U.S. National Report

Contributions to the Global Sea Level Observing System

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Introduction

The 2011 United States (U.S.) National Report to the Global Sea Level Observing System (GLOSS) Group of Experts (GE) XII is a summary of various ongoing U.S. programs and activities that support GLOSS goals and objectives as outlined in the GLOSS Implementation Plan. While programs and activities addressing sea level in the U.S. extend from federal to academic, this report focuses on three primary U.S. contributions to GLOSS:

- The NOAA National Ocean Service National Water Level Observation Network, managed by the Center for Operational Oceanographic Products and Services,
- The University of Hawaii Sea Level Center, and
- U.S. support for satellite altimeter operations and research

The first section of the report provides updates on operating status of the various components of the system. The second section provides updates on product development and delivery of data, including database support and web products, followed by the third section providing information on advancements in technology. A fourth section of the report has been added in 2011 to provide an overview of sea level observations for extreme events in the U.S. in alignment with one of the foci of the 2011 GLOSS Group of Experts meeting. Finally, the fifth section discusses regional activities in support of GLOSS.

The U.S. continues to be a leader and primary contributor to the international climate and sea level community. Vital to this continued support are international partnerships, innovative technological solutions, and sustained infrastructure for observing systems. The U.S. looks forward to continuing and enhancing collaborative sea level efforts with the international community.

Global Climate Observing System

The Global Climate Observing System (GCOS) is intended to be a long-term, user-driven operational system capable of providing the comprehensive observations required for:

- Monitoring the climate system,
- Detecting and attributing climate change,
- Assessing impacts of, and supporting adaptation to, climate variability and change,
- Application to national economic development,
- Research to improve understanding, modeling and prediction of the climate system.

GCOS addresses the total climate system including physical, chemical and biological properties, and atmospheric, oceanic, terrestrial, hydrologic, and cryospheric components. GLOSS is a primary component of GCOS.

NOAA Climate Program Office

The NOAA Climate Program Office (CPO) supports the ocean component of GCOS that will respond to the long term observational requirements of the operational forecast centers, international research programs, and major scientific assessments (http://www.climate.noaa.gov/).

In order for NOAA to fulfill its climate mission, the global ocean must be observed. A global observing system by definition crosses international boundaries, with potential for both benefits and responsibilities to be shared by many nations. All of NOAA's contributions to global ocean observation are managed in cooperation with the Joint World Meteorological Organization (WMO) - Intergovernmental Oceanographic Commission (IOC) of UNESCO Technical Commission for Oceanography and Marine Meteorology (JCOMM). NOAA has historically funded nearly half of the *in situ* elements of the international ocean climate observing system. Much of this work is accomplished through the CPO Climate Observations and Monitoring (COM) Program.

The goal of the COM Program is to provide comprehensive observations, data and analysis systems, climate data records, computational models, and research capabilities, which can address the current state of the climate at the accuracies and resolution required by the users; to provide capability to assimilate large and complex data sets into earth systems models in order to understand the climate of the past, provide attribution to the present and future states of the climate, and optimize observing systems; and to better quantify the information on atmospheric composition and feedbacks that contribute to changes in Earth's Climate. The COM Program designs, deploys, and maintains an integrated global network of oceanic and atmospheric observing instruments to produce continuous records and analyses of a range of ocean and atmosphere parameters. COM coordinates observing efforts across NOAA and other federal agencies, as well as internationally.

COM comprises the following major activities:

1. Build and sustain a global climate observing system according to the GCOS climate monitoring principles;
2. Develop and maintain long time-series indicators of climate variability and change;
3. Develop and maintain standard data sets for initialization and evaluation of climate forecast models, assessments of climate change, and informed risk management;
4. Perform diagnostic studies of observed patterns of climate variability and change on global to regional scales.

Sustained Ocean Observing System

The networks that make up the Sustained Ocean Observing System for Climate are: tide gauge stations, dedicated ships, ships of opportunity, ocean reference stations, Arctic observing systems, tropical moored buoys, surface drifting buoys, Argo profiling floats, data and assimilation subsystems, product delivery, and continuous satellite missions for sea surface temperature, sea surface height, surface vector winds, ocean color, and sea ice. NOAA CPO contributes to global implementation of nearly all networks.

The international Global Climate Observing System *Implementation Plan for the Global Observing System for Climate in support of the UNFCCC* (GCOS-138, updated 2010) (http://www.wmo.ch/pages/prog/gcos) helps guide the Climate Program Office system design and prioritization. The 2010 version of the implementation plan updates the original 2004 version, and includes a revised list of the GCOS Essential Climate Variables. It has been endorsed by the UNFCCC and by the Group on Earth Observation (GEO). http://www.wmo.int/pages/prog/gcos/Publications/gcos-138.pdf

NOAA's *Program Plan for Building a Sustained Ocean Observing System for Climate* is in complete accord with GCOS-138 and provides the framework for NOAA contributions to the international effort. All of the work supported by CPO is directed toward implementation of this international plan and the projects are being implemented in accordance with the GCOS Climate Monitoring Principles.

Tide gauge stations are necessary to the climate program for accurately measuring long-term trends in sea level change and for calibration and validation of the measurements from satellite altimeters, which are assimilated into global climate models for predicting climate variability and change. Many tide stations need to be upgraded with modern technology, particularly in less developed countries. Permanent GPS receivers are being installed, leading to a geocentrically located subset of 170 GCOS Climate Reference Stations, as identified in the original GCOS Implementation Plan, GCOS-92. The 170 Climate Reference Stations are also being upgraded for real-time reporting, not only for climate monitoring, but also to support marine hazard warning (e.g., tsunami warning). This Climate Reference Station subset of the GLOSS core network has historically been the focus of CPO support.

The University of Hawaii Sea Level Center is a NOAA partner who assists in the coordination of tide gauge operations within the international community. NOAA provides long-term support for the climate work at the UHSLC. Sea level stations within the U.S. are primarily operated by NOAA's Center for Operational Oceanographic Products and Services (CO-OPS).

I. Global Sea Level Observing Network Components and Operating Status

A. Tide Station Networks

NOAA National Ocean Service

NOAA has operated and maintained a network of coastal sea level (tide gauge) stations for over 150 years, and is the legal authority for sea level in the U.S. The NOAA National Ocean Service (NOS) Center for Operational Oceanographic Products and Services (CO-OPS) operates 210 long-term sea level stations, called the National Water Level Observation Network (NWLON). CO-OPS sea level stations are multi-purpose, supporting diverse applications with both real-time and long-term data, from safe and efficient navigation and coastal hazard mitigation to coastal zone management and climate observation. CO-OPS provides an "end-to-end" system of data collection, quality control, data management, and product delivery. CO-OPS distributes data directly from its own web site, through the Global Telecommunication System (GTS), through OPeNDAP and SOS servers, and through some specialized methods, such as ftp server. CO-OPS maintains a rigorous set of standards and methodologies and is recognized for the high level of accuracy and reliability in data delivery. Information on CO-OPS standards and protocols can be found at: http://tidesandcurrents.noaa.gov/pub.html

In addition to maintenance of this long-term network, CO-OPS has been tasked with three primary activities in support of NOAA's CPO goals, together comprising its primary contribution to GLOSS:

1) Upgrade the operation of selected National Water Level Observation Network Stations to ensure continuous operation and connection to geodetic reference frames

2) Operate and maintain water level measurement systems on Platform Harvest in support of calibration of the TOPEX/Poseidon and Jason 1 satellite altimeter missions

3) Develop and implement a routine annual sea level and extreme event analysis reporting capability that meets the requirements of the CPO

Several NWLON stations have been identified as critical components of GLOSS (See Appendix 1 for a full listing). 29 of the 210 NOAA NWLON stations are considered GLOSS stations, and contribute to the Joint Archive for Sea Level (JASL). Appendix 2 is a listing of additional NOAA sea level stations currently contributing to the JASL database. There are 54 total NOAA operational NWLON stations that actively contribute to the JASL archive. The 18 NWLON stations identified at the 1997 International Sea Level Workshop as critical to the global system for monitoring long term sea level trends are also identified in the tables as Climate Reference Network (CRN) stations. While reference to CRN is being phased out following the revision of the GCOS Implementation Plan, stations are still identified as such for the purposes of this report during transition.

Upgrade of NOAA Ocean Island Station Operations

Several coastal and island NWLON stations are critical to GCOS. Annual maintenance is often extremely important at these often remote locations, due to the fact that corrective maintenance is logistically very difficult and expensive. Redundancy in data collection and transmission is also critical, as the continuity and integrity of these important data sets must be maintained for accurate sea level measurements.

Although operation of all of the long-term NWLON and GLOSS stations is important, a subset of NOAA NWLON Ocean Island stations were targeted for priority upgrade to ensure their continuous operation, and work has been conducted over the past several years. These upgrades have included high accuracy acoustic or paroscientifc pressure sensors and redundant Data Collection Platforms (DCPs) with equal capability to the existing primary systems. Now that hardware upgrades of the highest priority stations are complete, stations will continue to be enhanced where needed with connections to geodetic reference systems (through leveling and/or GPS), followed by installation of NGS Continuously Operating Reference Systems (CORS) at selected sites. Table 1 provides a list of the ocean island NWLON stations (not including Hawaii) that were considered in this category as priority for upgrade. Stations with outstanding work in CORS installations are marked “No” in the respective category and will be addressed over the next two years.

Table 1. Ocean island NOAA NWLON stations (not including Hawaii) which have been upgraded.

Station	Upgraded	Geodetic Connection	CORS (GPS)
Guam	Yes	Yes	Yes
Kwajalein	Yes	Yes	Yes
Pago Pago	Yes	Yes	Yes
Wake Island	Yes	Yes	No
Midway	Yes	Yes	No
Adak	Yes	Yes	No
Bermuda	Yes	Yes	Yes
San Juan, PR	Yes	Yes	Yes
Magueyes Island, PR	Yes	Yes	Yes
Charlotte Amalie, VI	Yes	Yes	Yes
St. Croix, VI	Yes	Yes	Yes

University of Hawaii Sea Level Center

The University of Hawaii Sea Level Center (UHSLC) collects, processes, and distributes tide gauge measurements from around the world in support of various climate research activities. Primary support for the UHSLC is provided by the NOAA CPO. UHSLC datasets are used for a variety of research and operational activities, including assessments of sea level rise and variability, the calibration of altimeter data, and storm surge and tsunami monitoring. In support of satellite altimeter calibration and for absolute sea level rise monitoring, the UHSLC and the Pacific GPS Facility maintain co-located GPS systems at select tide gauge stations (GPS@TG). The UHSLC currently is a designated CLIVAR Data Assembly Center (DAC) and an IOC GLOSS data archive center. The UHSLC distributes data directly from its own web site and through a dedicated OPeNDAP server. The data are redistributed by the National Oceanographic Data Center (NODC), the Permanent Service for Mean Sea Level, the Climate Data Portal (CDP) maintained by the Pacific Marine Environmental Laboratory (PMEL) the National Virtual Ocean Data System (NVODS) the International Pacific Research Center's GODAEdata server, and the NOAA Observing System Architecture (NOSA) web site.

The UHSLC collaborates in the operation of 64 tide gauge stations in the global sea level network. All of these sites meet GLOSS standards for tsunami monitoring and are currently providing data to appropriate warning centers. The UHSLC in collaboration with the Pacific GPS Facility operates co- located continuous GPS (GPS@TG) receivers at 7 tide gauges, which constitute to the NASA/CNES Science Working Team for altimeter calibration, and provide local estimates of absolute sea level rise.

The UHSLC distributes three sea level data sets: Joint Archive for Sea Level (JASL), Fast Delivery Database, and Near Real-Time Data (See Section III: Product Development and Delivery).

Table 2. GLOSS Stations operated by or in collaboration with UHSLC.

GLOSS	STATION	COUNTRY	LAT	LONG	GPS?
182	Acajutla	El Salvador	13° 35'N	089° 50'W	
068	Ambon	Indonesia	03º 41'S	128º 11'E	
169	Baltra	Ecuador	00º 26'S	090º 17'W	
xxx	Barbers Point	USA	21° 19'N	158° 07'W	
049	Benoa	Indonesia	08º 46'S	115º 13'E	
069	Bitung	Indonesia	00º 27'N	125º 12'E	
173	Callao	Peru	12° 03'S	077° 09'W	
128	Chatham	New Zealand	43° 57'S	176° 34'W	
036	Chittagong	Bangladesh	22º 20'N	091º 38'E	
146	Christmas	Rep. of Kiribati	01º 59'N	157º 28'W	
291	Cilacap	Indonesia	07º 45'S	109º 00'E	
033	Colombo	Sri Lanka	06º 57'N	079º 51'E	

xxx	Curacao	Neth. Antilles	12° 06'N	068° 57'W	
xxx	Currimao	Philippines	18° 01'N	120° 29'E	
253	Dakar	Sénégal	14º 41’N	017º 25’W	
071	Davao	Philippines	07º 50’N	125º 38’E	
026	Diego Garcia	United Kingdom	07º 17’S	072º 24’E	
245	Fortaleza	Brazil	03º 43’S	38º 28’W	
107	French Frigate S	USA	23º 52’N	166º 17’W	
027	Gan	Rep. of Maldives	00º 41’S	073º 09’E	
xxx	Hanimaadhoo	Rep. of Maldives	06º 46’N	073º 10’E	
xxx	Hiva Oa	Fr. Polynesia	09° 49'S	139° 02'W	
109	Johnston	USA Trust	16º 44’N	169º 32’W	
145	Kanton	Rep. of Kiribati	02º 49’S	171º 43’W	
117	Kapingamarangi	Fd St Micronesia	01º 06’N	154º 47’E	
xxx	Kaumalapau	USA	20° 47'N	157° 00'W	
042	Ko Taphao Noi	Thailand	07º 49’N	098º 25’E	
172	La Libertad	Ecuador	02° 12'S	080° 55'W	
xxx	Lamu	Kenya	02º 16’S	040º 54’E	
xxx	Langkawi	Malaysia	06º 52’N	099º 46’E	
072	Legaspi	Philippines	13° 09'N	123° 45'E	
xxx	Lombok (Lembar)	Indonesia	08º 45’S	116º 04’E	
xxx	Limon	Costa Rica	10° 00'N	083° 02'W	
xxx	Lubang	Philippines	13° 49'N	120° 12'E	
120	Malakal	Rep. of Belau	07º 20’N	134º 28’E	GPS@TG
028	Male (Hulhule)	Rep. of Maldives	04º 11’N	073º 32’E	GPS@TG
073	Manila	Philippines	14º 38’N	121º 05’E	
163	Manzanillo	Mexico	19º 03’N	104º 20’W	GPS@TG
192	Mar Del Plata	Argentina	38º 02’S	057º 32’W	
xxx	Masirah	Oman	20º 41’N	058º 52’E	
xxx	Matarani	Peru	17° 00'S	072° 07'W	
008	Mombasa	Kenya	04º 04’S	039º 39’E	
141	Moulmein	Myanmar	16º 29’N	097º 37’E	
xxx	Muscat	Oman	23° 38'N	058° 34'W	
142	Nuku Hiva	French Polynesia	08º 55’S	140º 06’W	
045	Padang	Indonesia	00º 57’S	100º 22’E	
329	Palmeira	Cape Verde	16º 45’N	022º 59’W	GPS@TG
140	Papeete	French Polynesia	17º 32’S	149º 34’W	
143	Penrhyn	Cook Islands	08º 59’S	158º 03’W	
245	Ponta Delgada	Portugal	37º 44’N	025º 40’W	
018	Port Louis	Mauritius	20º 09’S	057º 30’E	
xxx	Prickley Bay	Grenada	12° 00'N	061° 46'W	
xxx	Prigi	Indonesia	08º 17’S	111º 44’E	
273	Pt. LaRue	Seychelles	04º 40’S	055º 32’E	
190	Puerto Deseado	Argentina	47° 45'S	065° 55'W	

191	Puerto Madryn	Argentina	42° 46'S	065° 02'W	
xxx	Puerto Plata	Dom. Rep.	19° 48'N	070° 42'W	
xxx	Punta Cana	Dom. Rep.	18°30'N	068° 23'W	
167	Quepos	Costa Rica	09° 24'N	084° 10'W	
075	Qui Nhon	Vietnam	13º 47'N	109º 15'E	
138	Rikitea	French Polynesia	23º 08'S	134º 57'W	
019	Rodrigues	Mauritius	19º 40'S	063º 25'E	
xxx	Roseau	Dominica	15° 18'N	061° 24'W	
xxx	Sabang	Indonesia	05º 50'N	095º 20'E	
118	Saipan	USA	15º 14'N	145º 45'E	
004	Salalah	Oman	16º 56'N	054º 00'E	
xxx	Salvador	Brazil	12º 58'S	038º 31'W	
xxx	Santa Cruz	Ecuador	00º 45'S	090º 19'W	
xxx	Saumlaki	Indonesia	08º 00'S	131º 18'E	
211	Settlement Pnt.	Bahamas	26º 41'N	078º 59'W	GPS@TG
xxx	Sibolga	Indonesia	01º 44'N	098º 48'E	
037	Sittwe	Myanmar	20º 09'N	092º 54'E	
xxx	Subic Bay	Philippines	14º 49'N	120º 17'E	
181	Ushuaia	Argentina	54° 48'S	068° 18'W	
xxx	Vung Tau	Vietnam	10º 20'N	107º 15'E	
119	Yap	Fd St Micronesia	09º 31'N	138º 08'E	
297	Zanzibar	Tanzania	06º 09'S	039º 11'E	

Note: GPS@TG indicates which stations have UHSLC GPS co-located at the tide stations.

In 2009 the UHSLC received funding from the NOAA Tsunami Program for installing and/or updating sea level stations in the Pacific Ocean and the Caribbean. In the Caribbean they have been working with the Puerto Rico Seismic Network. As of October 2011, new stations have been installed in Costa Rica (El Limón), Dominican Republic (Puerto Plata and Punta Cana), Curacao, Dominica and Grenada. The data from these stations are made available to the Tsunami Warning Centers and can also be accessed thru the website of the UHSLC (http://uhslc.soest.hawaii.edu/) and the IOC Sea Level Monitoring Facility (http://www.ioc-sealevelmonitoring.org/). In the Pacific the plans were to upgrade or perform new installations in Costa Rica, El Salvador, Peru (3 stations), Ecuador, Nicaragua, Philippines, Niue, French Polynesia, Hawaii and Mexico. This project ends in 2014. Staff of the UHSLC have also provided support for Caribbean Sea Level Network Operator's workshop in 2008 and 2011.

B. Satellite Altimeter Activities

Satellite Altimeter Operations

The launch of the Jason-2/Ocean Surface Topography Mission (Figure 1), on June 20, 2008, marked an important turning point in the evolution of satellite radar altimetry. Jason-2/OSTM is a joint effort by NOAA, NASA, France's Centre National d'Etudes Spatial (CNES), and the European Organization for the Exploitation of Meteorological Satellites (EUMETSAT). Its primary goal is to maintain continuity of the nearly two-decade record of ocean surface topography measurements established by the TOPEX/Poseidon and Jason-1 altimeter missions. These observations have proven be invaluable in the study of global mean sea level change, showing sea level rising at approximately 3.1 mm/yr between 1993 and 2011, more than 50% faster than over the past century, as well as revealing important new insights into regional sea-level change. The observations are also used to study eddy variability and large-scale circulation changes in the ocean. However, Jason-2/OSTM is different than its predecessors in that two operational agencies, NOAA and EUMETSAT, are participating for the first time. Plans are underway for a follow-on Jason-3 mission, to be launched in 2013 as a joint effort of NOAA, EUMETSAT and CNES.

Figure 1. Launch of Jason-2.

During the first six months of operation, known as the Tandem Mission, Jason-2/OSTM was flown along the same repeat orbit as Jason-1, but separated by 1 minute. In mid-February, 2009, Jason-1 was moved to an orbit that interleaves and lags Jason-2/OSTM by 5 days, effectively doubling the resolution of observations (157 km vs 315 km track spacing at equator, 5 day vs 10 day repeat period), thereby greatly improving the ability to monitor meso-scale sea level variability. The two satellites will continue this mode of operation, known as the Interleave Mission, indefinitely.

NOAA, working with CNES, is providing ground system support for Jason-2/OSTM. This includes command and control of the satellite, downloading telemetry, producing near-real time data products (OGDRs) and archiving and distributing all data products. EUMETSAT is sharing with NOAA the responsibility for downloading telemetry and producing OGDRs. CNES is producing all interim and final science data products (IGDRs and GDRs), as well as archiving and distributing them.

Satellite Data Analysis and Altimeter Drift Estimation

From the beginning of the TOPEX/Poseidon (T/P) mission, methods to estimate altimeter drift from comparisons with the global tide gauge network have continuously evolved, first in a research mode with NASA funding, and later becoming more general and operationally-oriented with some additional support from NOAA.

By the year 2000 the fundamental statistical footing for the method was firmly established, and it had been found that land motion at the tide gauges was the largest remaining source of error when estimating linear drift rates for the altimeters. To this point, however, the method, despite being quite general had only been applied on a regular basis to the TOPEX/Poseidon dataset. Also, a variety of versions of the basic programs existed for estimations based on data from different groups around the country.

With NOAA support, the University of South Florida (USF) was able to take assume the task of unifying the procedures for use on any altimeter dataset and put together a system that would enable taking in datasets from any source with relatively little difficulty.

USF now has in place an operational facility for ongoing comparisons between the available altimeter datasets and the global set of tide gauges using consistent, and proven, methods. These comparisons allow the estimation of any temporal drifts in the altimeter datasets, and allow the comparison of the different altimeter datasets with a single consistent sea surface height database. This means that these comparisons will be semi-absolute, in the sense that vertical offsets between different altimeters, even those which do not overlap in time, are determined as part of the procedure.

On a quasi-monthly basis USF downloads, processes and quality controls all of the tide gauge datasets that are used in USF products. These datasets are updated on a monthly basis at the UHSLC, and this timing sets a natural updating frequency for our products. In addition to updating the tide gauge datasets, code to translate any new altimeter products into the format required by our general routine must be written. This has been done for several altimeter products, including those produced at the NOAA Laboratory for Satellite Altimetry.

Satellite Altimeter Calibration

NOAA support for the TOPEX/Poseidon satellite altimeter mission through operation of a tide gauge station at Platform Harvest since 1993 provides water level measurements relative to the satellite altimeter closure analysis reference frame for calibration monitoring (B. Haines et al, 2003; Figure 2). Platform Harvest is an operational oil platform located 19.5 km west of Point Conception, CA. Maintenance of this station requires vertical surveys on the Platform to relate the water level sensor reference zeros (near the bottom catwalk) to the Global Positioning System (GPS) reference zero (located up top at the helipad on the Platform). Continuous data are required to monitor effects of waves on the water level measurements and to ensure provision of data during the times of altimeter over-flights every ten days. Platform Harvest tide gauge operations currently includes two digital bubbler pressure systems collecting continuous water level data streams surveyed into the Platform and Satellite Orbit Reference frames. Platform Harvest is one of several calibration sites located around the globe.

Figure 2. Platform Harvest Calibration Site.

C. Geodesy and Positioning

The National Geodetic Survey (NGS), an office of NOAA's National Ocean Service (NOS), is responsible for defining, maintaining and providing access to the National Spatial Reference System (NSRS). The NSRS is used by all civilian federal agencies and most of the public to establish coordinates for legal purposes. In the last 10 years the geometric component of the NSRS, latitude, longitude and ellipsoidal heights (NAD 83) has been defined via space geodetic techniques, especially GPS.

In 1986 NGS established a Continuously Operating GPS reference station network called the Cooperative International GPS Network (CIGNET) with three stations. By 1991 CIGNET had grown to 21 stations and in 1994 it was transferred to the International GPS Service now the International GNSS Service (IGS). Also in 1994 NGS established a new GPS network focused in the United States called the Continuously Operating Reference Station (CORS) network. It provides Global Navigation Satellite Systems (GNSS) data consisting of carrier phase and code range measurements in support of three dimensional positioning, meteorology, space weather, and geophysical applications throughout the United States, its territories, and a few foreign countries. Surveyors, GIS users, engineers, scientists, and the public at large that collect GPS data can use CORS data to improve the precision of their positions.

CORS-enhanced post-processed coordinates approach a few centimeters relative to the NSRS, both horizontally and vertically. The CORS network is a multi-purpose cooperative endeavor involving government, academic, and private organizations that independently own and operate each CORS. Each agency shares their data with NGS, and NGS in turn analyzes and distributes the data free of charge. As of October 2011, the CORS network contains over 1,800 stations, contributed by over 230 different organizations, and the network is growing at a rate of approximately 15 stations per month.

From the basic foundation established by the CORS network, NGS participates in a number of ways to support positioning of water level/tide gauge stations.

- NGS, in collaboration with CO-OPS and others, has established and operates a number of CORS located within 1 km of current CO-OPS NWLON stations. Most recently NGS installed a CORS CACC at Crescent City, California, USA.

- In addition NGS has successfully refurbished CORS BRMU, in Bermuda which is near the GLOSS Tide Gauge and an IGS reference frame site. NPRI CORS, a long-standing site that has been offline line for a number of years due to nearby construction, is back online.

- NGS has completed a complete re-analysis of all CORS data and on September 7, 2011 published coordinates and velocities for all CORS in NAD 83(2011, MA11, PA11) epoch 2010.00 and IGS08 epoch 2005.00.

- NGS defines the standards and guidelines for geodetic leveling that CO-OPS and its contractors use to level between tide gauge/water level stations and reference bench marks.

- NGS is a founding member of the IGS, is one of the 10 Analysis Centers and contributes rapid and final GPS orbits to IGS. It is also an IGS Regional Data Center.

Currently NGS is also the IGS Analysis Center Coordinator (ACC) for the period 2008-2012. Of the ten current IGS Analysis Centers, one center volunteers to perform the main product combination and quality control operations.

- NGS is the primary source of data for two GPS stations contained in the ~90+ fiducial reference frame stations used to define IGS08 reference defined and maintained by IGS.

- NGS provides a collection of Web services called Online Positioning User Service (OPUS). These services allow a user to upload GPS data that they have collected to NGS and receive back a coordinate based on automated processing by NGS on its servers using its own software. OPUS also now allows solutions to be published this allows a user to upload a data set with associated metadata and store it in an NGS database and publish the coordinates for use by others. CO-OPS and NGS have begun to use this functionality to process and archive the GPS data collected by CO-OPS on benchmarks at NWLON stations.

II. Product Development and Delivery

A. Current Sea Level Research and Derived Products

The latest summaries of climate research in the U.S. are found in the annual assessments compiled as annual publications of American Meteorological Society. Annual assessments of global sea level variations based on the latest research findings are also included. For instance see Merrifeld *et al* (2011).

University of South Florida Altimeter Products

The University of South Florida has expanded and improved its suite of products available to users over the past few years. A set of time series describing the differences of the various altimeter datasets relative to the global tide gauge network is now available.

