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NATIONAL WATER LEVEL OBSERVATION NETWORK (NWLON) PRIORITIZATION

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U.S. DEPARTMENT OF COMMERCE
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Center for Operational Oceanographic Products and Services
National Ocean Service
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The National Ocean Service (NOS) Center for Operational Oceanographic Products and Services (CO-OPS) provides the National infrastructure, science, and technical expertise to collect and distribute observations and predictions of water levels and currents data to ensure safe, efficient and environmentally sound maritime commerce. The Center provides a set of water level and tidal current products required to support NOS' Strategic Plan mission requirements, and to assist in providing operational oceanographic data/products required by NOAA's other Strategic Plan themes. For example, CO-OPS provides data and products required by the National Weather Service to meet its flood and tsunami warning responsibilities. The Center manages the National Water Level Observation Network (NWLON), a national network of Physical Oceanographic Real-Time Systems (PORTS®) in major U. S. harbors, and the National Current Observation Program (NCOP) consisting of current surveys in near shore and coastal areas utilizing bottom mounted platforms, subsurface buoys, horizontal sensors and quick response real time buoys. The Center: establishes standards for the collection and processing of water level and current data; collects and documents user requirements, which serve as the foundation for all resulting program activities; designs new and/or improved oceanographic observing systems; designs software to improve CO-OPS' data processing capabilities; maintains and operates oceanographic observing systems; performs operational data analysis/quality control; and produces/disseminates oceanographic products.

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EXECUTIVE SUMMARY

The stations and gaps in the National Oceanic and Atmospheric Administration (NOAA) National Water Level Observation Network (NWLON) are prioritized and ranked based on factors relating to tidal datums, marine navigation, and sea-level monitoring. The NWLON is a national observing network of over 210 real-time water level observing platforms throughout the oceanic and Great Lake coasts of the United States. The network provides authoritative support for a range of use-cases including safe and efficient marine navigation and resilience from the impacts of coastal flooding and long-term sea level rise. The critical data, products, and services produced by the network coupled with the requirement of a long-term resource commitment necessitated a comprehensive examination of where NWLON stations should be located and what locations should be prioritized when assessing the optimal network configuration.

This NWLON prioritization builds on the 2014 report (Gill 2014a) that visualizes station tidal datum coverage and gaps, utilizing geographic information systems (GIS). Datasets that represent the importance of NWLON stations were identified, cleaned, and organized to form 20 parameters that enable prioritization around 3 categories: Tidal Datums, Marine Navigation, and Sea Level Monitoring. Data were assigned to each existing NWLON station or NWLON gap and were normalized by the top 10 percentile resulting in a ranked contribution to the relative importance of each station (0 being the lowest to 1 being the highest). These ranking values were summed for each of the 3 categories and again normalized, this time by the maximum value to result in a 0 to 1 ranking for each station and gap for each of the 3 categories. The NWLON and gap prioritization rankings are visualized via a GIS framework and publicly available tool both as individual categories and as a total prioritized value (adding all 3 categories together).

The results provide useful insights into the importance of various NWLON stations and which existing NWLON gaps should be prioritized to be filled by new stations or through partner collaborations. Though the rankings are national, the results and analysis are presented region-by-region to highlight critical locations within each geographic region and to avoid comparisons between locations with very disparate physical and socioeconomic characteristics. The highest priority stations and gaps within each region include:

Northeast and Mid Atlantic (34 stations and 26 ranked gaps)

- Top 5 stations: Sandy Hook, NJ; Newport, RI; Boston, MA; The Battery, NY; Portland, ME
- Top 3 gaps: Great South Bay, NY; Great Egg Harbor and Barnegat Bay, NJ; Southern Shore, Outer Coast, LI

Southeast and Gulf (47 stations and 32 ranked gaps)

- Top 5 stations: Fort Pulaski, GA; Grand Isle, LA; Bay Waveland Yacht Club, MS; Charleston, SC; Key West, FL
- Top 3 gaps: Houston Ship Channel, Upper Galveston Bay, and East Bay, TX; Inner Bays, Indian River, FL; Upper St. Johns River, FL

West Coast (29 stations and 5 ranked gaps)

- Top 5 stations: San Francisco, CA; Los Angeles, CA; Alameda, CA; Point Rey, CA; Port Chicago, CA
- Top 3 gaps: Upper Columbia River, OR; South San Francisco Bay, CA; Stockton River Delta and Sacramento River Delta, CA

Alaska (27 stations and 21 ranked gaps)

- Top 5 stations: Ketchikan, AK; Alitak, AK; Seward, AK; Seldovia, AK; King Cove, AK
- Top 3 gaps: North Side Aleutians, AK; Aleutian Islands, South Side, AK; Port Wrangell, AK

Hawaii (6 stations and 2 gaps)

- Top 2 stations: Hilo, HI; Honolulu, HI
- Top 2 gaps: Southeast point of Hawaii Island, HI; South shore of Kahoʻolawe Island, HI

Puerto Rico and U.S. Virgin Islands (10 stations and no gaps)

- Top 5 stations: San Juan, PR; Lime Tree Bay, VI; Lameshur Bay, St Johns, VI; Charlotte Amalie, VI; and Culebra, PR

The results of the prioritization illustrate the most important existing stations and gaps to either sustain or address. In general, the highest ranking locations have aspects of all 3 categories that result in the high ranking. However, it is important to closely examine the individual category rankings when using the results. For instance, a station like Galveston Entrance Channel, TX, is only ranked 105 in datums and 137 in sea-level monitoring; however, it is first in the entire nation in marine navigation. Thus, even though this station is ranked only 48th nationally across all 3 categories, its dramatic importance in navigation makes it one of the most vital locations in the NWLON. When interpreting the results, the numerical order should be considered as a general guideline as variations in the methodologies or data inputs could result in slightly different rankings.

This report and the corresponding GIS layers and tool (dashboard) provide an invaluable resource to the Center for Operational Oceanographic Products and Services (CO-OPS) and National Ocean Service (NOS) leadership, as well as to our NOAA and external partners when evaluating the importance of existing NWLON stations and gaps. The results represent the most extensive effort made to better understand the mission critical capabilities to support future decisions regarding the NWLON. The authors recommend that this work be updated regularly as the network and conditions change, and also encourage an examination of the underlying gaps methodology following the next National Tidal Datum Epoch update in the coming years.

1.0 INTRODUCTION

The NOAA National Ocean Service (NOS) Center for Operational Oceanographic Products and Services (CO-OPS) collects and disseminates U.S. coastal and Great Lakes water level observations. These data support a variety of real-time needs—including safe and efficient marine navigation (Wolf 2013) and observation of potentially life threatening storm surge (Gill and Schultz 2001)—and these data support downstream products such as coastal water level datums (NOS 2003), tide predictions (Parker 2007), and observation and projection of sea level rise (SLR; Zervas 2009) and high tide flooding (HTF; Miller and Luscher 2019). The primary observing system utilized to collect these data is the National Water Level Observation Network (NWLON), a network of over 210 stations across the coastal U.S., Great Lakes, and Pacific Islands. The majority of NWLON stations have been installed for at least 20 years, and many have been operating nearly continuously for 80 years or more. The longest record is at San Francisco, CA, dating back to 1854. The vital products and data produced by these stations, coupled with their requirement of a long-term resource commitment, necessitates a comprehensive examination of where NWLON stations should be located and what locations should be prioritized when assessing the optimal network configuration.

An analysis of potential coverage gaps in the location of NWLON stations across the coastal U.S. was initially completed in 2008 (Gill and Fisher 2008) and then updated in 2014 (Gill 2014a). This gaps analysis focused on the spatial coverage for each NWLON station as related to their tidal characteristics and datums. Each NWLON had a coverage area largely dictated by spatial extent of where that station could provide adequate datum uncertainty to serve as a primary datum control station for the National Tidal Datum Epoch (NTDE). Remaining gaps in coverage along the coast were documented as locations where additional NWLON stations were needed to meet CO-OPS and NOAA's mission related to providing a tidal vertical reference frame. Though this analysis provided NWLON coverage areas and gaps, it did nothing to assess which of those NWLON stations are most important or which of the gaps should be prioritized to fill first. The prioritization will determine which locations are most vital to support the NOAA mission and which are lower priority. Should a change in appropriations occur, CO-OPS would be able to consult the results from this study to determine a course of action to maximize the NWLON.

To perform the prioritization, the existing geospatial polygons representing NWLON station coverage areas and gaps (Gill 2014a) were cleaned and prepared for analysis. A geographic information systems (GIS) approach was then developed to quantify the importance of each gap or station in regard to tidal datum coverage, marine navigation support, and sea-level monitoring. A series of data sets were collected or compiled which provide insights into the importance of each station or gap to these underlying categories. These data were organized and related to the gap or coverage polygons and then combined and normalized by category to yield ranked scores (1 being the highest for each category and 3 being the highest possible total).The ranked scores were broken into geographic regions to enable more detailed analysis and assessment, the results of which are presented here.

In addition to the results, a GIS tool was developed to provide easy access to the underlying GIS datasets and an interactive dashboard to allow users to quickly visualize and compare rankings of both NWLON stations and gaps spatially across all 3 categories.

2.0 METHODS

The NWLON collects and disseminates water level data that support mapping and charting, safe and efficient maritime commerce, and sea-level monitoring to protect coastal communities. Each water level station encompasses a coverage area based on tide range and timing of the tide, and gaps in these coverage areas exist where there are no active water level stations (Gill 2014a). The purpose of the study was to prioritize the NWLON, using data related to marine transportation, socioeconomics, and CO-OPS products to support the analysis. Data sources are cited in this report for ease of use in future analysis. This section outlines the methodology used to collect and prepare the data for analysis, the GIS analysis, and the ranking system developed to prioritize the network.

2.1 Identify and Collect Data

There were a total of 210 NWLON water level stations at the time this analysis was completed; 155 are ocean coast water level stations, the main focus of the study. The remaining stations are primarily within the Great Lakes, which lack significant tides, have different environmental considerations, and follow a very different coverage and gaps approach (Gill 2014b), and thus are not included here. Once the data were collected, a geospatial analysis prioritized 3 distinct uses of the NWLON: tidal datums, marine navigation support, and sea-level monitoring. Parameters within each usage category were used to assess the geospatial distribution, CO-OPS mission requirements, and socioeconomic benefits of the existing NWLON stations and gaps. Multiple data sources were used to obtain the necessary input for the analysis. Descriptions and, where available, website links of each data set used are supplied below. The authors used CO-OPS data files, readily accessible external data, and data from a Precision Navigation Socioeconomic Study (Goodhue et al. 2020). The following list encompasses the 3 categories and 20 parameters that were analyzed:

- Tidal Datums
    - Coverage Area in square km (not calculated for gaps)
    - Independent shoreline in km
    - CO-OPS subordinate stations controlled by a given NWLON station
    - Subordinate stations within coverage and gap polygons
    - CO-OPS discrete tidal zoning map
- Marine Navigation
    - CO-OPS top 175 ports
    - 2017 vessel count tracks
    - Port tonnage
    - Cargo value
    - Accidents, collisions, groundings (ACG)
    - Vessel calls and draft data
    - CO-OPS Operational Forecast System grids
    - CO-OPS tide predictions
- Sea-Level Monitoring
    - CO-OPS length of time series
    - CO-OPS High Tide Flooding Outlook

- CO-OPS 2050 projected number of flood days
- Global Sea Level Observing System Stations (GLOSS)
- National Weather Service (NWS) tsunami program funded gauges
- Population centers
- Storm Surge - flood return interval

2.1.1 Tidal Datums

NWLON enables a vertical reference system of tidal datums for the nation. A tidal datum is a standard elevation defined by a certain phase of the tide and is used as reference to measure local water levels (Gill and Schultz 2001). Examples include Mean High Water and Mean Lower Low Water. Tidal datums are chiefly used for estimating heights or depths on nautical charts and to determine horizontal maritime boundaries. The legal determinations of private and public lands, state owned tidelands, state submerged lands, U.S. Navigable waters, U.S. Territorial Sea, Contiguous Zone, and Exclusive Economic Zone, and the High Seas, or international waters, depend on the determination of tidal datums and their surveyed intersection with the coast.

The following data parameters contributed to determining the relative importance of each NWLON station or gap to the calculation of accurate and spatially complete tidal datums:

- Active water level stations: The geographic locations at which CO-OPS water level observations are presently being collected, including both NWLON and PORTS® stations.
- NWLON coverage and gaps for tidal datum control: An updated assessment from 2014 of the size and geospatial coverage of tidal datum coverage for the NWLON (Gill 2014b). The original gaps analysis report was first published in 2008 (Gill and Fisher 2008). The report provides a rationale for the number and location of NWLON stations that are required to support NOAA Missions and Goals. The NWLON coverage and gap polygons from the assessment were used in the present GIS analysis as a basis to determine the other parameters.
- Independent shoreline: The area hydrography shapefile contains the geometry and attributes of both perennial and intermittent bodies of water, including ponds, lakes, oceans, swamps (up to the U.S. nautical 3-mile limit), glaciers, and the area covered by large rivers, streams, and/or canals that are represented as double-line drainage (U.S. Census Bureau 2018). This data was used to assess the extent of shoreline encompassed by each NWLON coverage and gap polygon.
- Control Stations and Subordinate Stations: Control Stations (typically NWLON stations) are tide stations where observations have been made over 19 years or longer. These stations provide data to serve as primary control (i.e., to account for long-term variability in water level over the 19-year period) for calculating datums at subordinate stations. Subordinate stations are tide stations with data records shorter than 19 years (often with records of 1 year or less) and require a comparison with a Control Station to calculate a tidal datum (Gill and Schulz 2001). The information was used to determine how many control stations and how many subordinate stations reside within each NWLON coverage and gap area.
- CO-OPS Discrete Tidal Zoning Map: Discrete tide zones delineate geographic areas of similar tidal characteristics. For each discrete zone, a tide curve can be constructed by applying a time and range corrector to the observed water level data for the zone's assigned control water level station. Zones are grouped by geographic

region. For this study, the NWLON was rated higher if it was part of a tidal zone that CO-OPS already determined.

2.1.2 Marine Navigation

Navigation in U.S. harbors, shipping channels, and intracoastal waterways requires an accurate knowledge of the depth of the ocean and submerged hazards at the low-water phase of the tidal cycle. Passage underneath bridges requires knowledge of the clearance at the high water phase of the tide. Accurate real-time water level information helps mariners arrive at their port destination as safely as possible.

The following data parameters contributed to determining the relative importance of each NWLON station and gap to safe and efficient marine navigation:

- Top 175 ports: The ports used in the analysis are the coastal ports with datum coverage or gaps in the top 175 ports (excluding those in the Great Lakes) as determined by NOAA using data from the U.S. Census and U.S. Army Corps of Engineers (USACE) Waterborne Commerce Statistics Center (WCSC) tonnage (Wolfe and MacFarland 2013; Wolfe 2018; Appendix A). This information was used to determine what NWLON stations may be utilized when navigating to or from a specific port.
- Automatic Identification Systems (AIS) Tracks: In the U.S., the Coast Guard and industry collect AIS data, a navigation safety device that transmits and monitors the location and characteristics of many vessels in U.S. and international waters in real-time. This dataset represents annual vessel transit counts from 2017 summarized at a 100 m by 100 m geographic area. A single transit is counted each time a vessel track passes through, starts, or stops within a 100 m grid cell. The AIS tracks were used to determine ship routes that passed through within a 100 km radius of a specific NWLON or a specific gap polygon.
- Tonnage: WCSC data (Goodhue et al. 2020; Appendix B) were used to represent the tonnage for principal U.S. ports and all 50 states and U.S. territories, domestic and foreign. The amount of tonnage was used to rank the importance of the NWLON stations that were in a 100 km radius from the nearest the port.
- U.S. Coast Guard Marine Information for Safety and Law Enforcement (MISLE) Accident, Collision, and Grounding (ACG) Data: The MISLE dataset (Goodhue et al. 2020) was filtered to only include allisions, collisions, and groundings by waterway to evaluate the need for NWLON stations for safety at each U.S. port. The total number of ACGs within the coverage area of an NWLON were included in the rankings.
- U.S. Census Data - Cargo Value (CV): U.S. Census data (Goodhue et al. 2020; Appendix B) was used to determine which U.S. ports handle the most cargo by value. The 2017 import and export values were combined for each port. The CV was used to investigate the value of cargo at each port within 100 km of an NWLON station.
- Vessel Call data: Both inbound and outbound vessel call data (Goodhue et al. 2020) were used to produce a table consisting of the total number of vessel calls at each U.S. port. The vessels were related to NWLON stations within 100 km of each port.
- Operational Nowcast and Forecast Hydrodynamic Model Systems (OFS): OFS models provide water level nowcast and forecast predictions in addition to currents, water temperature, and salinity, as well as interpolated winds. There are several OFS grids in the Atlantic, Gulf of Mexico, and Pacific that use data from NWLON

stations. NWLON stations used in the OFS were given higher priority than those not used in OFS.

- Tide Predictions: Over 3000 locations in the U.S. generate tide predictions at any point in the recent past or future. Reference stations in the tide tables were given higher priority than subordinate stations.

2.1.3 Sea-Level Monitoring

Monitoring long-term sea level change is a critical component of the NWLON. The NWLON is the nation's most extensive network of sea level information, with observational records dating back more than 100 years at many locations. These enable NOAA to provide authoritative guidance regarding long-term sea level change and future sea level projections. In addition, the NWLON enables monitoring higher-frequency variability in sea level, such as HTF, storm surge, and tsunamis. These sea-level monitoring capabilities are a critical requirement to consider when prioritizing value.

The following data parameters contributed to determining the importance of each NWLON station or gap to monitoring different aspects of sea level change.

- Population of coastal counties: Data from the 2010 Decennial Census and the 2012-2016 5-year estimates from the American Community Survey (ACS) were joined to U.S. coastal counties produced by the Census Bureau to produce visual representations of population and other select census statistics. Some county-level data was not reported by the Decennial Census or the ACS in the U.S. territories and therefore does not appear in this product. Areas with higher populations were considered more important for water level stations.
- Global Sea Level Observing System (GLOSS): GLOSS is a set of global water level stations that have been internationally identified for the detection and monitoring of long-term sea level trends and accelerations. NOAA CO-OPS operates and maintains 28 stations, 26 of which are currently active, and presents routinely-updated analyses of the long-term trends and variability. These stations are given higher priority in the analysis.
- High Tide Flooding Outlook and 2050 projected number of flood days: CO-OPS provides an outlook that predicts the number of days that HTF will occur in the future. The projected number of flood days for the year 2050 are also noted. The NWLON stations that are included in the High Tide Flooding Outlook and those that are projected to have a greater number of flood days in 2050 are considered higher priority.
- Length of time series: Sea level trends are determined after 30 years of data. The longer the data series, the more accurate the trend, and the more valuable the station is to understanding and monitoring long-term sea level change. Length of time series is determined as the number of years from the time of station establishment to 2019. The longevity of the NWLON stations is used to determine the importance of the station in determining regional sea level trends.
- Tsunami: CO-OPS NWLON stations can be set to collect data at a higher frequency during a suspected tsunami event. The Tsunami Warning Centers use the data to verify tsunami events along the coastline. NWLONs that are tsunami stations, funded by the NWS, are identified and given a higher weight than others.

- Storm Surge: The potential impact of significant storm surge events is estimated by calculating the return interval of a major flood as described in Sweet et al. (2018). This estimate is capped at 100 years for stations where a major flood is extremely unlikely or has never occurred.

2.2 Data Preparation

Once the data were obtained, ESRI's ArcGIS Pro was used to prepare the data and perform analysis. Data were also compared to existing CO-OPS data holdings to ensure accurate representation of datum coverage and gaps.

2.2.1 Tidal Datums

Identifying data discrepancies

The active NWLON stations were joined to their datum coverage shapefile polygons by using their station identification numbers, and some discrepancies were found. The discrepancies were due to the following factors:

1. Some stations were no longer operational but had a corresponding coverage polygon.
2. Some stations were new stations that do not have correlating datum coverage.
3. Other than Hawaii, Pacific Island stations were not included in the gaps analysis and thus could not be included here.

The following NWLON stations do not have corresponding datum coverage and are not included in the prioritization. These stations are either located in the Pacific Islands or were only recently installed (Table 1).

