

## WRITTEN TESTIMONY OF

Lynne D. Talley, Ph.D.  
Distinguished Professor, Scripps Institution of Oceanography  
University of California, San Diego

**HEARING ON:  
H.R. 2219, A BILL TO REAUTHORIZE THE INTEGRATED COASTAL AND OCEAN  
OBSERVATION SYSTEM ACT OF 2009  
AND  
H.R. 1399, HYDROGRAPHIC SERVICES IMPROVEMENT AMENDMENTS ACT OF 2013  
BEFORE THE UNITED STATES HOUSE COMMITTEE ON NATURAL RESOURCES  
SUBCOMMITTEE ON FISHERIES, WILDLIFE, OCEANS AND INSULAR AFFAIRS**

June 13, 2013  
Washington, D.C.

Chairman Fleming, Ranking Member Sablan, and members of the Subcommittee, thank you for the opportunity to appear before you today. I am Lynne Talley, Distinguished Professor of Oceanography at UC San Diego's Scripps Institution of Oceanography (Scripps). I am a Fellow of the American Geophysical Union (AGU), the American Meteorological Society, The Oceanography Society, and the American Academy of Arts and Sciences. I am also the president-elect of the Ocean Sciences section of the AGU, which represents more than 7100 oceanographers of all disciplines.

Founded in 1903, Scripps Institution of Oceanography, which became a part of the University of California in 1912, supports the reauthorization of H.R. 2219, the Integrated Coastal Ocean Observing Systems (ICOOS) Act of 2009 and H.R. 1399, the Hydrographic Services Improvement Amendments Act of 2013. Scripps recommendations on H.R. 2219 are provided at the end of this testimony.

Research at Scripps encompasses physical, chemical, biological, geological, and geophysical studies of the oceans and Earth, with annual expenditures approaching \$200 million and a fleet of four research vessels and the research platform FLIP. Scripps is a Sea Grant institution and the headquarters of the Southern California Coastal Ocean Observing System (SCCOOS), one of the eleven Regional Associations of the Integrated Ocean Observing System (IOOS).

Thank you for the opportunity to come before you today to testify to the importance of ocean observations and of data management systems and integrated data-model analysis. I am an observational oceanographer, and have collected a large amount of data at sea on research vessels. My scientific expertise is oriented towards the open ocean, at the very largest scales of the circulation. I co-chair, with Richard Feely (NOAA/Pacific Marine Environmental Laboratory—PMEL), the U.S. component of the Global Ocean Observing System (GOOS) repeat hydrography program, a network of research ship observations that covers the globe, tracking changes in ocean chemistry, heat, and salinity on a 10-year time scale. Pending National Science Foundation (NSF) funding to a center headed by Jorge Sarmiento at Princeton University, I will oversee a major expansion into the Antarctic region of the global profiling float program Argo. The expansion includes sampling for nutrients and pH (ocean acidity), which are critical observations for the highly productive ecosystem and fisheries of the Southern Ocean. I will talk more about Argo below as a standout example of the enormous success of novel, simple technology in transforming how we observe the ocean.

I am not directly involved in Regional IOOS, which is focused on all of the coastal and Great Lakes regions of the U.S., nor have I received funding from NOAA, although I have worked closely with NOAA investigators throughout my career. I care passionately about and believe strongly in the value of sustained observations of all of the ocean, including coastal regions where we interface daily with the sea, and believe in the importance of integrating quality observations as part of the process of understanding and forecasting ocean conditions.

Because many Scripps scientists and students are deeply involved in IOOS, I sought input for my testimony from IOOS associations and experts at Scripps, including those involved with SCCOOS. Aspects of my testimony on the specifics of the ICOOS Reauthorization are drawn from these sources and validated by my 30 years of experience knowledge in observing the oceans.

My work has been greatly enhanced through direct collaborations with research and government institutions in many other countries—Japan, Europe, Russia, Chile, Australia, and, in the near future, South Africa and Argentina. Throughout my career, I have been involved in U.S. and international data management, with a focus on ensuring the highest quality data, available as soon as possible to all who can use it. Oceanographic science moves forward much more effectively with such open-source, near real-time data systems. Such data availability and data interoperability are at the heart of IOOS as well.

