

C I C O O R

NOAA Review

Cooperative Institute for
Climate and Ocean Research



CICOR
Woods Hole Oceanographic Institution
Woods Hole, Massachusetts
June 16-17, 2005

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Overview

This briefing book provides material describing the Cooperative Institute for Climate and Ocean Research (CICOR) and its host institution, the Woods Hole Oceanographic Institution (WHOI), and addressing the topics identified as the foci for the review.

CICOR is a NOAA Cooperative Institute sponsored by NOAA's Office of Oceanic and Atmospheric Research (OAR) at WHOI. CICOR provides a framework at WHOI for facilitating and coordinating NOAA-funded research, for building ties between WHOI investigators and colleagues at NOAA laboratories, and for developing cooperative NOAA-funded research at academic institutions. The NOAA-funded research done through CICOR consists of individual research projects funded by NOAA in response to proposals submitted by individual investigators to Announcements of Opportunity. WHOI investigators also carry on diverse research programs with funding from other Federal agencies, including the Office of Naval Research, the National Science Foundation, and the National Aerospace and Atmospheric Administration; and CICOR seeks wherever possible to leverage for NOAA the results of that research.

At the same time CICOR provides NOAA and NOAA-funded investigators access to WHOI facilities, including four ships, a manned submersible, unmanned underwater vehicles, and the Northeast National Ion Microprobe Facility. In collaboration with WHOI's Academic Programs Office, CICOR supports graduate education in the joint program between WHOI and the Massachusetts Institute of Technology (MIT), funds postdoctoral scholars, and summer student fellowships for undergraduates. CICOR is involved in outreach to enhance regional cooperation and publicize NOAA research.

CICOR has a small staff, its Director and an Administrator, with further staff support contributed by WHOI. CICOR facilitates the research of the scientific and technical staff of WHOI by establishing 5-year Cooperative Agreements with NOAA OAR that are the administrative vehicle by which NOAA research funds can be delivered to WHOI. CICOR was established with three research themes which have been carried forward in the Cooperative Agreements: 1) the coastal ocean and nearshore processes, 2) the ocean's role in climate and climate variability, and 3) marine ecosystem processes analyses.

CICOR has fostered collaborative research between NOAA scientists and university scientists and students since its inception in 1999. Research and planning activities have been carried out in partnership with NOAA's Atlantic Oceanographic and Meteorological Laboratory (AOML), Pacific Marine Environmental Laboratory (PMEL), Environmental Technology Laboratory (ETL), and Northeast Fisheries Science Center (NEFSC). The following NOAA offices and programs provide support for CICOR research: Arctic, NESDIS, NMFS, NOS, OAR, and OGP. From inception to July, 2004, CICOR research activities have resulted in 141 scientific publications, including 103 peer-reviewed publications. Since the beginning of the current Cooperative Agreement (Appendix III), CICOR has received \$19,181,183 (7/1/01-6/30/02, \$3,163,856; 7/1/02-6/30/03, \$4,694,858; 7/1/03-6/30/04, \$5,246,577; 7/1/04-1/31/05, \$6,075,892).

CICOR Review Agenda

Thursday, June 16, 2005 • WHOI Quissett Campus, Clark 507

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| <p>8:00–9:00 Review Panel Executive Session
Panel</p> <p>9:00–9:15 Welcome
<i>Bob Gagosian, President and Director, WHOI</i></p> <p>9:15–9:30 Welcome and overview of research
<i>Jim Luyten, Vice President and Director of Research, WHOI</i></p> <p>9:30–10:30 Overview of CICOR and Science Management within CICOR
<i>Bob Weller, Director of CICOR</i></p> <p>10:30–11:00 Coffee</p> <p>11:00–12:00 Highlights of CICOR Science
(20 min., 10 min. discussion)</p> <ul style="list-style-type: none">• Integration and Synthesis of the Georges Bank Broad-Scale Survey Results – <i>Peter Wiebe</i>• Harmful Algal Blooms (HABs): National Coordination and Event Response – <i>Don Anderson</i> <p>12:00–1:00 Lunch (unhosted)</p> <p>1:00–2:30 Highlights of CICOR science
(20 min., 10 min. discussion)</p> <ul style="list-style-type: none">• Ocean Reference Stations and Air-sea Fluxes – <i>Al Plueddemann</i>• Biological Control of the Vernal Population Increase of <i>Calanus Finmarchicus</i> on Georges Bank – <i>Dennis McGillicuddy</i>• Implementing the Argo Float Program: A Status Report After the First 5 Years – <i>Breck Owens</i>• Circulation and Climate Change in the Western Arctic: A Foray into Russian Waters – <i>Bob Pickart</i> | <p>2:30–3:00 Review Panel meets with CICOR Investigators</p> <p>3:00–3:30 Coffee</p> <p>3:30–5:00 WHOI facilities and education program, CICOR outreach</p> <ul style="list-style-type: none">• CICOR Task IV, ships and submersible use – <i>Bob Detrick, Vice President For Marine Facilities and Operations</i>• WHOI education program and CICOR – <i>John Farrington, Vice President for Academic Affairs and Dean</i>• CICOR outreach activities – <i>Bob Weller, Director of CICOR</i>• Discussion, question and answer <p>5:00–5:30 Executive Session of Review Panel</p> <p>5:30–7:00 Reception hosted by WHOI with Science Posters</p> <p>CICOR staff, principal investigators, graduate students, postdoctoral scholar and investigators; WHOI administration, Department Chairs and Center Directors; NOAA partners; Review Panel</p> |
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Friday, June 17, 2005 • WHOI Quissett Campus, Carriage House

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| <p>8:00–8:30 Executive Session
Review panel, CICOR Director</p> <p>8:30–9:00 Executive Session
Review Panel, NOAA partners (program managers, lab partners)</p> <p>9:00–10:30 Tour of WHOI facilities</p> <ul style="list-style-type: none">• <i>Woods Hole Village</i>
Mooring and rigging shop; Ships, submersibles, and vehicles; CAT scan; Ocean bottom seismometer lab• <i>Quissett Campus</i>
ARGO profiling float lab; Upper Ocean Processes lab; Accelerator Mass Spectrometer | <p>10:30–11:00 Coffee</p> <p>11:00–12:00 Committee Executive Session</p> <p>12:00–1:30 Lunch (unhosted)</p> <p>1:30–4:00 Committee Executive Session
Report writing/deliberations</p> <p>4:00 Debrief</p> |
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Review Team

Frank Kudrna, Chairperson

(SAB Member, panel Chair)

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Dr. Kudrna became President of Kudrna & Associates, Ltd. in March, 1986 and, since 1998, serves as the Chief Executive Officer. The firm, with offices in Chicago and DuPage County, provides diversified consulting engineering services in the areas of civil engineering to industrial, commercial and institutional clients including municipal, state and federal agencies. He served as President and Chief Operating Officer of Epstein Civil Engineering, Inc. from July 1982 through March 1986. As Director of the Illinois Division of Water Resources from November, 1977 to June, 1982, he coordinated the water resource activities of the State of Illinois. He directed a staff of 160 with an annual budget of \$19 million and also chaired the Governor's State Water Plan Task Force. Dr. Kudrna is a registered Professional Engineer and has been active in the National Society of Professional Engineers. He has been an instructor in the Graduate Program of City & Regional Planning at the Illinois Institute of Technology. He served as Chairman of the Illinois Delegation of the Great Lakes Commission where he was a Commissioner for twenty-five years. He served as a U. S. Board Member of the International Joint Commission, Great Lakes Diversions and Consumptive Uses Study Board and the International Great Lakes Levels Advisory Board. He serves on the U. S. Department of Commerce, Sea Grant National Advisory Panel.

Michael J. McPhaden, Ph.D.

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Dr. Michael J. McPhaden is a Senior Research Scientist and Director of the Tropical Atmosphere Ocean (TAO) Array Project Office at NOAA's Pacific Marine Environmental Laboratory in Seattle, Washington. His research focuses on large-scale trop-

ical ocean dynamics, ocean-atmosphere interactions, and the ocean's role in climate. For the past 20 years he has been involved in the development of ocean observing systems to support climate studies in all three tropical oceans and in particular is responsible for coordinating a multi-national network of deep ocean moored buoys across the Pacific basin for the study of El Niño and La Niña.

Dr. McPhaden received his Ph.D. from the Scripps Institution of Oceanography in Physical Oceanography and has B.S. in Physics from the State University of New York at Buffalo. He serves on several national and international scientific advisory committees, is a member of the editorial board of the Bulletin of the American Meteorological Society, and is past-president of the Ocean Sciences Section of the American Geophysical Union. He has received numerous awards and citations, including a Presidential Award for Meritorious Federal Service in 2004.

Andrew A. Rosenberg, Ph.D.

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Dr. Andrew Rosenberg is a Professor in the Institute for the Study of Earth, Oceans, and Space at the University of New Hampshire where, prior to April 2004, he was dean of the College of Life Sciences and Agriculture. Over the past three years he has also been a member of the U.S. Commission on Ocean Policy.

Prior to coming to UNH he was the Deputy Director of NOAA's National Marine Fisheries Service from 1998-2000, the senior career position in the agency. As Deputy Director he dealt with policy decisions on science and resource management issues nationwide as well as the administration of the agency. He was also a principle agency spokesperson before Congress, the public and technical audiences. Before becoming NMFS Deputy Director, Dr. Rosenberg was the NMFS Northeast Regional Administrator. He negotiated and implemented the recovery program for New England fisheries, reversing overfish-

ing and resource declines on George's Bank as well as other areas for groundfish and scallop fisheries. He also worked to develop and implement marine mammal recovery programs and endangered species protections throughout the northeast. He also has served as the U.S. lead representative in several international fishery management organizations such as NAFO, NASCO and FAO.

Dr. Rosenberg's scientific work is in the field of population dynamics, resource assessment and resource management policy. He holds a B.S. in Fisheries Biology from the University of Massachusetts, an M.S. in Oceanography from Oregon State University and a Ph.D. in Biology from Dalhousie University. He was on the faculty of Imperial College of Science and Technology in London for six years and was the Deputy Director of the Renewable Resources Assessment Group, and internationally known quantitative analysis and policy consultancy group. He currently also serves as the Senior Vice President of MRAG Americas, a consulting company with offices in Florida, Massachusetts and affiliated with MRAG, a London-based international marine resource consultancy.

LuAnne Thompson, Ph.D.

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LuAnne Thompson received her B.S. in physics from the University of California at Davis in 1983, and A. M. masters from Harvard University in physics in 1986. She received her Ph.D. in oceanography from the Joint Program in oceanography, MIT and Woods Hole, in 1991. She worked as a postdoctoral researcher from 1991 to 1993, then as an assistant professor at the School of Oceanography at the University of Washington. She was promoted to Associate Professor in 2000. She has been on the board of the Program on Climate Change at UW, and is a JISAO senior fellow (Joint Institute for the Study of the Atmospheres and Oceans, the NOAA joint institute at UW). She has been co-PI on two NASA science teams (JASON and QuikScat) and has been a co-author on several CLIVAR planning documents. She is currently serving on the Ad-Hoc Committee for Peta-Scale computing for the Geosciences (NSF), and on the Committee for Women in Physical Oceanography (NSF/ONR). She has taught numerous courses both at the undergraduate and graduate level on physical oceanography and climate dynamics.

Yochanan Kushnir, Ph.D.

(Ex-Officio Member)

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Dr. Yochanan Kushnir earned his Ph.D. in Atmospheric Science at Oregon State University in 1985. Currently he is a Doherty Senior Research Scientist at the Lamont Doherty Earth Observatory of Columbia University and the Director of the NOAA Cooperative Institute for Climate Applications and Research. Dr. Kushnir specializes in studying climate variability with emphasis on the role of ocean-atmosphere interaction. Using the recent instrumental climate record and a statistical analysis approach, he examines the characteristic patterns and temporal behavior of global and regional atmospheric variations on seasonal to decadal time scales and their linkage to variations in oceanic properties. He also emphasizes the application of global climate models to understand the dynamical mechanisms and origins of the variability. He has been conducting research on the patterns and predictability of the North and tropical Atlantic climate anomalies and their link to sea surface temperature variations. More recently he has been studying the global circulation response to ENSO interannual and decadal variability, particularly the influences on Northern Hemisphere climate and the Indian Summer Monsoon. Dr. Kushnir has been teaching undergraduate and graduate level climate courses in the Department of Earth and Environmental Science Department and the School of International and Public Affairs, Columbia University. He served as a member of the US National Academy panel on Decadal-to-Century-Scale Climate Variability and Change and the International CLIVAR Atlantic Implementation Panel. At present he is a member of the US CLIVAR Atlantic Implementation Panel and the US GLOBEC Science Steering Committee.

Introduction to Woods Hole Oceanographic Institution

The Woods Hole Oceanographic Institution is a private, independent, not-for-profit corporation dedicated to research and higher education at the frontier of ocean science. Its primary mission is to develop and effectively communicate a fundamental understanding of the processes and characteristics governing how the oceans function and how they interact with the Earth as a whole.

WHOI's goal is to be a world leader in advancing and communicating a basic understanding of the oceans and their role in the global system. In support of this mission, WHOI seeks to:

- Recruit, retain, and support the highest quality staff and students and provide an organization that nurtures creativity and innovation.
- Stress a flexible, multidisciplinary, and col-

laborative approach to the research and education activities of its staff within an equitable working environment.

