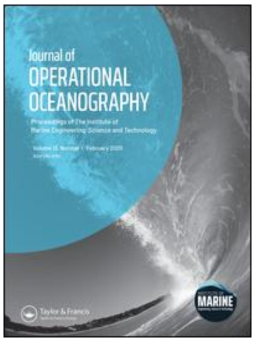

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NOAA's Physical Oceanographic Real-Time System (PORTS®)

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ABSTRACT
The National Oceanic and Atmospheric Administration's (NOAA) Physical Oceanographic Real-Time System (PORTS®) is an integrated system of sensors concentrated in seaports that provide accurate and reliable real-time information about environmental conditions. PORTS measures and disseminates observations for water levels, currents, waves, bridge air gap, water temperature, salinity, and meteorological parameters. PORTS was developed and implemented in the early 1990s in response to an accident in Tampa Bay where a vessel struck the Sunshine Skyway Bridge resulting in a substantial loss of life and property. The programme was established as a public-private partnership where the local community funds the establishment and maintenance of the local observing system, and NOAA provides the programme and data management. Today, PORTS has grown to over 30 locations around the country and services over 80% of the tonnage and over 90% of the value of cargo transiting U.S. seaports. A number of economic benefit studies have shown PORTS can reduce accidents by over 50% and significantly increase efficiency. This article examines the evolution of the programme in terms of addressing emerging observational needs, infusing new technology, enhancing products, conducting economic benefit studies, adapting business models, and serving other societal needs.

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Introduction

The Physical Oceanographic Real-Time System (PORTS®)[1] is a domestic cost-shared programme between the National Oceanic and Atmospheric Administration (NOAA) and the maritime community. PORTS provides a suite of environmental observations that provide safety and/or efficiency benefits primarily for maritime commerce; however, its publicly available data and products benefit many other economic sectors as well. It helps address a long-standing high priority for the marine transportation system community: the availability of timely, accurate and reliable data needed for safe and efficient operations (U.S. Department of Transportation 1999). Situational awareness of key observation parameters that describe the dynamic, and often challenging, an operational environment that commercial vessels transit daily in and out of our nation's seaports is essential to enabling best safety and efficiency decisions to be made. While safe and efficient commerce through our nation's seaports has always been vital to the nation's economy, ever larger vessels (Figure 1) and increasingly congested seaports make the provision of PORTS data even more beneficial. Shutting down a major seaport, such as Los Angeles/Long Beach, for a single day can cost the U.S. economy \$65–\$150 million (Congressional Budget Office 2006).

PORTS began as a demonstration project in Tampa Bay, Florida in 1991. Its development was prompted by a tragic 1980 accident in Tampa Bay when a vessel struck the Sunshine Skyway Bridge and caused the loss of 35 lives. While high winds and heavy rains were found to be the probable cause of the accident, other environmental conditions such as fog and currents were factors as well (National Transportation Safety Board 1981). The accident underscored the need for timely, accurate, and reliable environmental information to be available to ship operators. In response to the accident and subsequent Congressional interest, NOAA developed and established the PORTS programme, initially through several pilot demonstrations beginning in Tampa (NOAA and USCG 2000).

The development of PORTS considerably advanced the use of oceanographic information by: (1) providing data in near real-time (measurements taken every 6 minutes and disseminated within 12–18 minutes) to inform users of actual conditions, and (2) 'integrating' a variety of environmental parameters on one website, eliminating the need to go to multiple sites or sources for different observation

