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Before the
House Subcommittee on Fisheries Conservation, Wildlife and Oceans

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Chairman Gilchrest, Ranking Member Pallone, and members of the Subcommittee, thank you for the opportunity to appear before you today to present testimony on the California State University's Center for Integrative Coastal Observation, Research and Education (CICORE), and the development and implementation of ocean observing in California. My statement is organized to respond to the nine specific questions asked of me by Chairman Gilchrest in his letter of invitation to testify.

1. *Testimony on the development and implementation of California's ocean observing system:*

Current Observing Systems in California

The State of California has long recognized the importance of ocean observing and monitoring and has embraced monitoring systems at a number of levels. One of the original monitoring programs began in 1949 to study the ecological aspects of the collapse of the sardine population and fishery with the formation of the California Cooperative Oceanic Fisheries Investigations[1] (**CalCOFI**), a collaboration of NOAA National Marine Fisheries, California Department of Fish and Game and Scripps Institution of Oceanography. An expansion of this program, to cover the whole U.S. west coast and to focus on the management of its living resources, is being proposed as the Pacific COastal Ocean Observing System (**PACOOOS**).

Over the last few years, the need to establish systems for the long-term monitoring of the nation's coastal regions has been recognized and promoted by policymakers in California and Washington, D.C. A number of initiatives have enabled both the transformation of existing programs and the establishment of new monitoring programs directed at coastal monitoring. In part because funding sources have varied greatly, at first glance they may appear to create duplication and overlap. However, ongoing California programs are remarkably complementary and synergistic. These programs are serving to bridge the gap between research and operations and, in fact, are moving explicitly toward observing system goals through user outreach and through better communication, data sharing and data distribution between academia, state and federal agencies, NGOs and the general public.

Presented here are some of these programs, their goals and funding sources:

CICORE[2] (Center for Integrative Coastal Observation, Research and Education) is a nearshore (<100 m water depth, up to and onto the coast) observatory conceived by the presidents of the California State University (CSU) [3] and endorsed by the system's Chancellor and Board of Trustees. The program has received Congressionally-directed funding and is administered through the NOAA Coastal Services Center

[1] http://www.calcofi.org/
[2] http://cicore.mlml.calstate.edu
[3] http://www.calstate.edu/

(CSC) Coastal Ocean Technology Section (COTS). The principal goals of the program are to coordinate coastal observations at the 23 CSU campuses throughout California to provide a distributed monitoring program along the California coastline. This network allows characterization and observation of statewide and local coastal ocean variability, with a focus of making information accessible for applied needs and education. Ultimately, **CICORE** will become a key backbone element of both the **CeNCOOS** and **SCCOOS** Regional Associations, described below.

CIMT[4] (Center for Integrated Marine Technology) was initially known as the Winds to Whales Project. Based at UC Santa Cruz, in 2002 the program reorganized to pursue an integrated approach to looking at the ecosystem transformation of energy, starting with the initial forcing functions of the sun, wind and currents and following the energy up through the trophic levels of plants and animals to the top predators. The program uses northern Monterey Bay as its study region. The goals of the program also include sustained observations and technology development, and the program receives Congressionally directed funding administered through NOAA COTS. For these reasons, **CIMT** is also described as a monitoring program.

ACT[5] (Alliance for Coastal Technology) is a national program led by the University of Maryland. The program aims to be a clearinghouse for ocean instrumentation. This program is also a Congressionally directed funding program administered by NOAA COTS. Two California institutions, Moss Landing Marine Laboratories (MLML), and Monterey Bay Aquarium Research Institute (MBARI), are members.

There are other distributed observing efforts that exist in California. **NEOCO**[6] (Network for Environmental Observations of the Coastal Ocean) is funded by the University of California Marine Council to locate water quality monitoring devices at UC coastal campuses. **PISCO**[7] (Partnership for Interdisciplinary Studies of the Coastal Ocean) is a multi-institutional program, funded by the Packard Foundation, which addresses environmental issues at a number of specific sites along the west coast.

There are many other agencies and organizations that have monitoring operations in California, many of which are very local. NOAA and the California Regional Water Quality Boards are two examples of agencies that have specific observational mandates.

A goal in the creation of the federally recognized Regional Associations, described in detail in the next few paragraphs, is to identify all relevant needs and mandates, as well as existing efforts, so that coordinated systems can be developed to meet the regulatory and agency requirements for monitoring coastal California water quality.