***The importance of our oceans.*** The oceans, covering nearly three-quarters of the Earth's surface, are the lifeblood of our planet. They circulate heat and minerals that control the Earth's climate and weather, and they shape our coastlines. They provide food, transportation, recreation, and vital natural resources.

The ocean is becoming increasingly acidic, threatening organisms that form shells, including those in the burgeoning aquaculture industry. Events of very low oxygen, for instance those driven by runoff in the Gulf of Mexico, and by changing overturn and circulation along the Pacific Northwest coast, have adversely affected sea life. Coastal areas are under increasing stress as sea level rises and development of this fragile coastal zone accelerates. Furthermore, with an increasing proportion of our population living along our coasts, the risks due to natural hazards, from hurricanes to tsunami-generating earthquakes, are growing.

***Why observe the ocean?*** Observations are crucial for describing what is going on in the ocean and for predicting what will happen: observations allow us to describe and understand the underlying processes and provide the basis for useful modeling and forecasting. Data are essential to initialize short-term forecasts of sea conditions, coastal sea level, and weather. Data are essential to follow the seasonal and year-to-year changes in ocean heat content that can stoke hurricanes. Data are essential to track supplies of nutrients to the upper ocean to support the ecosystem. Data are essential to follow the year-to-year changes that are increasingly evident, for instance in Arctic sea ice cover and accompanying ecological changes, or in coastal changes in seawater acidity or oxygen levels that affect sea life and hence fisheries and aquaculture.

***How have we observed historically?*** Research ships, moored instruments, and shore-based stations have been and continue to be used to observe the physical state of the ocean, that is, sea level, tides, currents, surface and internal wave state, temperature, salinity, etc. Specialized physical observations from research ships now include those associated with turbulence and mixing. Ocean chemistry and biology have also been historically studied from ships and shore-based stations, using water samples and analyses carried out in laboratories.

Another observing technique is hydrographic surveying, which is the subject of H.R. 1399. This method provides detailed mapping of the ocean bottom, which can change in response to circulation, waves, and earthquakes, and is an essential NOAA mission. NOAA carries out most of this work using hydrographic quality multibeam sonar instrumentation. Hydrographic surveying requires exacting compliance with a variety of standards.—NOAA funds university scientists to improve operational charting, for example, the Center for Coastal Ocean Mapping (CCOM) at the University of New Hampshire.

The high cost of at-sea sampling restricts the amount of sampling that is possible. To be able to track changes in the ocean over hours to weeks to seasons and years, ship-based sampling, as represented in the predecessors to IOOS, must be replaced with autonomous sampling. Shore-based sampling can provide very long baselines, but is restricted in location.

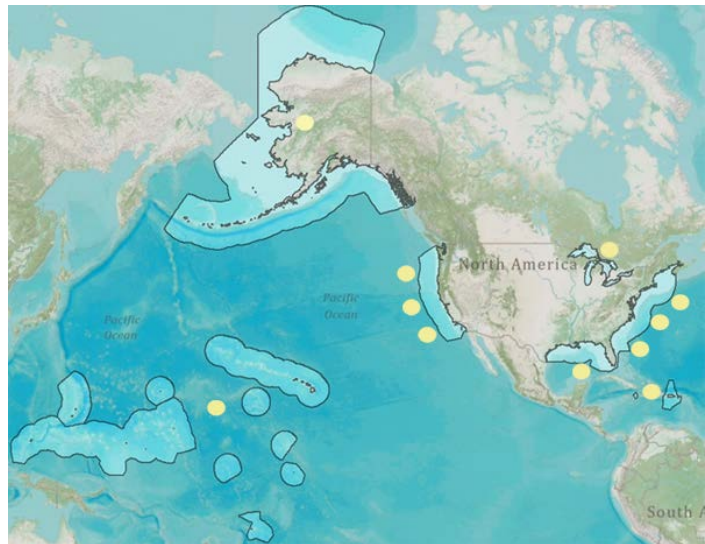
***How have ocean observations improved over the last two decades?*** For large-scale oceanography, the initial step of transforming our observations, from sparse and summer-biased to global and continuous in time, began with global satellite observations, which view only the sea surface. This transformation began in earnest in the

1990s with the advent of global satellite coverage of temperature, waves, wind forcing, surface heat fluxes, ocean color, and recently salinity.