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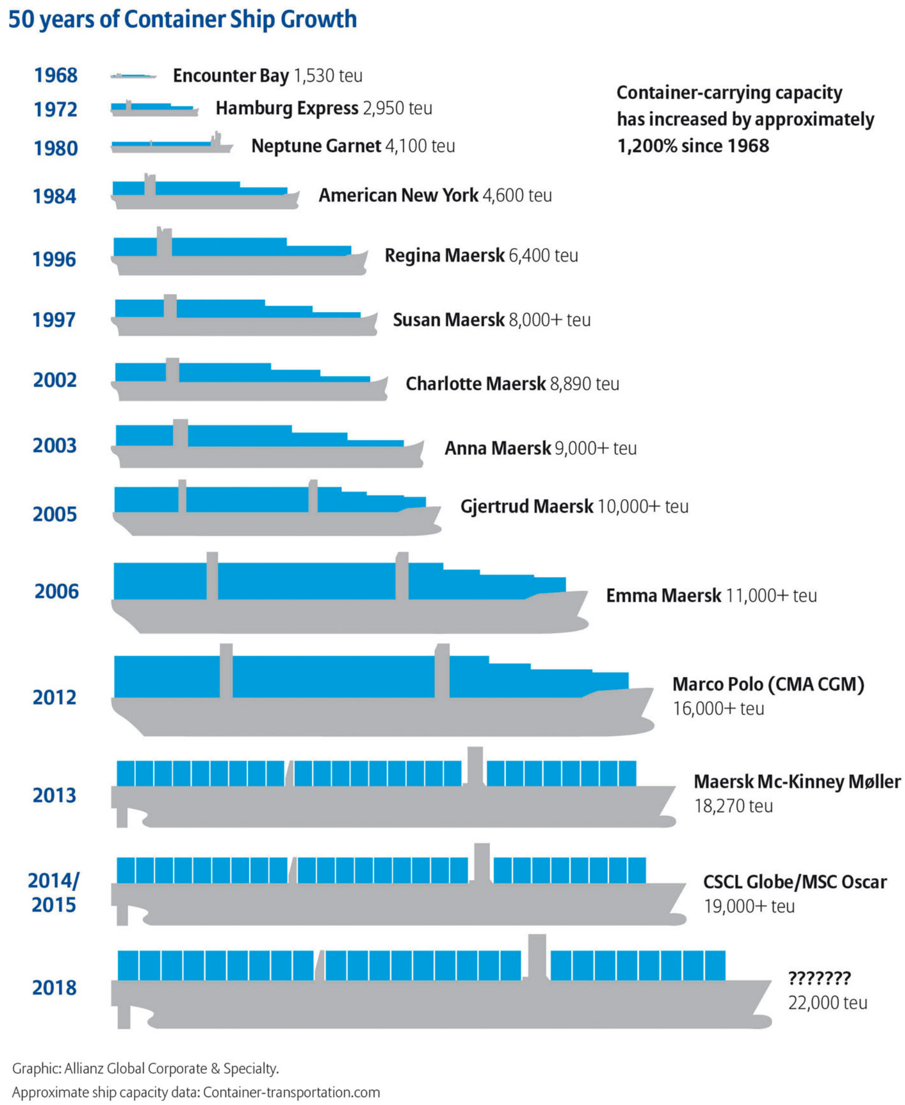

Figure 1. Ships getting larger. Source: Allianz Global Corporate & Specialty.
Note: Changes in ship size and capacity from 1968 to present.

types. The ability to get a comprehensive and easily understood view of the operating environment is particularly critical on the bridge of a vessel where there can many issues going on at the same time. With today's technology, while these features are now commonplace across many different observing systems and distribution portals, PORTS has continued to evolve to infuse new technology and provide additional parameters, expand to cover more locations, and to be the trusted source for this type of information.

What is PORTS?

PORTS is a national network of local observing systems. PORTS is built upon two, long-standing federally funded observation programmes that acquire physical oceanographic data and provide a broad suite of products and services. The National Water Level Observation Network (NWLON) is an *in-situ* network of long-term tide and water levels (Great Lakes) monitoring stations whose foundational purpose is to provide the reference framework upon which all other tide and water level products it generates are based, such as predictions, near real-time data, forecasts, long-term trends, and statistical analyses. The National Currents Observation Program (NCOP) conducts short-term current surveys (a number of short-term current observations acquired in a geographic locale) to support products such as tidal current predictions and hydrodynamic forecast models. Together, these national observation systems and the end-to-end operational infrastructure required to support them are the foundation upon which PORTS is built. The operational infrastructure provides the ability to: develop and set national standards enabling seamless data interoperability; test, evaluate, integrate, and infuse new technology to reduce costs and improve service delivery; maintain observing systems to ensure timely, reliable, and accurate data; ingest, quality control, process, analyse, and generate products. Essential to this is the oceanographic, engineering, information technology, and programme management expertise resident in NOAA's human capital.

In some locations, the real-time water level data provided by an NWLON station may be sufficient to meet local maritime safety and efficiency needs. Most major seaports have at least one NWLON station located within their geographic area, and sometimes several. Many NWLON stations also monitor and provide real-time wind, barometric pressure, and air temperature data. Most major seaports have had tidal current surveys conducted over past years that update and add to local tidal current predictions.

However, while these two national observing systems meet NOAA mission requirements for tide, water level, and current information, local requirements for safe and efficient maritime commerce often drive the need for additional real-time water levels, currents, and other oceanographic and meteorological observations. Every seaport is unique in terms of geography, types of vessels, cargo types, and other factors that may require a different subset of observation parameters to provide the mariner with a comprehensive understanding of his or her operating environment. PORTS has evolved over time and today can provide the overall suite of parameter types identified by user communities as most essential for safe and efficient maritime commerce (Figure 2). These parameters are:

