U.S. National Sea Level Report

Contributions to the Global Sea Level Observing System

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Introduction

The 2013 United States (U.S.) National Report to the Global Sea Level Observing System (GLOSS) Group of Experts (GE) XIII is a summary of various ongoing U.S. programs and activities that support GLOSS goals and objectives as outlined in the 2012 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 provides an overview of sea level observations for extreme events in the U.S. 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.

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 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 British Oceanographic Data Centre (BODC), and the Asia-Pacific Data-Research Center (APDRC).

The UHSLC collaborates in the operation of 53 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 10 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 two sea level data sets: Joint Archive for Sea Level (JASL), and Fast Delivery Database.

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	
049	Benoa	Indonesia	08º 46'S	115º 13'E	GPS@TG
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	GPS@TG
033	Colombo	Sri Lanka	06º 57'N	079º 51'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	GPS@TG
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	
042	Ko Taphao Noi	Thailand	07º 49'N	098º 25'E	
172	La Libertad	Ecuador	02° 12'S	080° 55'W	
072	Legaspi	Philippines	13° 09'N	123° 45'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
069	Manado	Indonesia	01° 26'N	125° 12'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	
008	Mombasa	Kenya	04º 04'S	039º 39'E	
141	Moulmein	Myanmar	16º 29'N	097º 37'E	
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	
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	
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	
347	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	
334	Salvador	Brazil	12º 58'S	038º 31'W	
211	Settlement Pnt.	Bahamas	26º 41'N	078º 59'W	GPS@TG
037	Sittwe	Myanmar	20º 09'N	092º 54'E	
181	Ushuaia	Argentina	54° 48'S	068° 18'W	
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.

The UHSLC receives support from the NOAA Tsunami Program for maintaining sea level stations in the Pacific Ocean (Quepos, Costa Rica; Acajutla, El Salvador; Callao, Matarani, and Talara, Peru; La Libertad, Ecuador; Hiva Oa, and Nuku Hiva, Fr. Polynesia; Legaspi, Philippines; and French Frigate Shoals, U.S.) and the Caribbean (Limon, Costa Rica; Punta Cana and Puerto Plata, Dominican Republic; Bullen Bay, Curacao; Roseau, Dominca; Prickly Bay, Grenada; El Porvenir, Panama; and Santa Marta and San Andres, Colombia). Maintenance in the Caribbean is provided in collaboration with the Puerto Rico Seismic Network. The data from these stations are made available to the Tsunami Warning Centers and can also be accessed through the website of the UHSLC (http://uhslc.soest.hawaii.edu/) and the IOC Sea Level Monitoring Facility (http://www.ioc-sealevelmonitoring.org/).

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 from research to operations Jason-2/OSTM is a joint effort led by NASA and France's Centre National d'Etudes Spatial (CNES), with two operational agencies, NOAA and the European Organization for the Exploitation of Meteorological Satellites (EUMETSAT), participating for the first time. Its primary goal is to maintain continuity of the more than 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 2.9 mm/yr between 1993 and 2013, nearly 50% faster than over the past century, as well as revealing important new insights into regional sea-level change. Jason sea surface height observations are also used to study eddy variability and large-scale circulation changes in the ocean.

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 continued this mode of operation, known as the Interleave Mission, until May 2012, when Jason-1 was put in a new orbit with a repeat cycle of 406 days to improve the resolution of the marine geoid. Jason-1 ceased transmitting in June 2012, after 11+ years of successful operation, and was officially deactivated in July 2012.

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.

A series of Jason follow-on missions is being developed to maintain continuity of the sea level climate data record beyond Jason-2/OSTM. Jason-3, a NOAA and EUMETSAT mission with support by CNES and NASA, is on schedule to be launched in 2015. Jason-3 ground operations and data processing will be the same as for Jason-2/OSTM. The follow-on to Jason-3 will be Jason-CS, a joint 5-partner mission, involving the European Space Agency (ESA), as well as NOAA, EUMETSAT, NASA, and CNES, to be launched in 2019. For Jason-CS, NOAA and EUMETSAT will exchange roles; EUMETSAT will be responsible for satellite command and control, as well as producing all science data products.

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 September 2013, the CORS network contains almost

2000 stations, contributed by over 200 different organizations, and the network is growing at a rate of approximately 50 stations a year.

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 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 research efforts have been focused on multidecadal sea level variability and extreme sea level events and climate variations. Multidecadal sea level variability in the Pacific has been related to significant changes in the Pacific trade winds (Merrifield and Maltrud, 2011; Merrifield et al., 2012). The multidecadal variations in trade wind forcing are reflected in the dominant climate indices in the region. The associated sea level changes strongly influence regional sea level trend estimates, however, the actual changes in water level and the impacts on island regions is minimal with variations on the order of centimeters over decades. The sea level records do provide an independent record of trade wind variability in the Pacific that we are comparing to storm track patterns in the western Pacific. We also are examining the basin-wide sea level response to the tropical wind adjustment, in particular in relationship to the low sea level rise rates along the eastern boundary of the basin.

The possibility of a low frequency variation in global sea level was considered based on tide gauge observations (Chambers et al., 2012). At issue is whether the globally averaged rate undergoes significant variation at multidecadal time scales during the tide gauge record, and in turn whether the recent high rates during the altimetry era represent a cyclical high trend period as part of that larger fluctuation. The possibility was not discounted, but the difficulty in estimating global averages from regionally biased tide gauge networks remains an ongoing issue for all sea level reconstructions, and ultimately it remains the limiting factor in determining the significance of globally averaged cycles at multidecadal time scales.

Changes in storm variability in the central Pacific on climate timescales have been inferred from tide gauge records at Midway Atoll (Aucan et al., 2012). Winter swell associated with North Pacific storms cause a setup of the atoll lagoon where the tide gauge is located, which can result in 1m sea level anomalies that are captured in the tide gauge record back to the mid-twentieth century. The tide gauge proxy for storm wave activity provides a rare indirect measure of wave variability in a region where other in situ measures of wave energy do not exist. The decadal variability in Midway sea level extremes provides insight into changing winds and storminess patterns in the region, and contributes to our understanding of wave climate changes due to shifting storm patterns.

NOAA NCDC Research

NOAA and the UHSLC are jointly conducting a program of applied research leading to the development of innovative methodologies and best practices for the formulation of probabilistic estimates of extreme still water level events under a changing climate for sea level stations in the Pacific Islands. Under this effort, extreme value analysis is being used investigate the tail of the sea level distribution and identify inherent cycles and covariability relationships. This will be used to account for 1) sea level and storminess variability as well as trends; and 2) differences that exist from location to location in terms of the relative importance of various contributors to extremes. Once this has been accomplished, the covariability of extremes to potential changes in the future will be explored. Supported in part through DOD/SERDP, the results of this effort include products that that can be used directly to support decision-making in areas ranging from area-wide vulnerability assessment related to climate adaptation planning and disaster risk reduction to site-specific analysis related to design and maintenance of facilities (see below).

NOAA Laboratory for Satellite Altimetry Research

Monthly the NOAA Laboratory for Satellite Altimetry produces global and regional time series and maps of mean sea level (http://ibis.grdl.noaa.gov/SAT/SeaLevelRise/). The altimetry data is from the Radar Altimeter Database System, which includes data from the reference series of TOPEX/POSEIDON, Jason-1, and Jason-2 and other missions suitable for sea level change studies (ERS-1, ERS-2, Envisat, CryoSat-2, SARAL/AltiKa, and GFO). These data are used for a variety of applications, including as one of the EPA's climate indicators. At LSA the data are used with GRACE and Argo observations to monitor the sea level rise budget.

