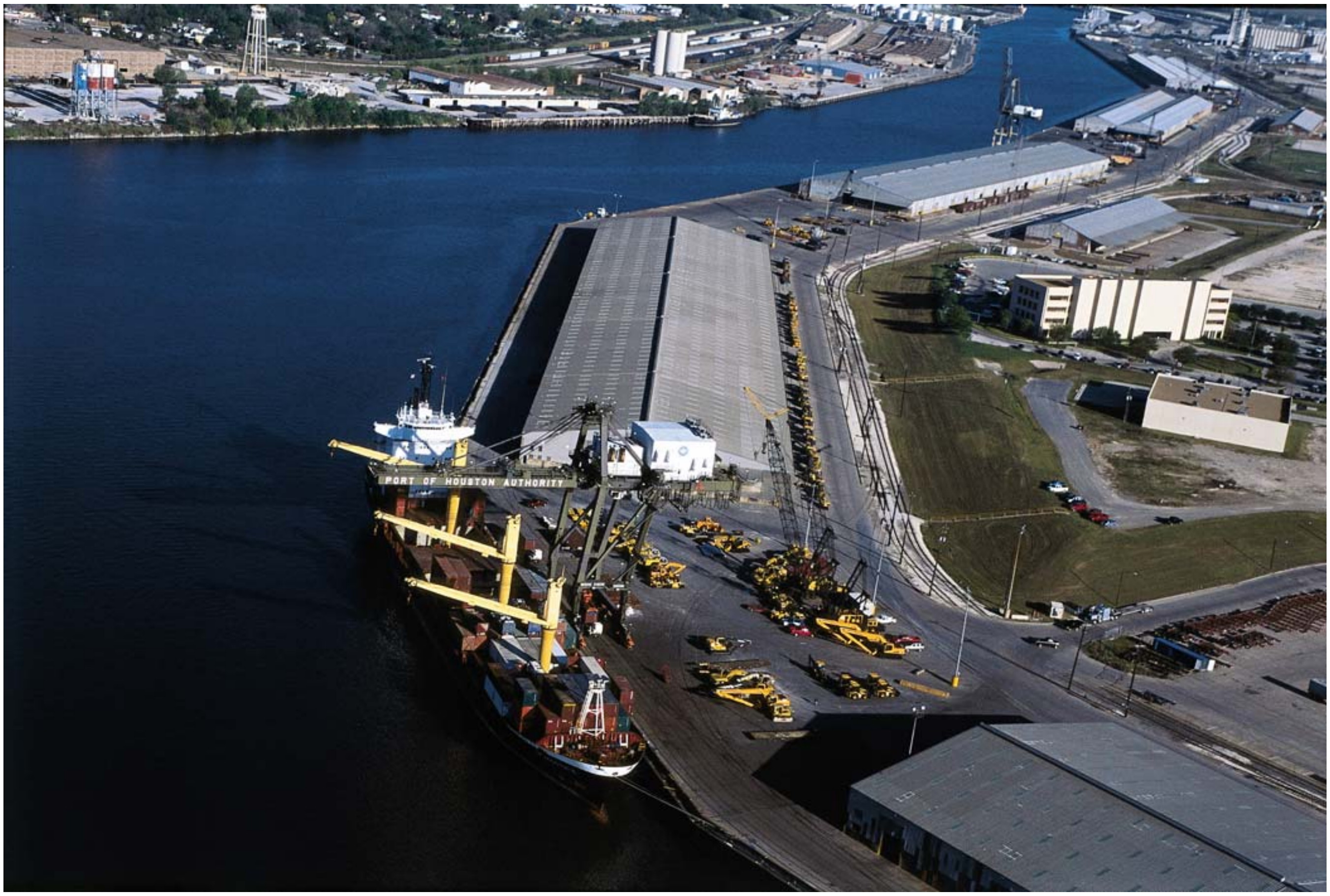
Estimating Economic Benefits from NOAA PORTS® Information:

A Case Study of Houston / Galveston



March 2007

THE PORT OF HOUSTON AUTHORITY

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A Case Study of Houston / Galveston

Report prepared for the Houston Ship Channel users and the Ports of Houston and Galveston by Dr. Hauke Kite-Powell of the Woods Hole Oceanographic Institute Marine Policy Center through the facilitation of the Houston Galveston Navigation Safety Advisory Committee (HOGANSAC). Funding for the report was provided by the National Oceanic and Atmospheric Administration (NOAA). The report utilizes a PORTS® economic assessment Methodology developed by Dr. Kite-Powell for NOAA and published under separate cover as a tool to estimate the economic benefits provided by an existing or proposed PORTS®.

Hauke Kite-Powell

March 2007

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NOTICE

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Summary

This report estimates the economic benefits derived from the Physical Oceanographic Real-Time System (PORTS®) installation at Houston/Galveston. We estimate benefits in dollar terms to the extent possible, and also describe non-quantifiable benefits.

Sources of economic benefit from Houston/Galveston PORTS® information include:

- 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 Galveston Bay by boaters and fishermen (winds, weather forecasts, and other information)
- Improved environmental/ecological planning and analysis, including hazardous material spill response

In Table 1 on the following page, we summarize estimates of the annual economic benefit to a range of activities. We divide these estimates into three categories: those estimates for which there is direct evidence and in which we can have a high degree of confidence; those that are likely to be realized at present but for which direct evidence is lacking and/or significant assumptions are required; and those that are more speculative or potential, and could be realized with the full utilization of Houston/Galveston PORTS® data by all potential users.

Our estimates suggest that some $11.9 million in direct annual economic benefits can be attributed to PORTS® data in the Houston/Galveston area with a reasonable degree of confidence. Another $2.2 to $3.7 million in annual benefits are less easily traced but may be linked to PORTS®; and an additional $1.8 to $2.8 million could potentially be realized with the full utilization of PORTS® data. Thus, our best estimate of the presently realized quantifiable benefit from Houston/Galveston PORTS® data is $14.1 to $15.6 million. This estimate is best interpreted as a lower bound on total benefits flowing from PORTS® data, since not all uses of PORTS® data can be quantified.