- *Tide/water level* observations to ensure a vessel accurately knows its underkeel clearance, i.e. the distance between the bottom of the vessel and the seafloor. This avoids groundings and also enables optimal use of the available water column by maximising the draft of a vessel transiting it. PORTS water level data has helped many seaports reduce their minimum underkeel clearance safety margins, thus increasing vessel capacity and realising additional revenue in every vessel transit.
- *Air gap* observations ensure the safe passage of a vessel under a bridge and are a relatively recent addition to PORTS given the emerging issue of ever larger vessels striking bridges. Some seaports have required the establishment of an air gap sensor on one or more bridges before allowing vessels of a certain class or larger to transit and have also reduced their overhead clearance safety margins.
- *Current profile* observations ensure safe vessel manoeuvers in areas with strong and variable currents. This is particularly needed in congested areas, locations where the federal channels have turns and doglegs, docking and anchorages, etc. Vessels with deep drafts (tens of feet) require current profiles to account for current speed and direction at variable depths that may affect their vessel draft. Aligning vessel transits with current direction can also increase efficiency.
- *Wave* observations help ensure safe vessel operations around entrances to estuaries and seaports where waves can be significant. Knowing wave conditions is particularly critical for vessel pilots, as they often must board or disembark commercial vessels offshore from pilot boats and cannot do so once wave conditions exceed their safety criteria.
- *Salinity and water temperature* aid mariners in correctly accounting for vessel buoyancy in estimating the draft of their vessel.
- *Wind speed and direction* are like current observations in that they enable mariners to account for potential impacts on ship track and manoeuvers. These observations support both safety and efficiency decisions.
- *Visibility* observations help determine where there may be large gaps in fog conditions that allow for partial port operations to be authorised versus shutting down the entire port region.

Again, while a seaport may not need all of these observation types, they are all available through PORTS, and users can tailor what near real-time observations are needed for their specific requirements.

Technology infusion

PORTS utilises the same data collection platform, communications, power supply, sensors, and other technology components employed by NOAA to operate and maintain the NWLON and NCOP. Given NOAA is the nation's authoritative source for tide, water level, and current data, the NWLON and NCOP are robustly designed to acquire data in a broad range of environmental conditions, sometimes in remote areas, from ice-covered arctic to warmer climates where corrosion, biofouling and other issues arise. Conditions can be very dynamic with tsunamis, hurricanes, and other extreme coastal events threatening operations. The operational and technology lessons gleaned from these observing systems are the foundation upon which PORTS builds.

NOAA continually monitors what new technologies for all components of their observing are emerging

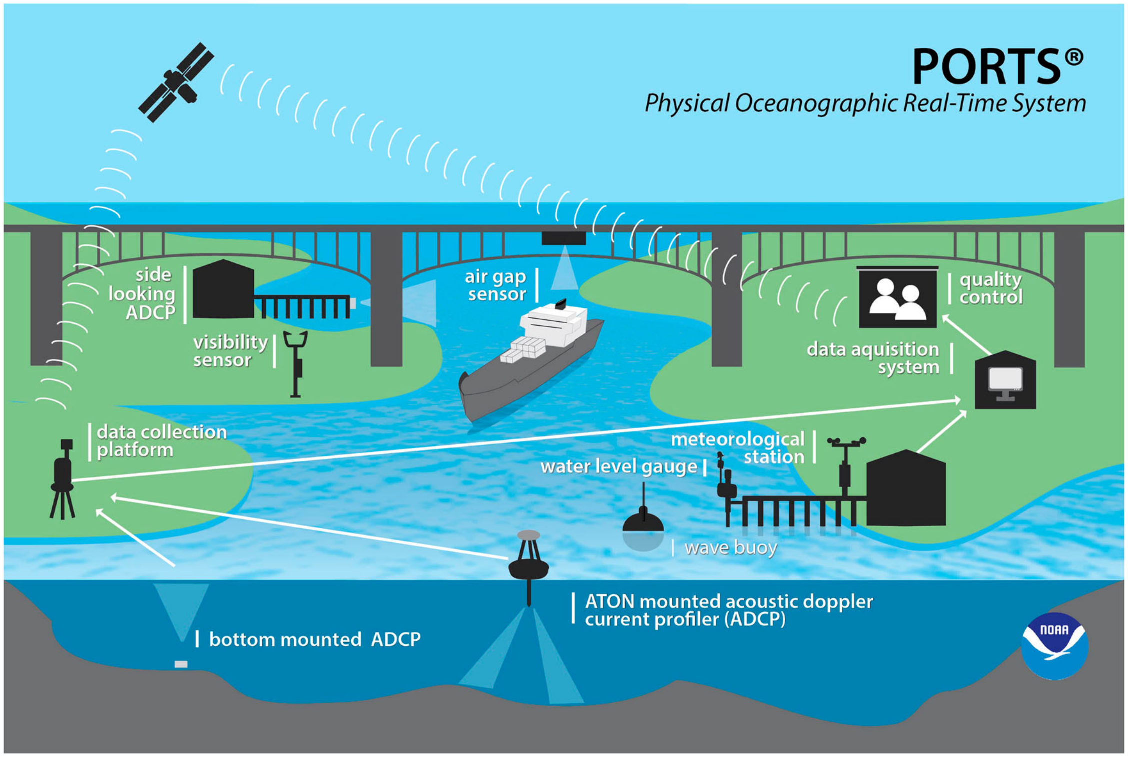

Figure 2. Ports overview. Source: NOAA.

