WRITTEN TESTIMONY OF

Eric Terrill, Ph.D.
Director, Coastal Observing Research and Development Center
Scripps Institution of Oceanography
University of California, San Diego

BEFORE THE UNITED STATES HOUSE COMMITTEE ON TRANSPORTATION AND INFRASTRUCTURE
SUBCOMMITTEE ON COAST GUARD AND MARITIME TRANSPORTATION

"Using New Ocean Technologies: Promoting Efficient Maritime Transportation and Improving Maritime Domain Awareness and Response Capability"
May 21, 2014
Washington, D.C.

Chairman Hunter, Ranking Member Garamendi, and members of the Subcommittee, thank you for the opportunity to appear before you today. My name is Eric Terrill, and I am the Director of the Coastal Observing Research and Development Center at UC San Diego's Scripps Institution of Oceanography (Scripps). At Scripps, I lead a team of technical staff in the operations and maintenance of distributed maritime and environmental sensor networks developed, deployed, and maintained by the Center. We partner with a number of federal and state agencies in our efforts to support national science and technical needs to sense and improve our understanding of the maritime environment.

A better part of my career has been dedicated to the field of ocean observing, environmental sensing, marine technology, and maritime domain awareness. I presently serve on a Federal Advisory Committee (FACA) for the U.S. Integrated Ocean Observing System (IOOS); a federal interagency effort led by the National Oceanic and Atmospheric Administration (NOAA). In 2003, I was part of the teams that founded, and remain the Technical Director of, the Southern California Coastal Ocean Observing System (SCCOOS) which is now a regional component of IOOS. I was also a lead scientist in the $21M California Coastal Ocean Currents Program, a pilot effort to map ocean currents using high frequency radar that now continues to operate after transitioning to NOAA. My team at Scripps has directly supported U.S. Marines during Operations Iraqi Freedom and Enduring Freedom with a network of real-time weather stations developed for unattended operation at forward operating bases. We also provide real-time wave observations to support training activities and the testing of new ships and surveillance systems for the Navy using expendable wave sensing technology developed at Scripps. I have served on teams responsible for transitioning new technologies to the Navy in projects sponsored by the Office of Naval Research and the Naval Surface Warfare Centers. I presently serve on a Maritime Domain Awareness (MDA) working group sponsored by U.S. Pacific Command (PACOM) to develop MDA solutions for small island nations in the western Pacific including the Republic of Palau and the Federated States of Micronesia. My education consists of a B.S. in Engineering and a Ph.D. in Applied Ocean Sciences – Physical Oceanography. Based upon my experience, I would like to communicate to the Committee that technical revolutions in micro-electronics, communications, and computational infrastructure are rapidly presenting opportunities for new ocean technologies to support growing U.S. MDA requirements.

Because Scripps Institution of Oceanography is involved in many, if not all, facets of ocean observation in support of MDA, I sought input for this testimony from various experts at my organization. I have also sought feedback on various topics from individuals within the USCG, US Navy, and NOAA. Aspects of my testimony on the specifics of technologies and data management are drawn from these sources and corroborated by my experience. My testimony is organized as follows: 1. Samples of historic and ongoing ocean observation programs are provided as examples of the research community's role in supporting national MDA. 2. Suggestions for future MDA demonstrations, partnerships, and tools are outlined. 3. Examples of ocean technologies and the opportunities they present are provided; and 4. I provide closing recommendations for action.

1. Long-term Observation Programs Provide a Foundation for Environmental Knowledge of Maritime Domain Awareness

Founded in 1903, Scripps Institution of Oceanography became a part of the University of California in 1912. Scripps has a long history of supporting national defense objectives and has provided recommendations and technologies to "improve the efficiency, safety and security of maritime transportation" with a focus on the "better use and integration of maritime domain awareness data."

During World War II, Scripps oceanographers worked closely with the Navy to create surf and swell forecasts for successful Allied landings in North Africa, the Pacific, and the beaches of Normandy. Just as important, Scripps educated active duty weather officers so they could apply this new forecasting science on a daily basis to plan operations. Scripps researchers also developed high frequency underwater sound systems to track submarines and detect mines, enabling secure Naval operations and improving maritime domain awareness. Research at Scripps currently 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 Floating Instrument Platform (FLIP). Scripps has a long history of initiating and maintaining environmental observing programs in the oceans, atmosphere and on land at regional to global scales. These observations are core to scientific discovery across numerous disciplines, and inform our understanding of society's most pressing issues.