Most of these benefits are in the nature of avoided costs (increased producer surplus, or profit) for commercial operations in the Houston Ship Channel and adjacent waterways and approaches, and avoided costs or increased consumer surplus, including non-market benefits, for recreational users of Galveston Bay.

confidence level	*source of benefit*	*nature of benefit*	*approx. annual value (2006 $)*
High confidence reasonably good confidence and/or direct evidence for benefits	avoided groundings, commercial vessels: PORTS® contributes to 60% reduction in grounding risk	avoided costs (surplus)	10,500,000
	increased draft/reduced lightering, inbound cargo	efficiency (surplus)	250,000
	reduced delays, commercial vessels	avoided costs (surplus)	125,000
	improved spill response (present practice)	avoided costs (surplus)	1,000,000
Subtotal – high confidence benefits			**$11.9 million**
Lower confidence more significant assumptions required to estimate benefits; less direct evidence	reduced distress cases, recreational boats	avoided costs (surplus, value of life)	200,000
	improved weather forecasts	non-market consumer surplus	1,500,000 – 3,000,000
	improved storm surge forecasts	avoided costs (surplus)	500,000
Subtotal – lower confidence benefits			**$2.2 -- 3.7 million**
Potential or speculative these benefits could be realized with additional investment or a higher level of utilization of PORTS® data	improved spill response (with add'l models & infrastructure)	avoided costs (potential; not realized at present)	1 – 2,000,000
	enhanced recreational boating	non-market consumer surplus	620,000
	enhanced recreational fishing	non-market consumer surplus	30,000
	enhanced beach recreation	non-market consumer suplus	120,000
Subtotal – potential or speculative benefits			**$1.8 – 2.8 million**
Non-quantified benefits	Educational use	non-market	N/A
	Scientific research	non-market	N/A

Table 1: Summary of Estimated Annual Benefits from Houston/Galveston PORTS®

Introduction

NOAA Physical Oceanographic Real-Time Systems (PORTS®) are near-shore ocean observing systems now operating in thirteen locations around the United States (www.tidesandcurrents.noaa.gov/ports.html). PORTS® installations provide near-real time information and, in some cases, forecasts about water levels and currents at specific points in a coastal water body. In some instances, they also provide information on wind speed and direction, barometric pressure, salinity, air gaps on bridges, and air and water temperature. In addition, co-located sensors (i.e., possibly operated by other parties and not part of the official NOAA PORTS® installation) may provide information on wave height, visibility, and other parameters, as well as digital still or video images of portions of the waterbody.

The information made available by PORTS® results in economic benefits because it is used by decision makers to make choices that affect economic well-being. To estimate the benefits that may accrue from a PORTS® installation, it is necessary to compare the outcome of these choices under two scenarios: the PORTS® scenario, in which the PORTS® data are available to decision makers; and a non-PORTS® scenario, in which these data are not available. The data and products enabled or affected by the PORTS® installation influence decisions made in industry, recreation, the research community, and public administration, changing the economic outcome from these activities, and thereby affecting economic well-being. The difference in outcome under the two scenarios is the benefit derived from the investment in PORTS®.

The most accurate measure of this benefit is the marginal increase in what economists call consumer and producer surplus. Consumer surplus is the difference between what consumers are willing to pay and what they actually pay. Producer surplus is the difference between the price received for a good or service sold and the costs of producing that good or service. Because this surplus is often difficult to estimate, economists also use other measures of benefit, such as the change in value added (contribution to Gross Domestic Product (GDP)), or reduction in cost to achieve the same level of output. These measures typically are less precise estimates of true social surplus. Usually, these measures are estimated as annual values at the level of a firm or other economic unit, and then aggregated over geographic regions and industries to estimate total annual benefits.

Benefits represent only one side of the investment decision. To estimate net benefits, or rates of return, it is necessary to have information on costs as well. In the case of PORTS®, there are two main categories of costs: the cost of data collection, quality control, processing, and archiving; and the cost of generating from these data the products that decision makers ultimately use. In the case of PORTS®, the first component (the direct capital and operating cost of the PORTS® installation) is usually well understood. The second component generally includes activities carried out by both public and private sector organizations, and these costs are likely to be more difficult to specify. The analysis of costs associated with the generation and use of PORTS® data is outside the scope of this report.

Economics of Information

A product, such as a real-time water level report for a harbor, represents information about the ocean environment. This information has value when it can be used by an individual or an organization to make a better decision – that is, a decision that results in an outcome that is economically superior. The standard economic approach to valuing information requires:

- A description of the information being valued and of the state of knowledge about the phenomena or conditions it describes. Typically, information is useful because it reduces uncertainty about the present or future state of nature in a particular context – for example, the location of a particular depth contour, or the exact water level in a dredged channel.

- A model of how this information is used to make decisions. Most decisions are made in the face of imperfect information, or uncertainty about how conditions will in fact develop and what the exact outcome will be. For example, PORTS® data may be used in decisions involving the navigation of commercial or recreational vessels. Here, the critical information concerns water depth, current speed and direction, wind speed and direction, or other information needed for the safe and efficient operation of a vessel.

- A model of how these decisions affect physical outcomes. Modeling the difference in outcome with and without the product in question usually requires making assumptions about how the decision makers will respond to the lack of the product in question.

- A model of how physical outcomes can be translated into economic outcomes. The value of a product is the difference between the expected value of the outcome of decisions using that product, and the expected value of the outcome without the product.

Quantifying Economic Value

The most appropriate measure of economic value of information resulting from a change in user decisions or behavior is the change in what economists refer to as "social surplus." Social surplus has two components: producer surplus and consumer surplus. Producer surplus in this case is generally a reduction in costs to businesses. Consumer surplus, as in the case of the surfer, is the difference between what one would be willing to pay and what one actually pays for, for example, a recreational experience. "Social surplus" is the sum of producer and consumer surplus. It is the appropriate measurement because it assures that only the value in excess of costs is counted, making it a unique measure that avoid the artificial inflation of values by double counting.

The problem with social surplus and both of its elements is that they can only be measured using exacting, time-consuming, and costly techniques. Other measures of economic activity (broadly termed "economic impacts") such as the value of sales at the wholesale or retail level, or value added (the most common example of which is GDP), are widely available, but measure social surplus in a rather imperfect manner.

In other situations, estimates of social surplus may be available but data to support an explicit model of how PORTS® information is used in economic decisions are lacking. In such cases, an order-of-magnitude estimate of potential value of PORTS® data may be obtained by applying a rule of thumb developed by Nordhaus (1996) and others: the value of weather and climate forecasts to economic activities that are sensitive to weather/climate tends to be on the order of one percent of the economic activity in question.

Studies of economic values from investments such as PORTS® thus often face a dilemma due to data constraints. The most appropriate measure is the least available, while the most available measures are the least appropriate. This is a major reason why these estimates of economic benefits often must be considered approximate.

Sources of Economic Benefit from PORTS®

PORTS® data, and products derived from PORTS® data, are used by a wide range of industrial, recreational, and public sector organizations and individuals. They include maritime shipping interests, recreational boaters and fishers, and marine resource and environmental managers.

For the purpose of this analysis, we use the following classification of benefits from PORTS® installations:

- Improved Safety of Shipping and Boating
    - Avoided groundings, commercial vessels
    - Avoided distress cases, recreational vessels

- Improved Efficiency of Marine Operations
    - Increased cargo carried per ship call (greater loaded draft)
    - Reduced delays (less allowance for error/margin in piloting decisions)
    - Improved Search and Rescue (SAR) performance (surface currents)

- Improved Environmental Protection and Planning
    - Improved hazardous material spill response
    - Improved environmental restoration/conservation activities

- Improved Recreational Experiences
    - Enhanced value from boating decisions (power, sail, windsurfing, kayaking, etc.)
    - Enhanced value from fishing decisions
    - Enhanced value from beach visit decisions

- Improved Weather and Coastal Marine Conditions Products
    - Improved general weather forecasts
    - Improved coastal marine weather forecasts
    - Improved storm surge forecasts

- Science and Education
    - Use of PORTS® data in scientific research
    - Use of PORTS® data in secondary education

While this list is not exhaustive, it captures to the best of our knowledge all of the major benefits generated by PORTS® data.