- Promote the development and use of advanced instrumentation and systems (including ships, vehicles and platforms) to make the required observations at sea and in the laboratory.
- Make the results of its research known to the public and policymakers and fosters its applications to new technology and products in ways consistent with the wise use of the oceans.

WHOI was founded in 1930 after a 1927 study committee of the National Academy of Sciences recommended establishing a permanent independent research laboratory on the East Coast to “prosecute oceanography in all



In a rare moment all three WHOI research vessels are in port. Knorr is in the foreground with Oceanus and the new Atlantis on the opposite side of the pier.



R/V Atlantis: Capacity, 59 people at sea for 60 days; Launched 1996; Length, 274 feet



R/V Knorr: Capacity, 58 people at sea for 60 days; Launched: 1970, converted in 1991; Length, 279 feet



R/V Oceanus: Oceanus is a mid-size research vessel designed for cruises lasting two to three weeks; Length, 77 feet



CRV Tioga: Length, 60 feet; Range, 350 miles; Endurance, usually one day, occasionally 2 to 3 days; Accommodations: 6 bunks (10 people on day trips)

its branches.” The strong tidal currents of Nantucket Sound keep Woods Hole harbor free of ice most days of the year; and an initial grant from the Rockefeller Foundation supported development of the Institution in Woods Hole with about a dozen scientists working in the summers, the construction of a laboratory building, and the commissioning of the 142-foot ketch *Atlantis*. WHOI grew substantially to support defense-related research during World War II and sustained steady growth in the decades following World War II.

The Institution is now located both in the village of Woods Hole, Massachusetts and on the nearby Quissett campus. The present organizational structure is summarized by the wiring diagram on page 11.

WHOI’s shore-based facilities occupy 219 acres of land and include 58 buildings and laboratories. WHOI staff numbers about 850, with roughly half directly involved in research. The education programs includes about 130 graduate students and about 35 summer fellows.

A major element of the Institution’s facilities are those dedicated to support work at sea. The Institution operates four research vessels: *R/V Atlantis*, *R/V Knorr*, *R/V Oceanus*, and *CRV Tioga*. *R/V Atlantis* sails worldwide most often carrying the deep submersible *DSV Alvin*. *R/V Knorr* sails worldwide while *R/V Oceanus* most often conducts research cruises in the Atlantic Ocean. These 3 large vessels are scheduled as part of the University-National Oceanographic Laboratory System (UNOLS), a consortium of 61 academic institutions working together to coordinate use of oceanographic research vessels and facilities. *CRV Tioga* is a new coastal research vessel for use in local waters.

The National Deep Submergence Facility (NDSF) builds and operates manned and unmanned submersibles and vehicles, including *DSV Alvin*, a manned deep-diving research submarine, and the unmanned vehicles: *ROV Jason II/Medea*, towed *Argo II*, and towed *DSL-120A*.

The submersible *Alvin* has accomplished more scientific research dives than any other HOV submersible in the world. *Alvin* is rated to a depth of 4,500 meters and is fully instrumented with a suite of sampling, data logging and camera options available for in-situ observations. The engineering staff of the *Alvin* Group can assist NOAA researchers in modifying existing or constructing new equipment to exploit the capabilities of the vehicle. The tethered vehicles operated by the WHOI Deep Submergence Laboratory are capable of a wide variety of imaging tasks, and offer unparalleled digital processing capabilities. Another community facility, Multidisciplinary Instrumentation in Support of Oceanography (MISO) provides instrumentation for deep-sea digital imaging, and is supported by the National Science Foundation. On land, examples of WHOI specialized facilities are the National Oceans Sciences Accelerator Mass Spectrometer (NOSAMS) facility, the mooring design and fabrication shops, and instrument test and calibration chambers.

The WHOI education program includes a graduate degree program that grants Masters and Ph.D. degrees from WHOI and a graduate degree program conducted in cooperation with the Massachusetts Institute of Technology. The WHOI/MIT Joint Program coordinates the faculties and courses taught by the two institutions and grants a singled, joint degree. Every summer there is the Geophysical Fluid Dynamics Fellowship Program that brings in students and faculty for a ten-week research and study program on a specific geophysical fluid dynamics topic. Postdoctoral education opportunities include the Postdoctoral Scholarship Program, 18-month awards to recent graduates, the Marine Policy Fellowship Program for professionals in the social sciences, law or the natural sciences who wish to apply their training to problems involving use of the oceans, and the Postdoctoral Investigator positions funded by individual research grants. Undergraduate education opportunities include the Minority Fellowship Program and the Summer Student Fellowship Program; undergraduates and advanced high school



Alvin: Length, 7.1 m; Beam, 2.6 m; Operating Depth, 4,500 m; Normal Dive Duration, 6-10 hours



Jason II/Medea: Depth capability, 6,500 m; Tether, 35 m, 20 mm diameter, neutrally buoyant; Size, 3.4 m long, 2.4 m high, 2.2 m wide, Weight: ~3,300 kg in air



Argo II: Depth Capability, 6,000 meters; Size, 4.6 m (L), 1.1 m (H), 1.1 m (W); Weight, 2,100 kg in air (approx.); Maximum Tow Speed: 0.5 knot



DSL 120A: Depth Capability: 6,000 meters; Depressor Weight: ~400 kg; Umbilical, 40 meters, neutrally buoyant; Towfish Size, 3.3 m (L), 1.1 m (H), 0.7 m (W) Towfish Weight: 390 kg in air (approx.)

students are also hosted as Guest Students in the summer by individual investigators.

WHOI research departments include Applied Ocean Physics and Engineering, Biology, Geology and Geophysics, Marine Chemistry and Geochemistry, and Physical Oceanography. Research centers and special programs include: The Marine Policy Center, the Woods Hole Center for Oceans and Human Health, the Cooperative Institute for Climate and Ocean Research, and the Woods Hole Sea Grant program. As foci for developing increased private support of ocean research, WHOI has set up four ocean institutes: the Deep Ocean Exploration Institute, the Ocean Life Institute, the Coastal Ocean Institute, and the Ocean and Climate Change Institute.

WHOI's annual research budget is approximately \$85M (excluding the cost of operating the ships, submersible, and ROVs - \$20M). Of that, about 76% comes from Federal agencies (\$14M from ONR, \$40M from NSF, \$8M from NOAA, and \$2.5M from other agencies) with another 14% (\$12M) coming as subcontracts with federal government prime contractors. The remaining \$8.5M comes from private funds (\$3M), income from WHOI endowments (\$4.5M), and other non-government sources (\$1M).



Located in the village of Woods Hole, Massachusetts, (top photo) and on the nearby Quissett campus, WHOI's shore-based facilities encompass 219 acres of land and waterfront and 58 buildings and laboratories.

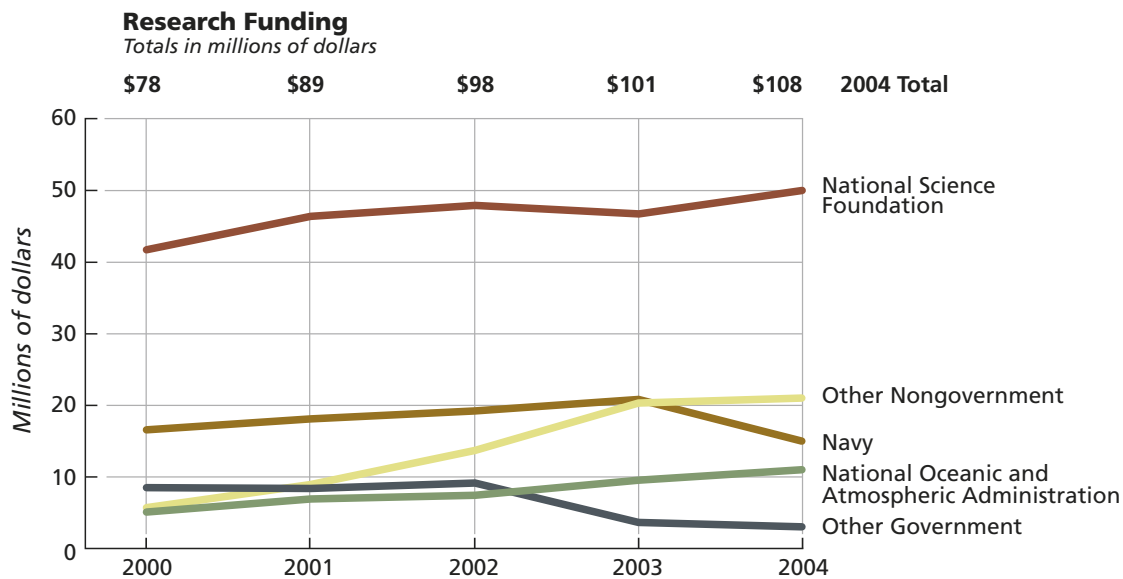
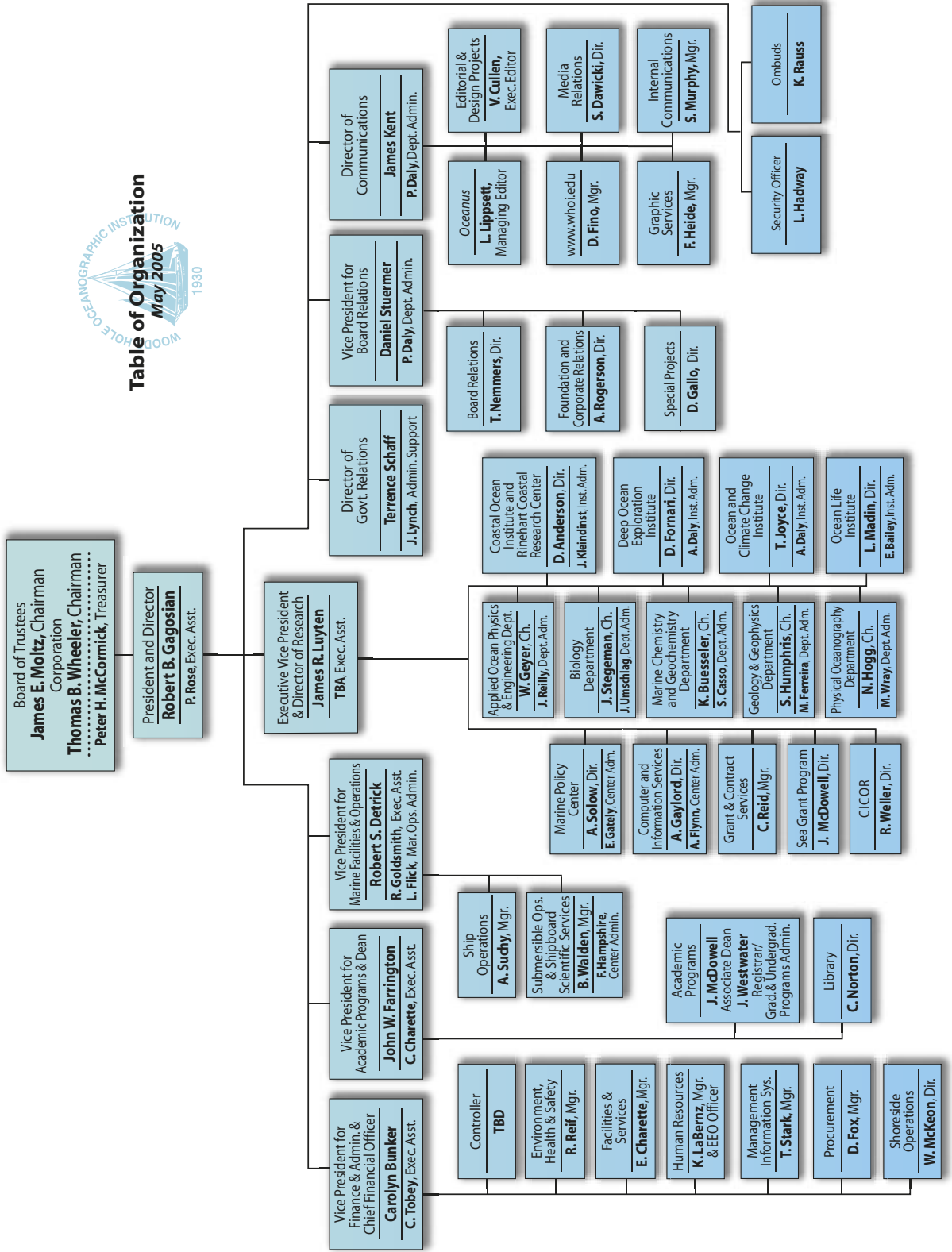


Table of Organization
 May 2005
 1930

Introduction to the Cooperative Institute for Climate and Ocean Research

CICOR is a Cooperative Institute of the NOAA Office of Oceanic and Atmospheric Research hosted by the Woods Hole Oceanographic Institution. CICOR's primary mission is to facilitate and build interaction between NOAA and academia through sponsored research organized around three broad themes. CICOR's closest NOAA Research Laboratory is the Northeast Fisheries Science Center (NEFSC) of the National Marine Fisheries Service (NMFS), which is located near WHOI in Woods Hole, Massachusetts. The Great Lakes Environmental Research Laboratory (GLERL) is CICOR's formal partner within the NOAA OAR structure. CICOR investigators also have research partnerships with other NOAA laboratories, including AOML (Atlantic Oceanographic and Meteorological Laboratory) in Miami, PMEL (Pacific Marine Environmental Laboratory) in Seattle, and the Environmental Technology Laboratory (ETL) in Boulder.