In 1949, the California Cooperative Oceanic Fisheries Investigations (CalCOFI) was formed around a unique partnership between the California Department of Fish & Wildlife, NOAA Fisheries Service and Scripps Institution of Oceanography. The organization was charged with studying the ecological aspects of the sardine population collapse off California. 65 years later, CALCOFI still exists with a broadened focus to study and monitor the marine environment off the coast of California and its living marine resources. Its persistent sampling of the California Current Ecosystem provides insight into variations in ocean climate, and is now serving as a testbed for new technologies to monitor the ocean conditions which impact marine life. This includes ocean acidification, dissolved oxygen, and diversity of marine life.

In 1975, Scripps researchers launched the Coastal Data Information Program (CDIP), a program that measures, models, forecasts and publicly disseminates real-time coastal wave information, and that now includes a network of over 50 wave buoys in 13 states and island territories. CDIP provides these updated and accurate wave data to the US Army Corps of Engineers (USACE), the National Oceanic and Atmospheric Administration (NOAA), and other federal agencies. The conditions at the ocean surface impact all at-sea operations, and the data are critical for the operational maritime community to ensure safe and efficient navigation for military, commercial, and recreational maritime traffic, and are relied upon by dredging project managers for safe operations. CDIP buoys provide highly accurate wave height, period, and direction information, which are used as input to marine forecasts and incorporated into coastal inundation models. During Hurricane Sandy, the CDIP wave buoy network on the East Coast provided continuous, near real-time wave observations (reported every 30 minutes) without failure or interruption. In fact, over 99% of all data produced by CDIP buoys during the storm were successfully transmitted.

In 1998, Scripps led the development of the revolutionary array of ocean monitoring sensors known as the Argo network. Launched in 2000, the Argo program now deploys a global array of more than 3,600 free drifting profiling floats to gather subsurface ocean data. Combined with satellite observations, 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 tracking changes in ocean climate.

An existing framework that connects local stakeholders to regional observing systems and a federal backbone is the Integrated Ocean Observing System (IOOS). Initiated 14 years ago as an interagency planning office (Ocean.US) that has evolved to now having a formal program office within NOAA, IOOS consists of eleven Regional Associations connected through a federal data backbone that is supported by a set of data standards. IOOS has shared many successes including providing on-scene environmental information to many of the extreme events that the country has been faced with (Hurricanes Katrina and Sandy, Cosco Busan oil spill in San Francisco, Deep Water Horizon Oil Spill in Gulf of Mexico to name a few). As a decision support system, IOOS observations provides many of the 'behind-the-scenes' environment data that is leveraged for day to day decision making.

2. Improving the Use and Integration of Maritime Awareness Data: the Need for Technology Demonstrations, Technology Transitions, and Modular, Problem Driven Applications

Need for demonstrations and partnerships:
A significant investment of time, funds, and process documentation is required for a full scale analysis of developing technologies for USCG applications and implementation. Process studies through demonstration projects are one means to efficiently determine applicability and feasibility of new technologies. Scripps recommends developing partnerships with agencies within the Department of Defense that are already making investments in developing maritime surveillance systems. The Office of Naval Research (ONR) routinely conducts small scale demonstrations to develop and test new concepts of operations and technologies. These science and technology investments have the ability to provide a low cost, flexible, and timely analysis of capabilities that can transition to operational users. Science and technology in a spiral development allows the capability to incrementally evolve and improve with lower risk. Successful demonstrations can be scaled to support operations, while unsuccessful demonstrations provide valuable lessons learned and save significantly on a USCG-wide full scale information technology guidance procedure.

