NOAA's Physical Oceanographic Real-Time Systems (PORTS®)

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Abstract **-** NOAA's Center for Operational Oceanographic Products and Services (CO-OPS) has developed the Physical Oceanographic Real-Time System (PORTS®) to meet the specific needs of the local maritime community by measuring, integrating, and disseminating observations of water levels, currents, salinity, wind, and bridge clearance, all of which help mariners successfully guide ships into and out of the Nation's seaports. In several locations, PORTS® also provides forecast model guidance which supports informed decision-making in advance of transit scheduling and loading operations. There are twenty PORTS® supporting 50 seaports nationally; eight of these PORTS® are in the Gulf of Mexico. Using PORTS® information in conjunction with NOAA Nautical Charts and US Coast Guard (USCG) Navigational Aids has proven to reduce groundings by as much as 50 percent (%). Future enhancements include integrating PORTS® data with other operational data disseminated via the USCG Automated Identification System (AIS), the integration of wave information, as well as a customizable PORTS® display system that creates personalized and preferred views of data products on the web.

I. INTRODUCTION

The National Oceanic and Atmospheric Administration's (NOAA) National Ocean Service (NOS), is responsible for providing real-time data and other navigation products to promote safe and efficient navigation within U.S. waters. The need for these products is great and rapidly increasing. Maritime commerce has tripled in the last 50 years and is expected to continue growing. Ships are getting larger, drawing more water, and pushing the channel depth limits to derive benefit from the last inch of cargo draft. Ninety-eight percent by weight of the Nation's international trade moves through U.S. ports and harbors, with 50% of these goods being hazardous materials.

A major challenge facing the Nation is to improve the economic efficiency and competitiveness of U.S. maritime commerce, while reducing the risks to life, property, and the coastal environment. With increased marine commerce come increased risks to the coastal environment making marine navigation safety a serious national concern. For example, from 1980 to 1988, tankers in the United States were involved in 468 groundings, 371 collisions, 97 rammings, 55 fires and explosions, and 95 deaths.

Although the situation described above is complex and has serious national implications, our need to remain economically competitive must not be at odds with our desire to protect the coastal marine environment. Consequently, it is the mission of NOS to exercise national leadership to advance the sustainable use of our coastal systems to provide for the Nation's economic prosperity and environmental well-being. The Center for Operational Products and Services (CO-OPS) of NOS contributes to this mission by providing timely and accurate water level and current information. These data are produced by the National Water Level Observation Network (NWLON) and through CO-OPS' operation of several Physical Oceanographic Real-Time Systems (PORTS®).

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14. ABSTRACT
NOAAs Center for Operational Oceanographic Products and Services (CO-OPS) has developed the Physical Oceanographic Real-Time System (PORTS®) to meet the specific needs of the local maritime community by measuring, integrating, and disseminating observations of water levels, currents, salinity, wind, and bridge clearance, all of which help mariners successfully guide ships into and out of the Nations seaports. In several locations, PORTS® also provides forecast model guidance which supports informed decision-making in advance of transit scheduling and loading operations. There are twenty PORTS® supporting 50 seaports nationally; eight of these PORTS® are in the Gulf of Mexico. Using PORTS® information in conjunction with NOAA Nautical Charts and US Coast Guard (USCG) Navigational Aids has proven to reduce groundings by as much as 50 percent (%). Future enhancements include integrating PORTS® data with other operational data disseminated via the USCG Automated Identification System (AIS), the integration of wave information, as well as a customizable PORTS® display system that creates personalized and preferred views of data products on the web.

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II. PORTS®

PORTS® is a decision support tool, which improves the safety and efficiency of maritime commerce and Coastal resource management through the integration of real-time environmental observations, forecasts and other geospatial information. PORTS® measures and disseminates observations and predictions for water levels and currents and other parameters, such as, winds, atmospheric pressure, visibility, and salinity needed by the mariner to navigate safely. PORTS® was built upon CO-OPS' real-time water level capabilities (i.e., NWLON) by adding incremental improvements to field systems, sensor capabilities, communications, information systems, and operational procedures to ensure that the full value of NOS' capabilities are available to the marine transportation community and other users requiring operational oceanographic information.