Notes: PORTS® sensors measure water levels, currents, waves, salinity, bridge clearance (air gap), winds, air and water temperature, and visibility. A data collection platform records the data every 6 minutes and sends it to NOAA via satellite, where it is reviewed for accuracy and posted online.

from industry and academia. NOAA tests and evaluates them to ensure their capabilities are fully understood, and that they can deliver potential improvements and efficiencies. If they are approved for the transition to operations, NOAA works to integrate them into the larger observing system, including any changes needed all the way through the data management system.

One of the first challenges for the fledgling PORTS programme was how to establish long-term *in-situ* current profilers given NOAA's prior experience was primarily in short-term deployments. The locations most desired by the user community were for the current measurements to be provided alongside federal channels and other offshore areas where large commercial vessels were navigating twists and turns in those areas. The initial approach was to deploy a bottom-mounted, upward-looking, acoustic Doppler current profiler (ADCP) that relied on a long cable run to provide power and return data. Given the limitations of a long cable run and their susceptibility to damage from anchors, trawlers, and other hazards, these deployments could be both expensive and not as reliable as desired.

In response, NOAA adopted two new ways of deploying current profilers to better meet user requirements. One methodology is to utilise a side-looking ADCP developed by industry that is mounted horizontally on a pier, bulkhead, or other vertical surface and provides measurements 200 m or more out into a waterway (Figure 3). The profiler is mounted on a platform attached to a steel channel to enable it to be easily raised and lowered for maintenance. While improving reliability and reducing expense, side-looking ADCPs have limited range and are best used where channels approach the shore.

Another methodology that has become most preferred utilises U.S. Coast Guard (USCG) aids-to-navigation (ATON) buoys, which are common in most U.S. seaports and typically located along the federal channel where the data are most needed. NOAA developed and transitioned to operations a methodology in 2005 to mount an ADCP on the ATON buoy (Bosley et al. 2005, 2006). Data from the buoy are transmitted via line-of-sight radio to a shore station data collection platform where it is processed, formatted, and then transmitted back to NOAA via the NOAA Geostationary Operational Environmental Satellite (GOES).

This system was recently modernised by placing all components on the buoy and using Iridium satellite communications to handle a large amount of data involved. Called iATON, the system significantly reduces costs by eliminating the shore station data collection platform, improves data reliability by eliminating the intermediate line of sight radio communication path,

Figure 3. Side-looking ADCP and MIAMI ports iATON buoy. Source: NOAA.

Notes: (left) A NOAA crew install a side-looker Acoustic Doppler Current Profiler onto a pier in Casco Bay, ME (right) a crew installs an iATON current meter on a U.S. Coast Guard aids-to-navigation buoy along the entrance channel to PortMiami.

and also extends the geographic scope of how far off shore ATONs can be leveraged (Hensley and Heitsenrether 2017). A new PORTS was just established in Miami, where iATONs now provide currents data as far as 3 miles offshore along the channel that takes a dogleg turn before vessels attain the protection of the entrance jetties. This PORTS system would not have been possible without the iATON system (Figure 3).

Other PORTS parameters identified by users were new to NOAA observing systems. Users identified visibility as an important parameter given the frequency and impact of fog on port operations in some parts of the country. While visibility was a commonly observed parameter along U.S. highways and other surface transportation systems, observation technology that could operate reliably in challenging coastal environment had not been extensively tested and evaluated. In 2008, NOAA, the Federal Aviation Administration, the US Army Corps of Engineers, and the USCG completed collaborative testing and evaluation of a number of visibility observing technologies, the results of which enabled NOAA to introduce a point source technology that has operated with a high degree of reliability since inception (Roggenstein et al. 2009). Thirteen visibility sensors have now been added to six PORTS locations (Figure 4).

Another parameter requested by users was for nearshore observations of wave height and direction. NOAA's PORTS programme did not have the operational infrastructure in place to support nearshore wave buoys, so a partnership was formed with the U.S. Army Corps of Engineers by leveraging their Coastal Data Information Program (CDIP). CDIP operates a network of nearshore buoys that monitor waves and other environmental data for supporting coastal studies and projects. Where CDIP buoys are already operating within the boundaries of an existing PORTS, that data are accessed, integrated, and provided to PORTS users through their respective PORTS portals. Where wave information is required, and a CDIP buoy is not being operated, PORTS partners can fund the deployment of one.