The next challenge was to match this global surface information with information about the ocean interior. Through development of new technology (autonomous drifting floats and steerable gliders) that could be deployed globally, new shore-based technologies such as high frequency radar that allow mapping of surface currents, and judicious use of more traditional moored technology in important regions (coastal regions and the tropics), we now have the ability to observe the ocean interior at time and space scales that nearly match those of the ocean surface observations. Increases in computing power allow us to combine these ocean observations through computer models, producing analyses of the ocean that are very similar to those we are familiar with in weather forecasting. For instance, we can now track sea level changes globally and understand the sources of the changes and local responses, including along the coasts, to strong forcings such as hurricanes.

**Transformation by new organizations for synthesis: integrated ocean observing systems.** In a data-rich world with many different types of observations, and enormous amounts of data, efficiency, productivity and effectiveness are only possible through intensive, well-designed data management systems. The vision for integrated ocean observing systems is to provide data portals for many different types of data, allowing users easy, online, one-stop shopping for everything they seek, and also allowing them to combine data sets from multiple sources. With today's cyberinfrastructure, such effective data management is not only possible, but is expected. It must be envisioned and carefully built with input from local users, which include commercial shipping companies, fishermen, local weather forecasters, recreational surfers and boaters, city managers, decision makers and educators. The data interfaces that have already been built by IOOS are regional and effective.

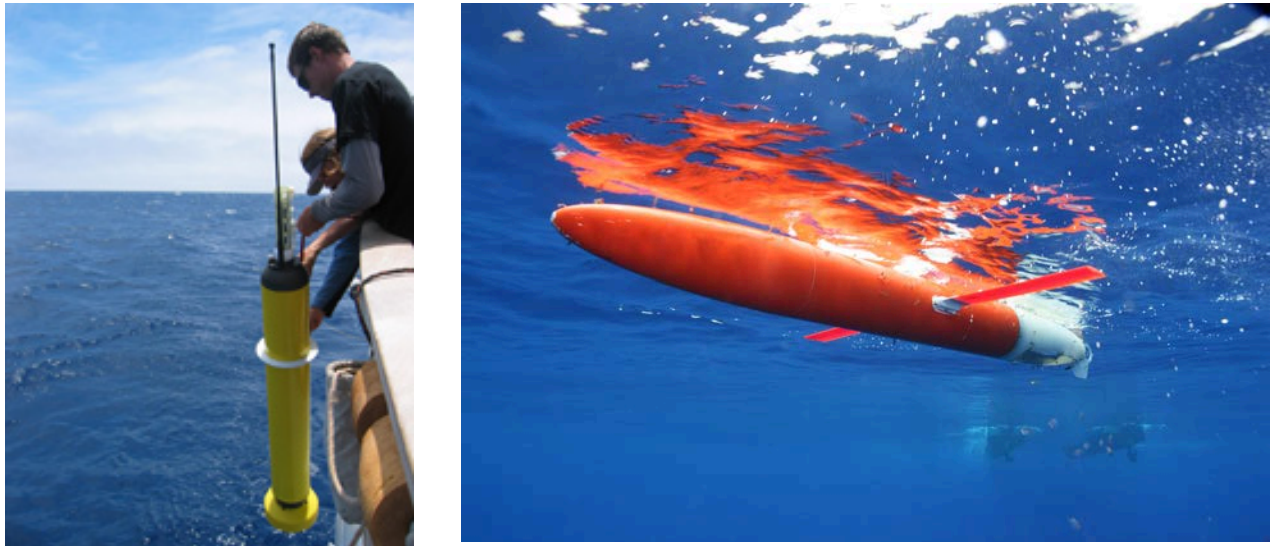
**What is U.S. IOOS?** The Integrated Coastal and Ocean Observation System (ICOOS) Act of 2009 provided the structure and foundation for the development of a U.S. Integrated Ocean Observing System (IOOS). U.S. IOOS is a national-regional partnership of 11 regional ocean observing systems and 17 federal organizations. The regional systems serve the nation's coastal communities, including the Great Lakes, the Caribbean and the Pacific Islands and territories (Figure 1). While focused on regional issues, each regional system aligns its observations and products with the national priority themes: **ecosystems and climate trends, water quality, marine operations, and coastal hazards**. The mission of U.S. IOOS is **to advance the utility** of marine observations to improve safety, enhance the economy, and protect our environment by creating a system to rapidly and systematically acquire and disseminate ocean, coastal, and Great Lakes data and data products. Integrated ocean information is available in near real time, as well as retrospectively. IOOS is unique and effective because it represents both federal and non-federal observations and assets. Easier and better access to this information is improving our ability to understand and predict coastal events such as storms, wave heights, and sea level change. Such knowledge is needed for everything from retail to development planning.