Prior to 1991, CO-OPS' efforts were centered around the operation of NWLON and circulation surveys, which provided data to establish and maintain the vertical water level reference frame required to support nautical chart production, establish state and federal boundaries, establish setbacks from the high waterline, and to support U.S. Army Corps of Engineers dredging projects. All activities were performed in a non real-time environment. PORTS® began in1991 as a demonstration project to prove the value of real-time information to the marine navigation community. PORTS® systems come in a variety of sizes and configurations, each specifically designed to meet local user requirements. The largest of NOS' existing PORTS® installations is comprised of more than 100 separate instruments. The smallest consist of a single water level gauge and associated meteorological instruments (e.g., winds, barometric pressure, etc.).

Full systems are presently installed in 20 locations throughout the U.S. (see

Figure 1.)

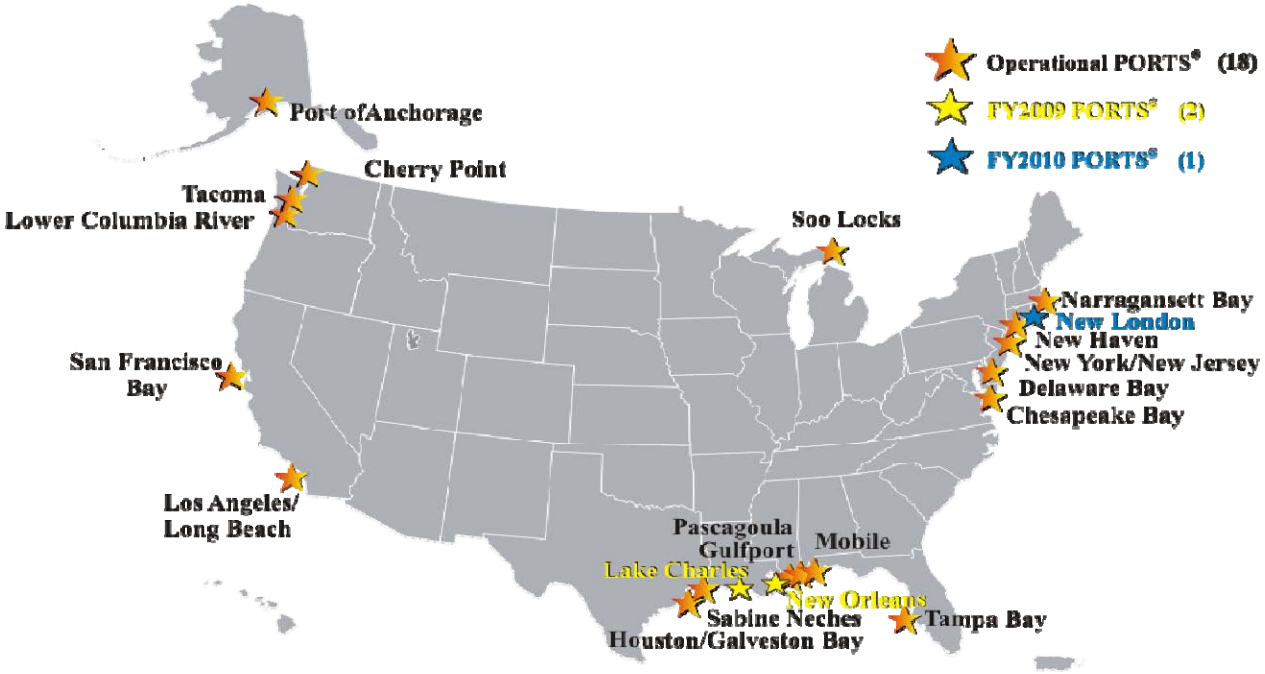

Figure 1. Locations of PORTS® throughout the U.S.

As part of the Department of Transportation's (DOT) Fiscal Year (FY) 1997 Appropriation, Congress directed the USCG to develop, in cooperation with the marine transportation community, a set of user-validated requirements for a Vessel Traffic System (VTS). The USCG convened a National Dialog Group to document the information required by the mariner to navigate safely. Included among these requirements are the need for real-time tide, current, bridge clearance, and other environmental information. NOS PORTS® was specifically identified by the National Dialog Group as a critical component of VTS to help ensure maritime safety in estuaries with complex and unpredictable oceanographic conditions. In addition, access to real-time water level information, such as that provided by NOAA, is required for the USCG to effectively implement its proposed under keel clearance policies.