In each of the benefit categories discussed above, it is possible to estimate the potential value of PORTS® data by assuming that all potential users of the information in fact make use of it as described. This potential value is an upper bound of sorts on what is likely to be the value actually realized during a given year, since the number of actual users is likely to be less than 100% of potential users, 100% of the time. Potential value is often easier to estimate than actual value because estimating potential value does not require data on how many users actually use the PORTS® data, and how often.

In situations where data or model limitations do not permit the application of the benefit frameworks described above, it may be possible to estimate at least the general scale of potential benefit by applying a "one percent proxy rule." Formulated by Nordhaus (1986) and other economists on the basis of experience with a number of forecast/nowcast value of information studies of industries and activities sensitive to weather, this rule suggest that the value of weather nowcast/forecast information to economic activity sensitive to weather conditions is generally on the order of one percent of the economic value generated by the economic activity. There is, of course, no guarantee that this rule will hold in all cases; but where no better estimate can be constructed, it provides an order of magnitude estimate of value that is likely to be reasonable.

Economic Benefits from Houston/Galveston PORTS®

Background: Houston/Galveston PORTS®

The Houston/Galveston Physical Oceanographic Real-Time System (PORTS®) is a public information acquisition and dissemination technology developed by the NOAA National Ocean Service (NOS) and operated in partnership with the Houston/Galveston Navigation Safety Advisory Committee (HOGANSAC). PORTS® was first deployed in the waters around Houston and Galveston in 1996-97. Communication links between sensor stations and the data acquisition system were upgrade in 2001 to improve reliability of transmission; and additional equipment upgrades were carried out in late 2006 and early 2007. The Houston/Galveston PORTS® infrastructure is operated and maintained under a contract between NOS and the Conrad Blucher Institute for Surveying and Science at Texas A&M University-Corpus Christi, which operates the Texas Coastal Ocean Observation Network (TCOON).

Houston/Galveston PORTS® provides information in near-real-time on currents, water levels, winds, air and water temperatures, barometric pressure, and conductivity/salinity at multiple locations with a data dissemination system that includes telephone voice response and World Wide Web/Internet sites (www.tidesandcurrents.noaa.gov/hgports/hgports.shtml?port=hg ; 1-866-447-6787 (1-866-HGPORTS)). Measurements are taken at six-minute intervals at six locations in Galveston Bay and surrounding waters, as shown in Table 2. The geographic locations of the sensors are illustrated in Figure 1.

	water level	current	wind	air and water temperature	barometric pressure	conductivity/ salinity
Morgans Point	X	X	X	X	X	X
Eagle Point	X		X	X	X	X
Bolivar Roads		X				
North Jetty	X		X	X	X	X
Pier 21	X			X	X	
Pleasure Pier	X		X	X	X	

Table 2: Houston/Galveston PORTS® sensor stations

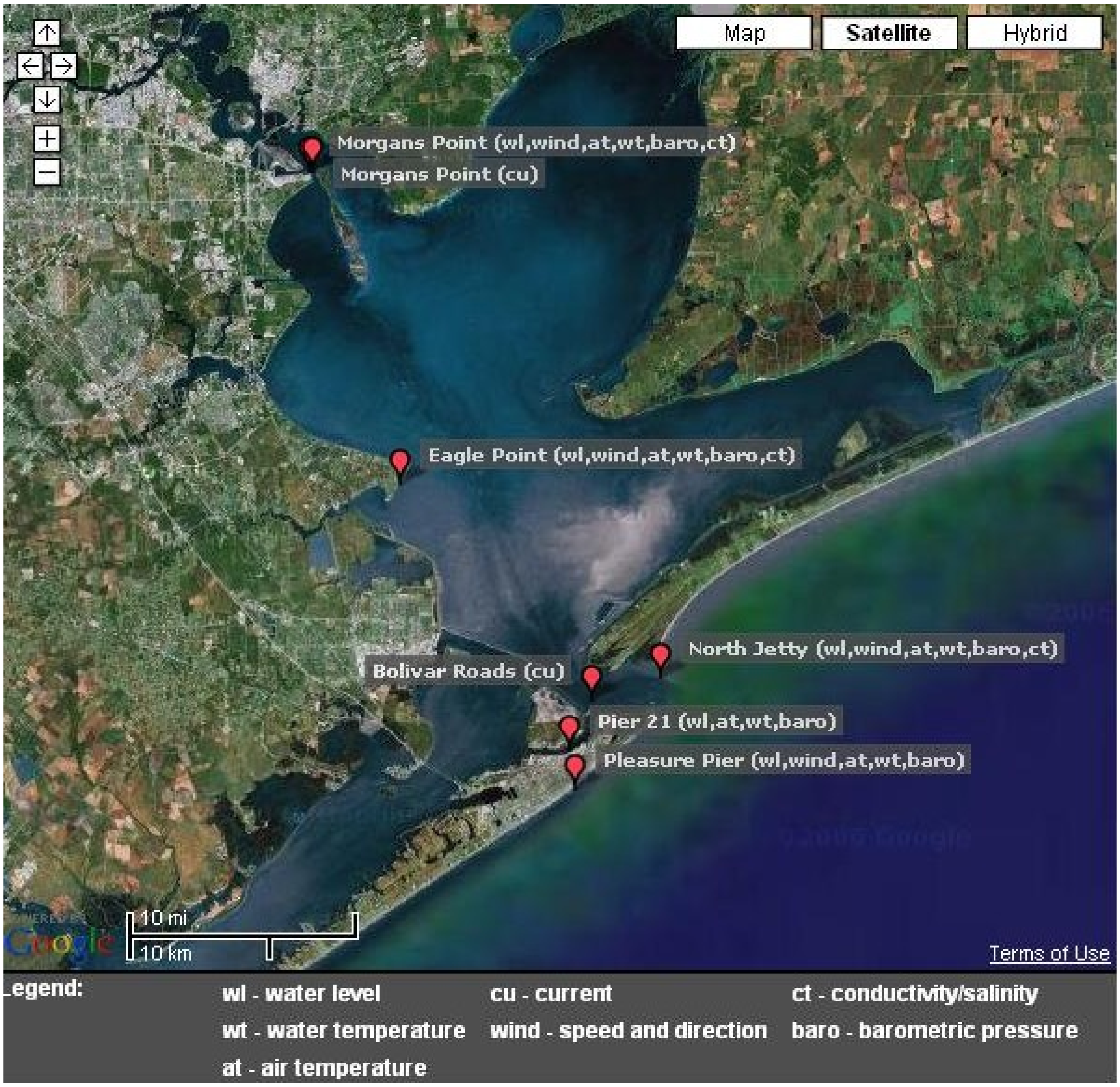
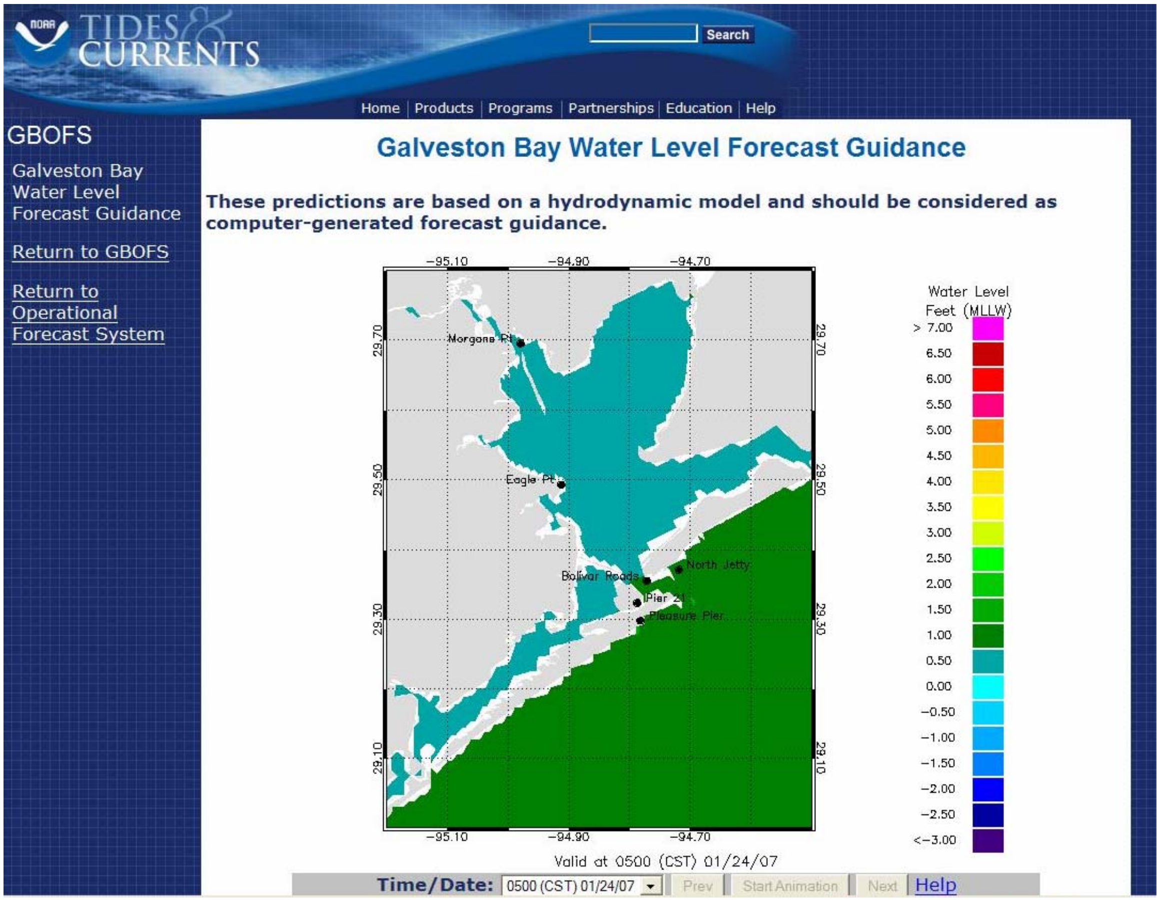