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[4] http://cimt.ucsc.edu/
[5] http://www.actonline.ws/
[6] http://www.es.ucsc.edu/~neoco/
[7] http://www.piscoweb.org/

Taken together, the entities described above are making steady progress toward building the backbone of coordinated, integrated, regional systems, consistent with the policy goals recommended in the Pew Ocean Commission's report[8] the National Research Council's[9] Ocean Report and the Preliminary Report of the U.S. Commission on Ocean Policy[10].

California's Emerging Regional Associations

A recommendation from Ocean.US[11], the federal interagency entity that is charged with coordinating the development of an operational and integrated and sustained ocean observing system (**IOOS**), is that certified Regional Associations be formed that will work at the national level to promote the establishment of a national Coastal Observing System and work at the local level to coordinate observing efforts. In California, **CeNCOOS**[12] (Central and Northern California Ocean Observing System) and **SCCOOS**[13] (Southern California Coastal Ocean Observing System) are the two emerging Regional Associations. The overlap between the systems will be at Point Conception, a natural geographic boundary. They will work with **NANOOS** (Northwest Association of Networked Ocean Observing Systems) to represent the west coast of the continental United States. These Regional Associations are in the initial formation stages, determining their governance structures and seeking certification. It will probably take about two years until they become functioning Regional Associations able to conduct Ocean.US mandates.

CeNCOOS presently has initial members from over 40 different agencies and institutions and has identified about 70 existing monitoring or observing systems in central and northern California. The association has hired a coordinator and is focusing on determining its governance structure with the goal of becoming accredited by June 2005. **SCCOOS**, which is headquartered at UCSD's Scripps Institute of Oceanography, has also received Congressionally directed funding administered through NOAA COTS. Both **SCCOOS** and **CeNCOOS** have also received competitive grant money from NOAA to begin the work of forming Regional Associations. These two Regional Associations are part of the eleven member National Federation of Regional Associations[14], a group working with Ocean.US to ensure Regional Association accreditation.

[8] http://www.pewoceans.org/
[9] http://www.nationalacademies.org/nrc/
[10] http://oceancommission.gov/
[11] http://ocean.us/index.jsp
[12] http://www.cencoos.org/
[13] http://www.sccoos.org/
[14] http://usnfra.org/index.jsp

Supplementary Efforts Sponsored by the State of California

The state of California continues to be a national leader in investing in coastal research, and its efforts are being coordinated thoughtfully with the federal Regional Association concept in mind. In 2000, California enacted the California Ocean Resources Stewardship Act, which led to the creation of the California Ocean Science Trust[15] (**CalOST**). This state-funded, non-profit organization has a mandate to fund marine and coastal research in California and to encourage coordinated, multi-agency, multi-institution approaches to ocean resource science. **CalOST** has appointed an executive secretary and is determining its role for promoting ocean observing and management in California.

In 2002, through voter-approved Propositions 40 and 50, the voters of California authorized the creation of a program to monitor coastal circulation. The California State Coastal Conservancy and the California State Water Resources Control Board will fund and administer the Coastal Ocean Currents Monitoring Program[16] (**COCMP**). Initial funding of $21 million dollars is for the development of backbone elements of coastal monitoring infrastructure. Two proposals, one from **SCCOOS** and the other from northern California, have been funded to create a statewide integrated system. The northern proposal will become a **CeNCOOS** component. The principal observing tool will be an array of surface current mapping[17] (SCM) radars, which will allow monitoring of ocean surface currents throughout the state. (SCM radars are also commonly referred to as "high frequency" or HF radar and by the name of the major manufacturer, CODAR.) Other infrastructure will include a shoreline surf and current monitoring array and three-dimensional modeling of coastal circulation. This program, with its emphasis on SCM radar technology, closely follows the recommendations of the Ocean.US surface current mapping initiative. SCM instruments are shore-based, seaward looking radars. Advantages of this technology include wide area coverage and lower maintenance costs compared with equipment placed in the ocean. SCM data will help with predicting beach closures caused by bacterial contamination, tracking oil and other pollutant spill trajectories, and the fate of the early stages of commercially important fisheries species.