CICOR completed its first cooperative agreement with NOAA OAR, which lasted 3 years, in the summer of 2001. A new 5-year cooperative agreement was signed July 2001. This new agreement was proposed and awarded with indirect cost rates (Laboratory Costs and General & Administrative Costs) that were lower than the overhead rates negotiated with our cognizant agency (ONR). For the duration of the five-year Cooperative Agreement, these rates remain fixed. Since WHOI overhead rates have typically increased each year, the difference between the overhead rates on CICOR proposals and the WHOI rate continues to increase. WHOI however, is required to charge all grants and contracts regardless of funding agency the same overhead rate. This is accomplished by WHOI contributing from its unrestricted funds the difference in overhead on CICOR projects. This contribution was \$162,850 in 2004.

In the cooperative agreement CICOR research is organized around three **science themes**. At the same time, for administrative purposes budgets are organized around four **tasks**.

CICOR's three research themes are: the coastal ocean and near-shore processes, the ocean's role in climate and climate variability, and marine ecosystem processes analysis. The coastal ocean and near-shore processes theme includes scientific research on fundamental processes of biology, physical oceanography, and sediment and sand transport, as well as the effects of contaminants and the changing environment upon ecosystems and habitats for marine mammals, fish, and humans. The research is interdisciplinary in nature. Finding solutions to the problems requires basic understanding of processes relevant to several fields. CICOR's second theme is the ocean's role in climate and climate variability. Over the past 25 years, there has been growing recognition of the critical role of sub-basin-scale oceanographic processes in the dynamics of the overall climate system. The time scales on which these processes operate and interact range from seasonal to millennial and beyond. Sustained observational studies and process experiments can provide important information about these processes. Marine ecosystem processes analysis is CICOR's third broad theme. It encompasses a wide range of community and ecosystem level studies. Many of these investigations concern the interaction of biological composition and structure with physical, chemical, or geological characteristics of the environment. Research on the species composition, trophic structure, and evolutionary history of a variety of marine ecosystems has long been a central strength of WHOI.

In addition to its mission of facilitating research, CICOR works to foster interaction between NOAA and academia and build the involvement of the external community in NOAA research. CICOR provides travel funds for WHOI staff to visit and interact with NOAA colleagues and also uses travel funds to support visits by leading scientists to come to WHOI to foster developing interests and collaborations. CICOR supports workshops, seminars, and colloquia in specific research areas with the same intent, that of developing for the community and in support of NOAA strategic planning recommendations, plans, and time lines for future research directions.

Education and outreach are also CICOR foci. CICOR supports postdoctoral scholars, graduate students, and summer (undergraduate) student fellows. CICOR's postdoctoral scholar is selected each year from among the pool of the best applicants to the WHOI Postdoctoral Scholar competition, with the goal of rotating the award among CICOR's three science themes and providing additional support to and involvement in a NOAA-funded research project. A new graduate student is funded each year, again with the guideline being that the support from CICOR rotates through the science themes and, where possible, involves a student in NOAA research. Starting in the summer of 2005, CICOR will support three summer student fellows, one in each of the science themes. These fellows have been paired with CICOR funded investigators. Outreach activities include interaction with the local high school science fair and the regional ocean sciences bowl, cruises by CICOR investigators that host NOAA Teachers at Sea, follow up collaboration with Teachers at Sea, hosting guest lecturers to highlight and foster NOAA research, and involving regional stakeholders in planning workshops.

CICOR provides the means for NOAA and NOAA-funded principal investigators to use WHOI facilities, including the research vessels and submersibles, as well as other land-based specialized facilities.

CICOR's four administrative tasks are summarized here. **Task I** provides support for the administrative activities of CICOR. As such, support is requested for the Director and staff, post-doctoral scholars associated with research in CICOR, fellowships for graduate students with interests in climate and related studies associated with research in CICOR, and a visiting scientist and travel program to develop and enhance research in CICOR. The budget also includes support for meetings of the CICOR Council of Fellows and the Executive Board and for education and outreach activities. CICOR receives \$110K from OAR each year to support Task I. In addition, research proposals funded through CICOR contribute a 4% program development cost to Task I. This contribution is essential if CICOR is to sustain support for the activities listed above. In the beginning, before program development cost funds were available, support from WHOI allowed CICOR to start support of a CICOR Postdoctoral Scholar.

The overwhelming majority of the funds administered by CICOR are associated with grants resulting from proposals submitted by WHOI principal investigators in response to NOAA announcements of opportunity. **Task II** activities include the research efforts in which the proposals and programs actively involve NOAA scientists as collaborators. **Task III** research efforts consist of proposals and currently funded programs supported by NOAA through the OAR, Office of Global Programs and other offices in NOAA, and are therefore directed toward NOAA's strategic goals. Collaboration with NOAA staff is encouraged in Task III activities but not required. Task II and Task III funds come to CICOR to administer when investigators submit research proposals to NOAA offices in response to funding opportunities identified by NOAA, when those proposals are selected for funding by NOAA, and when the NOAA office with the funds chooses to route them through CICOR. For funds to be routed through CICOR, the investigator-originated proposals must be relevant to one of the three research themes identified by CICOR in the

current Cooperative Agreement. That Cooperative Agreement, in effect, is an umbrella that sets by its choice of themes and by its budget estimates the bounds on the types and cost of the research done by CICOR investigators.

Task IV provides the administrative means for WHOI facilities to be used and paid for by NOAA principal investigators and NOAA-funded investigators from other institutions. A summary of CICOR Task IV activity is included in Appendix X. WHOI operates the Research Vessels *Atlantis*, *Knorr* and *Oceanus*, and the 60 ft. coastal research vessel *Tioga*. In addition a fleet of small boats designed to be trailered are useful for work in coastal estuaries, rivers and bays. WHOI operates the National Deep Submergence Facility which has its oversight in a Memorandum of Agreement signed by NOAA/NURP, the National Science Foundation and the Office of Naval Research. The National Deep Submergence Facility consists of both human occupied and remotely operated vehicles (HOV's and ROV's). The NDSF is major asset available to NOAA researchers both within and outside NURP. This research would include the NOAA Vents Program, research at ocean dump sites; research associated with NOAA's Marine Sanctuary Program; marine mammal research looking, for example, at whale carcass falls; sewage outfall systems; post-earthquake coastal margin disruption assessment and so forth. The use of other Institution facilities used to support NOAA research would be funded through this Task.

CICOR is administered by a Director, with 2 months support per year under Task I and 3 months of support provided by WHOI. WHOI also provides 3 months of support for an administrative manager, and the time of the CI Administrator and Grants and Contracts Manager who assists with financial and grant-related issues. CICOR research directions evolve under the guidance of the Director, an Executive Board, and a Council of Fellows. The CICOR Director and Administrator participate in annual meetings with OAR in Silver Spring; the CICOR Director has for the last three years been on the CI Directors' Executive Committee and attended the NOAA OAR Senior Research Council meetings and interacted with the NOAA Goal Teams.

Science Plan

Scientific Vision

CICOR's vision is to bring world class oceanographic expertise and facilities to NOAA research, to work with this mission-oriented agency to significantly improve understanding of the ocean, and to together build society's ability to live in a world in which the ocean greatly influences present and future variability and change.

CICOR provides a unified structure to facilitate at WHOI a variety of ocean research, education, and outreach activities to be carried out in collaboration with and in support of NOAA. CICOR's existence advances climate and oceanographic research and builds links between WHOI and NOAA in a number of ways:

- CICOR engages the world-class science expertise of WHOI, in areas including physical oceanography, biology, marine geology and geophysics, chemistry, applied ocean physics and engineering departments, and marine policy in NOAA research.
- CICOR actively participates in planning future NOAA research, building the engagement of WHOI and other external investigators and stakeholders, in the process.
- CICOR applies WHOI's substantial observational and technological research and development capabilities to NOAA's mission and makes them available to the NOAA research community.
- CICOR brings to bear on NOAA research problems and strategic goals the results of investments at WHOI and in the community by the other agencies funding ocean research, especially the National Science Foundation and the Office of Naval Research.
- CICOR supports the involvement and training of the next generation of researchers in NOAA research.

In particular, CICOR draws on WHOI strengths in science and observing methods with the intent of making significant contributions to understanding and predicting the role of the ocean in climate and climate variability, coastal ocean and near-shore processes, and marine communities and ecosystems. Improved understanding of the coupling between the ocean and the atmosphere and of the physical dynamics of the ocean together with improved global and coastal observations will be the bedrock requisite for improved prediction of both the physical environments of the global and coastal ocean and their ecosystems. Upon that foundation of physics and physical processes there must be a concerted drive to observe, understand, and predict the biological, chemical, and geological processes connected to the physical processes. CICOR looks to WHOI's Marine Policy Center and to external partners to build links between research, applications, and society. In some cases this is through WHOI participation in the developing regional operational and research structures, but in all cases CICOR and WHOI are committed to sharing research results and maximizing their benefits.

Science Plan & Relationship to NOAA Strategic Plan

The NOAA Strategic Plan (*New Priorities for the 21st Century: NOAA's Strategic Plan Updated for FY2005-2010*) identifies the NOAA mission as: "To understand and predict changes in the Earth's environment and conserve and manage coastal and marine resources to meet our Nation's economic, social, and environmental needs." NOAA goals are to:

- Protect, restore, and manage the use of coastal and ocean resources through an ecosystem-based approach to management.
- Understand climate variability and change to enhance society's ability to plan and respond.

- Serve the nation's commerce with information for safe, efficient, and environmentally sound transportation.
- Provide critical support for NOAA's mission. The strategies that NOAA has developed to address these goals as an end-to-end process involve the following activities:
 - Monitor and observe the land, sea atmosphere, and space to create an observational and data collection network that tracks Earth's changing systems;
 - Understand and describe how natural systems work together through investigation and interpretation of information;
 - Assess and predict the changes of natural systems and provide information about the future;
 - Engage, advise, and inform individuals, partners, communities, and industries to facilitate information flow, assure coordination and cooperation, and provide assistance in the use, evaluation, and application of information; and
 - Manage coastal and ocean resources to optimize benefits to the environment, the economy, and public safety.

Within this NOAA-wide context, NOAA OAR's vision statement (NOAA Research Strategic Plan for FY2003-FY2008 and Beyond: Understanding the Environment from the Bottom of the Ocean to the Surface of the Sun) is to carry out "societally relevant research that forms the scientific basis for more productive and harmonious relationship between humans and their environment." OAR's mission statement is "To conduct research, develop products, provide scientific understanding and leadership and to conduct outreach towards fostering NOAA's evolving environmental and economic mission."

For NOAA's National Marine Fisheries Service (NMFS), another partner for CICOR, the vision is that "The American people enjoy the riches and benefits of healthy and diverse marine ecosystems" and the mission is "Stewardship of living marine resources through science-based conservation and management and the promotion of healthy ecosystems." The NOAA National Ocean Service (NOS) (A Strategic Plan for NOAA's National Ocean Service; FY2003-FY2008 and Beyond) has responsibilities in the coastal regions and states its vision as "Sustaining the prosperity of America's oceans and coasts" and its mission as "To manage society's use of coastal and ocean ecosystems to sustain their natural resources and services."

The CICOR science plan directly addresses key needs if NOAA is to fulfill its mission of understanding and predicting change and managing and conserving coastal and marine resources, those of understanding the ocean's role in climate, understanding the coastal marine environment, and understanding marine ecosystems. The CICOR science plan is strongly linked to and supportive of the NOAA Strategic Plan's first and second goals, those pointing to an ecosystem-based approach to managing coastal and ocean resources and to improving understanding of climate variability. The CICOR science plan also makes key expertise and facilities available to NOAA and thus addresses the fourth goal.

The strategies that NOAA has developed and the goals of the line offices most closely aligned with CICOR, OAR, NMFS, and NOS, have many strong intersections with the visions and missions of both CICOR and its host institution, WHOI. CICOR, its WHOI scientists and staff, and WHOI are dedicated to developing and using observing systems, to better understanding the ocean and its role in the earth system, to improved modeling (and thus prediction) of the ocean, and to dialog about research results that will lead to improved management.

Goals & Objectives

CICOR's goals are to facilitate and foster cutting-edge research in its three thematic areas in support of NOAA's mission and strategic goals, to support the training of the next generation of leading ocean researchers, to make world-class ocean research facilities available to NOAA and NOAA-funded investigators, and to effectively communicate the results of its research.

The specific objectives of CICOR research are those identified by the individual research projects. Grouped by them, key leading objectives are:

Coastal ocean and near-shore processes

- To determine the dynamics which drive tidal and sub-tidal circulation on the southeastern flank of Georges Bank and drive the temporal evolution of the thermohaline structure over the Bank.
- To map the summit of Explorer Ridge off the west coast of the United States and Canada using the Autonomous Benthic Explorer (ABE).