There is value in establishing and carrying out these demonstrations with the participation of other agencies. For example, there are USCG and Office of Naval Research partnerships that exist for research programs in the Arctic; and operational partnerships exist in the Joint-Interagency Task Forces (eg. JIATF-S, JIATF-W) for combatting illegal drug trade on the high seas. One year ago, the U.S. Coast Guard R&D Center requested assistance from the Office of Naval Research to host a classified workshop to share with USCG details on emerging naval systems that might be relevant to addressing the challenges of MDA including monitoring vessel traffic. The workshop included a broad range of subject matter experts and one outcome from the meeting was the identification of various concepts of operation for different MDA challenges facing the U.S. Defining demonstration efforts to tackle these challenges as follow-on to the workshop, and more importantly, resourcing the R&D Center to partner with other appropriate S&T organizations such as ONR should be considered a logical next step.

One example of ocean technology development driven by emerging mission requirements is ONR's investment in developing small unattended sensors to aid environmental sensing in the maritime environment. Near-real time meteorological and oceanographic (METOC) data is paramount for U.S. Marine Corp and Naval Special Warfare tactical scale operations, yet traditional means for rapidly sensing the environment at the right time and place is difficult due to high costs and the size and complexity of the technology. Forecasts at precise locations are perishable, and require constant update of information for accuracy and verification. This places requirements on the need for tools to conduct timely synthesis of METOC information and to allow comparisons between models and data. For the last decade, ONR has made investments at Scripps and elsewhere to develop, test, and evaluate new sensors and operation procedures for improving tactical ocean and atmospheric environmental information collection. These efforts focused on developing techniques and procedures for best operational usage of powered unmanned underwater vehicles, low-cost weather stations, buoys, and wave sensing systems that communicate via satellite, and optimal methods for exploiting and fusing different types of data. These same systems could be used to track ocean conditions during hurricanes and provide valuable sea state information at offshore locations to support USCG operations and maritime commerce.

Another example of potential partnership and transition is the repurposing of land surveillance equipment. With the war in Afghanistan drawing down, opportunities are presenting themselves for applying investments in surveillance technologies developed and built for that theater to the maritime sector. For example, large and rapid procurement programs for aerostats and surveillance towers equipped with X-band radar and cameras were developed to provide force protection at forward operating bases. Large numbers of these systems were built to keep tempo with the escalation of Operation Enduring Freedom, and are now returning to the U.S. The same suite of sensors and networked architecture, with some modifications, may be well suited for providing capabilities to detect and track offshore vessels including illegal fishing boats. Maritime evaluations of these technologies are timely and currently being pursued on a pilot level by the U.S. Navy Naval Air Systems Command (NAVAIR) and Office of Naval Research. Scripps has supported these efforts both in the San Diego and overseas as part of fleet demonstrations in the Philippines. This summer two systems will be deployed in the Republic of Palau in partnership with U.S. Pacific Command (PACOM). Expanding the evaluation and demonstration of these technologies within U.S. waters in conjunction with U.S. law enforcement agencies and USCG is recommended, perhaps through a West Coast demonstration that would fuse various technologies and stakeholders. Supporting the U.S.'s expanding role of supporting MDA in the Pacific region, whether through expanded partnerships as part of our Pivot to the Pacific in Asia-Pacific or nations with Compacts of Free Association (Federated States of Micronesia, Palau), will be a future challenge for MDA technologies that can only be answered through systematic tests that will define appropriate strategies.

The Arctic presents another set of challenges for ocean technology developmentto support MDA. Arctic ice has begun to retreat, and is forecasted to continue doing so for the coming decades. As a result, maritime commerce, including the world's navies, is expected to begin taking advantage of new Arctic shipping lanes during summer months. Commercial activity on the sea floor is also expected to grow. Arctic waters are poorly observed, and the size and isolation of the region presents unique challenges to sense vessel traffic and ocean conditions. Characterizing the changing operational environment in terms of ice coverage and sea state will be required before new infrastructure, including floating offshore platforms, can be designed to operate in this extreme environment. Partnerships developed with the Navy, NOAA, National Science Foundation, and DARPA should be considered to leverage the respective investments of those agencies in improving U.S. sensing and forecasting capability for the Arctic.