III. PROGRAM OBJECTIVES

The objectives of the PORTS® program are to promote navigation safety, improve the efficiency of U.S. ports and harbors, and ensure the protection of coastal marine resources as follows.

***Navigation Safety*:** The real-time water level, current, and meteorological data provided through PORTS® represent one component of NOS' integrated program to promote safe navigation. PORTS® data, when combined with up-to-date nautical charts and precise positioning information, provide the mariner with a clearer picture of the potential dangers that can threaten navigation safety. NOS fulfills its navigation safety mission in close concert with other Federal agencies, such as the USCG.

Improved Economic Efficiency: Our Nation's waterfronts, ports, and harbors have historically been centers of rapid industrial and urban growth and have advanced critical national objectives by promoting energy exploration, fishery production, commerce, and recreation. Waterborne cargo and associated activities contribute more than $649 billion annually to the U.S. Gross Domestic Product, sustaining more than 13 million jobs. Marine Transportation System activities contribute over $212 billion in annual port sector federal/state/local taxes. Over 45 million TEUs (twenty-foot equivalent units) and 1.5 billion tons of foreign traffic were handled in 2006, with a value of nearly $1.3 trillion dollars. Ninety-nine percent of the volume of overseas trade (62% by value) enters or leaves the U.S. by ship[1].

Increasingly, shipping companies seeking to improve their efficiency, are implementing new navigation systems aboard ships to maximize cargo load while reducing uncertainties in under keel clearances. These new systems require the availability of real-time tide/current and other information. One foot of draft on an average 500,000 barrel crude tanker can equate to between 20,000-22,000 extra barrels of crude! Adding this much more crude per voyage can reduce the number of transects per year, reducing cost to shipping companies and thus for the U.S. consumer. Consequently, the cargo transport throughput of U.S. ports and harbors depends on many factors including marine environmental conditions. Knowledge of the currents, water levels, winds, waves, visibility, and density of the water can increase the amount of cargo moved through a port and harbor by safely utilizing every inch of dredged channel depth.

Coastal Resource Protection: Most ports are at the mouth of major estuaries which provide critical habitat for many important biological resources. For example, coastal waters provide nurseries and spawning grounds for 70 percent of the U.S. commercial and recreational fisheries. Commercial fishing employs more than 350,000 people in vessel and shore-related fisheries work. An additional seventeen

million people participate in recreational saltwater fishing, spending $7.2 billion annually. Activities within ports can greatly affect these critical resources. Dredging is but one such activity.

The increasing demands of maritime commerce will require expanded port facilities, both in efficiency and in size. Currently there are approximately 190 seaports offering more than 3,000 berths for commercial carriers. An estimated 60% of the Nation's coastal waterways require operational and maintenance dredging. Within coastal waters, some 200-250 million cubic yards of sediments are dredged each year. The shortage of available sites for the disposal of dredged material often prevents port expansion and threatens the continued use of waterways for shipping. There will be increasing demands to sacrifice wetlands to expand port infrastructure so the ports can be more competitive. PORTS® provides information on the physical processes that support wise decision making in our coastal zone. The availability of PORTS® data will help ensure that resource management decisions are based on the best science and information available.

In addition, prevention of maritime accidents is the most cost effective measure that can be taken to protect fragile coastal ecosystems. One major oil spill (e.g., EXXON VALDEZ) can cost billions of dollars and destroy sensitive marine habitats critical to supporting coastal marine ecosystems. PORTS® provides information to make navigation safer, thus reducing the likelihood of a maritime accident, and also provides the information necessary to mitigate the damages from a spill, should one occur.

IV. NATIONAL PORTS® POLICY

PORTS® is a partnership program based on extensive collaboration between NOS and the local maritime community to identify local needs. The enhancements that PORTS® bring to both navigation safety and efficiency can result in significant local economic benefits. At the present time, all costs to operate existing PORTS® are provided by the local user community. Absent special Congressional appropriation or clearly defined Federal Government funds, future PORTS® installations and operations will continue to be funded by the local user community. The requirement for local sponsorship of PORTS® operations and maintenance is essential for successful continuation of these systems.