Table 1. National Water Level Observation Network (NWLON) stations without corresponding datum coverage.

Station ID	Station Name	Reason
1619910	Sand Island, Midway Islands	Pacific Island station
1630000	Apra Harbor, Guam	Pacific Island station
1770000	Pago Pago, American Samoa	Pacific Island station
1820000	Kwajalein, Marshall Islands	Pacific Island station
1890000	Wake Island, Pacific Ocean	Pacific Island station
8411060	Cutler Farris Wharf	New station installed in 2010
8635027	Dahlgren	New station installed in 2015
8638901	CBBT, Ches. Channel	New station installed in 2018
8762482	West Bank 1, Bayou Gauche	New station installed in 2003
8764044	Berwick, Atchafalaya River	New station installed in 2003

Station ID	Station Name	Reason
8772471	Freeport SPIP, Freeport Harbor	New station installed in 2020
8773767	Matagorda Bay Entrance Channel, TX	New station installed in 2016
9468333	Unalakleet	New station installed in 2016
9759394	Mayaguez	New station installed in 2006

The following station is active and had datum coverage in the datum gaps report but was not included in the analysis due to uncertainty in the vertical control related to the coverage area (Table 2).

Table 2. National Water Level Observation Network (NWLON) stations with uncertainty in the vertical control.

Station ID	Station Name	Reason
8760922	Pilots Station East, S.W. Pass	New station installed in 2004

The following stations have existing datum coverage, but the NWLON stations are no longer active.

Table 3. Non-active National Water Level Observation Network (NWLON) stations.

Station ID	Coverage	Reason
8411250	Cutler Naval Base	Station moved to Cutler Farris North
8635150	Colonial Beach, Potomac River	Station destroyed in 2003 by Hurricane Isabel, replaced by 8635027
8638863	Chesapeake Bay Bridge Tunnel	Station relocated in 2018 and replaced by 8638901
8770570	Sabine Pass, TX	Station removed in 2020. This station will be replaced by Texas Point.
8772447	USCG Freeport, TX	Station relocated in 2020 and replaced by 8772471
9759412	Aguadilla	Station destroyed by Hurricane Sandy in 2012
8762372	East Bank 1, Bayou LaBranche	Station damaged by Hurricane Isaac in 2012

The updated NWLON Coverage and Gaps layers were created by clipping with ESRI's higher resolution world water bodies layer for better accuracy of coastline representation. Polygons were cleaned using the erase analysis tool to eliminate the overlap of layer for NWLON coverage polygons with the layer for gaps polygons. As polygons representing NWLON coverage were determined by Gill (2014) using the Bodnar equation (Bodnar 1981), these polygons were used to delete any overlapping gap area.

2.2.2 Marine Navigation

The navigation analysis and prioritization is primarily derived from the top 175 ports (originally described in Wolfe and MacFarland 2013; updated by Wolfe 2017; Appendix A). The port tonnage, CV, and draft data (total vessel calls and vessels within 1 foot of maximum draft) for the top 175 ports (excluding those in the Great Lakes) were extracted from Goodhue et al. (2020), if available, then populated into a csv file and later converted to a separate database. This data was joined to the ports shapefile to be used in the analysis. The ACG data was determined by intersecting the ACG feature layer with the coverage or gap area layers.

2.2.3 Sea-Level Monitoring

Coastal populations were calculated to enable the analysis for sea-level monitoring. The total coastal population associated with each NWLON station was calculated by adding populations from all coastal counties adjacent to the NWLON coverage polygon. The total county population was used even though it may overcount the actual coastal population directly affected by coastal flooding. Some NWLON stations or gaps did not have any population associated with them due to missing or incomplete coastal population data for those regions.

2.3 GIS Analysis

As mentioned in step 1, the prioritization of NWLON stations and gaps are based on 3 major categories: tidal datums, marine navigation, and sea-level monitoring. Each category has its own associated parameters that were analyzed and determined by Esri ArcGIS Pro tools. The GIS analysis results were then exported, and corresponding values associated with each NWLON station and gap were populated in a spreadsheet. The values for each parameter were normalized using the top 10 percentile value to eliminate the influence of outliers with 1 having the highest priority and 0 the least. Some of the qualitative parameters were given *yes* or *no* responses. In those instances, a *yes* is valued at 1 and a *no* is 0. Then the normalized parameters under each category were summed to get a total for each category. In order to give the same weight for each category, the totals of each category were then further normalized by the highest summation value of each category. This process ensures that tidal datums, marine navigation, and sea-level monitoring are weighted equally when calculating the total prioritization. The normalized category totals were summed to obtain the total prioritization value for the NWLON stations and gaps. These total values were nationally ranked to show the prioritization of a given NWLON coverage or a gap.

The prioritization values were joined to the NWLON stations and coverage gap shapefiles in ArcGIS Pro Map to rank and visualize the results. The values were classified by quantile to rank the relative importance of specific NWLON stations and gaps. The rankings are in 5 categories: high, medium high, medium, medium low, and low. The overall prioritization for the NWLON stations and coverage gaps are visually represented together, and the separate prioritization factors of tidal datums, marine navigation, and sea-level monitoring are represented for the NWLON stations. The GIS analysis was performed for each parameter under the 3 categories.

2.3.1 Tidal Datums

The process for prioritizing the datum category includes determining the area of single datum coverages; identifying the control stations and how many subordinate stations they control;

counting the number of subordinate stations; and identifying the stations that support the CO-OPS Discrete Tidal Zoning Map. GIS tools were used to identify stations that are covered by only their own datum (single coverage stations). Shoreline extent along the coverage area of single coverage stations and along gaps were analyzed by clipping shoreline data against coverages and gaps polygons and then calculating the perimeter of that extent in kilometers. Coverage area for single coverage stations was also calculated in square kilometers. Additionally, the number of subordinate stations in a coverage area or gap and those controlled by a given NWLON control station were summarized and enumerated. As support for Discrete Tidal Zoning is a qualitative parameter: a value of 1 is given for presence and a value of 0 for absence.

Once GIS analysis is completed for each parameter, the corresponding table is exported and values corresponding to each NWLON station or gap are populated in the master spreadsheet. Each parameter is then normalized using the top 10 percentile values described above and totaled across all datum parameters. Finally, these total datum values were normalized by the maximum value resulting in a range from 0 to 1.

2.3.2 Marine Navigation

The navigation prioritization is primarily based on seaports (or ports) and AIS track data. The ports associated with each NWLON coverage were assessed by counting all ports within a 100 km radius of a specific NWLON station. This approach was used to approximate which NWLON stations may be used while navigating to and from a port. Based on the 100 km distance, some ports may be associated with more than 1 NWLON station. If there is more than 1 port within the range of 1 NWLON station, the values for each port were combined to obtain values associated with that NWLON. Counting ports associated with gaps followed a similar process; however, in this case, we totaled ports within gap polygons, as there is no single point location to use for a similar 100 km radius. The number of AIS tracks, or number of vessels, were clipped and linked to the NWLON coverage and gap areas. However, there is not any AIS track/number of vessel data for Hawaii or U.S. territories, and thus this data could not be included for those regions. The tonnage, CV, ACGs, draft data, and number of vessels were normalized using the top 10 percentile values as discussed above. NWLON stations were identified that were in OFS grids and in Tide Prediction tables. These qualitative parameters were given a 1 or 0 value. Once all parameters are totaled, they are normalized by the maximum navigation value resulting in a range from 0 to 1.

2.3.3 Sea-Level Monitoring

There are 7 parameters used to prioritize sea-level monitoring. NWLON stations are identified as included in the High Tide Flooding Outlook, and the median value for the range of projected number of flood days in 2050 was utilized as an approximation for how important information on future flooding may be at a particular location. Storm surge/inundation estimates are provided for each NWLON station based off the return period for a major flood. While the longevity, or length of the time series, of the NWLON stations accounts for the importance of monitoring SLR. Stations are also listed as *yes/no* (1 or 0) if included in GLOSS and the NWS tsunami program which are both important for international coastal hazards monitoring. Coastal county populations were totaled by intersecting the NWLON or gap polygon with the coastal counties to find which counties were touching which polygons.

The resulting data were exported to a database table and populated to the master spreadsheet. The qualitative (1 or 0) parameters for sea-level monitoring include High Tide Flooding Outlook, the GLOSS network, or tsunami program station. The other parameters were normalized using the top 10 percentile as discussed above. Again, as with the other categories, the parameters are totaled and normalized to a range of 0 to 1.

3.0 RESULTS

The findings from the GIS analysis are described below and visually represented in the accompanying figures. The prioritization rankings are across all regions, but they are mapped regionally for visualization purposes. The maps are represented by the following regions: Northeast and Mid-Atlantic (northeast Maine to Virginia); Southeast and the Gulf of Mexico (North Carolina to the Texas/Mexico border); West Coast (California to Washington); Alaska; Hawaii; and Puerto Rico and the U.S. Virgin Islands.

3.1 Northeast and Mid-Atlantic

The Northeast and Mid-Atlantic regions include 34 existing NWLON stations and 27 NWLON gaps (26 polygons as 2 gaps are combined, Appendix E1) from northeast Maine to Virginia. Three of the existing stations (Cutler Farris Wharf, ME; Dahlgren, VA; and the new Chesapeake Bay Bridge Tunnel, VA) were recently installed and excluded from the overall rankings since they do not yet have a datum coverage area.

The stations with the highest overall priority in this region include Sandy Hook, NJ; Newport, RI; Boston, MA; The Battery, NY; and Portland, ME (Figure 1; Appendix C1). These stations are ranked highly due to a combination of relatively high importance of all tidal datums, marine navigation, and sea-level monitoring (Figures 2-5). Sandy Hook and The Battery rank in the top 10 nationally for the navigation category as they support a number of large ports, including the Port of New York and New Jersey, and Newark. The other 3 stations have slightly lower ranks for navigation but are all in the top 50% of all NWLON stations nationally.

All of these top 5 stations also rank highly in importance to sea-level monitoring as they are positioned closely to large coastal populations, are likely to see substantial HTF by 2050, and have time series extended back to at least 1930. Though ranked 7th overall in the region, the station at Atlantic City, NJ, is 2nd nationally for sea-level monitoring as it was established in 1911, is expected to experience 65-155 HTF days per year by 2050 and supports a relatively large coastal population. Lastly, with the exception of The Battery, the other top 4 stations all rank highly in regard to datums in the regions due to supporting a large number of subordinate stations (each of the 4 stations support at least 23 subordinate stations) and, in the case of Boston, a substantial single datum coverage coastline (about 600 km). Portland, ME, which comes in as 5th overall in the Northeast and Mid-Atlantic, ranks the highest nationally in regard to datum coverage due to over 1000 km of coastline with single datum coverage and control of 33 subordinate stations.

Stations with the lowest overall priority in this region include Ocean City Inlet, NJ; Bishops Head, MD; Eastport, ME; Woods Hole, MA; and Yorktown, VA. This is due to having relatively low importance to sea-level monitoring with the exception of Woods Hole (shorter and/or disjointed time series; not included in High Tide Flooding Outlook); to tidal datums (with the exception of Woods Hole, none of the stations provide single coverage of primary datum control, and all control less than 5 subordinate stations); and to marine navigation (all experience relatively low ship traffic and do not directly support any large ports).

The 3 most important gaps in the region are Great South Bay, NY; Great Egg Harbor and Barnegat Bay, NJ; and Southern Shore, Outer Coast, LI (Figures 1, 3-5; Appendix D1). These stations rank high largely due to the importance of tidal datums and sea-level monitoring. In particular, all 3 stations support a relatively large coastal population and have at least 8 subordinate stations within each of their gap areas.

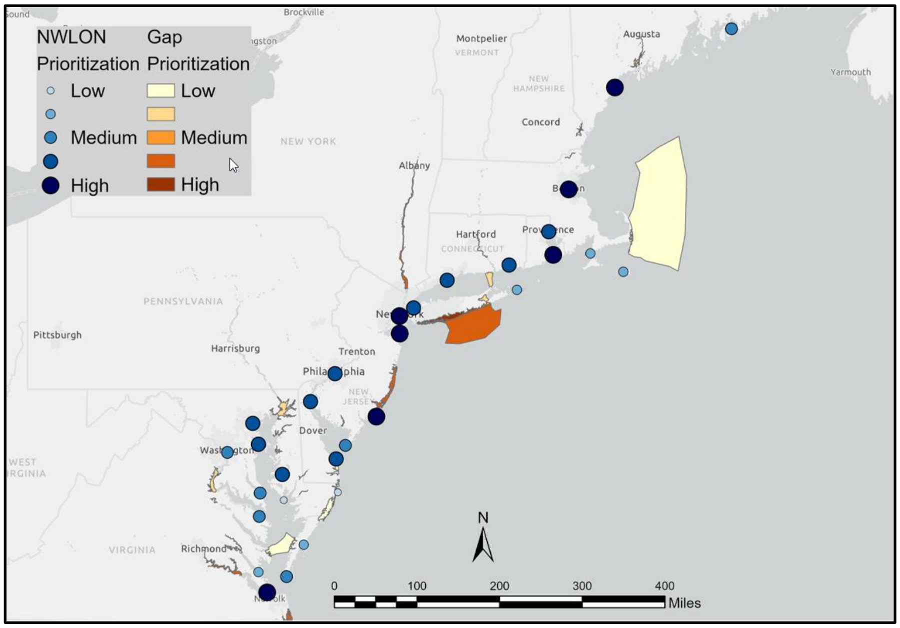

Figure 1. A map of the location of National Water Level Observation Network (NWLON) stations and coverage gaps along the U.S. Northeast and Mid-Atlantic coast. The stations are represented by light to dark blue colored circles and the coverage gaps are represented by light yellow to brown colored polygons. Larger symbols (for the stations) and darker colors (for both) indicate relatively greater priority or importance.

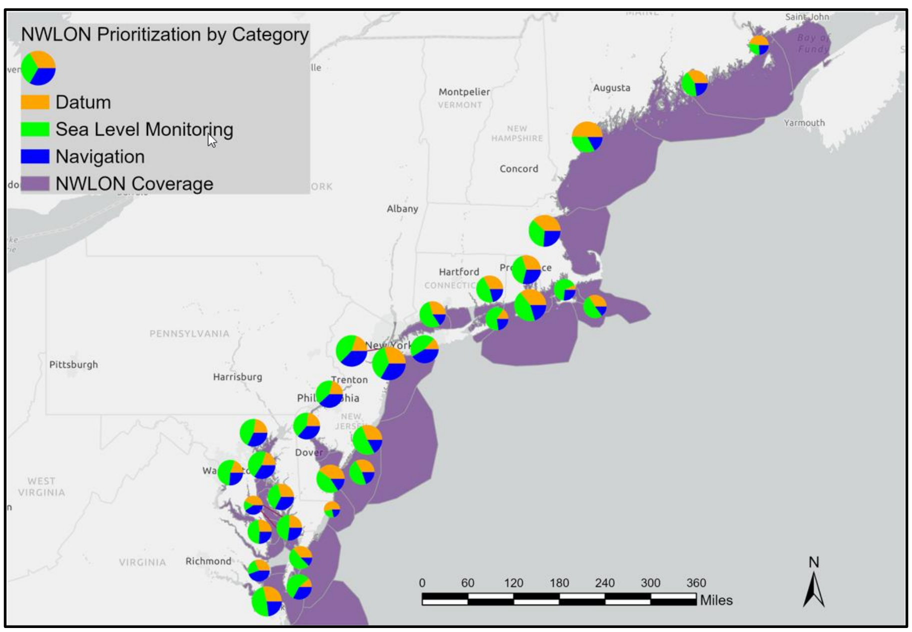

Figure 2. A map of National Water Level Observation Network (NWLON) stations and their coverages along the U.S. Northeast and Mid-Atlantic coast with pie charts showing the percentage of contribution of marine navigation (blue), sea-level monitoring (green), and tidal datums (orange) factors to the overall prioritization score. The size of the circles indicates the overall priority of the station and the purple polygons represent NWLON coverages.

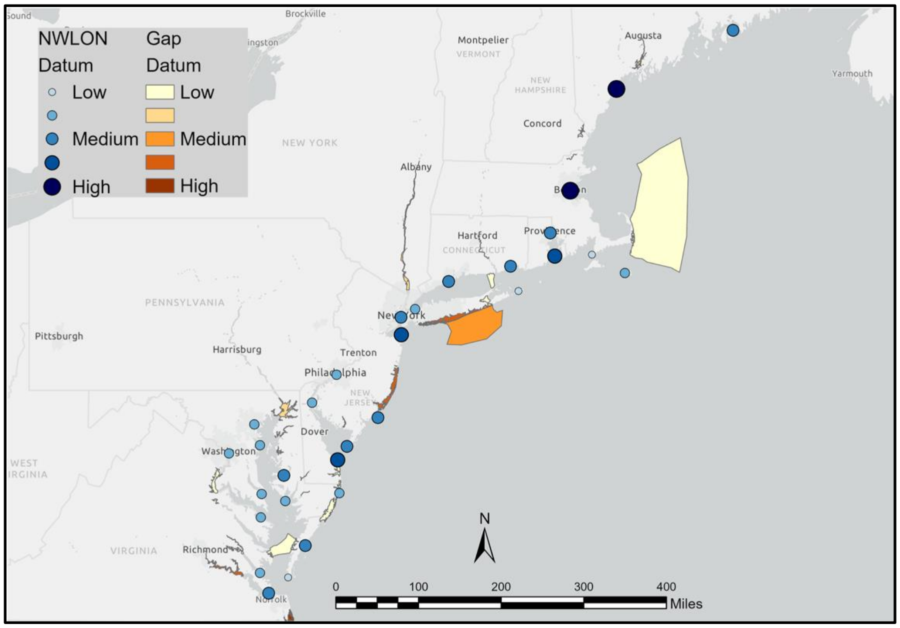

Figure 3. A map showing the relative importance of National Water Level Observation Network (NWLON) stations and coverage gaps along the U.S. Northeast and Mid-Atlantic coast for tidal datums. The stations are represented by light to dark blue colored circles and the coverage gaps are represented by light yellow to brown colored polygons. Larger symbols (for the stations) and darker colors (for both) indicate relatively greater priority or importance.

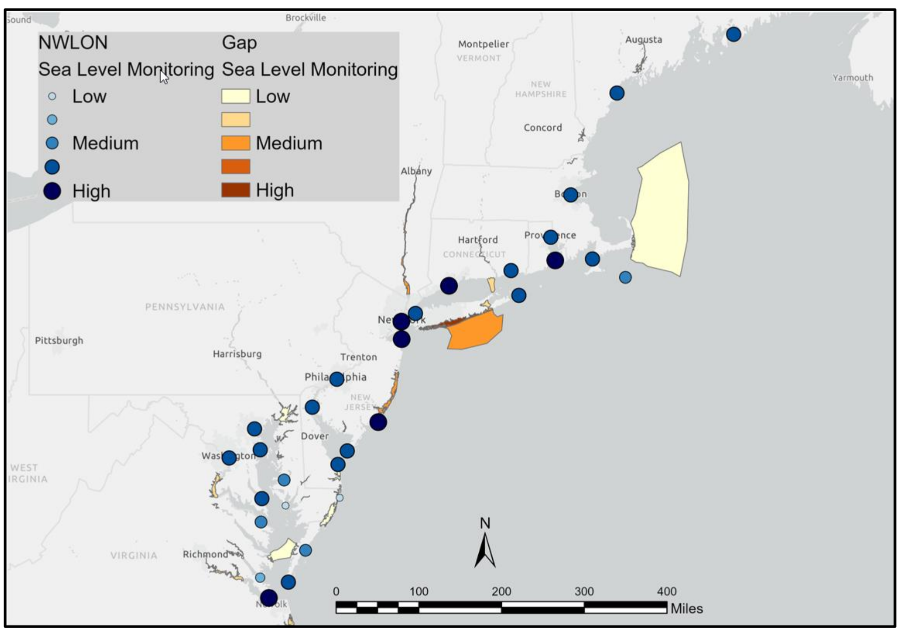

Figure 4. A map showing the relative importance of National Water Level Observation Network (NWLON) stations and coverage gaps along the U.S. Northeast and Mid-Atlantic coast for sea-level monitoring. The stations are represented by light to dark blue colored circles and the coverage gaps are represented by light yellow to brown colored polygons. Larger symbols (for the stations) and darker colors (for both) indicate relatively greater priority or importance.