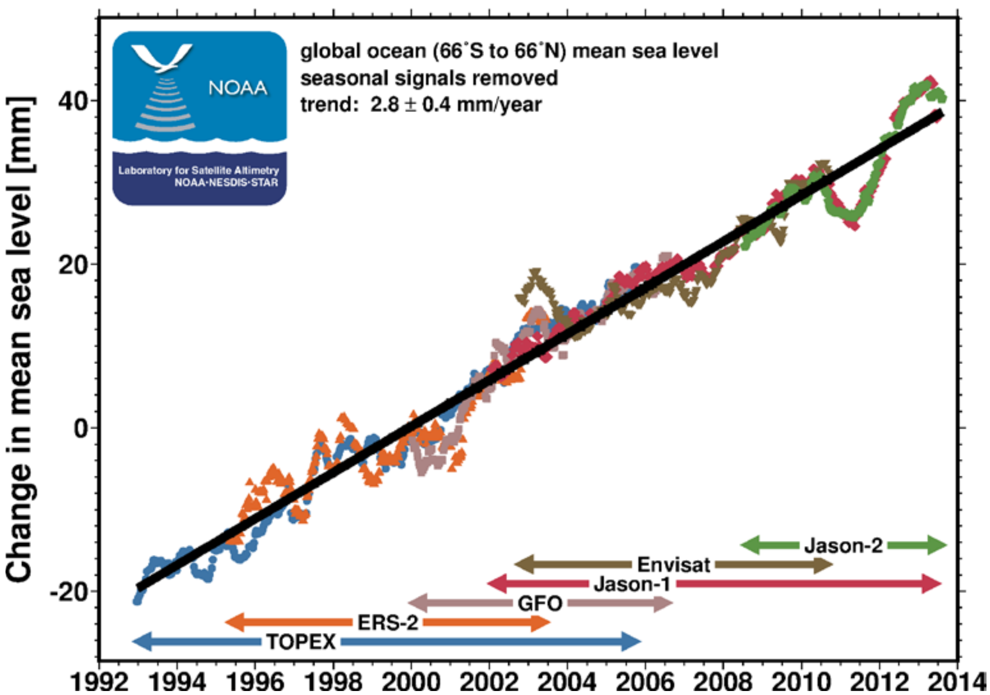

Figure 3. Variations in global mean sea level from altimetry (seasonal signals have been removed and no correction for glacial Isostatic adjustment has been applied.)

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 4 and 5).

Analyses of sea level trends and variability are currently available for 128 long-term NWLON stations at *Sea Levels Online*. Figures 6-8 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, 2011), 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.

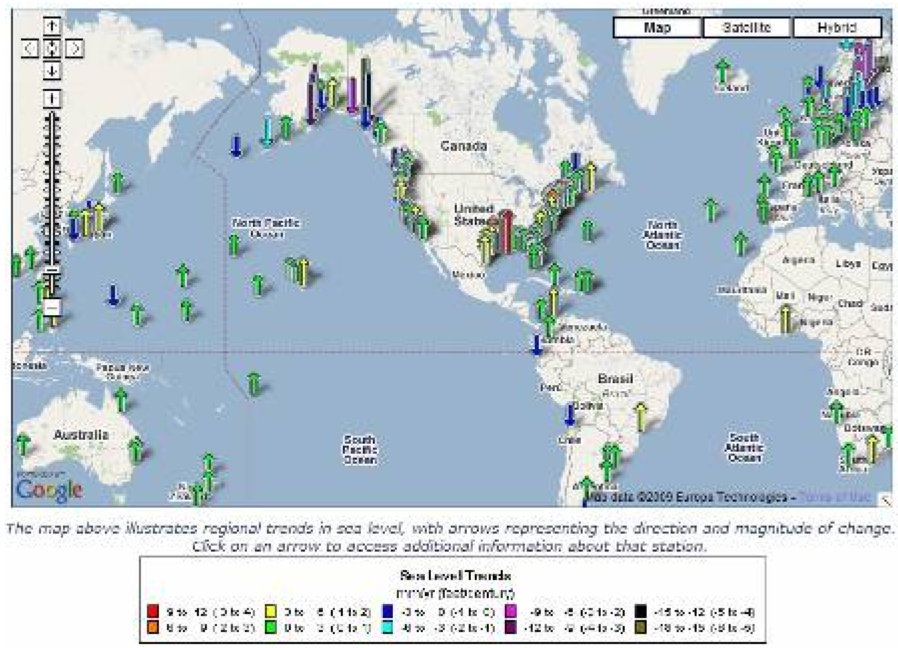

Figure 4. Google map interface for Relative Sea Level Trends.

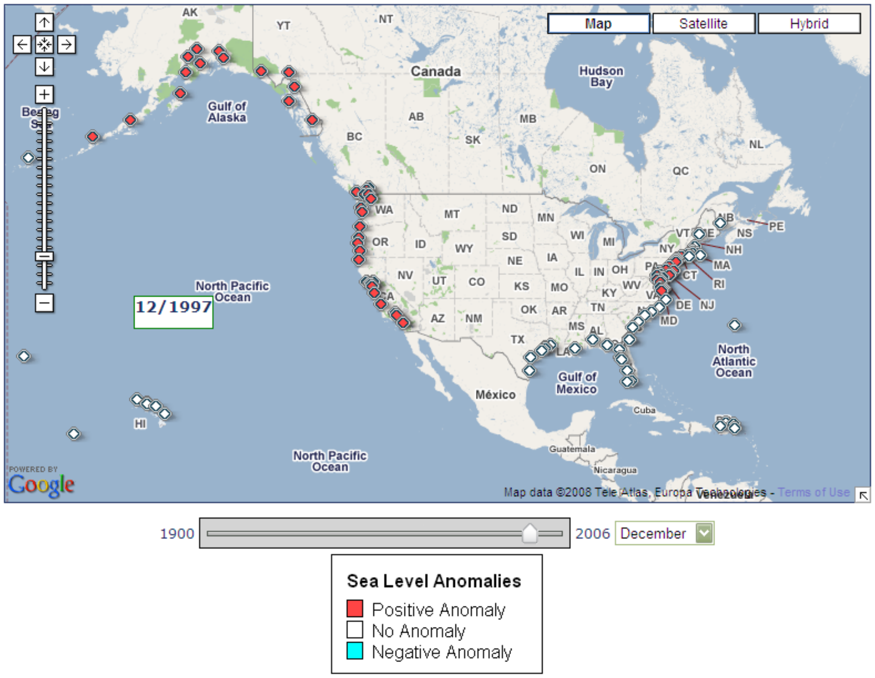

Figure 5. Google map interface for Sea Level Anomalies (shown for December 1997 to highlight anomalies associated with ENSO).

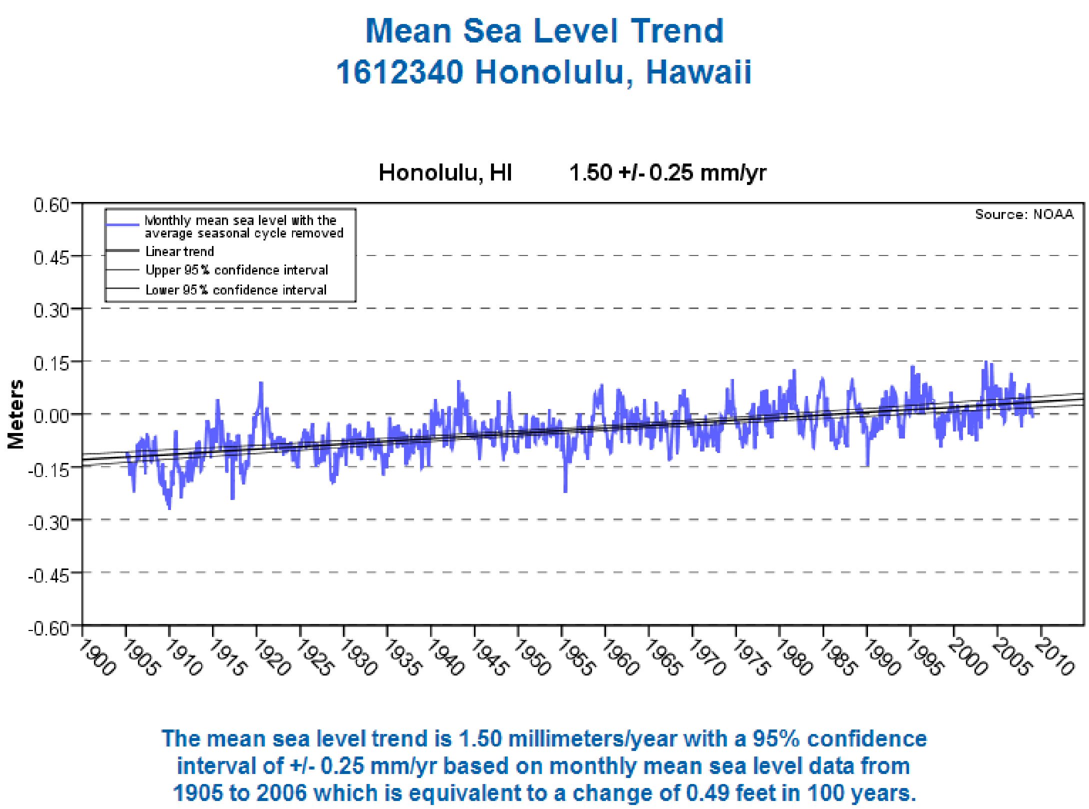

Figure 6. Sea level trend analyses.