Tools needed for interfacing to data:

The Government Accountability Office report on the USCG implementation of the Common Operational Picture (COP) identified a number of concerns with regards to data sharing and displays. The use of mapping overlays for data visualization can be extremely useful for displaying observations that assist in USCG missions such as search and rescue operations, marine safety and security, marine environmental protections, and ice operations. There is a wealth of direct observations and derived products that can be integrated into these systems including, but not limited to:

1.) Automatic Identification System (AIS)
2.) Bathymetry
3.) Navigational Charts

4.) Waves
5.) Surface and subsurface currents
6.) Satellite imagery
7.) Ice distribution

Many of these observations are available in a common data format that can be self-describing, machine-independent and delivered through a web service. Examples of these observations are found within the Integrated Ocean Observing System (IOOS) which, for many gridded products, utilize a Network Common Data Format (NetCDF) for file structure and are distributed via a Thematic Real-time Environmental Distributed Data Service (THREDDS). The Open Geospatial Consortium (OGC) provides recommendations and examples of data formats and services for data sharing and delivery. These technologies are developed and have proven examples for in-situ time series data (e.g. AIS, temperature, wind speed, salinity); gridded data and model output (e.g. HF radar derived service currents, waves, ice coverage); and imagery feeds (e.g. remotely sensed ocean color, pictures, charts). The data can also be displayed via open source – online platforms such as OpenLayers and Google Earth for unclassified interfaces or desktop applications such as TOPSIDE emerging from the Naval Undersea Warfare Center (NUWC) as a result of ONR-sponsored MDA and surveillance programs.

A USCG example is the Search and Rescue Optimal Planning System (SAROPS). This is an ArcGIS 9.3 (soon to migrate to 10.1) application designed specifically for search and rescue. SAROPS is directly supported by the USCG Environmental Data Sever (EDS), which accesses environmental data and models, archives that data, and upon request from SAROPS, returns data cubes for the SAROPS trajectory predictions. The EDS gathers data from the HF Radar National Network (HFRNet) and short term prediction based upon HFR data. I will expand upon this system and its history in the section addressing HF radar. A separate, but compatible tool, could be designed for tracking submerged oil spills, monitoring fishing areas or maintaining vessel awareness. Our experience in operational data systems suggest that large-scale "system of systems" or "one-stop shops" inevitably fail due to volume, complexity, or monumental requirements that prevent the system from ever deploying. Light-weight, problem/user driven applications have been found to be much more effective, easy to use, flexible, and can be rapidly developed and tuned to user needs. Underlying data feeds, such as the EDS, that are common to all applications are easily reused and custom products for the specific problem can be developed and added. Modular, problem driven applications will be more cost effective, straightforward to use, and flexible.

Scripps recommends designing modular, problem driven applications that can be built upon the same technology, but are tailored to a specific application or problem area. This approach was taken when developing an online visualization for the pilots in Los Angeles/Long Beach harbor. The stakeholders were primarily interested in overlays of charts, waves, surface currents, and wind predictions. An online, interactive application was built to match their needs.

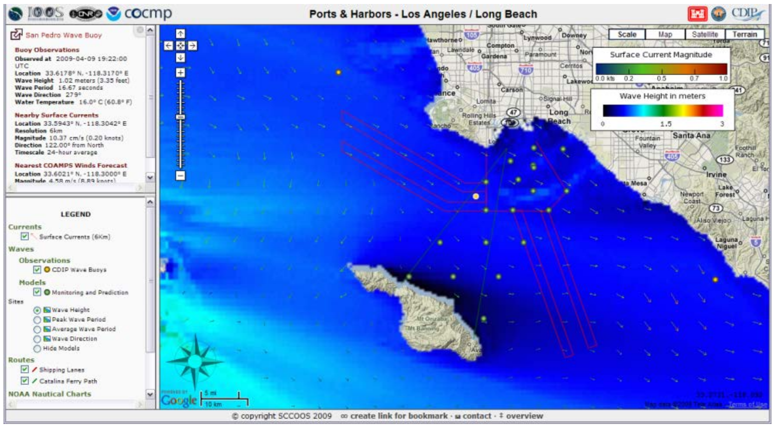

Figure 1. SCCOOS online ports/harbors custom interactive application

The Port of Los Angeles/Long Beach is an emerging example of the importance of timely and precise wave information. For background, maritime transportation plays a major role in Southern California's economy and national defense system. Combined, Los Angeles and Long Beach comprise the largest port in the U.S. and the fifth largest port in the world. The Port is presently seeing new classes of supertankers whose under-keel clearance can be limited when waves are too large. Precise measurement and forecasting of wave conditions and sea level is being explored to aide decision support tools for these tankers. The need for precise observations and forecasts exist throughout Southern California. The Port of San Diego includes the largest naval fleet in the world, and Port Hueneme is the only deep water port between Los Angeles and San Francisco and the only Navy controlled port between San Diego and the Puget Sound. The Santa Barbara Channel and San Pedro shelf are the locations of several active oil fields with sustained reserves, as well as major shipping channels.