**Figure 1.** U.S. IOOS is comprised of eleven Regional Associations, which guide development of and stakeholder input to regional observing activities. The RAs serve the nation's coastal communities, including the Great Lakes, the Caribbean and the Pacific Islands and territories. (<http://www.ioos.noaa.gov/regional.html>)

**Transformation by new technology: sensors and instruments.** Two related autonomous instruments, the drifting profiling float and the steerable glider (Figure 2), have completely transformed our ability to measure the ocean interior without research ships. Both were developed principally by Scripps physical oceanographer

Russ Davis and researchers at Woods Hole Oceanographic Institution in the 1990s. Floats are best suited for the deep, open ocean, while gliders are more efficiently used in coastal regions.



**Figure 2.** (Left) Profiling float from the global Argo profiling float array (10-day profiling to 2000 m, drifting with the current at 1000 m between profiles) (K. Lavender, personal communication). (Right) Underwater glider used primarily in coastal regions (6 hourly profiling to 1000 m while being steered to travel a horizontal distance of 6 km) (D. Rudnick, Scripps Institution of Oceanography).

From pilot arrays in the 1990s, the global float array “Argo” has filled the ocean with approximately 3000 floats at a given time, each profiling to 2,000 m depth every 10 days. Now in its tenth year, it has become difficult to imagine the world of ocean observing without Argo, which has recently completed its millionth profile at an extremely reasonable price of about \$170 per profile. In comparison, in all of the 20th century—a golden age for research ship observations—there were only half as many ocean profiles. Combined with satellite data, these data make it possible to operate global and regional ocean analysis models similar to those for weather forecasting in the atmosphere. They provide enormous amounts of new information on the ocean’s changing state at weekly to seasonal to year-to-year timescales. These observations and model analyses provide the data on open ocean conditions needed for weather forecasting, safe shipping and effective fisheries management, as well as offshore data needed for coastal ocean analyses.

For the coastal regions, the steerable underwater glider is proving to be the instrument of choice. It is useful to be able to guide the locations of observations where bottom depths vary radically, and where it is cost-effective to deploy and retrieve instruments. Notably, three IOOS regions—Southern California, the Pacific Northwest, and the mid-Atlantic coast—are now routinely operating fleets of gliders offering sustained, fine resolution observations of the coastal ocean from the surface to up to 1000 meter depth every six hours.

Underwater gliders have a demonstrated record of success. Perhaps the most notable community effort was in response to the 2010 Deepwater Horizon oil spill in the Gulf of Mexico, when a volunteer consortium of federal, industry, and academic partners provided gliders to a coordinated fleet. The gliders produced subsurface observations of temperature, salinity, and velocity in support of efforts to determine where oil was likely to be taken by currents. Data were made available in real time to modeling centers throughout the country, and were provided to a central database for all interested parties to access freely. The longest sustained program of glider observations continues off the California coast where gliders have been occupying three lines since 2006. This network of gliders has amassed nearly 7000 days of operation, covering a track over 150,000 km long, and yielding over 64,000 profiles of vital ocean data. Work is underway, including coordination through IOOS, to establish a national glider network along all the nation’s coasts, modeled after the spontaneous collaboration during the Gulf oil spill and the sustained success off California.