Figure 1: Houston/Galveston PORTS® sensor locations.
Source: www.tidesandcurrents.noaa.gov/hgports/hgports.shtml?port=hg

In 2004, NOS made available to the public a forecast guidance product that predicts water levels, currents, and winds for Galveston Bay, incorporating PORTS® measurements and meteorological forcing, on one-hour increments for a forecast horizon of 30 hours. The Galveston Bay Operational Forecast System (GBOFS) forecast product is available on the internet (www.tidesandcurrents.noaa.gov/ofs/gbofs/gbofs.html) together with PORTS®-based nowcasts. The GBOFS water level forecast is illustrated in Figure 2.



Galveston Bay Water Level Forecast Guidance

These predictions are based on a hydrodynamic model and should be considered as computer-generated forecast guidance.

Valid at 0500 (CST) 01/24/07

Time/Date: 0500 (CST) 01/24/07

Figure 2: Galveston Bay Operational Forecast System (GBOFS) water level forecast guidance.
Source: www.tidesandcurrents.noaa.gov/ofs/gbofs/gbofs.html

Houston/Galveston PORTS® stations operate in parallel with a wider network of sensors that make up the Texas Coastal Ocean Observation Network (TCOON). The network of water level sensors that became TCOON was first established by the National Ocean Service and the Texas General Land Office in 1988, and today consists of more than 40 stations along the coast of Texas (www.tidesandcurrents.noaa.gov/tcoon.shtml) that are managed by the Division of Nearshore Research at Texas A&M University, Corpus Christi. TCOON sensors monitor water level, wind speed, barometric pressure, salinity, water quality, and other environmental data at three hour intervals.

General Notes on Value of Houston/Galveston PORTS®

One set of measures of the overall utilization of the Houston/Galveston PORTS® data are the number of “hits” or visits to the Houston/Galveston PORTS® web pages, and the number of phone calls to retrieve Houston/Galveston PORTS® data via voice recordings. Historical data on both measures are shown in Figure 3.

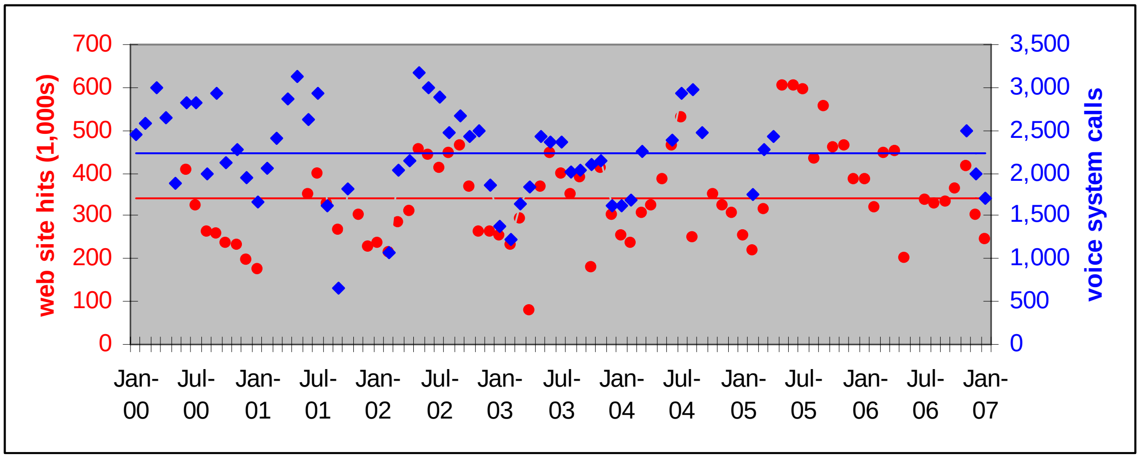


Figure 3: Monthly number of web site hits (left axis, red) and telephone/voice requests (right axis, blue) for Houston/Galveston PORTS® data, 2000-2006. Horizontal lines indicate mean values for both series. Source: NOAA CO-OPS.