Air gap is a relatively new and frequently requested PORTS parameter because of the increasing size of vessels transiting U.S. seaports. In many seaports, vessel's superstructures are striking bridges with increasing frequency, damaging both the bridge and the vessel, not to mention the obvious hazard to life. In response to this emerging issue, NOAA identified, tested, and

Figure 4. Visibility sensor. Source: NOA.

Note: A visibility sensor, part of Narragansett Bay PORTS® in Rhode Island, aids boaters in making safe decisions about where and when to sail when visibility is low outside.

integrated into PORTS an air gap sensor that provides real-time measurements of the distance between the lowest point of the bridge and the water level (Bushnell et al. 2005; Heitsenrether and Hensley 2013). The measurement takes into account not just variations in the water level, but fluctuations in the bridge elevation driven by temperature change, traffic loading, and other conditions. Many seaports have not allowed larger vessels to transit until an air gap sensor has been established, and in several cases, the safe import of large cranes to their final destinations was heavily reliant upon air gaps to clear bridges. As of 2017, there are 16 individual air gap sensors, serving 10 different PORTS systems around the country (Figure 5).

Data management and products

Situational awareness on the bridge of a ship, where there may be many activities requiring timely decisions to be made, can be greatly aided when all decision-support information can be accessed through one source, such as a web portal, piloting device, or other technology regardless of the multiple sources. However, before the real-time observations become PORTS products, an essential step is to quality control the data to ensure it accurately represents the existing conditions. High-quality data can prevent accidents and improve efficiency, while inaccurate data has the potential to cause, or contribute to, an accident – typically a grounding, allision, or collision. Given the significant potential damage a maritime accident can cause to life, property and the environment, there can be large legal liability associated with the provision of the data. To ensure high-quality data and products and to mitigate any risk of liability, a key function performed by NOAA is the continuous monitoring and management of the real-time data. NOAA operates the 24/7/365 Continuously Operating Real-time Monitoring System (CORMS), which performs quality control on all data acquired by PORTS before disseminating to users.

CORMS uses example-based reasoning automated routines (Vafaie and Cecere 2004) that check continuous 6-minute data from over 1600 sensors and flags that are suspect, missing, intermittent, or experiencing other issues. CORMS flags data that are missing or exceed preset maximum/minimum thresholds, the rate of change thresholds, and other criteria. Watch standers on duty at all times assess the flagged data and based upon their analysis, either approve its continued dissemination or stop dissemination and refer it to a team of oceanographers who conduct further analysis and determine why it was flagged. Once the issue has been resolved, data dissemination resumes. Automated routines have enabled the number of sensors to grow substantially over time without having to add more CORMS watch standers (Figure 6).

PORTS data are disseminated through a variety of platforms and products. Originally, given the limited access to the internet, the most common way of accessing PORTS data was through cell phone service using an automated menu tree to select data from a specific sensor. While this service is still available, the internet is now the most widely used method of accessing PORTS data and products, ranging from simple text displays to graphics. PORTS products have been adapted to display properly on a variety of devices ranging from smart phones to tablets to full monitors. PORTS displays provide a number of options ranging from viewing data from just one location to data from multiple sensors and/or multiple locations.

A product called MyPORTS allows users to customise their own data display. A user who may only need a subset of all available sensors on a regular basis can select just those sensors needed and create their own web

Figure 5. LA/Long beach air gap and Chesapeake Bay Cranes. Source: NOAA.

Notes: (left) A large container vessel transits under an air gap sensor on the Gerald Desmond Bridge in Long Beach, California. (right) Real-time air gap information from the Chesapeake Bay PORTS® was critical for transiting new super cranes under the Bay Bridge to the Port of Baltimore in 2012, ensuring the port could remain competitive in global maritime trade.

page, which will update automatically. The MyPORTS page can then be bookmarked and emailed to other users.

It is also possible for PORTS partners or other third parties to create value-added products that use PORTS data. For example, the Port of Portland developed an online planning tool called LOADMAX for vessels transiting the 100-mile-plus length of the Columbia River. The tool uses the PORTS near real-time data, river forecast data, and estimated vessel speed to estimate depth at various points along the river, optimising arrival and departure times, as well as how much cargo can be safely loaded. A mobile phone app called Transit Time was developed by the Conrad Blucher Institute to predict hydrodynamic conditions and visualise ship travel along the Houston, Texas ship channel for vessel transit planning. A number of private companies offer underkeel clearance models and services that rely on real-time data provided by PORTS to enable the optimal use of water depth within a channel.