The PORTS® partnership is founded on the principle that there are both local and National responsibilities. The local sponsor's responsibilities include, but are not limited to, the following:

- Design/installation costs, including the purchase of all equipment and contractor support
- Local operating/maintenance costs, which include repair/preventive maintenance for all locally resident instrumentation and computer equipment
- Telephone lines/communications equipment costs for local distribution of PORTS® information
- Spare parts/supplies, and the amortized costs to replace all equipment at the end of their expected life.

National PORTS® Program responsibilities include, but are not limited to, the following:

- Program Management – NOS will provide the personnel to oversee the operation of the PORTS® and see that all aspects of NOS responsibility are achieved.
- User Agreements – NOS will develop and maintain cooperative agreements between NOS and the local organization responsible for the operation of a PORTS®. These agreements will contain details regarding O&M requirements and the responsibilities for each organization.

- Installation of PORTS® – Utilizing funds provided by the local user community, NOS will design and implement new PORTS® systems. Installations will be accomplished through the use of, or in partnership with, private sector contractors.
- Data Collection Infrastructure – NOS operates and maintains data collection systems and a database of all data collected by PORTS® for data processing, product development and dissemination.
- Data Dissemination – NOS disseminates data from PORTS® over the internet and through a phone system. Internet products include data plots, chart overlays, data listings and single screen system data snapshots. The latest observation data is also available over the phone. Each PORTS® has its own phone number for access to data over the phone. NOS is also working with the Coast Guard to provide PORTS® data over their Automatic Identification System (AIS).
- Data Quality – NOS is responsible for the accuracy of the information products and services that it provides to ensure safe navigation. Operating a centralized data quality assurance system on a national scale is an appropriate role for the federal government, as well as an equitable contribution for NOS' participation in the PORTS® partnership.
- PORTS® National Standards – Standardized data formats and baseline accuracy requirements will enable the maritime community's ability to utilize PORTS® data with confidence and anticipate seamless transitions when transiting between ports. Standardization also enables manufacturers of digital charts, vessel traffic information systems, and other related private sector products to hold down equipment costs by not having to address variable, or proprietary, data formats.

NOS will continue to provide the necessary quality control through the Continuous Operational Real-time Monitoring System (CORMS). CORMS is a 24-hour/7-day a week, centralized quality control and decision support system that ingests real-time data (every six minutes) from all sensors for each PORTS® system; determines data quality and evaluates each PORTS® system's performance; identifies and communicates the presence of invalid or suspect PORTS® data to real-time users who rely on PORTS® data to ensure navigation safety; and provides decision making information needed by maintenance crews to affect repairs to PORTS® systems.

In addition, NOS will oversee the operation and maintenance (O&M) of each PORTS® to assure that the systems are maintained in accordance with PORTS® National Standards. The conscientious operation, maintenance and timely repair of the PORTS® components is critical to assure that reliable and accurate information is available for users.

V. PORTS® INSTRUMENTATION

Water Level (tide) Gage

PORTS® has incorporated a full suite of sensors to aid mariners, developed primarily from our National Water Level Observation Network (NWLON). PORTS® uses an acoustic measuring device to measure water level. Long gone are visual staff measurements and floats in stilling wells! Acoustic water level sensors are now used to determine the exact level of the water. With vessel sizes increasing, knowing the exact water level is becoming more and more important. Water level information can contribute to both safety and economics. Knowing the measured water level as compared to predictions can prevent a grounding in a low water event. It can contribute to economics by scheduling ship departures to coincide with high tide so more cargo may be loaded.

Meteorological Sensors

As mentioned above, PORTS® has incorporated meteorological sensors. With the assistance of NOAA's National Weather Service (NWS), PORTS® includes air temperature, wind speed and direction, and barometric pressure. Other available sensors include water temperature and conductivity which is used to determine salinity.

Current Meters

PORTS® also provides real-time current measurements using three different types of installations. By using these different types of installations PORTS® is able to acquire data in highly desirable locations for the user, many of which require different sampling strategies.