There is no significant overall trend in the data over the seven-year period from 2000 to 2006, although use of PORTS® data seems to be higher during the hurricane season. Web site visits average 340,000 per month, or 4.1 million per year; voice system requests average just over 2,200 per month, or about 27,000 per year.

These use statistics do not distinguish between user types, and there is little hard data on the utilization of PORTS® data by specific user categories. No systematic survey has been undertaken to determine how many users from each user group utilize Houston/Galveston PORTS® information, how often they do so, and how they utilize the information. Nonetheless, the web and voice use measures illustrated in Figure 3 are compatible with potential use estimates developed in the sections that follow, including annual waterways usage by some 200,000 commercial vessel transits and 3.1 million recreational boat trips. Anecdotal data gathered in the course of research for this report suggests that PORTS® data are used extensively by the maritime operations and safety communities, and by the National Weather Service in generating both marine and general weather forecasts and warnings. Awareness and utilization of PORTS® among recreational users is relatively strong in the Houston/Galveston area, but remains below the full potential. This leads to our classification (see Executive Summary) of many recreational benefit estimates as more speculative or potential. To achieve a higher degree of confidence in these estimates, it will be necessary to carry out specific surveys of these users.

Safety

Avoided Groundings, Commercial Vessels

PORTS® data have been available to maritime operations in the Houston/Galveston area since 1996/97, when the system was first installed. Major upgrades were performed to improve the reliability of the system, particularly the communication links with sensor stations, in 2000/01. Although they do not prove causality, historical data on grounding rates for commercial transits in the Houston/Galveston area suggest that a reduction in grounding risk accompanied the introduction of PORTS® in the late 1990s.

Data on commercial vessels grounding are available from the US Coast Guard's accident databases known as CASMAIN (1981-90) and MSIS (1992-present). Transit data are based on ACE Waterborne Commerce Statistics annual summaries (see USACE, various years). For our purposes, a "transit" is a vessel movement, so that a port call usually consists of two transits: one into and one out of the port. Depending on which waterways are included, the Houston/Galveston area hosts about 25,000 ship transits and 150,000 tug/tow transits annually at present.

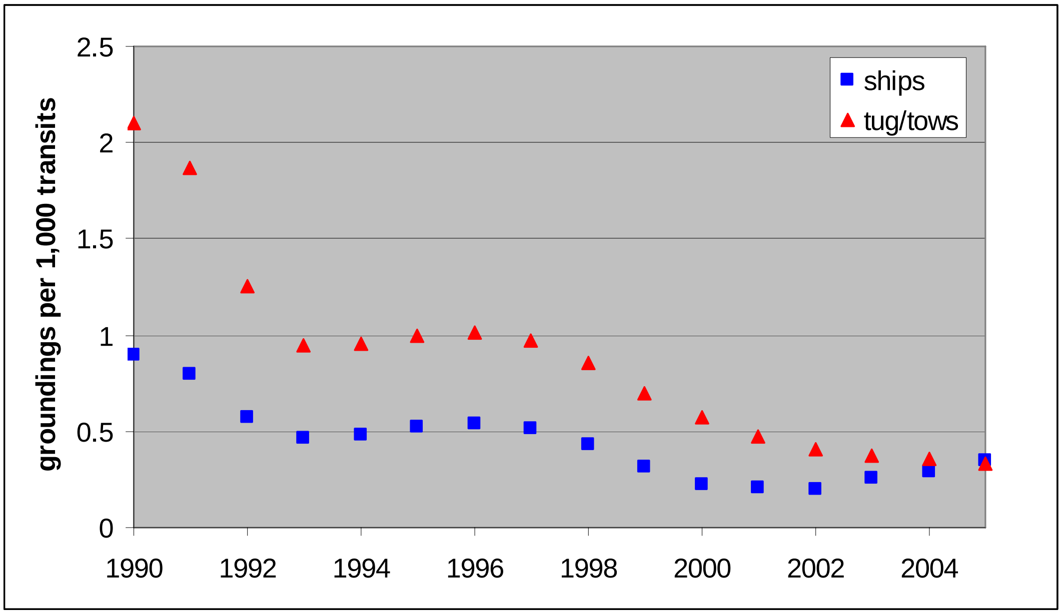


Figure 4: Grounding rates (5-point moving average) for commercial transits in the Houston/Galveston VTS region, based on data from US Coast Guard and US Army Corps of Engineers.

Figures 4 shows time series of grounding rates in the Houston/Galveston area for self-propelled ships and tug/tows. Grounding rates for all vessels decreased significantly from the 1980s to the early 1990s, possibly due to operational changes motivated by the aftermath of the *Exxon* Valdez accident and the Oil Pollution Act of 1990. The data also show a second distinct decline in grounding rates in the late 1990s, during the time when PORTS® data first became available. This correlation does not establish causality; other factors may well have contributed to this apparent decline in grounding risk. However, it is plausible that the availability of PORTS® data materially contributed to this development. Grounding rates for self-propelled ships appear to have decreased from 0.5 groundings/1,000 transits during 1993-1997 to about 0.25 groundings/1,000 transits during 2002-2005; grounding rates for tug/tows decreased from 1.0 to 0.4 during the same intervals. This is a decrease in grounding rates of 50% for ships and 60% for tug/tows – at present traffic levels, a reduction of 6 ship groundings and 90 tug/tow groundings per year from what would take place if pre-PORTS® rates had prevailed.

The availability of PORTS® data was perhaps the most significant change in the maritime operating environment of the Houston/Galveston region during the late 1990s. Given these developments, a plausible range for the decrease in grounding risk for in the region attributable to PORTS® data is half of the risk reduction seen in the data during the late 1990s. This implies that PORTS® data prevent about three ship (deep-draft) groundings and 45 tug/tow groundings per year in the Houston/Galveston area.

The economic loss associated with a grounding is the sum of all costs associated with the accident. Costs are classified as either internal or external. Internal costs are those arising from the vessel involved in the accident and other parts of the marine transportation system; they include damage to the vessel, loss of cargo, injury or death of crew members, cleanup costs, and delays due to blockage of the route, among others. External costs are those incurred outside the transportation system, including environmental degradation, human health risks, lost fishery revenues, and lost recreational benefits, among others. Both external and internal costs will vary with the severity of the accident; the size of the vessel(s) involved, their construction, and their cargo; and other factors. External costs will also vary greatly with the environmental and human health sensitivity of the location.