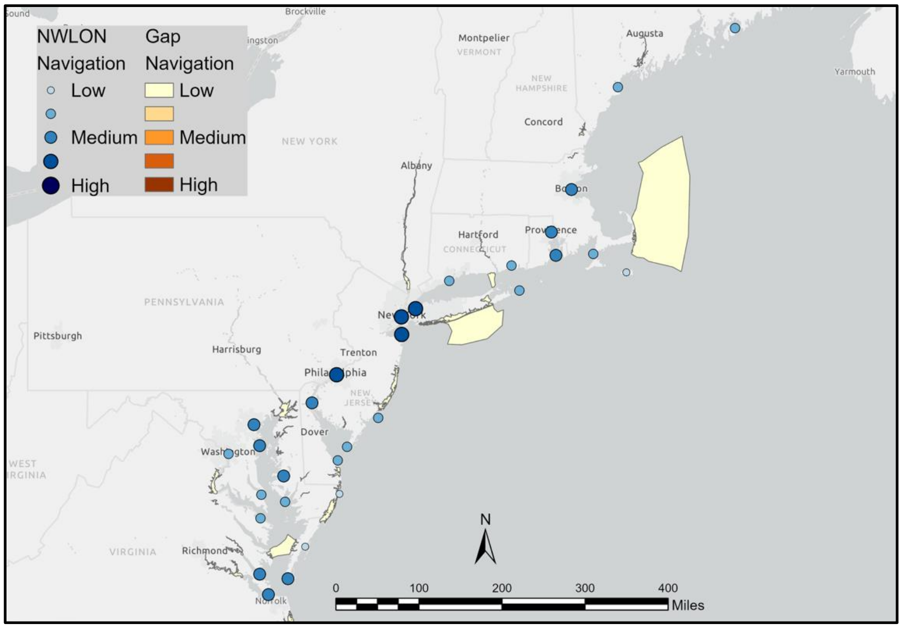

Figure 5. A map showing the relative importance of National Water Level Observation Network (NWLON) stations and coverage gaps along the U.S. Northeast and Mid-Atlantic coast for marine navigation. The stations are represented by light to dark blue colored circles and the coverage gaps are represented by light yellow to brown colored polygons. Larger symbols (for the stations) and darker colors (for both) indicate relatively greater priority or importance.

3.2 Southeast and Gulf

The Southeast and Gulf of Mexico region has 47 NWLON stations and 44 NWLON gaps (with only 32 gaps ranked, as several gaps are combined; Appendix E2) from North Carolina to the Texas/Mexico border. Four of the existing stations (West Bank 1, Bayou Gauche; Berwick, Atchafalaya River; Freeport SPIP, Freeport Harbor; and Matagorda Bay Entrance Channel, TX) were recently installed, and although those stations are included on the map, they were excluded from the overall rankings since they do not yet have a tidal datum coverage area. Pilots Station East, S.W. Pass, has a datum coverage area based on data from 2004-2008 and is on the map, but due to some uncertainty in the vertical control, it is not included in the analysis, either.

The stations with the highest overall priority in this region include Ft. Pulaski, GA; Grand Isle, LA; Bay Waveland Yacht Club, MS; Charleston, SC; and Key West, FL (Figure 6; Appendix C2). Fort Pulaski, Grand Isle, and Bay Waveland are ranked in the top 10 NWLON stations across the entire country. All 5 stations are also the top 5 stations for tidal datum coverage in this region and part of the top 10 stations nationally, due in part to the large single datum coverage of the shoreline (approximately 900, 1200, 800, 600, and 300 km, respectively). These stations also provide datum control to numerous subordinate stations (26, 27, 23, 87, and 86, respectively).

The stations in this region reflect a varied use of importance (Figures 7-10; Appendix C2). For example, Galveston Entrance Channel (ranked 16th overall in the region) and Galveston Pier 21 (ranked 8th overall in the region), TX, rank as the top 2 stations that support navigation in this region as well as nationally, but Galveston Pier 21 ranks in the bottom 5 regionally for tidal datum importance primarily due to having only 18 years of data and not many subordinate stations in its coverage. Galveston Pier 21 is a GLOSS station, important for monitoring sea level around the globe, and is also projected to have over 100 days of flooding in 2050, so it ranks in the top 5 for sea-level monitoring in the region and top 20 nationally. Galveston Entrance Channel, with only

7 years of data, ranks in the bottom 5 for sea-level monitoring, despite having a relatively high return interval of 10 years for major flooding.

Grand Isle, Calcasieu Pass, and Lake Charles, all in Louisiana, are the remaining top 5 stations for marine navigation regionally. Calcasieu Pass and Lake Charles are ranked in the bottom 5 for sea-level monitoring, mostly due to only having 16 years of data each, and in the case of Lake Charles, a 100-year return rate for flooding interval. In addition to Galveston Pier 21, Fort Pulaski, Bay Waveland, Pensacola, FL, and Duck, NC, round out the top 5 for sea-level monitoring in the region, mostly due to a long time series of data, importance in the international community, and their projection for a large number of flooding days expected in 2050.

Stations ranking overall in the lower tier in this region include Mobile, AL; Wrightsville Beach, NC; Fort Myers, FL; Berwick, LA; and USCG Station Hatteras, NC. This is due to a relatively lower importance for tidal datums—as they have small coverage areas or overlap with other NWLON coverage—or marine navigation, with the exception of Mobile, AL, as there are no major port facilities nearby. Wrightsville Beach ranks in the bottom 5 for sea-level monitoring, as well.

The top 3 NWLON gaps in the region are Houston Ship Channel, Upper Galveston Bay, and East Bay, TX; Inner Bays, Indian River, FL; and Upper St. Johns River, FL (Figures 6, 8-10; Appendix D2). These are 3 out of the top 4 gaps across the entire U.S. The high rankings are based on their importance for sea-level monitoring due to supporting a large coastal population or marine navigation due to the number of accidents and vessels transits in the region. Note that the following partner stations presently fill these gaps: Houston Ship Channel, Upper Galveston Bay, and East Bay, TX, presently filled by partner Texas Coastal Ocean Observation Network station; Inner Bays, Indian River, FL, which will be filled by the Florida Department of Environmental Protection; and Upper St. Johns River, FL, presently filled by partner Jacksonville Port Authority.

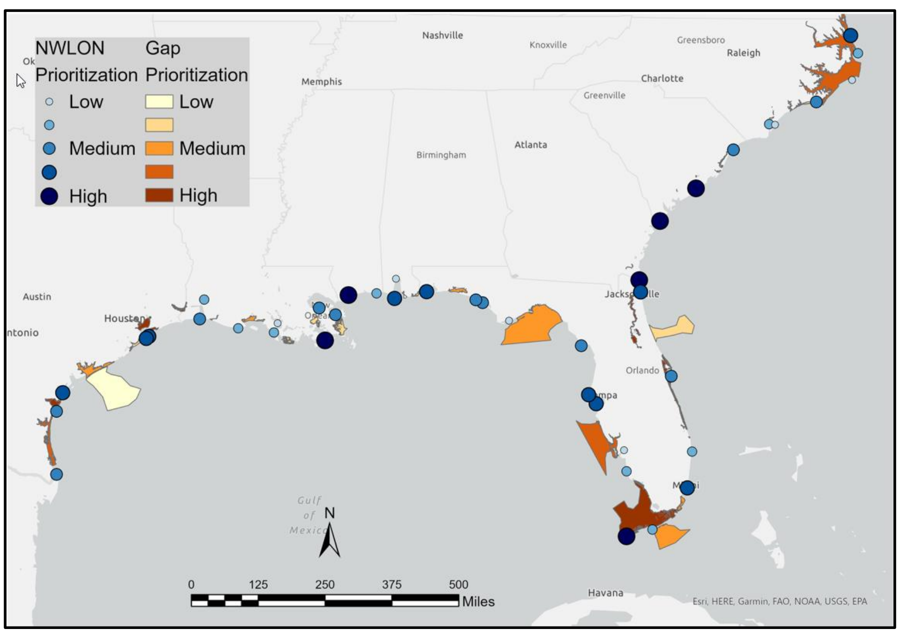

Figure 6. A map of the location of National Water Level Observation Network (NWLON) stations and coverage gaps along the U.S. Southeast and Gulf coast. The stations are represented by light to dark blue colored circles and the coverage gaps are represented by light yellow to brown colored polygons. Larger symbols (for the stations) and darker colors (for both) indicate relatively greater priority or importance.

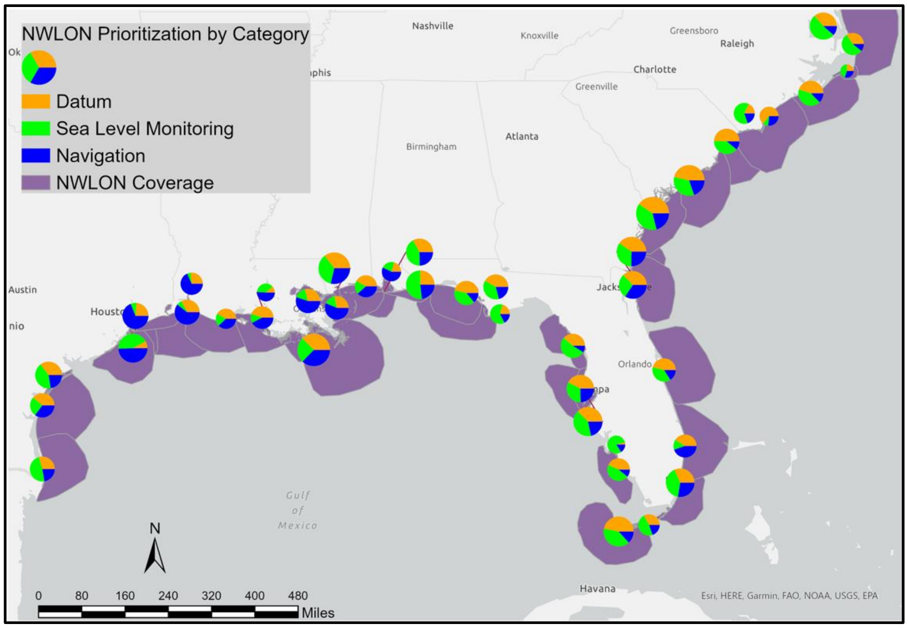

Figure 7. A map of National Water Level Observation Network (NWLON) stations and their coverages along the U.S. Southeast and Gulf coast with pie charts showing the percentage of contribution of marine navigation (blue), sea-level monitoring (green), and tidal datums (orange) factors to the overall prioritization score. The size of the circles indicates the overall priority of the station and the purple polygons represent NWLON coverages.

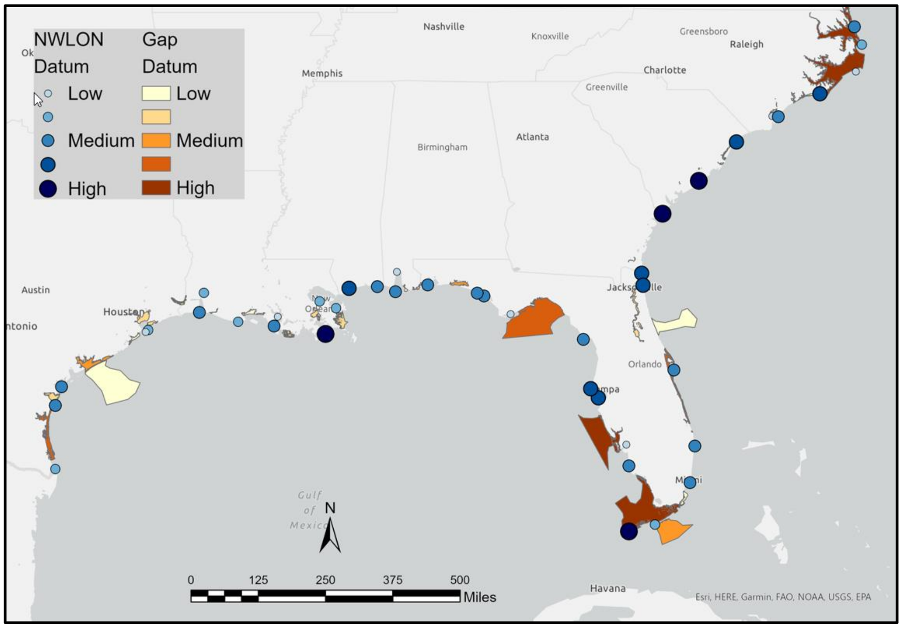

Figure 8. A map showing the relative importance of National Water Level Observation Network (NWLON) stations and coverage gap along the U.S. Southeast and Gulf coasts for tidal datums. The stations are represented by light to dark blue colored circles and the coverage gaps are represented by light yellow to brown colored polygons. Larger symbols (for the stations) and darker colors (for both) indicate relatively greater priority or importance.

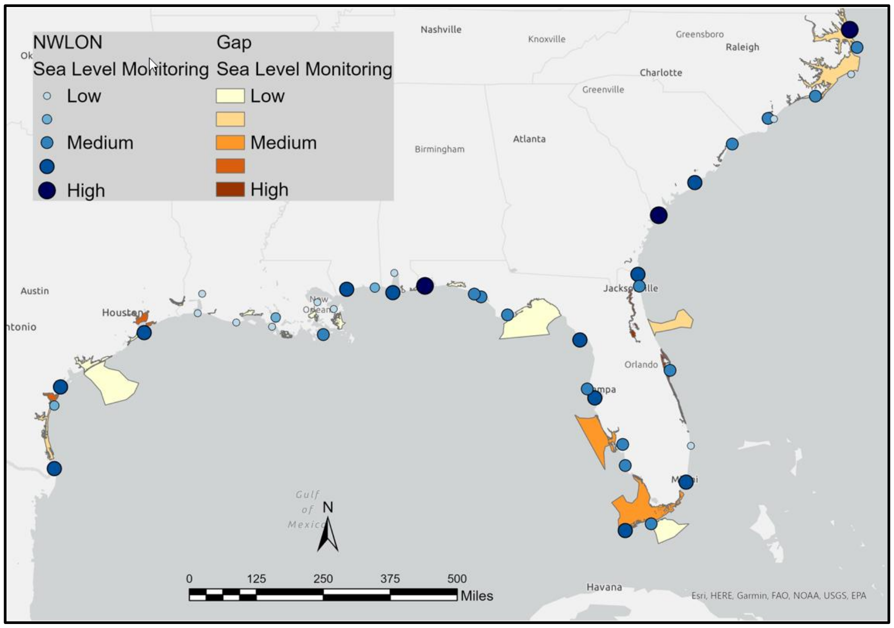

Figure 9. A map showing the relative importance of National Water Level Observation Network (NWLON) stations and coverage gaps along the U.S. Southeast and Gulf coast for sea-level monitoring. The stations are represented by light to dark blue colored circles and the coverage gaps are represented by light yellow to brown colored polygons. Larger symbols (for the stations) and darker colors (for both) indicate relatively greater priority or importance.

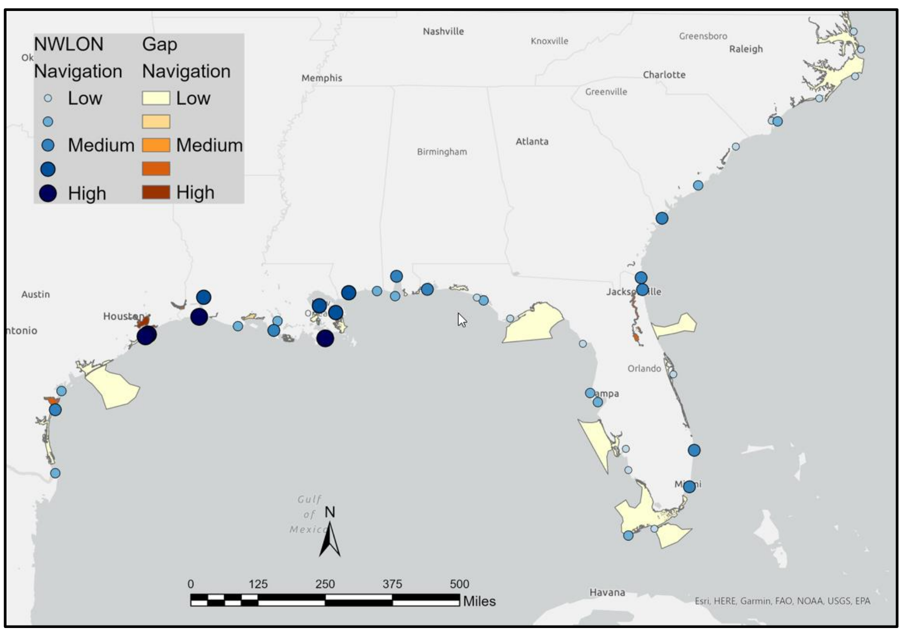

Figure 10. A map showing the relative importance of National Water Level Observation Network (NWLON) stations and coverage gaps along the U.S. Southeast and Gulf coast for marine navigation. The stations are represented by light to dark blue colored circles and the coverage gaps are represented by light yellow to brown colored polygons. Larger symbols (for the stations) and darker colors (for both) indicate relatively greater priority or importance.

3.3 West Coast

The West Coast has 29 NWLON stations and 6 NWLON gaps (5 polygons ranked as 2 gaps are combined; Appendix E3) from the Washington/Canada border to the California/Mexico border. The top priority stations for this region are San Francisco, CA; Los Angeles, CA; Alameda, CA; Point Rey, CA; and Port Chicago, CA (Figure 11; Appendix C3). These stations are highly ranked, mainly due to their importance for marine navigation (Figures 12 and 15; Appendix C3). In fact, these stations are the top 6 stations for navigation in this region (Santa Monica is the additional station ranking 4th for navigation), and all are in the top 15 priority overall for the entire nation for navigation. These stations see some of the most tonnage and vessel calls, as well as ACGs in the region.

San Francisco, CA; Point Rey, CA; Port Chicago, CA; Crescent City, CA; and Seattle, WA, are of top 5 importance for tidal datum in the region (Figures 12 and 13; Appendix C3), which is due to either a large datum coverage, large single shoreline distance coverage for datums, or the number of subordinate stations for which they provide control.

While Crescent City is ranked high for tidal datum, it is ranked in the bottom 5 for both sea-level monitoring and marine navigation, mainly due to a smaller population center and the station not being important for monitoring HTF.

Stations in this region important for sea-level monitoring are La Jolla, CA; San Francisco, CA; San Diego, CA; Los Angeles, CA; and South Beach, OR (Figures 12 and 14; Appendix C3). These stations are highly ranked for sea-level monitoring due to their lengthy time series records, inclusion in HTF outlooks, or importance as international GLOSS stations.

Stations ranked overall in the lowest priority in this region are: Cherry Point, WA; Port Angeles, WA; North Spit, CA; Longview, WA; and Neah Bay, WA. These rank low because of their relative lack of importance for tidal datums, their overlap with other stations, and their lack of importance for sea-level monitoring due to large return intervals for flooding and their shorter time series.

There are only 6 NWLON gaps identified on the West Coast. The top 3 NWLON gaps in this region are Upper Columbia River, OR; South San Francisco Bay, CA; and Stockton River Delta and Sacramento River Delta, CA (which are considered 1 gap; Figures 11, 13-15; Appendix D3). These are mainly due to population density, as well as tidal datum importance. Navigation plays a role in the Upper Columbia River, as well.

