

## SYMPOSIUM ON APPLICATIONS OF REAL-TIME OCEANOGRAPHIC CIRCULATION MODELING

Mark Twain once said, "After I had mastered the language of the water, all its grace and beauty, the poetry had gone out of the majestic river." Knowing the language or water levels and currents of a harbor or estuary is very important to the pilot of an 850-foot container vessel worth \$60,000,000. The chairman of the American Association of Port Authorities, **Gregory Halpin**, states that the port industry is vitally interested in real-time circulation data, since exact knowledge of water depth and movement will allow ships to be handled safely and economically. "People must be impressed with the fact that if you closed the ports of the country, we all soon would be unhappy, hungry, and threadbare!" It is necessary to understand better and try to predict the dynamics of our nation's waterways, but there always will remain, in contrast to Twain's feelings, a mysteriousness, a poetry, in the water that demands continuing investigations.

With these thoughts, the two-day Symposium on Applications of Real-Time Oceanographic Circulation Modeling opened on May 23, 1985, at APL's Kosciakoff Conference Center. Jointly sponsored by APL, the National Ocean Service of the National Oceanic and Atmospheric Administration, and the Marine Technology Society, the symposium brought together representatives of diverse interests including data users (marine shippers, coastal resource managers, estuarine researchers, Navy managers), instrumentation and communication developers, and oceanographic modelers. Invited speakers, poster sessions, and vendor displays focused attention on a new direction in applied oceanography, namely, the development of real-time instrumentation and modeling systems to provide accurate forecasts of circulation and water levels. Such systems require integration of measurements, telecommunications, and automated data processing technologies, as well as database management and advanced numerical modeling techniques.

A motivation for the symposium was the development of a real-time operational model/measurement system for the Delaware River and Bay by the National Ocean Service. The system acquires water-level data from four locations, meteorological data from two stations, and current data from the near-bottom to the near-surface by means of a remote, acoustic-Doppler current meter. Measurement data at each source are preprocessed and sent hourly by telemetry and phone lines to the National Ocean Service office in Rockville, Md. At this point, the data are incorporated into a

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two-dimensional, vertically averaged hydrodynamic model that is run on a Cyber 205 computer. The model generates, on demand, a 36-hour forecast of tides, water levels, and currents. By means of a personal computer linked via a phone line to the Cyber 205, a user at a remote location can obtain data listings, time series graphs, and vector circulation plots based on the historical and real-time climatology or on user-specified conditions. APL assisted in the system development, including the design and deployment of a buoy and a tower for meteorological data acquisition.

Several speakers at the symposium discussed real-time oceanographic applications and potential system users. Commercial shippers are primary users of such data.

**Patrick Lynch** (Association of Maryland Pilots) stated:

You really need some hard facts as to how deep the water is and how fast it is moving before you take a ship out. In the recent past, we went to the pier for the hard facts and looked at the pilings to see how much moss was exposed. Now one can look at a NOAA computer printout or monitor for accurate data, without resorting to moss.

Applications of real-time oceanographic circulation modeling to Coast Guard search-and-rescue operations and to pollution tracking were discussed by **David Paskausky** (Coast Guard Research and Development Center):

We have found the need to develop a technique of "nowcasting." An assimilative numerical model provides an objective analysis of your expected target position so that you can conduct an effective search.

Current plans call for incorporating satellite data pictures, aircraft sonobuoy data, and drifting float-transponder tracking information into future model-directed search systems.

According to **John Robinson** (National Ocean Service), "Real-time modeling is important in effectively bringing science to bear on the oil spill response problem." Several models have been run for over 300 spills in the last few years. Within two to four hours after a spill notification, environmental data and technical information are gathered and model runs are completed to provide trajectory forecasts. Field data acquisition and data information management may hold the key to minimizing damage from serious spill incidents.

The next generation water-level measurement system for the National Ocean Service is planned to be

nearly a real-time system. Measurements taken at stilling wells throughout U.S. coastal waters will be processed and transmitted through the GOES satellite directly to Rockville for database integration and data dissemination. **Wolfgang Scherer** (National Ocean Service) reported on an initiative for a future global sea-level monitoring program that would use 200 to 250 sensors distributed around the earth, in the hope of learning more about the rising sea level.

**Chris Mooers** (Naval Postgraduate School) noted:

One of the many Navy interests in real-time capability with ocean circulation modeling is with optimum ship routing, so that more than just surface gravity waves and wind fields are taken into account. Even using basic satellite remote sensing information to find where the eddies are located would probably aid in where best to steer your ship. . . . It would be useful to have the capability to keep track of mesoscale ocean circulation on a regional basis, and even more attractive to have this capability in a portable fashion so that one could deploy it in any of the global oceans where there is an interest. I would suspect that, over a regional domain of say 1000 kilometers square, within ten years we will have a respectable capability of forecasting the evolution of mesoscale variability on the order of two weeks to two months. We need to strike a resonant chord in the hearts of oceanographers to recognize that their self-interest is in some aspect in real-time systems.

Other applications of real-time circulation models discussed at the symposium included coastal flooding, dredging, remote sensing, and sedimentation studies. Real-time measurement systems consisting of recently developed sensors and low-cost microcomputers can provide data to all potential users, opening up new applications and solving more problems.