Variation of 50-Year Mean Sea Level Trends
1612340 Honolulu, Hawaii

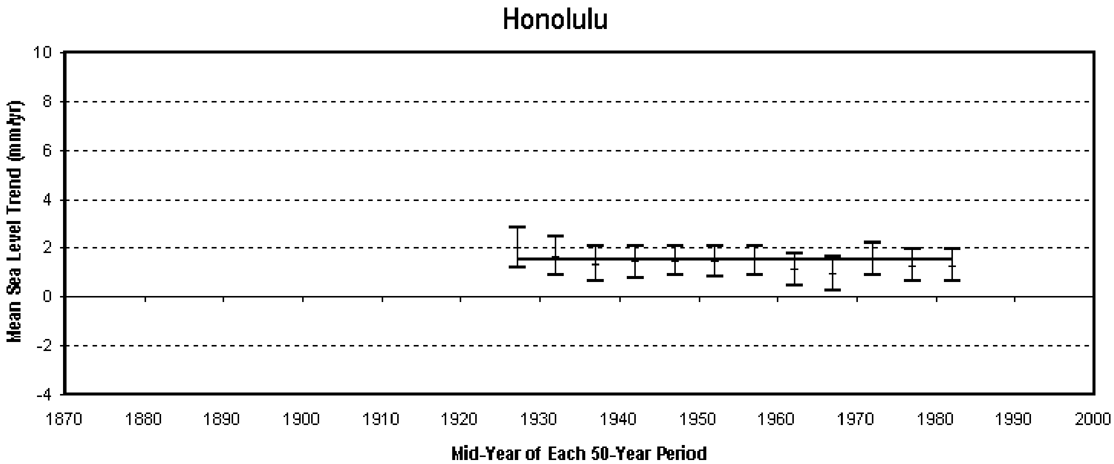

Figure 7. Long-term variation in trends.

Interannual variation
1612340 Honolulu, Hawaii

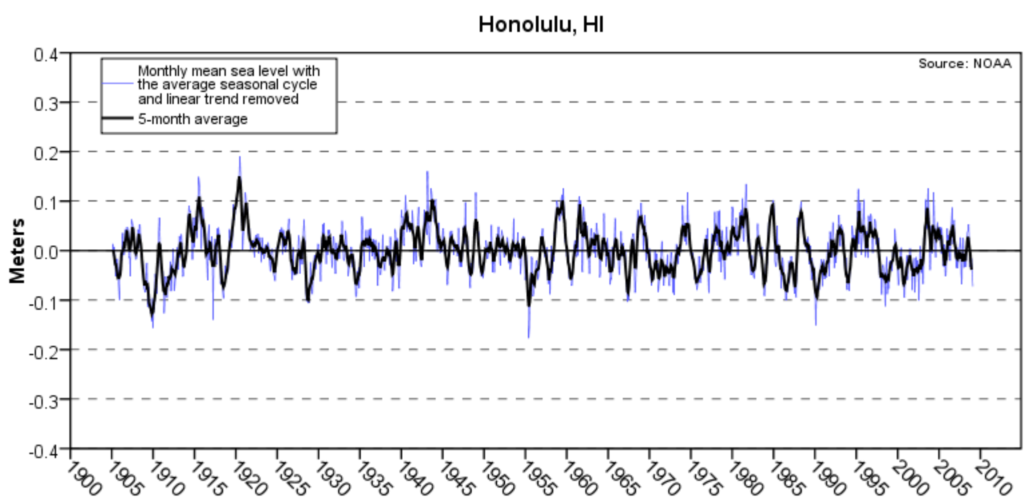

Figure 8. The monthly mean sea level anomalies are updated monthly.

Global Sea Level Trends

NOAA/CO-OPS operates and maintains 45 stations identified as long term sea level stations in the GLOSS Implementation Plans of 1997/2012 and routinely analyses the long-term trends and oceanographic variability. In addition, the sea level trend analysis has been extended to 39 new non-CO-OPS global stations for a total of 239 stations, including over 130 stations in the GLOSS Core Network (GCN) (See Figure 9 & Table 3). The data for these stations were obtained from the PSMSL. Long term sea level trends have recently been calculated for 12 new countries, expanding the geographic coverage presented at the 2011 GLOSS Group of Experts meeting to include 66 countries worldwide. The expanded number of stations will help capture the variability in relative sea level change internationally and contribute to global sea level rise estimates.

Furthermore, 135 historical stations were updated with all available data up to 2011 and trends were re-calculated. In some cases, the original source data may also have been updated, therefore the calculated trends may have changed. In the future, these updates will assist the review of sea level acceleration from climate change. In addition to rise and fall trend estimates, there are two updated products for a complete oceanographic assessment. The 'Average Seasonal Cycle' illustrates the regular fluctuations caused by coastal temperatures, salinities, winds, atmospheric pressures, and ocean currents, compared to the 'Interannual Variation' which delineates irregular conditions such as the El Nino-Southern Oscillation (ENSO) (See Figure 8). Station specific analysis and metadata have been expanded, including links to the historical and real-time data, where available. The products can be found here: http://www.tidesandcurrents.noaa.gov/sltrends/index.shtml.

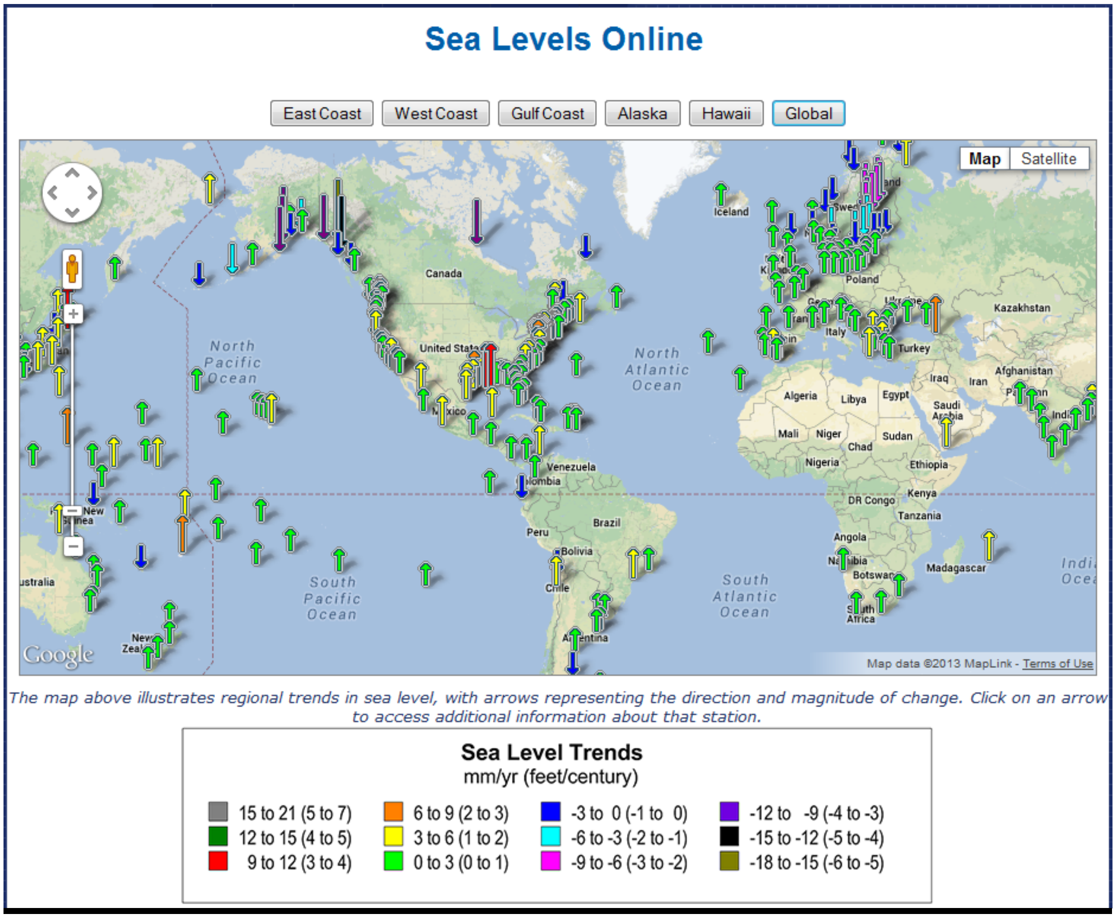

Figure 9. Global Sea Level Stations on *Sea Levels Online*.