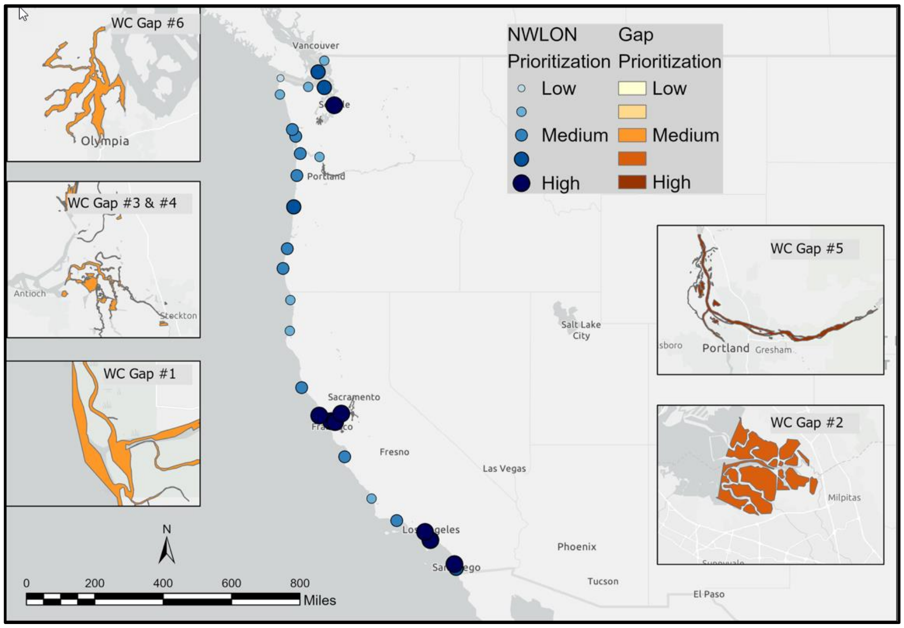

Figure 11. A map of the location of National Water Level Observation Network (NWLON) stations and coverage gaps along the U.S. West coast. The stations are represented by light to dark blue colored circles and the coverage gaps are represented by light yellow to brown colored polygons. Larger symbols (for the stations) and darker colors (for both) indicate relatively greater priority or importance.

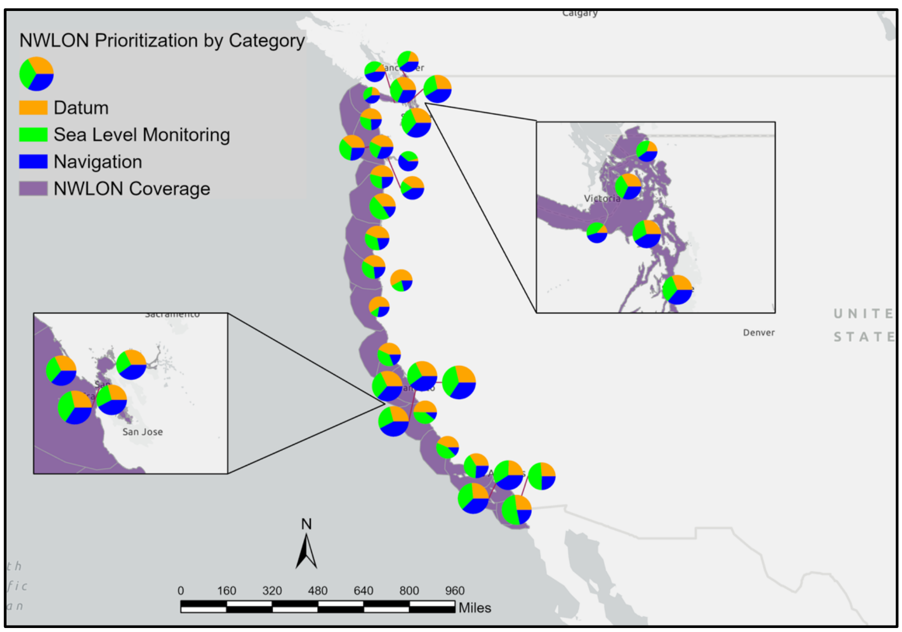

Figure 12. A map of National Water Level Observation Network (NWLON) stations and their coverages along the U.S. West coast with pie charts showing the percentage of contribution of marine navigation (blue), sea-level monitoring (green), and tidal datums (orange) factors to the overall prioritization score. The size of the circles indicates the overall priority of the station and the purple polygons represent NWLON coverages.

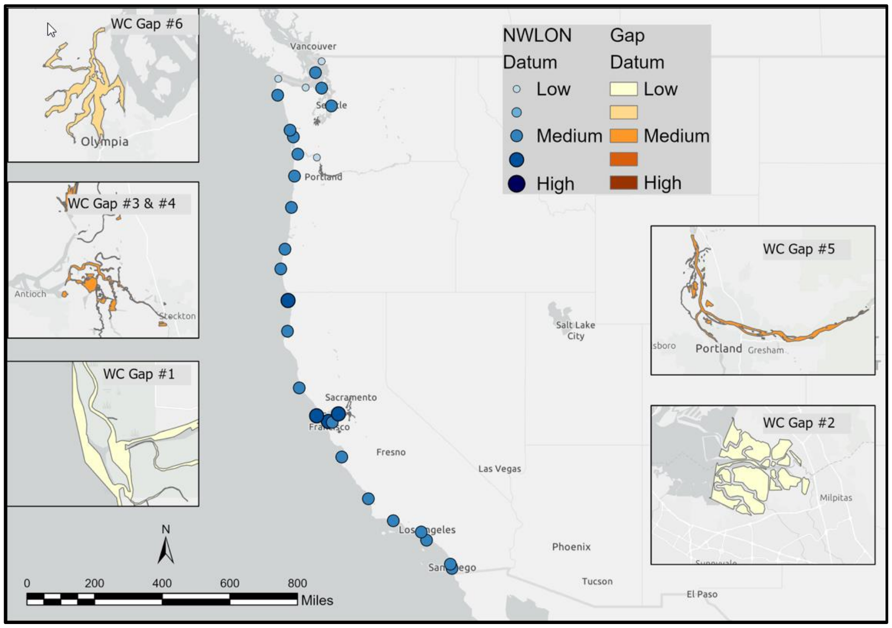

Figure 13. A map showing the relative importance of National Water Level Observation Network (NWLON) stations and coverage gaps along the U.S. West coast for tidal datums. The stations are represented by light to dark blue colored circles and the coverage gaps are represented by light yellow to brown colored polygons. Larger symbols (for the stations) and darker colors (for both) indicate relatively greater priority or importance.

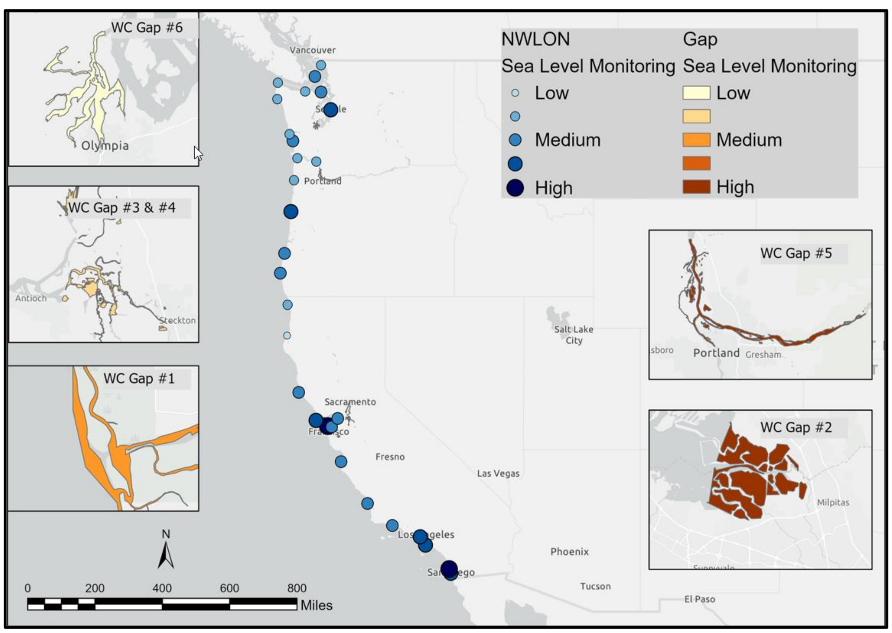

Figure 14. A map showing the relative importance of National Water Level Observation Network (NWLON) stations and coverage gaps along the U.S. West coast for sea-level monitoring. The stations are represented by light to dark blue colored circles and the coverage gaps are represented by light yellow to brown colored polygons. Larger symbols (for the stations) and darker colors (for both) indicate relatively greater priority or importance.

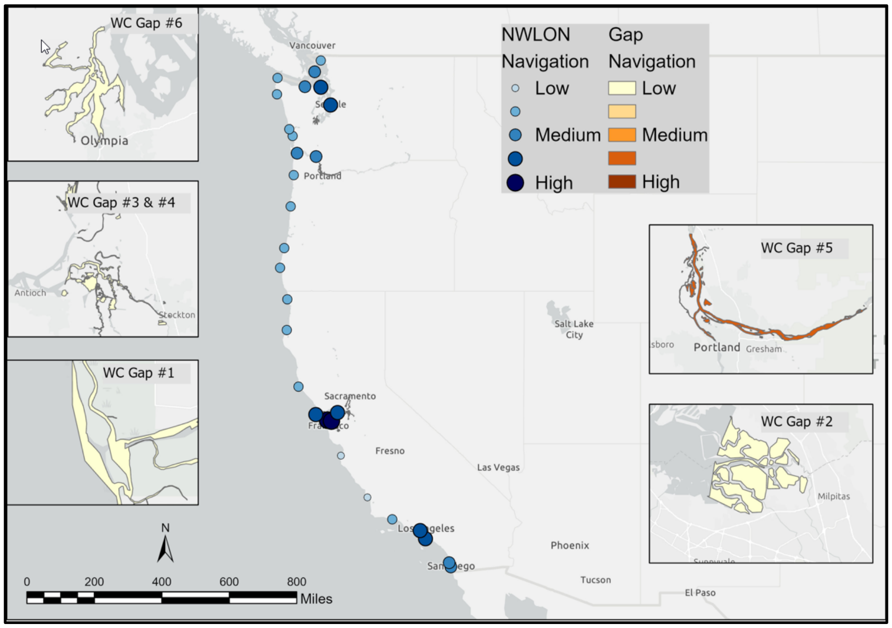

Figure 15. A map showing the relative importance of National Water Level Observation Network (NWLON) stations and coverage gaps along the U.S. West coast for marine navigation. The stations are represented by light to dark blue colored circles and the coverage gaps are represented by light yellow to brown colored polygons. Larger symbols (for the stations) and darker colors (for both) indicate relatively greater priority or importance.

3.4 Alaska

There are 27 NWLON stations in Alaska and 32 gaps, (21 ranked, as some of the gaps are combined; Appendix E4). The spatial extent and complexity of the Alaskan coastline leads to the greatest number of gaps in any state in the U.S. and nearly a quarter of all gaps identified. All Alaskan stations have an NWLON coverage polygon defined, with the exception of Unalakleet, since it was only established in 2011. Port Moller was recently re-established after a roughly 3-year gap, so the data used for ranking relies on the data collected up to August 2017.

The top 5 stations in Alaska are Ketchikan, Alitak, Seward, Seldovia, and King Cove (Figure 16; Appendix C4), with the top 2 stations (Ketchikan and Alitak) ranked nationally fairly far ahead of the remaining 3. Each of the top 5 stations are the only NWLON stations with tidal datum coverage for a substantial length of coastline (all exceeding 700 km of single coverage), and Ketchikan provides primary tidal datum control for 39 stations, resulting in one of the highest datum priority rankings in the nation. Stations ranked 6-11 in Alaska are fairly close in normalized score, mostly due to being ranked relatively high from a datums perspective, as well (all within the top 35 nationally).

Outside of tidal datums, however, all stations in Alaska are relatively low in importance for both marine navigation and sea-level monitoring compared to the rest of the NWLON network (Figure 17, 19, and 20; Appendix C4). This is driven in large part due to the relatively low coastal populations, limited marine traffic, and relatively small and sparsely located seaports. Further, due to land uplift in many Alaska station locations, HTF projections are not established since most locations will become less impacted by coastal flooding by 2050.

The lowest priority stations in Alaska include Village Cove, Skagway, Atkai, Port Moller, and Nikolski. These are low priority in part because they have relatively short time series (all with less than 40 years of data). The short data record means they are not yet important for sea-level monitoring and also have relatively low tidal datum importance since they don't yet provide primary datum control for any stations (though this could change for the next epoch update).

Further, the value to sea-level monitoring is lower since the regions are relatively sparsely populated. They are also some of the lowest ranked stations of all NWLON for marine navigation as there is very little documented ship traffic and there aren't any large ports nearby.

Of the many gaps in the Alaska region, the most important to address are North Side Aleutians (containing 4 gaps), Aleutian Islands, South Side (containing 3 gaps), Port Wrangell, and Shelikof Straits (Appendix E4). These are ranked highly (top 20 gaps nationally; Figures 16, 18-20; Appendix D4) primarily due to tidal datum coverage, as they each would support several existing subordinate stations (at least 5 subordinate stations for each gap) and provide datum coverage to a large expanse of coastline (all exceeding 2300 km). North Side Aleutians also has a port within its coverage areas, increasing the importance to marine navigation. Many of the remaining AK gaps rank relatively lower, as they would support fewer or no subordinate stations and have no recorded shipping statistics due to a lack of major ports.

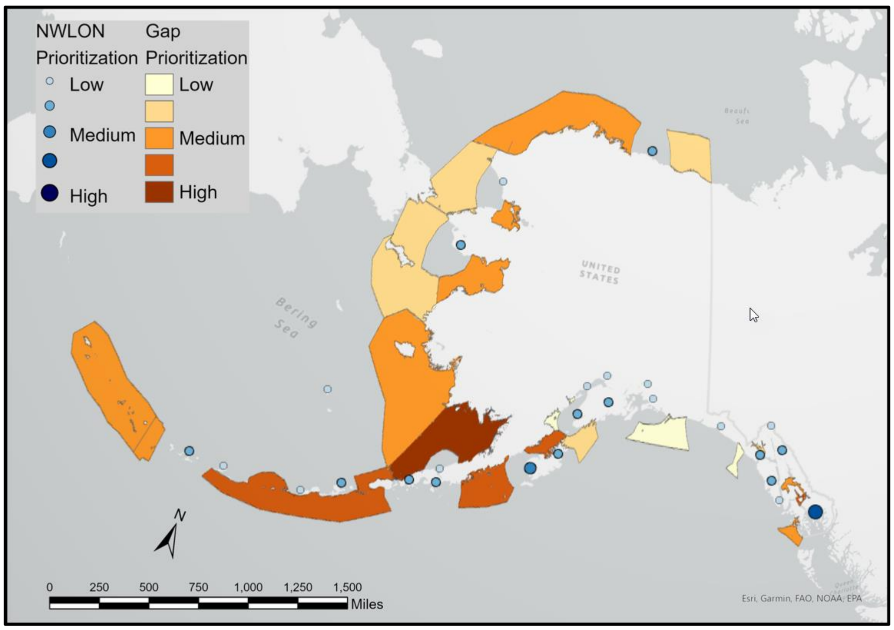

Figure 16. A map of the location of National Water Level Observation Network (NWLON) stations and coverage gaps along the Alaska coast. The stations are represented by light to dark blue colored circles and the coverage gaps are represented by light yellow to brown colored polygons. Larger symbols (for the stations) and darker colors (for both) indicate relatively greater priority or importance.

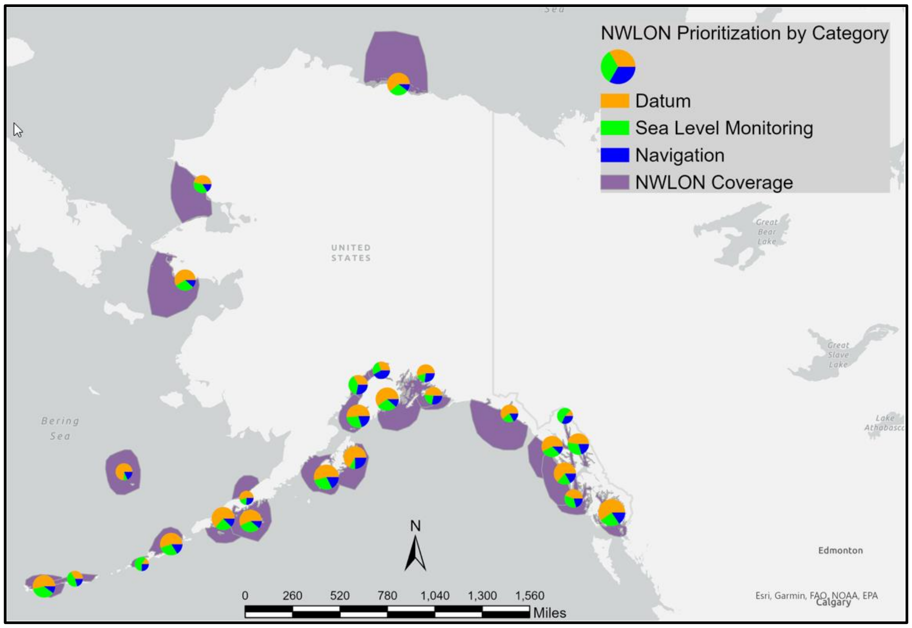

Figure 17. A map of National Water Level Observation Network (NWLON) stations and their coverages along the Alaska coast with pie charts showing the percentage of contribution of marine navigation (blue), sea-level monitoring (green), and tidal datums (orange) factors to the overall prioritization score. The size of the circles indicates the overall priority of the station and the purple polygons represent NWLON coverages.

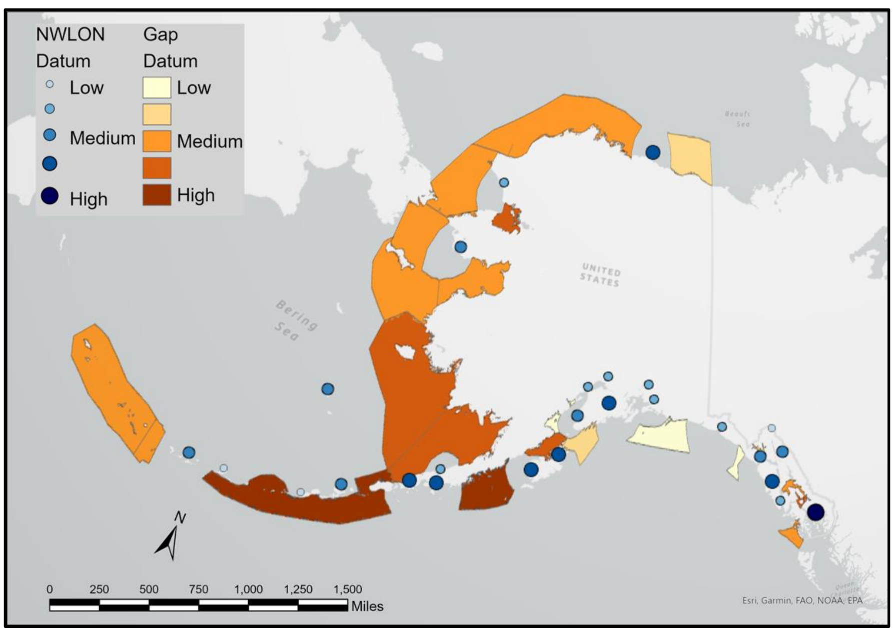

Figure 18. A map showing the relative importance of National Water Level Observation Network (NWLON) stations and coverage gaps along the Alaska coast for tidal datums. The stations are represented by light to dark blue colored circles and the coverage gaps are represented by light yellow to brown colored polygons. Larger symbols (for the stations) and darker colors (for both) indicate relatively greater priority or importance.

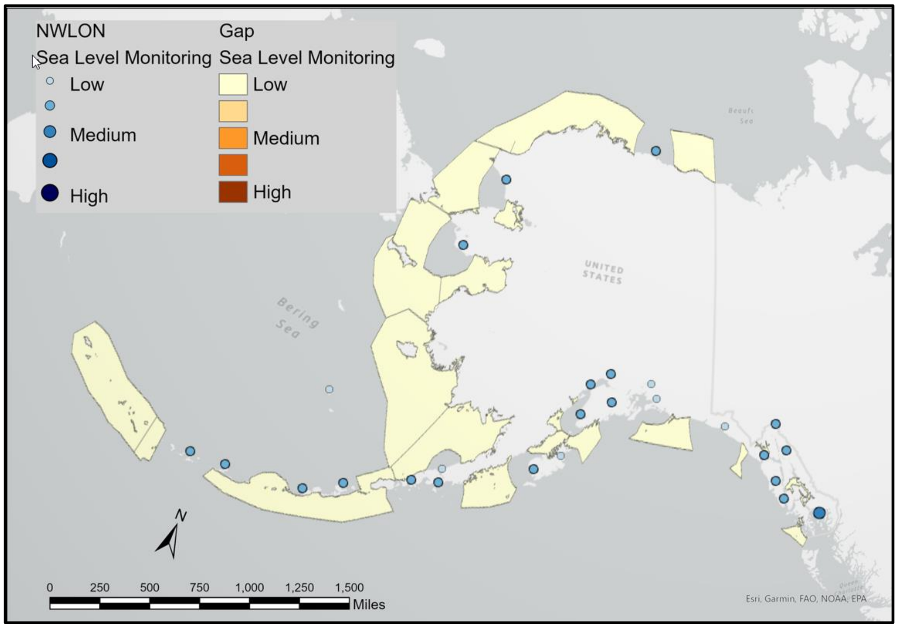

Figure 19. A map showing the relative importance of National Water Level Observation Network (NWLON) stations and coverage gaps along the Alaska coast for sea-level monitoring. The stations are represented by light to dark blue colored circles and the coverage gaps are represented by light yellow to brown colored polygons. Larger symbols (for the stations) and darker colors (for both) indicate relatively greater priority or importance.

