The New Jersey Shelf Observing System

Using an Ocean Observatory to Track Plumes, Particulates and People in the Coastal Ocean

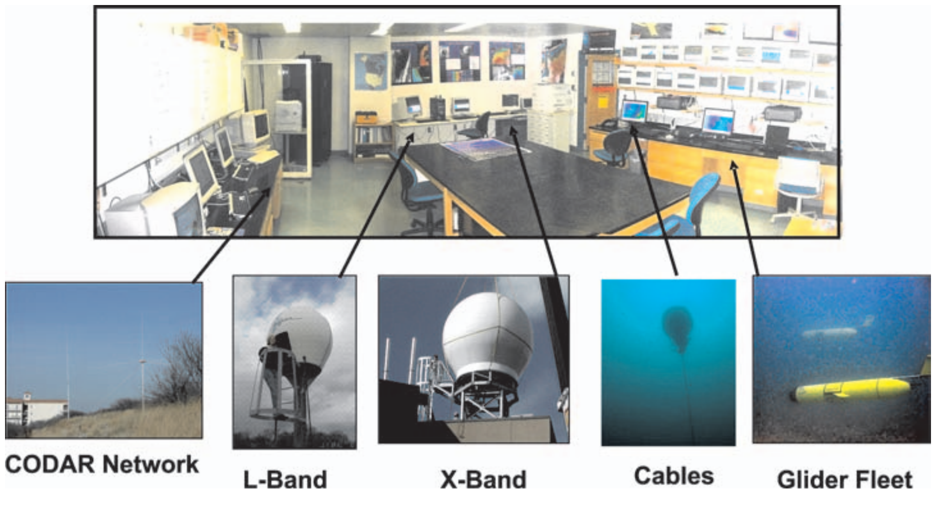
By Dr. Oscar Schofield
Associate Professor
Dr. Josh Kohut
Director of the COOL Room
and
Dr. Scott Glenn
Professor
Institute of Marine and Coastal Sciences
Rutgers University
New Brunswick, New Jersey

Over the next 50 years, coastal oceans throughout the world will undergo changes associated with the increased flux of nutrients resulting from the increasing human population living along the coasts. The potential coastal eutrophication may alter microbial community diversity and productivity, leading to change in the oxidation state of continental shelves. A change in the redox state of a coastal system can be catastrophic, leading to loss of fisheries, increased production of greenhouse gases, altered food webs and, potentially, the loss of marine biodiversity. While scientific efforts have developed some qualitative understanding of the processes underlying the redox state of continental shelves, scientists do not quantitatively understand which continental shelves will be most susceptible to catastrophic change, which might be more resilient and why. Fundamentally limiting understanding is the inability to sample the ocean on relevant scales in both space and time. For example, fixed-point sampling grids conducted from ships do not resolve the fractal variability in the physics, chemistry and biology of the coastal ocean. In addition, very few temporal measurements are sufficiently sustained to resolve the characteristics of episodic events or multi-year trends that play a large role in structuring marine ecosystems.

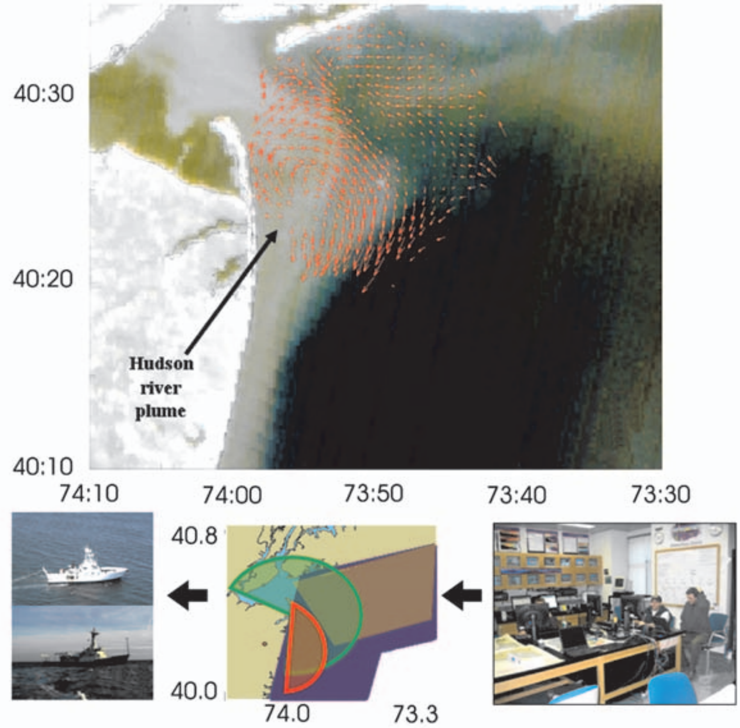
This lack of understanding fuels the motivation to build regional integrated coastal ocean observing networks. Like many others, the authors of this article were motivated at Rutgers University's Coastal Ocean Obser-vation Lab (RU COOL) to effectively sample the biogeochemically relevant space and time scales in the Mid-Atlantic Bight. This article will review the general design of the New Jersey Shelf Observing System (NJ SOS), which provides sustained measurements from a shore-based control center known as the COOL room. The authors of this article will also review how NJ SOS, which started as a regional research effort, but is developing into an international consortium providing a framework to exchange technology and sensors. This consortium will be used to compare and contrast continental shelves in the coming decade.