Average Seasonal Cycle in Meters +/- 95% Confidence Interval
[Source of data: PSMSL; Analysis: NOAA]

ID	Station Name	January	February	March	April
010-001	Reykjavik, Iceland	0.044 +/- 0.022	-0.006 +/- 0.022	-0.041 +/- 0.022	-0.097 +/- 0.022
015-011	Torshavn, Denmark	0.026 +/- 0.019	-0.017 +/- 0.018	-0.051 +/- 0.019	-0.101 +/- 0.019
025-001	Barentsburg, Norway	0.045 +/- 0.02	-0.019 +/- 0.02	-0.067 +/- 0.019	-0.108 +/- 0.019
030-003	Russkaya Gavan II, Russia	0.046 +/- 0.041	-0.007 +/- 0.041	-0.067 +/- 0.041	-0.151 +/- 0.04
030-018	Murmansk, Russia	0.062 +/- 0.033	-0.019 +/- 0.033	-0.065 +/- 0.032	-0.122 +/- 0.032
030-345	Dikson, Russia	-0.013 +/- 0.054	-0.066 +/- 0.054	-0.073 +/- 0.055	-0.114 +/- 0.055
030-447	Tiksi, Russia	-0.078 +/- 0.034	-0.101 +/- 0.034	-0.125 +/- 0.034	-0.13 +/- 0.034
030-725	Providenia, Russia	0.043 +/- 0.052	0.032 +/- 0.052	-0.024 +/- 0.052	-0.054 +/- 0.052
040-001	Vardo, Norway	0.102 +/- 0.027	0.018 +/- 0.027	-0.034 +/- 0.027	-0.112 +/- 0.027
040-015	Honningsvag, Norway	0.116 +/- 0.027	0.038 +/- 0.027	-0.04 +/- 0.027	-0.12 +/- 0.027
040-041	Andenes, Norway	0.113 +/- 0.029	0.036 +/- 0.029	-0.032 +/- 0.029	-0.1 +/- 0.029
040-081	Narvik, Norway	0.1 +/- 0.027	0.016 +/- 0.027	-0.043 +/- 0.027	-0.129 +/- 0.027
040-136	Rorvik, Norway	0.107 +/- 0.028	0.016 +/- 0.028	-0.039 +/- 0.028	-0.123 +/- 0.028
040-151	Heimsjo, Norway	0.087 +/- 0.021	0.011 +/- 0.021	-0.049 +/- 0.021	-0.112 +/- 0.021

Figure 10. The new Average Seasonal Cycle table on the website.

Table 3. Linear Relative Mean Sea Level (MSL) trends and 95% Confidence Intervals (CI) in mm/year. Source of data: PSMSL; Analysis: NOAA.

ID	Station Name	First Year	Last Year	Year Range	% Complete	MSL Trend	+/- 95% CI
010-001	Reykjavik, Iceland	1956	2011	56	97	2.33	0.50
015-011	Torshavn, Denmark	1957	2006	50	84	1.81	0.41
025-001	Barentsburg, Norway	1948	2010	63	93	-2.25	0.42
030-003	Russkaya Gavan II, Russia	1953	1993	41	96	-0.54	1.07
030-018	Murmansk, Russia	1952	2010	59	98	3.17	0.94
030-345	Dikson, Russia	1950	1997	48	97	2.05	1.38
030-447	Tiksi, Russia	1949	2009	61	100	1.56	0.72
030-725	Providenia, Russia	1951	1983	33	97	3.30	1.29
040-001	Vardo, Norway	1947	2011	65	65	-0.32	0.51
040-015	Honningsvag, Norway	1970	2011	42	94	1.45	0.97
040-041	Andenes, Norway	1938	2011	74	61	-0.93	0.50
040-081	Narvik, Norway	1928	2011	84	88	-2.06	0.48
040-136	Rorvik, Norway	1969	2011	43	97	-0.90	0.91
040-151	Heimsjo, Norway	1928	2011	84	96	-1.46	0.31
040-211	Maloy, Norway	1943	2011	69	96	0.59	0.40
040-221	Bergen, Norway	1883	2011	129	76	-0.52	0.20
040-261	Stavanger, Norway	1919	2011	93	91	0.42	0.22
040-301	Tregde, Norway	1927	2011	85	96	0.26	0.20
040-321	Oslo, Norway	1885	2011	127	77	-3.17	0.30
050-011	Smogen, Sweden	1911	2011	101	100	-1.85	0.26
050-032	Goteborg - Ringon, Klippan & Torshamnen, Sweden	1887	2011	125	99	-1.19	0.36
050-051	Klagshamn, Sweden	1929	2011	83	99	0.64	0.40
050-081	Kungholmsfort, Sweden	1887	2011	125	100	0.02	0.25
050-123	Landsort Norra & Landsort, Sweden	1887	2011	125	100	-2.84	0.30
050-141	Stockholm, Sweden	1889	2011	123	100	-3.81	0.32
050-191	Ratan, Sweden	1892	2011	120	100	-7.75	0.39
050-201	Furuogrund, Sweden	1916	2011	96	100	-8.10	0.57
060-001	Kemi, Finland	1920	2010	91	96	-6.99	0.63
060-011	Oulu/Uleaborg, Finland	1889	2010	122	95	-6.38	0.41
060-021	Raahe/Brahestad, Finland	1922	2010	89	92	-6.85	0.66
060-041	Pietarsaari/Jakobstad, Finland	1914	2010	97	98	-7.29	0.57
060-051	Vaasa/Vasa, Finland	1883	2010	128	92	-7.33	0.34
060-071	Kaskinen/Kasko, Finland	1926	2010	85	97	-6.50	0.68
060-101	Mantyluoto, Finland	1910	2010	101	98	-5.91	0.50
060-241	Turku/Abo, Finland	1922	2010	89	98	-3.67	0.61
060-281	Foglo/Degerby, Finland	1923	2010	88	94	-3.75	0.59
060-331	Hanko/Hango, Finland	1887	2010	124	88	-2.67	0.37
060-351	Helsinki, Finland	1879	2010	132	100	-2.33	0.34
060-361	Hamina, Finland	1928	2010	83	98	-1.03	0.79
080-081	Daugavgriva, Latvia	1872	1938	67	93	0.16	0.99
080-151	Liepaja, Latvia	1865	1936	72	88	0.88	0.72
080-181	Kaliningrad, Russia	1926	1986	61	86	1.84	0.89
084-161	Klaipeda, Lithuania	1898	2011	114	92	1.48	0.40
110-022	Gdansk/Nowy Port, Poland	1951	1999	49	100	2.91	1.24
110-047	Wladyslawowo, Poland	1951	1999	49	100	2.46	1.27
110-057	Ustka, Poland	1951	1999	49	100	1.71	1.17
110-072	Kolobrzeg, Poland	1951	1999	49	100	1.27	1.08
110-092	Swinoujscie, Poland	1811	1999	189	96	0.80	0.12