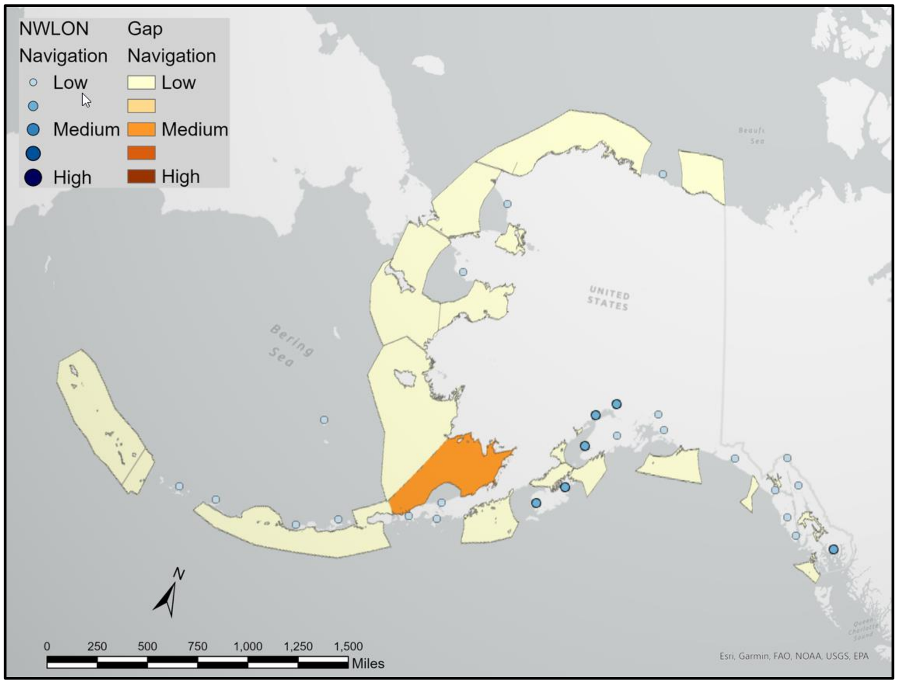

Figure 20. A map showing the relative importance of National Water Level Observation Network (NWLON) stations and coverage gaps along the Alaska coast for marine navigation. The stations are represented by light to dark blue colored circles and the coverage gaps are represented by light yellow to brown colored polygons. Larger symbols (for the stations) and darker colors (for both) indicate relatively greater priority or importance.

3.5 Hawaii

There are 6 NWLON stations on the Hawaiian Islands, and they all rank relatively similarly in terms of importance. Though there are additional 5 NWLON stations on various Pacific islands, these are not included in the rankings as they do not generally support subordinate datum stations. There are only 2 NWLON gaps on the Hawaiian Islands (Appendix E4)

Of the 6 Hawaiian stations, the stations at Hilo and Honolulu rank closely as the top 2, while Kawaihae ranks as the least important (Figure 21; Appendix C5). This is primarily because Honolulu and Hilo have the longest time series (114 years and 92 years, respectively) and thus are pivotal locations for observing SLR. Kawaihae has only been operating for 31 years. Honolulu and Hilo also support some amount of vessel traffic due to their location near a port, while Kawaihai does not. Other than Honolulu and Mokuoloe, whose datum coverage completely overlaps, the remaining stations all provide some amount of single primary coverage. The 2 gaps in the Hawaiian Islands are both relatively low (Figures 21, 23-25; Appendix D5) in priority due to minimal shoreline coverage, low coastal population, and low importance to marine navigation.

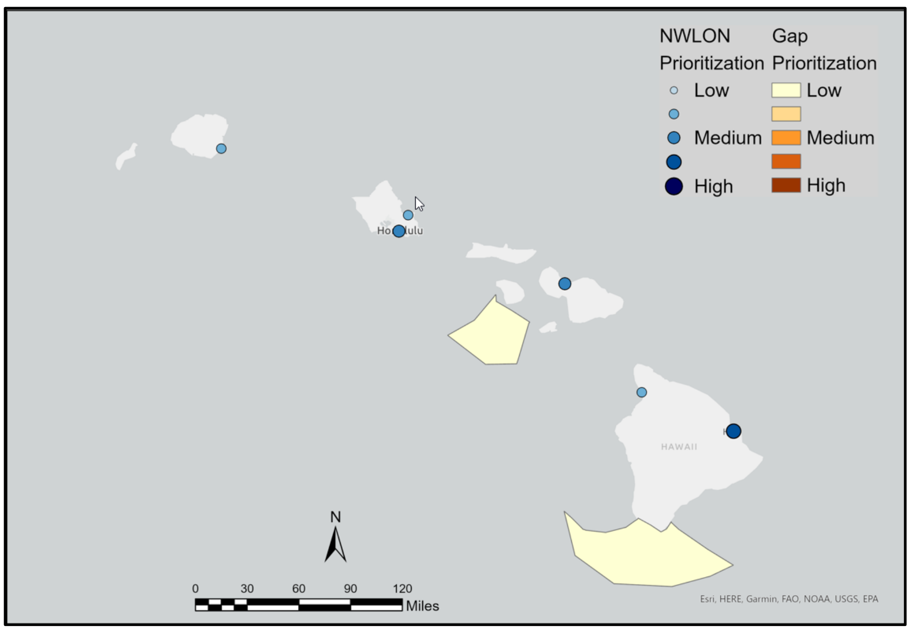

Figure 21. A map of the location of National Water Level Observation Network (NWLON) stations and coverage gaps along the Hawaii coast. The stations are represented by light to dark blue colored circles and the coverage gaps are represented by light yellow to brown colored polygons. Larger symbols (for the stations) and darker colors indicate relatively greater priority or importance.

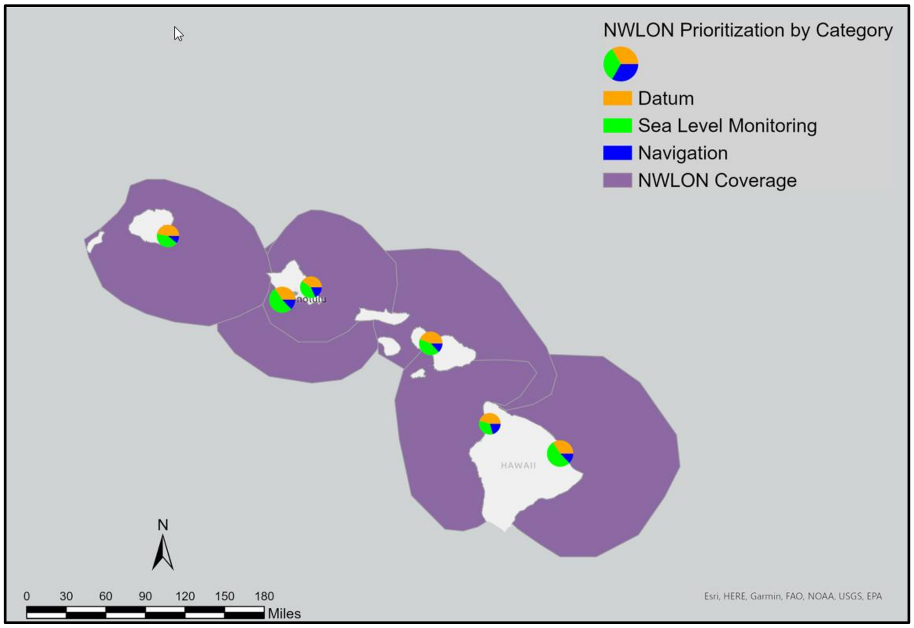

Figure 22. A map of National Water Level Observation Network (NWLON) stations and their coverages along the Hawaii coast with pie charts showing the percentage of contribution of marine navigation (blue), sea-level monitoring (green), and tidal datums (orange) factors to the overall prioritization score. The size of the circles indicates the overall priority of the station and the purple polygons represent NWLON coverages.

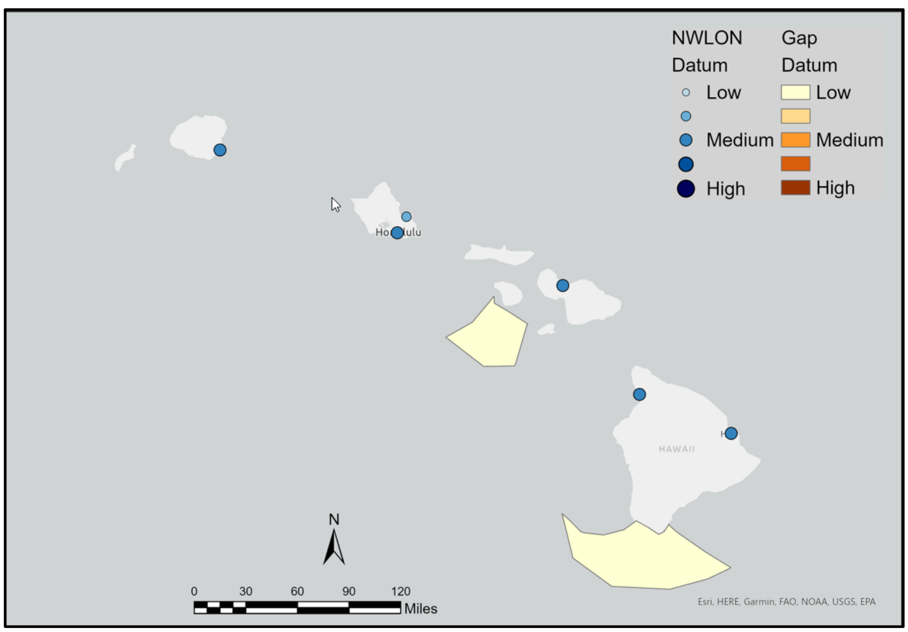

Figure 23. A map showing the relative importance of National Water Level Observation Network (NWLON) stations and coverage gaps along the Hawaii coast for tidal datums. The stations are represented by light to dark blue colored circles and the coverage gaps are represented by light yellow to brown colored polygons. Larger symbols (for the stations) and darker colors (for both) indicate relatively greater priority or importance.

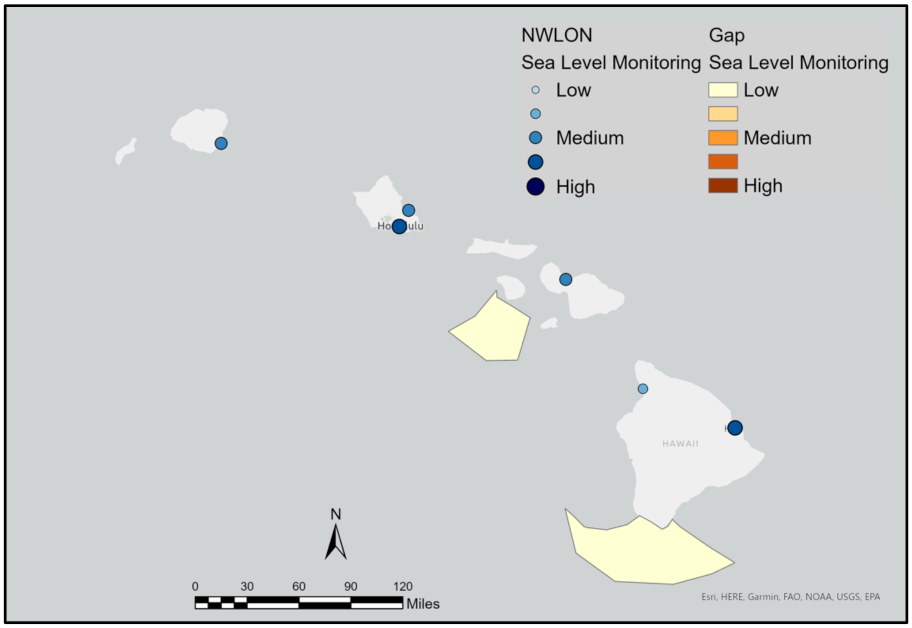

Figure 24. A map showing the relative importance of National Water Level Observation Network (NWLON) stations and coverage gaps along the Hawaii coast for sea-level monitoring. The stations are represented by light to dark blue colored circles and the coverage gaps are represented by light yellow to brown colored polygons. Larger symbols (for the stations) and darker colors (for both) indicate relatively greater priority or importance.

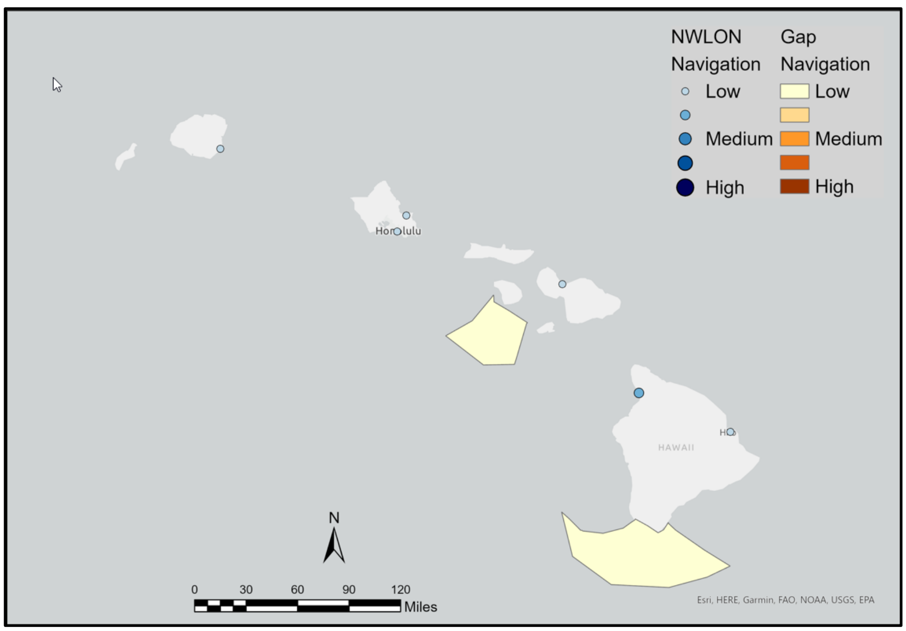

Figure 25. A map showing the relative importance of National Water Level Observation Network (NWLON) stations and coverage gaps along the Hawaii coast for marine navigation. The stations are represented by light to dark blue colored circles and the coverage gaps are represented by light yellow to brown colored polygons. Larger symbols (for the stations) and darker colors (for both) indicate relatively greater priority or importance.

3.6 Puerto Rico and U.S. Virgin Islands

There are 10 NWLON stations in Puerto Rico and the U.S. Virgin Islands. There are no gaps in NWLON coverage in this region. The top stations in the region are San Juan, PR; Lime Tree Bay, VI; Lameshur Bay, St Johns, VI; Charlotte Amalie, VI; and Culebra, PR, and they are important in the region for all 3 factors: tidal datums, sea-level monitoring, and marine navigation (Figure 26-30; Appendix C6). San Juan is slightly less important for marine navigation as the tonnage and vessel size is lower here than in the other locations, including Vieques Island, PR.

Although in the lower tier overall for this region, both Magueyes Island, PR, and Christiansted, St Croix, VI, are highly ranked for sea-level monitoring. Christiansted is also ranked in the top 5 for tidal datum.

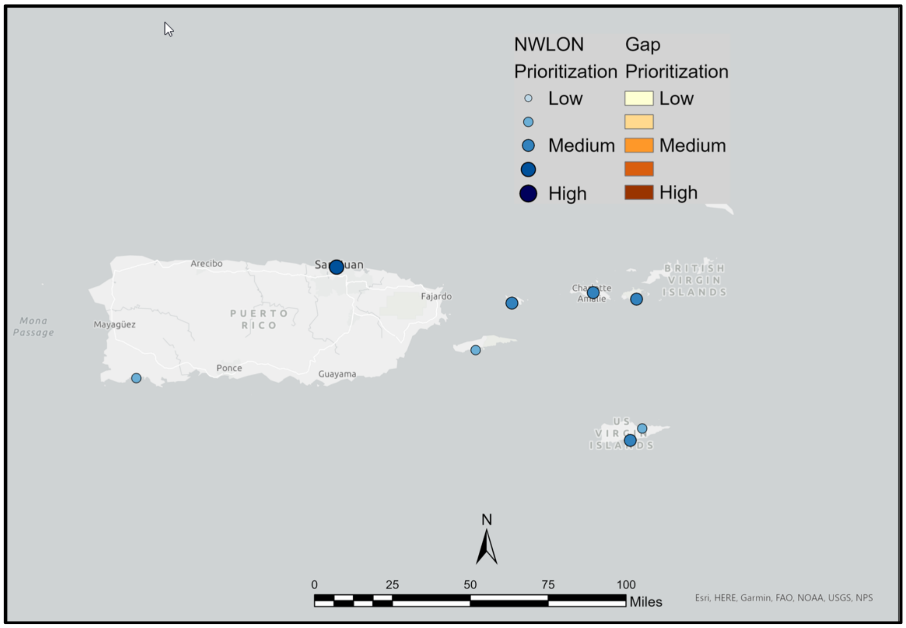

Figure 26. A map of the location of National Water Level Observation Network (NWLON) stations along the U.S. Virgin Islands and Puerto Rico. The stations are represented by light to dark blue colored circles. Larger symbols and darker colors indicate relatively greater priority or importance. There are no gaps in this region.

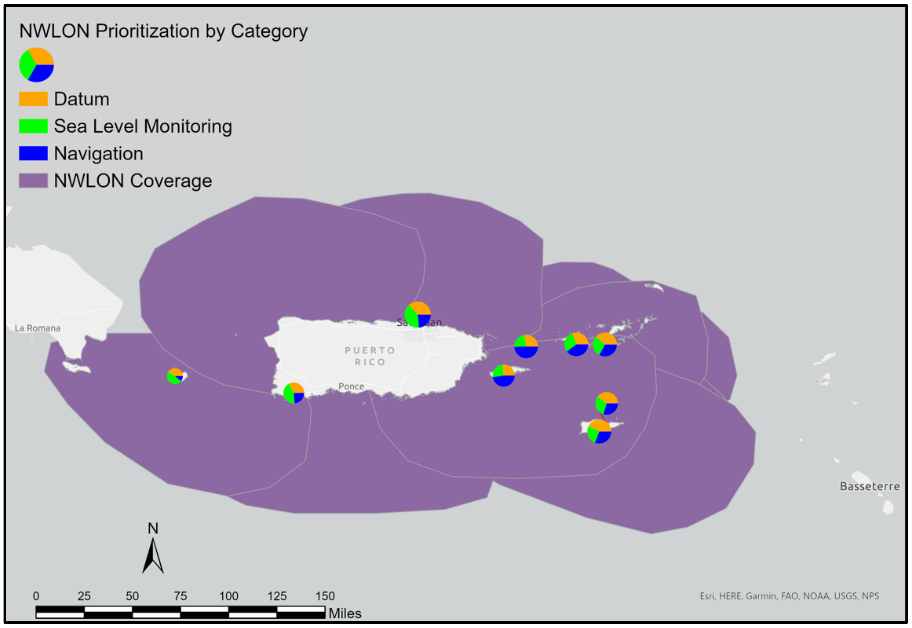

Figure 27. A map of National Water Level Observation Network (NWLON) stations and their coverages along the U.S. Virgin Islands and Puerto Rico with pie charts showing the percentage of contribution of marine navigation (blue), sea-level monitoring (green), and tidal datums (orange) factors to the overall prioritization score. The size of the circles indicates the overall priority of the station and the purple polygons represent NWLON coverages.