There has also been a concerted effort to reduce the land motion uncertainties. This work has been done in collaboration with the TIGA (GPS on tide gauge) work of Guy Wöppelmann and Tilo Schöne. These errors are presently the largest source of uncertainty in the altimeter drift estimation, but this error component is steadily decreasing thanks to the expansion of the set of continuously operating GPS receivers at tide gauges, and the lengthening of the GPS time series. The products that are now available use the present best information on land motion derived from a set of about nearly 100 GPS receivers. In addition, USF has made substantial progress in putting proper error bars on these land motion estimates and matching these to individual tide gauges.

The system USF has in place assumes that there are a finite number of altimeter databases that will be updated on a roughly monthly basis, assuming changes to that database had occurred, of course. This led to a well-defined set of codes. What has become apparent, however, is that users of this system increasingly want to use these tide gauge analyses as a way of checking and improving their development of the altimeter sets rather than simply as hindsight check on how they are doing. This is particularly true for users developing Jason-1/2 datasets.

For example, if someone is developing alternate sea state bias corrections, they would like to send a dataset, have an analysis done, examine the results, modify their corrections, and repeat. This sort of iterative cycle can be repeated many times. USF is also doing these sorts of calculations for multiple altimeter groups. The net result is the need for a much more responsive system and the ability to handle multiple versions of the same altimeter databases.

USF is also in the process of streamlining the annual updating and selection of the tide gauges used in the analyses. USF expects to be able (on the same time frame) to utilize a set of nearly 100 gauges (c.f., the present set of 64) that have an improved global coverage, particularly in the Southern Hemisphere, and make use of improved land motion corrections. This update should be completed by the beginning of calendar 2012.

Finally, after the system was set up, feedback from users has led to work on several changes and improvements. First, the decision to reference to a “standard” TOPEX dataset was very unpopular and we have re-coded to replace this with a reference to whichever TOPEX dataset the user specifies. Second, as the time series have lengthened, questions about the handling of long period tides, particularly the Msf and Mf components, have been raised and we are adapting our methods appropriately. Third, in order to be able to treat new missions as soon as possible (i.e., after only two cycles were in hand), the optimization procedure was changed for determining the altimeter, tide gauge height differences. This led to somewhat larger random errors even after the time series had grown substantially, which is not necessary. USF has done simulations that will allow us to decide quantitatively when a given altimeter series is long enough to switch back to the original method. This improvement has been completed.

University of Hawaii Sea Level Center Research

UHSLC researchers completed a study of the spatial pattern of Pacific sea-level rise during 1993-2009 from satellite altimetry compared to previous time periods as sampled by the tide gauge network (Merrifield, 2011). Notably the region of highest rise rates in the western Pacific is shown to be associated with a steady increase in trade wind strength over that time period. The trade wind increase and sea level response appear to be unrelated to the dominant climate time scale indices in the region such as ENSO, the Pacific Decadal Oscillation, and the North Pacific Gyre Oscillation. The multi-decadal change has similar time variability as a global warming pattern that is represented by the dominant EOF mode of outgoing long-wave radiation. The sea level pattern appears to represent an oceanic response to recent warming trends via the intensification of trades driven by increased latent heat release. Numerical model simulations confirm that the multi-decadal wind change can account for the observed sea-level rise pattern (Merrifield and Maltrud, 2011).

An analysis of extreme sea level events using the global array of tide gauge data is near completion. Extreme climatologies are characterized in terms of tidal forcing, storm variability, and larger-scale wind-driven ocean variability. Trends in these forcing components have been assessed and the impact of global sea-level rise on extremes is a current focus. In addition, land motion trends from GPS measurements are being incorporated into various algorithms for estimating global sea level from tide gauges (Merrifield et al., 2009).

NOAA Research

The Pacific Storms Climatology Products project under the direction of the NOAA National Climatic Data Center (NCDC) regional climate services is exploring how the climate-related processes that govern extreme storm events are expressed within and between three thematic areas: *heavy rains*, *strong winds*, and *high seas*. Theme-specific data integration and product development teams have been formed to conduct analyses of historical records collected throughout the Pacific region. These teams are comprised of recognized agency and university-based experts. They include representatives from NOAA's National Climatic Data Center (NCDC) as well as the University of Hawaii, University of Victoria, University of Guam, and Oregon State University. The results of these analyses is an integrated suite of products that include the delineation of rates of sea level rise and high water return periods, as well as changes in the frequency of both short-lived intense rainfall events and extended periods of heavy rains, and the linkages of these patterns and trends to climate indices. Taken together, these products serve to reveal the patterns and trends of extremes within and between locations and regions, how they have been expressed historically, and may be expected to be expressed in a changing climate. Sources of information include the University of Hawaii Sea Level Center (UHSLC) Joint Archive for Sea Level: Research Quality Data Set and the GLOSS/CLIVAR "fast delivery" sea level dataset.

B. Data Delivery

Database Support and Maintenance

Permanent Service for Mean Sea Level (PSMSL)

Since 1933, the Permanent Service for Mean Sea Level (PSMSL) has been responsible for the collection, publication, analysis and interpretation of sea level data from the global network of tide gauges. Both NOAA and the University of Hawaii Sea Level Center contribute sea level data to PSMSL for long-term archival. http://www.pol.ac.uk/psmsl/.

NOAA Database and Delivery

The NESDIS National Data Centers (NCDC, NODC, and NGDC) archive and disseminate the basic datasets used to determine both global (absolute) SLR and local (relative) SLR. These include all NOAA satellite and in-situ station data used in constructing SLR analyses (altimetry, geodetic control, atmospheric observations, SSTs and ocean thermal properties, etc.).

The NWLON is also multipurpose and supports other NOAA missions that are national in scope:

- It is a fundamental component of NOAA's capability for storm surge monitoring and warning. The NWLON data are routine data sets to the NOAA Advanced Weather Information Processing System (AWIPS) system. The NWLON stations also can be automatically put into high-rate satellite dissemination on a user-driven or event-driven trigger. These data become part of the National Weather Service (NWS) pipeline for marine forecasts. Both the real-time data and the tidal datums computed at NWLON stations provide critical input for the NOAA SLOSH model (Sea, Lake, and Overland Surges from Hurricanes), a computerized model run by the National Hurricane Center (NHC) to estimate storm surge heights and winds resulting from historical, hypothetical, or predicted hurricanes. An extensive upgrade to meteorological sensors on NWLON stations is now complete; it resulted in 181 NWLON stations (91%) including at least one meteorological sensor.

- It is a fundamental component of NOAA's capability for tsunami warning. The NOAA Tsunami Warning Centers have access to high-rate data through the GOES when events are manually or automatically triggered.

In addition to meteorological sensors, the NWLON stations are capable of adding other sensors for long-term measurements for water conductivity and temperature and for water quality parameters.

A comprehensive CO-OPS web-site is maintained and allows users full access to all data and products on a 24 X 7 basis (http://tidesandcurrents.noaa.gov). All raw observed data (6-minute data with quality control flags attached) are automatically available over the web-site after the data collection systems receive each hourly transmission and after they undergo the quality control checks. Derived data products are made available through the web-site after verification.

Access to 1-minute water level data is now available through CO-OPS' tsunami website: http://tidesandcurrents.noaa.gov/tsunami/. This site was developed in collaboration with the NOAA Tsunami Warning Centers and the Pacific Marine Environmental Laboratory (PMEL) to support tsunami warning and modeling efforts.

Harmonic analyses are routinely performed and accepted sets of harmonic constants used for tidal prediction are maintained in the database and made available over the web-site. Tide prediction products based upon the accepted sets of harmonic constituents are also made available “on-the-fly” over the web-site.

System-wide tidal datum updates to new National Tidal Datum Epochs are made using the archived data and derived products in the data base. Accepted tidal datums are maintained and can be accessed over the web-site as well. Tidal datums are computed using documented standard operating procedures. Published bench mark sheets showing bench mark locations and elevations are prepared and updated and accessible over the web-site. Water level datums (International Great Lakes Datum, IGLD) in the Great Lakes are also updated every 25-30 years to account for movement of the earth’s crust due to isostatic rebound. The Great Lakes are one of the world’s greatest freshwater resources, and is shared and jointly managed by the U.S. and Canada. Updates in the IGLD are critical to updating of nautical charts and navigation safety, particularly during periods of low lake levels.

During storm events and other human-induced events, real-time (6-minute) data are made immediately available to users (http://tidesonline.nos.noaa.gov/ and http://glakesonline.nos.noaa.gov/ .

Real-time water level data in context with other real-time data are accessible for some NWLON stations if they are part of a local Physical Oceanographic Real Time System (PORTS®) (http://tidesandcurrents.noaa.gov/d_ports.html).

A number of 6 and 1-minute data products are available through the Integrated Ocean Observing System (IOOS) Web Portal, available through an OPeNDAP Server in a variety of formats. http://opendap.co-ops.nos.noaa.gov/content/

Sea level data associated sea level products are all available over the web-site for use by PSMSL, UHSLC, and the WOCE communities.

University of Hawaii Sea Level Center

The UHSLC distributes three sea level data sets. For a detailed station listing, please refer to the Appendices.

Joint Archive for Sea Level (JASL)

The Joint Archive for Sea Level JASL data set is designed to be user friendly, scientifically valid, well-documented, and standardized for archiving at international data banks. JASL data are provided internally by the UH Sea Level Network and by over 60 agencies representing over 70 countries. In the past year, the UHSLC increased its JASL holdings to 14,515 station-years of hourly quality assured data. The JASL set now includes 8166 station years of data in 328 series at 248 GLOSS sites.

Fast Delivery Database

The Fast Delivery Database supports various international programs, in particular CLIVAR and GCOS. The database has been designated by the IOC as a component of the GLOSS program. The fast delivery data are used extensively by the altimeter community for ongoing assessment and calibration of satellite altimeter datasets. The fast delivery sea level dataset now includes 277 stations, 214 of which are located at GLOSS sites.

High Frequency Data

Near Real-Time Data (collection + up to a three hour delay, H-3 delay) and daily filtered values (J-2 delay) are provided, primarily for stations that UHSLC directly operates and maintains. UHSLC has committed to hosting the GLOSS High Frequency database in collaboration with the Institute of Flanders (VLIZ).

The UHSLC provides monthly maps of the Pacific sea level fields through the JCOMM. UHSLC also produces quarterly updates of an index of the tropical Pacific upper layer volume and annual updates of indices of the ridge-trough system and equatorial currents for the Pacific Ocean. The analysis includes tide gauge and altimeter sea surface elevation comparisons.

C. Web Products

NOAA Sea Levels Online

NOAA's primary delivery method of local sea level trends to the public is through its *Sea Levels Online* website (http://tidesandcurrents.noaa.gov/sltrends). This site provides access both to NOAA long-term NWLON stations and to international stations. In 2008, the Sea Levels Online website was redesigned and a new Google Map interface was introduced to provide easier access for users to water level stations in their region of interest (Figures 3 and 4).

Analyses of sea level trends and variability are currently available for 128 long-term NWLON stations at *Sea Levels Online*. Figures 5-7 illustrate the types of analyses available for all long-term stations. In 2011, linear sea level trends were recalculated for all stations with trends published in the previous NOAA Technical Sea Level Trends Report (Zervas, 2009), using all available data up to the end of 2010. These updated trends will be added to the website with an expanded explanation of trend confidence intervals.

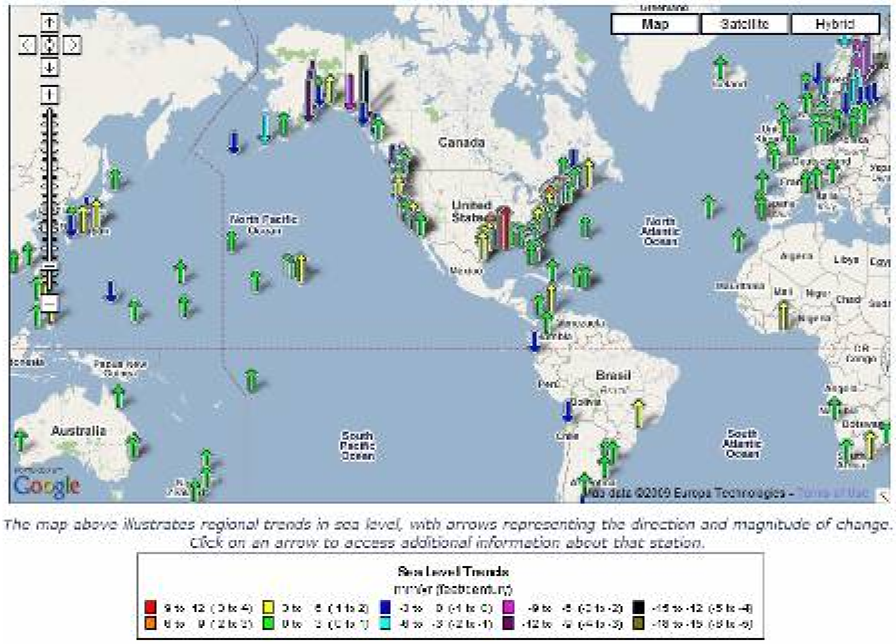

Figure 3. Google map interface for Relative Sea Level Trends.

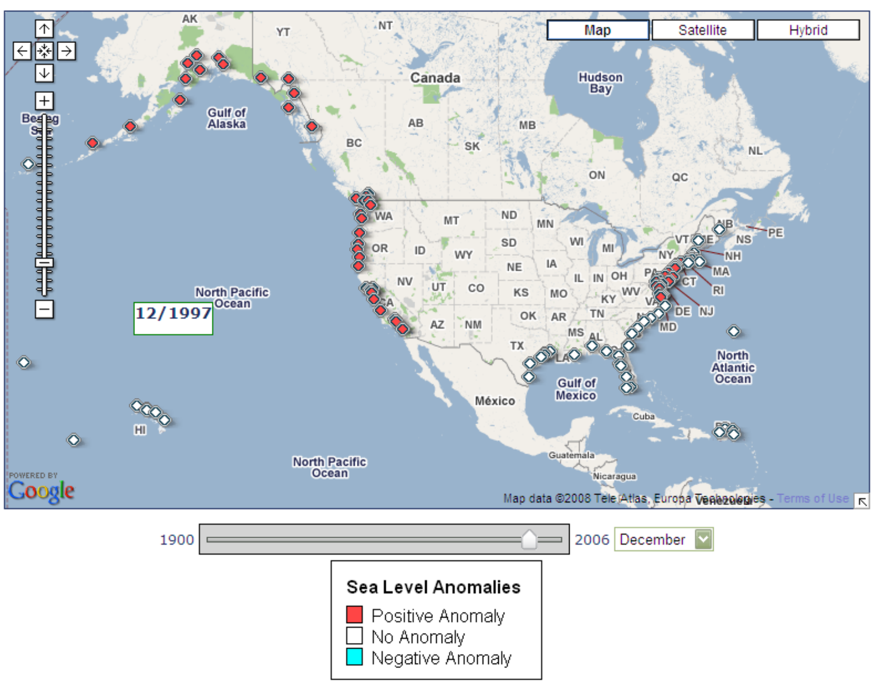

Figure 4. Google map interface for Sea Level Anomalies (shown for December 1997 to highlight anomalies associated with ENSO).

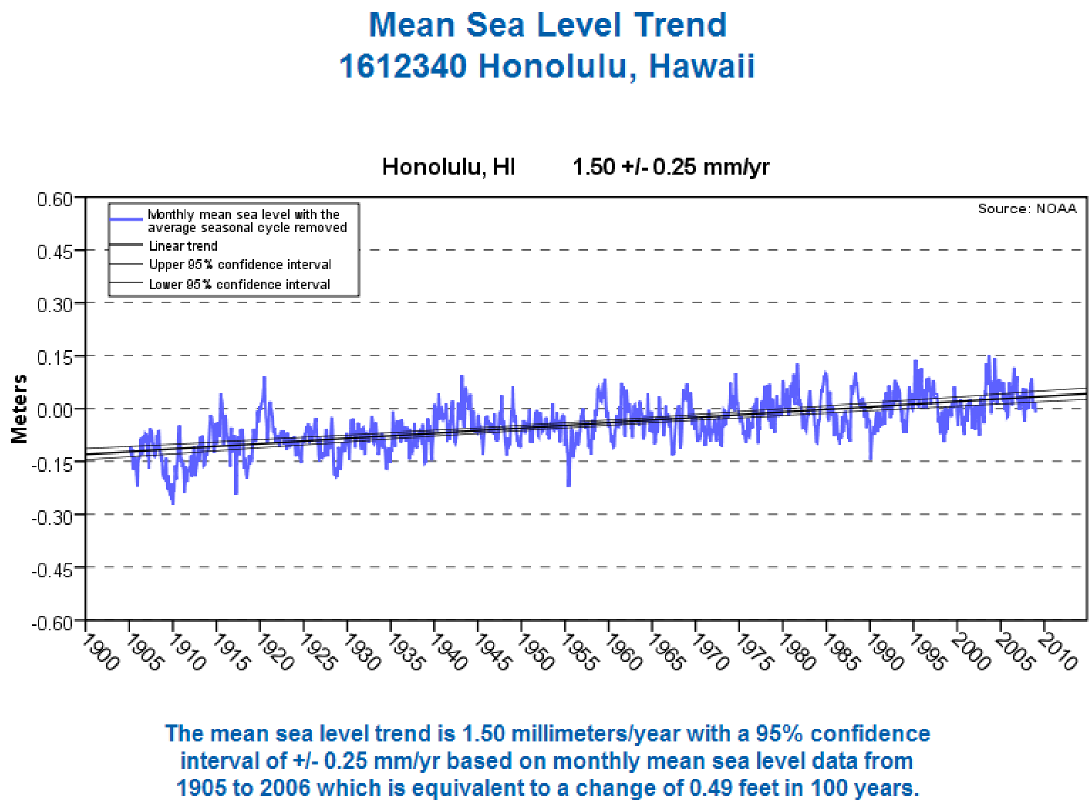

Figure 5. Sea level trend analyses.

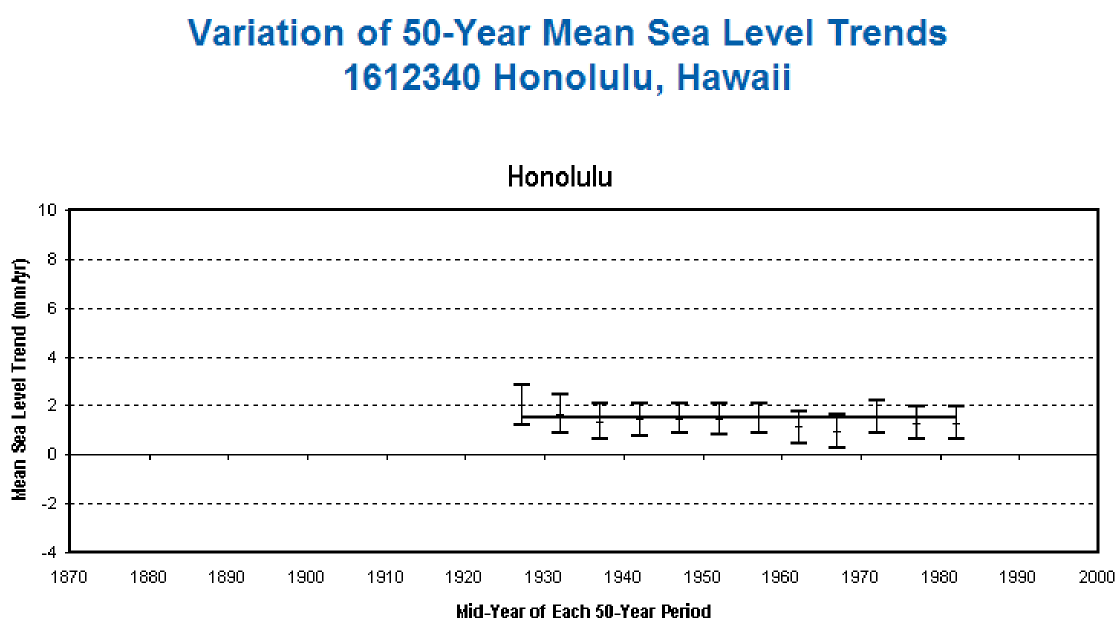

Figure 6. Long-term variation in trends.

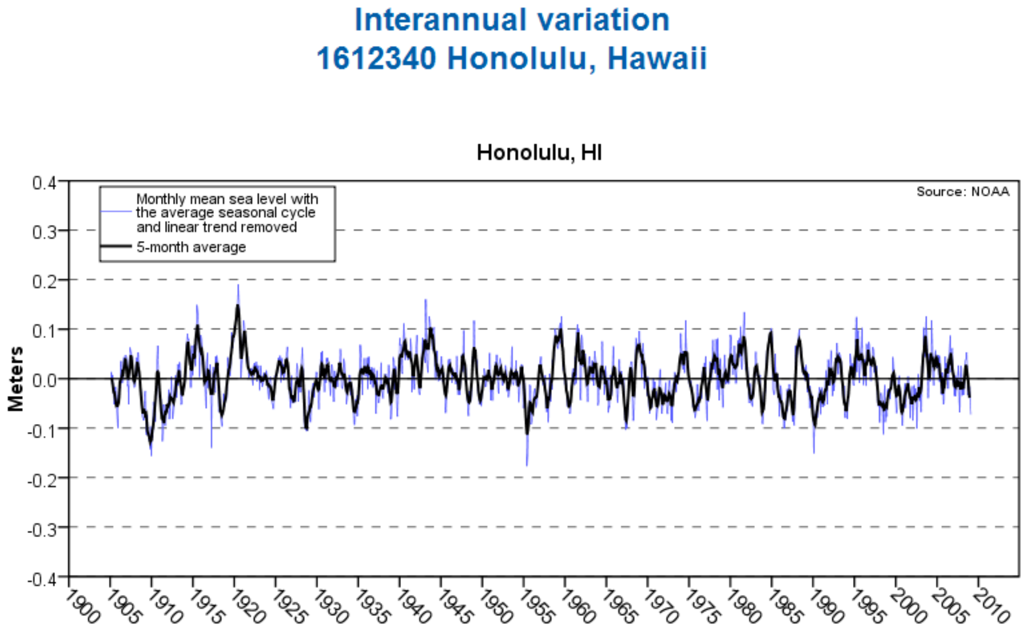

Figure 7. The monthly mean sea level anomalies are updated monthly.

Global Sea Level Trends

62 water level stations were identified in the International Sea Level Workshop Report (1997) as a core global subset for long-term sea level trends. The Climate Observations Program Plan calls these climate "reference stations." While the 2010 GCOS Implementation Plan no longer recognizes this subset of priority stations, they have driven prioritization of global sea level trend analysis over the past several years. In 2006, CO-OPS completed the development of the routine analyses of these 62 reference stations, including 18 NWLON stations and 44 non-NOAA global stations (See Figures 8 and 9). The monthly mean sea level data for the non-NOAA stations were obtained from the Permanent Service for Mean Sea Level (PSMSL) website. The data set obtained was their Revised Local Reference (RLR) data which has been carefully quality-controlled for datum continuity. Since 2006, this global sea level analysis has been drastically expanded.

Long term sea level trends have recently been calculated for 9 new countries, expanding the geographic coverage presented at the 2009 GLOSS Group of Experts meeting to now include 59 countries worldwide. Furthermore, 70 historical stations were updated with new data since 2005 and trends were re-calculated through 2010. In addition to the linear trends, there are two additional updated products available to provide a more complete oceanographic assessment at each location. The 'Average Seasonal Cycle' illustrates the regular fluctuations in coastal temperatures, salinities, winds, atmospheric pressures, and ocean currents, compared to the 'Interannual Variation' which delineates irregular conditions and periodic variations such as El Nino-Southern Oscillation (ENSO). The full suite of products can be found here: http://www.tidesandcurrents.noaa.gov/sltrends/index.shtml.

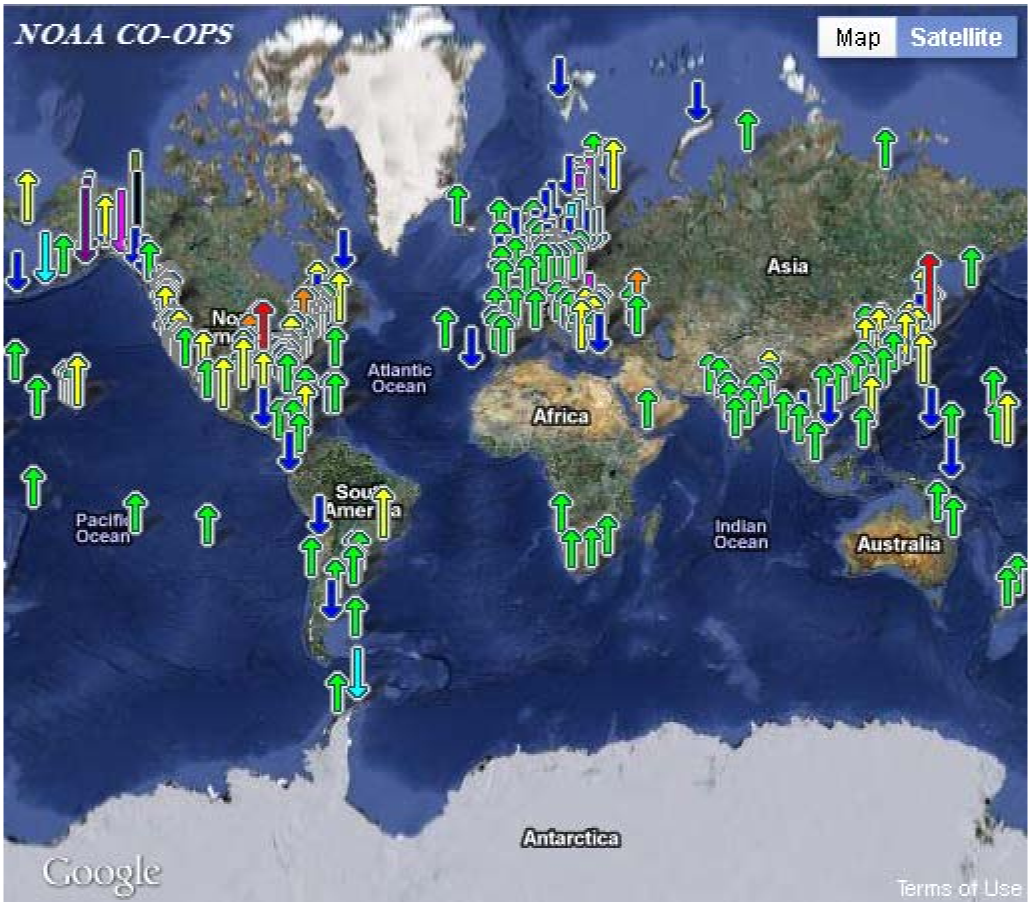

Figure 8. Global Sea Level Stations on *Sea Levels Online.*

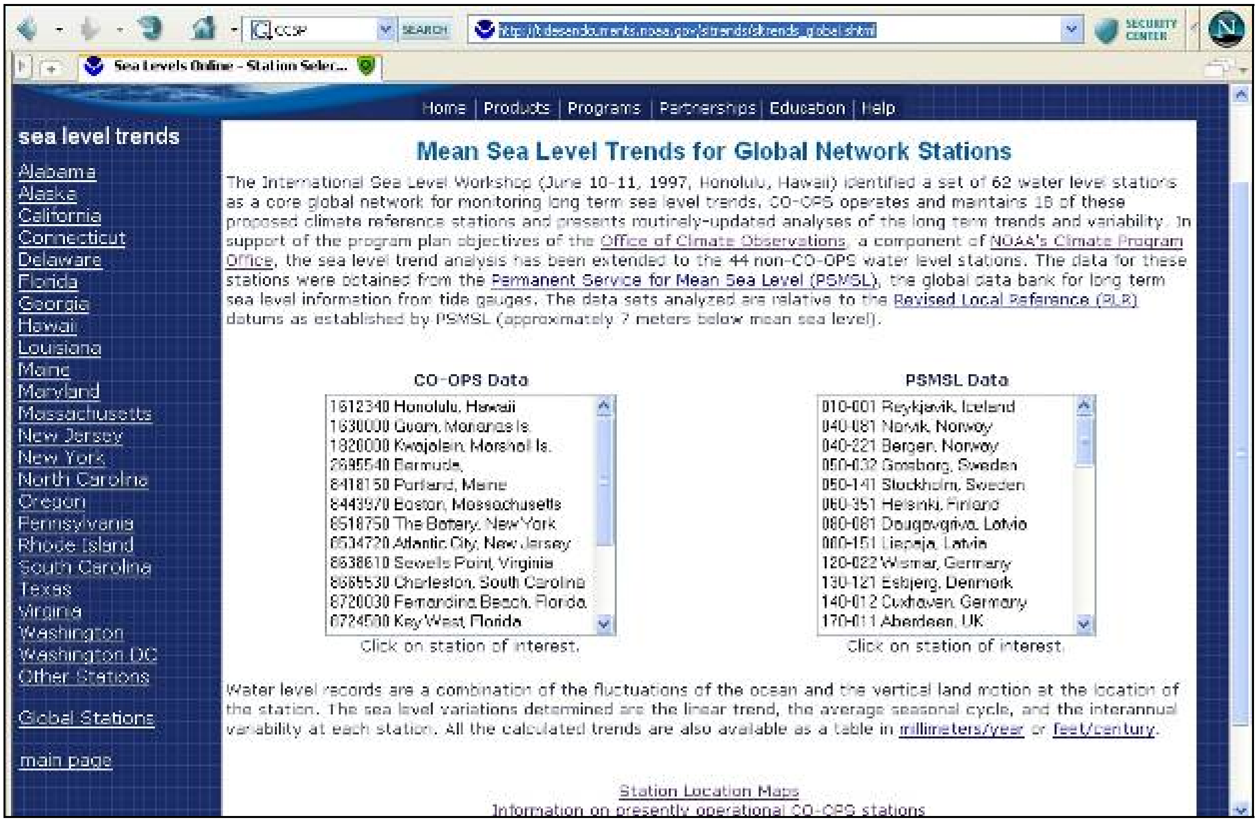

Figure 9. The NOAA web-site for viewing information on sea level trends and monthly mean sea level anomalies at global tide stations.