120-012	Warnemunde 2, Germany	1855	2010	156	100	1.25	0.12
120-022	Wismar 2, Germany	1848	2010	163	100	1.41	0.10
130-001	Gedser, Denmark	1898	2011	114	99	1.05	0.18
130-021	Kobenhavn, Denmark	1889	2011	123	98	0.67	0.21
130-031	Hornbaek, Denmark	1898	2011	114	98	0.37	0.22
130-041	Korsor, Denmark	1897	2011	115	98	0.81	0.18
130-051	Slipshavn, Denmark	1896	2011	116	96	1.01	0.16
130-071	Fredericia, Denmark	1889	2011	123	99	1.09	0.11
130-081	Aarhus, Denmark	1888	2011	124	96	0.63	0.11
130-091	Frederikshavn, Denmark	1894	2011	118	96	0.14	0.15
130-101	Hirtshals, Denmark	1892	2011	120	96	-0.17	0.21
130-121	Esbjerg, Denmark	1889	2011	123	98	1.23	0.26
140-012	Cuxhaven 2, Germany	1843	2008	166	100	2.53	0.16
160-011	Zeebrugge, Belgium	1942	2010	69	72	2.35	0.39
160-021	Oostende, Belgium	1937	2010	74	93	1.78	0.25
160-031	Nieuwpoort, Belgium	1943	2010	68	67	2.53	0.44
170-001	Lerwick, UK	1957	2011	55	91	-0.02	0.41
170-011	Aberdeen I & II, UK	1862	2011	150	95	0.72	0.09
170-053	North Shields, UK	1895	2011	117	93	1.91	0.14
170-101	Sheerness, UK	1832	2009	178	54	1.66	0.10
170-161	Newlyn, UK	1915	2011	97	99	1.76	0.17
170-251	Stornoway, UK	1977	2011	35	89	1.92	0.94
175-071	Dublin, Ireland	1938	2001	64	99	0.07	0.42
190-001	Dunkerque, France	1942	2011	70	60	1.71	0.40
190-051	Le Havre, France	1941	2011	71	58	2.45	0.52
190-091	Brest, France	1807	2011	205	89	1.05	0.08
190-141	St. John de Luz/Socoa, France	1942	2011	70	57	1.40	0.58
200-030	La Coruna I, Spain	1943	2010	68	98	1.53	0.43
210-021	Cascais, Portugal	1882	1993	112	93	1.27	0.15
210-031	Lagos, Portugal	1908	1999	92	78	1.50	0.24
220-003	Cadiz III, Spain	1961	2010	50	97	4.02	0.74
220-011	Algeciras, Spain	1943	2002	60	81	0.43	0.30
220-031	Malaga, Spain	1944	2010	67	82	0.65	0.50
230-051	Marseille, France	1885	2011	127	97	1.25	0.14
250-011	Genova, Italy	1884	1997	114	78	1.20	0.14
270-061	Trieste, Italy	1905	2011	107	94	1.27	0.20
280-006	Rovinj, Croatia	1955	2009	55	99	0.58	0.46
280-011	Bakar, Croatia	1930	2009	80	86	0.97	0.36
280-021	Split Rt Marjana, Croatia	1952	2009	58	99	0.28	0.48
280-031	Split Harbour-Gradska Luka, Croatia	1954	2009	56	100	0.62	0.48
280-081	Dubrovnik, Croatia	1956	2009	54	99	1.02	0.45
290-017	Katakolon, Greece	1969	2011	43	89	1.81	0.66
290-021	Kalamai, Greece	1969	2011	43	78	4.37	0.58
290-034	Khalkis North, Greece	1969	2011	43	88	0.35	1.02
290-051	Thessaloniki, Greece	1969	2011	43	90	3.73	0.80
290-065	Alexandroupolis, Greece	1969	2011	43	88	1.78	0.81
290-071	Khios, Greece	1969	2011	43	88	3.58	0.87
290-091	Leros, Greece	1969	2011	43	79	1.06	0.71
290-110	Rodhos, Greece	1969	2011	43	69	0.91	1.19
295-021	Bourgas, Bulgaria	1929	1996	68	86	1.91	0.90

295-051	Varna, Bulgaria	1929	1996	68	95	1.22	0.85
297-021	Constantza, Romania	1933	1997	65	95	1.37	0.97
298-041	Sevastopol, Ukraine	1910	1994	85	97	1.26	0.78
300-001	Tuapse, Russia	1917	2010	94	99	2.44	0.58
305-021	Poti, Georgia	1874	2009	136	94	6.59	0.29
340-001	Ceuta, Spain	1944	2009	66	96	0.52	0.29
360-001	Ponta Delgada, Portugal	1978	2007	30	69	2.58	1.01
370-032	Santa Cruz de Tenerife I & Tenerife, Spain	1927	2009	83	88	1.62	0.31
427-001	Walvis Bay, Namibia	1958	2011	54	50	0.60	1.02
430-061	Simons Bay, South Africa	1957	2011	55	79	1.94	0.27
430-088	Port Elizabeth, South Africa	1978	2011	34	79	2.39	1.11
430-091	Durban, South Africa	1971	2011	41	72	1.23	0.70
450-012	Port Louis I & II, Mauritius	1942	2011	70	96	3.51	1.15
485-001	Aden, Yemen	1879	2011	133	50	3.02	0.22
490-021	Karachi, Pakistan	1916	2011	96	55	1.12	0.54
500-011	Kandla, India	1950	2008	59	82	2.06	0.60
500-041	Mumbai/Bombay, India	1878	2008	131	91	0.79	0.11
500-065	Marmagao, India	1969	2008	40	64	0.91	0.51
500-081	Cochin, India	1939	2007	69	93	1.71	0.36
500-091	Chennai/Madras, India	1916	2008	93	59	0.32	0.37
500-101	Vishakhapatnam, India	1937	2007	71	86	0.79	0.45
500-106	Paradip, India	1966	2008	43	74	0.77	1.13
500-109	Gangra, India	1974	2006	33	96	1.45	1.31
500-110	Haldia, India	1970	2008	39	93	2.59	1.00
500-131	Diamond Harbour, India	1948	2007	60	96	4.67	0.68
545-001	Ko Taphao Noi, Thailand	1940	2010	71	95	0.90	0.96
555-011	Raffles Light House, Singapore	1973	2011	39	86	1.53	1.01
555-021	Sultan Shoal, Singapore	1969	2011	43	89	3.16	0.79
555-051	Sembawang, Singapore	1954	2011	58	79	-0.82	0.69
600-021	Ko Lak, Thailand	1940	2010	71	97	0.08	0.27
600-041	Fort Phrachula Chomklao/Pom Phrachun, Thailand	1940	2010	71	95	20.60	0.77
605-041	Quinhon, Vietnam	1977	2006	30	99	-1.25	1.60
605-081	Hondau, Vietnam	1957	2001	45	99	2.18	0.71
609-001	Macau, China	1925	1985	61	97	0.25	0.50
610-002	Zhapo, China	1959	2011	53	99	2.11	0.45
610-005	Xiamen, China	1954	2004	51	99	1.12	0.56
610-016	Kanmen, China	1959	2011	53	99	1.83	0.38
610-032	Lusi, China	1961	2011	51	81	4.97	0.61
610-039	Qinhuangdao, China	1950	1994	45	99	-0.04	0.63
610-044	Dalian, China	1954	2011	58	78	2.06	0.52
611-010	Quarry Bay & North Point, China	1929	2011	83	76	1.36	0.54
611-014	Tai Po Kau, Hong Kong	1963	2011	49	94	2.92	0.74
611-017	Tsim Bei Tsui, Hong Kong	1974	2011	38	80	0.41	1.58
612-002	Keelung II, Taiwan	1956	1995	40	99	0.46	0.78
620-027	Mokpo, South Korea	1960	2009	50	99	3.35	0.55
620-033	Jeju, South Korea	1964	2009	46	99	5.35	0.49
620-046	Busan/Pusan, South Korea	1960	2009	50	99	1.97	0.38
620-051	Ulsan, South Korea	1962	2009	48	97	1.29	0.65
620-061	Mugho, South Korea	1965	2009	45	97	0.80	0.49
625-011	Wonsan, North Korea	1962	1992	31	100	1.28	0.83