While not a formal part of the PORTS programme, under the National Operational Coastal Modeling Program NOAA operates hydrodynamic models in most major seaports areas and is steadily working toward complete coverage of the nation's coasts, including the Great Lakes. The hydrodynamic models provide nowcast (modeled observations) and forecast guidance out 48 hours for many of the same parameters that PORTS provide in near real-time, and at a greater spatial resolution, mutually extending the value of both observations/nowcasts and forecasts. Vessel schedules can be aligned with favourable environmental conditions such as taking advantage of tidal currents to reduce fuel usage. The information also allows cargo optimisation for available water depth. For example, if water levels are forecast to higher than normal over the next few days, the vessel may be able to load and transport more cargo. If they are forecast to be lower, the vessel may not load as much cargo or can decide to wait until sufficient water depth is available.

The PORTS partnership

A PORTS is established when the local maritime community identifies its requirements for real-time observations within a desired geographic area, identifies the funding needed to establish and maintain the local PORTS, and enters into an agreement with NOAA. PORTS partners are as diverse as the maritime community is itself and are typically pilots, port authorities, marine exchanges, state agencies, private industry, and other federal agencies (US Navy and USACE). While ship pilots are the main frontline users of the system to make the best safety of life and property decisions, the entire local maritime community is heavily reliant on the safe and efficient passage of vessels and recognises the critical role played by PORTS. The maritime community comes together to identify areas within the port

Figure 6. CORMS watchstanders. Source: NOAA.

Note: A member of CORMS reviews environmental data streaming in from sensors across the country.

where real-time data can address specific issues or challenges. Sometimes PORTS systems are motivated by other factors. For example, a number of PORTS have been established, or are being considered, due to the construction of liquid natural gas facilities given the hazardous nature of the cargo and the local safety concerns. Other PORTS have been established or expanded due to the opening of the post-PANAMAX canal and the advent of larger vessels requiring both 50-foot authorised depth channels and also adequate bridge clearance. A number of ports would not allow certain large class vessels to enter until a PORTS air gap sensor was in service.

It is important to realise that one PORTS may service one or more seaports depending on the geography of the area, the local parties that are interested in partnering to establish the PORTS, and their span of responsibility. Any NWLON stations that may be located in the area have their data incorporated into PORTS data displays, but NOAA is still responsible for their maintenance.

A PORTS can be as small as one sensor servicing a seaport up to hundreds of sensors. For example, Savannah, Georgia uses an air gap sensor to ensure safe passage of vessels under the Talmadge Memorial Bridge, although the local NWLON station at Fort Pulaski, Georgia is also displayed. Jacksonville, Florida uses 32 sensors in addition to the one local NWLON station. Some PORTS start with the establishment of one or two sensors and then have more added on as the users and local community learn how to most effectively use them, gain confidence in the system, and realise the benefits.

Safety and economic benefits

PORTS has grown over the decades to a system of over 30 PORTS that service over 75 seaports. There are over 300 seaports in the U.S., and commerce can be tracked using statistics such as tonnage, value, number of transits, vessel types, and other statistics. No *one* statistic can adequately capture all the types of vessels and cargo that transit U.S. seaports—containers, bulk commodity, tankers, and even cruise liners. Every seaport will have a different mix, which may or may not be dominated by one type. For example; the port of Baltimore, Maryland is the largest total tonnage port in the U.S. and ranks near the top of lists compiled by other statistics as well (Sprung, 2017). Port Fourchon, Louisiana will not be found anywhere near the tonnage lists, but it services over 90% of the Gulf of Mexico deepwater oil production and furnishes about 18% of the nation's oil supply (http://portfourchon.com/seaport/port-facts/) (Figure 7).

A PORTS economic assessment methodology has been developed to estimate the economic benefits provided by PORTS (Kite-Powell, 2005a). The approach estimates with varying degrees of confidence the benefits