This expanded analysis has now extended the compilation of the data and the reports from the 62 global reference stations to nearly all of the 182 stations identified in Annex IV of the Global Sea Level Observing System (GLOSS) Implementation Plan 1997 (IOC Technical Series No. 50) (http://unesdoc.unesco.org/images/0011/001126/112650eo.pdf) as GLOSS-LTT (Long Term Trend) (Table 3). 45 of the GLOSS-LTT stations are CO-OPS stations and their sea level trends and variations were already available on Sea Levels Online.

Table 3. Global Stations with Sea Level Analysis Completed.
(Data Source: PSMSL; Analysis: NOAA)

Reykjavik, Iceland	Korsor, Denmark	Durban, South Africa	Tonoura/Hamada, Japan
Torshavn, Denmark	Slipshavn, Denmark	Aden, Yemen	Toyama, Japan
Barentsburg , Norway	Fredericia, Denmark	Karachi, Pakistan	Wajima, Japan
Russkaya Gavan II, Russia	Aarhus, Denmark	Kandla, India	Chichijima, Japan
Murmansk, Russia	Hirtshals, Denmark	Mumbai/Bombay, India	Legaspi, Philippines
Dikson, Russia	Esbjerg, Denmark	Marmagao, India	Jolo, Philippines
Tiksi, Russia	Cuxhaven 2, Germany	Cochin, India	Rabaul, Papua New Guinea
Providenia, Russia	Oostende, Belgium	Chennai/Madras, India	Townsville , Australia
Vardo, Norway	Lerwick, UK	Vishakhapatnam, India	Bundaberg, Australia
Honningsvag, Norway	North Shields, UK	Paradip, India	Wellington, New Zealand
Narvik, Norway	Newlyn, UK	Gangra, India	Lyttelton II, New Zealand
Rorvik, Norway	Stornoway, UK	Haldia, India	Majuro B/C, Marshall Islands

Heimsjo, Norway	Malin Head, Ireland	Diamond Harbour, India	Rikitea, France
Maloy, Norway	Dublin, Ireland	Port Blair, India	Easter Island E, Chile
Bergen, Norway	Socoa, France	Ko Taphao Noi, Thailand	Prince Rupert, Canada
Stavanger, Norway	La Coruna , Spain	Raffles Light House, Singapore	Vancouver, Canada
Tregde, Norway	Cascais, Portugal	Sultan Shoal, Singapore	Victoria, Canada
Smogen, Sweden	Lagos, Portugal	Ko Lak, Thailand	Tofino, Canada
Klagshamn, Sweden	Tarifa, Spain	Quinhon, Vietnam	Ensenada, Mexico
Kungholmsfort, Sweden	Malaga, Spain	Hondau, Vietnam	Cabo San Lucas, Mexico
Landsort, Sweden	Marseille, France	Macau, China	Guaymas, Mexico
Stockholm, Sweden	Trieste, Italy	Zhapo, China	Manzanillo, Mexico
Ratan, Sweden	Rovinj, Croatia	Xiamen, China	Acajutla, El Salvador
Furuogrund, Sweden	Bakar, Croatia	Kanmen, China	Quepos, Costa Rica
Kemi, Finland	Split Rt Marjana, Croatia	Lusi, China	Balboa, Panama
Oulu/Uleaborg, Finland	Split Harbour-Gradska, Croatia	Dalian, China	Buenaventura, Colombia
Raahe/Brahestad, Finland	Dubrovnik, Croatia	Quarry Bay/North Point, China	La Libertad II, Ecuador
Pietarsaari/Jakobstad, Finland	Katakolon, Greece	Tai Po Kau, Hong Kong	Antofagasta , Chile
Vaasa/Vasa, Finland	Kalamai, Greece	Tsim Bei Tsui, Hong Kong	Talcahuano, Chile
Kaskinen/Kasko, Finland	Khalkis North, Greece	Keelung II, Taiwan	Puerto Deseado, Argentina
Mantyluoto, Finland	Thessaloniki, Greece	Mokpo, South Korea	Puerto Madryn, Argentina
Turku/Abo, Finland	Kavalla, Greece	Pusan, South Korea	Quequen, Argentina
Degerby, Finland	Alexandroupolis, Greece	Ulsan, South Korea	Mar Del Plata (NB), Argentina
Hanko/Hango, Finland	Khios, Greece	Mugho, South Korea	Buenos Aires, Argentina
Helsinki, Finland	Leros, Greece	Wonsan, North Korea	Stanley I/II, UK
Hamina, Finland	Rodhos, Greece	Yuzhno Kurilsk, Russia	Montevideo, Uruguay
Liepaja, Latvia	Bourgas, Bulgaria	Petropavlovsk-Kamchatsky, Russia	Cananeia, Brazil
Kaliningrad, Russia	Varna, Bulgaria	Abashiri, Japan	Cartagena, Colombia
Gdansk/Nowy Port, Poland	Constantza, Romania	Kushiro, Japan	Cristobal, Panama
Wladyslawowo, Poland	Tuapse, Russia	Hakodate I, Japan	Progreso, Mexico
Ustka, Poland	Poti, Georgia	Wakkanai, Japan	Cabo San Antonio, Cuba
Kolobrzeg, Poland	Batumi, Georgia	Mera, Japan	Saint John, N.B., Canada
Swinoujscie, Poland	Ceuta, Spain	Aburatsubo, Japan	Halifax, Canada
Warnemunde , Germany	Ponta Delgada, Portugal	Kushimoto, Japan	Pointe-Au-Pere, Canada
Wismar, Germany	Funchal I & II, Portugal	Hosojima, Japan	Quebec, Canada
Gedser, Denmark	Walvis Bay, Namibia	Aburatsu, Japan	Neuville, Canada
Kobenhavn, Denmark	Simons Bay, South Africa	Nagasaki, Japan	Nain, Canada
Hornbaek, Denmark	Port Elizabeth, South Africa	Naha, Japan	Bahia Esperanza, Antarctica

University of Hawaii Sea Level Center

The University of Hawaii Sea Level Center website hosts a variety of products, in addition to providing access to raw sea level data. Products include: global sea level deviations, tide gauge-altimeter analysis (deviations and anomalies), upper ocean volume, current indices, and topography. http://uhslc.soest.hawaii.edu/

NOAA Laboratory for Satellite Altimetry

NOAA's Laboratory for Satellite Altimetry website includes resources and links to a variety of satellite altimeter products. Projects included on the site include: satellite altimeter sea level rise data, near real-time processed analysis, historical sea level, ERS altimetry data, information on Geosat, geophysics research, and sea floor topography. It also provides updates on new research, and provides access to partner agency websites. http://ibis.grdl.noaa.gov/SAT/SAT.html

Pacific Storms Climatology Project

The Pacific Storms Climatology Products project website (Figure 10) http://www.pacificstormsclimatology.org/ provides access to an integrated suite of products that delineate patterns and trends of storm frequency and intensity - "storminess"- within the Pacific region. These products are derived from analyses of historical records collected from in-situ stations located throughout the Pacific. The primary audience for these products is scientists, engineers, and others with a technical background. This site also provides access to information that will help non-technical users to learn about the climate-related processes that govern ext

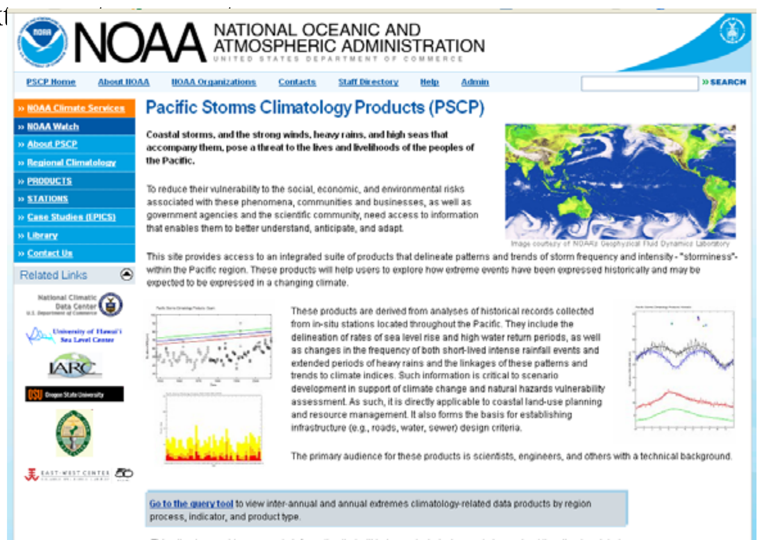

Figure 10. Pacific Storms Climatology Products Website.

D. Using Sea Level Data and Research to Inform Policy

The U.S. Army Corps of Engineers (USACE), the primary agency responsible for coastal engineering project in the US has recognized the potential for changing sea levels to impact the planning and design of coastal projects. The first guidance was issued in 1986 followed by the publication of the 1987 National Research Council study "Responding to Changes in Sea Level: Engineering Implications." (NRC, 1987) The most recent update to the sea-level change (SLC) guidance was in 2009 in the form of an Engineer Circular (EC) 1165-2-211, "Incorporating Sea-Level Change Considerations in Civil Works Programs." (USACE, 2009a, updated to EC 1165-2-212 in 2011) The 2009 guidance was developed with sea-level science experts at NOAA's

National Ocean Service and the U.S. Geological Survey. The USACE goal is to develop practical, nationally consistent, legally justifiable, and cost effective measures, both structural and nonstructural, to reduce vulnerabilities and improve the resilience of our water resources infrastructure to changes associated with rising global sea level.

The USACE is currently developing implementation guidance in the form of a Civil Works Technical Letter (CWTL) that outlines the recommended planning and engineering approach at the regional and project level for addressing impacts of projected sea level change at Corps of Engineers projects. All of the primary mission areas of the Corps are being addressed, with emphasis on navigation, flood risk management, coastal storm damage reduction, and ecosystems. The guidance development is utilizing an interdisciplinary team that includes representatives from all the different regions of the USACE as well as from other key federal agencies dealing with infrastructure and systems. Representatives include numerous agencies, including the National Oceanic and Atmospheric Administration (NOAA), U.S. Geological Survey (USGS), Federal Emergency Management Agency (FEMA), U.S. Coast Guard, U.S. Naval Academy, Federal Highway Administration, Bureau of Reclamation, National Park Service (NPS), and the U.S. Navy. Personnel from the University of Southampton (UK), HR Wallingford (UK), and Moffatt & Nichol are also participating.

The 2009 EC directs the formulation and evaluation of project alternatives using low, intermediate, and high rates of future SLC for both the “with” and “without” project conditions. The existing trends computed by NOAA at long-term tide stations are used as the baseline “low” rate for projects in the vicinity of the station. Various climate models are used for the out-year projections.

III. New Technology

A. GPS on Tide Gauges

For NGS Continuously Operating Reference System (CORS) reference bench marks (typically two) that are located within a 1.6 km leveling distance of a NOAA water level station, a direct leveling connection is made between the CORS reference bench marks and the tidal bench marks in the water level station network every 5 years. The order and class of the leveling run between the CORS reference marks and tidal bench mark shall be the same as that of leveling run for the local level network.

Table 4. Long-term CO-OPS water level stations within 5 kilometers of National Geodetic Survey (NGS) CORS-GPS stations.

NWLON Station ID	GLOSS Station ID	PSMSL Station ID	Location	CORS Station ID	CO-OPS Sea Level Trend	NGS CORS Trend	Estimated Absolute Sea Level Rise
1612340	108 LTT	155	Honolulu	HNLC	1.5	-0.1	1.4
1617760	287 LTT	300	Hilo	HILR	3.27		
1617760	287 LTT	300	Hilo	HILO	3.27	-1.8	1.5

				Removed 2010			
1820000	111 LTT	513	Kwajalein	KWJ1 Removed 2002	1.43	-1	0.4
2695540	221 LTT	368	Bermuda	BRMU	2.04	-1.1	0.9
8410140	LTT	332	Eastport	EPRT	2	-0.2	1.8
8413320		525	Bar Harbor	BARH	2.04	0.3	2.3
8419870		288	Seavey Is.	POR3 Removed 2003	1.76	0.1	1.9
8419870		288	Seavey Is.	POR4 Removed 2004	1.76	0.6	2.4
8452660	290 LTT	351	Newport	NPRI	2.58	-1.3	1.3
8461490		429	New London	CTGR	2.25	-0.5	1.8
8518750	LTT	12	The Battery	NYBP, NYBR	2.77		
8531680	LTT	366	Sandy Hook	SHK5	3.9	-2.3	1.6
8531680	LTT	366	Sandy Hook	SHK6	3.9	-0.6	3.3
8551910		786	Reedy Point	RED5	3.46	-3.1	0.4
8551910		786	Reedy Point	RED6	3.46	1.8	5.3
8557380		224	Lewes	CHL1 Removed 2002	3.2	-2.4	0.8
8557380		224	Lewes	CHL2 Removed 2000	3.2	0	3.2
8575512	LTT	311	Annapolis	LOYF	3.44		
8577330		412	Solomons Is.	MDSI	3.41	-1.1	2.3
8577330		412	Solomons Is.	SOL1 Removed 2007	3.41	-2.3	1.1
8631044			Wachapreague	VIMS		-3.4	
8637624		597	Gloucester Point	VAGP	3.81	-2.7	1.1
8637624		597	Gloucester Point	GLPT Removed 2006	3.81	-2.5	1.3
8651370	219	1636	Duck	NCDU		-6.2	
8651370	219	1636	Duck	NCDK Removed 2007		0.2	
8651370	219	1636	Duck	DUCK Removed 2004		-1.7	
8656483			Beaufort	NCBE	2.57		
8656483			Beaufort	FMC1, FMC2 Removed 2000	2.57	-1	1.6
8665530	LTT	234	Charleston	SCHA	3.15		
8665530	LTT	234	Charleston	SCCC	3.15	-1.1	2.1
8724580	216 LTT	188	Key West	CHIN	2.24		
8725110		1107	Naples	NAPL	2.02	-2.7	-0.7
8735180		1156	Dauphin Is.	ALDI	2.98		
8761724		526	Grand Isle	GRIS	9.24	-7.3	1.9
8771450	217 LTT	161	Galveston Pier 21	TXGA	6.39	-2.8	3.6
8771510		828	Galveston Pleasure Pier	TXGV	6.84	0	6.8
9410230	159 LTT	256	La Jolla	SIO3	2.07	-0.6	1.5
9410230	159 LTT	256	La Jolla	SIO5	2.07		
9413450		1352	Monterey	P231	1.34		
9415144			Port Chicago	P262	2.08		
9416841			Arena Cove	P059			

9435380	157	1196	South Beach	P367	2.72	-0.5	2.2
9435380	157	1196	South Beach	NEWP Removed 2007	2.72	0.6	3.3
9439040	LTT	265	Astoria	TPW2	-0.31		
9449880	LTT	384	Friday Harbor	SC02	1.13		
9454050		566	Cordova	EYAC	5.76		
9455500		1070	Seldovia	SELD	-9.45		
9455760		1350	Nikiski	KEN5	-9.8	12.7	2.9
9455760		1350	Nikiski	KEN6	-9.8	11.3	1.5
9459272		567	Kodiak Is.	KODK Removed 2006	-10.42	12.5	2.1
9459450	100	1634	Sand Point	AB07	0.92		
9461380	302 LTT	487	Adak Is.	AB21	-2.75		
9462620	102	757	Unalaska	AVO9	-5.72	1.7	-4.0
9751401		1447	Lime Tree Bay	VIKH	1.74	1.1	2.8
9751639		1393	Charlotte Amalie	VITH	1.2	1	2.2
9759110		759	Magueyes Is.	PRMI	1.35	0.8	2.2

Note: LTT indicates that a station is part of the GLOSS subset of stations for long term trends.

NGS will also be installing new CORS-GPS receivers as close as possible to the water level stations at San Francisco, California and South Beach, Oregon.

For a full list of distances between CORS and tide stations, see http://www.ngs.noaa.gov/CORS/Tiga/tiga_link.html.

GPS technology and procedures will be implemented in the operational plan:

(1) to support the development of a seamless, geocentric reference system for the acquisition, management, and archiving of NOAA water level data. This will provide a national and global digital database, which will comply with the minimum geo-spatial metadata standards of the National Spatial Data Infrastructure (NSDI) and connect the NOAA water level database to the NGS National Spatial Reference System (NSRS);

(2) to establish transformation functions between NOAA chart datum (MLLW) and the geocentric reference system to support NOAA 3-dimensional hydrographic surveys, the implementation of Electronic Chart Display and Information Systems (ECDIS), and the NOAA Vertical Datum transformation (V-Datum tool) and tidal datum models. Integration of GPS procedures into NOAAPORTS® operations will support the development of tidally-controlled Digital Elevation Maps and Models for use in programs such as marsh restoration.

(3) to support water level datum transfers by using GPS derived orthometric heights.

(4) to monitor crustal motions (horizontal and vertical) to support global climate change investigations.

GPS-derived orthometric heights can be accurately determined and used for water level datum transfers according to (a) the established guidelines for 3-D precise relative positioning to measure ellipsoid heights, (b) properly connecting to several NAVD88 bench marks, and ©) using the latest high-resolution modeled geoid heights for the area of interest. In many remote locations, the use of GPS-derived orthometric heights for datum transfer will be more efficient (timely) and more cost-effective than the use of conventional differential surveying techniques and may, under certain circumstances, preclude the installation of additional water level stations to establish a datum.

B. New Sensor Testing

Microwave Sensor Testing

CO-OPS continues to analyze state-of-the-art and emerging technologies to identify potential improvements in data quality and operating efficiency and to maintain core expertise for long term sea level monitoring throughout the United States coasts. It is acknowledged that many others throughout the international ocean observing community have already recognized that microwave radar range sensors offer many potential benefits for long-term sea level monitoring. The most notable advantage of such sensors is the ability to measure water level remotely, from above the sea surface.

Over the past 3.5 years, CO-OPS has been conducting a series of extensive laboratory and long term field tests with several different microwave radar range sensors to determine their suitability for use as water level sensors in the NWLON and other CO-OPS measurements systems. Intermediate results from CO-OPS test efforts conducted to date have been reported at various international meetings, including the 2009 GLOSS GE XI meeting in Paris, and through several reports over the last three years. A brief summary update on latest field test analysis conducted to date is reported here and further details are available in associated references.

Most notable is the significant milestone to which recent test results have led: CO-OPS has recommended limited acceptance of radar water level sensors for use in its network of coastal observatories and a transition of the new technology to operational applications is currently underway. (**http://tidesandcurrents.noaa.gov/publications/Technical_Report_NOS_CO-OPS_061.pdf**)

Summary of Field Test Results

Sensors from four different manufacturers were selected for testing based on recent sensor developments and results of multiple related studies conducted over the last several years. CO-OP's test planning was completed in January 2008 and test execution began in February 2008.

Based on results from several individual laboratory tests and field data collected over 2.5 years at three different sites, the Design Analysis WaterLog® H-3611i (subsequently referred to as WaterLog®) has been identified as the best suited of the four selected sensors for CO-OPS measurement applications at this time. All four sensors demonstrated good performance and yielded similar accuracy. It is acknowledged that several documented studies indicate that other institutions/organizations have been successful in collecting accurate, high quality water level observations using microwave radar sensors other than the WaterLog® unit.

NOAA in no way endorses one tested sensor over another for general applications or one manufacturer over another. Selection of the WaterLog® as the sensor best suited for NOAA at this point is based on quantitative criteria specifically designed with CO-OPS' unique operations and applications in mind, as well as specific aspects of each sensor operating within this application.

Table 5 provides an overview of the characteristics of the WaterLog® that give it an advantage in this setting. Testing of newer versions of the other three sensors, as well those from other manufacturers including Design Analysis may continue and they may still be considered for use in CO-OPS operational water level stations based on analysis of system performance and mission requirements.

Table 5. Aspects of WaterLog® sensor that influenced selection for use at Port Townsend and similar environments.

Sensor Characteristic	Resulting Advantages
Smaller signal spreading angle (10 degrees)	Narrow footprint, high spatial measurement resolution, and decreased likelihood of false echoes when transmitting in enclosed well/sump (required in Great Lakes applications).
Required input voltage of 10-16 Volts DC	Low enough power requirement to operate in system consisting of DCP with just one 12-volt battery and one solar panel.
SDI 12 interface	Three-wire interface easily connects to Xpert DCP used by NOAA; sensor can be powered directly from DCP, eliminating need for additional power source.
Time of Flight (TOF) Tool Windows-based software - configuring sensor parameters	Sensor configuration parameters can be set very easily via laptop and RS232 connection. Software setup with graphics makes most parameters easy to understand.
TOF – automated plotting of return signals	A plot of sensor return signal, intensity versus range, is easily generated.
TOF – preventing detection of return signals from obstructions	TOF software can be used to easily eliminate return signals from obstructions in sensor field of view (in scenario where sensor still has a clear view of water surface).
TOF – enabling fast time response	Sensor time response can be easily adjusted to be very short (5 seconds) via TOF software.
1-Hz sampling	Sensor comes from the factory capable of logging range data to DCP at 1-Hz rate.
26 -GHz pulse signal	Addresses NTIA concerns about the possibility of sensor

	transmissions causing harmful interference.
Consistent, reliable, long-term performance	No signs of system reboots, sensor failures, or power downs. Minimal dropouts/gaps in 1-Hz record.

Since CO-OPS maintains real-time water level observations at more than 200 different coastal locations affected by varying combinations of meteorological and oceanographic conditions, field testing a new NWLON water level sensor must assess the impact of various environmental parameters on sensor performance. For this reason, microwave radar sensors were initially installed for field testing at three different NWLON station locations with varying coastal environments

Because many periods of field test data have indicated that radar sensors meet accuracy requirements and at some times may be more accurate than the Aquatrak acoustic sensors, CO-OPS recommends the limited acceptance of radar water level sensors for use in coastal regions with characteristics similar to those of the field test sites described: semi-enclosed, fetch limited coastal regions with a small wave environment. Ultimately, a coastal classification system that evaluates average wind, wave, and tidal environments across U.S. coastal regions covered by NWLON stations will be developed to identify which NWLON stations are suitable for installation of microwave radar sensors. In the meantime, areas that have minimal impact from surface waves (beyond short, high frequency wind sea waves) may be considered suitable for microwave radar sensor use.

Transition to Operations

Since many NWLON stations are located in semi- enclosed regions, CO-OPS has developed a plan for a limited transition of WaterLog® radar sensors to operational observatories. Transition efforts involve three different categories of applications:

1. Introducing WaterLog® sensors to a subset of existing NWLON stations located in favorable environments.
2. Enabling limited use of WaterLog® sensors in hydrographic survey (hydro) applications.
3. Identifying new CO-OPS water level stations where WaterLog® sensors can be introduced from start of a station's creation.

CO-OPS will proceed with the introduction of WaterLog® sensors to existing NWLON stations prudently, especially at station sites where data archives along with calculated datums extend far back in time. When a new WaterLog® sensor is introduced to an existing NWLON station, where all current systems are working adequately as expected, the existing primary water level sensor at the station will remain operational and collect data for at least one year to obtain an overlapping data set between new and previous measurement technologies. Detailed analysis will be conducted and documented with the resulting overlapping records to establish a case for continuity prior to officially switching to the WaterLog® sensor for primary measurements. Analysis will include calculation and comparison of multiple tidal datums.

CO-OPS first operational radar water sensors were installed at three stations in Mobile Bay, Alabama in July 2011. The new stations are part of the Mobile Bay Storm Surge Monitoring Network (MBSSMN). The establishment of this new storm surge network involved challenging station requirements in locations with limited infrastructure, so usage of remote radar range sensors provided many operational advantages.

C. Arctic Bottom-Mounted Pressure Sensors

NOAA continues to operate and maintain NWLON tide stations at Prudhoe Bay Alaska which has now been in continuous operation on the North Slope since late 1993, at Red Dog Mine in Kotzebue Sound since 2003 and at Nome, Norton Sound since 1992.