The unique challenge for marine operations in Southern California is to assure that the vast amount of maritime traffic is provided with the highest quality ocean observations and models to assure safe and efficient transit as well as effective event response. The Integrated Ocean Observing System is addressing this challenge by partnering with institutions and agencies to provide data access and products for waves, surface currents, and winds, all critical parameters for safe maritime operations. The integration of the wave data on the NOAA PORTS site is now underway at four ports: Los Angeles/Long Beach, San Francisco, Mouth of the Columbia and the Chesapeake. This will serve as a template for further IOOS data integration and displays. In summary, the concerns raised by the July, 2013 GAO report are not insurmountable through adoption of common standards, building from existing data display and fusion systems, and partnering with organizations already invested in MDA.

3. Improving the Use and Integration of Maritime Domain Awareness Data: Emerging Technologies and Emerging Needs

High Frequency Radar (HFR):

High-frequency radar (HF radar) systems measure reflecting radio waves off the surface of the ocean. Each HF radar land-based installation is sited near the coastline and includes two antennas: the first transmits a radio signal out across the ocean's surface, and the second listens for the reflected radio signal after it has bounced off the ocean's waves. By measuring and processing the change in frequency of the radio signal that returns, known as the Doppler shift, the system determines how fast the water is moving toward or away from the antenna. Data from neighboring antennas are processed and displayed to the user as surface currents maps in near real-time.

A national HF radar network (HFRNet) has been established to measure surface currents throughout the U.S., and is currently supported by NOAA-IOOS and used in operational applications through delivery of products by the National Data Buoy Center (NDBC). Scripps developed and has operated data management for integration, distribution, and visualization of HFR surface currents for 10 years since the national network was initiated. The network includes approximately 31 participating organizations, with approximately 133 radars operating 24/7/365.

Beginning in 2000, the USCG Research and Development Center began a multi-year investigation into the utility of near real-time HF radar derived surface current measurements for search and rescue (SAR). This assessment showed a better comparison of radar-derived currents when compared against available NOAA tidal current predictions. Additionally a key element using the HF radar currents was the development of the Short Term Predictive System (STPS), a forecasting model that uses statistical information for surface current prediction. Following these evaluation studies, available in situ data were used to evaluate and define appropriate parameters for inclusions in the USCG search and planning tool as the inclusion of HF radar currents reduced the search area for USCG operators by two-thirds. Current velocities from HFRNet and the STPS forecasts are included in the USCG SAR Optimal Planning System. Data is made available in an easily digestible format through web services that were previously mentioned. This allows for integration in multiple applications and the data are used across an array of varying operational GIS based displays.

