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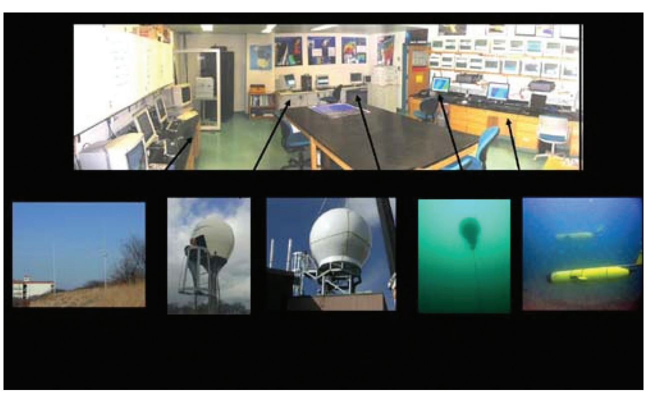
The world's continental shelves—the narrow ribbon between the major land masses and the deep ocean basins—cover only about 10% of the surface of the Earth, but are some of the world's most productive ecosystems and are home to most of the world's fish species. Across these continental shelves, sediments and chemicals supplied by rivers and beaches are transformed as they travel to the deep sea moving material into the deep ocean basins where it will remain for thousands to millions of years. These transport pathways are influenced by winds from the atmosphere pushing water at the surface ocean, currents from the deep ocean on the offshore side, and freshwater inputs from the inshore side. The biology and chemistry is continually changing as the water is transported. Understanding all these processes is extremely difficult. Historically, oceanographers use ships to study these processes; however, ships are slow, moving at the speed of a 10-speed bicycle, and therefore, it is difficult to collect the data that is required.



Developing new approaches to study the ocean is now especially critical. Human populations continue to grow and concentrate along the coasts. Globally, human activity is increasing the atmospheric concentrations of carbon dioxide, nitrogen, and other elements. Locally, we require food, water, and energy; protection from severe weather; and we produce waste. Continental shelves are affected by these increasing human pressures, responding both to the cycles and trends of global climate, and to the local needs and impacts of expanding coastal populations. Quoting the U.S. Commission on Ocean Policy, we need "sound science for wise decisions" to ensure the sustainable use of our coastal oceans for this and future generations. These needs have motivated many to start building integrated ocean observatories to study the ocean. One such observatory that has been developed is the Coastal Ocean Observation Lab (COOL).

COOL is an integrated network that was developed to allow scientists, environmental managers, and society to maintain a continuous presence in the ocean. The goal is to develop, demonstrate, and deploy the technologies that will allow humans to explore the oceans for sustained periods of time whether they are in New Jersey, California, Kansas, or another country. The goal is to ultimately develop a global capability. The COOL system currently consists of several technologies (Figures 1 and 2). Data is collected from 1) the international constellation of satellites used to measure the physics, chemistry, and biology of the ocean; 2) radar networks, which continually measure the surface currents for the entire continental shelf; 3) propeller-driven underwater robotic vehicles, which patrol the ocean collecting data; 4) sea-floor instrument packages, which are connected by cables that allow data to be instantly delivered back to shore; and 5) a fleet of unmanned smart robotic gliders, which can remain at sea for months at a time. These advanced technologies are then coupled to models which can be used to forecast the future and study "why" something happens in the ocean. The data from all these technologies are delivered back to a shore-based laboratory and immediately delivered to the world via the World Wide Web. This is a big step forward, as just a few years ago, it took months to years before ocean data collected by scientific instruments could be delivered to anybody.

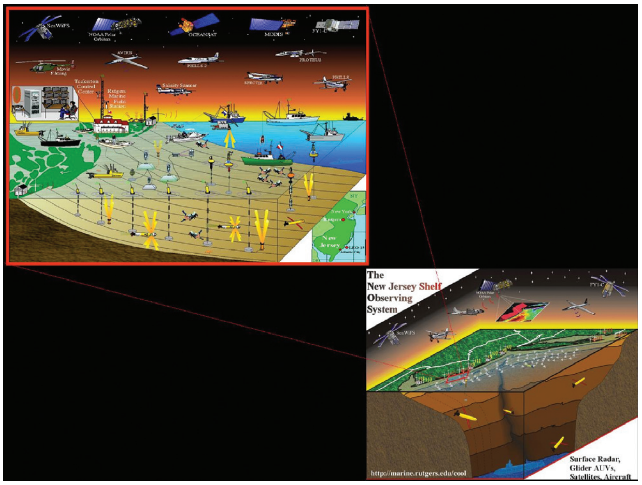


Figure 1. Overview of technologies involved in the COOL Room Observing network.

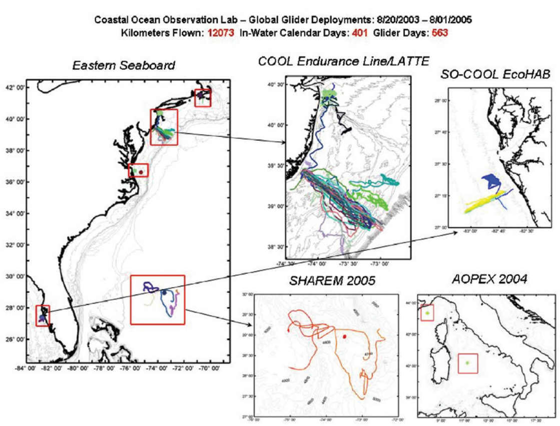


Figure 2. Locations where COOL ocean robots have been flying.