630-001	Yuzhno Kurilsk, Russia	1948	1994	47	95	2.74	0.62
630-021	Petropavlovsk-Kamchatsky, Russia	1957	2010	54	99	2.35	0.54
641-003	Abashiri, Japan	1965	2011	47	96	1.35	0.50
641-021	Kushiro, Japan	1947	2011	65	97	9.39	0.30
641-031	Hakodate I, Japan	1961	2011	51	99	-0.39	0.38
641-061	Wakkanai, Japan	1975	2011	37	99	3.67	0.55
642-021	Ofunato I & II, Japan	1965	2011	47	93	4.78	0.55
642-061	Mera, Japan	1931	2011	81	96	3.78	0.20
642-091	Aburatsubo, Japan	1930	2011	82	97	3.63	0.21
642-141	Kushimoto, Japan	1957	2011	55	98	3.45	0.56
645-011	Hosojima, Japan	1930	2011	82	98	-0.43	0.29
645-021	Aburatsu, Japan	1960	2011	52	100	1.89	0.47
645-064	Nagasaki, Japan	1965	2011	47	99	2.20	0.42
646-024	Naha, Japan	1966	2011	46	99	2.18	0.72
647-023	Hamada II & Tonoura, Japan	1894	2011	118	70	0.48	0.24
647-068	Toyama, Japan	1975	2011	37	98	3.73	0.60
647-071	Wajima, Japan	1930	2011	82	98	-0.20	0.23
648-001	Chichijima, Japan	1975	2011	37	99	4.50	1.18
660-011	Manila, Philippines	1901	2010	110	83	13.39	1.18
660-021	Legaspi, Albay, Philippines	1947	2009	63	97	5.38	0.72
660-121	Davao, Davao Gulf, Philippines	1948	1994	47	79	5.32	1.30
660-141	Jolo, Philippines	1947	1996	50	85	0.19	1.12
670-021	Rabaul, Papua New Guinea	1966	1997	32	83	-2.59	4.92
680-021	Weipa, Australia	1966	2010	45	75	3.48	1.54
680-051	Townsville I, Australia	1959	2010	52	100	1.48	0.42
680-073	Bundaberg, Burnett Heads, Australia	1966	2010	45	98	0.58	0.51
680-078	Brisbane, Australia	1966	2010	45	87	0.09	0.68
680-135	Newcastle III & V, Australia	1925	2010	86	98	1.04	0.69
680-140	Sydney, Fort Denison 1 & 2, Australia	1886	2010	125	100	0.65	0.10
680-471	Fremantle, Australia	1897	2010	114	92	1.54	0.24
680-479	Carnarvon, Australia	1965	2010	46	81	2.89	1.61
680-494	Port Hedland, Australia	1966	2010	45	92	2.18	1.71
690-002	Auckland II, New Zealand	1903	2000	98	96	1.29	0.20
690-011	Wellington Harbour, New Zealand	1944	2011	68	94	2.45	0.29
690-022	Lyttelton II, New Zealand	1924	2000	77	89	2.36	0.29
690-041	Bluff/Southland Harbour, New Zealand	1917	2011	95	26	1.57	0.24
710-026	Kapingamarangi, Federated States Of Micronesia	1978	2008	31	91	2.53	2.63
710-032	Pohnpei B & C, Federated States of Micronesia	1974	2011	38	96	3.87	2.72
711-021	Malakal B, Palau	1969	2009	41	94	1.73	3.05
720-017	Majuro B & C, Marshall Islands	1968	2011	44	94	3.60	1.22
732-012	Funafuti & Funafuti B, Tuvalu	1977	2011	35	96	3.74	2.95
734-004	Honiara-B & Honiara II , Solomon Islands	1974	2011	38	98	2.80	4.39
740-021	Noumea-Numbo & Noumea-Chaleix, New Caledonia	1970	2011	42	60	-1.85	2.69
742-012	Suva A, Fiji	1972	2011	40	91	6.30	1.51
750-012	Kanton Island & Kanton Island B, Kiribati	1949	2007	59	84	0.58	0.87
775-001	Penrhyn, Cook Islands	1977	2010	34	93	2.40	1.84
780-011	Papeete-B, Fare Ute Point, Soc.Is., French Polynesia	1975	2009	35	95	2.51	0.94
785-006	Rarotonga & Rarotonga B, Cook Islands	1977	2011	35	81	1.51	1.31
808-001	Rikitea, France	1969	2003	35	87	1.72	0.97

810-003	Easter Island E, Chile	1970	2010	41	81	0.33	1.26
822-001	Prince Rupert, Canada	1909	2011	103	81	1.12	0.24
822-071	Vancouver, Canada	1910	2011	102	82	0.37	0.23
822-101	Victoria, Canada	1909	2011	103	99	0.63	0.21
822-116	Tofino, Canada	1909	2010	102	76	-1.70	0.30
830-001	Ensenada, Mexico	1956	1990	35	96	2.34	1.38
830-020	Cabo San Lucas, Mexico	1974	2003	30	77	1.68	3.62
830-031	Guaymas, Mexico	1952	1988	37	85	4.09	1.35
830-071	Manzanillo, Mexico	1954	2003	50	89	3.18	2.17
830-091	Salina Cruz, Mexico	1952	1989	38	81	1.17	1.44
833-011	Acajutla, El Salvador	1962	1991	30	98	2.50	1.77
836-011	Quepos, Costa Rica	1957	1994	38	97	0.63	1.87
840-011	Balboa, Panama	1908	2003	96	99	1.49	0.25
842-011	Buenaventura, Colombia	1941	1969	29	91	0.96	1.22
845-012	La Libertad II, Ecuador	1948	2003	56	94	-1.22	0.97
845-031	Santa Cruz, Ecuador	1978	2007	30	91	0.89	3.83
850-012	Antofagasta 2, Chile	1945	2010	66	91	-0.80	0.43
850-021	Caldera, Chile	1950	1991	42	97	3.01	0.74
860-002	Ushuaia I & II, Argentina	1957	2006	50	85	0.72	0.85
860-011	Puerto Deseado, Argentina	1970	2002	33	42	-0.06	1.93
860-031	Puerto Madryn, Argentina	1944	2000	57	74	1.50	0.79
860-081	Quequen, Argentina	1918	1982	65	98	0.85	0.31
860-101	Mar Del Plata(Naval Base), Argentina	1957	2010	54	95	0.53	0.41
860-151	Buenos Aires, Argentina	1905	1987	83	100	1.57	0.30
863-002	Stanley I & II, UK	1964	2008	45	60	0.55	0.48
870-011	Montevideo, Uruguay	1938	2009	72	78	1.37	0.55
874-051	Cananeia, Brazil	1954	2006	53	97	4.20	0.63
874-092	Ilha Fiscal, Brazil	1963	2011	49	94	2.18	1.30
902-021	Cartagena, Colombia	1949	1992	44	84	5.31	0.37
904-011	Cristobal, Panama	1909	1980	72	100	1.41	0.22
920-001	Progreso, Mexico	1952	1990	39	83	4.67	0.94
930-031	Gibara, Cuba	1974	2011	38	98	1.41	0.96
930-071	Cabo San Antonio, Cuba	1971	2011	41	82	3.32	1.37
970-001	Saint John, N.B., Canada	1914	1999	86	73	2.75	0.33
970-011	Halifax, Canada	1985	2011	27	79	3.12	0.13
970-061	Pointe-Au-Pere, Neuville St Johns, Canada	1900	1983	84	79	-0.36	0.40
970-071	Quebec/Lauzon, Canada	1910	2011	102	75	-0.17	0.45
970-089	Neuville, Canada	1914	2011	98	70	0.19	0.73
970-121	St. Johns, NFLD, Canada	1935	2010	76	71	2.06	0.45
970-134	Nain, Canada	1963	2010	48	36	-2.02	0.74
970-141	Churchill, Canada	1940	2011	72	90	-9.48	0.57
999-001	Bahia Esperanza, Antarctica	1961	1993	33	35	-4.82	2.58
999-003	Argentine Islands, Antarctica	1958	2009	52	98	1.43	0.45

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 11) 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 extreme storm events.