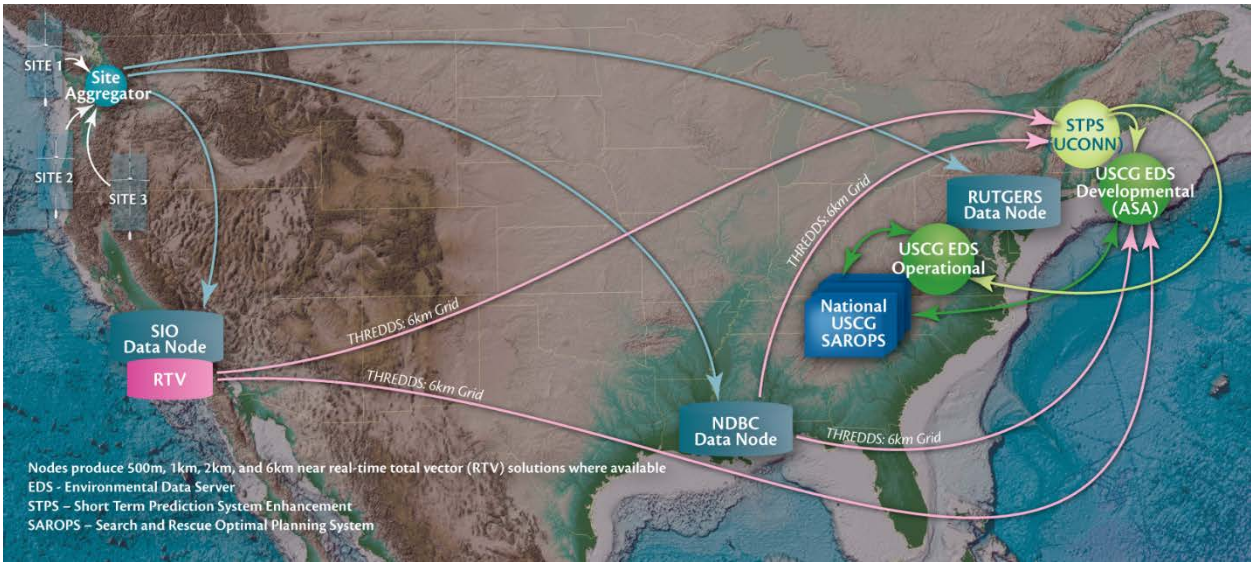

Figure 2. HFRNet data distribution for the SAROPS tool

Additional integrated operations that are cross-agency applications between USCG and NOAA include:

1. Oil Spill: Office of Response and Restoration (OR&R) Emergency Response Division (ERD) - Official NOAA forecasts for oil spill trajectories General NOAA Operational Modeling Environment (GNOME); National Preparedness Response Exercise Program (NPREP); CA Office of Spill Prevention and Response (OSPR)
2. Environmental Assessment: Office of Response and Restoration (OR&R) Assessment and Restoration Division (ARD) - Environmental Response Management Application (ERMA)

HF radar technology is also being developed for over-the-horizon ship tracking applications and is an emerging technology for maritime domain awareness. In 2008, the Department of Homeland Security established two DHS Science & Technology (S&T) Centers of Excellence (CoE) – the National Center for Secure and Resilient Maritime Commerce (CSR) and the Center for Island, Maritime, and Extreme Environmental Security (CIMES). Their missions include basic research and education that develops and transitions new technologies supporting Maritime Domain Awareness (MDA) at three scales – the global scale observed via satellite, the approach scale observed by beyond-the-horizon HF radar, and the local scale observed via line-of-site microwave radars, cameras and underwater acoustics. The HF radar research focused on development of a dual-use surface current mapping and vessel-tracking capability. This capability is designed to bridge a surveillance gap between the low update rates provided by global satellite coverage and the high update rates of local line-of-sight microwave radars and underwater acoustic sensors in ports and harbors. The integration of the long range capabilities of HF radar and shorter range target detection provided by microwave systems was recently demonstrated for the first time independent of DHS as part of U.S. Navy exercises in the Pacific (Balikatan 2014) as a collaboration between Scripps, NAVAIR, and PACOM. The results of this test, and other tests previously conducted in the U.S. under Department of Homeland Security funding, suggest that the U.S. HF radar network operated for IOOS to map coastal currents could be operated in a manner to provide dual-use function for identifying ship traffic. However, this opportunity will remain elusive under the current funding model for this national asset as the network is funded only at 50% operational capability of the $10M/year build out plan as identified in the U.S. IOOS National Surface Current Mapping Plan.

Unmanned Vehicles:

Unmanned Underwater Vehicles (UUVs), also referred to as Autonomous Underwater Vehicles (AUVs) continue to develop as the frontier technology for subsurface exploration and sensing advances. Examples include buoyancy driven gliders, such as the SPRAY system developed by Scripps for wide area environmental surveillance and propeller powered vehicles such as the REMUS (Remote Environmental Monitoring UnitS), originally designed by the Woods Hole Oceanographic Institution (WHOI) and now available commercially from Hydroid Inc., for short duration, high-resolution surveys. Both vehicles can employ a variety of acoustic, optical, and physical sensors to analyze open ocean, littoral and benthic environments and can assist the USCG in detecting and tracking oil spills of unknown origin, finding sunken wrecks, mapping bathymetry and hazards, and detecting illegal fishing activities.