The ocean's role in climate and climate variability

- To investigate the variability of the thermohaline circulation and freshwater storage in the Arctic basin.
- To create an inverse model of the Atlantic basin three-dimensional circulation and use it to investigate the uptake, transport, and storage of carbon in the Atlantic Ocean.
- To assess air-sea carbon dioxide exchange rates in the world's oceans using bomb ^{14}C inventories derived from the WOCE global survey.
- To study the concentration, transport, and divergence of total inorganic anthropogenic carbon and their temporal variations in the Atlantic.
- To investigate the role of the ocean in tropical Atlantic variability on interannual to decadal time scales, using an ocean general circulation model (OGCM) to examine how the ocean

responds and feedbacks to the sea surface temperature dipole in the tropical Atlantic.

- To study the decadal variability of the oceanic circulation in the Atlantic and its sensitivity to surface wind and buoyancy forcing using an OGCM.
- To locate and quantify the circulation components that contribute to the eastern Pacific equatorial cold tongue.
- At two contrasting sites in the eastern equatorial Pacific, one north of the cold tongue at the northern summer latitude of the ITCZ and one at 3°S in the cold tongue, characterize the air-sea fluxes of heat, freshwater, and momentum and the local air-sea coupling and determine the balance of processes that controlled the evolution of sea surface temperature and upper ocean structure during the 1997-1998 ENSO.
- To quantify air-sea exchanges, to identify errors in those quantities in climatologies and models, and to motivate improvements to those models by obtaining high quality surface meteorology along repeating, cross-basin tracklines of Volunteer Observing Ships (VOS).
- To quantify air-sea exchanges, to identify errors in those quantities in climatologies and models, to motivate improvements to those models by obtaining high quality surface meteorology, to observe upper ocean variability, to investigate ocean model performance, and to explore links between the surface fluxes and the upper ocean by obtaining high quality, sustained time series observations at ocean sites key to coupled climate variability and change.
- To determine the physical processes that maintain relatively cool sea surface temperatures under the Peru-Chile stratocumulus cloud deck, to obtain accurate air-sea fluxes characteristic of the region, and to explore the role of the cool ocean in maintaining the persistent stratus cloud cover there.
- To obtain accurate air-sea fluxes in the Tradewinds region of the western North Atlantic Ocean and to investigate the role of local air-sea interaction in tropical Atlantic variability.

- To obtain accurate air-sea fluxes at the long-term Hawaii Ocean Timeseries/Station Aloha site and participate in collaborative studies of the multidisciplinary ocean variability seen at that site.
- To develop high quality global fields of the air-sea fluxes on daily, 1°x1° grid and use those data to investigate the ocean's role in climate.
- To develop, construct, and deploy ARGO profiling floats as the means to provide long-term observations of upper ocean thermohaline structure and thus the ability to investigate the ocean's role in climate.
- To obtain, quality-control, and serve to the community surface meteorological data from U.S. research vessels.
- To produce an improved, high-resolution, global, near-real-time, sea surface temperature analysis through combination of infrared and microwave satellite data and to demonstrate the impact of these improved sea surface temperatures on operational models.

Marine ecosystem processes analysis

- To construct an end-to-end food budget for shelf ecosystems, spanning trophic levels from microbial to top predators.
- To investigate links between top and middle trophic levels in the northern California Current System and to develop predictive bio-physical models of mammal and seabird occurrence patterns.
- To provide organizational and infrastructure support to the academic community engaged in harmful algal bloom (HAB) research and to provide technical support to the HAB management community.
- To involve students and young researchers in research on biogeochemical interactions and feedbacks, exchange processes, and air-sea fluxes as part of the Surface Ocean Lower Atmosphere Study (SOLAS).
- To develop improved methods for acoustic assessment of fish standing stocks.

Criteria Used to Measure Progress in Accomplishing Goals & Objectives

There are two general categories of criteria. The first addresses whether or not CICOR is effective as a Cooperative Institute and thus successful at its goals of facilitating and fostering NOAA research, supporting the training of the next generation of leading ocean researchers, making world-class ocean research facilities available to NOAA and NOAA-funded investigators, and effectively communicating the results of its research. In this category metrics for progress are: involvement of WHOI investigators in NOAA research programs, the growth of activities that develop future NOAA research plans, and the successful graduation of students, completion of postdoctoral positions, and the transition of both into the research community.

WHOI/CICOR investigator involvement in NOAA research is high. They have played lead roles and partnered closely with colleagues from NEFSC in the GLOBEC (Global Ocean Ecosystems Dynamics Program) Georges Bank research program, from field observations through synthesis. They are both participants in planning groups (such as the U.S. CLIVAR Scientific Steering Committee and the U.S. CLIVAR Atlantic, Pacific, and Pan-American Panels) and key investigators in many climate programs under NOAA's Office of Global Programs, including the Climate Variability, Climate Prediction in the Americas, and Climate Observation Program. They are key players in NOAA Ocean Exploration and ECOHAB (Ecology and Oceanography of Harmful Algal Blooms) programs.

CICOR has led the Cooperative Institutes in holding the first of what will be a series of workshops addressing regional ecosystems research planning. Following a dialog with the NOAA climate and ecosystems goal team leads, seeking to build on the partnerships and successes of the GLOBEX Georges Bank program, and noting the convergence of interest from several Federal agencies on coastal observing systems, CICOR partnered with NEFSC to hold a Workshop on

Planning Coordinated Research on Ecosystems, Climate, and Policy in the Northeast in January 2005 (<http://www.who.edu/science/cicor/workshop05/report.html>). A copy of the workshop report is included as Appendix XII. The CICOR Director has followed up the dialog with OAR to work with NOAA to develop a plan for regional ecosystems research. The Director of CICOR has also briefed the NOAA Climate Working Group on the U.S. CLIVAR research program and on the role of the external community in NOAA climate research. Later this summer, CICOR will bring together key international researchers who study the role of the Indian Ocean in climate variability, with the intent of catalyzing progression toward a long-term research program in that region that includes U.S. participation.

The graduate students that have completed their degrees or are in residence now with NOAA and CICOR support are listed in Appendix VII The Postdoctoral Scholars and Investigators that have completed their appointments or are now in residence are listed in Appendix VI. Funding to involve students in SOLAS workshops has further supported the development of the second generation.

CICOR has successfully provided facilities access. *R/V Oceanus* conducted NOAA supported research cruises to investigate harmful algal blooms in the Gulf of Maine in May/June 2003 and June 2004. *R/V Atlantis* supported Dr. Barbara Hickey's study of the ecology and oceanography of the toxic algae *Pseudo-Nitzschia* in the coastal ocean off the Pacific Northwest in September 2004. *R/V Oceanus* was used by Dr. Al Plueddemann in February 2003.

The second category addresses the research progress of the individual projects funded through CICOR. Many of these projects are basic research. These projects produce annual reports, which are provided to CICOR and to the NOAA program managers. The investigators report at meetings such as the annual AGU and AMS meetings and at dedicated program-

matic meetings, such as that of the CLIVAR Atlantic program. These reports together with publications document progress in each of the individual research efforts. The continued success of CICOR investigators in competing for funds and the high level of their engagement in big research programs both document success at basic research.

A number of CICOR's projects are devoted to the global ocean climate observing system. They have made excellent progress and have had a major impact. Included among them are the efforts that have helped build ARGO to 60.2 % completion, sustain three of the four existing Ocean Reference Stations, and field the only routine deployments of high quality surface meteorological sensors in VOS. Finally, some CICOR projects support the engagement of the community in NOAA research or provide programmatic support. The success of these efforts can be judged by impact on future research plans and the success of the cooperative efforts. In the case of the CICOR/NEFSC workshop on climate and marine ecosystems, an active dialog with NOAA climate and ecosystems goal teams and program managers continues, indicative of a positive impact. As another example, the U.S. National Office for Marine Biotoxins and Harmful Algal Blooms has been extremely active and successful in support and coordination of that community.

Major Scientific Themes

CICOR's three research themes are: the coastal ocean and near-shore processes, the ocean's role in climate and climate variability, and marine ecosystem processes analysis.

The **coastal ocean and near-shore processes theme** includes scientific research on fundamental processes of biology, physical oceanography, and sediment and sand transport, as well as the effects of contaminants and the changing environment upon ecosystems and habitats for marine mammals, fish, and humans. The research is interdisciplinary in nature. Finding solutions to the problems requires basic understanding of

processes relevant to several fields.

CICOR's second theme **is the ocean's role in climate and climate variability**. Over the past 25 years, there has been growing recognition of the critical role of (sub-basin-scale) oceanographic processes in the dynamics of the overall climate system. The time scales on which these processes operate and interact range from seasonal to millennial and beyond. Sustained observational studies and process experiments can provide important information about these (relatively high frequency) processes.

Marine ecosystem processes analysis is CICOR's third broad theme. It encompasses a wide range of community and ecosystem level studies. Many of these investigations concern the interaction of biological composition and structure with physical, chemical, or geological characteristics of the environment. Research on the species composition, trophic structure, and evolutionary history of a variety of marine ecosystems has long been a central strength of WHOI.

Identification of the Major Scientific Themes

The three science themes were identified during the initial dialog with OAR that led up to the Memorandum of Agreement that established CICOR (Appendix I). They represent the convergence of the research interests of WHOI investigators, the intent of WHOI to move forward in key areas of ocean research and observations, and the needs and plans of NOAA research.

The coastal ocean theme stems from strong research interest and activity by coastal physical oceanographers, by coastal sand transport and processes researchers in the applied ocean physics and engineering department, and by investigators in the biology department.

The climate theme reflects both strong interest and investment in scientific research in this topic and in the development of new, cutting

edge observing systems and instrumentation that enable further research progress. WHOI participation in the World Ocean Circulation Experiment (WOCE) and in the Tropical Ocean Global Atmosphere (TOGA) Program lead to considerable participation in the current international Climate Variability (CLIVAR) program. CLIVAR research is a core interest of the NOAA Office of Global Programs.

Joint work with NOAA NMFS NEFSC and NOAA support for work during the GLOBEC Georges Bank program combined with WHOI strengths in marine ecosystem research made this a logical third scientific theme around which to organize continuing collaborations with NOAA.

Status of Themes/Sub-themes

Highly productive research activity continues in CICOR's three science themes. Publications are summarized in Appendix VIII.

In basic research, the completion of work in a scientific theme not always evident. This stems from the evolutionary nature of research, where work to address hypotheses and challenges leads to a more complete understanding of the problem, which then in turn illuminates additional questions and uncertainties, which leads to further research. To summarize as well as possible the progress under CICOR themes we have here introduced several metrics.

First, some of the CICOR projects have made major contributions to the NOAA Climate Observation Program. The ARGO construction at WHOI has produced 412 floats, 23% of those deployed by the U.S., and helped the the ARGO array reach 60.2 % of completion of the initial deployment. At the same time the WHOI effort has provided the data from these floats. The WHOI ARGO group plans to construct another 105 floats this year. The Ocean Reference Station effort at WHOI provides three out of the four such long term climate reference sites now deployed and provides

that data by ftp to operational weather centers for model validation and improvement.

Second, CICOR projects are key to the analysis and synthesis of work in major cooperative projects, specifically in the GLOBEC Georges Bank program and in the Harmful Algal Bloom (ECO HAB) program. The transition from field observations to synthesis and collaborative publication is an essential step not only toward the transition of results from basic research to applications but also to the maturation and evolution of the research effort.

Generally, the climate and marine ecosystems themes are healthy, evolving and active. CICOR research efforts are making contributions. However, it is of concern that there has not been more growth and development of CICOR research efforts in the coastal theme. At WHOI, there is an active, multidisciplinary coastal research community and there has been much attention to the development and evolution of coastal observing systems. CICOR is now putting a priority on seeking and developing opportunities to grow the efforts under the coastal theme. The CICOR Director as a co-PI on the recently funded regional governance proposal for the coastal IOOS in the northeast. A greater dialog will be sought with the National Ocean Service about the role that CICOR and CICOR investigators can play in NOAA coastal ocean research. There is great opportunity for NOAA to leverage at WHOI the coastal research and observing system development efforts funded by other agencies.

What are the emerging thematic areas? Why?

CICOR's three main science themes remain active and vital and will continue. Within these themes foci are emerging and receiving increased attention.

A convergence of the very successful collaborations in the GLOBEC George's Bank program, research interests at WHOI, at the NEFSC, and partners, and the present active development of

next generation sensors, sampling plans, and observing systems has lead to a new emphasis on developing marine ecosystems research initiatives in the northwestern North Atlantic. CICOR and NEFSC have partnered on a January 2005 planning workshop and are pursuing development of funding within the NOAA planning process.

Synergetic with the increasing interest in a marine ecosystems initiative in the northwestern North Atlantic is rapid development of research and operational coastal ocean observing efforts. There are active dialogs with other institutions in New England and down through the Mid-Atlantic Bight about development of observing plans to be put forward for funding under the NSF ORION infrastructure project, of collaborative participation the regional coastal element of the IOOS, and of collaborative efforts to link research efforts to improved coastal atmospheric and oceanic models.

Another new focus is on the role of the Indian ocean in climate. WHOI investigators have over the years participated in studies in the Indian Ocean, including a surface mooring deployment in 1994-1995 in the Arabian Sea. However, the logistical challenges and undeveloped understanding of the impact of the data sparse Indian Ocean on climate held back development of more comprehensive plans for research in that region. In recent years, research findings have pointed to the covariability of climate over different parts of the globe, including North America, with Indian Ocean sea surface temperature variability and NOAA, in collaboration with international partners ecosystems, has initiated development of long-term observations. Lisan Yu, a WHOI CICOR investigator, has continued to study the air-sea fluxes and sea surface temperature variability in the Indian Ocean. She will, with CICOR and the WHOI Climate Institute, organize a colloquium of international experts in August 2005 to stimulate further dialog in the U.S. about research plans to study the role of the Indian Ocean in Climate.