2. *What is the status of the Center for Integrative Coastal Observation, Research and Education (CICORE) System?*

The **CICORE** program was established in 2002 as a coastal observing research and academic program distributed among CSU campuses located along the California Coast. **CICORE** leverages the intellectual and infrastructure resources of the CSU system and seeks to address the coastal monitoring priorities of stakeholders along the entire California coast. Among others, **CICORE** partners include the California

[15] http://resources.ca.gov/ocean/CORSA/CORSA_index.html
[16] http://www.cocmp.org/index.html
[17] http://oceancurrents.us

Department of Fish and Game, the State Regional Water Quality Board, local harbor districts, the three National Marine Sanctuaries, and two of the three National Estuarine Research Reserves. Now in its second year, and funded for a third year, **CICORE** is one of the 16 NOAA Coastal Observing Systems[18] (COTS) programs either funded by Congressional directive (nine) or through COTS competitive announcements (seven).

CICORE draws upon the strengths and expertise of California State University (CSU) campuses dotting the entire California coastline, including CSU Hayward, Humboldt State University, CSU Long Beach, CSU Monterey Bay, Moss Landing Marine Laboratories, San Diego State University, San Francisco State University, San Jose State University, and California Polytechnic State University, San Luis Obispo. In addition, **CICORE** leverages the expertise of scientists at the Florida Environmental Research Institute and Old Dominion University. Together these groups work together to perform *in situ* observations and collaborate on periodic field efforts in areas of stakeholder interest. The program anticipates adding other CSU campuses each year in an orderly manner to ensure maximal benefits to the identified educational and resource priorities in the coastal region.

The California State University and **CICORE** are indispensable to the region's ability to meet national and state goals related to coastal observation. The CSU is the nation's largest university system, with 23 campuses and seven off-campus centers, 409,000 students, and 44,000 faculty and staff. Stretching from Humboldt in the north to San Diego in the south, the CSU offers a wealth of relevant applied research expertise and is uniquely positioned geographically to undertake the observing mission. Moreover, the CSU is renowned for the quality of its teaching and for its job-ready graduates. For example, the CSU produces about 60% of California's teachers and a large fraction of the staffers in local, state and federal environmental agencies. Many of the professionals needed to implement coastal observing systems will be trained by the CSU, and the **CICORE** program is important for the preparation of all these individuals.

3. *What types of data are being collected and what technologies are used?*

The **CICORE** program set as its observational region an important area missed by many of the existing monitoring programs, the region extending from the 100 meter isobath (water depth) into and onto the coast, including California's bays, estuaries and wetlands. This critical zone, between "deep water" and the shore, is where most impacts occur yet is seldom systematically sampled and monitored. **CICORE** has distinguished itself in establishing a program based on three technologies, which provide critical information in the coastal region. These are:

• high resolution spectral imaging for mapping and classification of shallow water and wetlands areas,

[18] http://www.csc.noaa.gov/cots/projects.html

• high resolution acoustic seafloor mapping and characterization of critical shallow water habitat areas, and

• *in situ* sensors for time series measurements of water quality and current measurements at discrete locations throughout California.

In addition, each **CICORE** partner may obtain local data directly pertinent to their regional needs. Data from these technologies are combined with other observational systems to develop and produce products to directly address concerns of policy makers, regulators, scientists and the public.

High Resolution Spectral Imaging: High resolution or hyperspectral imaging (HSI) is emerging as a key assessment tool for coastal water and shoreline characterization and monitoring. Florida Environmental Research Institute (FERI) is the civilian agency working with the Naval Research Laboratories' Portable Hyperspectral Imager for Low Light Spectroscopy (PHILLS) sensor, and is responsible for developing domestic applications. In collaboration with FERI, **CICORE** is developing this technology and using it for a number of assessment and monitoring purposes. Acoustic ship surveys cannot be conducted in very shallow water; it is too dangerous for safe ship operations. HSI technologies allow for high resolution mapping (on the scale of meters) over thousands of square kilometers per year. **CICORE** is actively collecting co-located seafloor mapping and hyperspectral imagery in order to develop and validate the retrieval of bathymetry and habitat classification in this difficult to assess environment. Once these algorithms are verified, the hyperspectral imagery will provide an effective way to quickly map the shallow water environment. The other uses of hyperspectral data being developed relate to terrestrial land-use and runoff interactions, vegetation mapping, and water column processes. These include (but are not limited to) fresh water fluxes and resulting ecological shifts, assessment of benthic vegetation and kelp canopy growth and coverage, and identifying and tracking of Harmful Algal Blooms (HABs). With the planned inclusion of laser ranging LIDAR, these data will be extended to issues of coastal erosion and shoreline instability. **CICORE** is presently working with the San Francisco Bay National Estuarine Research Reserve[19] to investigate invasive plant species (Spartina and Pepperweed), documenting both the spread of the invading plants and the ecological changes occurring as a consequence. Another application of HSI data is the ability to not only map the distribution of kelp beds, but also to assess the age and health of the kelp fronds. This information will help guide harvesting permits.