NOAA has also been working to develop tide station configurations that will withstand the harsh winter environment. In August 2008, two bottom mounted offshore platforms were deployed beyond the bottom ice scouring about 3 km offshore in about 30 meters of water at Point Barrow, AK. Each platform housed an internally recording pressure measuring system outfitted with acoustic modems for periodically uploading the data from the water's surface. The surface receiver would be either on a boat when there was open water, or a snow machine after boring a hole through the ice after solid freeze over (See Figure 11). The platforms are periodically referenced to benchmarks via staff shots and differential GPS. The platforms were each equipped with acoustic releases for recovery. The systems were recovered after one year of deployment, data were downloaded, the platforms were refurbished and batteries replaced and the platforms were re-deployed within three-days, and final platform recovery occurred in August 2010. These offshore data represent a continuous two-year time series of water level data at Point Barrow resulting in updated tidal datums and tidal prediction products. These bottom-mounted configurations proved successful in sustained data collection unattended throughout the harsh winter environment. This method of data collection has been subsequently used to support NOAA hydrography surveys in Kotzebue Sound as well as water level data collection in support of VDatum model development (vertical datum transformation tool: vdatum.noaa.gov) near Norton Sound and St. Lawrence Island.

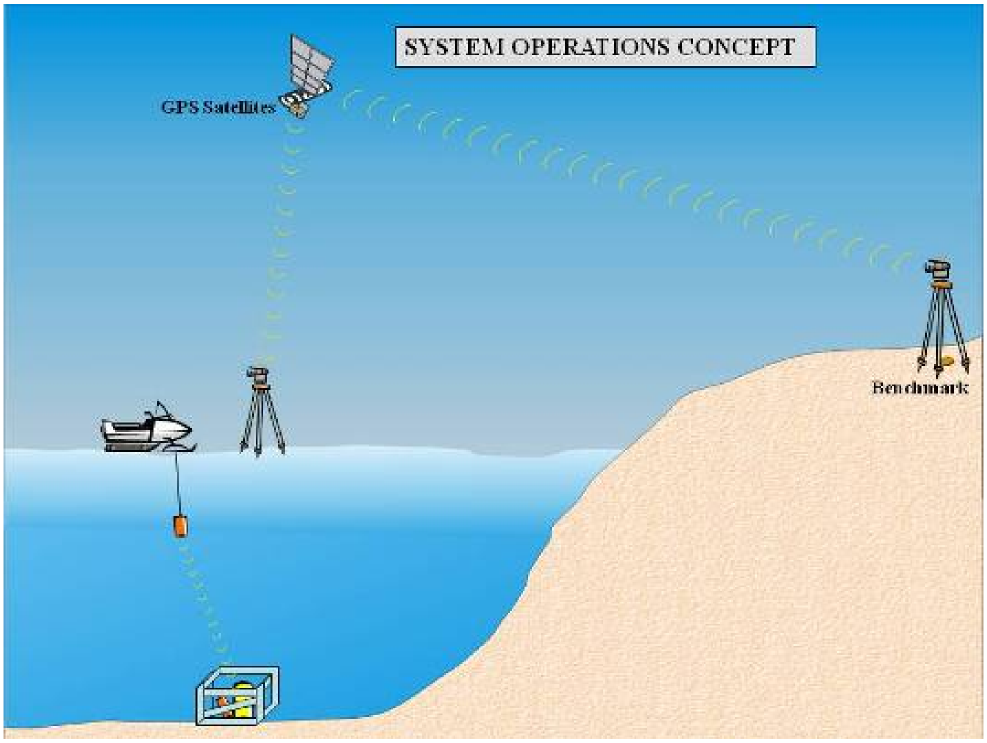

Figure 11. Schematic of Point Barrow Testing Configuration.

IV. Measurement of Extreme Water Levels

A. Station Configurations and Upgrades

Important to any long-term monitoring observing system, data and datum continuity are extremely important. Observing systems required for long-term sustained monitoring purposes must aspire to un-interrupted measurement of water level, even during the harshest environments that cause the extreme highest and lowest water levels. Collection of long-time histories of the frequency and duration of extreme events enables exceedance probability analyses for high and low waters, for instance (see Section V.C. Exceedance Probability).

By virtue of their location at the ocean's edge, water level observing stations are exposed to severe damage from wind, storm surge and waves during the very storms which make their operation so important. Stations not designed to withstand severe conditions are often severely damaged or destroyed resulting in significant data gaps until the systems can be replaced and brought back on-line. Strengthening key water level station infrastructure and sensor configurations ensures that observations of water level, wind speed and direction, barometric pressure, and air and water temperature will be available when the information is needed most and without interruption over the long-term. NOAA National Water Level Observing Network (NWLON) water level stations have several attributes to ensure data and datum continuity listed below. Other agencies and organizations employ these or other similar attributes.

- Primary and backup sensors and data collection platforms (DCPs). A less expensive and less accurate pressure system is used to fill gaps using comparative gains and offsets if the primary sensor (acoustic sensor) malfunctions or exceeds measurement capability (either maximum of minimum measurement limited exceeded due to storm surge or storm withdrawal).
- Complete redundancy. If one primary/backup system goes down or is destroyed, a completely separate system (both primary and backup DCP's and sensors) is installed and operated nearby to provide continuous data. This is more expensive but is an option that has proven itself at remote locations where it is often extremely hard and expensive to perform corrective maintenance and repair.
- Multiple modes of data collection. NOAA uses 6-minute interval satellite radio communication as a primary mode backed up by telephone. If a storm destroys both of these connections, data are continued to be collected for up to a month with internal memory for subsequent download by field personnel.
- Hardened water level station structures. NOAA uses existing piers and wharf structures wherever possible, however if these do not provide the appropriate level of hardening to withstand flooding form storm surge and waves, raised instrumentation platforms are installed atop existing infrastructure. I some instances, separate high four-pile structures are designed and built next to existing infrastructure to ensure data continuity during extreme surges.

NOAA is investing in new Microwave Water Level systems (MWWL) to eventually replace existing primary system acoustic and pressure sensors where feasible. These systems should provide even better performance in terms of lost data because they have no components in the water subject to damage and costly repair and maintenance.

- Independent hardened structures. Even with all of the steps taken in the previous bullets in place, water level stations can still often be destroyed and damaged if the storm makes landfall near the station and it is subjected to extreme waves, flooding, extreme winds, and debris fields and damage of the nearby supporting piers and docks. NOAA has recently implemented a NOAA Sentinel system (described below) to ensure data continuity even during some of the most severe events and direct "hits".

NOAA Sentinels are deployed in open coastal areas most vulnerable to severe storms such as land-fall hurricanes in the US Gulf of Mexico. Sentinels have been established at four locations which were selected based on two objectives; re-establish NWLON stations either destroyed or heavily damaged by recent hurricanes; and establish new stations in areas identified as gaps in the NWLON. Additional Sentinels are being established with partnership federal and state agencies as funding becomes available. Two Sentinels off the coast of Texas have just been completed.

NOAA Sentinels are large single-pile structures (see Figure 12). A single-pile structure presents a minimal profile to a storm coming from any direction. Engineering specifications based on Category 4 generated wind and wave action analysis determined that the platforms stand at least 25 feet above the sea surface on a 4-foot diameter single pile. The piles are driven 60-80 feet into the seafloor to ensure stability. The Sentinels are expected to enhance GLOSS objectives by ensuring continuous records during storm events and reducing the number of long data gaps due to storm damage. These stations will also improve the ability to record maximum water levels.

Figure 12. One of the US NOAA Sentinel Tide Stations in the Gulf of Mexico.

B. The Role of Coastal Tide Stations in U.S. Storm Surge Warning

For tropical cyclones impacting the U.S. coast, tide gauges play a crucial role in monitoring real-time conditions and recording events of record. Many stations in hurricane-vulnerable areas such as the Gulf of Mexico have been hardened to withstand hurricane conditions, continuing to transmit critical storm tide measurements during the worst of storm conditions. Forecasters, emergency managers, first responders, and other decision makers depend upon real-time water level records during severe storm surge events in order to monitor and respond to evolving severe conditions.

The NOAA storm surge monitoring network in Mobile Bay has employed the use of a new water level sensor system based upon microwave radar. These sensors are located high enough to observe severe surge events, and are located on robust platforms that are likely to withstand extreme floods and winds.

Additionally, it is critical that the peak water level event of record is recorded for coastal regions because this information is needed to define engineering design conditions, set insurance rates, develop evacuation plans, and validate storm surge models. First, long term water level records are analyzed in order to understand the frequency and level of significant storm surges. Engineers use this data to set design conditions for coastal regions (e.g., for 100 year or 500 year events). CO-OPS also analyzes the records at long-term stations to provide this analysis to decisions makers (see Section V.C. for discussion; http://tidesandcurrents.noaa.gov/est/). However, if water level observations are lost during the highest water level events, the accuracy of these analyses are compromised. Second, storm surge models are used to augment sparse observation records (due to the rare occurrence of events, the relatively low density of observation stations, and the historical loss of those stations due to storm surges). This is often done by simulating conditions from thousands of hypothetical storms. However, the accuracy of these models cannot be validated with a small historical observation record that does not contain the maximum water level events (due to station failure or loss during storms), , and the analyses and products based on them (engineering design conditions, building codes, insurance rates, evacuation plans) have lower confidence and accuracy.

CO-OPS produces several products supporting users of storm surge records, both during and following tropical cyclones that impact the coast of the U.S. and its territories. When the National Weather Service issues a tropical storm or hurricane warning for the U.S. coast, CO-OPS issues the Storm QuickLook product (http://tidesandcurrents.noaa.gov/quicklook.shtml). This product provides a synopsis of near real-time water level and meteorological observations at locations affected by the tropical cyclone. It is updated four times per day (typically one hour after the National Hurricane Center issues a forecast showing the path of the hurricane). The Storm QuickLook product has three main sections: 1) a GIS map highlighting NOS tide gauge locations and tropical cyclone data (including track and intensity and satellite imagery), 2) a text section with a summary of present water level conditions along with the time and height of the next two high tides at selected locations, and the latest NWS public advisory information about the storm, and 3) time series plots of water level, wind, barometric pressure, air temperature, and water temperature observations from CO-OPS, which are updated in real-time. The QuickLook product highlights the subset of the stations that most significantly affected by a storm, and provides links to real-time data at additional locations.

Following a significant storm surge event, it is important to validate the maximum water elevation due to the storm. One such method that is robust and highly accurate is to review water level data measured at NOS tide gauges during the storm. CO-OPS provides a report to the National Weather Service highlighting preliminary maximum storm tide and storm surge measurements, as well as maximum wind and minimum barometric pressure measured during the period where the storm’s impacts were felt along the coast. These reports are typically disseminated within 5 days following a storm to provide local Weather Forecast Offices and their customers with a rapid assessment of water level measurements. For significant storms, CO-OPS will issue a Water Level and Meteorological Data Report, which includes a brief synopsis of the storm, along with data tables highlighting extreme storm tide, storm surge and meteorological observations at all locations affected by a storm and time series plots highlighting water level data before, during and after the storm.

C. Web Products

Exceedance Probability

NOAA provides exceedance probability statistics for select water level stations with at least 30 years of data through its *Extreme Water Levels* website (http://tidesandcurrents.noaa.gov/est/). In September 2011, the main website for the product was released and statistics provided for water level stations in California, Hawaii, Oregon, Washington and the Pacific Islands on the home page of the Center for Operational Oceanographic Products and Services (CO-OPS) under the product menu (Figure 13). The product will provide exceedance probability statistics on the remaining water level stations in Alaska and on the East and Gulf Coasts that meet the 30 years of data criteria by April 30, 2012.

Access to statistics for individual stations is via a Google Map Interface where users can select a station in a region of interest (Figure 14). From the pop-up menu which provides the 1% exceedance probability levels for the selected stations, users may select the Extreme Water Levels page, the Exceedance Probability Curves, or the Exceedance Probability Levels (Figure 15). This site provides access to the monthly highest and lowest water levels overlaid by the exceedance probability levels (Figure 15), exceedance probability curves relative to return periods (Figure 16), and exceedance probability levels relative to tidal datums (Figure 17).

Extremely high or low water levels at coastal locations are a public concern and an important factor in coastal hazard assessment, navigational safety, and ecosystem management. Exceedance probability is the likelihood that water levels will exceed a given elevation based on historic values. The Product provides exceedance probability statistics for select CO-OPS water level stations with at least 30 years of data. When used in conjunction with real time station data exceedance probability statistics can be used to evaluate current conditions and determine when a rare event has occurred. This information may also be instrumental in planning for the possibility of dangerously high or low water events on a local level. Because these statistics are station specific, use for evaluating surrounding areas may be limited.

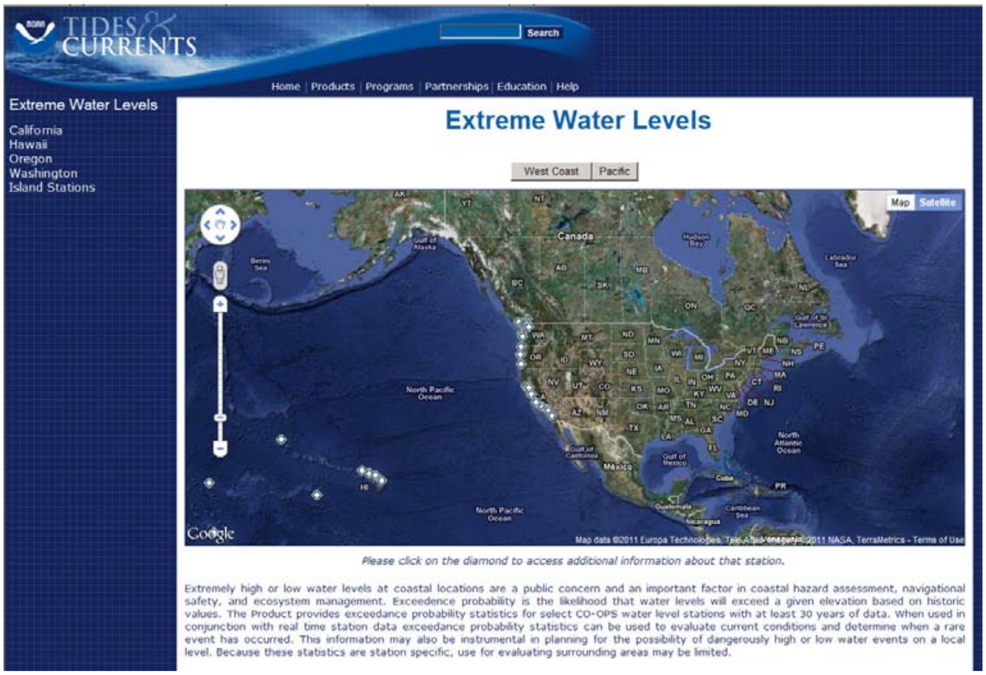

Figure 13: Google Map Interface for Exceedance Probability Statistics on Extreme Water Levels.

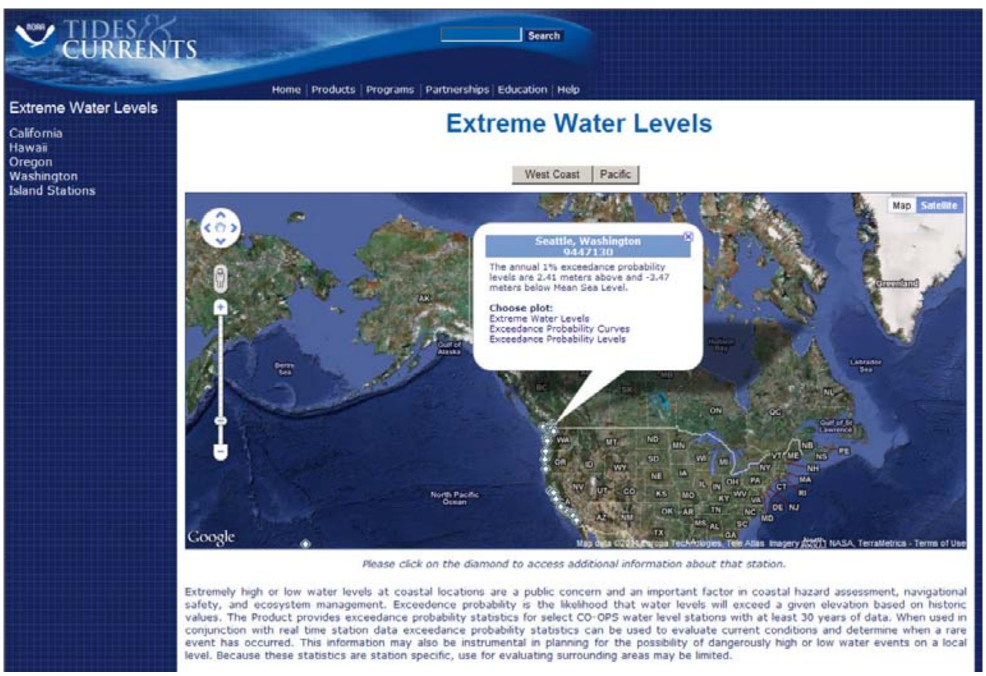

Figure 14: Pop-up menu for example station Seattle 9447130 from which users can select Extreme Water Levels, Exceedance Probability Curves, or Exceedance Probability Levels.

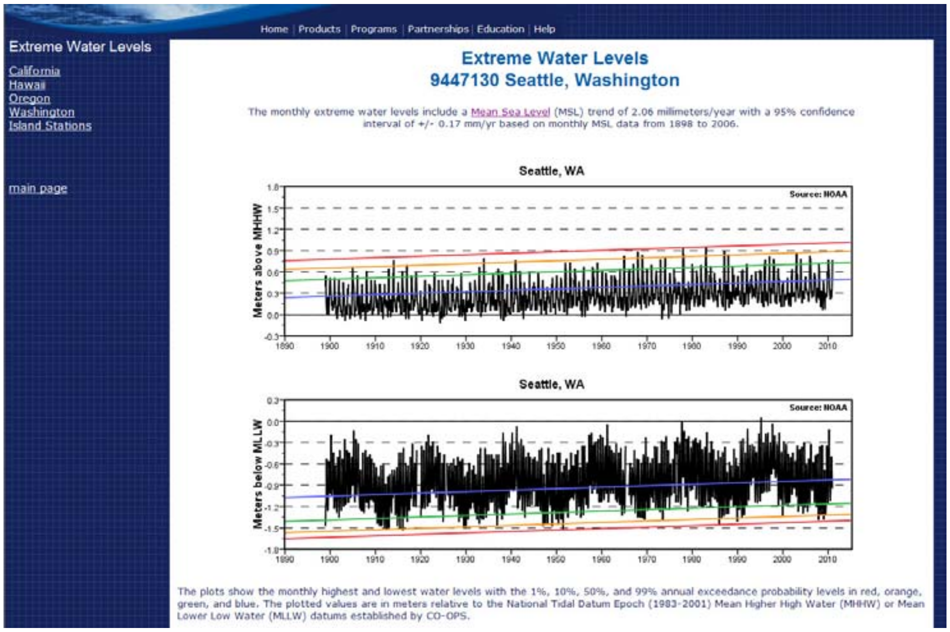

Figure 15: The monthly highest and lowest water levels overlaid by the exceedance probability levels.

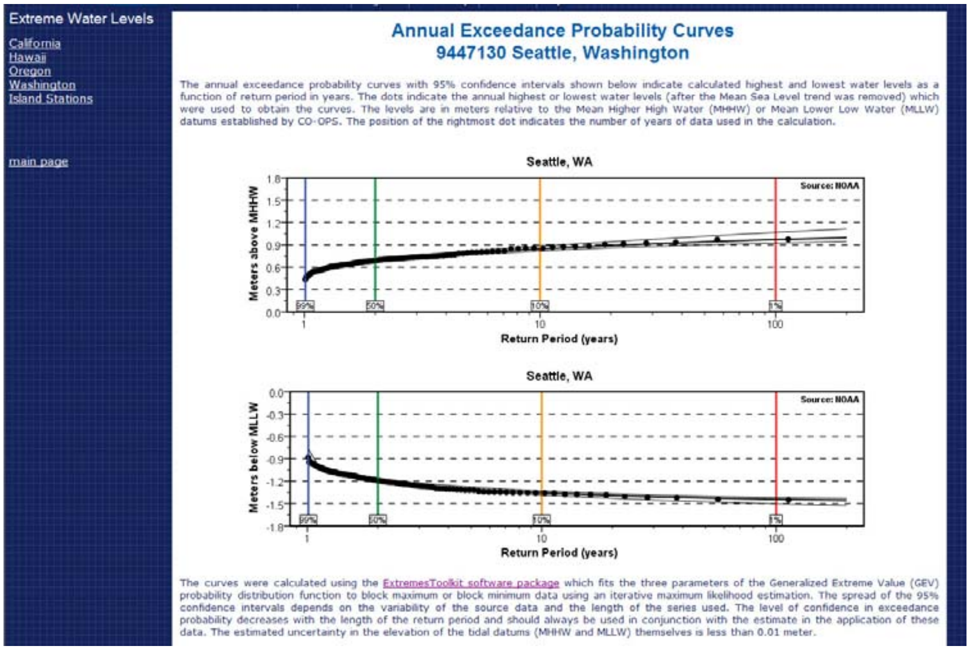

Figure 16: Exceedance Probability Curves relative to Return Periods with 1 year, 2 years, 10 years, and 100 years identified.

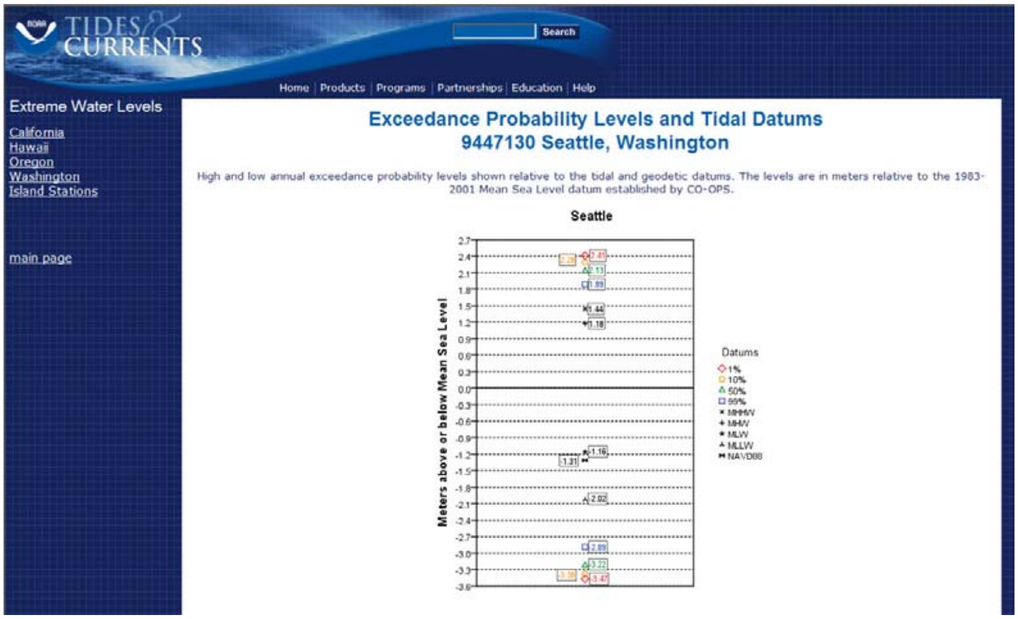

Figure 17: Exceedance probability levels relative to tidal and geodetic datums.

Pacific Storms Climatology Products

The Pacific Storms Climatology Products project website http://www.pacificstormsclimatology.org/ also provides access to a range of exceedance probability products including the exceedance probabilities calculated from standard Generalized Extreme Value (GEV) analysis and from a modified "Peak Over Threshold (POT)" form of extreme value analysis. While similar to the NOAA CO-OPS Exceedance Probability analysis, the Pacific Storms Climatology Product provides a regional product which utilizes annual GEV analysis of multiple parameters (not just water level). The results of the analysis (Figures 18a and 18b) are cumulative probability curves for the annual and seasonal observed elevations and non-tidal residual elevations. Another product available via the web site is long-term trends calculated using modified "non-stationary" versions of the GEV and POT analysis for the annual maxima and extreme event, for the annual and seasonal series for the entire length of each station record. Such information is critical to risk assessment scenario development in support of coastal land-use planning and resource management. It also forms the basis for establishing infrastructure (roads, water, sewer) design criteria, among other things.

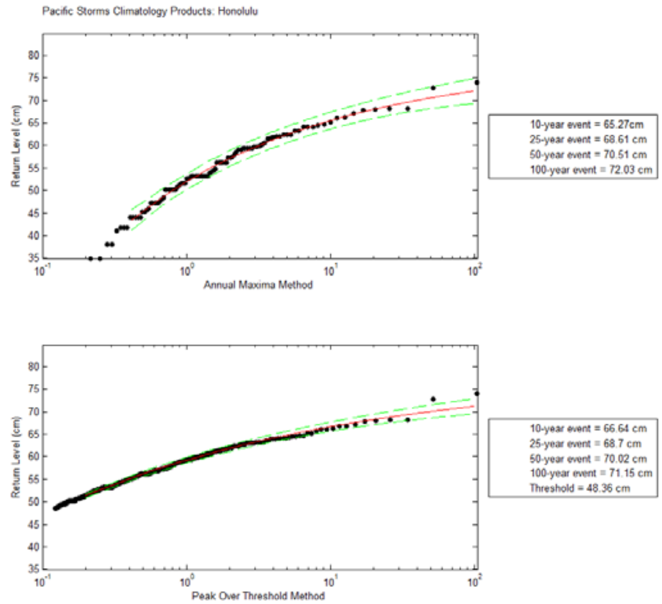

Figure 18a. Pacific Storms Climatology Products.

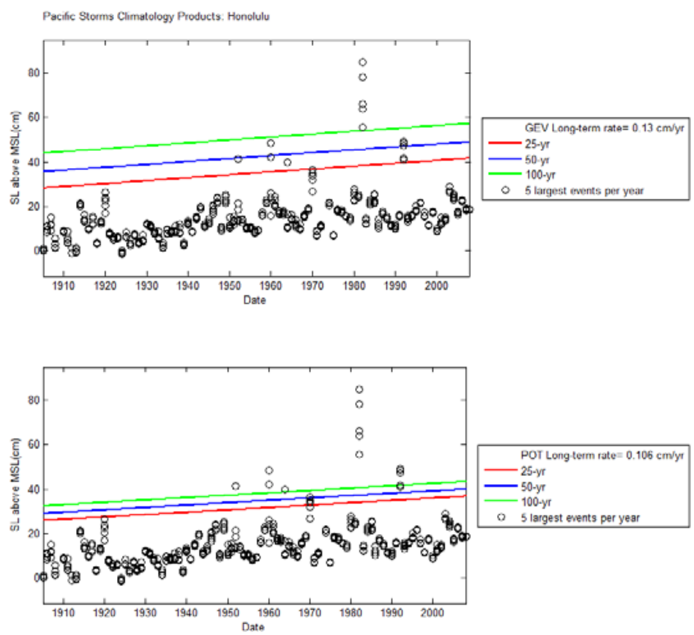

Figure 18b. Pacific Storms Climatology Products: Exceedance Probability.