What is the COOL Room?

The COOL room is a shore-based laboratory that controls the ocean observatory. It provides scientists control over remote assets collecting data in the field. The data is collected from an international constellation of satellites (SeaSpace X-band and L-band receiving satellite dishes), a triple-nested multi-static array of high-frequency radars spanning the northeast United States, a propeller-driven autonomous underwater vehicle (Hydroid Inc. Remus vehicle), an electro-optic fiber optic cable outfitted with a two-



The layout of the COOL room. Each bank of computers is dedicated to a different component of the observatory.



Maps of the surface currents measured by the observatory and its ability to improve drifter (and human) locations at sea.

way shore-based communication and power delivery system (WETSAT) and a fleet of autonomous Webb Slocum gliders (Webb Research). Data is delivered in nearreal-time, analyzed and posted to the Internet through a series of websites. The data enables adaptive sampling by ships, planes and other field platforms. Adaptive sampling requires the data acquired in the field to be successfully analyzed in the COOL room and be reliably distributed to people or robotic assets in the field. This needs a robust two-way communication network. The COOL room uses a redundant communication network that allows for graceful degradation of the data stream as assets often operate outside the high-bandwidth communication networks. The network consists of high-speed radio modems, broadband wireless networks, cell phone networks and global satellite networks. The availability of the Iridium network gives the COOL room a global footprint, allowing assets to be deployed all over Earth and be controlled remotely from the COOL room. The COOL room allows any land-locked scientist to be at sea, under all conditions, at any time of day. For example, the system routinely allows a person to sit at home during large storms (hurricanes and nor'easters) and monitor the ocean's response in real time. This remote interaction is one of the hallmarks of coastal ocean observing networks, and is a transformational step for oceanographic research. More importantly, these observatories will change how human society interacts and manages the oceans. Many of the current scientific research questions also have broad applicability to those in the applied maritime community. Two such examples of projects being addressed by NJ SOS are material transport and search and rescue.

From the Land to the Deep Sea

Buoyant coastal currents extend along much of the East Coast of the United States and are fed by numerous rivers generally characterized by moderate flow rates. Despite these moderate flows, the buoyant plumes appear to dominate the transport of nutrients and chemical contaminants to the coastal ocean. This is especially true for the New York and New Jersey harbors, which arguably hold the distinction of being one of the most contaminated estuaries on the East Coast. Therefore, understanding the transport of sediment and the associated material from the harbor to the coastal ocean is a fundamental problem for state and federal water-quality managers, a difficult task considering how dynamic these plumes are in space and time. The plumes are modified by bottom topography, shoreline geometry, atmospheric forcing, tides and river outflow. This makes sampling a plume using moorings or fixed sampling grids impossible.

The National Science Foundation (NSF) is currently supporting the Lagrangian Transport and Transformation Experiment (LaTTE) program which is focused on the physical circulation mechanisms that alter the transport and transformation of the chemistry and biology of the harbor plume as it flows into the coastal ocean. To monitor and adaptively sample the plume, this project intimately relies on the ocean observatory. The real-time data from all remote assets are used to direct ships and gliders. Ocean color imagery and sea-surface temperature provide maps that help define the spatial extent of the Hudson River plume. These daily composites are then advected through time using the hourly data from the surface current radars. Data is compiled in real-time in the COOL room and transferred to ships at sea using the nested communication network. This adaptive capacity allows ships to adjust sampling strategies on the fly. Supplementing the ship data are Webb gliders that provide sub-surface maps of the river plume. Here, the scientist benefits from having a 3D picture of the plume and its contents over a time period sufficiently long enough to study the transformation of organic material. The environmental managers benefit from a real-time picture of the plume, allowing adaptive sampling and increased understanding of potential deposit centers of pollutants, heavy metals, and organic and inorganic particulates flowing out of the harbor.