High Resolution Acoustic Seafloor Mapping: The second observing technology is the use of multibeam and sidescan acoustic imaging to characterize nearshore habitats. The seafloor mapping component is characterizing and quantifying the diverse benthic habitats found in the nearshore region. It will be many years before the entire coastal region will be mapped with the resolution possible with the multibeam acoustic surveys employed by **CICORE**. The program is identifying sensitive sites undergoing benthic

[19] http://www.sfbaynerr.org

modification. These data have been used to identify critical fishery habitats and, in a subtractive mode, identify areas of deposition and erosion. These are the first high-resolution images being produced in a number of critical areas. One application of these data are to assist the cruise ship industry in locating anchorage areas that will not disturb sensitive benthic habitats.

In Situ Monitoring: The third technology is *in situ* monitoring. Robust methodology for high temporal resolution monitoring of the basic water quality parameters temperature, salinity, density, sediment load, and water clarity provide the basis of a distributed network of instruments that provides web-accessible data in near real time. These *in situ* measurements are critical for both assessment of regulatory decisions and investigating long term trends related to climate variability. Other measured parameters at selected sites also include currents, fluorescence, oxygen and nutrients. In this shallow coastal environment, fluctuation of fresh water flow is one of the major modifying parameters. The deployed instrument array tries to focus on these critical regions to obtain the data that will assist scientists, planners and resource managers needing water quality information.

These combined measurements constitute an observing system that characterizes the near shore coastal zone and allows monitoring in real time of the water quality fluctuations. Real time water quality monitoring and habitat characterization are two data sets frequently requested by regulatory agencies to ensure balanced management plans for coastal resources.

4. *How are issues of data processing, distribution and archival handled?*

Data processing and archival systems pose a formidable challenge for coastal observatories, yet one that is critical to the success of any observing system. **CICORE** participates in regional workshops on data standards and is following the Ocean.US Data Management and Communications (DMAC) recommendations on data discovery, access and archiving. **CICORE** data are posted to web accessible sites as quickly as possible to ensure the data are openly available to the public. The *in situ* data are posted in near real time, while the acoustic mapping and hyperspectral imagery require more intensive post collection processing before the data can be made available. The numerous data sets can be accessed at the main **CICORE** site or through the individual partner sites listed in the table below. The hyperspectral imagery generates terabytes of data. Users can view these data through IMS servers at FERI and California Polytechnic State University, San Luis Obispo. Data extraction requests are handled by FERI. Similarly, the high resolution acoustic bathymetry can be viewed and retrieved from the California State University, Monterey Bay Seafloor Mapping site.

CICORE web pages at the member institutions:

Moss Landing Marine Laboratories	http://cicore.mlml.calstate
California Polytechnic State University, San Luis Obispo	http://www.marine.calpoly.edu/cicore/default.shtml
California State University, Hayward	http://www.sci.csuhayward.edu/cicore/
California State University, Monterey Bay	http://seafloor.csumb.edu/CICOREweb.html http://seafloor.csumb.edu/arcims.htm
Humboldt State University	http://cicore.humboldt.edu/
San Francisco State University	http://sfbeams.sfsu.edu
Florida Environmental Research Institute	http://www.flenvironmental.org/ http://www.flenvironmental.org/HyDroDB/login.asp

5. *Does CICORE represent all of the ocean observing systems in California?*

No, as detailed in response to question one, above, **CICORE** is one of many complementary programs in California engaged in ocean observing. These programs are working together to establish Regional Associations which are part of the coastal component of the U.S. Integrated Ocean Observing System.

6. *If not, are other systems and CICORE coordinating to avoid duplication and collect uniform data to support a regional system*?

Absolutely. The challenge of coastal ocean observing in California is larger than any one institution and the only way it can be effectively addressed is through collaboration. As detailed earlier, **CICORE** is one of several existing, and complementary, ocean observing programs. In northern California, other existing programs include **CIMT**, **ACT**, **NEOCO**, and **PISCO**. Many local, State, particularly California Fish and Game, and Federal (NOAA and USGS) agencies also maintain observing or monitoring programs that span portions of California's 3425 miles of coast line. In general, the existing programs complement one another well in a number of ways, including the area covered, the variables measured, and the technologies employed.