WHOI investigators involved in paleoceanographic research have indicated a desire to have CICOR further explore with NOAA the agency's interest in this work. A preliminary dialog has started with the Cooperative Institutes at Princeton and LDEO to organize a workshop on this topic.

Scientific Partnerships

What is your relationship to the OAR Laboratories and other NOAA entities?

CICOR has sought an ongoing dialog with a number of NOAA laboratories through having their representation on the CICOR Executive Board and their service as CICOR Fellows (Appendix V); OAR headquarters, NEFSC, AOML, GLERL, OGP, and GFDL, NDBC, NOS are represented among these groups. Through their members on the Board and as Fellows, these elements of NOAA are asked for input on the evolution of CICOR's research themes and our approach to its goals and objectives.

Working partnerships have evolved in the course of research programs. The close joint work between WHOI and NEFSC investigators in the GLOBEC George's Bank program is one example. The Ocean Reference Station project that maintains climate quality surface moorings off northern Chile, north of Hawaii, and near Barbados is a close partnership with NOAA ETL. The high quality surface meteorological data collected by the Ocean Reference Station buoys are provided via an ftp site to the NOAA National Centers for Environmental Prediction (NCEP). These data are not inserted on the Global Telecommunication System (GTS) because if this were done they would be used by model centers like NCEP to initialize their atmospheric general circulation models. Instead, they are withheld and provided in near-real time via a WHOI ftp site. This permits these data to be used as an independent means of validating the NCEP model's performance and to serve as a means to work together to analyze and improve these models.

Ongoing engineering and scientific exchange is carried out with PMEL. Investigators from PMEL and WHOI have participated in and helped plan and oversee NOAA-funded research in EPIC (Eastern Pacific Investigation of Climate, funded under OGP's Pan American Climate Study (PACS) program initially and now under OGP's Climate Prediction Program for the Americas (CPPA). Information and technology exchange with PMEL involves mooring design, moored instrumentation, and meteorological sensors. Joint projects with AOML include observing efforts from Volunteer Observing Ships (VOS) and CLIVAR research in the Atlantic Ocean. WHOI/CICOR investigators also share common interests with GLERL, specifically in observing systems including autonomous vehicles and coastal and lake observatories and in ecosystems modeling and prediction. WHOI staff have visited GLERL, and CICOR will provide support for and encourage further visits and collaborations.

Because of common interests, a dialog is kept up with the National Data Buoy Center about meteorological sensors and moored instrumentation. This dialog ranges from discussion with NDBC management and with their contractors about how WHOI can assist in their operations by providing technical expertise and the benefit of past experience with WHOI/CICOR radiation sensors for testing on NDBC buoys off New England.

CICOR has also worked to establish a dialog with the two NOAA matrix management groups, the Climate goal team and the Ecosystems goal team, most closely aligned with CICOR's science themes. This is done by visits to NOAA in Silver Spring, participation in meetings such as the April 2005 meeting of the Climate Working Group, and by workshops such as that held in January 2005 to develop community plans for climate and ecosystems research in the northeastern United States. CICOR investigators participate in the annual review of the NOAA Climate Observation program, and a subset serves on the NOAA Climate Observing System Council.

CICOR coordinates activities with other Cooperative Institutes. The ARGO float program involves JISAO (University of Washington) and JIMO (Scripps Institution of Oceanography). Collaborative work involving CICOR and JIMO has been done under the umbrella of CORC (Consortium on the Ocean's Role in Climate), and the evolution of CORC's themes has involved a dialog between NOAA, JIMO, and CICOR.

What, if any, formal procedures do you have for joint planning?

Many CICOR investigators are funded when they respond to announcements of opportunity associated with major research programs such as CLIVAR. Such research and the planning of further research in these programs is coordinated by program specific planning and oversight groups, such as the U.S. CLIVAR Scientific Steering Committee and the international CLIVAR VAMOS (Variability of the American Monsoon Systems) Panel. Joint CICOR, PMEL, ETL activities for a future program planned for late 2007 and likely to be supported by the CPPA element of OGP, for example, are now being planned by a the scientific steering group for VOCALS (VAMOS Ocean Cloud Atmosphere Land Study). That steering group has among its members investigators from CICOR, PMEL, and ETL. The steering group meets annually. Such joint planning in turn leads to the coordinated submission to NOAA Marine and Aviation Operations (NMAO) of forms requesting scheduling of ship and aircraft time. The Director of CICOR recently submitted NOAA Form 77-65 to request the joint use of the NOAA ship Ron Brown for fieldwork in FY 2008.

Science Review

Recent Science Highlights and Accomplishments

For this review, we have selected a subset of projects for oral presentation in order to convey representative highlights and allow interaction between the review panel and diverse investigators. At the same time, we have asked our younger investigators, including graduate students and post-doctoral investigators to participate in the poster session and reception. The five talks will be:

- Integration and Synthesis of the Georges Bank Broad-Scale Survey Results
– Peter Wiebe
- Harmful algal blooms (HABs): National coordination and event response
– Don Anderson
- Ocean Reference Stations and Air-sea Fluxes
– Al Plueddemann
- Biological Control of the Vernal Population Increase of *Calanus Finmarchicus* on Georges Bank – Dennis McGillicuddy
- Implementing the Argo Float Program: A status report after the first 5 years
– Breck Owens
- Circulation and Climate Change in the Western Arctic: A Foray into Russian Waters
– Bob Pickart

To capture a broader spectrum of research highlights, a summary is presented in bulleted form below. We also have provided annual reports from all projects for 2004 in the briefing binder (Appendix II).

- Don Anderson's ECOHAB project ran a program to make possible rapid community response to bloom events and coordinated U.S. and international workshops and planning efforts addressing improved modeling of HABs.
- Postdoctoral Investigator Brian Ward con-

tributed to the team effort of developing an improved model of the diurnal warming of sea surface temperature by blending satellite infrared and microwave sea surface temperature data.

- Sandra Castro and Gary Wick's effort, a collaboration with the project Brian Ward is involved in, have provided estimates of the errors in diurnal warming models and have developed their algorithms for linking the skin temperature of the ocean surface, which is what is observed by satellites, with the bulk temperature, which is observed by various in-situ methods.
- Andrey Proshutinsky's development of annual gridded Arctic Ocean temperature and salinity fields in the upper 500 m in collaboration with the Arctic and Antarctic Research Institute in St. Petersburg, Russia and his model studies finding the importance to the region of the variability of the circulations of the Beaufort, Greenland, Labrador, and Irminger Sea Gyres.
- Alison Macdonald and colleagues have developed an inverse box model of the Atlantic Ocean that is clarifying how carbon is taken in, stored, and transported by the Atlantic Ocean.
- Terry Joyce and Jiang Yang have found that atmospheric forcing is essential to the establishment of the tropical Atlantic sea surface temperature dipole, though oceanic transports can act to damp its growth.
- Lisan Yu's production for the Atlantic Ocean of a new, improved air-sea flux product with daily and $1^\circ \times 1^\circ$ resolution, verified against high quality mooring and ship data.
- Robert Weller and Al Plueddemann's establishment and maintenance of the unique, high quality Ocean Reference Station time series surface moorings off northern Chile (20°S ,

- 85°W), in the North Atlantic tradewinds (15°N, 51°W) and north of Hawaii and their collaboration with modeling centers and other investigators in the use of this high quality, independent data to illuminate biases and other errors in climatologies, model-based fields, and in remotely-sensed products. The first accurate time series of surface meteorology and air-sea fluxes has been collected under the Peru-Chile stratus deck that plays a key role in Pacific climate variability, and the first quantitative assessment of the upper ocean heat budget in this region has been made.
- Dave Hosom and Robert Weller's collection of high quality surface meteorological data along long, cross-basin ship tracks using VOS. This data with its high spatial resolution together with the high time resolution Ocean Reference Station data provides the means to investigate spatial as well as temporal variability, to quantify errors and biases in space as well as time, and to support the data assimilative synthesis of improved global flux fields by Lisan Yu.
 - Breck Owens' group pushed forward the development of the ARGO float technology and constructed and deployed ARGO floats in collaboration with partners at SIO, the University of Washington, and PMEL.
 - Bernadette Sloyan's development of an inverse model for the circulation in the eastern tropical Pacific Ocean, allows improved understanding of how the eastern Pacific cold tongue is maintained.
 - Graduate student Tom Farrar's analyses of air-sea interaction and upper ocean variability at two sites spanning the eastern Pacific cold tongue during the 1997-1998 ENSO event have provided unprecedented quantification of the processes involved in setting sea surface temperatures there.
 - Jim Lerczak, Bob Beardsley, and Steve Lentz provided a kinematic and dynamical description of the currents and stratification in the tidal mixing frontal zone on the southern flank of Georges Bank, and the response of the frontal zone to surface wind forcing and intrusions of the shelfbreak front.
 - John Steele's analysis of an end-to-end food budget for Georges Bank showed that because some predators can switch to different prey that it was essential to management of fisheries resources there to develop a comprehensive food budget including all trophic levels.
 - Cynthia Tynan's U.S. GLOBEC project has modeled the occurrence patterns of top predators (cetaceans and seabirds) in the northern California Current System and quantified covariability with changes in forcing from physical and biological processes, providing a basis for the development of a climate-based predictive capability.
 - Dezhang Chu has studied the use of multi-beam sonar for acoustic assessment of fish stocks and developed software to support the use of such hardware for that task.
 - Maureen Conte's research uses a novel method based upon the isotopic composition of higher plant-derived leaf wax aerosols to directly quantify large regional scale and temporal patterns of carbon isotopic fractionation of atmospheric CO₂ by terrestrial photosynthesis. These data will improve current model estimates of the magnitude and geographical pattern of carbon sinks and lead to a better understanding of how terrestrial sinks are linked to regional climate variability. The study is also generating unique information on the organic composition of aerosols and variations in sources (e.g. biomass burning).
 - The NOAA-NSF funded multi-investigator US GLOBEC Georges Bank Broad-scale group led by Peter Wiebe has produced a comprehensive set of maps of biological (zooplankton biomass and species, nutrients, chlorophyll), and physical variables measured on the 30 cruises taken during the 5 year study period (1995 to 1999). The data sets, krigged to fit a common grid, form the basis for study of monthly and interannual variations of the biological and physical fields on the bank, and the associated climate forc-

ing. Adjoint modeling (conducted by Dennis McGuillicuddy, among others), of one of the target zooplankton species, *Calanus finmarchicus*, has revealed that this species increase in numbers and biomass on the bank is controlled mostly by local biological processes and not advection from upstream sources.

- Bob Pickart, Andrey Proshutinsky, and Carin Ashjian participated in the summer of 2004 in the inaugural cruise of the new Russia- U.S. Census of the Arctic program. The three-leg expedition marks the beginning of this joint, multidisciplinary effort to improve understanding of climate change in the Arctic. Two canyons, the Barrow Canyon and the Herald Canyon, are the paths by which Pacific water enters the Arctic through the Bering Strait. This program carried out the first high-resolution cross-stream survey of Herald Canyon, which is in Russian waters, and greatly improves our understanding of the currents, water masses, and plankton found there.

Additional research highlights will be presented at the briefing by students, postdoctoral scholars and investigators in the form of posters. A sampling of the investigators' posters with the following titles can be found in Appendix XIII.

- Monitoring Boreal Forest Regrowth Dynamics Using Satellite Data Products
Scott J. Goetz, Daniel Steinberg, Greg Fiske, The Woods Hole Research Center and Edward Hyer, Eric Kasischke, The University of Maryland, College Park, MD
- WHOI / UOP / VOS PROGRAM (CORCIII and CICOR)
Robert Weller, Frank Bahr, Dave Hosom, Woods Hole Oceanographic Institution
- Sources Of The Cold Tongue In The Eastern Tropical Pacific Ocean
Bernadette M. Sloyan, Woods Hole Oceanographic Institution and Gregory C. Johnson and William S. Kessler, NOAA/ PMEL, Seattle, Washington
- Assessment of Air-Sea CO₂ Exchange Rates in the World's Oceans Using Bomb 14C Inventories Derived from the WOCE Global Survey
Alison M. Macdonald^{1,III}, Tsung-Hung Peng^{2,II}, Rik Wanninkhof², and Robert Key^{3,I}
¹Woods Hole Oceanographic Institution, ²NOAA/AOML/OCD, ³Princeton University
- Variations in CO₂ Concentration, Transport and Divergence in the Atlantic
Alison M. Macdonald and John M. Toole, Woods Hole Oceanographic Institution In collaboration with Dennis Hansell, Rosenstiel School of Marine and Atmospheric Sciences, U. of Miami
- Processing and Visualization of Multi-beam Sonar
Dezhang Chu, Woods Hole Oceanographic Institution
- Observations from the Southeast Subtropical Pacific: Non-Local Influences in the Heat and Salt Budgets,
Keir Colbo and Robert Weller, Woods Hole Oceanographic Institution
- Comparison of NWP Model/Reanalysis Air-Sea Fluxes of Heat and Momentum to In Situ Observations at Several Sites in the Tropical Pacific
J. Tom Farrar, Robert A. Weller (PI), and Kelan Huang, Woods Hole Oceanographic Institution
- Meteorology and Air-Sea Fluxes from Ocean Reference Stations
Al Plueddemann and Bob Weller, Woods Hole Oceanographic Institution
- How Accurate are Surface Meteorology Measurements From a Buoy?
Keir Colbo and Robert Weller, Woods Hole Oceanographic Institution
- Intraseasonal Variability in SST and Upper Ocean Currents in the Climatological Eastern Pacific Warm Pool
J. Tom Farrar and Robert A. Weller

Outreach and Education

Ongoing educational activities/opportunities

Post-Doctoral Scholars

The Institution Post-Doctoral Scholars program is a highly competitive program in which the Scholars are selected by an Institution-wide Fellowship Committee from a pool of 100-170 applicants. The ranking is based upon academic records, research promise and relevance of scientific interests to those of the Institution Staff. CICOR annually supports a new CICOR Post-doctoral Scholar. This is an 18-month appointment, and applicants are solicited through a special advertisement. Candidates are chosen for the CICOR Postdoctoral Scholar appointment based upon a review by the Fellowship Committee and of the academic credentials and research interests of the candidates that are compatible with a research topic of mutual interest to both the Institution and CICOR. In addition, a CICOR representative reviews the final pool of top-ranked applicants and makes recommendations, taking into account current funded NOAA research at WHOI, potential future research supportive of NOAA research goals, and the rotation of the CICOR Post-Doctoral Scholar award among the three research themes in CICOR. Last year, to fill the need for support, CICOR provided an additional support position for an African American Post-Doctoral Scholar. CICOR PIs regularly serve as formal and informal advisors to post-doctoral scholars. For more information on current and previous CICOR-funded post-doctoral scholars, see Appendix VI.