We use here an estimate of the cost of groundings that is based on the approach taken in the Coast Guard's *Port Needs Study* (PNS) (USCG 1991), taking into account relevant parameters such as vessel size, nature of cargo, and nature of the transit area. The PNS study included in its loss estimation each of the following categories of losses (see Schwenk 1991):

- loss of human life and personal injuries,
- vessel hull damage,
- cargo loss and damage,
- economic cost of the vessel being out of service,
- spill clean up costs,
- losses in tourism and recreation,
- losses in commercial fish species,
- impacts on marine birds and mammals,
- losses due to LPG/LNG fires and explosions, and
- bridge and navigational aids damage.

Not included in the estimation procedure are damages to on-shore facilities and water supplies, legal fees for litigation over vessel casualties, cumulative effects of consecutive spills, effects of chemical releases into the air, and non-use values.

A summary of the PNS loss estimation procedure is provided by Schwenk (1991). In addition to its own procedures, PNS draws on several sources for damage estimation models. These include the Natural Resource Damage Assessment Model (see below); several models developed by A.T. Kearney (1990) for losses in tourism, property values, and subsistence households; and models by ERG (1990) for losses due to cleanup costs and to vessel damage and repair. The PNS data, which reflect inputs from all of these models, are used to estimate the losses associated with one accident involving various vessel types (tanker, dry cargo, tug/barge) and sizes in each study area.

Perhaps the most volatile element in the PNS loss estimation procedure is the model used to calculate natural resource damages. These damages -- loss of fish, birds, marine plants, and other species -- account for between 10 and 40 percent of total damages, depending on the location and nature of the accident. The PNS results are based on a version of the Department of the Interior's Natural Resource Damage Assessment Model for Coastal and Marine Environments (NRDAM/CME) which has since been replaced by a new version of NRDAM/CME (see Federal Register 59(5):1062-1189). The new version includes a new model of restoration costs and makes use of updated biological, chemical, and economic data. Preliminary analysis of the new model's parameters suggests that there is no consistent way to scale results from the previous version to reflect the likely new model results. The cost estimation algorithm we have used here therefore includes natural resource damage estimates based on an "old" version of the NRDAM/CME.

Based on the PNS data, the average economic loss associated with self-propelled ship grounding in the Houston/Galveston region is $3 million for tankers and $1 million for dry cargo vessels, and the average economic loss associated with tug/tow groundings is $100,000 (in current 2006 dollars). These averages take into account the distribution of vessel size and cargo for each port, and also reflect seasonal averages for environmental losses. Tankers account for over half of the Houston/Galveston ship transits. Using the assumptions described above, the reduction in grounding risk due to PORTS® translates into a conservative estimate of $10.5 million in avoided costs per year.

Anecdotal evidence derived from interviews with vessel operators and pilots supports the conclusion that PORTS® data have significantly improved the safety of maritime transits in the Houston/Galveston area. Tug/tow operations are strongly affected by winds and currents. Winds above 20-25 knots make if difficult to safely maneuver many tows due to horsepower limitations, and associated chop on open sections of waterways can generate excessive stress on couplings between barges. There are a limited number of safe “hold” points for tows as they approach exposed sections of their routes in the Galveston Bay area. Having advance notice of wind conditions in the Bay is therefore of great importance to tow operators. Strong channel currents, particularly at the intersection of the Intracoastal Waterway and the Houston Ship Channel at Bolivar Roads (Area 25/26), can complicate turning maneuvers for tows; and knowledge of real-time current speed and direction can help operators plan and execute these maneuvers safely, particularly in high-traffic areas. Houston VTS watchstanders routinely field requests by radio from tow operators for PORTS® wind and current information. For self-propelled ships and for tows, the current at Morgan’s Point is often cited as a critical factor in safe execution of maneuvers between the Ship Channel and nearby docks. Both Houston and Galveston-Texas Pilots report an improvement in safety and a reduced risk of grounding and collision with PORTS® information.

Reduced distress cases, recreational vessels

Nationally, hazardous water and weather are a causal factor in about 10% of recreational boating accidents. About 130,000 recreational boats are registered in the counties adjacent to Galveston Bay[1] as of 2005-06 (State of Texas). If we assume that recreational boating activity and accident rates in the Houston/Galveston area are similar to those in other parts of the US Gulf Coast, this suggests about seven significant weather-related accidents per year in the Houston/Galveston region, with 0.5 fatalities, 5 injuries, and $100,000 in property damage. These numbers are consistent with search and rescue statistics provided by the US Coast Guard in Houston (see below).

If we assume a value of life of $4 million, the direct cost associated with weather-related recreational boating accidents on Galveston Bay is on the order of $2 million/year. All of these could potentially be avoided by scrupulous use of PORTS® and other weather information. Observers knowledgeable about the Galveston Bay recreational boating community suggest that between 25 and 50 percent of boaters are aware of, and make use of PORTS® data today. A conservative estimate of benefits from PORTS® in this instance may be 10% of expected losses, or $200,000/year.

Efficiency

Increased cargo carried per transit

The majority of draft-constrained transits in the Houston/Galveston area are crude oil imports carried in VLCCs or Suezmax tankers, many of which are lightered by use of shuttle tankers (also generally draft constrained) prior to entering the port. (There are also some dry bulk export transits that are draft constrained in channel segments north of the main Houston Ship Channel.) Approximately 400 VLCCs or Suezmax arrivals take place over the course of the year; and an estimated 8% of these tanker arrivals take place on days when weather events (strong winds from the north associated with cold fronts, or strong easterly winds) produce water levels in Houston/Galveston that differ significantly (often by 2 to 3 feet) from predictions based on lunar cycles. These are situations where operational decisions – to what draft to load the shuttle tanker – can make use of PORTS® water level data and forecasts.

If 10 percent of the tank ship arrivals taking place during such weather events can use PORTS® data to optimize loading of shuttle tankers and the entry of the delivering vessel to maximize draft carried into the terminals and thereby eliminate one shuttle tanker loading, this translates to 3.2 eliminated shuttle tanker movements per year. At a cost of $80,000 per shuttle tanker movement (US Army Corps of Engineers), this is equivalent to a cost savings of about $250,000/year.

Reduced delays

Pilots for both Houston and Galveston indicate that certain vessel movements – primarily tankers and cruise ships – are sometimes delayed by water level, wind, or current speed

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[1] Brazoria, Chambers, Fort Bend, Galveston, Hardin, Harris, Jefferson, Liberty, Matagorda, and Mongomery.

considerations. Hard data on these delays are not available. If we assume, conservatively, that PORTS® data reduces delays in one percent of ship transits (250 transits/year) by 60 minutes, and an average operating cost of \$500/hr, this translates to \$125,000/year in operating cost savings.

Improved SAR performance

According to search and rescue officials (K. Luttrell p.c., 2006), PORTS® data (primarily wind and current information) were used in six search and rescue (SAR) cases in the Houston-Galveston area in a recent 12-month period. The corresponding case duration (time during which SAR assets were actively engaged) ranged from 10 to 17 hours. If PORTS® data can improve the effectiveness of the SAR response in such a way as to reduce the average case duration, this can potentially result in both direct cost savings and reduced loss of life. The former effect is small, possibly on the order of \$10,000/year; the latter is captured by the estimate of benefits from “Reduced distress cases, recreational vessels” above.