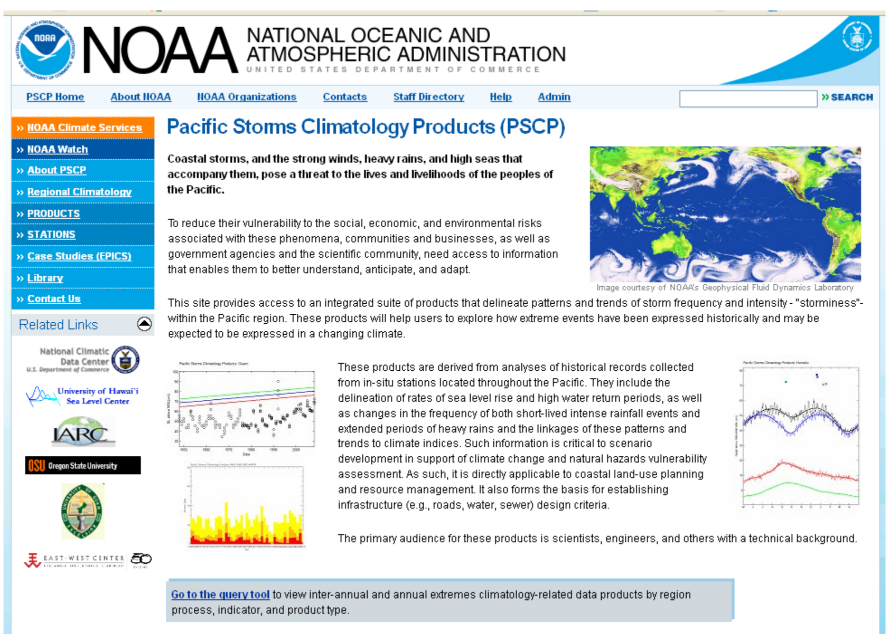

Figure 11. Pacific Storms Climatology Products Website.

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 Measurement Technology

A. GPS on Tide Gauges

Continuous GPS

Precise determination of vertical land motion at tide stations continues to be a priority area of investigation for NOAA. Previously, NOAA has investigated use of GPS data from CORS located nearby tide stations to estimate absolute sea level change (Snay *et al*. 2007). This past year, NOAA published a NOAA technical report on estimating vertical land motion from long-term tide gauge records (Zervas, *et al.*, 2013). This indirect estimation provides information at locations at which continuously operating GPS stations have not yet been established. Using funding provide by NOAA Office of Climate Observations, new CORS will continue to be established at NWLON stations that are part of the Global Sea Level Observing System (GLOSS) network as budgets allow.

Table 4 (below) provides the current listing of co-located CORS and NWLON stations that are within 1.0 km of each other and for which leveling connections can be made in the future.

Table 4. Table of NOAA NWLON and CORS stations located within 1.0 km of each other.

Tide Station	Lat., deg., N	Lon., deg., E	Relative Sea Level Rate (2σ error), mm/yr	Time Span for Tide Gauge Data (years)	CGPS Station (distance to tide gauge), km	NGS-adopted IGS08 Vertical Velocity at CGPS Station, mm/yr	Multi-solution ITRF2008 Vertical Velocity at CGPS Station (2σ), mm/yr	Time span of CGPS Data used in multi-solution (years)
Eastport, ME	44.903	293.015	2.13 (0.20)	1929 – 2012 (84)	EPRT (0.85)	-0.2	-0.23 (0.40)	1998.7 – 2011.3 (12.6)
Newport, RI	41.505	288.673	2.73 (0.18)	1930 – 2012 (83)	NPRI (0.54)	-1.3	-0.33 (0.40)	1999.6 – 2007.7 (8.1)
Sandy Hook, NJ	40.467	285.990	4.06 (0.23)	1932 – 2012 (81)	SHK1 (0.52) SHK2 (0.53) SHK5 (0.52) SHK6 (0.53)	-0.6	-2.75 (0.94) -0.50 (6.10) -2.23 (2.64) -0.50 (6.10)	1998.0 – 2006.3 (8.3) 1995.8 – 2006.3 (10.5) 2006.3 – 2011.3 (7.0) 2006.3 – 2011.2 (6.9)
Reedy Point, DE	39.558	284.427	3.67 (0.55)	1956 – 2012 (57)	RED1 (0.46) RED2 (0.49) RED5 (0.46)	-3.1	-3.05 (3.12) +1.88 (6.92) N/A	1999.1 – 2007.3 (8.2) 2000.1 – 2007.3 (7.2)
Gloucester Point, VA	37.247	283.500	3.81 (0.47)	1950 – 2003 (54)	GLPT (0.18) VAGP (0.19)	-2.5 -2.7	-2.24 (0.40) N/A	1997.5 – 2006.6 (9.1)
Duck, NC	36.183	284.253	4.59 (0.94)	1978 – 2011 (34)	DUCK (0.39)	-1.7	-2.09 (0.40)	1997.6 – 2003.3 (5.7)
Beaufort, NC	34.720	283.330	2.70 (0.39)	1953 – 2012 (0.39)	NCBE (0.21)	Predicted	N/A	
Charleston, SC	32.782	280.075	3.10 (0.23)	1921 – 2012 (92)	SCHA (0.28)	Predicted	N/A	
Key West, FL	24.553	278.192	2.29 (0.15)	1913 – 2012 (100)	CHIN (0.68)	Predicted	N/A	
Grand Isle, LA	29.263	270.043	9.07 (0.49)	1947 – 2012 (66)	GRIS (0.28)	-7.3	-7.15 (6.94)	2007.2 – 2011.3 (4.1)
Galveston PP, TX	29.285	265.212	6.61 (0.70)	1957 – 2012 (56)	TXGV (0.13)	0.0	+0.12 (7.40)	2007.1 – 2011.3 (4.2)
La Jolla, CA	32.867	242.742	2.02 (0.26)	1924 – 2012				

				(89)	SIO3 (0.75)	-0.6	+0.17 (0.40)	1994.0 – 2012.2 (18.2)
Crescent City, CA	41.745	235.817	-0.81 (0.34)	1933 – 2012 (80)	CACC (0.13)	Predicted	N/A	
South Beach), OR	44.625	235.957	2.34 (0.82)	1967 – 2012 (46)	ORSB (0.46)	Predicted	N/A	
Cordova, AK	60.558	214.247	1.28 (1.02)	1979 2012 (34)	EYAC (1.05)	Predicted	N/A	
Kodiak, AK	57.732	207.488	-10.78 (0.98)	1975 – 2012 (38)	KODK (0.72)	+12.5	+12.32 (0.42)	2003.0 – 2006.6 (3.6)
Unalaska, AK	53.880	193.463	-5.48 (0.56)	1957 – 2012 (56)	AV09 (0.58)	+1.7	+2.52 (0.80)	2004.3 - 2013.5 (9.2)
Honolulu, HI	21.307	202.133	1.42 (0.45)	1905-2012 (107)	HNLC (0.0)	-0.1		1997 – 2011(14)
Bermuda	32.373	295.297	2.09 (0.82)	1932-2012 (80)	BRMU (0.7)	-1.1		1994 – 2011(17)

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

General GPS Technology Implementation at NOAA

GPS technology and procedures will be implemented in operational plans:

(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. Continued Testing of Microwave Radar Water Level Sensors and Transition to Operations

Based on the many advantages offered by microwave radar wave level sensors (MWWL), successful MWWL installations reported throughout the international community, and previously reported results from NOAA's first phase of laboratory and long term field testing, the effort to introduce MWWL measurement technology across NOAA's NWLON continues. Also, a second phase of field testing has recently commenced, with the primary objective of better understanding MWWL sensor performance in intermediate to high energy wave regimes.

As previously reported, CO-OPS recommended limited operational use of radar water level sensors across the NWLON in low wave energy sites based of results reported in the following 2011 reference: (**http://tidesandcurrents.noaa.gov/publications/Technical_Report_NOS_CO-OPS_061.pdf**). A conservative approach has been pursued for the initial transition to operations effort, with MWWL installations being limited to low wave energy NWLON station sites. This is not to suggest that MWWL sensors cannot meet operational performance requirements in higher energy wave environments but rather an indication of NOAA's very limited amount of supporting field test data along with lack of thorough understanding of a MWWL sensor's performance over a broad range of ocean wave conditions to date.

Transition to Operations in Low Wave Environments

Since many NWLON stations are located in low wave environments, similar to test locations that yielded excellent test long-term results, NOAA has been able to make significant progress with the initial transition efforts, even with a conservative approach to site selection to date. Since CO-OPS first installation of operational MWWL sensors in Mobile Bay, Alabama in July 2011, several additional operational installations have followed. A transition committee has been formed to oversee all decisions on related efforts, which fall under three different categories of applications:

1. Introducing MWWL sensors to a subset of existing NWLON stations located in environments that can be easily classified as favorable.
2. Use of MWWL sensors at new or rebuilt NWLON long-term stations.
3. Use of MWWL sensors in new, temporary water level stations that are established to support hydrographic surveys.

To assist in evaluating suitability of proposed MWWL installation locations, an environmental assessment of each prospective site is compiled and reviewed by the overseeing committee. This is based on all available oceanographic and meteorological archive data as well as bathymetry and coastal boundary conditions.