Graduate Student Research

CICOR also supports a Graduate Student Research Assistant in the MIT/WHOI Joint Program. In 1968 the Massachusetts Institute of Technology (MIT) and the Woods Hole Oceanographic Institution (WHOI) initiated a cooperative academic program leading to graduate

degrees in oceanography and in oceanographic engineering. Joint degrees are single documents awarded by both institutions. The guiding principle for this unique venture between a leading academic university and an independent oceanographic research and education institution has been to provide the highest quality graduate education for each student.

Students admitted to the MIT/WHOI Joint Program in Oceanography and Oceanographic Engineering not only have access to the faculty and staff of both institutions but also to their extensive physical facilities. All decisions from admission to the conferring of the degree -- a single document issued by both institutions -- are made by consensus of joint MIT/WHOI committees.

Each year a Joint Program Student is paired with a CICOR PI. In addition to this contribution to the Joint Program, CICOR has also funded other graduate students through grants and through its program development funds. Furthermore, CICOR PIs are often advisors to guest and Joint Program students. For more information on current and previous CICOR-funded graduate research assistants, see Appendix VII.

Summer Student Fellows

Based on recommendations from the CICOR Fellows in 2004, we are in the summer of 2005 adding support for three CICOR Summer Student Fellowships, one in each of the research themes in CICOR. These are advanced undergraduate students selected from a very competitive pool to study and work with a WHOI oceanographer for the summer and to be exposed, through a series of lectures specifically tailored to the summer fellows and other seminars, to oceanographic research. The Summer Student Fellowships have proven to be a very effective method to recruit promising undergraduates to the graduate

education programs in oceanography offered by WHOI and other U.S. academic research institutions. As with the graduate students and post-doctoral scholars, CICOR PIs have taken leading roles in advising Summer Student Fellows - Summer Fellow, Aaron Donohoe was advised by Al Plueddemann in 2002.

Through these education programs CICOR contributes to the education of the next generation oceanographers, including those needed to staff NOAA laboratories and NOAA line offices and headquarters. Examples of this include: Dr. Molly Baringer (PhD 2/1994) now at NOAA AOML, Dr. Benjamin Evans (9/1999) now at the Pacific Hydrographic Branch, Seattle, Dr. William Sunda (6/1975), now at NMFS, Beaufort, South Carolina, and Dr. Peter Ortner (2/1978) now acting Director of NOAA AOML.

Local K-12 Outreach

Locally, CICOR provides a \$100 Savings Bond and Certificate for award to a highly ranked ocean-related project at the Falmouth High School science fair. CICOR is planning to expand this participation in local high school science fairs and use this as a means to initiate dialog with the heads of the science departments in these schools about other means by which CICOR can assist in ocean-related educational activities at this level. A CICOR representative also participates along with Sea Grant in the regional Ocean Sciences Bowl for high school students, which is called the Blue Lobster Bowl. One meeting was held this spring with the head of the curriculum of the Woods Hole Summer School of Science, which targets ages 7-16, to investigate a more formal follow on to the involvement of a CICOR-supported graduate student in one course last summer.

A number of CICOR PIs are members of NE-COSEE. The New England COSEE seeks to strengthen the New England region's capacity to develop and provide high-quality ocean science education in both formal and informal settings, by understanding the needs of, working with, and facilitating interactions among educators, re-

searchers, and the public. For example, Al Plueddemann is a member of the NE-COSEE Science Advisory Group and has participated in several workshops geared towards K-12 Outreach.

Another example of NE-COSEE involvement is the active role that Alison MacDonald has taken in Ocean Science Education INstitute (OSEI-II). She has been working with education professionals and, specifically teachers in Massachusetts New Bedford Global Learning Charter School. Here, she has been bringing physical oceanography concepts and the results of her own research (such as that described in the highlights for NOAA/CICOR grants 37122326 and 31722350) to middle school students, and participating in the larger effort to bring oceanography into Massachusetts' middle school curricula.

U.S. Research Vessel Surface Meteorology Data Assembly Center at Florida State University, Tallahassee, FL annually participates in the FSU Young Scholars Program, by sponsoring the research activities of 2 high school students. The YSP students spend six weeks on the FSU campus taking classes and conducting directed research. They have been involved in the YSP program since 1998.

Current and planned outreach activities

Teacher At Sea Program Involvement

A strong education and outreach effort within CICOR is its involvement in the NOAA Teacher-at-Sea program (<http://www.tas.noaa.gov/>). In 2002, the STRATUS research cruise brought a NOAA Teacher-at-Sea for the first time to a non-NOAA vessel, in this case to the *R/V Roger Revelle*, chartered from UNOLS by NOAA for the STRATUS cruise. [The goal of the Stratus project is to observe and understand air-sea interactions and the surface forcing in the region of the cold tongue/intertropical convergence zone (ITCZ). For more information about the project see: <http://uop.whoi.edu/projects/Stratus/stratus.htm>] This Teacher-at-Sea was Debra Brice, from San Marcos, California. Her middle school classes were hosted for tours

and a question and answer session in San Diego during pre-cruise preparation by Scripps Institution of Oceanography and the WHOI science party. Debra Brice and Vivianna Zamorano, a Chilean TAS from Arica, Chile (where the cruise ended) participated in the cruise and interacted extensively with the science party while providing real time links to classrooms in the United States. At the end of the cruise, the ship and science party hosted tours by classes from Vivianna Zamorano's school. Interaction with Debra Brice continues through the present with support by a grant from Toyota and NSF obtained by Brice.

In December 2004, the stratus cruise hosted Mary Cook from Arkansas as the TAS along with Diane Stanitski, a program manager in the NOAA Climate Observation program. During this cruise the NOAA Adopt-a-Drifter program was initiated, in which class rooms "adopt" a surface drifting buoy and subsequently follow its track and data while learning more about the oceans. An amazing interaction developed during the cruise between Mary Cook, Diane Stanitski and the on board science. Together with the Chief Boatswain of the NOAA Ship Ronald H. Brown, they produced a book about this research cruise aimed at middle school students. A copy is included in the briefing material (Appendix XIV). In the last year, WHOI provided use of its high quality video editing facilities to John Kermond of NOAA OGP to develop a short presentation from his extensive video coverage of this cruise. As the STRATUS cruises typically return each year to Arica, subsequent cruises have again provided opportunities for classes from Zamorano's school to learn about oceanographic ships and research.

When in port in Central and South America, the science party on these cruises to the Stratus Ocean Reference Station regularly participate in interviews with the local press. These dialogs typically cover both the involvement of participants from these countries in the research and questions about ENSO, which has a major impact on these countries. In association with

obtaining clearance to sample in national waters, local observers are invited from the countries from which the ship sails and from which the ship docks at the end of the cruise. Additionally, as bunk and lab space is available and as ship time allows, these participants, which include researchers and their graduate students as well as members of the naval oceanographic services of these countries, are invited to participate in the research and carry out their own research projects. We have over the years assisted the Ecuadorian naval oceanographers with research buoy recovery near the Galapagos and the Chilean naval oceanographers with the deployment and annual maintenance of a Chile owned and operated tsunami warning buoy (DART hardware purchased by Chile from PMEL; on the first cruise we provided space for both PMEL and NDBC staff to train the Chileans). On as many cruises as possible to and from Chile we invite participation from students and researchers from the University of Concepcion, Concepcion, Chile with which WHOI has an memorandum of understanding focused on education activities. That relationship also leads to our participation in lectures at the University of Concepcion and in an Austral Summer School for Central and South American graduate students organized each year by the University of Concepcion. Last December's cruise off Chile also provided sampling opportunities in support of a graduate student at Texas A&M University and one at the University of Chile, Santiago.

National Office for Marine Biotoxins and HABs

The National Office for Marine Biotoxins and Harmful Algal Blooms at Woods Hole Oceanographic Institution maintains a webpage, "Harmful Algae", <http://www.whoi.edu/redtide>. This website strives to serve as a comprehensive resource for a broad range of user groups, including scientists, managers, the general public, journalists and students. Although there are many HAB-related websites in the U.S., this is the only one that deals with the entire range of U.S. HAB problems and provides access to information on national HAB research programs. It is used as a

central repository for information about HABs in the U.S. and every week, this site is one of the top 5 sites visited of all the WHOI websites. They receive numerous requests for specific information, images, etc. from individuals – particularly students and journalists.

The National Office is directly involved in numerous presentations that are given each year to various types of audiences – journalists, students, scientists, etc.

The office also distributes many reports and publications, including Proceedings from the various international HAB conferences, Monitoring and Management Strategies for Harmful Algal Blooms in Coastal Waters (published by APEC and IOC), The Ecology and Oceanography Of Harmful Algal Blooms: A National Research Agenda, Estimated Annual Economic Impacts from Harmful Algal Blooms (HABs) in the United States, and other reports.

SAMOS Initiative

Shawn Smith at the U.S. Research Vessel Surface Meteorology Data Assembly Center notes that the SAMOS (Shipboard Automated Meteorological and Oceanographic Systems) initiative has a number of educational goals. The focus of the training activities lies in the production of a handbook (or guide) to best procedures and practices for meteorological measurements at sea. The handbook is aimed at the sea-going research community and ships' technical staff. Topics will include information on preferred sensor location, calibration, in-situ comparisons, documentation, metadata, bulk flux methodology, and measurement error. Plans are for a dynamic handbook which will be available on-line. The structure proposed will have "drill down" capacity, keeping the top level of the handbook fairly simple and allowing users to search for additional technical detail if desired. In the future, users will be able to download relevant computer code, specifications, and technical information whether on land or at sea (as broadband ship-to-shore communication technology develops). Future plans also include holding training workshops for

marine technicians. The handbook development is being led by NOAA ETL.

WHOI Communications Office

WHOI has an active communication office, outreach and government affairs personnel and works at outreach in many areas. Examples of activities organized by WHOI that CICOR scientists participate in are: presentation to the annual visit by the Ocean Science Journalism Fellows--a group of seven to nine science journalists who spend a week at WHOI, visiting with investigators and students to learn the latest advances in ocean sciences, and make connections that yield long-term dividends by building better mutual understanding between scientists and journalists. Scientists also conduct phone interviews with reporters and are supported by a communications office that supports the following activities:

- The Information Office and Exhibit Center fulfilled 7,500 information requests from the public in 2004, and hosted 30,000 visitors.
- The WHOI Media Relations Web page got 163,000 visits in 2004, and fielded more than 5,000 information requests from the media.
- WHOI was featured in 543 newspaper articles in 2004, and in more than 18 national science broadcast programs or documentaries
- www.who.edu got almost 4 million external visits in 2004 (by comparison, the Smithsonian got 10 million)
- www.oceanusmag.who.edu, the online version of Oceanus magazine, got more than 30,000 visits in March--about 1,000 visits per day.

CICOR funded investigators are also involved with briefings to Senators, Congressman and congressional staff and provision of testimony at congressional hearings. In 2000, for example,

WHOI hosted Senators Craig from Idaho and Senator Chaffee from Rhode Island for a series of briefings on the ocean's role in climate and for WHOI staff to answer their questions about climate variability and change. In May 2002 Congressman Gilchrest and staff visited WHOI to learn more about ocean observing systems. In July 2001 and July 2004, the CICOR Director provided testimony on ocean observing system development to the House Resources Committee. CICOR PI, Don Anderson testified in March 2003 to the House Science Committee on Harmful Algal Bloom legislation and in July 200 Ray Schmitt testified before the Senate Commerce Committee on the ocean's role in climate change.