Several hydrodynamic models were discussed that highlighted the timely use of input data and reporting of results. The accompanying table presents a list of modelers and an example location for each model application. There are many similarities in the models;

an open discussion was held on their utility and weaknesses. **Alan Blumberg** (DYNALYSIS) pointed out that models generally do not have wide applicability and are developed for specific locations. "Modeling is basically still an art," said **Robert Baltzer** (U.S. Geological Survey). "To make a model work well, a good bit of art is used in setting up the model and analyzing the data." A significant expenditure of time, money, and effort is necessary to develop and validate a model that will be used in several locations and applications. However, a balance must be achieved between the high objectives of the researcher and the need to apply the model. **Dan Fread** (National Weather Service) stated that in spite of the need for accuracy, if we build models and get the model/measurement systems into place, they will evolve naturally into better tools as more data are obtained.

Even though the physics of circulation is well understood, the development of adequate models is hampered by the lack of funding. Also, real-time measurement systems do not find a ready market. **Chris Mooers** suggested one solution:

We need a regional approach, an interagency approach, with one agency taking the lead to pull together present capabilities in order to provide operational products. I think you would see very interesting developments because there would be real competition between regions rather than between agencies. Furthermore, a good class of circulation models can meet many, many needs. There may be some need to broker the agencies, modelers, and users to get the desirable end result.

The commercial shipping industry, as a system product user, may also be an excellent source of support. **David Bastian** (Army Corps of Engineers) mentioned that

Most of the users or potential users don't understand the capabilities of real-time oceanographic modeling—they need educating. If the pilots, lighter company, terminal company, and port authorities

Modelers and locations for applying their models.

<i>Investigator</i>	<i>Affiliation</i>	<i>Example Application Area</i>	<i>Product</i>
Richard Patchen	National Ocean Service	Delaware Bay	Tides, currents, water level
George Mellor	Princeton University	New York Harbor	Tides, currents
Malcom Spaulding	University of Rhode Island	North Sea	Tides, currents
H. Lee Butler	Army Corps of Engineers	Coos Bay, Kings Bay	Tides, currents
Bryan Pearce	University of Maine	Bay of Fundy	Tides, water level
Dan Fread	National Weather Service	Mississippi River	Water level
Alan Blumberg	Dynalysis	Santa Barbara Channel	Currents
John Bennett	Environmental Research Laboratory	Lake Michigan	Currents

could all get together, they could really use real-time systems if they knew what they could do.

However, **Joseph Bishop** (National Advisory Committee on Oceans and Atmosphere) cautioned:

It is up to the oceanographers and modelers to find out what are the needs of the users. The users are not going to come banging on your door saying, "Here is a million dollars; solve all my problems and have fun while you're doing it." The key is that we have to work with industry and find out what they need to know.

Another issue dealt with the meaning of "real time" for each user. Most applications need tide and water level data 6 to 24 hours in advance. A key factor is the ability to predict the meteorological parameters during the forecast interval. Another point made by **Tom Curtin** (Office of Naval Research) is that the real-time forecast will require the use of data up to a week before the prediction, so the correlation scales and dynamics for an area are important and need to be known for long periods. It was felt that transmission of data from the sensor to the model should be as fast as possible so that transmission time would not be a limiting factor, and so that the variety of user response needs could be met.

**John Flipse** (vice chancellor and associate dean of Texas A&M University) discussed another critical issue to real-time systems, namely, liability. Using two examples, he pointed out the legal implications of providing incomplete or incorrect data to the captain or pilot of a large vessel that is subsequently involved in a collision or grounding. Even though a captain has command of and responsibility for his vessel, the involvement of real-time oceanographic forecast data may contribute to the assignment of liability in case of an accident. A study is needed to determine who has responsibility for errors in real-time model predictions.

Quality in modeling was the topic discussed by **Gilbert Maton** (Tracor, Inc.). A quality product, whether derived from models or from any industry, is one that has fitness for use. "The goods and services provided must respond to the overall needs of the user in affordability, delivery, and fitness for use. The last is judged from the user's viewpoint, not from that of

the designer, operator, or distributor." Models have several characteristics: technological, psychological, time orientation (e.g., real-time), contractual, and ethical. To illustrate the ethical characteristics, he retold this story:

In Roman times, it was fashionable to have statues (models) of gods and public figures, or oneself, as subjects for homage, tribute, and other purposes of the patron (user), who would benefit from the model through the increased admiration and respect of his peers.

The models in those days were produced in marble by sculptors. I might order a bust of myself to display to the public or my associates. If an unscrupulous modeler, because of a miscalculated chisel blow, took off my ear just before completion time, he might mask or conceal the defect in the model by carefully formulating the ear from wax, marble dust, and vegetable pigments to make it look like marble and paste it on the model.

When it was completed, I would pay for this beautiful model and display it with pride, only to discover later, after a period of exposure to the environment, that I'd been had. As a user, I would no longer have confidence in the modeler (or perhaps any modeler). I expected a product that was true, genuine, and unmarred. These characteristics in modeling are as essential now as 2000 years ago.

The future development of real-time measurement and modeling systems will be stimulated by the coordination and education of the modelers and the users. System developers will have to examine liability issues and carefully consider appropriate product needs and formats. Finally, system requirements need to be specified to obtain highly useful information cost-effectively.

The Real-Time Oceanographic Circulation Modeling Symposium at APL may be the first of several meetings of this type. A complete proceedings of the meeting will be published in the near future. In bringing together various interest groups to focus on the subject, a more concentrated and effective effort can be made to use existing technology and analytical tools to serve the public better and to continue our quest for understanding of the poetry of the world oceans.