Sea Level Alert

In order for coastal communities to realize current impacts and become resilient to future changes, sea level advisories/bulletins that systematically monitor for and document non-tidal anomalies (residuals) and flood-watch (elevation) conditions are necessary. The need for this type of product became apparent after an exceptional sea level anomaly along the U.S. East

Coast in June - July of 2009 when higher than normal sea levels coincided with a perigean-spring tide and flooded many coastal regions (Sweet et al., 2009). The event spurred numerous public inquiries to the National Oceanic and Atmospheric Administration's (NOAA) Center for Operational Oceanographic Products and Services (CO-OPS) from coastal communities concerned because of the lack of any coastal storm signatures normally associated with such an anomaly. A subsequent NOAA report provided insight into some of the mechanisms involved in the event and methods for tracking their reoccurrences.

CO-OPS is the U.S. authority responsible for defining sea level datums and tracking their relative changes in support of marine navigation and national and state land-use boundaries. CO-OPS National Water Level Observation Network's (NWLON) long-term and widespread observations largely define a *total water level measurement* impacting a coastal community. In addition to long-term trends, NWLON data also capture significant short-term changes and conveyance of high-water variations (from surge to seasonal scale) provides invaluable insight into inundation patterns ultimately needed for a more comprehensive planning guide.

A CO-OPS Sea Level Alert will enhance high-water monitoring capabilities by:

- Seasonally calibrating sea level anomaly thresholds to a locality in terms of flood potential
- Detecting sea level anomalies and alerting for near-term superposition with large tide-range conditions (i.e., spring tides).
- Monitoring for flood-watch occurrences
- Identifying important regional physical forcing mechanisms to help explain flood events
- Displaying near-real time and archived information to establish a clear and direct communication with a community in regards to its past, present and future flood patterns.

A pilot project is underway for Charleston, SC, an area with little remaining free board in terms of its downtown infrastructure. The National Weather Service (NWS) issues multiple flood watches for Charleston every year that largely result from astronomical (earth-sun-moon system) tide forcing alone and NOAA's Coastal Services Center (CSC) often receives inquiries regarding downtown flooding during sunny, nondescript days. This project will allow for a deeper appreciation of surge-to-seasonal patterns of variability and compliment a community's living memory of sea level elevations/impacts needed to motivate societal adaptation as sea levels rise. Coordination with NWS's local Weather Forecasting Offices (WFO) is planned and the project will expand to other incident-prone regions once demonstration is accepted.

V. Regional Activities

A. Pacific Islands Integrated Water Level Service

Regional partners including the US NOAA, the Australian BOM IOC, and GLOSS through the UHSLC, among others are coordinating on the creation and distribution of climate-related sea level products and services as a path-finding activities towards the creation of a fully integrated 'end-to end' system of regional water level services. Such a system will contribute to climate adaptation planning and disaster risk-reduction efforts underway and planned throughout the Pacific Islands region. It will also advance water level monitoring and research.

B. Support of Regional Tsunami Warning Systems

U.S. Tsunami Program

Although the frequency of damaging tsunamis in the U.S. is low compared to many other natural hazards, the impacts can be extremely high. In 2005, the National Science and Technology Council (NSTC) and the U.S. Sub-Committee for Disaster Reduction released a report outlining the U.S. President's strategy for reducing the tsunami risk (NSTC, 2005). The NSTC is the principal means for the President to coordinate science and technology policy across the U.S. Federal government. To support the national strategy for minimizing the impact of tsunami, NOAA relies on a network of global data, acquired and processed in real-time, in addition to high-quality global databases supporting advanced scientific modeling. NOAA has upgraded its sea level stations for near-shore monitoring, upgrading and expanding the network of seismic stations in partnership with the USGS, and expanding the Deep-ocean Assessment and Reporting of Tsunami (DART®)stations in the Atlantic, Caribbean, Gulf of Mexico and Pacific regions as part of the GEOSS. NOAA, in collaboration with the recently expanded National Tsunami Hazard Mitigation Program (NTHMP), is advancing modeling and mapping activities, hazard assessment and data stewardship, quantitative assessment of socio-economic impacts and increased preparedness.

New and Upgraded Tsunami Capable Tide Stations

Following the 2004 Indian Ocean tsunami disaster, the U.S. evaluated and strengthened its national tsunami warning system. NOAA has upgraded its existing National Water Level Observation Network (NWLON) tide stations with new Data Collection Platforms (DCPs) and communication technology, and filled gaps in the existing water level network with new tsunami-capable NWLON tide stations. NOAA's Tsunami Warning Centers also receive sea level data (1-minute averages transmitted every 5 minutes) from GLOSS stations operated by the University of Hawaii Sea Level Center (UHSLC). These tide stations, in addition to international tide stations in multiple countries, comprise an integrated coastal water level observation network, critical for tsunami detection and warning.

From 2005-2007, NOAA installed 16 new NWLON stations and 33 NWLON station upgrades, in support of the U.S. Tsunami Program. In addition to these priority locations, NOAA has been systematically upgrading NWLON stations along all U.S. Coasts, including its possessions and territories. There are currently 169 NWLON stations operating with full tsunami capabilities.

NWLON stations configured to support tsunami collect 1-minute averaged water level values in addition to the standard 6-minute averaged values. Unlike the previous generation of DCPs which transmitted 6-minute average water level values hourly via Geostationary Operational Environmental Satellites (GOES), the new DCPs transmit water level data every 6 minutes. 6-minute GOES transmissions include primary and backup 6-minute averaged water level data, as well as 1-minute water level data. The messages also include data quality parameters (mean, standard deviation and outliers) and data from any meteorological sensors operating at the station, as well as the preceding water level values from the primary and redundant sensors which can be used to fill data gaps should a transmission be missed. Upgraded NWLON stations also collect 15-second data from the backup water level sensor, which are stored at the backup DCP on a flash memory card. 15-second data are not transmitted via GOES, or routinely archived, but are available for post-event analysis and modeling through the DCP's 56K modem or direct serial connection at the DCP. Enhancements are also under development, in order to increase two-way communication capabilities at tsunami stations for diagnostics, firmware upgrades, reconfiguration, trouble shooting, and data retrieval, thereby eliminating the need to travel to the site, and promoting quicker response to problems and outages.

IOC Tsunami Warning Systems

The IOC of UNESCO has successfully coordinated the Pacific Tsunami Warning System since 1965. After the 2004 Sumatra tsunami, IOC was mandated to assist Indian Ocean Member States in development of an Indian Ocean Tsunami Warning System (IOTWS). The effort began at the same time to develop Early Warning Systems for tsunami and other coastal hazards in both the Caribbean (CARIBE-EWS), the Mediterranean and Northeast Atlantic Ocean (NEAMTWS). These TWSs, owned and operated by the Member States, collect, analyze, and disseminate seismic and sea level data in support of warning and preparedness. The U.S. has played an active role in the PTWS, IOTWS, and the CARIBE-EWS, both through collection of observations and providing tsunami warnings, and through provision of technical expertise and also has participated in the sessions of the NEAMTWS.

Sustainable Sea Level Observations

In support of the CARIBE-EWS, the U.S. through NOAA's National Ocean Service, installed in 2011 a new, sustainable sea level station in Barbuda. Site selection was focused on providing maximum benefit to the region through enhanced warning products, and was founded on scientifically-assessed vulnerability in the country of Antigua and Barbuda. This station is fully operational and contributing data to the Tsunami Warning Centers.

Puerto Rico Seismic Network of the University of Puerto Rico at Mayagüez

The Puerto Rico Seismic Network (PRSN) of the University of Puerto Rico at Mayagüez (UPRM) operates 6 sea level stations in Puerto Rico. The 6 tide gauge stations are NOS compliant and were funded by FEMA and the UPRM and installed and with the support and guidance of NOS/NOAA between 2006 and 2008 (Table 6). All of these stations also meet GLOSS standards for sea level observations and are currently providing data to appropriate warning centers and weather service offices. The data are transmitted every 6 minutes on GOES. In addition some of these stations have been updated to transmit data every minute over the internet. The data can be accessed on the home page of the PRSN, http://redsismica.uprm.edu, Tides and Currents site of NOAA, http://tidesandcurrents.noaa.gov and Tides on Line site of NOAA http://tidesonline.nos.noaa.gov/monitor.html.

Table 6. PRSN Sea Level Stations in Puerto Rico, USA.

Station	State	GOES ID	Transmission Interval over GOES	Station Number	Lat	Long
ARECIBO	PR	3366454E	6 min	975-7809	18.47 N	66.70 W
FAJARDO	PR	3366C35A	6 min	975-3216	18.33 N	65.63 W
MAYAGUEZ	PR	336633DE	6 min	975-9394	18.22 N	67.16 W
ISABEL II, VIEQUES	PR	3366D02C	6 min	975-2619	18.15 N	65.44 W
PENUELAS	PR	3366A6BC	6 min	975-B053	17.97 N	66.76 W
YABUCOA	PR	3366B5CA	6 min	975-422B	18.06 N	65.84 W

Each station is equipped with an acoustic and pressure sensor, 2 DCPs, air and water temperature sensors. All stations also have a meteorology package consisting of a wind, air temperature/relative humidity, barometric and rain gauges. The power of the station is autonomous and runs off solar panels. Timing is provided with a GPS. For leveling purposes, each sea level station has 6 benchmarks which have all been observed with GPS. Second-order, class I levels were used in connections at all the stations.

A GOES receiver and central recording system is operational at the Puerto Rico Seismic Network to receive the data from these and other sea level stations operated by NOAA and other sea level operators in the Caribbean and Adjacent regions. These stations are monitored 24/7 as part of the PRSN Earthquake and Tsunami Information and Warning System. XCONNECT software of Sutron is used for display and quality control of the data. The West Coast and Alaska Tsunami Warning Center software, Tide View, is used to mesh observed tsunami information with the forecast model and compare observed waves with predicted tide and estimated tsunami arrival times, as well as digitally filter the tsunami signal. PRSN is also developing a suite of codes in house to add quality control to sea level data, and to feed 1-minute live stream to remote clients, including the Tsunami Warning Centers.

The PRSN also supports efforts to improve sea level observations in the Caribbean for tsunami and other coastal hazards. In 2008 it hosted the IOC-GLOSS-PRSN Caribbean Training Course for Operators of Sea Level Stations, and had a workshop this year to discuss post-tsunami survey measurements. In 2008 it also installed a NOAA/NOS and GLOSS compliant station in the Dominican Republic for which it continues to provide support. Another project includes updating the Road Town, Tortola, British Virgin Islands station. At the end of this year (Late November), PRSN and Oficina Nacional de Meteorologia (Onamet) will install a tsunami ready tide gauge in the Dominican Republic, in the south province of Barahona.

It has been collaborating with the University of Hawaii in the installation and upgrade of an additional 10 stations in the Caribbean in support of tsunami monitoring. As part of these efforts, as of 2011, El Limon in Costa Rica, Curacao, Grenada, Dominica and Puerto Plata and Punta Cana have been installed. By 2014, when this project ends, additional stations are to be installed in Turks and Caicos, Panama and Colombia (2 stations). By 2011 the PRSN in coordination with the Tsunami Unit of UNESCO has plans to install a new coastal sea level station in Port au Prince, Haiti. In 2011, also with UNESCO, the PRSN has begun evaluating additional sites for the installation of sea level stations in the Central America and several islands in the Caribbean. The website of the PRSN has links to data of many of the stations operational in the Caribbean and Adjacent regions.

Caribbean Tsunami Warning Program

The Caribbean Tsunami Warning Program (CTWP) was established in 2010 as the first step of a phased approach for the establishment of a Caribbean Tsunami Warning Center (CTWC). This office currently provides support and guidance for tsunami observations, including seismic and sea level systems, tsunami forecasting, communications and education and preparedness. It works closely with the Pacific Tsunami Warning Center and the West Coast and Alaska Tsunami Warning Center, the UNESCO Intergovernmental Oceanographic Commission's Intergovernmental Coordination Group for Tsunamis and Other Coastal Hazards Warning System for the Caribbean Sea and Adjacent Regions as well as other local, national and regional stakeholders. At the request of the CARIBE EWS it maintains a database on sea level stations in the Caribbean and hosts on its website (http://www.srh.noaa.gov/srh/ctwp/) an interactive Google Map of sea level stations (See Figure 19). As of 2011 the CARIBE EWS station inventory included 100 coastal stations and 7 DART stations in the Caribbean and Western Atlantic (non US mainland). Of these stations, all the DART stations have been installed and 34 coastal sea level stations are contributing data over GOES or FTP at least every 6 minutes. Plans are underway for new installations and upgrades at another 30 stations. For other locations, funds are required for new installations or upgrades to the current facilities.

In addition to maintaining an inventory of sea level stations in the Caribbean and Western Atlantic basin, the CTWP helped organize the 2nd regional GLOSS-CARIBE EWS sea level network operator's workshop **"Strengthening Sea Level Observation Network and Coordination Activities in the Caribbean"** in January 2011. Plans are underway for a third course in early 2012 in Mexico. The CTWP, thru initiatives with NOAA, US State Department and the Tsunami Unit is maintaining discussions with the Caribbean stakeholders and particularly the Caribbean Community Center for Climate Change regarding the upgrade of existing stations in the CARICOM nations and a Caribbean Sea Level Data Center. Another project focuses on the development and strengthening sea level observations and data analysis for the tsunami and hydro meteorological community.

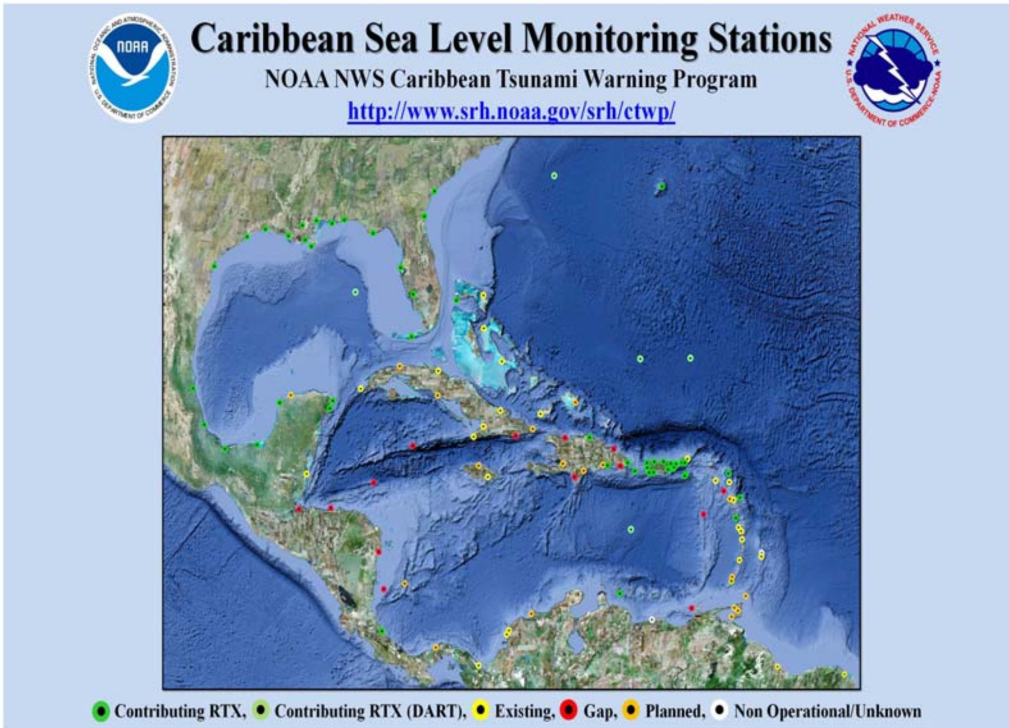

Figure 19. Current status of sea level stations in the Caribbean.

C. Contributions to an Arctic Observing System

In 2011, NOAA released an Arctic Vision and Strategy specifically to support the 2010 President's *Final Recommendations of the Interagency Ocean Policy Task Force* that called for "better ways to conserve, protect, and sustainably manage Arctic coastal and ocean resources… new collaborations and partnerships to better monitor and assess environmental conditions…improvement of the scientific understanding of the Arctic system and how it is changing in response to climate-induced and other changes."

According to the NOAA Arctic Vision and Strategy:

> "The Arctic has profound significance for climate and functioning of ecosystems around the globe. The region is particularly vulnerable and prone to rapid change. Increasing air and ocean temperatures, thawing permafrost, loss of sea ice, and shifts in ecosystems are evidence of widespread and dramatic ongoing change. As a result, critical environmental, economic, and national security issues are emerging, many of which have significant impacts for human lives, livelihoods, and coastal communities. Though NOAA has numerous and diverse capabilities that support these emerging issues, a strategic approach that leverages NOAA's existing priorities and strengths, as well as those of our national and international partners, is needed."

The document continues to explain that the "Arctic region needs accurate land and tidal elevations to build flood protections, harden infrastructure, ensure safe and efficient marine transportation, model storm surge, and monitor sea levels." Specifically in order to advance the objective for resilient and healthy Arctic communities and economies, NOAA's five-year action plan strategy is to:

- Overhaul the Arctic Geospatial Framework of geodetic control and water levels to correct errors of several meters in positioning and enable centimeter level measurements and elevations
- Deliver scientific support for Arctic pollution response to protect ecosystems (contingency plans, place-based drills, incident response training, community workshops, spill trajectory modeling, baseline environmental assessments)
- Incorporate local knowledge into preparedness, response, assessment, and restoration
- Survey and map Arctic waters and shoreline
- Support coastal communities with adaptive strategies and planning tools for understanding how climate change affects health and welfare

,
In order to accomplish these tasks, NOAA will specifically address several milestones:

- Acquire Arctic hydrographic and shoreline data for accurate nautical charts and storm surge models.
- Conduct airborne gravity surveys over Alaska to correct meters-level errors in Arctic positioning
- Explore potential partnerships to establish Continuously Operating Reference Stations and water level stations for accurate datums and positions.
- Advance appropriate tidal or hydrodynamic models, and datum transformation tools to support accurate and efficient Arctic hydrographic surveys.

- Assess and compile scientific research as well as traditional knowledge related to the impacts of resource development and pollution applicable to the Arctic.

In addition, with increased funding, NOAA would be able to:

- Upgrade National Water Level Observation Network stations for accurate water level measurements
- Model the geoid and densify CORS in northern and western Alaska for precise positioning
- Begin expansion of VDatum to Alaska for mapping and coastal community protection against storm surge and sea level change

- Increase the number of permanent NWLON stations co-located with CORS established in AK/Arctic gap areas

V. APPENDIX 1: Status of NOAA/CO-OPS GLOSS Stations in the United States

GLOSS ID	Location	Status
111	Kwajelein	• Ongoing, currently using an acoustic gauge with pressure gauge backup – with redundant DCP • PSMSL data through 2010 • JASL (055A) data through 2011 • CRN station
206	San Juan, PR	• Ongoing, currently using an acoustic gauge with pressure gauge backup – with redundant DCP • PSMSL data through 2010 • JASL (245A) data through 2011
221	Bermuda	• Ongoing, currently using an acoustic gauge with pressure gauge backup – with redundant DCP • PSMSL data through 2010 • JASL (259A) data through 2011 • CRN station
302	Adak, AK	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2010 • JASL (040A) data through 2011
149	Apra Harbor, Guam	• Ongoing, currently using a digital/pressure bubbler gauge – with redundant DCP • PSMSL data through 2010 • JASL (053A) data through 2011 • CRN station
219	Duck Pier, NC	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2010 • JASL (260A) data through 2011
289	Fort Pulaski, GA	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2010 • JASL (752A) data through 2005
217	Galveston Pier 21, TX	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2010 • JASL (775A) data through 2011
287	Hilo, HI	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2010 • JASL (060A) data through 2011
108	Honolulu. HI	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2010 • JASL (057B) data through 2011 • CRN station
109	Johnston Island	No longer operated by NOAA as of 2003 – operated by UHSLC since 2004

GLOSS ID	Location	Status
		• PSMSL data through 2003 • JASL (052A) data through 2011
216	Key West, FL	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2010 • JASL (242A) data through 2011 • CRN station
159	La Jolla, CA	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2010 • JASL (554A) data through 2011 • CRN station
303	Attu Island, AK	No longer operated by NOAA – station may be re-established using Tsunami funding • PSMSL data 1943 through 1966 • JASL (550A) data 1943 through 1966
218	Miami (Haulover Pier), FL	• Destroyed in 1992 by hurricane – moved to Virginia Key, FL which was assigned GLOSS ID 332. Ongoing, currently using an acoustic gauge with pressure gauge backup – station is not connected to datum at Miami. • PSMSL data 1987 through 1992 • JASL (241A) Miami data 1985 through 1992 • JASL (755A) Virginia Key data 1996 through 2011
106	Midway Island	• Ongoing, currently using an acoustic gauge with pressure gauge backup – with redundant DCP • PSMSL data through 2010 • JASL (050A) data through 2011
290	Newport, RI	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2010 • JASL (253A) data through 2011
74	Nome, AK	• Ongoing, currently using a dual orifice digital/bubbler system • PSMSL data through 2010 • JASL (0595A) data through 2011
144	Pago Pago, AS	• Ongoing, currently using an acoustic gauge with pressure gauge backup – with redundant DCP • PSMSL data through 2010 • JASL (056A) data through 2011
288	Pensacola, FL	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2010 • JASL (762A) data through 2011 • CRN station
151	Prudhoe Bay, AK	• Ongoing, currently using an acoustic gauge during the ice – free season and a digital/bubbler system during the winter • PSMSL data through 2010 • JASL (579A) data through 2011
158	San Francisco, CA	• Ongoing, currently using a dual orifice digital/bubbler system PSMSL data through 2010 • JASL (551A) data through 2011

GLOSS ID	Location	Status
		• CRN station
100	Sand Point, AK	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2010 • JASL (574A) data through 2011
150	Seward, AK	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2010 • JASL (560C) data through 2011
154	Sitka, AK	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2010 • JASL (559A) data through 2011
157	South Beach, OR	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2010 • JASL (592A) data through 2011
102	Unalaska (Dutch Harbor), AK	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2010 • JASL (041B) data through 2011
220	Atlantic City, NJ	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2010 • JASL (264A) data through 2011 • CRN station
105	Wake Island	• Ongoing, currently using an acoustic gauge with pressure gauge backup – with redundant DCP • PSMSL data through 2010 • JASL (051A) data through 2011

VI. APPENDIX 2: Status of additional operational non- GLOSS JASL NWLON Stations in the United States

JASL ID	Location	Status
039A	Kodiak, AK	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2010 • JASL data through 2011
058A	Nawiliwili, HI	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2010 • JASL data through 2011
059A	Kahului, HI	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2010 • JASL data through 2011
061A	Mokuoloe, HI	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2010 • JASL data through 2008
552A	Kawaihae, HI	• Ongoing, currently using an acoustic gauge with pressure gauge backup • JASL data through 2008
555A	Monterey, CA	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2010 • JASL data through 2008
556A	Crescent City, CA	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2010 • JASL data through 2011 • CRN station
557A	Port Orford, OR	• Ongoing, currently using a dual orifice digital/bubbler system • PSMSL data through 2010 • JASL data through 2008
558A	Neah Bay, WA	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2010 • JASL data through 2011 • CRN station
561A	Seldovia, AK	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2010 • JASL data through 2008
562A	Valdez. AK	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2010 • JASL data through 2008
564A	Willapa Bay (Toke Point),	• Ongoing, currently using an acoustic gauge with pressure

JASL ID	Location	Status
	WA	gauge backup • PSMSL data through 2010 • JASL data through 2008
565A	Port San Luis, CA	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2010 • JASL data through 2008
567A	Los Angeles, CA	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2010 • JASL data through 2008
570A	Yakutat, AK	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2010 • JASL data through 2011
571A	Ketchikan, AK	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2010 • JASL data through 2011 • CRN station
572A	Astoria, OR	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2010 • JASL data through 2008
573A	Arena Cove, CA	• Ongoing, currently using an acoustic gauge with pressure gauge backup • JASL data through 2008
575A	Charleston, OR	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2010 • JASL data through 2008
576A	Humboldt Bay (North Spit), CA	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2010 • JASL data through 2008
578A	Santa Monica, CA	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2010 • JASL data through 2008
583B	Cordova, AK	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2010 • JASL data through 2008
594A	Platform Harvest, CA	• Ongoing, currently two DCP's with paroscientific pressure digital bubbler sensors • JASL data 1995 through 1999
246A	Magueyes Island, PR	• Ongoing, currently using an acoustic gauge with pressure gauge backup – with redundant DCP • PSMSL data through 2010 • JASL data through 2008

JASL ID	Location	Status
261A	Charleston, SC	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2010 • JASL data through 2011 • CRN station
240A	Fernandina Beach, FL	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2010 • JASL data through 2008 • CRN station
252A	Portland, ME	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2010 • JASL data through 2008 • CRN station
254A	Lime Tree bay, VI	• Ongoing, currently using an acoustic gauge with pressure gauge backup – with redundant DCP • PSMSL data through 2010 • JASL data through 2008
255A	Charlotte Amalie, VI	• Ongoing, currently using an acoustic gauge with pressure gauge backup – with redundant DCP • PSMSL data through 2010 • JASL data through 2008
279A	Montauk, NY	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2010 • JASL data through 2008
740A	Eastport, ME	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2010 • JASL data through 2008
741A	Boston, MA	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2010 • JASL data through 2008 • CRN station
742A	Woods Hole. MA	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2010 • JASL data through 2008
743A	Nantucket, MA	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2010 • JASL data through 2008
744A	New London, CT	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2010 • JASL data through 2008
745A	New York (The Battery), NY	• Ongoing, currently using an acoustic gauge with pressure gauge backup

JASL ID	Location	Status
		• PSMSL data through 2010 • JASL data through 2008 • CRN station
746A	Cape May, NJ	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2010 • JASL data through 2008
747A	Lewes, DE	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2010 • JASL data through 2008
749A	Chesapeake BBT, VA	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2010 • JASL data through 2008
750A	Wilmington, NC	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2010 • JASL data through 2008
753A	Mayport, FL	• Removed in 2000, used an acoustic gauge with pressure gauge backup. Replaced with Mayport, Bar Pilots Dock. • PSMSL data through 2000 • JASL data through 2000
757A	Naples,FL	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2010 • JASL data through 2008
759A	St. Petersburg, FL	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2010 • JASL data through 2008
760A	Apalachicola, FL	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2010 • JASL data through 2008
761A	Panama City Beach, FL	• Removed in 2008, used an acoustic gauge with pressure gauge backup • JASL data through 2008
763A	Dauphin Island, AL	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2010 • JASL data through 2008
765A	Grand Isle, LA	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2010 • JASL data through 2008
766A	Sabine Pass, TX	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data 1958 through 1985 • JASL data through 2008

JASL ID	Location	Status
767A	Galveston Pleasure Pier, TX	• Removed in 2011, used an acoustic gauge with pressure gauge backup. Replaced with Galveston, North Jetty. • PSMSL data through 2010 • JASL data through 2008
769A	Rockport, TX	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2010 • JASL data through 2008
770A	Corpus Christi, TX	• Ongoing, currently using an acoustic gauge with pressure gauge backup • JASL data 1992 through 1999
772A	Port Isabel, TX	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2010 • JASL data through 2008
773A	Clearwater Beach, FL	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2010 • JASL data through 2008
774A	Port Canaveral (Trident Pier), FL	• Ongoing, currently using an acoustic gauge with pressure gauge backup • JASL data through 2008

VII. APPENDIX 3: UHSLC Fast Delivery, JASL and Real-time datasets.

The GLOSS/CLIVAR (formerly known as the WOCE) fast sea level data is distributed as hourly, daily, and monthly values. This project is supported by the NOAA Climate and Global Change program, and is one of the activities of the University of Hawaii Sea Level Center.