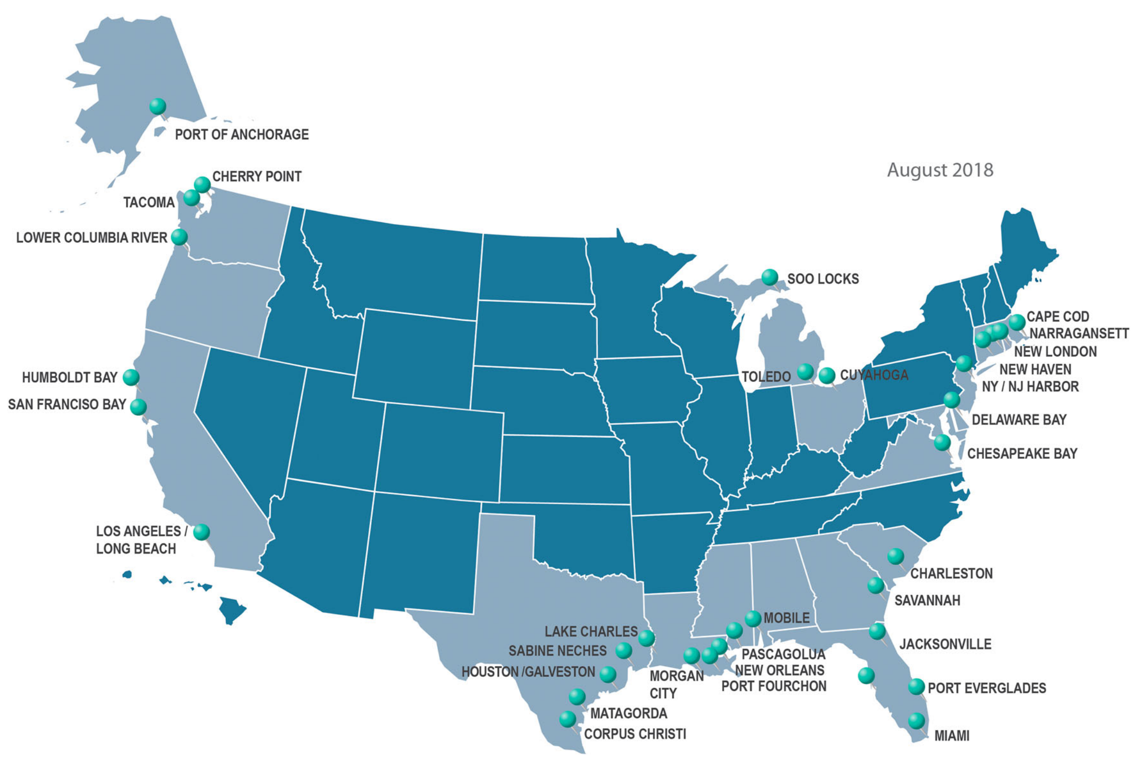

Figure 7. Ports location map. Source: NOAA.

Note: This map shows the 33 existing PORTS locations in the United States (as of August 2018), consisting of over 550 sensors.

in dollars, and also assesses nonquantifiable benefits. Potential sources of economic benefit from PORTS information considered by this methodology included:

- Greater draft allowance/increased cargo capacity and reduced transit delays for commercial maritime transportation (water level information).
- Reduced risk of groundings/allisions for maritime traffic (currents and wind information).
- Enhanced recreational use of coastal waters boaters, windsurfers, etc. (winds, weather forecasts, and other information).
- Improved environmental/ecological planning and analysis, including hazardous material spill response

From 2005 to 2010 benefits were determined by individual PORTS beginning with Tampa Bay, Florida ($7 million in 2005 dollars) (Kite-Powell, 2005b), then Houston Galveston, Texas ($15.6 million in 2006 dollars) (Kite-Powell, 2007), New York/New Jersey ($9.9 million in 2009 dollars) (Kite-Powell, 2009) and Columbia River ($7.5 million in 2009 dollars) (Kite-Powell, 2010). In each case, significant annual economic benefits were identified, with over $50 million cumulatively in today's dollars. Perhaps most significantly, a 50% or more reduction in accidents was identified at three of the locations where the availability of real-time information was a new capability. Columbia River has operated a PORTS like system since the mid-1980s and already realised the safety improvements.

In 2013, an NOAA economic report that built on the four preceding reports was published that looked at the economic benefits if a national system of PORTS was established for 175 coastal ports (Wolfe and MacFarland 2013). These ports were identified on the basis of tonnage, national security, commercial fishing, and other factors. Benefits were defined for the 58 ports that had access to PORTS data in 2010 and the 117 that did not to identify the benefits PORTS are and could be generating. The report found that

> shippers and marine pilots have found the PORTS information to be the single most important source of information when they are working with ships that are operating very close to the channel bottom (depth constrained) or bridges spanning the channels and during times of adverse weather.

The analysis conservatively indicated that PORTS could potentially provide a total benefit of $300 million annually for the 175 ports, as well as significant improvements in marine safety, with reductions in the commercial marine accident rates of:

- Groundings were reduced by 59%.
- Overall accident rate (allisions, collisions and groundings) reduced 33%.
- Mortality reduced 60%.
- Morbidity reduced 45%.
- Property damage reduced by 37%.

In addition, the socioeconomic effect from PORTS if fully implemented at the top U.S. 175 ports would be,

- PORTS could help sustain 34,000–46,000 jobs.
- PORTS could help support $1.6–$2.4 billion in wages.