In recognition of the emerging national priority to monitor the coastal ocean, organizations on the west coast have begun to organize three regional associations that will allow the pursuit of the goals articulated by Ocean.US, the National Research Council Ocean Report, the Pew Oceans Trust Report, and the U.S. Commission on Ocean Policy. These associations are: Southern California Coastal Ocean Observing System (**SCCOOS**), the Central and Northern California Ocean Observing System (**CeNCOOS**), and Northwest Affiliated Network of Ocean Observing Systems (**NANOOS**) in Oregon and Washington. They will form three geographically overlapping and coordinated Regional Associations for an integrated

approach to implementing local, state and federal ocean monitoring needs. **CeNCOOS** and **SCCOOS** have already signed a memorandum of understanding to ensure coordination of regional associations in California. **CICORE** partners are involved in all three emerging Regional Associations.

Meanwhile, the state-sponsored **COCMP** program will build backbone elements of a regional observing system. **CICORE** partners Humboldt State University, San Francisco State University, Moss Landing Marine Laboratories and California Polytechnic State University, San Luis Obispo are lead organizations in the State **COCMP** observing system that will directly support the national Integrated Ocean Observing System.

7. *How will the CICORE system support a national ocean observing system?*

The **CICORE** program was developed specifically with the nation's ocean observatory priorities in mind. Throughout the development and expansion of the **CICORE** program, partner institutions have paid close attention to the observational goals of Ocean.US, Congress and COTS. These have formed the basis of the **CICORE** observatory backbone and the technological approaches that are adapted through the program. As described earlier, once the Regional Associations are accredited and receive sustained federal funding, **CICORE** will conduct its monitoring as part of the federally recognized Integrated Ocean Observing Systems (**IOOS**). In addition, the core technologies being developed by CICORE (specifically high resolution digital mapping) will be made available to all other Regional Associations.

8. *Does the CICORE system incorporate requests or requirements of user groups to produce usable products?*

Yes. First, **CICORE** established an Advisory Council whose members include individuals from industry, the regulatory community, scientists, EPA, NOAA and other COTS programs. Secondly, **CICORE** has actively sought community partnerships in identifying program stakeholders and products. During the last data collection effort, **CICORE** partnered with the San Francisco National Estuarine Research Reserve and the Point Reyes National Seashore Recreation Area in planning the overflight and imagery coverage. In addition, **CICORE** carried a **CIMT** sensor on the airplane to provide intercomparison of instruments. **CICORE** is also working with the State Water Quality Board in expanding the *in situ* array. These are just a few examples of outreach efforts.

9. *Please include any other information you think is pertinent to the overall discussion of ocean observing systems.*

The technology, expertise, and organizational capabilities now exist to produce real-time, continuous observations of and predictions about the ocean in much the same way as we can produce observations and predictions about the atmosphere and

weather. Deployment and operation of an Integrated and Sustained Ocean Observing System will (1) improve the safety and efficiency of marine operations; (2) mitigate the effects of natural hazards more effectively; (3) improve predictions of climate change and its socio-economic consequences; (4) improve national security; (5) reduce public health risks; (6) help protect and restore healthy ecosystems; and (7) sustain and restore living marine resources. An initial economic analysis by independent economists under contract to NOAA estimated $5 to $6 of return for industry, government, and the public for every $1 invested in ocean observing and predictions. Immediate returns are expected in maritime safety and efficiencies for shipping, fishing, energy, tourist, and other industries; search-and-rescue; national security; and monitoring and clean-up of discharges and spills to ocean waters.

Because responsibility for ocean observing and monitoring is currently distributed among a number of federal agencies, federal legislation is needed to resolve issues of governance, roles and responsibilities, and allocate sustained funding. We in the research community appreciate the fact that this committee, and others in Congress, are taking a serious look at determining the best ways to approach this important work.

As Congress considers the recommendations of the U.S. Commission on Ocean Policy and efforts to establish a coherent coastal ocean monitoring program, it is imperative to realize that the stability of the long-term operations is a goal, as important as the development of the infrastructure. With that in mind, I encourage you to promote a broad interagency approach, lead by Ocean.US, to support the emerging Ocean Observing Regional Associations (RAs). The RAs will become the regional mechanisms for monitoring the ocean and they need to have the ability to respond to local and regional needs and to be able to receive funding from multiple sources, federal, state and other.

This concludes my testimony. I hope that you will view me and my colleagues engaged in ocean observing in California as a resource to this committee as you continue your important work in coastal ocean observing.