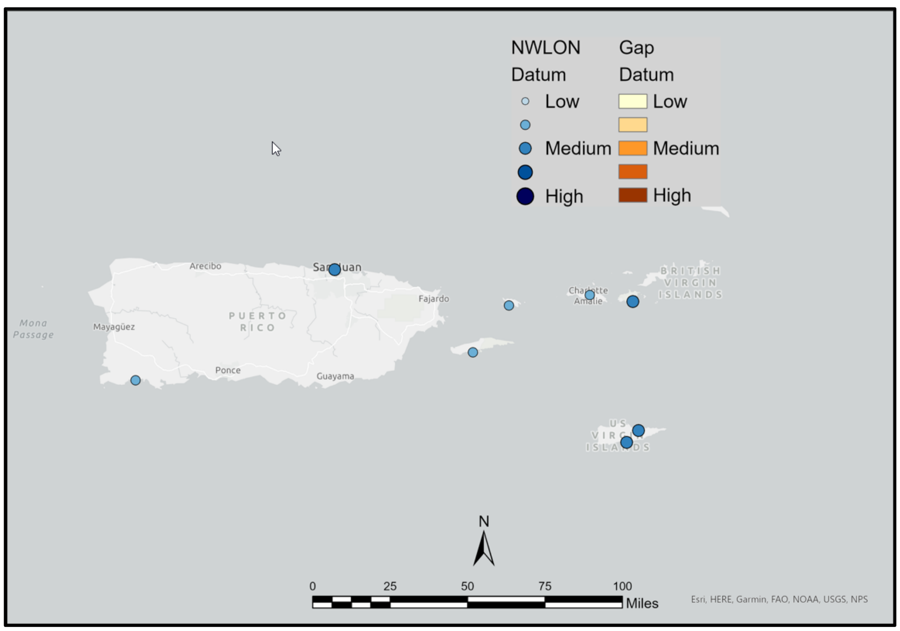

Figure 28. A map showing the relative importance of National Water Level Observation Network (NWLON) stations along the U.S. Virgin Islands and Puerto Rico for tidal datums. The stations are represented by light to dark blue colored circles. Larger symbols and darker colors indicate relatively greater priority or importance. There are no gaps in this region.

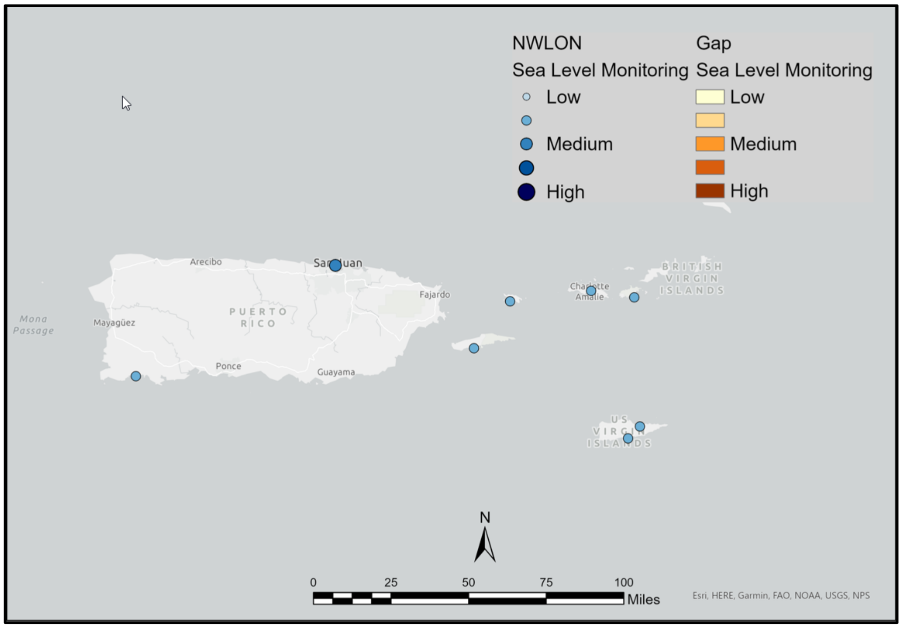

Figure 29. A map showing the relative importance of National Water Level Observation Network (NWLON) stations along the U.S. Virgin Islands and Puerto Rico for sea-level monitoring. The stations are represented by light to dark blue colored circles. Larger symbols and darker colors indicate relatively greater priority or importance. There are no gaps in this region.

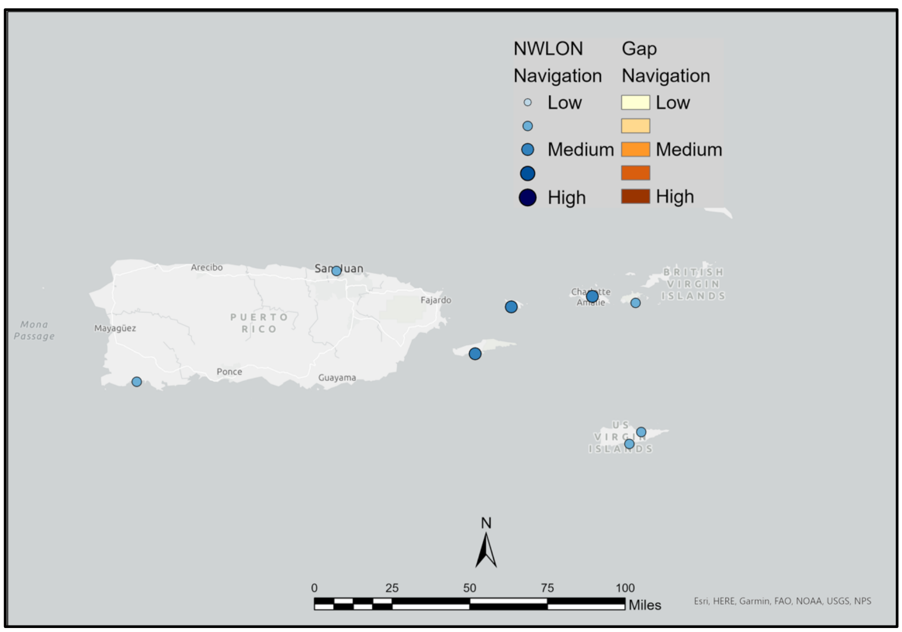

Figure 30. A map showing the relative importance of National Water Level Observation Network (NWLON) stations along the U.S. Virgin Islands and Puerto Rico for marine navigation. The stations are represented by light to dark blue colored circles. Larger symbols and darker colors indicate relatively greater priority or importance. There are no gaps in this region.

4.0 DISCUSSION AND CONCLUSIONS

In this report, we present a methodology and detail the results of a study to prioritize stations and coverage gaps in the NWLON. The approach combines and ranks aspects of 3 critical components that the NWLON supports: tidal datums, marine navigation, and sea-level monitoring. Normalized values from these 3 categories are then combined into a single national ranking for both NWLON stations and gaps. The data analysis was performed using a GIS framework, and an interactive GIS web tool was developed to make visualization, dissemination, and application of the results as intuitive as possible.

Results of the study indicate which NWLON stations and gaps in NWLON coverage are the most critical, or the least critical, across a variety of use cases and applications. We find that, though some general comparisons can be made nationally, geographic and economic differences between regions are such that a regional view may be more valuable to consider. For instance, most Alaska stations have relatively low overall rankings (the highest is Ketchikan at number 40) primarily due to their very low rankings for sea-level monitoring (e.g., low coastal populations, low future flood projections) and marine navigation (fewer, smaller ports and less ship traffic). This does not mean that these stations are not important, however, as they are typically some of the most important for tidal datums (e.g., Ketchikan ranks 4th), and many provide the only datum coverage for vast expanses of coastline. A direct comparison of the Alaska stations to those in the West Coast or Southeast regions where there are large population centers and some of the most globally significant seaports is not really a fair one. As such, we favor comparing stations within regions as the optimal approach for using this study.

With that in mind, this study describes the level of importance for stations and gaps for a region across the 3 categories. Though the most critical stations or gaps in each region often have relatively high importance across the categories (e.g., Sandy Hook, NJ, is the highest ranked station in the Northeast and Mid-Atlantic and is top 15 in all 3 categories), it can be illuminating to understand how stations or gaps support some applications more than others. For instance, in the Northeast and Mid-Atlantic region, The Battery, NY, is the second highest ranked station but only 89th in tidal datum. This is because the station has a small coverage area and there are other stations nearby which could potentially provide datum coverage to some of the same locations. However, The Battery also ranks 8th and 7th in marine navigation and sea-level monitoring, respectively. Clearly, The Battery is an important station, and understanding that it is an especially critical station for both SLR and safe and efficient marine navigation could be valuable information to CO-OPS and NOS leadership or NOAA partners if they want to understand and highlight components of the NWLON.

Similarly, it can be helpful to look at stations in a region which primarily support only a single category. For example, Galveston Entrance Channel, TX, is ranked 105 in tidal datums and 137 in sea-level monitoring but is ranked 1st in the entire nation in supporting marine navigation. The relatively low rankings of the other 2 categories mean the station is only 16th in the Gulf of Mexico and Southeast and 48th overall. Clearly, this total ranking should not be taken to mean this station is of middling importance when it is so critically important to marine navigation. Again, understanding the importance of this station and what factors contribute to this importance is useful when evaluating the NWLON and for communicating the importance to leadership and partners.

This study also prioritizes gaps in the NWLON network, which is critical for determining priorities for future station locations or partner collaborations. Similar to interpreting the results of the station prioritization, the gaps are best viewed regionally to avoid geographically disparate comparisons. With that in mind, the most important gaps in each region are typically those near larger population centers, with substantial ship traffic and with several subordinate stations within the gap. For instance, Houston Ship Channel is the highest ranking gap in the Southeast and Gulf of Mexico region because it sees the largest amount of ship traffic of any gap in the country, has a relatively important port within the gap, has close proximity to a substantial coastal population, and covers 4 subordinate stations. However, similarly to the station prioritization, there are gaps that are highly ranked in 1 or 2 of the categories, and thus should still be considered as priorities. For example, Great South Bay, NY, has minimal ship traffic; however, it is the highest ranking gap in the Northeast due to the large coastal population in that portion of Long Island, the large amount of shoreline the gap covers, and coverage of 12 subordinate stations. With this in mind, we recommend focusing on the top 3-5 gaps in each region as those that are most critical to address in the near term.

This study has some significant limitations that should be kept in mind when using the results to make decisions on future station installations or resource allocation. Most importantly, the rankings should not be taken as a precise 1 to 143 ordering, but rather to assist in general grouping (e.g., the top third of stations are really important, the middle third are moderately important, and the bottom third are generally less important). This is important as the choices for categories and numerical values are fairly arbitrary, and subtle changes to these choices could result in variations in the specific numerical rankings. However, through trial and error, we have found that even with these changes, the more qualitative groupings still hold and thus can be considered fairly robust.

Another major limitation is that this entire construct is based on NWLON station tidal datum coverage as calculated by Gill (2014a). Though using datums is a reasonable way to define the spatial extent of where a station is representative of the oceanography of a region, it does not account for other physical parameters that NWLON stations support. For instance, a station might have a much smaller or larger coverage area for being representative of physical variables such as storm surge, HTF, or SLR. Accounting for these other, mission critical variables when defining NWLON coverages and gaps could result in different lists and priorities.

Lastly, the variables we were able to include, and how the variables were calculated, are limited by the data readily available to us and by being able to calculate results efficiently. For instance, utilizing a flood return level to represent storm surge is fairly simplistic, and there could be other ways to account for this based on impacts or the oceanography. To relate NWLON stations to specific ports, a 100 km radius was used, but there could be NWLON stations within 100 km that pilots never use when traveling to certain ports, and there could be stations farther than 100 km away that are frequently used by pilots traveling to a certain port (e.g., a pilot taking a vessel from the Chesapeake Bay entrance up to the port of Baltimore). However, to best account for this would require having information on specific vessel tracks or survey input from pilots, neither of which were readily available, and so this approximation was made. There are many other minor choices made throughout this process that could result in slight variations in the rankings, as well.

In conclusion, the results of this prioritization will provide a valuable resource to CO-OPS and NOS leadership, as well as to our NOAA and external partners when evaluating the importance of both existing NWLON stations and gaps in coverage. The results represent the most extensive effort made to better understand the mission critical capabilities the NWLON supports and will facilitate future decisions regarding NWLON station installation, relocation, or removal. It is important to note that this study represents only the starting point to an ongoing evaluation and prioritization effort. We strongly recommend that the existing NWLON gaps analysis (Gill 2014) be updated following the completion of the next National Tidal Datum Epoch update (likely completed by 2026). This update should not only include updated stations, gaps, and tidal datum calculations but also an updated methodology that includes consideration of other oceanographic factors, such as storm surge and SLR. Once completed, this prioritization should be updated to reflect the new NWLON coverage areas and gaps and then continued to be updated with new data on a 5-year basis moving forward.

DATA ACCESS

The GIS data used for the prioritization of NWLON gaps and coverages and the resulting prioritization GIS tool (dashboard) are listed below. When navigating the dashboard tool, clicking on a station or a gap on the map will produce a pie chart with the contribution of each of the 3 categories to the overall ranking. In addition, clicking on the station listed on the right will zoom to the location of the NWLON or gap.

National Water Level Observation Network (NWLON) Prioritization Dashboard
National Water Level Observation Network (NWLON) Prioritization study layers

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APPENDICES

Appendix A

Table A. CO-OPS's top 175 Ports.

Ranking	Port Name
1	Houston, TX
2	New Orleans, LA
3	Los Angeles, CA
4	Gramercy, LA
5	Newark, NJ
6	Port Arthur, TX
7	Corpus Christi, TX
8	Norfolk-Newport News, VA
9	Long Beach, CA
10	Savannah, GA
11	Mobile, AL
12	Lake Charles, LA
13	Baltimore, MD
14	Baton Rouge, LA
15	Morgan City, LA
16	Wilmington, DE
17	Texas City, TX
18	Beaumont, TX
19	Tacoma, WA
20	Charleston, SC
21	Philadelphia, PA
22	Seattle, WA
23	Oakland, CA
24	Pascagoula, MS
25	New York, NY
26	Richmond, CA
27	Freeport, TX

Ranking	**Port Name**
28	Portland, OR
29	Kalama, WA
30	Tampa, FL
31	El Segundo, CA
32	Boston, MA
33	Longview, WA
34	Jacksonville, FL
35	Port Everglades, FL
36	Martinez, CA
37	Vancouver, WA
38	US Navy
39	Paulsboro, NJ
40	Miami, FL
41	Perth Amboy, NJ
42	Toledo-Sandusky, OH
43	San Juan, PR
44	Chester, PA
45	Ponce, PR
46	Wilmington, NC
47	Galveston, TX
48	San Francisco, CA
49	Providence, RI
50	Anchorage, AK
51	Buffalo-Niagara Falls, NY
52	Detroit, MI
53	Stockton, CA
54	Portland, ME
55	Bellingham, WA
56	Chicago, IL
57	Fajardo, PR

Ranking	Port Name
58	Port Huron, MI
59	Carquinez Strait, CA
60	Port Canaveral, FL
61	Anacortes, WA
62	New Haven, CT
63	Duluth, MN - Superior, WI
64	Blaine, WA
65	Brunswick, GA
66	Aberdeen-Hoquiam, WA
67	Coos Bay, OR
68	Portsmouth, NH
69	Port Lavaca, TX
70	Christiansted, VI
71	Gulfport, MS
72	Brownsville, TX
73	Ashtabula-Conneaut, OH
74	Port Manatee, FL
75	Cleveland, OH
76	Panama City, FL
77	Albany, NY
78	Port Hueneme, CA
79	San Diego, CA
80	Beaufort-Morehead City, NC
81	Milwaukee, WI
82	Searsport, ME
83	Sault Ste Marie, MI
84	Marquette, MI
85	West Palm Beach, FL
86	San Joaquin River, CA

Ranking	Port Name
87	Redwood City, CA
88	Olympia, WA
89	Camden, NJ
90	Fall River, MA
91	Valdez, AK
92	Port Angeles, WA
93	St. Rose, LA
94	Hopewell, VA
95	Crockett, CA
96	Green Bay, WI
97	Ketchikan, AK
98	Oswego, NY
99	Calais, ME
100	Avondale, LA
101	Astoria, OR
102	Saginaw-Bay City, MI
103	Fernandina, FL
104	Everett, WA
105	Port Sulphur, LA
106	Eastport, ME
107	Belfast, ME
108	New London, CT
109	Humacao, PR
110	Eureka, CA
111	Selby, CA
112	Bridgeport, CT
113	Good Hope, LA
114	Destrehan, LA
115	Pensacola, FL
116	Ogdensburg, NY

Ranking	Port Name
117	Alpena, MI
118	Sabine, TX
119	Rochester, NY
120	Newport, RI
121	Juneau, AK (and Douglas Harbor)
122	Gloucester City, NJ
123	Skagway, AK
124	Capitan, CA
125	Gary, IN
126	Escanaba, MI
127	Richmond-Petersburg, VA
128	Kahului, HI
129	Washington, DC
130	Presque Isle, MI
131	Hilo, HI
132	Frederiksted, VI
133	Port Townsend, WA
134	San Pablo Bay, CA
135	Charlotte Amalie, VI
136	Alexandria Bay, NY
137	Detour City, MI
138	Mayaguez, PR
139	Marinette, WI
140	Georgetown, SC
141	Kona, HI
142	Fort Pierce, FL
143	Sitka, AK
144	New Bedford, MA
145	Cape Vincent, NY

Ranking	Port Name
146	Wrangell, AK
147	Salem, MA
148	Plymouth, MA
149	Annapolis, MD
150	Key West, FL
151	Erie, PA
152	Aguadilla, PR
153	Dutch Harbor, AK
154	Empire/Venice, LA
155	Kodiak, AK
156	Reedville, VA
157	Intracoastal City, LA
158	Naknek, AK
159	Westport, WA
160	Cherry Point, WA
161	Port Fourchon, LA
162	Salis, PR
163	Cove Point, MD
164	Louisiana Offshore Oil Port (LOOP)
165	Apra Harbor, Naval Base Guam
166	Naval Base Kitsap, Bangor, WA
167	Naval Base Kitsap, Bremerton, WA
168	Marine Corps Base Camp Pendleton, CA
169	Naval Surface Warfare Center, Dahlgren, VA
170	Naval Sub Base, Kings Bay, GA
171	Manchester Fuel Depot, Manchester, WA
172	Joint Base Pearl Harbor-Hickam
173	Saipan, CNMI
174	St. Thomas, VI
175	USNR Earle, Leonardo Piers, Leonardo, NJ

Appendix B

Table B. 2017 Cargo value (CV) and Port Tonnage.