Circulation and Search and Rescue

The spatial variability in continental shelf circulation is well known. Until recently, the lack of data forced scientists, the U.S. Coast Guard, the U.S. Navy and hazardous materials response groups to rely on the climatology of circulation patterns to conduct operations. Climatological approaches do a poor job in capturing the true variability of the circulation. The coastal ocean dynamics applications radar (CODAR) is a high-frequency radar system that uses radio waves to remotely measure ocean surface currents as far out as 200 kilometers offshore. Surface current maps are now provided hourly which indicate the

“A change in the redox state of a coastal system can be catastrophic, leading to loss of fisheries, increased production of greenhouse gases, altered food webs and, potentially, the loss of marine biodiversity.”

directions and speeds of the current. These maps have great potential for search and rescue. Demonstration projects are being conducted to provide proof of concept for using these surface current maps in Coast Guard search and rescue operations. This effort uses the existing high-frequency radar network off the coast of New Jersey (operated by the COOL room) and near the mouth of Long Island Sound (operated by the universities of Connecticut and Rhode Island). Drifting buoys are used to simulate boats adrift at sea, and search areas are defined with and without the use of CODAR.

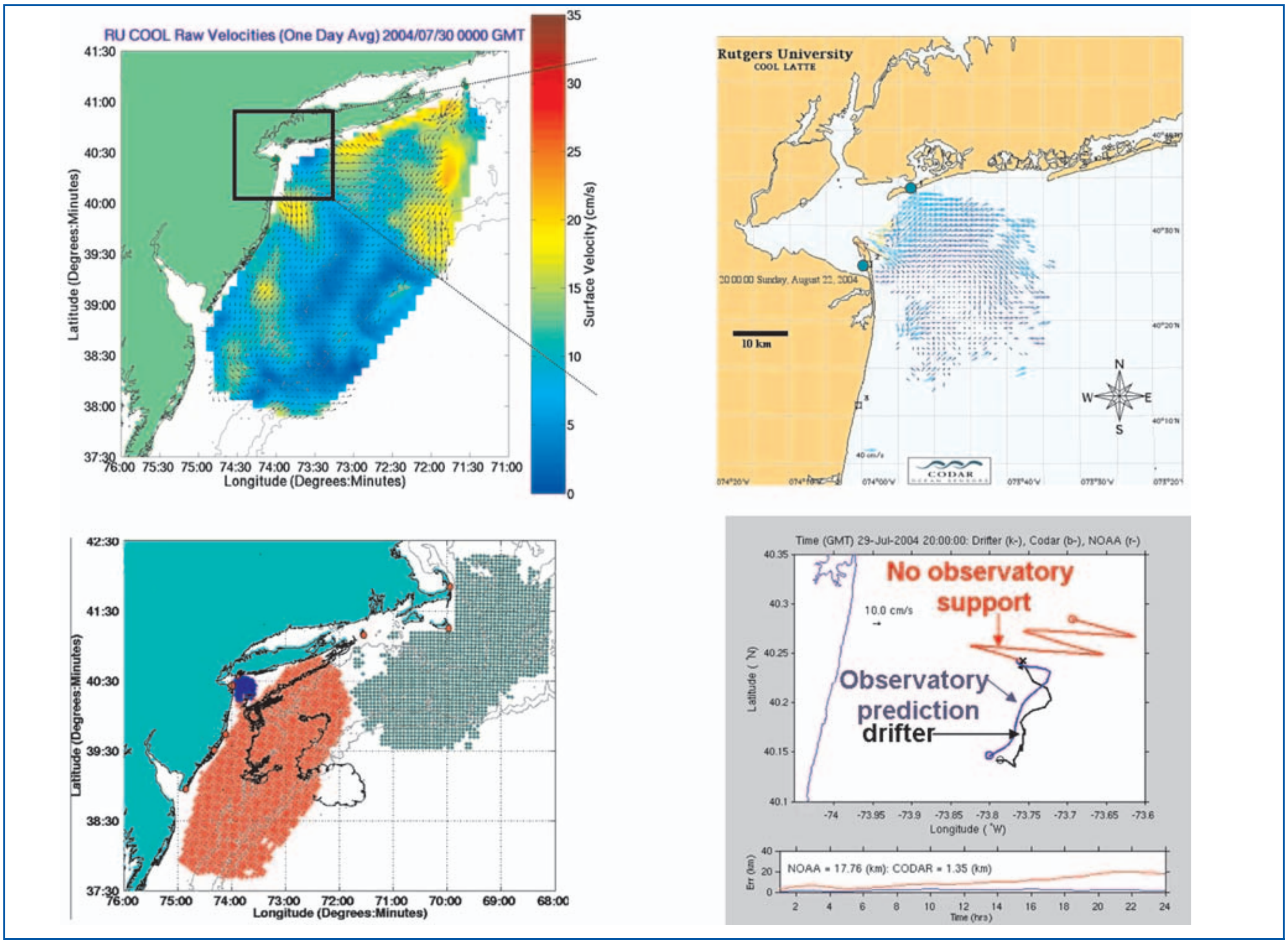
Here, the observatory benefits science by providing continuous spatial circulation data, thus allowing a robust means to understand advection of material on the continental shelf, while simultaneously providing the potential to greatly improve Coast Guard search and rescue operations.