Joint Archive for Sea Level: Research Quality Data Set

The Joint Archive for Sea Level (JASL), a collaboration between the University of Hawaii Sea Level Center (UHSLC) and the World Data Center-A for Oceanography, the National Oceanographic Data Center (NODC), and the National Coastal Data Development Center (NCDDC), continues to acquire, quality control, manage, and distribute sea level data as initiated by the Tropical Ocean Global Atmosphere (TOGA) Program, which ended in 1994. The TOGA ocean monitoring networks were primarily in the tropics. Since the end of TOGA, the JASL has slowly begun to absorb sea level sites in oceanographically strategic locations beyond the tropics. The JASL is now an official Global Sea Level Observing System (GLOSS) data center. The JASL Research Quality Data Set (RQDS) is the largest global collection of quality-controlled hourly sea level. Efforts are underway to acquire new sites and uncover historic records as available.

The JASL receives hourly data from regional and national sea level networks. The data are inspected and obvious errors such as data spikes and time shifts are corrected. Gaps less than 25 hours are interpolated. Reference level problems are referred back to the originator. If the originators cannot resolve the reference level shift, comparisons with neighboring sites or examination of the hourly residuals may warrant an adjustment. Descriptive station information and quality assessments are prepared. The objective is to assemble a scientifically valid, well-documented archive of hourly, daily, and monthly sea level values in standardized formats. These data are annually submitted to the World Data Center-A for Oceanography (WDCA) and the monthly values are provided to the Permanent Service for Mean Sea Level.

General Information for Desired Stations as of October 25, 2011:

Notes on columns:
Pxxx: Pacific Ocean, Axxx: Atlantic Ocean, Ixxx: Indian Ocean
CI: Completeness index or percentage of data span without missing data.
QC-YEARS: years which have received quality control.

JASL	TOGA	GLOSS	STATION	COUNTRY	COORDINATES	QC-YEARS	CI	AGENCY
001A	Pxxx	115	Pohnpei-A	Fd St Micronesia	06-59N 158-14E	1969-1971	100	Scripps Inst. Ocean.
001B	Pxxx	115	Pohnpei-B	Fd St Micronesia	06-59N 158-15E	1974-2004	98	UH Sea Level Center
001C	Pxxx	115	Pohnpei-C	Fd St Micronesia	06-59N 158-12E	2001-2009	100	Nat. Tidal Ctr., BOM
002A	Pxxx	113	Tarawa-A,Betio	Rep. of Kiribati	01-22N 172-56E	1974-1983	78	UH Sea Level Center
002B	Pxxx	113	Tarawa-B,Bairiki	Rep. of Kiribati	01-20N 173-01E	1983-1988	98	UH Sea Level Center
002C	Pxxx	113	Tarawa-C,Betio	Rep. of Kiribati	01-22N 172-56E	1988-1997	100	UH Sea Level Center
002D	Pxxx	113	Tarawa-D,Betio	Rep. of Kiribati	01-22N 172-56E	1992-2009	93	Nat. Tidal Ctr., BOM
003A	Pxxx	169	Baltra-A	Ecuador	00-26S 090-17W	1968-1977	93	National Ocean Service
003B	Pxxx	169	Baltra-B	Ecuador	00-26S 090-17W	1985-2010	86	UH Sea Level Center
004A	Pxxx	114	Nauru-A	Rep. of Nauru	00-32S 166-54E	1974-1995	95	UH Sea Level Center

004B	Pxxx	114	Nauru-B	Rep. of Nauru	00-32S	166-55E	1993-2009	91	Nat. Tidal Ctr., BOM
005A	Pxxx	112	Majuro-A	Rep. Marshall I.	07-06N	171-22E	1968-1999	92	UH Sea Level Center
005B	Pxxx	112	Majuro-B	Rep. Marshall I.	07-07N	171-22E	1993-2009	98	Nat. Tidal Ctr., BOM
006A	Pxxx	xxx	Enewetok-A	Rep. Marshall I.	11-26N	162-23E	1951-1971	98	Scripps Inst. Ocean.
006B	Pxxx	xxx	Enewetok-B	Rep. Marshall I.	11-26N	162-23E	1974-1979	94	UH Sea Level Center
007A	Pxxx	120	Malakal-A	Rep. of Belau	07-20N	134-29E	1926-1939	92	Japan Ocean. Data Cen.
007B	Pxxx	120	Malakal-B	Rep. of Belau	07-20N	134-28E	1969-2009	96	UH Sea Level Center
008A	Pxxx	119	Yap-A	Fd St Micronesia	09-31N	138-08E	1951-1952	100	Scripps Inst. Ocean.
008B	Pxxx	119	Yap-B	Fd St Micronesia	09-31N	138-08E	1969-2005	92	UH Sea Level Center
009A	Pxxx	066	Honiara-A	Solomon Islands	09-26S	159-57E	1974-1995	98	UH Sea Level Center
009B	Pxxx	066	Honiara-B	Solomon Islands	09-25S	159-57E	1994-2009	98	Nat. Tidal Ctr., BOM
010A	Pxxx	065	Rabaul	Papua New Guinea	04-12S	152-11E	1966-1997	85	UH Sea Level Center
011A	Pxxx	146	Christmas-A	Rep. of Kiribati	01-59N	157-29W	1955-1972	89	Scripps Inst. Ocean.
011B	Pxxx	146	Christmas-B	Rep. of Kiribati	01-59N	157-28W	1974-2003	96	UH Sea Level Center
012A	Pxxx	xxx	Fanning-A	Rep. of Kiribati	03-54N	159-23W	1957-1958	88	Scripps Inst. Ocean.
012B	Pxxx	xxx	Fanning-B	Rep. of Kiribati	03-54N	159-23W	1972-1987	95	UH Sea Level Center
012C	Pxxx	xxx	Fanning-C	Rep. of Kiribati	03-51N	159-22W	1988-1990	78	UH Sea Level Center
013A	Pxxx	145	Kanton-A	Rep. of Kiribati	02-49S	171-43W	1949-1967	100	Scripps Inst. Ocean.
013B	Pxxx	145	Kanton-B	Rep. of Kiribati	02-49S	171-43W	1972-2007	87	UH Sea Level Center
014A	Pxxx	107	French Frigate S	USA	23-52N	166-17W	1974-2004	97	UH Sea Level Center
015A	Pxxx	140	Papeete-A	French Polynesia	17-32S	149-34W	1969-1975	91	UH Sea Level Center
015B	Pxxx	140	Papeete-B	French Polynesia	17-32S	149-34W	1975-2009	97	National Ocean Service
016A	Pxxx	138	Rikitea	French Polynesia	23-08S	134-57W	1969-2003	92	UH Sea Level Center
017A	Pxxx	xxx	Hiva Oa	French Polynesia	09-49S	139-02W	1977-1980	75	UH Sea Level Center
018A	Pxxx	122	Suva-A	Fiji	18-08S	178-26E	1972-1997	91	National Ocean Service
018B	Pxxx	122	Suva-B	Fiji	18-08S	178-26E	1998-2009	99	Nat. Tidal Ctr., BOM
019A	Pxxx	123	Noumea	France	22-18S	166-26E	1967-2003	99	UH Sea Level Center
021A	Pxxx	176	Juan Fernandez-A	Chile	33-37S	078-50W	1977-1984	67	UH Sea Level Center
021B	Pxxx	176	Juan Fernandez-B	Chile	33-38S	078-50W	1985-2010	89	SHOA
022A	Pxxx	137	Easter-A	Chile	27-09S	109-27W	1957-1958	97	SHOA
022B	Pxxx	137	Easter-B	Chile	27-09S	109-27W	1962-1963	100	SHOA
022C	Pxxx	137	Easter-C	Chile	27-09S	109-28W	1970-2010	83	SHOA
023A	Pxxx	139	Rarotonga-A	Cook Islands	21-12S	159-47W	1977-1997	98	UH Sea Level Center
023B	Pxxx	139	Rarotonga-B	Cook Islands	21-12S	159-47W	1993-2009	99	Nat. Tidal Ctr., BOM
024A	Pxxx	143	Penrhyn	Cook Islands	08-59S	158-03W	1977-2010	95	UH Sea Level Center
025A	Pxxx	121	Funafuti-A	Tuvalu	08-32S	179-12E	1977-1999	97	UH Sea Level Center
025B	Pxxx	121	Funafuti-B	Tuvalu	08-30S	179-13E	1993-2009	97	Nat. Tidal Ctr., BOM
026A	Pxxx	xxx	Honolulu,Kewalo	USA	21-18N	157-52W	1978-1986	96	UH Sea Level Center
027A	Pxxx	xxx	Honolulu,Pier 45	USA	21-19N	157-53W	1985-1988	100	UH Sea Level Center
028A	Pxxx	118	Saipan-A	N. Mariana Is.	15-13N	145-44E	1938-1940	97	Japan Ocean. Data Cen.
028B	Pxxx	118	Saipan-B	N. Mariana Is.	15-14N	145-45E	1978-2009	87	UH Sea Level Center
029A	Pxxx	117	Kapingamarangi	Fd St Micronesia	01-06N	154-47E	1978-2008	94	UH Sea Level Center
030A	Pxxx	xxx	Santa Cruz	Ecuador	00-45S	090-19W	1978-2007	95	UH Sea Level Center
031A	Pxxx	142	Nuku Hiva	French Polynesia	08-56S	140-05W	1982-1997	49	UH Sea Level Center
033A	Pxxx	069	Bitung	Indonesia	01-26N	125-12E	1986-2009	37	BAKOSURTANAL
034A	Pxxx	161	Cabo San Lucas	Mexico	22-53N	109-55W	1973-2003	81	CICESE
035A	Pxxx	177	San Felix	Chile	26-18S	080-07W	1987-2010	83	SHOA
036A	Pxxx	160	Guadalupe	Mexico	28-53N	118-18W	1977-1985	75	CICESE
037A	Pxxx	xxx	Pago Bay, Guam	USA Trust	13-26N	144-48E	2004-2011	90	National Ocean Service
038A	Pxxx	125	Nuku'alofa	Tonga	21-08S	175-11W	1990-2009	98	Nat. Tidal Ctr., BOM
039A	Pxxx	xxx	Kodiak,Alaska	USA	57-44N	152-31W	1975-2010	85	National Ocean Service
040A	Pxxx	302	Adak,Alaska	USA	51-52N	176-38W	1950-2011	92	National Ocean Service
041A	Pxxx	102	Dutch Harbor-A,AK	USA	53-53N	166-32W	1950-1955	100	National Ocean Service
041B	Pxxx	102	Dutch Harbor-B,AK	USA	53-53N	166-32W	1982-2011	97	National Ocean Service
043A	Pxxx	xxx	Palmyra	USA Trust	05-53N	162-05W	1947-1949	95	National Ocean Service
045A	Pxxx	xxx	Jarvis	USA	00-23S	160-02W	1957-1957	27	UH Sea Level Center
046A	Pxxx	xxx	Port Vila-A	Vanuatu	17-44S	168-19E	1977-1982	87	unconfirmed
046B	Pxxx	xxx	Port Vila-B	Vanuatu	17-46S	168-18E	1993-2009	94	Nat. Tidal Ctr., BOM
047A	Pxxx	103	Chichijima	Japan	27-06N	142-11E	1975-2010	100	Japan Meteor. Agency
048A	Pxxx	xxx	Anewa Bay	Papua New Guinea	06-11S	155-53E	1968-1977	85	UH Sea Level Center
049A	Pxxx	104	Minamitorishima	Japan	24-18N	153-59E	1997-2010	93	Japan Meteor. Agency
050A	Pxxx	106	Midway	USA Trust	28-13N	177-22W	1947-2011	93	National Ocean Service
051A	Pxxx	105	Wake	USA Trust	19-17N	166-37E	1950-2011	92	National Ocean Service
052A	Pxxx	109	Johnston	USA Trust	16-44N	169-32W	1947-2003	95	National Ocean Service
053A	Pxxx	149	Guam	USA Trust	13-26N	144-39E	1948-2010	93	National Ocean Service
054A	Pxxx	116	Truk	Fd St Micronesia	07-27N	151-51E	1963-1991	89	National Ocean Service
055A	Pxxx	111	Kwajalein	Rep. Marshall I.	08-44N	167-44E	1946-2011	98	National Ocean Service
056A	Pxxx	144	Pago Pago	USA Trust	14-17S	170-41W	1948-2011	96	National Ocean Service
057A	Pxxx	108	Honolulu-A	USA	21-18N	157-52W	1877-1892	32	National Ocean Service
057B	Pxxx	108	Honolulu-B	USA	21-18N	157-52W	1905-2011	98	National Ocean Service
058A	Pxxx	xxx	Nawiliwili	USA	21-58N	159-21W	1954-2011	99	National Ocean Service
059A	Pxxx	xxx	Kahului	USA	20-54N	156-28W	1950-2011	93	National Ocean Service
060A	Pxxx	287	Hilo	USA	19-44N	155-04W	1927-2011	82	National Ocean Service
061A	Pxxx	xxx	Mokuoloe	USA	21-26N	157-48W	1957-2011	81	National Ocean Service
062A	Pxxx	124	Norfolk Island-A	Australia	29-04S	167-57E	1985-1986	98	CSIRO
062B	Pxxx	124	Norfolk Island-B	Australia	29-04S	167-56E	1994-1999	100	CSIRO
063A	Pxxx	xxx	Wewak	Papua New Guinea	03-34S	143-38E	1984-1994	82	CSIRO
064A	Pxxx	xxx	Port Moresby	Papua New Guinea	09-29S	147-08E	1984-1993	98	CSIRO
065A	Pxxx	xxx	Manus	Papua New Guinea	02-01S	147-16E	1984-1994	73	CSIRO
066A	Pxxx	xxx	Madang	Papua New Guinea	05-12S	145-48E	1984-1998	81	CSIRO
067A	Pxxx	xxx	Lae	Papua New Guinea	06-44S	146-59E	1984-1997	83	CSIRO

068A	Pxxx	xxx	Kavieng	Papua New Guinea	02-35S	150-48E	1984-1994	95	CSIRO
069A	Pxxx	063	Alotau	Papua New Guinea	10-10S	150-27E	1984-1995	62	CSIRO
070A	Pxxx	127	Auckland	New Zealand	36-51S	174-46E	1984-1988	100	Royal New Zealand Navy
071A	Pxxx	101	Wellington	New Zealand	41-17S	174-47E	1944-2010	97	LINZ
072A	Pxxx	129	Bluff	New Zealand	46-36S	168-21E	1984-2010	60	LINZ
073A	Pxxx	xxx	Tauranga	New Zealand	37-39S	176-11E	1984-2010	87	LINZ
074A	Pxxx	xxx	Westport	New Zealand	41-44S	171-36E	1984-1985	100	Royal New Zealand Navy
075A	Pxxx	xxx	Wanganui	New Zealand	39-57S	174-59E	1984-1985	97	Royal New Zealand Navy
076A	Pxxx	xxx	Taranaki	New Zealand	39-03S	174-02E	1984-2010	89	LINZ
077A	Pxxx	xxx	Nelson	New Zealand	41-16S	173-16E	1984-2010	58	LINZ
078A	Pxxx	xxx	Gisborne	New Zealand	38-41S	178-02E	1984-1985	98	Royal New Zealand Navy
079A	Pxxx	128	Chatham	New Zealand	43-57S	176-34W	2001-2010	51	UH Sea Level Center
080A	Pxxx	174	Antofagasta	Chile	23-39S	070-24W	1945-2010	93	SHOA
081A	Pxxx	175	Valparaiso	Chile	33-02S	071-38W	1944-2010	85	SHOA
082A	Pxxx	182	Acajutla-A	El Salvador	13-35N	089-50W	1962-2001	96	Inst. Geograf. Nacional
082B	Pxxx	182	Acajutla-B	El Salvador	13-35N	089-50W	2001-2009	52	Inst. Geograf. Nacional
083A	Pxxx	xxx	Arica	Chile	18-28S	070-20W	1982-1998	98	SHOA
084A	Pxxx	xxx	Lobos de Afuera	Peru	06-56S	080-43W	1982-2009	96	DHNM
085A	Pxxx	170	Buenaventura	Colombia	03-54N	077-06W	1953-2011	92	IDEAM
086A	Pxxx	xxx	La Union-A	El Salvador	13-20N	087-49W	1954-1980	77	National Ocean Service
086B	Pxxx	xxx	La Union-B	El Salvador	13-20N	087-49W	2001-2010	74	Inst. Geograf. Nacional
087A	Pxxx	167	Quepos	Costa Rica	09-24N	084-10W	1961-1994	83	SERMAR
088A	Pxxx	xxx	Caldera	Chile	27-04S	070-50W	1980-1998	97	SHOA
089A	Pxxx	xxx	Manta-A	Ecuador	00-57S	080-44W	1979-1981	100	INOCAR
089B	Pxxx	xxx	Manta-B	Ecuador	00-56S	080-43W	1990-2008	82	INOCAR
090A	Pxxx	162	Socorro	Mexico	18-44N	111-01W	1957-1959	81	CICESE
091A	Pxxx	172	La Libertad	Ecuador	02-12S	080-55W	1949-2010	97	INOCAR
092A	Pxxx	xxx	Talara-A	Peru	04-35S	081-17W	1950-1965	92	National Ocean Service
092B	Pxxx	xxx	Talara-B	Peru	04-35S	081-17W	1988-2010	76	DHNM
093A	Pxxx	173	Callao-A	Peru	12-03S	077-09W	1950-1965	98	National Ocean Service
093B	Pxxx	173	Callao-B	Peru	12-03S	077-09W	1970-2010	97	DHNM
094A	Pxxx	xxx	Matarani-A	Peru	17-00S	072-07W	1954-1964	98	National Ocean Service
094B	Pxxx	xxx	Matarani-B	Peru	17-00S	072-07W	1992-2010	84	DHNM
096A	Pxxx	xxx	San Juan-A	Peru	15-22S	075-12W	1978-2003	80	DHNM
096B	Pxxx	xxx	San Juan-B	Peru	15-22S	075-12W	2003-2010	94	DHNM
098A	Pxxx	xxx	Esmeraldas	Ecuador	00-60N	079-39W	1990-2010	92	INOCAR
300A	Pxxx	xxx	Naos-A	Panama	08-55N	079-32W	1961-1965	99	Scripps Inst. Ocean.
300B	Pxxx	xxx	Naos-B	Panama	08-55N	079-32W	1991-1997	84	National Ocean Service
301A	Pxxx	xxx	Puerto Quetzal-A	Guatemala	13-55N	090-47W	1983-1984	90	UH Sea Level Center
301B	Pxxx	xxx	Puerto Quetzal-B	Guatemala	13-55N	090-47W	1992-1995	77	UH Sea Level Center
301C	Pxxx	xxx	Puerto Quetzal-C	Guatemala	13-55N	090-50W	2001-2002	100	National Ocean Service
302A	Pxxx	168	Balboa	Panama	08-58N	079-34W	1907-2010	98	Autoridad Canal Panama
303A	Pxxx	171	Tumaco	Colombia	01-50N	078-44W	1951-2011	83	IDEAM
304A	Pxxx	xxx	Pto. Armuelles-A	Panama	08-16N	082-52W	1955-1968	95	Inst. Geograf. Nac.
304B	Pxxx	xxx	Pto. Armuelles-B	Panama	08-16N	082-52W	1983-2001	94	Inst. Geograf. Nac.
305A	Pxxx	xxx	Cedros Island	Mexico	28-06N	115-11W	1976-1989	75	CICESE
307A	Pxxx	xxx	San Felipe	Mexico	31-01N	114-49W	1982-1986	52	UNAM
308A	Pxxx	xxx	San Quintin	Mexico	30-29N	115-59W	1977-1990	97	CICESE
310A	Pxxx	xxx	Bahia Los Angeles	Mexico	28-58N	113-33W	1973-1994	74	CICESE
313A	Pxxx	xxx	Catalina-A	USA	33-27N	118-29W	1978-1979	96	Scripps Inst. Ocean.
313B	Pxxx	xxx	Catalina-B	USA	33-27N	118-29W	1980-1988	86	Scripps Inst. Ocean.
316A	Pxxx	267	Acapulco-A,Gro.	Mexico	16-50N	099-55W	1952-1995	91	UNAM
316B	Pxxx	267	Acapulco-B,Gro.	Mexico	16-50N	099-55W	1999-2005	88	Secretaria de Marina
317A	Pxxx	xxx	Ensenada	Mexico	31-51N	116-38W	1956-1991	84	UNAM
318A	Pxxx	xxx	Puerto Madero	Mexico	14-43N	092-26W	1986-1988	99	UNAM
319A	Pxxx	xxx	Loreto	Mexico	26-01N	111-22W	1975-1988	73	CICESE
320A	Pxxx	293	Cendering	Malaysia	05-16N	103-11E	1984-2006	99	Dept. Survey/Mapping
321A	Pxxx	xxx	Johor Baharu	Malaysia	01-28N	103-48E	1983-2006	96	Dept. Survey/Mapping
322A	Pxxx	xxx	Kuantan	Malaysia	03-59N	103-26E	1983-2006	99	Dept. Survey/Mapping
323A	Pxxx	xxx	Tioman	Malaysia	02-48N	104-08E	1985-2006	97	Dept. Survey/Mapping
324A	Pxxx	xxx	Sedili	Malaysia	01-56N	104-07E	1986-2006	98	Dept. Survey/Mapping
325A	Pxxx	xxx	Kukup	Malaysia	01-20N	103-27E	1985-2006	97	Dept. Survey/Mapping
326A	Pxxx	xxx	Geting	Malaysia	06-14N	102-06E	1986-2006	99	Dept. Survey/Mapping
327A	Pxxx	044	Keppel Harbour	Singapore	01-16N	103-49E	1981-1990	99	Port Singapore Auth.
328A	Pxxx	039	Ko Lak	Thailand	11-48N	099-49E	1985-2010	94	Naval Hydro. Dept.
329A	Pxxx	077	Hong Kong-A	China	22-18N	114-12E	1962-1985	97	Hong Kong Observatory
329B	Pxxx	077	Hong Kong-B	China	22-18N	114-13E	1986-2010	99	Hong Kong Observatory
330A	Pxxx	xxx	Rosslyn Bay	Australia	23-10S	150-47E	1993-2009	100	Nat. Tidal Ctr., BOM
331A	Pxxx	058	Brisbane	Australia	27-22S	153-10E	1984-2009	98	Nat. Tidal Ctr., BOM
332A	Pxxx	059	Bundaberg	Australia	24-50S	152-23E	1984-2009	98	Nat. Tidal Ctr., BOM
333A	Pxxx	057	Fort Denison	Australia	33-51S	151-14E	1965-2009	95	Nat. Tidal Ctr., BOM
334A	Pxxx	060	Townsville	Australia	19-15S	146-50E	1984-2009	100	Nat. Tidal Ctr., BOM
335A	Pxxx	056	Spring Bay	Australia	42-33S	147-56E	1985-2009	96	Nat. Tidal Ctr., BOM
336A	Pxxx	061	Booby Island	Australia	10-36S	141-55E	1988-2009	93	Nat. Tidal Ctr., BOM
337A	Pxxx	044	Victoria Dock	Singapore	01-16N	103-49E	1972-1981	95	Port Singapore Auth.
338A	Pxxx	xxx	Macau	Portugal	22-10N	113-33E	1978-1985	80	Inst. Hidro. Marinha
339A	Pxxx	xxx	Hobart	Australia	42-53S	147-20E	1985-2006	85	Nat. Tidal Ctr., BOM
340A	Pxxx	xxx	Kaohsiung	Rep. of China	22-37N	120-17E	1980-2010	98	Central Weather Bureau
341A	Pxxx	xxx	Keelung	Rep. of China	25-09N	121-45E	1980-2010	85	Central Weather Bureau
345A	Pxxx	xxx	Nakano Shima	Japan	29-51N	129-51E	1984-2010	99	Japan Ocean. Data Cen.
347A	Pxxx	327	Abashiri	Japan	44-01N	144-17E	1968-2010	98	Japan Meteor. Agency