Port Name	2017 Combined Values (USD)	2017 Tonnage (Tons)
Aberdeen-Hoquiam, WA	2,456,015,028	
Aguadilla, PR	20,202,342	
Albany, NY	468,860,628	6,009,212
Anacortes, WA	1,002,444,169	9,212,192
Anchorage, AK	4,664,115,980	3,297,827
Annapolis, MD	19,301,818	
Apra Harbor, Naval Base Guam		
Astoria, OR	49,098,562	
Avondale, LA		
Baltimore, MD	53,942,441,301	45,474,946
Baton Rouge, LA	9,930,156,828	77,013,042
Beaufort-Morehead City, NC	631,901,164	2,517,846
Beaumont, TX	13,239,843,573	89,437,326
Belfast, ME	5,196,735	
Bellingham, WA	1,489,255,703	
Blaine, WA	695,895,554	
Boston, MA	9,775,422,767	16,618,977
Bridgeport, CT	12,485,790	2,031,424
Brownsville, TX	1,028,884,609	7,763,455
Brunswick, GA	18,041,354,792	2,487,757
Calais, ME	134,113,999	
Camden, NJ	126,915,192	6,734,653
Capitan, CA	21,076	
Carquinez Strait, CA	3,370,983,428	
Charleston, SC	69,750,643,504	26,980,805
Charlotte Amalie, VI	56,396,117	
Cherry Point, WA		
Chester, PA	9,030,921,216	2,187,677
Christiansted, VI	1,837,202,362	
Coos Bay, OR	150,627,335	2,108,362
Corpus Christi, TX	22,732,985,390	87,322,735
Cove Point, MD		

Port Name	2017 Combined Values (USD)	2017 Tonnage (Tons)
Crockett, CA	261,348,364	
Destrehan, LA	222,882	
Dutch Harbor, AK		
Eastport, ME	83,829,168	
El Segundo, CA	3,840,657,459	
Empire/Venice, LA		
Eureka, CA	19,450,575	
Everett, WA	1,351,180,353	1,590,855
Fajardo, PR	1,056,188,980	
Fall River, MA	5,412,395	
Fernandina, FL	149,143,953	
Fort Pierce, FL	8,673,958	
Frederiksted, VI	263,258,871	
Freeport, TX	8,751,127,669	24,484,399
Galveston, TX		7,836,405
Georgetown, SC	3,383,941	
Gloucester City, NJ	59,606,389	
Good Hope, LA		
Gramercy, LA	19,202,721,180	
Gulfport, MS	2,791,762,422	2,312,058
Hilo, HI	18,405,169	2,164,653
Hopewell, VA	4,363,361	804,584
Houston, TX	131,474,342,440	260,070,837
Humacao, PR		
Intracoastal City, LA		
Jacksonville, FL	25,321,698,323	18,526,032
Joint Base Pearl Harbor-Hickam		
Juneau, AK (and Douglas Harbor)	142,327,680	
Kahului, HI	10,079,948	3,670,922
Kalama, WA	3,547,629,965	14,956,426
Ketchikan, AK	95,165,924	851,802
Key West, FL	10,577,306	
Kodiak, AK		
Kona, HI	1,293,508	
Lake Charles, LA	11,178,173,759	54,316,852
Long Beach, CA	99,896,578,633	85,997,092

Port Name	**2017 Combined Values (USD)**	**2017 Tonnage (Tons)**
Longview, WA	2,733,205,375	13,587,726
Los Angeles, CA	283,939,690,551	65,826,557
Louisiana Offshore Oil Port (LOOP)		
Manchester Fuel Depot, Manchester, WA		
Marine Corps Base Camp Pendleton, CA		
Martinez, CA	3,512,107,382	
Mayaguez, PR	6,349,737	
Miami, FL	23,893,514,058	7,824,022
Mobile, AL	15,511,942,327	58,157,248
Morgan City, LA	8,071,448,921	
Naknek, AK		
Naval Air Station Whidbey Island, Oak Harbor		
Naval Base Kitsap, Bangor, WA		
Naval Base Kitsap, Bremerton, WA		
Naval Sub Base, Kings Bay, GA		
Naval Surface Warfare Center, Dahlgren, VA		
New Bedford, MA	26,216,201	
New Haven, CT	982,072,229	8,868,274
New London, CT	111,614,665	
New Orleans, LA	50,170,665,369	96,341,576
New York, NY	41,576,649,783	135,874,693
Newark, NJ	148,163,152,857	
Newport, RI	46,748,266	
Norfolk-Newport News, VA	72,946,152,057	
Oakland, CA	47,789,592,990	19,393,310
Olympia, WA	119,141,707	1,089,375
Panama City, FL	2,966,158,709	2,021,710
Pascagoula, MS	5,546,945,021	25,644,568
Paulsboro, NJ	822,816,364	18,362,258
Pensacola, FL	14,368,626	765,483
Perth Amboy, NJ	3,046,835,374	
Philadelphia, PA	22,560,954,764	28,523,744
Plymouth, MA	299,706	
Ponce, PR	1,476,200,134	1,118,002

Port Name	2017 Combined Values (USD)	2017 Tonnage (Tons)
Port Angeles, WA	90,722,020	773,840
Port Arthur, TX	15,338,137,209	39,203,245
Port Canaveral, FL	1,083,196,961	5,086,577
Port Everglades, FL	23,172,641,038	24,901,038
Port Fourchon, LA		6,494,985
Port Hueneme, CA	9,589,071,065	1,853,096
Port Lavaca, TX	912,162,832	
Port Manatee, FL	838,400,630	3,791,805
Port Sulphur, LA	15,292,623	
Port Townsend, WA	1,644,303	
Portland, ME	1,908,648,815	4,898,165
Portland, OR	10,484,571,476	23,164,727
Portsmouth, NH	1,022,754,391	2,627,091
Providence, RI	8,513,207,006	8,489,693
Redwood City, CA	39,303,727	2,156,950
Reedville, VA		
Richmond-Petersburg, VA	64,316,401	
Richmond, CA	8,595,486,529	27,772,571
Sabine, TX	847,454,153	
Saipan, CNMI		
Salem, MA	1,895,235	
Salis, PR		
San Diego, CA	7,060,548,162	1,522,212
San Francisco, CA	4,382,428,841	1,704,910
San Joaquin River, CA	30,313,104	
San Juan, PR	9,902,192,826	10,296,551
San Pablo Bay, CA	23,552,251	
Savannah, GA	89,633,902,964	39,865,610
Searsport, ME	427,338,460	1,442,361
Seattle, WA	25,024,237,436	25,206,600
Selby, CA	280,422,792	
Sitka, AK	432,336	
Skagway, AK	96,825,491	
St. Rose, LA	7,597,494	
St. Thomas, VI		
Stockton, CA	932,779,681	5,061,690

Port Name	2017 Combined Values (USD)	2017 Tonnage (Tons)
Tacoma, WA	50,221,167,996	23,550,756
Tampa, FL	3,456,288,868	33,120,240
Texas City, TX	8,580,354,197	37,751,062
USNR Earle, Leonardo Piers, Leonardo, NJ		
Valdez, AK		27,971,737
Vancouver, WA	4,177,665,567	8,422,170
Washington, DC	33,304,584	
West Palm Beach, FL	2,237,826,810	
Westport, WA		
Wilmington, DE	11,366,639,916	6,864,705
Wilmington, NC	7,797,840,463	5,518,252
Wrangell, AK	2,733,001	

Appendix C

Table C. National Water Level Observation Network (NWLON) prioritization ranking by region.

C1. Northeast and Mid-Atlantic										
Station ID	**Station Location**	**Prioritization Total**	**Prioritization National Rank**	**Datum Total**	**Datum National Rank**	**Sea Level Monitoring Total**	**Sea Level Monitoring National Rank**	**Navigation Total**	**Navigation National Rank**	**Prioritization Regional Rank**
8531680	Sandy Hook, NJ	2.40	2	0.70	15	0.90	8	0.79	7	1
8452660	Newport, RI	2.18	5	0.78	8	0.96	3	0.44	44	2
8443970	Boston, MA	2.16	6	0.82	7	0.78	14	0.57	23	3
8518750	The Battery, NY	2.12	8	0.42	89	0.90	7	0.79	8	4
8418150	Portland, ME	2.02	10	1.00	1	0.68	33	0.35	63	5
8638610	Sewells Point, VA	1.93	16	0.56	41	0.93	4	0.44	43	6
8534720	Atlantic City, NJ	1.88	20	0.59	32	0.97	2	0.33	68	7
8454000	Providence, RI	1.80	23	0.54	49	0.74	27	0.52	28	8
8557380	Lewes, DE	1.69	28	0.68	20	0.74	24	0.27	80	9
8516945	Kings Point, NY	1.69	29	0.22	124	0.77	15	0.70	16	10

8574680	Baltimore, MD	1.63	32	0.37	99	0.74	26	0.53	27	11
8575512	Annapolis, MD	1.62	33	0.32	111	0.75	22	0.55	25	12
8545240	Philadelphia, PA	1.58	36	0.34	108	0.64	41	0.60	20	13
8461490	New London, CT	1.56	38	0.51	59	0.72	28	0.33	67	14
8551910	Reedy Point, DE	1.54	39	0.35	103	0.63	45	0.56	24	15
8571892	Cambridge, MD	1.48	43	0.42	90	0.58	53	0.48	34	16
8467150	Bridgeport, CT	1.46	47	0.43	88	0.80	11	0.23	94	17
8413320	Bar Harbor, ME	1.43	49	0.49	65	0.62	47	0.33	69	18
8594900	Washington, DC	1.40	52	0.27	121	0.76	19	0.37	60	19
8577330	Solomons Island, MD	1.39	53	0.35	104	0.67	34	0.38	58	20
8632200	Kiptopeke, VA	1.36	55	0.16	133	0.76	20	0.45	41	21
8536110	Cape May, NJ	1.35	58	0.45	81	0.64	43	0.27	82	22
8635750	Lewisetta, VA	1.25	67	0.34	106	0.59	49	0.33	70	23
8449130	Nantucket Island, MA	1.14	83	0.39	95	0.58	51	0.17	115	24

8631044	Wachapreague, VA	1.14	86	0.41	91	0.58	50	0.14	120	25
8510560	Montauk, NY	1.13	88	0.18	129	0.69	31	0.26	83	26
8637689	Yorktown USCG Training Ctr, VA	1.03	105	0.32	110	0.25	115	0.46	40	27
8447930	Woods Hole, MA	1.00	107	0.07	139	0.66	36	0.27	81	28
8410140	Eastport, ME	0.80	123	0.38	96	0.23	118	0.20	100	29
8571421	Bishops Head, MD	0.79	125	0.34	109	0.13	134	0.32	72	30
8570283	Ocean City Inlet, MD	0.55	137	0.30	118	0.14	133	0.12	127	31

C2. Southeast and Gulf										
Station ID	**Station Location**	**Prioritization Total**	**Prioritization National Rank**	**Datum Total**	**Datum National Rank**	**Sea Level Monitoring Total**	**Sea Level Monitoring National Rank**	**Navigation Total**	**Navigation National Rank**	**Prioritization Regional Rank**
8670870	Fort Pulaski, GA	2.32	3	0.94	2	0.89	9	0.49	32	1
8761724	Grand Isle, LA	2.26	4	0.84	6	0.57	56	0.84	5	2
8747437	Bay Waveland YC, MS	2.14	7	0.76	9	0.77	16	0.61	19	3
8665530	Charleston, SC	2.02	11	0.94	3	0.68	32	0.40	50	4
8724580	Key West, FL	1.92	18	0.90	5	0.76	18	0.26	85	5
8720030	Fernandina Beach, FL	1.86	21	0.75	10	0.64	40	0.47	37	6
8726520	St. Petersburg, FL	1.82	22	0.68	19	0.75	23	0.39	53	7
8771450	Galveston Pier 21, TX	1.80	24	0.14	134	0.77	17	0.89	2	8
8729840	Pensacola, FL	1.75	25	0.44	86	0.91	6	0.40	48	9
8723214	Virginia Key, FL	1.74	26	0.55	45	0.71	30	0.48	33	10
8720218	Mayport, FL	1.65	31	0.62	26	0.47	73	0.57	22	11

8726724	Clearwater Beach, FL	1.60	34	0.68	18	0.52	62	0.39	52	12
8651370	Duck, NC	1.58	35	0.58	37	0.82	10	0.18	109	13
8735180	Dauphin Island, AL	1.57	37	0.52	56	0.66	37	0.39	55	14
8774770	Rockport, TX	1.54	40	0.55	47	0.65	39	0.35	64	15
8771341	Galveston Entrance Channel, TX	1.45	48	0.34	105	0.11	137	1.00	1	16
8661070	Springmaid Pier, SC	1.38	54	0.68	17	0.55	59	0.15	117	17
8656483	Beaufort (Duke Marine Lab), NC	1.35	56	0.61	27	0.56	57	0.17	113	18
8729108	Panama City, FL	1.35	59	0.56	39	0.50	66	0.28	76	19
8768094	Calcasieu Pass, LA	1.34	60	0.44	84	0.09	139	0.81	6	20
8779770	Port Isabel, TX	1.33	61	0.39	94	0.64	42	0.30	73	21
8761927	USCG New Canal Station, LA	1.27	64	0.37	98	0.20	123	0.70	15	22
8775870	Bob Hall Pier, Corpus Christi, TX	1.27	65	0.49	67	0.33	91	0.45	42	23
8727520	Cedar Key, FL	1.26	66	0.49	72	0.66	38	0.11	134	24
8729210	Panama City Beach, FL	1.25	68	0.58	36	0.49	70	0.18	111	25

8761305	Shell Beach, Lake Borgne, LA	1.20	74	0.34	107	0.19	124	0.68	18	26
8721604	Trident Pier, FL	1.16	81	0.54	50	0.44	78	0.19	102	27
8722670	Lake Worth Pier, FL	1.14	85	0.47	77	0.16	129	0.51	29	28
8764227	LAWMA, Amerada Pass, LA	1.10	90	0.50	64	0.14	132	0.47	38	29
8725110	Naples, FL	1.09	92	0.47	73	0.50	67	0.12	128	30
8767816	Lake Charles, LA	1.06	99	0.28	119	0.06	142	0.73	13	31
8652587	Oregon Inlet, NC	1.05	101	0.36	102	0.57	54	0.11	130	32
8741533	Pascagoula, MS	1.04	103	0.44	83	0.21	122	0.40	49	33
8723970	Vaca Key, FL	0.97	112	0.32	112	0.46	74	0.19	101	34
8658120	Wilmington, NC	0.95	115	0.17	131	0.59	48	0.19	104	35
8766072	Freshwater Canal Locks, LA	0.88	120	0.37	101	0.18	126	0.34	66	36
8728690	Apalachicola, FL	0.83	121	0.17	130	0.51	64	0.14	122	37
8737048	Mobile, AL	0.81	122	0.17	132	0.18	125	0.46	39	38
8658163	Wrightsville Beach, NC	0.78	126	0.50	62	0.07	141	0.21	97	39

8725520	Fort Myers, FL	0.69	128	0.03	143	0.56	58	0.11	141	40
8764044	Berwick, LA	0.69	129	0.08	138	0.26	110	0.35	62	41
8654467	USCG Station Hatteras, NC	0.38	143	0.10	137	0.17	128	0.11	131	42

C3. West Coast										
Station ID	**Station Location**	**Prioritization Total**	**Prioritization National Rank**	**Datum Total**	**Datum National Rank**	**Sea Level Monitoring Total**	**Sea Level Monitoring National Rank**	**Navigation Total**	**Navigation National Rank**	**Prioritization Regional Rank**
9414290	San Francisco, CA	2.48	1	0.71	14	0.92	5	0.85	4	1
9410660	Los Angeles, CA	2.07	9	0.55	44	0.74	25	0.78	11	2
9414750	Alameda, CA	2.01	12	0.59	33	0.57	55	0.85	3	3
9415020	Point Rey, CA	2.00	13	0.64	23	0.63	44	0.73	12	4
9415144	Port Chicago, CA	1.97	14	0.64	24	0.55	60	0.79	9	5
9410230	La Jolla, CA	1.95	15	0.53	54	1.00	1	0.42	46	6
9447130	Seattle, WA	1.92	17	0.60	29	0.63	46	0.69	17	7
9410840	Santa Monica, CA	1.92	19	0.47	75	0.67	35	0.78	10	8
9444900	Port Townsend, WA	1.72	27	0.49	69	0.52	63	0.71	14	9
9410170	San Diego, CA	1.65	30	0.44	85	0.80	12	0.42	47	10
9435380	South Beach, OR	1.50	42	0.55	46	0.71	29	0.24	88	11

9449880	Friday Harbor, WA	1.47	44	0.49	66	0.51	65	0.47	36	12
9440910	Toke Point, WA	1.42	51	0.54	51	0.50	68	0.38	57	13
9411340	Santa Barbara, CA	1.35	57	0.46	79	0.54	61	0.35	61	14
9432780	Charleston, OR	1.30	63	0.57	38	0.45	75	0.28	75	15
9441102	Westport, WA	1.24	69	0.53	53	0.33	95	0.39	56	16
9439040	Astoria, OR	1.22	71	0.49	70	0.23	117	0.50	30	17
9431647	Port Orford, OR	1.21	73	0.50	60	0.43	79	0.28	77	18
9413450	Monterey, CA	1.19	76	0.59	31	0.47	72	0.13	124	19
9416841	Arena Cove, CA	1.19	77	0.51	58	0.45	76	0.23	92	20
9437540	Garibaldi, OR	1.18	78	0.54	48	0.35	89	0.29	74	21
9412110	Port San Luis, CA	1.12	89	0.49	71	0.49	71	0.15	119	22
9419750	Crescent City, CA	1.08	97	0.63	25	0.23	119	0.23	93	23
9442396	La Push, WA	1.03	106	0.47	74	0.31	102	0.25	86	24
9449424	Cherry Point, WA	0.98	109	0.20	127	0.39	83	0.39	54	25

9444090	Port Angeles, WA	0.95	116	0.13	136	0.39	84	0.43	45	26
9418767	North Spit, CA	0.93	117	0.55	43	0.12	135	0.26	84	27
9440422	Longview, WA	0.88	119	0.04	142	0.30	104	0.54	26	28
9443090	Neah Bay, WA	0.60	136	0.14	135	0.22	120	0.24	89	29

C4. Alaska										
Station ID	Station Location	Prioritization Total	Prioritization National Rank	Datum Total	Datum National Rank	Sea Level Monitoring Total	Sea Level Monitoring National Rank	Navigation Total	Navigation National Rank	Prioritization Regional Rank
9450460	Ketchikan, AK	1.54	41	0.92	4	0.37	86	0.24	87	1
9457804	Alitak, AK	1.32	62	0.71	13	0.38	85	0.23	90	2
9455090	Seward, AK	1.15	82	0.69	16	0.33	94	0.13	123	3
9455500	Seldovia, AK	1.14	84	0.59	34	0.33	97	0.23	91	4
9459881	King Cove, AK	1.13	87	0.72	12	0.27	107	0.14	121	5
9457292	Kodiak Island, AK	1.10	91	0.73	11	0.09	138	0.27	79	6
9497645	Prudhoe Bay, AK	1.09	93	0.67	21	0.31	100	0.11	135	7
9461380	Adak Island, AK	1.09	95	0.58	35	0.39	82	0.11	137	8
9462620	Unalaska, AK	1.08	96	0.60	30	0.31	101	0.17	114	9
9459450	Sand Point, AK	1.07	98	0.60	28	0.34	90	0.12	126	10
9451600	Sitka, AK	1.05	102	0.67	22	0.21	121	0.18	110	11

9452210	Juneau, AK	0.98	110	0.47	76	0.31	99	0.20	99	12
9452634	Elfin Cove, AK	0.97	113	0.56	42	0.29	105	0.12	125	13
9468756	Nome, AK	0.95	114	0.56	40	0.28	106	0.11	136	14
9455760	Nikiski, AK	0.80	124	0.26	122	0.32	98	0.22	95	15
9451054	Port Alexander, AK	0.71	127	0.32	115	0.25	116	0.15	118	16
9491094	Red Dog Dock, AK	0.69	130	0.32	113	0.25	112	0.11	138	17
9454240	Valdez, AK	0.68	131	0.37	97	0.12	136	0.19	105	18
9453220	Yakutat, AK	0.66	132	0.40	93	0.15	131	0.11	132	19
9454050	Cordova, AK	0.66	133	0.31	116	0.16	130	0.18	108	20
9455920	Anchorage, AK	0.65	134	0.20	126	0.18	127	0.27	78	21
9464212	Village Cove, Pribilof Is, AK	0.61	135	0.45	80	0.05	143	0.11	133	22
9452400	Skagway, AK	0.55	138	0.07	140	0.31	103	0.18	112	23
9461710	Atka, AK	0.54	139	0.18	128	0.25	113	0.11	139	24
9463502	Port Moller, AK	0.43	141	0.24	123	0.09	140	0.11	140	25

9462450	Nikolski, AK	0.43	142	0.07	141	0.25	114	0.11	142	26

C5. Hawaii										
Station ID	**Station Location**	**Prioritization Total**	**Prioritization National Rank**	**Datum Total**	**Datum National Rank**	**Sea Level Monitoring Total**	**Sea Level Monitoring National Rank**	**Navigation Total**	**Navigation National Rank**	**Prioritization Regional Rank**
1617760	Hilo, HI	1.47	45	0.50	61	0.78	13	0.19	103	1
1612340	Honolulu, HI	1.42	50	0.49	68	0.75	21	0.18	106	2
1615680	Kahului, HI	1.17	79	0.51	57	0.50	69	0.15	116	3
1611400	Nawiliwili, HI	1.06	100	0.50	63	0.45	77	0.11	129	4
1612480	Mokuoloe, HI	1.00	108	0.40	92	0.41	80	0.18	107	5
1617433	Kawaihae, HI	0.98	111	0.44	82	0.33	92	0.20	98	6

C6. Puerto Rico and U.S. Virgin Islands										
Station ID	**Station Location**	**Prioritization Total**	**Prioritization National Rank**	**Datum Total**	**Datum National Rank**	**Sea Level Monitoring Total**	**Sea Level Monitoring National Rank**	**Navigation Total**	**Navigation National Rank**	**Prioritization Regional Rank**
9755371	San Juan, PR	1.46	46	0.53	52	0.58	52	0.34	65	1
9751401	Lime Tree Bay, VI	1.22	70	0.52	55	0.33	96	0.38	59	2
9751381	Lameshur Bay, St Johns, VI	1.21	72	0.46	78	0.35	88	0.40	51	3
9751639	Charlotte Amalie, VI	1.19	75	0.37	100	0.35	87	0.47	35	4
9752235	Culebra, PR	1.17	80	0.32	114	0.27	108	0.58	21	5
9751364	Christiansted, St Croix, VI	1.09	94	0.43	87	0.33	93	0.32	71	6
9752695	Vieques Island, PR	1.03	104	0.28	120	0.26	109	0.49	31	7
9759110	Maguey Island, PR	0.92	118	0.30	117	0.40	81	0.22	96	8
9759938	Mona Island, PR	0.54	140	0.22	125	0.26	111	0.06	143	9

Appendix D

Table D. Gap prioritization ranking by region
(For gap names, please refer to Appendix E.)