Who will build the observatory networks in the United States? Building integrated ocean networks is an active research problem requiring fundamental advances in sensors, cyber infrastructure, data assimilation models, and fixed and mobile platforms. These advances are necessary to improve the ability to uncover when and where the material is found, and to understand why it is there. Without these technological advances, these networks will not reach their full potential for commercial and environmental communities. Over the next decade, the United States will deploy significant infrastructure to enhance the nation’s ability to see the oceans in all of its dimensions. Currently, the two major initiatives are the Integrated Ocean Observing System (IOOS) and the Ocean Observatories Initiative (OOI). The NSF’s OOI will develop state-of-the-art coastal, regional and global ocean observation capabilities that will provide advances in research and engineering.

These systems will complement the applied and mobile integrated networks being developed by Office of Naval Research. As the capabilities mature, the societal benefit will only be realized if the systems are deployed and sustained on an operational basis. This operational network is provided by the National Oceanic and Atmospheric Administration’s IOOS. These diverse efforts all complement each other and will provide a capability that will be greater than a sum of the parts.

International Partners with NJ SOS

The NJ SOS is not unique, as many similar coastal observing networks are being deployed globally. Some are focused exclusively on research prob-



The maps of the surface currents measured by the NJ SOS CODAR network.

"...understanding the transport of sediment and the associated material from the harbor to the coastal ocean is a fundamental problem for state and federal water-quality managers..."

lems, while others have an applied focus.

Success in the future will be measured by how the observatories simultaneously serve both of these needs. This will require efficient and open exchange between all the observatories. In the past, information and technology exchange between systems has largely been informal and facilitated by the desire of scientists to work with each other.

In an effort to formalize some of these informal collaborations, an ocean observatory consortium was established in the spring of 2005. The consortium, the International Collaborating Ocean Observing Laboratories (ICOOL), represents partnership between several observatories in the United States, Canada, Norway and England.

The primary goal of these laboratories is the exchange of technology, models and experience. Examples of such efforts include the planned deployment of NJ SOS gliders in England, Japan, Germany and Norway in the fall of 2005 to provide these groups data to facilitate garnering funds to purchase their own gliders. As the global network of coastal observatories continues to evolve, consortia like ICOOL will allow for interoperability, the efficient integration of various rapidly evolving technologies throughout the global network and the expansion of resources that any community can leverage from.

Acknowledgements

The authors specifically wish to acknowledge the amazing people of the COOL room, their partners in LaTTE and Coast Guard search and rescue programs. The authors would also like to thank their ICOOL partners. /st/

For more information, visit our website at www.sea-technology.com.

Dr. Oscar Schofield is an associate professor of biological oceanography at the Institute of Marine and Coastal Sciences at Rutgers University. He is a co-founder of the COOL group with Dr. Scott Glenn. His research is focused on the coupling between physics and its impact on the ecology of the oceans.

Dr. Josh Kohut is the director of the COOL room at the Institute of Marine and Coastal Sciences at Rutgers University. He has established the northeast array of long range CODAR radars and, in partnership, has been developing K-grey outreach that allows society to better manage the world's oceans.

Dr. Scott Glenn is a professor of physical oceanography at the Institute of Marine and Coastal Sciences at Rutgers University. He is a co-founder of the COOL group with Dr. Oscar Schofield. His research is focused on the coupling between physics and its impact on the ecology of the oceans.