Bottom Mounted

The first real-time current data was provided via a bottom mounted current meter, similar to the design CO-OPS used in tidal current surveys. This design provides a vertical profile of the current information for a column of water. Tidal current survey systems are self contained and the data are processed at post-deployment. To make the leap to real-time processing a cable was added to the system to enable data downloading on a continuous basis. As one might imagine, running a long cable to a sensor has been expensive and problematic. Because of this, NOS has favored the following two options described below.

Buoy Mounted

In cooperation with the USCG, NOS developed a current meter mount that fits on the cleat of an Aid-to-Navigation (ATON) buoy. Current data is frequently needed at or near navigation channels, which makes an ATON installation a logical choice. Buoy mounted current meters also provide a vertical profile of the water column.

Horizontal Mounted (Sidelooker)

The horizontally mounted current meter or "sidelooker" is ideal for narrower waterways usually at or near a pier. The "sidelooker" provides a horizontal profile, at a specific depth, across the channel. This is very useful in determining where the strongest current is within the navigation channel.

Air Gap Sensor

One of our newest instruments is an "air gap" sensor. This sensor measures the distance between the bottom of a bridge and the surface of the water. It is a physical measurement providing mariners an accurate air gap measurement to help determine vessel clearance under bridges.

VI. PORTS® NEW PRODUCTS

There are a host of new products becoming available as part of the PORTS® suite of products. Two of these new web products include PDA displays of all sensors within a PORTS® for a snapshot in time and a build-your-own PORTS® display page called "MyPORTS". The PDA display takes the standard PORTS® web based text screen and reformats it for a PDA display. These text screens list all available sensors within a PORTS® and display the latest observation from each. Data older than 20 minutes are

not displayed. The URL for this product is http://mobile.tidesandcurrents.noaa.gov/. "MyPORTS" is a product which allows a user to customize a page to meet their needs. It lists all plots available for a specific PORTS® and provides users the capability to select desired plots and drag them anywhere on their page. Once the page is built, it can be saved and bookmarked for later use. The URL for "MyPORTS" is http://tidesandcurrents.noaa.gov/myports/.

Another new capability under development is the ability to transmit PORTS® data over the U.S. Coast Guard's (USCG) Automatic Identification System (AIS). AIS has primarily been used as a sensor to aid in vessel tracking, complementing the information available through vessel voice reports, radar, and visual means. However, NOAA and the U.S. Army Corps of Engineers (USACE) have been working with the USCG to transmit environmental data, zone messages, and waterways management information over AIS as well. AIS equipment aboard vessels will receive the data, which then may be displayed on shipboard navigation systems[2].

Two new instruments that CO-OPS is working to integrate into PORTS® are waves and visibility. NOAA plans to utilize the existing wave buoy network of the USACE and integrate data from this network into specific PORTS® where buoys are co-located. If PORTS® users desire to add additional wave sensors, NOAA will work with the USACE to add these new sensors into their network, benefitting both programs. Also new to the PORTS® is a visibility sensor. NOAA has tested several sensors with the FAA and the USACE, selected a sensor and is now integrating it into PORTS® systems. First installation of this sensors is scheduled for late fall 2009.

VII. SUMMARY

The challenges facing NOS as it endeavors to provide national leadership to advance the sustainable use of the coastal marine environment are complex and have potentially significant consequences for the Nation if solutions are not found. No one component of NOAA or the Federal Government can address these problems alone. Balancing the national priorities of safety, economic prosperity, and environmental well-being requires the integration of Federal, state, and local governmental agencies, the academic community, public interests groups, and the strong support and participation by the private sector to ensure the health, safety and sustainable use of our country's coastal areas.

This document has defined and described the NOS PORTS® Program. PORTS® is but one component of the NOS' integrated Navigation Services Program within NOS' Coastal Stewardship mission. In this time of diminishing federal resources, partnerships with other federal, state, and local organizations, in conjunction with the private sector, represent a viable solution to address these National needs. The partnerships created through the PORTS® Program described above serve as one successful role model for the Federal Government, acting in concert with the user community, to meet National needs.

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