the GOES-R HES-CW sensor will be a hyperspectral instrument.

Besides additional research, however, there are several needs within CIOSS that would improve our ability to interact with NOAA. In order of priority, these are:

- The immediate need for a Deputy Director, to oversee existing and new outreach activities, aggressively seek out new opportunities for NOAA partnerships, arrange logistics for scientific exchanges and help in the day-to-day administrative tasks.
- The need for a dedicated scientific analyst, to help transition research at CIOSS to products at CoastWatch and other NOAA offices; to help define the need for new products at CoastWatch and within the IOOS system.
- The establishment of a more formal “Modeling and Data Assimilation Team” within CIOSS, interacting with NOAA, other Federal agencies and academic institutions to help NOAA develop the modeling capabilities for coastal ocean modeling and prediction in the IOOS era.
- The establishment of an REU (Research Experiences for Undergraduates) program to promote undergraduate research in CIOSS Theme areas and increase the number of graduate students in those disciplines, which is vital to NOAA’s future needs for scientific personnel.

During CIOSS’ first 4 years, Mike Freilich has served as Deputy Director, while primarily acting as the Associate Dean of COAS. Advice to CIOSS was considered part of the duties of the Associate Dean and Dr. Freilich took no salary from CIOSS for his work as Deputy Director. Those funds were used, instead, as start-up funds for the outreach efforts at SMILE and HMSC, which were not initially part of the budget. Dr. Freilich is moving to NASA for several years in the role of Director of the Earth Science Division in the Science Mission Directorate (beginning in November, 2006). At the same time, CIOSS activities are taking far more of the CIOSS Director's time than is presently covered by CIOSS funding. Thus, there is an immediate need to consider funding for a Deputy Director. The Deputy Director (DD) would be of immense value in increasing interactions with the other CI's, NESDIS and other NOAA line offices, leading to the development of new collaborations and projects. The DD would also oversee education and outreach activities, help in the preparation of progress reports and proposals and engage in the day-to-day operation of the CIOSS Office, working with the Administrative Specialist. At present, the Director fulfills all of those tasks, but his travel schedule results in significant periods of time when the Administrative Specialist must conduct CIOSS business alone.

A second critical, need is for a full-time specialist for data analysis and product development. The primary task for this position would be in the transition of research results to products for CoastWatch, other NOAA operational units, other IOOS partners (State and local resource managers), etc. This would involve serving as a scientific liaison to our partners at NOAA and elsewhere, to some degree compensating for the lack of local NOAA personnel. The Scientific Analyst would actively work with those partners in defining the need for products that could be developed from CIOSS research in both remote sensing and modeling. This may, in turn, affect the priority given to different research projects and activities. Note that a NOAA employee could fill this role.

As described in the previous section, another use for additional funding would be to establish a more permanent Modeling and Data Assimilation Team. NOAA is expected to form the National Backbone for coastal ocean modeling and prediction in the future IOOS structure, but this capability does not presently exist within NOAA. Thus, there is a need for “Risk Reduction” for coastal modeling, similar to the Risk Reduction needed for future satellites and sensors. A modeling team might have some similarities to that of the COAST program, with a core of modelers within CIOSS working with NOAA colleagues in NOS, NCEP, the JCSDA, OAR and other government (including state and local) offices, as well as other academic institutions. The exact structure of that team remains to be defined, as do possible sources of funding. But the need for such a team and the ability of the modelers within CIOSS to form the nucleus of that team are clear. The modeling and data assimilation workshop planned for April may help in clarifying both NOAA’s future needs and the role a CIOSS Modeling and Data Assimilation Team could play in meeting those needs.

A fourth initiative that should be pursued is the establishment of a "Research Experiences for Undergraduates" program, covering the CIOSS Theme areas (both remote sensing and modeling). This could take the form of research projects for OSU undergraduates in the Honors Program (during the school year and summer) and a summer program for undergraduates from all universities. This would introduce undergraduates to remote sensing and modeling in the context of oceanography and atmospheric sciences, hopefully leading to graduate studies and/or careers in those fields. COAS had an REU program in the 1980's, which was organized by Strub. Based on this experience, we know that such a program requires a significant amount of effort to organize and run, which could be the responsibility of the Deputy Director and Administrative Specialist. Costs of such a program are modest, but may have a large impact on NOAA’s future workforce.

There is another issue facing CIOSS, on which the panel might want to comment. This is the continuation of the planned activities of the COAST project. NOAA has recently placed plans for the entire HES sensor on hold, including the Coastal Waters Imager (HES-CW). Since the initial motivation for the COAST project was risk reduction for the HES-CW, we have a concern about the continuation of the COAST activity. However, the hyperspectral, high-resolution data sets that COAST collected off the U.S. West Coast in September 2006 can be used to simulate the coverage of any future ocean color sensor, in either a polar orbit (VIIRS) or a geostationary orbit (HES-CW, its replacement, a NASA experimental sensor, etc.). The similar data sets planned for collection off the East and Gulf Coasts by the COAST investigators are vital to the development of algorithms for numerous applications in optically complex coastal waters. CIOSS would welcome comments by the Review Panel members on the value of ongoing COAST activities in collecting hyperspectral coastal optical data and using those data in the development of algorithms for future ocean color sensors.