The goal is to explore the oceans and allow people to make smart decisions regarding the ocean. Decisions are being made everyday on a range of topics and scales. Where should I go fishing today? When should I bring my ships into port? Should we build offshore wind farms to contribute to the energy grid? Where will the hurricane make landfall? Where should my growing municipality locate its outfall? How should our nation respond to rising greenhouse gases? Wise decisions are based on some type of prediction, ranging from experience-driven rules-of-thumb to complex model results. Most predictions, in turn, are based on two types of information, an observation of our present state, and an understanding of the processes that will evolve that state into the future. Predictions as simple as “red sky at night, sailors delight,” or as complex as weather forecasts that require an initial condition and a mathematical description of the laws of physics, illustrate the overarching need for both observation and understanding to make predictions.

Provided below are two examples highlighting the complex processes of coastal circulation.

Example 1: Buoyant plumes and material transport from the land to the deep sea. Buoyant coastal currents extend along much of the U.S. East Coast and are fed by numerous rivers. These 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 Harbor, which arguably holds 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. These plumes are modified by bottom topography (shape of the sea floor), shoreline geometry, atmospheric conditions, tides, and river outflow. This makes sampling a plume using moorings impractical.

To monitor and adaptively sample the plume, scientists use the ocean observatory. The real-time data from all remote technologies are used to direct ships and gliders. Ocean color satellite imagery and sea surface temperature provide maps that help define where the Hudson River plume is. These satellite snapshots are then moved forward in time using the measured surface currents and simple models. The data and the forecasts are compiled in real time in the COOL room and then transferred to scientists working on ships at sea. This allows ships and roving fleets of ocean robots to adjust sampling strategies on the fly. Here, the scientist benefits from having a three-dimensional picture of the plume and its contents over a time period that is 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, organic and inorganic particulates flowing out of the harbor.

Example 2: Shelf circulation, and search and rescue. The spatial variability in continental shelf circulation is well known; however, until recently, the lack of data forced scientists, the Coast Guard, the Navy, and HazMat response groups to assume circulation was constant (5 cm/s water flow to the south). Measurements made by a High Frequency (HF) radar system uses radio waves to remotely measure ocean surface currents as far out as 200 km offshore. Surface current maps are now provided hourly, which indicate the directions and speeds of the current. These maps have great potential for search and rescue. Demonstration projects are being conducted to see if these surface current maps can help in Coast Guard search and rescue operations. This effort uses the existing HF 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 (or bodies) adrift at sea and search areas are defined with and without the use of Coastal Ocean Dynamics Applications Radar (CODAR).

These networks will transform how oceanographic research is conducted so this a very exciting time for oceanography. We are ready to tackle scientific problems that have challenged oceanographers for centuries while simultaneously serving the society that supports ocean research. The continued development of long-term monitoring, adaptive sampling, and dynamic forecast systems will especially enhance our understanding of the processes occurring on continental shelves, which are dynamic in space and time, and difficult to sample using traditional techniques. The importance and urgency of the research combined with the adventure of being at sea, makes for a rich life. This adventure will, in the next few years, be available to all and based on our experiences, we will all be richer for it.

Additional Reading

M. Carlowicz,. "The new wave of coastal ocean observing," *Oceanus,* vol. 43(1), 2004.

S. Gallager. "Sensors to make sense of the sea," *Oceanus,* vol. 43(2), 2004.

R. Geyer. "Where the rivers meet the sea," *Oceanus,* vol. 43(1), 2004.

Web Sites

http://www.thecoolroom.org/

The official COOL Room Web site by Rutgers University Coastal Ocean Observation Lab: This Web site will allow access to the data described in this article.

http://marine.rutgers.edu/neos/

The NorthEast Observing System (NEOS): Real-time and archived data are available from observing stations throughout the entire Northeast United States

http://www.csc.noaa.gov/coos/

Glossary

Buoyant—having the quality of rising or floating in a fluid; tending to rise or float.

Topography—the surface features of an object or how it looks its texture, direct relation between these features and materials properties (hardness, reflectivity etc.).

Moorings—equipment, such as anchors or chains, for holding fast a vessel or oceanographic equipment.

Real-time data—data that relates to systems that update information at the same rate as they receive data, enabling them to direct or control a process.

Organic—pertaining to carbon-based compounds produced by living plants, animals or by synthetic processes.

Inorganic—pertaining to substances not of organic origin.

National Oceanic and Atmospheric Administration Coastal Services Center: NOAA provides access to data from observing systems for the entire United States coastline. Data come from diverse technologies including buoys, bottom instruments, ship surveys, satellites, and autonomously operated vehicles.

COOL Room Further Reading

Related articles about coastal ocean environments:

Staying on Top: These Shoes Just Did It

http://seawifs.gsfc.nasa.gov/OCEAN_PLANET/HTML/oceanography_currents_2.html

Beach: Nike Shoes Wash Up

http://www.mindfully.org/Plastic/Nike-Pacific-Dump-Ebbsmeyer.htm

Wind-Driven Ocean Currents: Of Shoes and Ships and Rubber Decks and a Message in a Bottle

http://www.islandnet.com/~see/weather/elements/shoes.htm