Environmental Protection: improved spill response

There has not been a major vessel-related spill in Houston/Galveston since 2001. On September 22, 2001, the Liberian tank ship *New Amity* collided with the tank barge *NMS 1486* (UTV *Carson*) in the Houston Ship Channel. As a result, some 50,000 gallons (120 tons) of intermediate fuel oil spilled into the waterways from the *New Amity*’s fuel tank. In part because of warm water temperatures, the oil spread quickly to near-shore areas beyond the reach of skimmers (O’Brien 2002), highlighting the importance of real-time surface current information to effective spill response. The Ship Channel was temporarily closed and about 20% of the spilled oil was eventually recovered.

Damage assessment model exercises suggest that damages associated with a major spill in the Houston/Galveston area would likely range from \$500 million to \$1 billion. It is not known precisely how the availability of PORTS® data would influence spill response efforts in the event of such a spill, or how that change in response would affect (reduce) environmental damages. If we assume, conservatively, a 1% to 5% reduction in damages due to the use of PORTS® data in spill response activities, and that such spills will happen in the Houston/Galveston region once every 25 years, the expected annual benefit is between about \$200,000 and \$2 million.

This estimate is in line with anecdotal evidence about the use of current information and models in spill response activities. Martin *et al.* (2005; p.c. 2007) list 21 spills along the Texas coast between 1996 and 2006 for which surface current data from the Texas Automated Buoy System (TABS) were used in planning spill response measures. They estimate that near-real-time current information saved at least \$225,000 in avoided costs during the response to the 1996 Buffalo Marine Barge 292 spill in the Houston Ship Channel.

According to spill response officials, present technology and practice typically allows for the recovery of about 10 percent of spilled oil (Watabayashi, p.c. 2005). Some oil spill modelers suggest that greater improvements in cleanup effectiveness will be possible once PORTS®-like data are integrated directly with more sophisticated hydrodynamic current models and models of hydrocarbon transport and fate. Such models exist today and are used in risk assessment exercises, but only to a limited extent in guiding “live” spill response activities. If these models are combined with appropriate spill response, modelers suggest that it may be possible to increase recovery to 20% and target recovery efforts more effectively to minimize environmental damage (French McCay p.c. 2005). If this can be achieved, environmental damages may be reduced by an additional 5% or so. In Houston/Galveston, using the above assumptions, that means another $1 million to $2 million/year in expected avoided losses.

Enhanced Value of Recreation Activities

It is estimated that between 25 and 50 percent of the recreational boating community around Galveston Bay is aware of and (at least occasionally) making use of PORTS® (L. Wise, p.c. 2006). In a similar setting (Tampa Bay), about 9% of boaters surveyed in 2003-2004 indicated that they would like to have more or better information about weather (tide, wind, lightning, seas); and one third of these mentioned the internet as the preferred medium for obtaining this information (Sidman *et al*. 2004).

Boating

About 130,000 recreational boats are registered in the counties adjacent to Galveston Bay[2] as of 2005-06 (Texas Parks and Wildlife Department, p.c. 2006). The typical boater makes about 2 trips per month, averaged over the year – or 24 trips/year. In addition to making direct use of PORTS® data, boaters benefit from NOAA’s marine forecasts, which incorporate PORTS® information. Forecasters at the Houston/Galveston NWS office report that inclusion of PORTS® data results in “substantially better marine forecasts” (B. Kyle, p.c. 2006).

Assuming that a boating day generates economic surplus equal to about 10 percent of actual expenditures (Hushak 1999), we estimate the per day surplus from recreational boating at $20/day. If PORTS® data leads to a one percent increase in positive boating day experiences in Tampa Bay, this suggests in annual non-market benefit from PORTS® of $624,000.

Fishing

Using data collected by the Texas Parks and Wildlife Department (Lee Green, p.c. 2006), we estimate some 300,000 to 350,000 person-days of recreational fishing activity on Galveston Bay each year. Recreational fishers and guides/charter operators are interested in water temperature and in details of current speed and direction (fish are usually not caught during slack water). Estimates of willingness to pay for increased fishing success on the Gulf coast range from $3 to $23 per fishing trip (Haab *et al.* 2000).

Using a value of $10 per fishing trip, and assuming that PORTS® data leads to improved fishing success on one percent of fishing trips, we estimate the value of PORTS® data to

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[2] Brazoria, Chambers, Fort Bend, Galveston, Hardin, Harris, Jefferson, Liberty, Matagorda, and Mongomery counties.

fishers in Tampa Bay at about $30,000/year. We consider this a potential benefit because although there is anecdotal data suggesting that between 25 and 50% of Galveston Bay recreational boaters use PORTS® data, we do not know how many recreational fishermen routinely utilize PORTS® data at this time.

Beach Visits

An estimated 800,000 annual beach visits take place along the Gulf Coast shores of Galveston (Galveston Parks and Recreation Dept.). Typical expenditures directly associated with beach recreation are $25 per beach day, and generate an estimated $15 of consumer surplus per beach day (Pendleton 2003). Assuming that PORTS® can lead to a one percent improvement in economic surplus generated by beach use, this suggests an annual benefit of $120,000. We consider this to be a potential or speculative benefit because there is no solid evidence that beach visitors regularly make use of PORTS® data at this time.

Enhanced Weather Forecasts

General Weather and Coastal Marine Forecasts

PORTS® data are used in the local analysis and prediction system operated by NOAA's National Weather Service office for Houston/Galveston. As such, these data help improve both general weather forecasts for the Galveston Bay area and coastal marine weather forecasts. The value of improved coastal marine forecasts is reflected in the improved recreational boating experience of local boaters, as discussed above. The improved general weather forecasts benefit all users of weather forecasts in the Houston/Galveston area.

Data used include water level information (for coastal flooding), wind speed and direction, and temperature. The weather service uses PORTS® data to verify marine warnings generally, and as a basis for marine warnings issued for Galveston Bay and nearby coastal waters. The Houston/Galveston office of the National Weather Service typically issues about 20 severe weather warnings/year, as well as several coastal flood warnings (see below). Some of these warnings are based directly on PORTS® data (B. Kyle, NOAA NWS, p.c. 2006).

The exact contribution of PORTS® data to improved weather forecasts for the Galveston Bay area is not known. Using Lazo and Chestnut's (2002) estimate of about $15/household/year for the value of significant improvements to general weather forecasts, assuming that PORTS® data contribute 10 percent of such an improvement, for an estimated one to two million affected households in the greater Houston metropolitan area, results in an annual benefit from improved weather forecasting of $1.5 to $3.0 million. We consider this a lower confidence estimate because although the mechanism is clear and the use of PORTS® data in this context is well established, the magnitude of the contribution of PORTS® to the weather forecast is difficult to quantify.