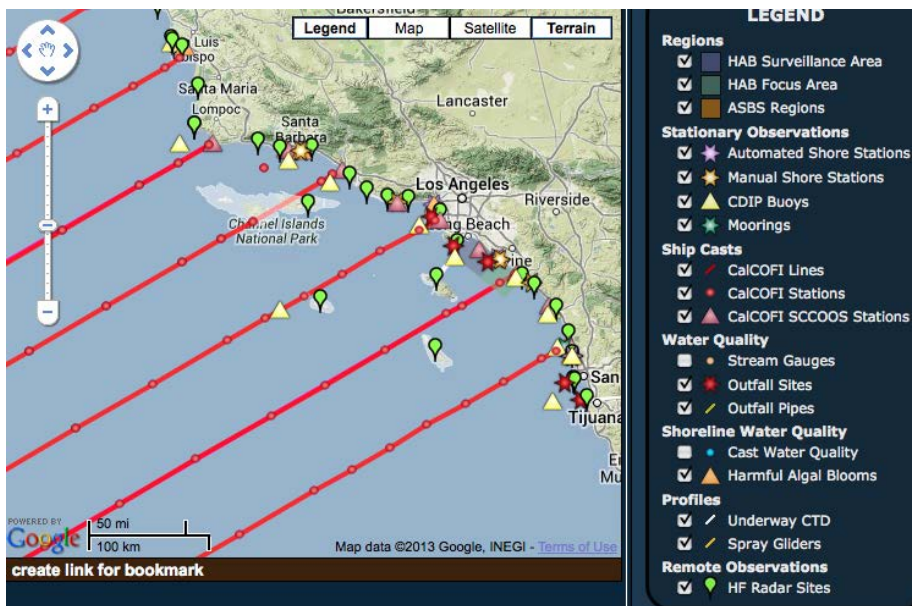


High frequency (HF) radar (Figure 3) deployed along the coast allows high resolution mapping of surface currents that cannot be achieved through any other technology or measurement system. HF radar measures surface currents over a range of up to 200 km. The California coastal network of HF radar station was funded originally by the state for its importance in tracking oil spills, and is now essential for search and rescue (Coast Guard), as well as for marine navigation, and fisheries and water quality management. On the east coast, HF radar data are also used to support development of offshore wind energy. At this time, without IOOS, HF radar operations in the US would not be supported.



**Figure 3.** High frequency radar receiving antenna, used for measuring speed and direction of ocean surface currents in near real time. <http://www.ioos.noaa.gov/hfradar/>

Beyond these new autonomous ocean observations, enormous improvements in oceanography of coastal regions are taking place because of the extensive instrumentation arrays along the coasts (Figure 4), with some support from IOOS. These include the long-established wave buoy networks that are now fully integrated into IOOS. For example, SCCOOS wave information leverages a partnership with the Army Corps of Engineers' Coastal Data Information Program (CDIP). It is representative of the high level of leveraging that is a critical component of IOOS. There are also regions, such as PacIOOS in Hawaii, which have populated many areas of the Pacific with wave buoys through this collaboration.



**Figure 4.** SCCOOS (Southern California Coastal Ocean Observing System) observation sites and types. <http://www.sccoos.org/interactive-map/>

Within its emphasis on ecosystems and water quality, IOOS is incorporating long-term, near-coastal measurements of *ocean pH (ocean acidity)*, as well as oxygen and nitrate. The program to monitor ocean acidification was started in the Pacific Northwest IOOS and is now being expanded to the entire west coast. While the specific IOOS funding for acidification observations is small, it provides a seed for the full coastal observing system, and also provides data portal and synthesis capabilities. Each region will have a point of contact to work with shellfish growers to collect and interpret the data.

For example, in the SCCOOS region the new moored pH observations allow real-time detection of sudden events, as well as monitoring of slow changes over years of the state of ocean acidification. Such events are already bringing corrosive water onto the shelf, and conditions are expected to worsen over time. These observations allow laboratory simulations of the conditions with a wide variety of organisms to study the harmful or lethal impact those conditions can have. The real-time data also allow local shellfishing and shellfish

farming communities to be warned of harmful events. The research enabled by the observations includes the study of the impact on fish stocks off the West Coast.

***Role of in situ measurements in satellite calibration and validation.*** In addition to the many direct uses of ocean observations, they are also used to calibrate and validate satellites. Calibration measurements are those necessary for satellite data to be translated into desired measurements. Validation measurements are made to test how accurate the measurements are. For many ocean satellite observations, measurements are "indirect"; they observe something related to the desired measurement. We model the relationship between the observation and the desired measurement as well as external effects, say, of the atmosphere, on satellite data in order to get the measurements we need. For the models to be as accurate as possible, in situ observations of the actual property are needed. For example, in coastal regions, where satellites are used to monitor ocean color, in situ observations of the actual chlorophyll concentrations at the time of the satellite observation are essential for calibration of the satellite signal, reducing its uncertainties.