348A	Pxxx	326	Hamada	Japan	34-54N	132-04E	1984-2010	96	Japan Meteor. Agency
349A	Pxxx	325	Toyama	Japan	36-46N	137-13E	1967-2010	99	Japan Meteor. Agency
350A	Pxxx	089	Kushiro	Japan	42-58N	144-23E	1963-2010	97	Japan Meteor. Agency
351A	Pxxx	087	Ofunato	Japan	39-01N	141-45E	1965-2010	100	Japan Meteor. Agency
352A	Pxxx	086	Mera	Japan	34-55N	139-50E	1965-2010	95	Japan Meteor. Agency
353A	Pxxx	085	Kushimoto	Japan	33-28N	135-47E	1961-2010	97	Japan Meteor. Agency
354A	Pxxx	082	Aburatsu	Japan	31-34N	131-25E	1961-2010	100	Japan Meteor. Agency
355A	Pxxx	081	Naha	Japan	26-13N	127-40E	1966-2010	100	Japan Meteor. Agency
356A	Pxxx	xxx	Maisaka	Japan	34-41N	137-37E	1968-2010	97	Japan Meteor. Agency
357A	Pxxx	xxx	Miyakejima	Japan	34-04N	139-29E	1964-2010	99	Japan Ocean. Data Cen.
358A	Pxxx	xxx	Hosojima	Japan	32-25N	131-41E	1933-1975	86	Japan Ocean. Data Cen.
359A	Pxxx	xxx	Naze	Japan	28-23N	129-30E	1957-2010	94	Japan Ocean. Data Cen.
360A	Pxxx	324	Wakkanai	Japan	45-25N	141-41E	1967-2010	99	Japan Meteor. Agency
362A	Pxxx	083	Nagasaki	Japan	32-44N	129-52E	1985-2010	100	Japan Meteor. Agency
363A	Pxxx	xxx	Nishinoomote	Japan	30-44N	130-60E	1965-2010	98	Japan Ocean. Data Cen.
364A	Pxxx	088	Hakodate	Japan	41-47N	140-44E	1964-2010	94	Japan Meteor. Agency
365A	Pxxx	xxx	Ishigaki	Japan	24-20N	124-09E	1969-2010	99	Japan Meteor. Agency
370A	Pxxx	073	Manila	Philippines	14-35N	120-58E	1984-2008	90	Ocean. Surveys Div.
371A	Pxxx	072	Legaspi	Philippines	13-09N	123-45E	1984-2007	86	Ocean. Surveys Div.
372A	Pxxx	071	Davao-A	Philippines	07-05N	125-38E	1984-1997	92	Ocean. Surveys Div.
372B	Pxxx	071	Davao-B	Philippines	07-05N	125-38E	1998-2008	54	Ocean. Surveys Div.
373A	Pxxx	070	Jolo	Philippines	06-04N	121-00E	1984-1995	86	Ocean. Surveys Div.
375A	Pxxx	xxx	Hachinohe	Japan	40-32N	141-32E	1980-2010	99	Japan Meteor. Agency
376A	Pxxx	247	Xiamen	China	24-27N	118-04E	1954-1997	100	PRC NODC
379A	Pxxx	xxx	Cebu	Philippines	10-18N	123-55E	1998-2008	87	Ocean. Surveys Div.
380A	Pxxx	xxx	Puerto Princesa	Philippines	09-45N	118-44E	1998-2007	83	Ocean. Surveys Div.
381A	Pxxx	075	Qui Nohn	Vietnam	13-46N	109-15E	1994-2009	57	Mar. Hydromet. Center
383A	Pxxx	xxx	Vung Tau	Vietnam	10-20N	107-04E	1986-2002	97	Mar. Hydromet. Center
385A	Pxxx	xxx	Tawau	Malaysia	04-14N	117-53E	1987-2006	95	Dept. Survey/Mapping
386A	Pxxx	xxx	Kota Kinabalu	Malaysia	05-59N	116-04E	1987-2006	92	Dept. Survey/Mapping
387A	Pxxx	xxx	Bintulu	Malaysia	03-13N	113-04E	1992-2006	89	Dept. Survey/Mapping
388A	Pxxx	xxx	Miri	Malaysia	04-24N	113-58E	1992-2006	42	Dept. Survey/Mapping
389A	Pxxx	xxx	Sandakan	Malaysia	05-49N	118-04E	1993-2006	97	Dept. Survey/Mapping
391A	Pxxx	165	Clipperton-A	France	10-17N	109-13W	1985-1985	47	NOAA/PMEL
391B	Pxxx	165	Clipperton-B	France	10-17N	109-13W	1986-1988	100	NOAA/PMEL
393A	Pxxx	xxx	Puerto Vallarta	Mexico	20-37N	105-15W	1973-1991	40	UNAM
394A	Pxxx	xxx	Salina Cruz	Mexico	16-10N	095-12W	1952-1991	81	UNAM
395A	Pxxx	163	Manzanillo-A	Mexico	19-03N	104-20W	1953-1982	95	UNAM
395B	Pxxx	163	Manzanillo-B	Mexico	19-03N	104-20W	1992-2003	78	National Ocean Service
396A	Pxxx	xxx	Puntarenas	Costa Rica	09-58N	084-50W	1970-1980	71	SERMAR
397A	Pxxx	xxx	Guaymas	Mexico	27-56N	110-54W	1953-1986	81	UNAM
398A	Pxxx	xxx	Marsden Point	New Zealand	35-50S	174-30E	1975-2010	81	LINZ
399A	Pxxx	148	Lord Howe-A	Australia	31-31S	159-04E	1958-1967	80	Scripps Inst. Ocean.
399B	Pxxx	148	Lord Howe-B	Australia	31-31S	159-04E	1991-2006	96	Nat. Tidal Ctr., BOM
400A	Pxxx	331	Lombrum	Papua New Guinea	02-02S	147-23E	1994-2009	93	Nat. Tidal Ctr., BOM
401A	Pxxx	xxx	Apia-A	Western Samoa	13-49S	171-45W	1954-1971	88	Scripps Inst. Ocean.
401B	Pxxx	xxx	Apia-B	Western Samoa	13-49S	171-45W	1993-2009	99	Nat. Tidal Ctr., BOM
402A	Pxxx	xxx	Lautoka	Fiji	17-36S	177-26E	1992-2009	99	Nat. Tidal Ctr., BOM
403A	Pxxx	xxx	Jackson	New Zealand	43-59S	168-37E	1999-2009	100	Nat. Tidal Ctr., BOM
410A	Pxxx	xxx	Lungsurannaga	Indonesia	02-06N	117-45E	1943-1944	95	Japan Ocean. Data Cen.
411A	Pxxx	xxx	Balikpapan	Indonesia	01-16S	116-48E	1942-1943	100	Japan Ocean. Data Cen.
414A	Pxxx	xxx	Bajor	Indonesia	00-41S	117-25E	1943-1944	97	Japan Ocean. Data Cen.
540A	Pxxx	155	Prince Rupert-A	Canada	54-19N	130-20W	1910-1918	79	MEDS
540B	Pxxx	155	Prince Rupert-B	Canada	54-19N	130-19W	1963-2010	99	MEDS
542A	Pxxx	156	Tofino	Canada	49-09N	125-55W	1963-2010	95	MEDS
543A	Pxxx	xxx	Victoria,BC	Canada	48-25N	123-22W	1909-2007	99	MEDS
550A	Pxxx	xxx	Massacre Bay,AK	USA	52-50N	173-12E	1943-1966	88	National Ocean Service
551A	Pxxx	158	San Francisco,CA	USA	37-48N	122-28W	1897-2011	100	National Ocean Service
552A	Pxxx	xxx	Kawaihae,HI	USA	20-02N	155-50W	1989-2011	90	National Ocean Service
553A	Pxxx	xxx	Port Allen,HI	USA	21-54N	159-36W	1989-1997	98	National Ocean Service
554A	Pxxx	159	La Jolla,CA	USA	32-52N	117-15W	1924-2011	94	National Ocean Service
555A	Pxxx	xxx	Monterey,CA	USA	36-36N	121-53W	1973-2011	100	National Ocean Service
556A	Pxxx	xxx	Crescent City,CA	USA	41-45N	124-11W	1933-2011	91	National Ocean Service
557A	Pxxx	xxx	Port Orford,OR	USA	42-44N	124-30W	1996-2011	80	National Ocean Service
558A	Pxxx	xxx	Neah Bay,WA	USA	48-22N	124-37W	1934-2011	97	National Ocean Service
559A	Pxxx	154	Sitka,AK	USA	57-03N	135-21W	1938-2011	99	National Ocean Service
560A	Pxxx	150	Seward-A,AK	USA	60-07N	149-26W	1925-1932	98	National Ocean Service
560B	Pxxx	150	Seward-B,AK	USA	60-07N	149-26W	1944-1949	77	National Ocean Service
560C	Pxxx	150	Seward-C,AK	USA	60-07N	149-26W	1967-2011	88	National Ocean Service
561A	Pxxx	xxx	Seldovia,AK	USA	59-26N	151-43W	1975-2011	89	National Ocean Service
562A	Pxxx	xxx	Valdez,AK	USA	61-08N	146-22W	1973-2011	90	National Ocean Service
564A	Pxxx	xxx	Willapa Bay,WA	USA	46-43N	123-58W	1972-2011	96	National Ocean Service
565A	Pxxx	xxx	Port San Luis,CA	USA	35-11N	120-46W	1948-2011	89	National Ocean Service
567A	Pxxx	xxx	Los Angeles,CA	USA	33-43N	118-16W	1923-2011	99	National Ocean Service
569A	Pxxx	xxx	San Diego,CA	USA	32-43N	117-10W	1906-2011	97	National Ocean Service
570A	Pxxx	xxx	Yakutat,AK	USA	59-33N	139-44W	1961-2011	92	National Ocean Service
571A	Pxxx	xxx	Ketchikan,AK	USA	55-20N	131-38W	1918-2011	75	National Ocean Service
572A	Pxxx	xxx	Astoria,OR	USA	46-13N	123-46W	1925-2011	98	National Ocean Service
573A	Pxxx	xxx	Arena Cove,CA	USA	38-55N	123-43W	1996-2011	100	National Ocean Service
574A	Pxxx	100	Sand Point,AK	USA	55-20N	160-30W	1973-2011	97	National Ocean Service
575A	Pxxx	xxx	Charleston,OR	USA	43-21N	124-19W	1978-2011	99	National Ocean Service

576A	Pxxx	xxx	Humboldt Bay,CA	USA	40-46N	124-13W	1993-2011	99	National Ocean Service
577A	Pxxx	xxx	Santa Barbara,CA	USA	34-25N	119-41W	1996-2011	53	National Ocean Service
578A	Pxxx	xxx	Santa Monica,CA	USA	34-01N	118-30W	1973-2011	94	National Ocean Service
579A	Pxxx	151	Prudhoe Bay,AK	USA	70-24N	148-32W	1993-2011	100	National Ocean Service
583A	Pxxx	xxx	Cordova-A,AK	USA	60-34N	145-45W	1949-1953	94	National Ocean Service
583B	Pxxx	xxx	Cordova-B,AK	USA	60-34N	145-45W	1964-2011	87	National Ocean Service
584A	Pxxx	xxx	Port Angeles,WA	USA	48-08N	123-26W	1979-2011	71	National Ocean Service
590A	Pxxx	xxx	Matavai	French Polynesia	17-31S	149-31W	1958-1967	65	Scripps Inst. Ocean.
592A	Pxxx	157	South Beach,OR	USA	44-38N	124-03W	1967-2011	99	National Ocean Service
594A	Pxxx	xxx	Harvest Oil P.,CA	USA	34-28N	120-40W	1995-2011	58	National Ocean Service
595A	Pxxx	074	Nome, AK	USA	64-30N	165-26W	1992-2011	82	National Ocean Service
599A	Pxxx	xxx	Diego Ramirez	Chile	56-31S	068-43W	1991-1997	95	SHOA
626A	Pxxx	309	Providenya-A	Russia	64-24N	173-12W	1977-1985	100	Inst. Hydromet. Infor.
626B	Pxxx	309	Providenya-B	Russia	64-24N	173-12W	1986-1989	100	Inst. Hydromet. Infor.
630A	Pxxx	079	Dalian-A	China	38-56N	121-40E	1975-1990	98	PRC NODC
631A	Pxxx	079	Laohutan-A	China	38-52N	121-41E	1991-1997	100	PRC NODC
632A	Pxxx	094	Kanmen-A	China	28-05N	121-17E	1975-1997	100	PRC NODC
633A	Pxxx	283	Lusi-A	China	32-08N	121-37E	1975-1996	98	PRC NODC
635A	Pxxx	078	Zhapo-A	China	21-35N	111-50E	1975-1997	100	PRC NODC
636A	Pxxx	xxx	Beihai	China	21-29N	109-05E	1975-1997	100	PRC NODC
637A	Pxxx	xxx	Dongfang	China	19-06N	108-37E	1975-1997	100	PRC NODC
638A	Pxxx	xxx	Haikou	China	20-01N	110-17E	1976-1997	100	PRC NODC
639A	Pxxx	xxx	Lianyungang	China	34-45N	119-25E	1975-1997	100	PRC NODC
641A	Pxxx	xxx	Shanwei	China	22-45N	115-21E	1975-1997	98	PRC NODC
642A	Pxxx	xxx	Shijiusuo	China	35-23N	119-33E	1975-1997	100	PRC NODC
650A	Pxxx	xxx	Hon Dau-A	Vietnam	20-40N	106-49E	1960-1960	100	Mar. Hydromet. Center
650B	Pxxx	xxx	Hon Dau-B	Vietnam	20-40N	106-49E	1995-1995	75	TEDIPORT
651A	Pxxx	xxx	Vung Ang	Vietnam	18-05N	106-17E	1996-1997	100	TEDIPORT
663A	Pxxx	134	Scott Base	New Zealand	77-51S	166-45E	2001-2006	92	NIWA
665A	Pxxx	xxx	Timaru	New Zealand	44-23S	171-15E	1987-2010	57	LINZ
667A	Pxxx	xxx	Lyttelton	New Zealand	43-36S	172-43E	1995-2010	97	LINZ
668A	Pxxx	xxx	Napier	New Zealand	39-29S	176-55E	1989-2010	80	LINZ
669A	Pxxx	xxx	Port Chalmers	New Zealand	45-49S	170-39E	1985-2010	60	LINZ
670A	Pxxx	xxx	Champerico	Guatemala	14-18N	091-55W	1974-1975	98	Oregon State Univerity
671A	Pxxx	xxx	La Paz	Mexico	24-10N	110-21W	1952-1983	71	UNAM
672A	Pxxx	164	Puerto Angel	Mexico	15-39N	096-30W	1962-1984	74	UNAM
673A	Pxxx	xxx	Mazatlan	Mexico	23-12N	106-25W	1953-1975	97	UNAM
674A	Pxxx	xxx	San Carlos	Mexico	24-47N	112-07W	1968-1983	51	UNAM
675A	Pxxx	xxx	San Jose	Guatemala	13-55N	090-50W	1955-1975	93	Oregon State Univerity
676A	Pxxx	xxx	Topolobampo	Mexico	25-36N	109-03W	1956-1974	94	UNAM
677A	Pxxx	xxx	Yavaros	Mexico	26-42N	109-31W	1970-1973	85	UNAM
678A	Pxxx	xxx	Paita-A	Peru	05-05S	081-10W	1981-1984	100	National Ocean Service
678B	Pxxx	xxx	Paita-B	Peru	05-05S	081-10W	1988-2009	88	DHNM
679A	Pxxx	xxx	Corinto-A	Nicaragua	12-17N	087-07W	1967-1967	99	National Ocean Service
679B	Pxxx	xxx	Corinto-B	Nicaragua	12-29N	087-10W	2001-2001	50	National Ocean Service
680A	Pxxx	130	Macquerie Is.-A	Australia	54-29S	158-58E	1912-1913	97	Nat. Tidal Ctr., BOM
680B	Pxxx	130	Macquerie Is.-B	Australia	54-29S	158-58E	1968-1972	45	Nat. Tidal Ctr., BOM
680C	Pxxx	130	Macquerie Is.-C	Australia	54-29S	158-58E	1993-2007	79	Nat. Tidal Ctr., BOM
681A	Pxxx	xxx	San Martin-A	Argentina	68-08S	067-06W	1995-1995	8	Alfred Wegener Inst.
681B	Pxxx	xxx	San Martin-B	Argentina	68-08S	067-06W	1998-1998	5	Alfred Wegener Inst.
681C	Pxxx	xxx	San Martin-C	Argentina	68-08S	067-06W	1998-1999	100	Alfred Wegener Inst.
682A	Pxxx	xxx	Dallmann-A	Argentina	62-14S	058-41W	1996-1997	99	Alfred Wegener Inst.
682B	Pxxx	xxx	Dallmann-B	Argentina	62-14S	058-41W	1997-1997	69	Alfred Wegener Inst.
682C	Pxxx	xxx	Dallmann-C	Argentina	62-14S	058-41W	1998-1999	100	Alfred Wegener Inst.
683A	Pxxx	xxx	Pisco-A	Peru	13-25S	076-08W	1985-1990	67	DHNM
683B	Pxxx	xxx	Pisco-B	Peru	13-25S	076-08W	1991-2010	71	DHNM
684A	Pxxx	178	Puerto Montt	Chile	41-29S	072-58W	1980-2010	94	SHOA
698A	Pxxx	xxx	Tinian	N. Mariana Is.	14-58N	145-37E	1991-1997	93	USGS
699A	Pxxx	044	Tanjong Pagar	Singapore	01-16N	103-51E	1988-2010	95	Port Singapore Auth.
101A	Ixxx	008	Mombasa	Kenya	04-04S	039-39E	1986-2008	73	UH Sea Level Center
102A	Ixxx	xxx	Dar Es Salaam	Tanzania	06-49S	039-17E	1986-1990	87	UH Sea Level Center
103A	Ixxx	018	Port Louis-A	Mauritius	20-09S	057-29E	1942-1947	90	Inst. Ocean. Sciences
103B	Ixxx	018	Port Louis-B	Mauritius	20-09S	057-29E	1964-1965	86	Inst. Ocean. Sciences
103C	Ixxx	018	Port Louis-C	Mauritius	20-09S	057-30E	1986-2008	99	UH Sea Level Center
104B	Ixxx	026	Diego Garcia-B	United Kingdom	07-14S	072-26E	1969-1969	41	Scripps Inst. Ocean.
104C	Ixxx	026	Diego Garcia-C	United Kingdom	07-17S	072-24E	1988-2000	80	UH Sea Level Center
104D	Ixxx	026	Diego Garcia-D	United Kingdom	07-17S	072-24E	2003-2009	76	UH Sea Level Center
105A	Ixxx	019	Rodrigues	Mauritius	19-40S	063-25E	1986-2003	96	UH Sea Level Center
106A	Ixxx	xxx	Praslin	Seychelles	04-21S	055-46E	1987-1989	89	UH Sea Level Center
107A	Ixxx	045	Padang-A	Indonesia	00-57S	100-22E	1986-1998	53	BAKOSURTANAL
107B	Ixxx	045	Padang-B	Indonesia	00-60S	100-23E	2005-2007	83	BAKOSURTANAL
108A	Ixxx	028	Male-A	Rep. of Maldives	04-11N	073-31E	1988-1989	100	Lanka Hydraulic Inst.
108B	Ixxx	028	Male-B,Hulule	Rep. of Maldives	04-11N	073-32E	1989-2010	94	UH Sea Level Center
109A	Ixxx	027	Gan	Rep. of Maldives	00-41S	073-09E	1987-2009	91	UH Sea Level Center
110A	Ixxx	xxx	Muscat	Oman	23-38N	058-34E	1987-1993	77	UH Sea Level Center
111A	Ixxx	xxx	Port Victoria-A	Seychelles	04-37S	055-28E	1977-1982	84	Inst. Ocean. Sciences
111B	Ixxx	xxx	Port Victoria-B	Seychelles	04-37S	055-28E	1986-1992	96	UH Sea Level Center
113A	Ixxx	xxx	Masirah	Oman	20-41N	058-52E	1996-2008	79	UH Sea Level Center
114A	Ixxx	004	Salalah	Oman	16-56N	054-00E	1989-2009	87	UH Sea Level Center
115A	Ixxx	033	Colombo-A	Sri Lanka	06-56N	079-51E	1953-1965	94	Nat. Aquatic Resources
115B	Ixxx	033	Colombo-B	Sri Lanka	06-57N	079-51E	1989-1992	96	UH Sea Level Center

115C	Ixxx	033	Colombo-C	Sri Lanka	06-57N 079-51E	2006-2010	100	UH Sea Level Center
117A	Ixxx	xxx	Hanimaadhoo	Rep. of Maldives	06-46N 073-10E	1991-2002	98	UH Sea Level Center
119A	Ixxx	002	Djibouti	Rep. of Djibouti	11-37N 043-08E	2007-2011	99	Port of Djibouti
121A	Ixxx	339	Pt. La Rue	Seychelles	04-40S 055-32E	1993-2004	98	UH Sea Level Center
122A	Ixxx	xxx	Sibolga-A	Indonesia	01-45N 098-46E	1989-2004	89	BAKOSURTANAL
122B	Ixxx	xxx	Sibolga-B	Indonesia	01-45N 098-46E	2005-2008	99	BAKOSURTANAL
123A	Ixxx	347	Sabang	Indonesia	05-50N 95-20E	2005-2008	100	BAKOSURTANAL
125A	Ixxx	xxx	Prigi	Indonesia	08-17S 111-44E	2007-2008	83	BAKOSURTANAL
127A	Ixxx	095	Syowa	Japan	69-00S 039-36E	1987-2007	100	Japan Ocean. Data Cen.
128A	Ixxx	308	Thevenard	Australia	32-09S 133-38E	1998-2009	99	Nat. Tidal Ctr., BOM
129A	Ixxx	055	Portland,Vict.	Australia	38-21S 141-37E	1991-2009	99	Nat. Tidal Ctr., BOM
130A	Ixxx	278	Casey	Australia	66-17S 110-32E	1996-2006	90	Nat. Tidal Ctr., BOM
133A	Ixxx	068	Ambon-A	Indonesia	03-41S 128-11E	1992-2004	46	BAKOSURTANAL
133B	Ixxx	068	Ambon-B	Indonesia	03-41S 128-11E	2008-2009	99	BAKOSURTANAL
134A	Ixxx	xxx	Hiron Point	Bangladesh	21-47N 089-28E	1977-2003	99	BIWTA
135A	Ixxx	xxx	Khal #10	Bangladesh	22-16N 091-49E	1983-1992	62	BIWTA
136A	Ixxx	xxx	Cox's Bazaar	Bangladesh	21-27N 091-50E	1983-2006	89	BIWTA
137A	Ixxx	xxx	Teknaf	Bangladesh	20-53N 092-18E	1983-1988	59	BIWTA
138A	Ixxx	036	Charchanga	Bangladesh	22-13N 091-03E	1980-2000	97	BIWTA
139A	Ixxx	xxx	Khepupara	Bangladesh	21-50N 089-50E	1987-2000	96	BIWTA
140A	Ixxx	xxx	Kelang	Malaysia	03-03N 101-22E	1983-2006	97	Dept. Survey/Mapping
141A	Ixxx	xxx	Keling	Malaysia	02-13N 102-09E	1984-2006	99	Dept. Survey/Mapping
142A	Ixxx	xxx	Langkawi	Malaysia	06-26N 099-46E	1985-2006	99	Dept. Survey/Mapping
143A	Ixxx	043	Lumut	Malaysia	04-14N 100-37E	1984-2006	97	Dept. Survey/Mapping
144A	Ixxx	xxx	Penang	Malaysia	05-25N 100-21E	1984-2006	97	Dept. Survey/Mapping
147A	Ixxx	030	Karachi-A	Pakistan	24-48N 066-58E	1985-1994	83	Nat. Inst. of Ocean.
147B	Ixxx	030	Karachi-B	Pakistan	24-49N 066-59E	2007-2011	99	PNHD
148A	Ixxx	042	Ko Taphao Noi	Thailand	07-50N 098-26E	1985-2010	97	Naval Hydro. Dept.
149A	Ixxx	xxx	Lamu-A	Kenya	02-16S 040-54E	1989-1989	68	Kenya Marine Fisheries
149B	Ixxx	xxx	Lamu-B	Kenya	02-16S 040-54E	1995-2004	100	UH Sea Level Center
150A	Ixxx	015	Nosy Be	Madagascar	13-24S 048-18E	1987-2000	59	CNRO
151A	Ixxx	297	Zanzibar	Tanzania	06-09S 039-11E	1984-2006	100	UH Sea Level Center
155A	Ixxx	096	Dzaoudzi	Mayotte	12-47S 045-15E	1985-1995	67	SHOM
158A	Ixxx	xxx	Meneng	Indonesia	08-07S 114-23E	1987-1989	94	Center for Ocean. Res.
159A	Ixxx	xxx	Pari	Indonesia	05-51S 106-37E	1987-1990	84	Center for Ocean. Res.
160A	Ixxx	292	Surabaya	Indonesia	07-13S 112-44E	1984-2004	81	BAKOSURTANAL
161A	Ixxx	xxx	Jakarta	Indonesia	06-07S 106-51E	1984-2004	62	BAKOSURTANAL
162A	Ixxx	291	Cilacap-A	Indonesia	07-45S 109-01E	1984-2004	40	BAKOSURTANAL
162B	Ixxx	291	Cilacap-B	Indonesia	07-45S 109-01E	2007-2008	100	BAKOSURTANAL
163A	Ixxx	049	Benoa-A	Indonesia	08-45S 115-13E	1988-2004	69	BAKOSURTANAL
163B	Ixxx	049	Benoa-B	Indonesia	08-45S 115-13E	2006-2007	98	BAKOSURTANAL
164A	Ixxx	017	Reunion	France	20-55S 055-18E	1982-1986	93	SHOM
165A	Ixxx	xxx	Wyndham	Australia	15-27S 128-06E	1984-2005	97	Nat. Tidal Ctr., BOM
166A	Ixxx	040	Broome	Australia	18-00S 122-13E	1986-2009	86	Nat. Tidal Ctr., BOM
167A	Ixxx	052	Carnarvon	Australia	24-54S 113-39E	1984-2005	82	Nat. Tidal Ctr., BOM
168A	Ixxx	062	Darwin	Australia	12-28S 130-51E	1984-2009	98	Nat. Tidal Ctr., BOM
169A	Ixxx	051	Port Hedland	Australia	20-19S 118-34E	1984-2005	98	Nat. Tidal Ctr., BOM
170A	Ixxx	047	Christmas	Australia	10-25S 105-40E	1986-2009	24	Nat. Tidal Ctr., BOM
171A	Ixxx	046	Cocos	Australia	12-07S 096-54E	1985-2009	95	Nat. Tidal Ctr., BOM
172A	Ixxx	003	Aden	Yemen	12-47N 044-59E	2007-2011	94	Port of Aden
173A	Ixxx	277	Davis	Australia	68-27S 077-58E	1993-2006	100	Nat. Tidal Ctr., BOM
175A	Ixxx	053	Fremantle	Australia	32-03S 115-44E	1984-2009	99	Nat. Tidal Ctr., BOM
176A	Ixxx	054	Esperance	Australia	33-52S 121-54E	1985-2009	98	Nat. Tidal Ctr., BOM
177A	Ixxx	022	Mawson	Australia	67-36S 062-52E	1992-2006	93	Nat. Tidal Ctr., BOM
178A	Ixxx	021	Crozet-A	France	46-26S 051-52E	1995-1999	52	LEGOS/OMP
178B	Ixxx	021	Crozet-B	France	46-26S 051-52E	2000-2001	76	LEGOS/OMP
179A	Ixxx	024	Saint Paul	France	38-43S 077-32E	1994-2006	92	LEGOS/OMP
180A	Ixxx	023	Kerguelen	France	49-21S 070-13E	1993-2010	99	LEGOS/OMP
181A	Ixxx	013	Durban	South Africa	29-52S 031-03E	1970-2009	65	SANHO
182A	Ixxx	xxx	Mina Sulman	Bahrain	26-14N 050-36E	1979-2007	68	Survey Directorate
184A	Ixxx	076	Port Elizabeth	South Africa	33-58S 025-38E	1973-2010	71	SANHO
185A	Ixxx	xxx	Mossel Bay	South Africa	34-11S 022-08E	1964-2010	72	SANHO
186A	Ixxx	xxx	Knysna	South Africa	32-02S 023-02E	1966-2010	62	SANHO
187A	Ixxx	xxx	East London	South Africa	33-01S 027-55E	1965-2010	56	SANHO
188A	Ixxx	xxx	Richard's Bay	South Africa	28-48S 032-05E	1977-2010	55	SANHO
189A	Ixxx	131	Dumont d'Urville	France	66-40S 140-01E	2008-2010	93	LEGOS/OMP
190A	Ixxx	xxx	Maputo-A	Mozambique	26-10S 032-42E	1974-1974	100	Inst. Hidro. Marinha
190B	Ixxx	xxx	Maputo-B	Mozambique	25-59S 032-34E	1981-1986	49	INAHINA
191A	Ixxx	xxx	Antonio Enes	Mozambique	16-14S 039-54E	1967-1967	31	Inst. Hidro. Marinha
192A	Ixxx	011	Pemba-A	Mozambique	12-58S 040-30E	1971-1973	25	Inst. Hidro. Marinha
192B	Ixxx	011	Pemba-B	Mozambique	12-58S 040-29E	1982-1984	64	INAHINA
192C	Ixxx	011	Pemba-C	Mozambique	12-58S 040-29E	2007-2009	98	INAHINA
193A	Ixxx	xxx	Nacala-A	Mozambique	14-28S 040-41E	1975-1975	18	Inst. Hidro. Marinha
193B	Ixxx	xxx	Nacala-B	Mozambique	14-28S 040-41E	1982-1983	100	Inst. Hidro. Marinha
907A	Ixxx	037	Akyab (Sittwe)	Myanmar	20-08N 092-54E	2006-2009	99	UH Sea Level Center
915A	Ixxx	337	Chabahar	Iran	25-18N 060-36E	2007-2011	98	HDNCC
201A	Axxx	199	St. Peter&Paul R.	Brazil	00-55N 029-21W	1982-1985	99	ORSTOM
202A	Axxx	xxx	Natal-A	Brazil	05-45S 035-12W	1982-1983	100	ORSTOM
202B	Axxx	xxx	Natal-B	Brazil	05-45S 035-12W	1983-1984	99	ORSTOM
202C	Axxx	xxx	Natal-C	Brazil	05-45S 035-12W	1984-1985	100	ORSTOM
203A	Axxx	198	Fer. de Nor.-A	Brazil	03-50S 032-24W	1982-1983	100	ORSTOM