D1. Northeast and Mid-Atlantic									
GAP Number	**Prioritization Total**	**Prioritization National Rank**	**Datum Total**	**Datum National Rank**	**Sea Level Monitoring Total**	**Sea Level Monitoring National Rank**	**Navigation Total**	**Navigation National Rank**	**Prioritization Regional Rank**
EC GAP #34	1.64	6	0.70	11	0.94	3	0.00	50	1
EC GAP #31	1.13	12	0.66	13	0.48	14	0.00	52	2
EC GAP #35	1.07	15	0.49	23	0.58	9	0.00	47	3
EC GAP #17	1.05	17	0.66	12	0.20	24	0.19	9	4
EC GAP #33	0.92	20	0.31	36	0.45	15	0.16	13	5
EC GAP #36	0.76	24	0.22	46	0.54	12	0.00	63	6
EC GAP #22	0.44	41	0.08	65	0.36	16	0.00	56	7
EC GAP #37	0.42	44	0.08	63	0.34	19	0.00	64	8
EC GAP #38	0.38	46	0.03	78	0.35	17	0.00	49	9
EC GAP #26	0.36	49	0.29	39	0.07	39	0.00	48	10
EC GAP #43	0.34	51	0.23	44	0.11	31	0.00	75	11
EC GAP #39	0.30	53	0.27	40	0.03	50	0.00	82	12
EC GAP #40	0.21	59	0.16	50	0.05	42	0.00	43	13

EC GAP #27	0.19	60	0.16	52	0.04	49	0.00	81	14
EC GAP #41	0.19	61	0.01	84	0.18	26	0.00	74	15
EC GAP #42	0.18	63	0.02	81	0.16	27	0.00	65	16
EC GAP #19	0.17	65	0.16	53	0.02	60	0.00	45	17
EC GAP #18	0.17	66	0.16	51	0.01	72	0.00	85	18
EC GAP #29	0.14	70	0.10	61	0.04	43	0.00	79	19
EC GAP #28	0.12	71	0.04	74	0.08	35	0.00	76	20
EC GAP #25	0.12	72	0.11	58	0.01	62	0.00	70	21
EC GAP #30	0.10	75	0.07	67	0.03	52	0.00	68	22
EC GAP #23	0.08	76	0.02	83	0.07	41	0.00	67	23
EC GAP #21	0.08	77	0.06	69	0.02	55	0.00	61	24
EC GAP #24	0.05	80	0.03	77	0.02	56	0.00	69	25
EC GAP #20	0.04	82	0.03	80	0.01	68	0.00	84	26

D2. Southeast and Gulf									
GAP Number	**Prioritization Total**	**Prioritization National Rank**	**Datum Total**	**Datum National Rank**	**Sea Level Monitoring Total**	**Sea Level Monitoring National Rank**	**Navigation Total**	**Navigation National Rank**	**Prioritization Regional Rank**
GOMEX GAP #8	2.15	1	0.37	31	0.77	6	1.00	1	1
EC GAP #3	1.82	3	0.70	10	1.00	1	0.12	16	2
EC GAP #5	1.81	4	0.30	38	0.89	4	0.62	5	3
GOMEX GAP #3	1.70	5	0.36	32	0.65	7	0.69	3	4
GOMEX GAP #25	1.60	7	1.00	1	0.60	8	0.00	46	5
GOMEX GAP #11	1.52	8	0.40	30	0.32	20	0.79	2	6
EC GAP #14	1.43	9	1.00	2	0.26	22	0.18	11	7
GOMEX GAP #23	1.36	10	0.83	5	0.53	13	0.00	42	8
GOMEX GAP #1	0.99	18	0.75	9	0.23	23	0.01	30	9
GOMEX GAP #22	0.80	22	0.77	7	0.02	53	0.00	53	10
EC GAP #2	0.73	25	0.15	55	0.57	10	0.00	33	11
GOMEX GAP #5	0.68	27	0.45	25	0.04	44	0.19	8	12
GOMEX GAP #21	0.66	29	0.57	17	0.10	34	0.00	55	13
EC GAP #1	0.54	35	0.51	21	0.03	51	0.00	44	14
GOMEX GAP #13	0.47	38	0.12	57	0.04	45	0.31	7	15
EC GAP #10	0.44	40	0.23	45	0.11	32	0.10	18	16

EC GAP #4	0.43	43	0.09	62	0.34	18	0.00	51	17
GOMEX GAP #15	0.38	45	0.21	47	0.12	30	0.05	21	18
GOMEX GAP #16	0.37	48	0.36	33	0.02	61	0.00	62	19
GOMEX GAP #20	0.36	50	0.26	41	0.10	33	0.00	54	20
EC GAP #12	0.30	54	0.11	59	0.19	25	0.00	58	21
GOMEX GAP #7	0.28	56	0.08	64	0.12	29	0.08	19	22
GOMEX GAP #14	0.27	57	0.25	43	0.02	54	0.00	60	23
EC GAP #13	0.25	58	0.17	49	0.08	36	0.00	59	24
GOMEX GAP #19	0.17	67	0.13	56	0.04	47	0.00	57	25
EC GAP #09	0.16	68	0.07	66	0.08	37	0.00	66	26
EC GAP #7	0.14	69	0.06	70	0.08	38	0.00	77	27
EC GAP #11	0.12	73	0.05	73	0.07	40	0.00	78	28
GOMEX GAP #4	0.11	74	0.10	60	0.02	59	0.00	40	29
EC GAP #8	0.04	81	0.01	86	0.04	48	0.00	36	30
EC GAP #6	0.03	84	0.02	82	0.01	63	0.00	83	31
GOMEX GAP #12	0.03	85	0.03	76	0.00	82	0.00	71	32

D3. West Coast									
GAP Number	**Prioritization Total**	**Prioritization National Rank**	**Datum Total**	**Datum National Rank**	**Sea Level Monitoring Total**	**Sea Level Monitoring National Rank**	**Navigation Total**	**Navigation National Rank**	**Prioritization Regional Rank**
WC Gap #5	1.90	2	0.42	28	0.84	5	0.64	4	1
WC Gap #2	1.06	16	0.06	71	1.00	2	0.00	72	2
WC Gap #3 and Gap #4	0.77	23	0.45	26	0.30	21	0.03	26	3
WC Gap #1	0.60	31	0.05	72	0.55	11	0.00	73	4
WC gap #6	0.56	33	0.30	37	0.15	28	0.11	17	5

D4. Alaska									
GAP Number	**Prioritization Total**	**Prioritization National Rank**	**Datum Total**	**Datum National Rank**	**Sea Level Monitoring Total**	**Sea Level Monitoring National Rank**	**Navigation Total**	**Navigation National Rank**	**Prioritization Regional Rank**
AK GAP #15	1.21	11	0.75	8	0.01	64	0.45	6	1
AK GAP #12	1.12	13	0.95	4	0.00	81	0.17	12	2
AK GAP #11	1.07	14	1.00	3	0.00	78	0.07	20	3
AK GAP #10	0.94	19	0.80	6	0.02	57	0.13	15	4
AK GAP #2	0.83	21	0.64	15	0.01	76	0.19	10	5
AK GAP #19	0.71	26	0.65	14	0.01	67	0.04	22	6
AK GAP #3	0.68	28	0.54	19	0.01	74	0.13	14	7
AK GAP #25	0.64	30	0.62	16	0.01	75	0.01	31	8
AK GAP #27	0.57	32	0.55	18	0.01	69	0.01	32	9
AK GAP #23	0.55	34	0.53	20	0.01	70	0.00	34	10
AK GAP #1	0.51	36	0.47	24	0.00	77	0.03	25	11
AK GAP #31	0.50	37	0.50	22	0.00	85	0.00	35	12
AK GAP #26	0.45	39	0.43	27	0.01	73	0.01	29	13
AK GAP #21	0.44	42	0.41	29	0.01	71	0.01	28	14
AK GAP #7	0.37	47	0.31	35	0.02	58	0.04	23	15
AK GAP #30	0.33	52	0.33	34	0.00	80	0.00	38	16

AK GAP #4	0.28	55	0.25	42	0.00	84	0.03	24	17
AK GAP #9	0.19	62	0.18	48	0.01	65	0.00	41	18
AK GAP #6	0.18	64	0.16	54	0.00	79	0.02	27	19
AK GAP #8	0.07	78	0.06	68	0.01	66	0.00	39	20
AK GAP #5	0.04	83	0.03	75	0.00	83	0.00	37	21

D5. Hawaii									
GAP Number	**Prioritization Total**	**Prioritization National Rank**	**Datum Total**	**Datum National Rank**	**Sea Level Monitoring Total**	**Sea Level Monitoring National Rank**	**Navigation Total**	**Navigation National Rank**	**Prioritization Regional Rank**
Hawaii GAP #1	0.06	79	0.03	79	0.04	46	0.00	80	1
Hawaii GAP #2	0.01	86	0.01	85	0.00	86	0.00	86	2

Appendix E

Table E. Gap names and IDs by region.

E1. Northeast and Mid-Atlantic			
GAP Number	**STATE**	**Gap Name**	**Note**
EC GAP #43	ME	Upper Kennebec River	
EC GAP #42	NH	Vicinity of Bellamy River	
EC GAP #41	NH/MA	Upper Merrimack River	
EC GAP #40	MA	Outer Cape Cod coast	
EC GAP #39	CT	Upper Connecticut River	
EC GAP #38	CT/NY	Eastern Long Island Sound	
EC GAP #37	NY	Western Peconic Bays	
EC GAP #36	NY	Inside Shinnecock/Moriches Bay	
EC GAP #35		Southern Shore, Outer Coast, Long Island	
EC GAP #34	NY	Great South Bay	
EC GAP #33	NY	Mid-Hudson River	
EC GAP #31	NJ	Great Egg Harbor and Barnegat Bay	This polygon represents 2 gaps: 1. #31 (Great Egg Harbor) and 2. #32 (Barnegat Bay)
EC GAP #30	NJ	Maurice River	
EC GAP #29	DE	Indian River	

EC GAP #28	MD	Isle of Wight and Assawoman Bays	
EC GAP #27	MD	Chincoteague Bay	
EC GAP #26	MD	Havre de Grace, Upper Chesapeake Bay	
EC GAP #25	MD	Upper Chester River	
EC GAP #24	MD	Vicinity of Wye River, Eastern Bay	
EC GAP #23	MD	Upper Nanticoke River	
EC GAP #22	MD/VA	Potomac River	
EC GAP #21	MD	Upper Wicomico River	
EC GAP #20	VA	Upper Rappahannock River	
EC GAP #19	VA	Lower Chesapeake Bay Vicinity of Rappahannock Shoal	
EC GAP #18	VA	Upper York River	
EC GAP #17	VA	Upper James River	

E2. Southeast and Gulf			
GAP Number	**STATE**	**Gap Name**	**Note**
EC GAP #14	NC	Cedar Island, Pamlico Sound, and Albemarle Sound	This polygon represents 3 gaps: 1. #14 (Cedar Island, Southern Pamlico Sound), 2. #15 (Western Pamlico Sound), and 3. #16 (Albemarle Sound)
EC GAP #13	NC	Bogue Inlet/Sound	
EC GAP #12	NC	New River	
EC GAP #11	NC	Upper Cape Fear River	
EC GAP #10	SC	Winyah Bay	
EC GAP #9	SC	South Santee River	
EC GAP #8	SC	Upper Cooper River	
EC GAP #7	SC	Upper Edisto River	
EC GAP #6	GA	Upper Satilla River	
EC GAP #5	FL	Upper St. Johns River	
EC GAP #4	FL	Outer Coast, Vicinity of Flagler Beach	
EC GAP #3	FL	Inner Bays, Indian River	
EC GAP #2	FL	Southern Biscayne Bay	
EC GAP #1	FL	Ocean Coast Key Colony Beach	
GOMEX GAP #25	FL	Chokoloskee, Cape Sable, Northern Florida Bay, and Lower Keys and Vicinity	This polygon represents 4 gaps: 1. #25 (Chokoloskee), 2. #26 (Cape Sable),

			3. #27 (Northern Florida Bay), and 4. #28 (Lower Keys [Gulf of Mexico side] and Vicinity)
GOMEX GAP #23	FL	Vicinity and Outer Coast of Venice, and Charlotte Harbor	This polygon represents 2 gaps: 1. #23 (Vicinity and Outer Coast of Venice) and 2. #24 (Charlotte Harbor)
GOMEX GAP #22	FL	Apalachee Bay, St. George Sound and Vicinity	
GOMEX GAP #21	FL	Choctawhatchee Bay	
GOMEX GAP #20	AL/FL	Wolf Bay, AL, and Perdido Bay	
GOMEX GAP #19	AL	Weeks Bay	
GOMEX GAP #18	LA/MS	Lower Pearl River	The polygon for this gap is missing
GOMEX GAP #16	LA	Lower Mississippi River and Breton Sound	This polygon represents 2 gaps: 1. #16 (Lower Mississippi River) and 2. #17 (Breton Sound)
GOMEX GAP #15		Lake Salvador	
GOMEX GAP #14	LA	Houma Ship Canal	
GOMEX GAP #13	LA	Upper Vermillion and West Cote Blanche Bays	
GOMEX GAP #12		Lower and Upper Mud Lake Vicinity	
GOMEX GAP #11	TX/LA	Upper Neches and Sabine Rivers	
GOMEX GAP #8	TX	Houston Ship Channel, Upper Galveston Bay, and East Bay	This polygon represents 3 gaps: 1. #8 (Houston Ship Channel), 2. #9 (Upper Galveston Bay), and 3. #10 (East Bay)
GOMEX GAP #7	TX	West Bay	
GOMEX GAP #5	TX	Lavaca, Keller, Carancahua, Tres Palacios Bays, and Matagorda and East Matagorda Bays	This polygon represents 2 gaps: 1. #5 (Lavaca, Keller, Carancahua, Tres Palacios Bays) and 2. #6 (Matagorda, East Matagorda Bays)

GOMEX GAP #4		Outer Coast, Pass Cavallo	
GOMEX GAP #3	TX	Corpus Christi Bay; Aransas Pass Inside	
GOMEX GAP #1	TX	Southern and Northern Laguna Madre	This polygon represents 2 gaps: 1. #1 (Southern Laguna Madre) and 2. #2 (Northern Laguna Madre)

E3. West Coast			
GAP Number	**STATE**	**Gap Name**	**Note**
WC Gap #1	CA	Tijuana Slough	
WC Gap #2	CA	South San Francisco Bay	
WC Gap #3 and Gap #4	CA	Stockton River Delta and Sacramento River Delta	This polygon represents 2 gaps: 1. #3 (Stockton River Delta) and 2. #4 (Sacramento River Delta)
WC Gap #5	OR/WA	Upper Columbia River	
WC gap #6	WA	Olympia, Budd Inlet	

E4. Alaska			
GAP Number	**STATE**	**Gap Name**	**Note**
AK GAP #1	AK	Craig, Bucareli Bay	
AK GAP #2	AK	Snow Passage	
AK GAP #3	AK	Frederick Sound	
AK GAP #4	AK	Glacier Bay	
AK GAP #5	AK	Entrance to Dry Bay	
AK GAP #6	AK	Cape St. Elias, Controller Bay	
AK GAP #7	AK	Cook Inlet Entrance	
AK GAP #8	AK	Tuxedni Bay	
AK GAP #9	AK	Kamishak Bay	
AK GAP #10	AK	Shelikof Straits	
AK GAP #11	AK	Port Wrangell to Chignik Bay, Alaska Peninsula	
AK GAP #12	AK	Aleutian Islands, South Side, Unimak Island to Unalaska Island	This polygon represents 3 gaps: 1. #12 (Aleutian Islands, South Side, Unimak Island to Unalaska Island), 2. #13 (Aleutian Islands, South Side, Unalaska Island to Atka Island), and 3. #14 (North Side Unimak Island)
AK GAP #15	AK	North Side Aleutians East, Kvichak Bay Vicinity, Nushagak Bay, and Hagemeister Island Vicinity	This polygon represents 4 gaps: 1. #15 (North Side Aleutians East), 2. #16 (Kvichak Bay Vicinity), 3. #17 (Nushagak Bay), and 4. #18 (Hagemeister Island Vicinity)

AK GAP #19	AK	Kuskokwim Bay and Toksook Bay Vicinity	This polygon represents 2 gaps: 1. #19 (Kuskokwim Bay) and 2. #20 (Toksook Bay Vicinity)
AK GAP #21	AK	Yukon River Delta and Eastern St. Lawrence Island	This polygon represents 2 gaps: 1. #21 (Yukon River Delta) and 2. #22 (Eastern St. Lawrence Island)
AK GAP #23	AK	Stebbins – Southern Norton Sound and Eastern Kotzebue Sound	This polygon represents 2 gaps: 1. #23 (Stebbins, Southern Norton Sound) and 2. #24 (Eastern Norton Sound)
AK GAP #25	AK	Eastern Kotzebue Sound	
AK GAP #26	AK	Bering Straits	
AK GAP #27	AK	Chukchi Sea – Cape Sabine Vicinity, Chukchi Sea – Icy Cape Vicinity, and Pt. Barrow	This polygon represents 3 gaps: 1. #27 (Chukchi Sea, Cape Sabine Vicinity), 2. #28 (Chukchi Sea, Icy Cape Vicinity), and 3. #29 (Pt. Barrow)
AK GAP #30	AK	Prudhoe Bay to Canadian Border	
AK GAP #31	AK	Amchitka Island and Attu Island	This polygon represents 2 gaps: 1. #31 (Amchitka Island) and 2. #32 (Attu Island)

E5. Hawaii			
GAP Number	**STATE**	**Gap Name**	**Note**
Hawaii GAP #1	HI	Southeast Point of Hawaii Island	
Hawaii GAP #2	HI	South shore of Kaho’olawe Island	

ACRONYMS

Acronym	**Term**
ACG	Accidents, Collisions, Groundings
ACS	American Community Survey
AIS	Automatic Identification System
CO-OPS	Center for Operational Oceanographic Products and Services
CV	Cargo Value
ESRI	Environmental Systems Research Institute
GIS	Geographic Information System
GLOSS	Global Sea Level Observing System Stations
HTF	High Tide Flooding
MISLE	Marine Information for Safety and Law Enforcement
NCOP	National Current Observation Program
NOAA	National Oceanic and Atmospheric Administration
NOS	National Ocean Service
NWLON	National Water Level Observation Network
NTDE	National Tidal Datum Epoch
NWS	National Weather Service
OFS	Operational Forecast System
PORTS®	Physical Oceanographic Real-Time Systems
SLR	Sea Level Rise
USACE	United States Army Corps of Engineers
WCSC	Waterborne Commerce Statistics Center