To reach a broader community with the type of information that has been provided at such briefings, CICOR will to continue to improve its website to develop it as a resource where people can learn more about NOAA ocean research and to provide information about its scientific themes and research results. At present, CICOR is joining with JIMO (Joint Institute for Marine Observation) and the Center for Educational Outreach Connections (CEOC), both at Scripps Institution of Oceanography in a proposal to NOAA to seek funding for an education and outreach broker

The proposed collaboration focuses on the application, evaluation and dissemination of a brokering approach to facilitate NOAA-funded scientists' involvement in educational initiatives to promote environmental literacy. Together, JIMO, CICOR and CEOC will demonstrate how fostering partnerships between the NOAA-funded science and education communities can position NOAA to take greater advantage of its inspirational assets and have a powerfully beneficial impact on science education in the US.

Building on strategies developed with NASA and more recently NSF funds, the brokers will serve as catalysts for efficient and effective participation by NOAA-funded scientists in exist-

ing EPO initiatives that promote environmental literacy. Brokers make it easier, more expeditious and ultimately more appealing for scientists to contribute to EPO by identifying specific EPO opportunities, then matching individual scientists with EPO options that best suit the scientists' research foci, available resources (time + \$), and personal preferences. Brokers will share their approach with the other NOAA CIs.

Science Management Plan

It is important to reiterate here that CICOR is an administrative, planning, and facilitation structure serving NOAA, WHOI, and other external investigators funded by NOAA. CICOR investigators respond to NOAA Announcements of Opportunity, submit proposals, and if successful are awarded funds by NOAA through CICOR. The \$110K base funds from NOAA OAR and the program development funds are devoted to Task I activities including education, outreach, and increasing engagement in planning and execution of NOAA research. That the principal mode of research is competitive grants funded in response to NOAA announcements is the context for how CICOR manages its science.

Identification of new intellectual opportunities

New opportunities are divided among those in the near-term (reflected by present and soon to be released Announcements of Opportunity) and in the future. Roughly, the near-term are those to be found in the present fiscal year out through the present fiscal year plus two years, in which NOAA research budgets are highly constrained, if not fixed, and the future are those in years for which there is open discussion of identifying the programs to meet NOAA strategic goals.

To address the near-term opportunities CICOR tracks the activities of the NOAA Goal Teams and programs, posts on the CICOR websites notice of new announcements of opportunity, asks the WHOI staff and CICOR Fellows for recommendations for visitors to stimulate dialog of new opportunities, provides travel support for WHOI staff to visit NOAA laboratories to develop dialogs there, and communicates news of opportunities to WHOI departments. In parallel, CICOR asks its Fellows, funded investigators, and WHOI staff for input on their

interests and works to connect investigators with program managers.

To identify the future opportunities CICOR stimulates visits, funds travel by WHOI investigators to NOAA laboratories, other institutions, and planning meetings, organizes workshops and colloquia, participates in meetings of the NOAA goal teams, and works with the research administration of WHOI to play a role in setting new directions.

Recent examples of intellectual opportunities

In January 2005, CICOR worked with the Northeast Fisheries Science Center (NEFSC) to host a Workshop focusing on climate variability, fisheries and marine ecosystems, and policy issues in the waters off the northeast United States. The CICOR Director noted the potential for synergies between developing observing programs and infrastructure funded by other agencies, the unique mix of expertise on climate, ecosystems, and marine policy to be found at WHOI, and the strong working relationship that was forged during the GLOBEC Georges Bank program between investigators at WHOI and NEFSC. The workshop report is provided in the briefing material; it develops in support of long-term planning by NOAA research and the community recommendations, priorities, and a timeline for research in this region for the next 10-15 years.

The potential for close synergies between diverse efforts to develop and use cutting edge ocean observing systems was noted last year by WHOI. A study group on access to the sea developed recommendations for WHOI-wide coordination of and emphasis on ocean observing systems. In response, the Center for Ocean Seafloor and Marine Observing Systems (COS-

MOS) was established and startup support for a director, senior engineer, and staff assistant were provided by WHOI. The decision was taken to overlay COSMOS on CICOR so that they share a common director and staff support. This ensures that the development and use of new observing capabilities by all agencies is coordinated and that opportunities to direct these next-generation observing system capabilities to NOAA research are facilitated.

Recent research results, including work by CICOR investigator Lisan Yu, have pointed to the important role of Indian Ocean Variability in global climate. To sharpen the focus on this issue and begin to hasten the development of a well-formulated research agenda, CICOR will work with the WHOI Climate Institute to host highly regarded international visitors in a colloquium of the role of the Indian Ocean in climate this August. Included among the invited visitors are: Dr. Stuart Godfrey (CSIRO, Hobart, Australia), Dr. Toshio Yamagato (Program Director, Climate Variations Research Program, Frontier Research Center for Global Change (FRCGC) JAMSTEC, Yokosuka, Japan), Dr. Peter Webster (Georgia Tech), Dr. Roger Lukas (U. Hawaii), Dr. Mike McPhaden (NOAA PMEL), and Drs. Jim Hurrell and Markus Jochum (NCAR).

A target for a future workshop or other planning efforts is paleoceanography. One of WHOI's assets is its collection of strong investigators in this field. Discussion with Cooperative Institute directors Drs. Jorge Sarmiento (Princeton University, CICS) and Joachanan Kushnir (Lamont Doherty Earth Observatory of Columbia University, CICAR) at the early 2005 meeting of the directors in Silver Spring, MD identified a common interest in paleoclimate and paleoceanographic research and led to plans to pursue better coordination of these interests, development of a research strategy for this community, and fostering a dialog with NOAA research about efforts to be planned in this field.

Strategy for new starts (projects, techniques, campaigns, etc.)

CICOR sees focused workshops that engage the research community (internally and externally to both NOAA and WHOI) and lead to well-defined and articulate recommendations, priorities, and timelines as a very effective approach, especially when done in concert with elements of NOAA (laboratories, goal teams, line offices.) In support of the January WHOI/NEFSC workshop CICOR used some Task I funds and also sought and received support from the Climate Goal Team lead, Dr. Chet Koblinsky.

In other cases, as for the August colloquium on the role of the Indian Ocean, CICOR sees the intellectual energy associated with visits by key researchers as the catalyst for initiating discussions and planning for new starts. To accomplish this CICOR will draw on Task I visitor travel support and partner where possible with groups and centers at WHOI to bring in additional energy and resources. This support is not limited to bringing visitors to WHOI; CICOR provides travel support for WHOI investigators to go to NOAA laboratories and community planning meetings to seed development of new efforts.

CICOR is also involved in WHOI-wide consideration of new opportunities. When in 2004 the President of WHOI commissioned an institution-wide examination of "access to the sea" including the development of cutting edge observing systems and the commitment of the institution to research that required long-term, ongoing observational efforts, CICOR staff and investigators were eager participants. The center that resulted, COSMOS, and the close relationship between CICOR and COSMOS reflects the CICOR strategy to be intimately involved in research and infrastructure devoted to access to the sea and in the development and use of cutting edge observing systems.

How much of the Institute resources are reserved for new opportunities or bright ideas?

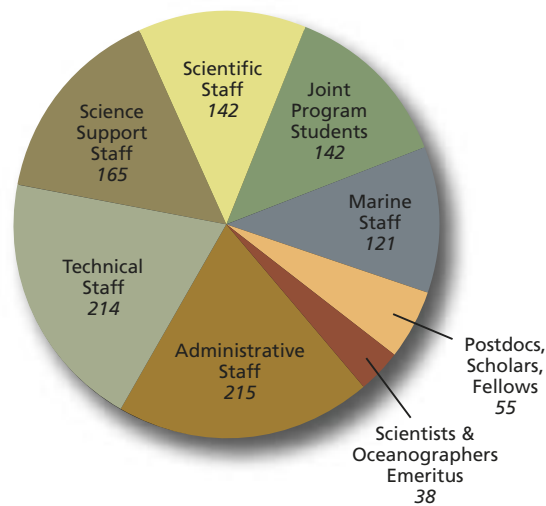
As summarized in the preamble to this section, CICOR does not have the ability to directly fund new research projects. Instead CICOR devotes a fraction of its Task I funds (estimated expenditure for August 2004 to August 2005 to be \$52,949) to seeding and developing new ideas through visits, seminars, colloquia, and workshops designed to stimulate and engage the WHOI community in new areas, build the interaction with the NOAA research planning teams, and thus initiate research planning and proposal writing into a submission cycle. In addition, about one-third of the salary support of the CICOR Director is devoted to identifying and collecting from the WHOI community new ideas and following through with discussions with NOAA about future support for these ideas.

CICOR seeks additional support as needed to carry out these activities when the necessary support is significant. To support the joint CICOR/NEFSC workshop in January 2005, for example, the CICOR Director sought and received in response to a short proposal an additional \$20K of support from the NOAA Climate Office.

What is the demographic structure of the Institute employees?

Strictly speaking, CICOR has no employees distinct from employees of the Woods Hole Oceanographic Institution. CICOR funds two part-time employees, the Director (Robert Weller) and the Administrative Manager (Patricia White) who are officially employees of the Physical Oceanography department. The CICOR Administrator, (Claire Reid), Administrative Manager and all but two months of the Director's time, are covered by WHOI's contribution to CICOR. These employees are subject to WHOI's human resources policies and procedures.

Of the 33 science projects funded through CICOR 6 have been lead by women and 6 by minorities. The WHOI community that CICOR serves and represents has the following internal demographic characteristics:



WHOI has cooperatively established a Woods Hole Scientific Community Diversity Initiative with the Marine Biological Laboratory, the Northeast Fisheries Science Center Woods Hole Laboratory, the Sea Education Association, the United States Geological Survey-Woods Hole, and the Woods Hole Research Center. This group of research institutions has signed a Memorandum of Understanding (Appendix XI) that confirms the Institutions commitment to diversity and its belief that diversity is a strength to be developed in the community.

What is provided for human resources development? (Recruitment, rewards, training)

All WHOI personnel associated with CICOR are subject to the Institution's human resources policies and procedures. The Institutions Human Resources Office has a staff of 14 dedicated professionals who oversee and administer all human resource activities including hiring, (which is conducted in consort with departments), and a comprehensive benefits program covering ev-

everything from health and life insurance to sick leave, retirement and education/tuition benefits, to name a few.

WHOI has an ongoing professional development opportunities organized through its Staff Training and Development Facility. The facility offers training in a variety of computer software, safety issues (in conjunction with the Safety Office), short courses as opportunities and needs arise, and other professional development courses as needed. The facility also offers internationally recognized assessment and certification in the Microsoft Office Users Suite.

The Institution conducts yearly performance evaluations that are carried out through departmental committees and which become part of each employee's permanent record. These yearly evaluations require that employees assess their goals and accomplishments over the course of the year and offer an opportunity for supervisors and employees to discuss such progress as well as to consider future goals and promotions. These performance reviews are used to determine yearly merit increases.

The Institution recognizes the significant contributions of its employees and students in making the Institution a world leader in ocean science. It supports activities that acknowledge those contributions and that foster positive morale and Institution spirit. These activities can take the form of a variety of events, both formal and informal. For example, WHOI has an Annual Employee Service Recognition, an Institution-wide event to acknowledge employee service, including retirees. Special recognition is given to active employees in regular status, at half time or more, who have completed more than 10 years of accrued service. Service is recognized in 10 year increments.

Special Performance Awards for individuals and groups are given to acknowledge special employee performance over and above one's normal duties and responsibilities. The recipients are nominated by their peers. The awards, usually a

plaque and a modest check, are presented at the annual Employee Service Recognition event.

The Summer Picnic and Holiday Party are Institution-wide events, open to employees, students and their families. There are also occasional socials which are periodic events targeted to recognize particular special employee groups, e.g., a dinner party for recent retirees and their spouses, receptions for foreign visitors, their families and their WHOI sponsors/hosts, etc. Other social events may include ship homecomings or farewells, casual TGIF's or other special events that take place from time to time.

The Human Resources Office also coordinates a new mentoring program that was initiated in 2003-04. The beta program which included approximately 50 people from all areas of the institution, was reviewed highly by participants and has been rolled-out Institution-wide during 2004-05. This formalized mentoring program is in addition to the long-time informal mentoring that has evolved with the WHOI culture as well as departmental mentors that are assigned to scientific staff.

Financial Information

CICOR was created in 1998 and was originally funded by a 3-year cooperative agreement. During the life of that first agreement, CICOR received a total of \$5,598,820. On 1 July 2001 a new cooperative agreement was initiated. This provides all the funds that are governed by CICOR.

The cooperative agreement is organized by Tasks. Task I provides support for the administrative activities of CICOR. The base funding awarded each year from OAR is \$110,000. It provides approximately 2 months of support for the Director and support for a post-doctoral scholar and partial support for a Graduate Student associated with research in CICOR. The budget also includes support for meetings of the CICOR Council of Fellows and the Executive Board, and for travel by the Director to various NOAA meetings including meetings of Coop-

erative Institute Directors and the NOAA planning meetings.

CICOR also receives Program Development support as part of the funding of most of the science and research proposals. These funds provide further support for Post-Doctoral Scholars, Graduate Students, a Visitor program. This Visiting Scientist program enables scientists from other institutions and from NOAA Laboratories to visit and conduct research at the Institution, participating in collaborative programs with CICOR Fellows. Program Development funds are also our only source of support for various Educational and Outreach projects described in other sections of this report.