203B	Axxx	198	Fer. de Nor.-B	Brazil	03-50S	032-24W	1984-1985	100	ORSTOM
203C	Axxx	198	Fer. de Nor.-C	Brazil	03-50S	032-24W	1985-1986	100	LPAO/INPE
204A	Axxx	265	Trindade	Brazil	20-30S	029-19W	1983-1983	16	ORSTOM
205A	Axxx	xxx	Arrecife-A	Spain	28-57N	013-34W	1959-1973	98	Inst. Espanol Ocean.
205B	Axxx	xxx	Arrecife-B	Spain	28-57N	013-34W	1973-1985	69	Inst. Espanol Ocean.
205D	Axxx	xxx	Arrecife-D	Spain	28-57N	013-34W	1987-1991	90	Inst. Espanol Ocean.
206A	Axxx	xxx	S.Cruz Palma-A	Spain	28-41N	017-45W	1949-1959	100	Inst. Espanol Ocean.
206B	Axxx	xxx	S.Cruz Palma-B	Spain	28-41N	017-45W	1959-1981	93	Inst. Espanol Ocean.
206D	Axxx	xxx	S.Cruz Palma-D	Spain	28-41N	017-45W	1989-1990	93	Inst. Espanol Ocean.
207A	Axxx	249	Ceuta	Spain	35-54N	005-19W	1944-2008	96	Inst. Espanol Ocean.
208A	Axxx	xxx	Vigo	Spain	42-14N	008-44W	1943-1990	100	Inst. Espanol Ocean.
209A	Axxx	246	Cascais	Portugal	38-42N	009-25W	1959-2005	88	Inst. Geogr. Port.
210A	Axxx	244	Flores,Azores	Portugal	39-27N	031-07W	1976-2009	58	Inst. Hidro. Marinha
211A	Axxx	245	Ponta Delgada	Portugal	37-44N	025-40W	1978-2007	68	Inst. Hidro. Marinha
212A	Axxx	xxx	Horta,Azores	Portugal	38-32N	028-37W	1984-1986	87	Inst. Hidro. Marinha
214A	Axxx	xxx	Lameshur Bay,VI	USA	18-19N	064-43W	2006-2011	99	National Ocean Service
215A	Axxx	xxx	Angra Heroismo-A	Portugal	38-39N	027-14W	1957-1962	100	Inst. Hidro. Marinha
215B	Axxx	xxx	Angra Heroismo-B	Portugal	38-39N	027-14W	1976-1983	94	Inst. Hidro. Marinha
216A	Axxx	254	Porto Grande	Portugal	16-52N	024-59W	1990-1993	38	Inst. Hidro. Marinha
217A	Axxx	251	Las Palmas-A	Spain	28-06N	015-24W	1949-1956	95	Inst. Espanol Ocean.
217B	Axxx	251	Las Palmas-B	Spain	28-06N	015-24W	1971-1982	88	Inst. Espanol Ocean.
217C	Axxx	251	Las Palmas-C	Spain	28-06N	015-24W	1983-1991	73	Inst. Espanol Ocean.
217D	Axxx	251	Las Palmas-D	Spain	28-08N	015-25W	1991-2008	100	Inst. Espanol Ocean.
218B	Axxx	250	Funchal-B	Portugal	32-39N	016-55W	1976-2009	75	Inst. Hidro. Marinha
219A	Axxx	xxx	Culebra,PR	USA	18-18N	065-18W	2005-2011	93	National Ocean Service
220A	Axxx	314	Walvis Bay	Namibia	22-57S	014-30E	1959-1998	49	SANHO
221A	Axxx	268	Simon's Town	South Africa	34-11S	018-26E	1959-2009	80	SANHO
222A	Axxx	xxx	Praia-A	Cape Verde	14-55N	023-30W	1984-1985	100	ORSTOM
222C	Axxx	xxx	Praia-C	Cape Verde	14-55N	023-31W	1995-1996	64	National Ocean Service
223A	Axxx	253	Dakar-A	Senegal	14-40N	017-26W	1982-1983	100	ORSTOM
223B	Axxx	253	Dakar-B	Senegal	14-40N	017-26W	1983-1985	100	ORSTOM
223C	Axxx	253	Dakar-C	Senegal	14-40N	017-26W	1986-1986	44	ORSTOM
223D	Axxx	253	Dakar-D	Senegal	14-40N	017-26W	1986-1989	94	ORSTOM
223E	Axxx	253	Dakar-E	Senegal	14-41N	017-25W	1996-2009	64	UH Sea Level Center
225A	Axxx	260	Sao Tome	Sao Tome/Principe	00-01N	006-31E	1985-1988	58	ORSTOM
227A	Axxx	202	Cayenne	France	04-51N	052-17W	2006-2007	67	SHOM
228A	Axxx	xxx	Tenerife	Spain	28-29N	016-14W	1992-2009	94	Puertos del Estado
229A	Axxx	xxx	Belem	Brazil	01-27S	048-30W	1955-1968	96	National Ocean Service
230A	Axxx	257	Abidjan-Vridi	Ivory Coast	05-15N	004-00W	1982-1988	100	ORSTOM
231A	Axxx	335	Takoradi-A	Ghana	04-53N	001-45W	1983-1986	100	ORSTOM
231B	Axxx	335	Takoradi-B	Ghana	04-53N	001-45W	2004-2005	100	NIO,India
231C	Axxx	335	Takoradi-C	Ghana	04-53N	001-45W	2007-2009	77	Survey of Ghana
233A	Axxx	259	Lagos-A	Nigeria	06-25N	003-27E	1961-1969	63	POL
233C	Axxx	259	Lagos-C	Nigeria	06-25N	003-25E	1992-1996	74	NIOMR
234A	Axxx	261	Pointe Noire-A	Congo	04-48S	011-51E	1980-1988	77	ORSTOM
234B	Axxx	261	Pointe Noire-B	Congo	04-47S	011-50E	2008-2011	93	PAPN
235A	Axxx	329	Palmeira,C.Verde	Portugal	16-45N	022-59W	2000-2010	87	UH Sea Level Center
236A	Axxx	xxx	Luanda	Angola	08-47S	013-14E	1972-1975	100	Inst. Hidro. Marinha
237A	Axxx	262	Lobito	Angola	12-20S	013-34E	1971-1975	88	Inst. Hidro. Marinha
238A	Axxx	xxx	Mocamedes	Angola	15-12S	012-09E	1971-1975	98	Inst. Hidro. Marinha
239A	Axxx	215	Siboney	Cuba	23-06N	082-28W	1990-1990	99	Inst. Cubano De Hidro.
240A	Axxx	xxx	Fernandina Beach	USA	30-40N	081-28W	1897-2011	45	National Ocean Service
241A	Axxx	xxx	Miami,Haulover P.	USA	25-54N	080-07W	1985-1992	96	National Ocean Service
242A	Axxx	216	Key West	USA	24-33N	081-49W	1913-2011	98	National Ocean Service
243A	Axxx	xxx	Penuelas, PR	USA	17-58N	066-46W	2001-2005	100	National Ocean Service
244A	Axxx	276	Gibara	Cuba	21-07N	076-07W	1985-1992	100	Inst. Cubano De Hidro.
245A	Axxx	206	San Juan	USA	18-28N	066-07W	1977-2011	95	National Ocean Service
246A	Axxx	xxx	Magueyes Island	USA	17-58N	067-03W	1965-2011	97	National Ocean Service
247A	Axxx	328	La Guaira	Venezuela	10-37N	066-56W	1985-1994	97	Inst. Ocean. Venezuela
248A	Axxx	203	Port-of-Spain	Trinidad/Tobago	10-39N	061-31W	1984-1992	81	Trin/Tob. Hydro. Unit
249A	Axxx	xxx	Bridgetown-A	Barbados	13-06N	059-37W	1968-1970	98	National Ocean Service
249B	Axxx	xxx	Bridgetown-B	Barbados	13-06N	059-37W	1990-1991	92	Gov. of Barbados
249C	Axxx	xxx	Bridgetown-C	Barbados	13-06N	059-37W	1993-1996	45	Gov. of Barbados
249D	Axxx	xxx	Bridgetown-D	Barbados	13-06N	059-37W	2008-2010	80	Gov. of Barbados
250A	Axxx	212	Veracruz-A,Ver.	Mexico	19-12N	096-08W	1985-2008	54	UNAM
250B	Axxx	212	Veracruz-B,Ver.	Mexico	19-12N	096-08W	1999-2004	63	Secretaria de Marina
251A	Axxx	xxx	Guantanamo Bay-A	Cuba	19-54N	075-09W	1937-1948	81	National Ocean Service
251B	Axxx	xxx	Guantanamo Bay-B	Cuba	19-54N	075-09W	1995-1997	89	National Ocean Service
252A	Axxx	xxx	Portland,ME	USA	43-39N	070-15W	1910-2011	97	National Ocean Service
253A	Axxx	290	Newport,RI	USA	41-30N	071-20W	1930-2011	96	National Ocean Service
254A	Axxx	xxx	Limetree Bay	USA	17-42N	064-45W	1982-2011	92	National Ocean Service
255A	Axxx	xxx	Charlotte Amalie	USA	18-20N	064-55W	1978-2011	89	National Ocean Service
256A	Axxx	012	Exuma Cays	Bahamas	23-46N	076-06W	1992-1993	99	HBOI
257A	Axxx	211	Settlement Pnt.-A	Bahamas	26-43N	078-60W	1985-2002	91	National Ocean Service
257B	Axxx	211	Settlement Pnt.-B	Bahamas	26-41N	078-59W	2002-2003	78	National Ocean Service
258A	Axxx	xxx	Christiansted,VI	USA	17-45N	064-42W	2006-2011	98	National Ocean Service
259A	Axxx	221	Bermuda-A	United Kingdom	32-22N	064-42W	1932-1949	78	National Ocean Service
259B	Axxx	221	Bermuda-B	United Kingdom	32-22N	064-42W	1985-2011	82	National Ocean Service
260A	Axxx	219	Duck Pier,NC	USA	36-11N	075-45W	1978-2011	99	National Ocean Service
261A	Axxx	xxx	Charleston,SC	USA	32-47N	079-56W	1921-2011	98	National Ocean Service
262A	Axxx	xxx	St. Augustine,FL	USA	29-51N	081-16W	1978-2002	42	National Ocean Service

263A	Axxx	xxx	Aguadilla,PR	USA	18-27N	067-10W	2006-2011	86	National Ocean Service
264A	Axxx	220	Atlantic City,NJ	USA	39-21N	074-25W	1911-2011	94	National Ocean Service
265A	Axxx	207	Cartagena-A	Colombia	10-23N	075-32W	1951-1993	90	IDEAM
265B	Axxx	207	Cartagena-B	Colombia	10-23N	075-32W	1993-2011	63	IDEAM
266A	Axxx	208	Cristobal	Panama	09-21N	079-55W	1907-2010	92	Autoridad Canal Panama
267A	Axxx	xxx	Mona Is.,PR	USA	18-05N	067-56W	2006-2011	88	National Ocean Service
268A	Axxx	xxx	Limon	Costa Rica	10-00N	083-02W	1970-1981	66	SERMAR
269A	Axxx	xxx	Cochino Pequeno	Honduras	15-57N	086-30W	1995-1996	100	National Ocean Service
270A	Axxx	204	Le Robert	France	14-41N	060-56W	1976-1984	61	SHOM
271A	Axxx	338	Fort de France	France	14-35N	061-03W	1976-2007	17	SHOM
272A	Axxx	xxx	Pointe-a-Pitre	France	16-14N	061-32W	1991-1998	96	Meteo-France
274A	Axxx	xxx	Churchill	Canada	58-46N	094-11W	1961-2010	92	MEDS
275A	Axxx	222	Halifax	Canada	44-40N	063-35W	1920-2010	98	MEDS
276A	Axxx	223	St. John's-A	Canada	47-34N	052-42W	1961-1993	96	MEDS
276B	Axxx	223	St. John's-B	Canada	47-34N	052-42W	1993-2006	97	MEDS
277A	Axxx	xxx	Madero,Tampico	Mexico	22-16N	097-48W	2004-2007	89	National Ocean Service
279A	Axxx	xxx	Montauk	USA	41-03N	071-58W	1959-2011	89	National Ocean Service
280A	Axxx	195	Rio de Janeiro	Brazil	22-54S	043-10W	1963-2010	95	Dir. Hidro. e Navegacao
281A	Axxx	194	Cananeia	Brazil	25-01S	047-56W	1954-2006	99	Inst. Ocean. USP
283A	Axxx	336	Fortaleza-A	Brazil	03-43S	038-29W	1955-1968	95	National Ocean Service
283B	Axxx	336	Fortaleza-B	Brazil	03-43S	038-28W	1995-1998	100	LPAO/INPE
284A	Axxx	xxx	Termisa	Brazil	04-49S	037-03W	1993-1995	97	LPAO/INPE
285A	Axxx	xxx	Buenos Aires	Argentina	34-40S	058-30W	1905-1961	100	Ser. Hidro. Naval
286A	Axxx	190	Puerto Deseado	Argentina	47-45S	065-55W	1988-1989	87	Ser. Hidro. Naval
287A	Axxx	xxx	Puerto Williams	Chile	54-56S	067-37W	1985-1998	88	SHOA
288A	Axxx	229	Reykjavik	Iceland	64-09N	021-56W	1984-1999	94	Iceland Hydro. Serv.
289A	Axxx	248	Gibraltar	United Kingdom	36-09N	005-22W	1961-2000	69	Hidrographic Office
290A	Axxx	305	Port Stanley-A	United Kingdom	52-42S	057-52W	1964-1974	47	POL
290B	Axxx	305	Port Stanley-B	United Kingdom	51-45S	057-56W	1992-2009	91	POL
291A	Axxx	263	Ascension	United Kingdom	07-55S	014-25W	1993-2009	64	POL
292A	Axxx	264	St. Helena	United Kingdom	15-55S	005-43W	1993-2006	75	POL
293A	Axxx	236	Lerwick	United Kingdom	60-09N	001-08W	1959-2010	95	POL
294A	Axxx	241	Newlyn	United Kingdom	50-06N	005-33W	1915-2010	98	POL
295A	Axxx	238	Stornoway	United Kingdom	58-13N	006-23W	1976-2010	83	POL
296A	Axxx	xxx	Sisimiut	Denmark	66-56N	053-40W	1991-1998	85	Danish Navig./Hydro.
297A	Axxx	228	Ammassalik	Denmark	65-36N	037-00W	1990-1998	78	Danish Navig./Hydro.
298A	Axxx	xxx	Ilulissat	Denmark	69-13N	051-06W	1992-1997	82	Danish Navig./Hydro.
299A	Axxx	344	Qaqortoq	Denmark	60-43N	046-02W	1991-1998	83	Danish Navig./Hydro.
600A	Axxx	181	Ushuaia	Argentina	54-48S	068-18W	1996-2006	78	National Ocean Service
601A	Axxx	185	Esperanza	Argentina	63-24S	056-60W	1996-1998	86	National Ocean Service
700A	Axxx	188	Faraday	United Kingdom	65-15S	064-16W	1959-2009	73	POL
701A	Axxx	xxx	Port Nolloth	South Africa	29-15S	016-52E	1958-2010	76	SANHO
702A	Axxx	xxx	Luderitz	South Africa	26-39S	015-09E	1958-2010	66	SANHO
703A	Axxx	xxx	Saldahna Bay	South Africa	33-01S	017-57E	1973-2010	72	SANHO
704A	Axxx	xxx	Cape Town	South Africa	33-54S	018-26E	1967-2009	75	SANHO
705A	Axxx	xxx	L. Cornwallis I.	Canada	75-23N	096-57W	1986-1994	100	MEDS
707A	Axxx	xxx	Canavieiras	Brazil	15-40S	038-58W	1956-1961	95	National Ocean Service
708A	Axxx	334	Salvador,USCGS	Brazil	12-58S	038-31W	1955-1964	92	National Ocean Service
708B	Axxx	334	Salvador-B	Brazil	12-58S	038-31W	2004-2006	96	UHSLC/DHN/IBGE
709A	Axxx	195	R.Janeiro,USCGS	Brazil	22-56S	043-08W	1955-1968	70	National Ocean Service
710A	Axxx	xxx	Suape	Brazil	08-21S	034-57W	1982-1984	98	LPAO/INPE
711A	Axxx	xxx	Luis Corriea	Brazil	02-52S	041-40W	1984-1985	100	LPAO/INPE
712A	Axxx	xxx	Recife,USCGS	Brazil	08-03S	034-52W	1955-1968	86	National Ocean Service
714A	Axxx	193	Porto Rio Grande	Brazil	32-08S	052-06W	1981-2003	22	Dir. Hidro. e Navegacao
715A	Axxx	200	Madeira	Brazil	02-34S	044-23W	1988-2003	85	Dir. Hidro. e Navegacao
716A	Axxx	201	Santana-A	Brazil	00-03S	051-11W	1970-1972	100	Dir. Hidro. e Navegacao
716B	Axxx	201	Santana-B	Brazil	00-03S	051-11W	1975-1976	100	Dir. Hidro. e Navegacao
716C	Axxx	201	Santana-C	Brazil	00-03S	051-11W	1984-1985	100	Dir. Hidro. e Navegacao
716D	Axxx	201	Santana-D	Brazil	00-03S	051-11W	1996-1997	100	Dir. Hidro. e Navegacao
716E	Axxx	201	Santana-E	Brazil	00-04S	051-10W	2006-2007	93	IBGE
717A	Axxx	201	Santana SSN-A	Brazil	00-04S	051-10W	1994-1995	99	Dir. Hidro. e Navegacao
717B	Axxx	201	Santana SSN-B	Brazil	00-04S	051-10W	1999-2000	99	Dir. Hidro. e Navegacao
718A	Axxx	xxx	Imbituba	Brazil	28-08S	048-24W	2001-2007	79	IBGE
719A	Axxx	xxx	Macae	Brazil	22-14S	041-28W	2001-2007	86	IBGE
720A	Axxx	xxx	South Caicos	United Kingdom	21-29N	071-32W	1992-1992	76	NOAA/AOML
721A	Axxx	213	Progreso-A, Yuc.	Mexico	21-17N	089-40W	1980-1984	98	UNAM
721B	Axxx	213	Progreso-B, Yuc.	Mexico	21-17N	089-40W	1999-2004	63	Secretaria de Marina
723A	Axxx	xxx	Lagos, Algarve	Portugal	37-06N	008-40W	1986-2000	72	Inst. Geogr. Port.
724A	Axxx	xxx	Puerto Cabezas	Nicaragua	14-03N	083-23W	2001-2002	100	National Ocean Service
727A	Axxx	xxx	Nassau	Bahamas	25-05N	077-21W	1904-1905	100	National Ocean Service
728A	Axxx	xxx	Point Fortin	Trinidad/Tobago	10-06N	061-25W	1987-1996	61	Trin/Tob. Hydro. Unit
729A	Axxx	192	Mar Del Plata	Argentina	38-03S	057-33W	2004-2009	98	UH Sea Level Center
730A	Axxx	189	Base Prat	Chile	62-29S	059-38W	1984-2002	96	SHOA
732A	Axxx	xxx	Isabel Segunda,PR	USA	18-09N	065-27W	2009-2011	100	National Ocean Service
733A	Axxx	xxx	Esperanza,PR	USA	18-06N	065-28W	2005-2011	92	National Ocean Service
734A	Axxx	xxx	Yabucoa,PR	USA	18-03N	065-50W	2008-2011	94	National Ocean Service
735A	Axxx	xxx	Arecibo,PR	USA	18-29N	066-42W	2008-2011	100	National Ocean Service
736A	Axxx	xxx	Mayaguez,PR	USA	18-13N	067-10W	2008-2011	100	National Ocean Service
737A	Axxx	xxx	San Andres	Colombia	12-35N	081-42W	1997-2011	55	IDEAM
740A	Axxx	xxx	Eastport,ME	USA	44-54N	066-59W	1929-2011	94	National Ocean Service
741A	Axxx	xxx	Boston,MA	USA	42-21N	071-03W	1921-2011	99	National Ocean Service

742A	Axxx	xxx	Woods Hole,MA	USA	41-31N	070-40W	1957-2011	90	National Ocean Service
743A	Axxx	xxx	Nantucket,MA	USA	41-17N	070-06W	1965-2011	96	National Ocean Service
744A	Axxx	xxx	New London,CT	USA	41-21N	072-05W	1938-2011	95	National Ocean Service
745A	Axxx	xxx	New York,NY	USA	40-42N	074-01W	1958-2011	87	National Ocean Service
746A	Axxx	xxx	Cape May,NJ	USA	38-58N	074-58W	1965-2011	89	National Ocean Service
747A	Axxx	xxx	Lewes,DE	USA	38-47N	075-07W	1957-2011	97	National Ocean Service
749A	Axxx	xxx	Chesapeake BBT,VA	USA	36-58N	076-07W	1975-2011	99	National Ocean Service
750A	Axxx	xxx	Wilmington,NC	USA	34-14N	077-57W	1935-2011	98	National Ocean Service
752A	Axxx	289	Fort Pulaski,GA	USA	32-02N	080-54W	1935-2011	95	National Ocean Service
753A	Axxx	xxx	Mayport,FL	USA	30-24N	081-26W	1928-2000	99	National Ocean Service
754A	Axxx	xxx	Cocoa Beach,FL	USA	28-22N	080-36W	1994-1996	98	National Ocean Service
755A	Axxx	332	Virginia Key,FL	USA	25-44N	080-10W	1996-2011	99	National Ocean Service
757A	Axxx	xxx	Naples,FL	USA	26-08N	081-48W	1996-2011	95	National Ocean Service
759A	Axxx	xxx	St. Petersburg,FL	USA	27-46N	082-38W	1946-2011	96	National Ocean Service
760A	Axxx	xxx	Apalachicola,FL	USA	29-44N	084-59W	1996-2011	97	National Ocean Service
761A	Axxx	xxx	Panama City Bh,FL	USA	30-13N	085-53W	1993-2008	97	National Ocean Service
762A	Axxx	288	Pensacola,FL	USA	30-24N	087-13W	1923-2011	96	National Ocean Service
763A	Axxx	xxx	Dauphin Island AL	USA	30-15N	088-05W	1996-2011	70	National Ocean Service
764A	Axxx	xxx	South Pass,LA	USA	28-59N	089-08W	1993-1999	90	National Ocean Service
765A	Axxx	xxx	Grand Isle,LA	USA	29-16N	089-57W	1980-2011	97	National Ocean Service
766A	Axxx	xxx	Sabine Pass N, TX	USA	29-44N	093-52W	1992-2011	98	National Ocean Service
767A	Axxx	xxx	Galveston,P.Pier	USA	29-17N	094-47W	1957-2011	97	National Ocean Service
769A	Axxx	xxx	Rockport,TX	USA	28-01N	097-03W	1987-2011	100	National Ocean Service
770A	Axxx	xxx	Corpus Cristi,TX	USA	27-35N	097-13W	1988-2011	99	National Ocean Service
772A	Axxx	xxx	Port Isabel,TX	USA	26-04N	097-13W	1977-2011	97	National Ocean Service
773A	Axxx	xxx	Clearwater Bch,FL	USA	27-59N	082-50W	1996-2011	96	National Ocean Service
774A	Axxx	xxx	Port Canaveral,FL	USA	28-25N	080-36W	1994-2011	98	National Ocean Service
775A	Axxx	217	Galveston,Pier21	USA	29-19N	094-48W	1904-2011	96	National Ocean Service
779A	Axxx	xxx	C.Carmen	Mexico	18-32N	091-50W	1957-1979	57	UNAM
780A	Axxx	xxx	Puerto Cortes-A	Honduras	15-50N	087-57W	1948-1968	99	National Ocean Service
780B	Axxx	xxx	Puerto Cortes-B	Honduras	15-50N	087-52W	2001-2002	100	National Ocean Service
781A	Axxx	xxx	Belize	British Honduras	17-30N	088-11W	1964-1967	84	National Ocean Service
782A	Axxx	210	Port Royal	Jamaica	17-56N	076-51W	1965-1971	99	National Ocean Service
783A	Axxx	xxx	Fajardo-A,PR	USA	18-20N	065-38W	1921-1923	95	National Ocean Service
783B	Axxx	xxx	Fajardo-B,PR	USA	18-20N	065-38W	2008-2011	100	National Ocean Service
784A	Axxx	xxx	Puerto Castilla	Honduras	16-01N	086-02W	1955-1967	78	National Ocean Service
800A	Axxx	322	Andenes	Norway	69-19N	16-09E	1991-2003	99	NHS
803A	Axxx	234	Rorvik	Norway	64-52N	11-15E	1969-2003	96	NHS
804A	Axxx	321	Tregde	Norway	58-00N	007-34E	1927-2003	94	NHS
805A	Axxx	323	Vardo	Norway	70-20N	31-06E	1947-2003	60	NHS
806A	Axxx	xxx	Nouakchott	Mauritania	17-59N	016-02W	2007-2011	90	PAN
807A	Axxx	349	Alexandria	Egypt	31-13N	029-55E	2009-2011	94	NIOF
816A	Axxx	350	Port Sonara	Cameroon	04-00S	009-08E	2008-2011	83	SNR
819A	Axxx	233	Goteborg-Torsh.	Sweden	57-41N	011-48E	1967-2006	100	SMHI
822A	Axxx	242	Brest	France	48-23N	004-30W	1846-2007	91	SHOM
823A	Axxx	345	Ny-Alesund	Norway	78-56N	11-57E	1976-2003	89	NHS
824A	Axxx	205	Marseille	France	43-18N	005-21E	1985-2007	48	SHOM
825A	Axxx	284	Cuxhaven	Germany	53-52N	008-43E	1917-1987	100	BFG
826A	Axxx	341	Stockholm	Sweden	59-20N	018-05E	1889-2007	99	SMHI
830A	Axxx	243	La Coruna	Spain	43-22N	008-24W	1943-2008	97	Inst. Espanol Ocean.
832A	Axxx	342	Rothera	United Kingdom	67-34S	068-08W	2002-2009	66	POL
833A	Axxx	224	Nain	Canada	56-33N	061-42W	2001-2006	83	MEDS
834A	Axxx	239	Malin Head	Ireland	55-22N	007-20W	1958-2001	95	QUB
835A	Axxx	xxx	Castletownsend	Ireland	51-32N	009-11W	2004-2008	87	J.Murphy HMRC

*CI: completeness index in percent

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