The role of UUVs in mapping the seafloor has received public attention in light of the Malaysian Air tragedy. UUVs are rapidly becoming ‘underwater pickup trucks’, and can precisely navigate at depths unreachable by divers and conduct surveys with a variety of surveillance sensors at speeds and efficiencies unattainable by other means. My team at Scripps has used smaller versions of the same system that found the Air France crash site to conduct surveys to map ecosystems and natural resources, map subsurface plumes, detect changes in bathymetry after typhoons, and search and identify missing aircraft and sunken ships. In conjunction with collaborators at the University of Delaware, we recently used UUVs equipped with sidescan sonar to find two missing planes from WWII and over a dozen unknown ships in the western Pacific Visualization of large data sets generated by UUVs has the capability to map habitats and show impacts from sunken buoys and anchor scours. Onboard sensors such as fluorometers can measure the presence of oil. Aggregation of imagery and sensor information can assist the USCG mission in determining the risk of oil leaks from submerged wrecks. With over 6000 ships from WWII believed to be resting on the seafloor, a significant amount of oil remains submerged aboard long-sunk vessels. The threat of oil leaks is increasing due to 70 years of corrosion.

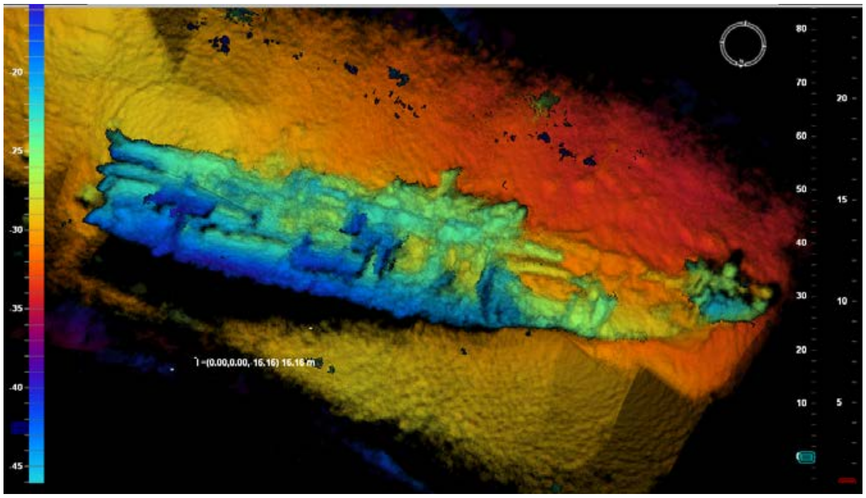

Figure 3. Mosaic image of submerged wreck from multibeam sonar

Another UUV are the buoyancy propelled underwater gliders were used in the 2010 Deepwater Horizon spill in the Gulf of Mexico for analyzing water column properties and detecting the presence of oil. Gliders narrowed the search zone for subsurface oil and provided valuable information to constrain ocean forecast models that were being used to predict where the oil might be transported. Through IOOS, the glider community is establishing a common data format for glider near real-time data feeds. This will significantly improve the ingestion and display of glider data retrieved from varying platform vendors. Ocean gliders have proved invaluable in providing persistent underwater surveillance of changing ocean conditions for purposes of tracking changing climate signals including El Nino. The data are used by operational forecast models operated by NOAA and the Navy, and is an excellent example of technology developed by the Navy transitioning to other agencies within the U.S. Government. NOAA and its IOOS partners have recently drafted a National Network Glider Plan to provide an implementation roadmap to serve U.S. needs to monitor the subsurface ocean. Implementation of the plan is recommended so that U.S. has the capability to understand and forecast changing ocean conditions for fisheries and coastal weather predictions.