***How has IOOS developed?*** U.S. IOOS is still developing and building out into a full system, but it has already proven its utility and value. All of the systems collect data that are provided to users through regional data portals tailored to local users. The importance of the regional systems is that the directors, scientists and staff work directly with local users and with local coastal issues. These issues obviously differ from one region to another – while Southern California normally has extremely low storm surges in comparison with, say, the East and Gulf coasts, which can be pounded by hurricanes, Southern California has a complex wave climate, including significant island shadowing that can significantly impact the region's heavy commercial maritime traffic.

***Examples of IOOS applications:***

- ***Superstorm Sandy:*** IOOS observations allowed the marine transportation industry, military, energy sector, and local communities to make advance preparations, saving money and property.
- ***Deepwater Horizon oil spill:*** The IOOS data management system rapidly and efficiently allowed for the seamless integration of data from non-federal sources—such as high-frequency radar surface current mapping systems and underwater gliders—for use by the Unified Area Command. Prior to this, valuable non-federal information collected by universities, state agencies or private companies was not assessable to federal responders. Approximately 75% of the data now served by NOAA's National Weather Service through the National Data Buoy Center is from non-federal sources, most of which is directly attributable to the work being done and supported by the Regional Associations.
- ***Commercial marine operations:*** Combined, the Port of Long Beach (LB) and the Port of Los Angeles (LA) create the 5th busiest ports in the world, serving as the world's leading gateway for U.S.-Asia trade. The challenge for the Ports is to assure that all traffic—including cargo, fishing, Harbor Pilots, and recreational boaters—transit to and from the harbor safely. SCCOOS provides a customized website for the port entrances to provide real-time information on marine conditions, knowledge of which are necessary for safe and efficient passage. The site is used for maritime traffic for either near real-time decisions as to their immediate transit, or for planning purposes through available forecast information.
- ***Military marine operations:*** surface current, wave, and wind observations and forecasts are provided by SCCOOS in an integrated display for use by the Pt. Mugu Naval Air Warfare Center, Weapons Division, in their testing and operational activities in the coastal ocean off of Southern California. Virtually all test projects—including testing of pilot ejection safety limits, cruise missile and target flight altitude settings, ship passenger transfers, small boat operations, and target recover—use this sea condition information at some point in their test scenarios. The data are also used to develop seasonal estimates of effects on the Navy's test systems. These valuable end uses are only possible because of synergies between academia, government and industry.
- ***Water quality:*** SCCOOS products, when coupled with compliance-based water quality monitoring required by the State of California, aide in identifying the source of pollution that impact beaches and coastal waters. In 2012, the Orange County Sanitation District (OCSD) diverted flow of treated effluent from their offshore outfall pipe to a secondary pipe just 1 mile from shore as a part of a temporary maintenance

project. SCCOOS provided real-time data to track the outfall plume, which allowed the OCSD to minimize potential impacts to local beachgoers.

***What did the ICOOS Act envision when it was first authorized in 2009?***

The ICOOS Act is critical foundation for the U.S. IOOS system. The Act provides:

- A framework for the innovative partnership of 17 Federal agencies and 11 regional systems that are the core of the program;
- A regional approach to national issues that draws on regional expertise to provide information on the scale that is important to users;
- The process to develop standards and protocols that allow for the seamless exchange of information to and from the regional and national levels;
- The structure that allows the efficient public/private partnerships that are the hallmark of the program's work; and;
- The incentive for multiple federal agencies and other entities to collaborate, share resources and to build a single system that serves many purposes.

***Developing new IOOS technologies.*** Technological innovations can drive revolutions in observing and therefore in science and applications, as illustrated by the success of the global float and emerging underwater glider deployments, which was technology in its infancy a mere ten years ago. In most areas, we are already aware of technology development needs. In other cases, engineering systems analysis will identify priorities for technology development. The Administration's recent budget requests have requested technology and sensor development funding. The current draft of the ICOOS reauthorization bill does not seem to include funding for this critical and much needed effort. Technology development should focus on increasing capabilities and lowering costs strategically to enable the deployment of a comprehensive coastal observing system.