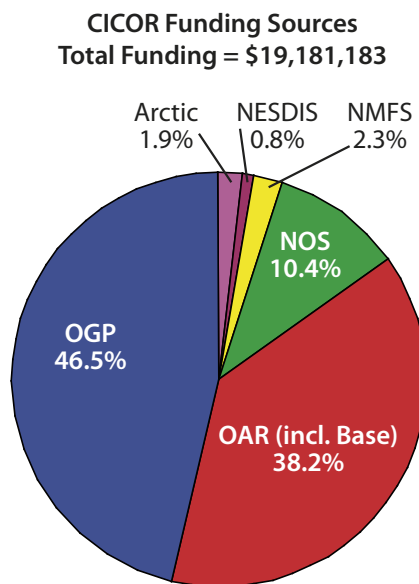
The research effort in Task II consists of those proposals and programs that actively involve NOAA scientists as collaborators. The research efforts in Task III consist of proposals and currently funded programs supported by NOAA through the OAR, OGP, NMFS, NOS, and other external funding offices in NOAA, and are therefore directed toward NOAA's strategic goals. We encourage active collaboration with NOAA staff but none is required under this task.

Task IV includes support for various facilities, such as UNOLS ships, submersibles, and unmanned vehicles that are used in support of NOAA's mission and cooperative research.

The funding received as of May 1, 2005 is broken down by Task as follows:

All funds, other than Task I funds, are received as a result of the award of competitive proposals submitted to various offices of NOAA. These proposals are prepared by Principal Investigators who have a particular interest in doing research to support NOAA's mission and strategic plan. So far in this cooperative agreement we have received funds for 33 individual science and research projects and several Task IV projects that provide funding for facilities. The Research Projects awarded thus far are listed on the following page. Another version of this list divided by Task and Theme with award totals is included as Appendix IV.

The funding from CICOR comes from a variety of sources within NOAA. The following chart shows how the funding is divided between these sources.

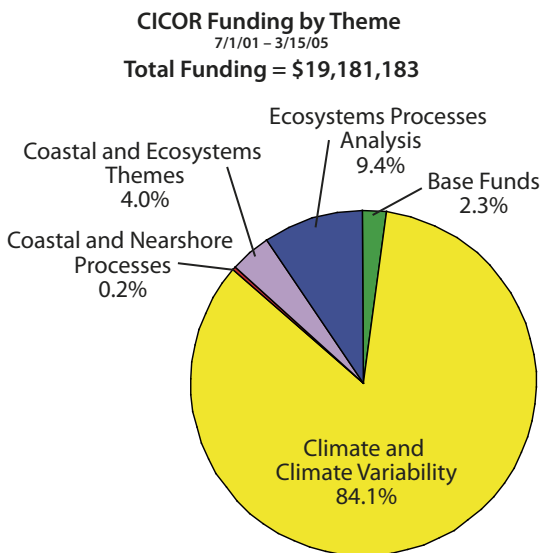


CICOR Cooperative Agreement					
July 1, 2001 – June 30 2006					
	Funds Received as of May 1, 2005				
	Year 1	Year 2	Year 3	Year 4	Total
Task I - Administrative, Program Development	222,021	286,256	416,050	237,220	1,161,547
Task II - NOAA Collaborators	385,733	567,467	365,712	668,926	1,987,838
Task III - Support of NOAA mission/goals	2,556,102	3,841,135	4,117,008	4,677,295	15,191,540
Task IV - Facilities	0	0	347,807	492,451	840,258
TOTAL	3,163,856	4,694,858	5,246,577	6,075,892	19,181,183

Principal Investigator		Title
Wade McGillis	WHOI	2003 SOLAS Summer School
Lisan Yu & Robert Weller	WHOI	A Fifty Year Analysis of Global Ocean Surface Heat Flux to Improve the Understanding of the Role of the Ocean in Climate
William Emery	Univ of Colorado	A Multi-Sensor Improved Sea-Surface Temperature (MISST) for GODAE
Al Plueddemann	WHOI	A Northwest Tropical Atlantic Station for Flux Measurement
Robert Weller	WHOI	Air Sea Interaction in the Eastern Tropical Pacific ITCZ/Cold Tongue Complex
Wade McGillis, James Edson & Gene Teray	WHOI	Air-Sea Carbon Dioxide Fluxes and Surface Physical Processes
Di Jin	WHOI	An Analysis of Fishing Vessel Accidents in Fishing Areas off the NE U.S.
Di Jin	WHOI	An Analysis of the Relationship between Fish Harvesting and Processing Sectors
Robert Beardsley & Steve Lentz	WHOI	Analysis of the 1999 Georges Bank Tidal Mixing Front Moored Array Data
Maureen Conte	Marine Biological Lab	Applic. of the Leaf Wax-Aerosol Method to Assess Spatial and Temporal... Terrestrial Photosynthesis, #PO11343.00
Allison Macdonald	WHOI	Assessment of Air-Sea CO ₂ Exchange Rates in the World's Oceans using Bomb 14C Inventories derived from WOCE Global Survey
Mark Johnson & Peter Tyack	WHOI	Behavior of Sperm Whales in the North Atlantic - Yr. 1
Scott Goetz	Woods Hole Research Center	Carbon Dynamics of North American Boreal Forest Regrowth
Dana Yoerger et al	WHOI	Collaborative Research with PMEL: Exploring the Submarine Ring of Fire
Robert Pickart	WHOI	Flow of Pacific Water Through the Western Chukchi: Dynamics and Biological Implications
Cyndy Tynan	WHOI	GLOBEC Target Species: Interactions with Top Trophic Levels
Peter Wiebe & Robert Groman	WHOI	GLOBEC-01: Phase IV Support for the Scientific Investigators' Data Synthesis Symposia
Peter Wiebe et al	WHOI	GLOBEC-01: Integration and Synthesis of the Georges Bank Broad-Scale Survey Results
John Steele	WHOI	GLOBEC-01: Patterns of Energy Flow and Utilization on Georges Bank -Simulation Modeling and Data Analysis
David Hosom & Robert Weller	WHOI	Implementation of the One High Density XBT Line with TSG and IMET Instru. in the Tropical Atlantic
Robert Weller	WHOI	Long-Term Evolution and Coupling of the Boundary Layers in the Stratus Deck Regions of the Eastern Pacific
Brian Ward & James Edson	WHOI	Multi-Sensor Improved Sea-Surface Temperature (MISST) for GODAE

Al Plueddemann & Robert Weller	WHOI	Ocean Reference Stations
Dezhang Chu	WHOI	Processing and Visualization of Multi-Beam Sonar Data
Bernedette Sloyan	WHOI	Sources of Cold Tongue in the Eastern Tropical Pacific
W. Breckner Owens	WHOI	The ARGO Project: Global Ocean Observations for Understanding and Prediction of Climate Variability
Wade McGillis	WHOI	The Effect of Small Scale Variability of pCO ₂ on the Determination of Air-Sea CO ₂ Fluxes
Jiayan Yang & Terry Joyce	WHOI	The Oceanic Role in Climate Variability on Interannual to Decadal Time Scales
R. Xin Huang	WHOI	Thermohaline Circulation in the Atlantic and its Variability under the Energy Constraint
Donald Anderson	WHOI	U.S. Program in Marine Biotoxins and Harmful Algae
James O'Brian & Shawn Smith	Florida State Univ	U.S. Research Vessel Surface Meteorology Data Assembly Center
Andre Proshutinsky	WHOI	Variability of Thermohaline Circulation and Freshwater Storage in the Arctic Ocean
John Toole & Allison Macdonald	WHOI	Variations in Oceanic CO ₂ Concentration, Transport and Divergence in the Atlantic

The science and research that has been funded through CICOR can be broken down by Theme. The three themes discussed in detail in other sections of this report do have some overlap and thus some projects can properly be seen as contributing to more than one of them. The following graph shows how the funds received can be distributed to the themes or combination of themes.



The Wood Hole Oceanographic Institution also provides support for CICOR in several ways. It provides additional salary support for the Director and salary support for the Administrative Manager as well as the CI Administrator. WHOI also provides additional travel support for the CICOR staff to attend various Cooperative Institute meetings and miscellaneous support for office equipment and supplies, graphic and web assistance. This has been over \$ 369,000 for the first four years of the current cooperative agreement.

A second way that WHOI provides support to CICOR is with reduced overhead rates. At the time of the preparation of the proposal for the cooperative agreement, WHOI agreed to accept reduced overhead rates fixed for the life of the cooperative agreement. WHOI is required to recover overhead rates from all projects at the negotiated rate and therefore must contribute the difference from Institution unrestricted funds. As the WHOI negotiated rates increase slightly each year the difference between these rates and the rates given to CICOR increases. Also,

as more awards are received and more salary is charged to CICOR, the need for the overhead differential increases. Contributions of Institution funds for overhead for the current cooperative agreement have been more than \$359,000.

Are there any issues in interacting with NOAA that require attention?

Interaction with NOAA requires constant attention and much of CICOR's staff's available time. This is necessary to track the process by which future research is planned, to process proposals and track awards to CICOR investigators, to carry out required reporting, to prepare for reviews, new Cooperative Agreements, and the upcoming re-competition of all Cooperative Institutes.

Of most concern are: 1) the lack of timeliness in the provision of funds for projects and our inability to track the progress of awards within NOAA, 2) the burden and potential disruption posed by the convergence of the new Cooperative Agreement and the re-competition, 3) the lack of formal engagement of CI investigators in the NOAA procedures for requesting ship time and making arrangements for charter of UNOLS ships when NOAA research vessels are not available, and 4) the lack of a role for the Cooperative Institutes in the NOAA planning processes. We have seen it take up to 5 months for funds to arrive following acknowledgement that a proposal has been funded. During this time we are unable to routinely track the progress of the award paperwork within NOAA. This delays the start of research, frustrates the principal investigator and the CICOR staff that fields his/her calls about the award, and complicates CICOR's management of research funds. In one case, the delay introduced a hiatus into graduate student support that CICOR had to fill with Task I funds.

Coming soon after this review, the need to prepare a new Cooperative Agreement and the need to sometime soon after to prepare to re-compete CICOR will create an administrative

burden beyond what can be supported by the base funds provided to Task I by NOAA. It will require CICOR to seek additional support from WHOI to meet these tasks, and will introduce uncertainty and concern into the NOAA-funded principal investigator community at WHOI. A number of CICOR projects have a long-term perspective (research projects such as the ARGO float program and the maintenance of the Ocean Reference Stations; operational efforts like the provision of UNOLS ship time via Task IV).

With the present Cooperative Agreement and all CICOR proposals under it with funding end dates of June 30, 2006, only one year away, the investigators must soon engage in preparing new proposals. Yet, CICOR cannot yet provide guidance of start and end dates for these new proposals. Nor can CICOR yet explain to investigators the sequence of events likely for the next five years: new or renewal proposals linked to a new or extended Cooperative Agreement, new contributions to a new Cooperative Agreement, new proposals following a re-competition, hiatus in NOAA funding or termination of NOAA funding.

The third issue is that of arranging for ship time for CICOR field projects. Over the years, investigators within NOAA have had formal procedures for requesting ship time from NOAA NMAO while CI investigators have not. This had lead to a very opaque pathway for CICOR investigators to request ship time, with no clear procedure and great sensitivity to the awareness of individual investigators and program managers of the vagaries of NOAA ship allocation and chartering policies and procedures. The withdrawal of NOAA support for WHOI and other vessels late in the planning process has caused tension, as has the uncertainty of NOAA's ability to cover charter costs in a timely fashion. There has in the last year been improvement with NOAA's creation of a ship scheduling panel with representation by the NOAA Climate Observation program.

The fourth issue is that of the role of the Cooperative Institutes in NOAA planning processes. The Cooperative Institutes are closely aligned to and supportive of NOAA strategic plans and of the activities of the laboratories. Yet, they do not have a role comparable to that of the OAR laboratories, and have restrictions on the extent to which they can participate in the development of NOAA research plans and budgets. This disparity has, over the years, been a source of frustration for the external community. Annual meetings of the directors with OAR and discussion of this issue has led to three directors (the executive committee, consisting of the present lead director plus the past and next lead directors) being allowed to attend NOAA OAR Senior Research Council meetings. It has also led to greater dialog between the institutes and the NOAA goal teams. However, the institutes are still restricted from key stages of the process during which priorities are decided and budgets divided between internal and external activities.

It is of high importance to CICOR and WHOI that both the mechanics and timeliness of funding awards be improved, for the timelines, tasks, and procedures for the next Cooperative Agreement and the re-competition be provided in detail, for there to be improvements to the procedures for arranging ship time and making durable agreements to charter UNOLS vessels, and that there be continued improvements made in the engagement by NOAA of the Cooperative Institutes in the NOAA planning processes.

Are there any issues in interacting with WHOI that require attention?

CICOR enjoys strong support from WHOI. WHOI contributes financially (support for the Director, the Administrator, the Administrative Manager; the difference between the CICOR overhead rate and the WHOI overhead rate) and by participating in ongoing dialog with all levels of NOAA. The area in which continuing attention by CICOR staff is needed is the ongoing education and engagement of the WHOI community about NOAA research and about the role of facilitating NOAA research. For many at WHOI, NOAA research, its planning and funding procedures, remains more opaque than, for example, NSF research. This is especially true for parts of NOAA that do not use Announcements of Opportunity to solicit proposals. CICOR must continue to be proactive, originate and hold workshops, and development further engagement of the WHOI community in NOAA research.