Storm Surge Forecasts

Storm surges in the Houston/Galveston area are associated with large storm events, such as hurricanes; and significant increases in coastal water levels are also associated with prolonged moderate to strong easterly winds. These surges can produce tide levels 2 to 3 feet above normal, and can cause extensive damage. Much of this damage cannot be avoided by an improved forecast, but marginal improvements in response activities (securing boats and structures, evacuating areas) may be possible or less costly with a more accurate and timely forecast.

The Galveston Bay area is considered among the most endangered in the country from storm surge because of its large population and because the geography of the generally flat and low-lying waterfront offers little defense against rising water levels. Nearshore areas along tidal bays and rivers are particularly vulnerable. A large storm surge can submerge much of downtown Galveston and Houston.

Major storm surge events hitting urban areas can cause billions of dollars in damages (models of damage from a major hurricane striking the Houston area suggest damage as high as $40 to $50 billion). Conservatively assuming a $1 billion storm surge damage from a major storm once every 20 years in the Galveston Bay area, we estimate an annualized risk from storm surge of $50 million. The precise contribution of PORTS® data to storm surge forecast quality and risk reduction is not known. Applying the one percent rule, we estimate an annualized value of $500,000 from improved storm surge prediction.

Qualitative Effects and Values

PORTS® data are used in educational and scientific activities that are valuable but do not lend themselves readily to economic quantification. Examples of these are highlighted below. Although we do not attempt to quantify benefits from these activities, they are important uses of PORTS® data and suggest that the quantified benefits should be treated as a lower bound estimate of total benefits from PORTS®.

Scientific Research/Water quality management

Water temperature and other water quality parameters are monitored by agencies such as the Texas Department of State Health Services (Heideman, p.c. 2007) to determine the risk of vibrio (a shellfish disease) in oysters harvested from Galveston Bay) and to establish guidelines for the safe handling of these oysters following harvest. The Texas Parks and Wildlife Department (Robinson, p.c. 2007) monitors water temperature to anticipate cold-water fish kills, which can occur when water temperatures drop below 45 degrees F, and to decide when to close “thermal refuge” areas to fishing. Some of these water temperature data come from PORTS® sensors.

Civil Engineering Projects

PORTS® data are used on some civil engineering projects, including channel improvement work and eel grass restoration efforts, in the Houston/Galveston area. The extent to which this use of PORTS® data reduces the overall cost of these civil engineering projects – by reducing the need for deployment of project-specific water level and current sensors – is not known, but could be a source of benefit from PORTS®.

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Bibliography

A.T. Kearney. 1990. Methodology for estimating the environmental costs of OCS oil and gas exploration, development, production, and transportation. Kearney Centaur Division. Washington: A.T. Kearney.

Allen, A. 2004. CODAR for Coast Guard applications: business case. USCG R&D Center, Groton, CT.

Amrozowicz, M.D. 1996. The quantitative risk of oil tanker groundings. Master's degree thesis, Ocean Engineering Department, Massachusetts Institute of Technology, Cambridge, Massachusetts.

Berger, J.O. 1985. *Statistical decision theory and Bayesian analysis*. New York, Springer Verlag.

Eastern Research Group (ERG), Inc. 1990. Estimates of costs associated with oil and hazardous chemical spills and costs of idle resources during vessel repairs. Prepared for the John A. Volpe National Transportation Systems Center as part of the Port Needs Study (see USCG 1991).

French, D.P., H.Z. Schuttenberg, and T. Isaji. 1999. Probabilities of oil exceeding thresholds of concern: examples from an evaluation for Florida Power and Light. Pages 243-270 in Proceedings of the AMOP 99 Technical Seminar, June 2-4 1999, Calgary, Alberta, Canada.

French McCay, D.P., M.A. Jones, and L. Coakley. 1999. Oil spill modeling for contingency planning and impact assessment and example application for Florida Power and Light. Applied Science Associated, Narragansett, Rhode Island.

Haab, T., J. Whitehead, and T. McConnell. 2000. The economic value of marine recreational fishing in the Southeast United States. 1997 Southeast Economic Data Analysis Final Report.

Hushak, L. 1999. Recreational boating in Ohio: an economic impact study. Ohio Sea Grant Publication. Columbus, Ohio.

Kite-Powell, H.L., C.S. Colgan, M.J. Kaiser, M. Luger, T. Pelsoci, L. Pendleton, A.G. Pulsipher, K.F. Wellman, and K. Wieand. 2004. Estimating the economic benefits of regional ocean observing systems. A report prepared for the National Oceanographic Partnership Program. Marine Policy Center, Woods Hole Oceanographic Institution.

Lazo, J.K. and L.G. Chestnut. 2002. Economic value of current and improved weather forecasts in the US household sector. Report prepared for NOAA. Stratus Consulting, Boulder, CO.

Leeworthy, V.R. and P.C. Wiley. 2001. Current participation patterns in marine recreation. National Survey on Recreation and the Environment 2000. NOAA, Silver Spring, MD.

Martin, R.D., N.L. Guinasso Jr., L.L. Lee III, J.N. Walpert, L.C. Bender, R.D. Hetland, S.K. Baum, and M.K. Howard. 2005. Ten years of realtime, near-surface current observations supporting oil spill response. *Proceedings of the 2005 Oil Spill Conference*, pp. 541-545. American Petroleum Institute, Washington D.C.

Nordhaus, W.D. 1986. The value of information. In: R. Krasnow, ed., *Policy aspects of climate forecasting*. Proceedings of a Seminar held in Washington, D.C., March 4, 1986. Resources for the Future, Washington.

Pendleton, L. 2004. Harnessing ocean observing technologies to improve beach management: examining the potential economic benefits of an improvement in the Southern California Coastal Ocean Observing System. In: Kite-Powell *et al.* (2004).

O'Brien, M.L. 2002. At-sea recovery of heavy oils – a reasonable response strategy? *3rd R&D Forum on High-Density Oil Spill Response*, The International Tanker Owners Pollution Federation Ltd., Houndsditch, London, UK.

Raiffa, Howard. 1970. *Decision Analysis: Introductory Lectures on Choices under Uncertainty*. Boston: Addison Wesley.

Schwenk, J.C. 1991. Unit costs of vessel casualty consequences. Prepared for the John A. Volpe National Transportation Systems Center as part of the Port Needs Study (see USCG 1991).

Sidman, C., T. Fik, and B. Sargent. 2004. A recreational boating characterization for Tampa and Sarasota Bays. University of Florida Sea Grant, TP-130.

United States Army Corps of Engineers (USACE). Waterborne Commerce of the United States, various years. http://www.iwr.usace.army.mil/ndc/wcsc/wcsc.htm.

United States Coast Guard (USCG). 1991. Port Needs Study (Vessel Traffic Services Benefits). DOT-CG-N-01-91. National Technical Information Service, document PB92-107697.

United States Coast Guard (USCG). 2004. Boating Statistics – 2003. COMDTPUB P16754.17. http://www.uscgboating.org/statistics/accident_stats.htm

Viscusi, W.K. 1993. The value of risks to life and health. *Journal of Economic Literature* 31:1912-46.