***Continuation and expansion of the Integrated Ocean Observing System.*** The IOOS set in place through authorization in 2009 has already significantly advanced our capabilities in coastal hazard prediction and warnings, navigational systems, search and rescue, fish stock assessments, prediction of algal blooms in coastal regions, climate forecasts, and health warnings. Given its vital importance to addressing societal issues, it is critical that we continue to focus on the financial, infrastructure, and institutional issues related to continued and expanding implementation of the IOOS. It is also crucial that we sustain the unprecedented degree of cooperation among multiple academic, governmental and private organizations that comprise today's IOOS. However, this will only be possible if sufficient financial resources are provided to deploy and maintain instrumentation and deliver data.

**COMMENTS ON H.R. 2219, A BILL TO REAUTHORIZE THE INTEGRATED COASTAL AND  
OCEAN OBSERVATION SYSTEM ACT OF 2009**

Scripps Institution of Oceanography

Scripps Institution of Oceanography (Scripps) supports reauthorization of the Integrated Coastal and Ocean Observation System (ICOOS) Act of 2009 but has concerns regarding the authorized level of funding contained in H.R. 2219.

H.R. 2219 reauthorizes the ICOOS Act by striking “are authorized to be appropriated to the Secretary of Commerce for fiscal years 2009 through 2013 such sums as are necessary” and inserting “is authorized to be appropriated to the Secretary of Commerce for each of fiscal years 2014 through 2018 \$29,600,000.”

The level of funding authorized in H.R. 2219 would have significant negative impacts for the U.S. Integrated Ocean Observing System (IOOS). U.S. IOOS received appropriations of \$34.9 million in FY 2013 and the President’s Budget Request for FY 2014 included \$41.5 million for the program. If the program were to receive funding no higher than the amount authorized in H.R. 2219 over the next five years, currently deployed observing assets would have to be removed and the quality and reliability of data would be compromised.

The ICOOS Act of 2009 required an Independent Cost Estimate (ICE) for the build out and sustainment of U.S. IOOS. This assessment was completed by NASA’s Jet Propulsion Laboratory (JPL) in 2012. Scripps and the IOOS Association, a nonprofit organization formed by the regional IOOS systems in support of U.S. IOOS, support a reauthorization of the ICOOS Act that is consistent with the ICE. This would require the following authorized funding levels, beginning with the amount requested by the President in FY 2014:

FY 2014: \$35 million for Regional IOOS, \$6.5 million for National IOOS  
FY 2015: \$39 million for Regional IOOS, \$10 million for National IOOS  
FY 2016: \$44 million for Regional IOOS, \$15 million for National IOOS  
FY 2017: \$55 million for Regional IOOS, \$20 million for National IOOS  
FY 2018: \$66 million for Regional IOOS, \$25 million for National IOOS

In addition, the following revisions to the ICOOS Act would enhance the effectiveness of U.S. IOOS. These changes are not included in H.R. 2219.

***Clarifying the role of the Regional Associations:*** The ICOOS Act refers to regional partners as “regional information coordinating entities” and notes that this includes the Regional Associations (the regional observing systems). This has created an ambiguity regarding whether more regional entities, beyond the existing eleven, may be formed. The formation of subregional entities would be problematic because the existing regions were formed based on ecological principles and geography, and they mirror other regional systems, such as those created by the National Ocean Policy. We suggest that the reauthorization of the ICOOS Act should clarify that no new regional entities may be formed.

***Interagency financing:*** IOOS is an interagency program designed to build partnerships between federal agencies. These partnerships often involve the transfer of funds, but NOAA has interpreted the relevant language in the ICOOS Act as prohibiting such transfers. We suggest that the reauthorization of the ICOOS Act should explicitly allow for such transfers.

***Certification:*** The ICOOS Act requires certification of non-Federal assets. This involves certification of both the regional entities and of data, which is the process that NOAA is taking. We suggest that the reauthorization should clarify that certification involves two different processes.

***Liability:*** This is a critical issue for the regional systems as they begin to serve more forecasted information. NOAA has determined that the liability protections for the regional systems included in the ICOOS Act are limited to three people per regional system. We suggest that the reauthorization of the ICOOS Act should clarify that this liability protection should not be limited to an arbitrary number of people within the regional systems, but rather extended to those who need it.