A follow-on internal NOAA 2017 study to the 2013 report investigated in more depth the incidence of accidents (allisions, collisions, and groundings or ACGs) from over the period 2005 to 2016 based on locations with and without PORTS (Wolfe 2017). The study used accident data from the USCG Marine Information and Safety and Law Enforcement and economic data from the USACE Channel Portfolio Tool database. The study assessed: (1) overall trends in ACGs, (2) relative accident rates; (3) morbidity and mortality costs; (4) property losses associated with vessel, cargo, facility, and other sources; (5) costs of petroleum release remediation resulting from ACGs; and, (6) identification of ports where updated and/or additional navigational aids might be beneficial. Overall, 77 locations with PORTS and 163 without PORTS were analysed. Some of the most significant impacts of PORTS included:

- ACG rates (vessel transits per accident occurrence) at locations with PORTS witnessed an overall increase approaching 163%, while locations without PORTS decreased by about 30%
- Over 10 years, locations with PORTS were estimated to have realised about $183 million (two-thirds) of total savings from ACG reduction alone. There were 19 fewer lives lost (present value of $102 million), 41 fewer injuries (present value of $8 million), lower property losses (present value of $72 million), and reduced oil pollution remediation costs (present value about $1 million)
- More speculatively, if PORTS were installed at all major locations without PORTS at the end of 2016 over $107 million might be saved over 10 years, only considering ACG reduction. There were about 2 fewer lives lost (present value of $14 million), 84 fewer injuries (present value of $24 million), lower property losses (present value of $69 million), and *de minimis* reduced oil pollution remediation costs (present value $0.1 million).

- The top 23 locations (20% of the 116 locations identified) account for almost 62% of all ACGs during the study period and suggest the most benefit could be derived from having PORTS established there.

While this paper focuses on PORTS benefits to the marine transportation sector, it would be remiss not to briefly note other societal areas that also benefit from the data it provides.

PORTS data is also used by:

- Emergency responders for oil and other hazardous material spills to inform and validate trajectory models used to predict where spills are going and when they will arrive, and environmental conditions needed for planning both containment and cleanup operations such as deploying vessels, booms, etc.
- Emergency responders to natural hazards such as hurricanes and other severe events. Environmental conditions are used to preposition response assets and well as support response actions during and after the event.
- Government and private sector weather forecasters to inform and validate marine weather and storm surge forecasts.
- Recreational users for recreational boating safety, windsurfing, surfing, fishing, tourism, and related purposes.
- Coastal planners for natural habitat and coastal infrastructure planning.
- Academia and researchers for a better understanding of coastal oceanographic dynamics (e.g. citations).

Looking forward

Since its inception, the PORTS programme has evolved and grown into a true national programme that services over 90% of the nation's commerce by both tonnage and value through its seaports. Early technical challenges posed by the ability to acquire observations in near real-time and disseminate through integrated products and services have been overcome. The ability to deliver the entire suite of environmental parameters needed to provide users with full situational awareness of their operating environment has also been achieved. Like all well managed observing systems, there is an ongoing test and evaluation process for the identification and infusion of new technologies to continually improve services while reducing costs. Given the cost share nature of the programme, while it has developed and grown in a non-strategic nature (first come, first served), today most of the nation's major seaports have a PORTS. Maintaining, expanding, and enhancing the exiting suite of 33 PORTS has become the primary focus of the programme versus adding new locations although that is still occurring. Another focus area is on the integration and dissemination of PORTS data through hydrodynamic forecast models, the USCG National Automatic Identification System, other Automatic Identification Systems, and other venues. This enables ingestion, integration and display of PORTS data on electronic displays on vessel bridges, portable pilot units, and other devices with other information that allows features such as alerts, warnings, tide controlled depths and other to be realised. The PORTS programme will continue to evolve in concert with the larger fabric of the marine transportation system.

Summary

NOAA's PORTS programme has been delivering safety and economic benefits to the Nation for over 25 years. It has continued to expand and evolve to meet the emerging needs of its users while leveraging technological advances to reduce costs and improve products. It is a unique public-private partnership that leverages the respective strengths of its partners. NOAA brings the federal backbone observing systems of NWLON and NCOP, the accompanying national standards, data management, and expertise that provide the operational infrastructure at the national level, while partners bring the local requirements and funding needed to build a robust and diverse coastal observing system that serves multiple societal needs beyond the maritime community. A progression of economic studies has consistently documented substantial safety and economic benefits as a result of the programme. Future enhancements for the programme will focus on the continued infusion of new technology, data visualisation improvements, integration of PORTS data and products with hydrodynamic models, as well as integration with other navigation safety information, such as electronic navigation charts, and targeted precision navigation products that address specific issues within a seaport.

Note

1. The term Physical Oceanographic Real-Time System is trademarked to NOAA under US Patent and Trademark Office Registration Number 2,490,304 on 18 September 2001.

Disclosure statement

No potential conflict of interest was reported by the author.

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