Another use of glider technologies that is worth mentioning is the modernization of the Tropical Ocean and Atmosphere Observing (TAO) system. The TAO system has proved highly valuable for improving understanding and forecasting of El Nino/Southern Oscillation (ENSO) variability, including its impacts on North American rainfall and temperature. The ENSO cycle is operationally relevant to USCG and first responder interests as typically the larger and stronger winter storms occur during the El Nino phase of the ENSO cycle, with coastal erosion and coastal flooding typically the norm. As it becomes increasingly difficult to sustain the conventional observations initiated in the 1980s that provide us El Nino forecast capabilities, new observational technologies are being examined to enhance the effectiveness and efficiency of the ENSO observing system. A nascent project has begun that will augment the equatorial Pacific distribution of Argo floats, demonstrate the use of glider technology as an alternative to subsurface moorings, and evaluate the impact of these novel approaches in combination with other related satellite and in situ observations. The goal is to demonstrate how this suite observation technologies will improve our knowledge of the evolving physical state of the tropical Pacific Ocean, as well as provide an improved equatorial Pacific dataset for researchers and for operational ocean state and forecasting centers around the world.

Education/Training:

Scripps-UCSD is well positioned to serve the Nation's maritime security needs by educating the next generation technical workforce. It is well recognized that the country's capability to remain competitive on a global scale is tied to our success in stimulating interest in Science, Technology, Engineering, and Mathematics (STEM) fields. For the maritime sector, Scripps presently plays an educational role at the MS and PhD programs, especially through the Applied Ocean Sciences (AOS) program. For example, a recent USCG masters graduate of the program went on teach at the USCG Academy and is now at Office of Science and Technology Policy, Executive Office of the President. Another active-duty naval officer who obtained his Ph.D. at Scripps was recently nominated for appointment to the rank of rear admiral and will become the next Commander of the Naval Meteorology and Oceanography Command.

Additionally, grants provide partnerships for education and training. Through the National Science Foundation's (NSF) program Ship-based Science Technical Support in the Arctic (STARC), Scripps provides marine science and technical services to NSF-supported research cruises aboard the U.S. Coast Guard cutters HEALY and POLAR SEA. This program is a collaborative between the Shipboard Technical Support (STS) department at Scripps and the Marine Technician Group (MTG) at Oregon State University (OSU) that provides the highest level of shipboard technical support possible. The program uses a model for Arctic shipboard technical support that follows best practices of the University-National Oceanographic Laboratory System (UNOLS) fleet.

Education and training of students, new technicians and USCG personnel in use of technology and techniques at sea are among the broader impacts of this effort, thus growing the technical knowledge base that supports U.S. oceanographic research. Scripps supports the acquisition and appropriate handling of underway shipboard data in concert with national data centers such as the NSF-supported Rolling Deck to Repository (R2R) program, making data available to the academic community and the public at large. Scripps and OSU will coordinate with NSF, USCG and the Arctic Icebreaker Coordinating Committee to define priorities for maintenance and upgrades to science equipment onboard.

4. Closing and Recommendations

In closing, I would like to thank the Committee for the opportunity to testify on the role of ocean technologies and provide suggestions for the U.S. to leverage on-going investments to promote and improve maritime domain awareness. Scripps' scientists are leaders in research and operational use of maritime technologies and have a long history with national defense-related science, and as an organization, we are privileged to be positioned to provide national service to this increasingly important topic. I believe that development of partnerships between USGS and other agencies (e.g. ONR, NAVAIR, DARPA) for purposes of pursuing defense-related observational strategies and then testing those strategies through demonstrations is very important. The west-coast is well poised to support these demonstrations. In addition to recommending stronger partnerships between the USCG and the DOD research enterprise, it is recommended that the Integrated Coastal and Ocean Observation System Act of 2009 be reauthorized. This Act has been introduced in the House and is awaiting Senate approval. This legislation authorizes IOOS and provides the interagency framework to guide the nation's strategy to sense the ocean, and connect ocean data across Federal/non-federal partnerships. NOAA-IOOS directly supports USCG missions for Search and Rescue and Oil Spill Response and reauthorization of ICOOS would continue to foster NOAA-USCG partnerships. Scripps recommends full funding for the U.S. National Surface Current Mapping Plan to provide national uniformity in the benefits of the network including search and rescue and oil spill response. The funding for this Plan has remained flat funded at the 50% operational capability level since being established as a NOAA budget line three years ago. Funding of the IOOS national glider plan is another logical step once it has been completely vetted by the user community.