Regarding category one, a criteria has been developed for introducing a MWWL sensor at an existing NWLON station, with the ultimate goal of transitioning the MWWL sensor to become the primary source of operational data. After the MWWL is installed at an NWLON station, the existing primary water level sensor will remain operational and overlapping data will be collected for at least one year. Analysis criteria to be applied to the overlapping sensor records have also been defined. For each new MWWL installation at an NWLON site, results will be documented in order to establish a case for continuity in long term records prior to officially switching to the MWWL sensor for primary measurements. Analysis will include calculation and comparison of multiple tidal datums. Since 2011, 4 new MWWL systems have been installed at NWLON operational stations (in addition to the previously reported 4, for a total of 8).

Regarding category 2, MWWL sensors have been installed at over 10 operational hydrographic stations since 2011. All installations have successfully yielded the required data and operational deployment experiences have resulted in very beneficial input to the continued evolution of system design and installation procedures.

Progress on category 3 has included incorporation of MWWL sensors at 2 new long-term water level sites and there are plans for MWWL sensor use at several additional new and/or rebuilt station sites during the coming two years.

As the number of MWWL station sensor continued to increase, NOAA has continued to develop new laboratory facilities to support routine calibration and verification testing. All of the test results that NOAA has obtained over the past several yeast, including problems encountered and lessons learned, have been used to develop and document a standard, five-step MWWL sensor pre-deployment laboratory test procedure. This test procedure is specifically designed to decrease the likelihood of problems during field deployment. CO-OPS has implemented the requirements to conduct the following tests to verify sensors' basic functionality and accuracy prior to field deployment:

1) Fixed Target Test for Resolution Verification
2) Time Response Verification
3) Sensor Offset Derivation
4) Dynamic Liquid Target Test
5) Range Accuracy Verification

Continued Field Testing – Intermediate to High Wave Environments

Test results reported to date support CO-OPS operational use of MWWL sensors in low wave energy environments only; understanding measurement capabilities in high wave energy environments remains in work in progress. Up until very recently, CO-OPS had only collected MWWL test data at one very high wave energy field site - the Duck, NC NWLON station. This is located on the 'Outer Banks' of North Carolina, which is known to be one of the most energetic wave environments on the U. S. East coast, mainly due to the relatively short distance from coastline to the continental shelf break. No test data have been collected where surface dynamics express intermediate energy. Since NOAA's transition of MWWL technology to operational applications has been pursued, several operational planning discussions have revealed significant interest in using MWWL sensors at multiple NWLON sites in intermediate wave environments, where sensor's performance is not clearly understood.

Based on these motivating factors, additional MWWL test locations have been established at NWLON stations located at Lake Worth, FL, La Jolla, CA, and Monterey, CA during 2013. Installations were completed in the August-September 2013 time frame in an attempt to capture data through the Summer-Fall-Winter seasonal wave transition. Every site includes a source of nearby wave observations. Preliminary results are planned to be analysis results will be ready for reporting and presentation by early 2014.

C. Development and Testing of Water Level Measurement Systems for Remote Arctic Regions

NOAA continues to operate and maintain a number of NWLON tide stations along the Arctic Alaska coast. Those that fall within the Arctic Circle include 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 and test a water level measurement system that is designed for long-term deployments in remote Artic regions. 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 12). The platforms are periodically referenced to land based benchmarks via staff shots and differential GPS. The platforms were each equipped with acoustic releases for recovery. Continuous barometric pressure measurements were available from a nearby airport, for use in final derivation of water level values.

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 was the first time in the history NOAA was able to collect year-round water level data in Beaufort Sea. These two years of water level data collection efforts validated the proof of concept that year-round water level data could be collected in Arctic.

NOS is planning to further develop and evolve this type of bottom mounted water level measurement system, by incorporating by enhancing bottom mount design and implementing a real time data communication system. System design will be split into two levels. Level 1 will involve the development and test of a system capable of measuring and transmitting data during summer months (ice free) and level 2 will involve a design for and real time data transmissions all year round. CO-OPS has recently completed the integration of a prototype system consisting of a bottom mounted pressure sensor gauge and a real time transmissions capability using Iridium Short-Burst Data modems. Two versions of the system are planned to be deployed for initial field testing at the Money Point, VA NWLON station in CY 2013. These tests will include various options such as buoy with acoustic modem and real time telemetry, buoy with cable and real time telemetry, and cabled observatory and real time telemetry. Once these tests are successful, then CO-OPS will transition this technology to operations in the near future.

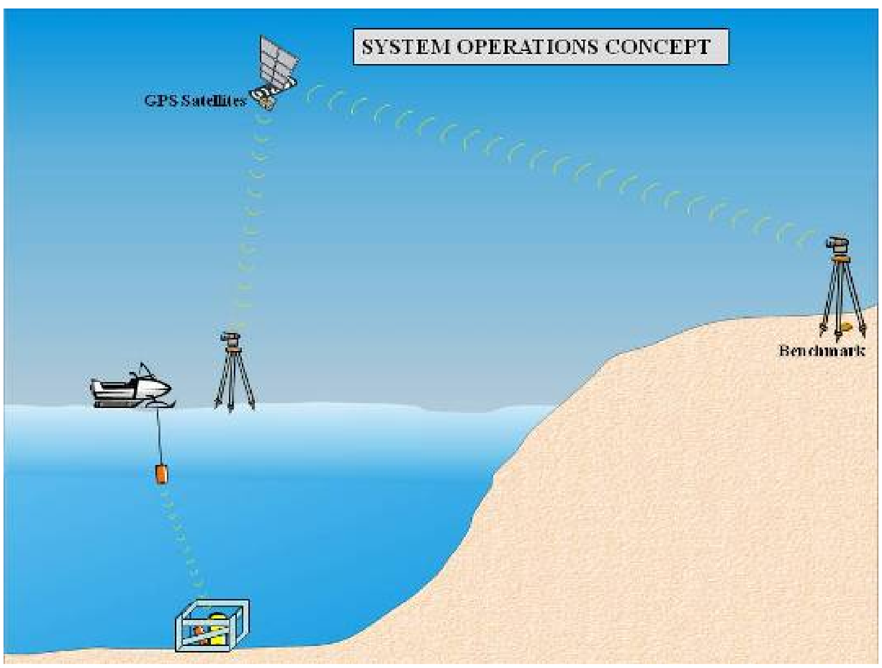

Figure 12. Schematic of Point Barrow Testing Configuration.

IV. Measurement of Extreme Water Levels

A. Station Configurations and Upgrades

Data and datum continuity are extremely important to any long-term monitoring observing system. 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. It is important for all applications of the data from sea level stations to collect the extreme low water values as well and stations are established to measure the full anticipated excursion of water levels, from extreme lowest to extreme highest. 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. At some locations, two separate independent systems are installed within a short distance. If one primary/backup system goes down or is destroyed, a completely separate system (both primary and backup DCP's and sensors) provides 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. Integrating new technology. 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, and four more have been funded and are underway through Texas A&M University.

NOAA Sentinels are large single-pile structures (see Figure 13). 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 13. 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. CO-OPS is presently testing this microwave water level technology for use in other environments. Over 100 stations that are part of the National Water Level Observation Network (NWLON) and over 25 stations that are part of the Physical Oceanographic Real-Time System (PORTS) have been approved for transition to microwave radar, with station upgrades tentatively planned to begin in 2015.

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 contains three main sections: 1) a map highlighting NOS tide gauge locations and tropical cyclone data (including track, intensity and satellite imagery), 2) an analysis 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 and barometric pressure 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. Real-time water level observations within the QuickLook product can be adjusted referenced to multiple vertical datums including Mean Lower Low Water (MLLW), Mean Sea Level (MSL), the North American Vertical Datum (NAVD88) and beginning in 2013, Mean Higher High Water (MHHW). MHHW provides an estimate of when flooding inundation may occur at coastal locations and allows for an easier comparison between observed storm tide and storm surge guidance, which is referenced to ground level.

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. In 2012, reports were completed for Hurricane Isaac and Hurricane Sandy. These and other reports can be found on http://www.tidesandcurrents.noaa.gov under Publications.

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 16), exceedance probability curves relative to return periods (Figure 17), and exceedance probability levels relative to tidal datums (Figure 18).

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.

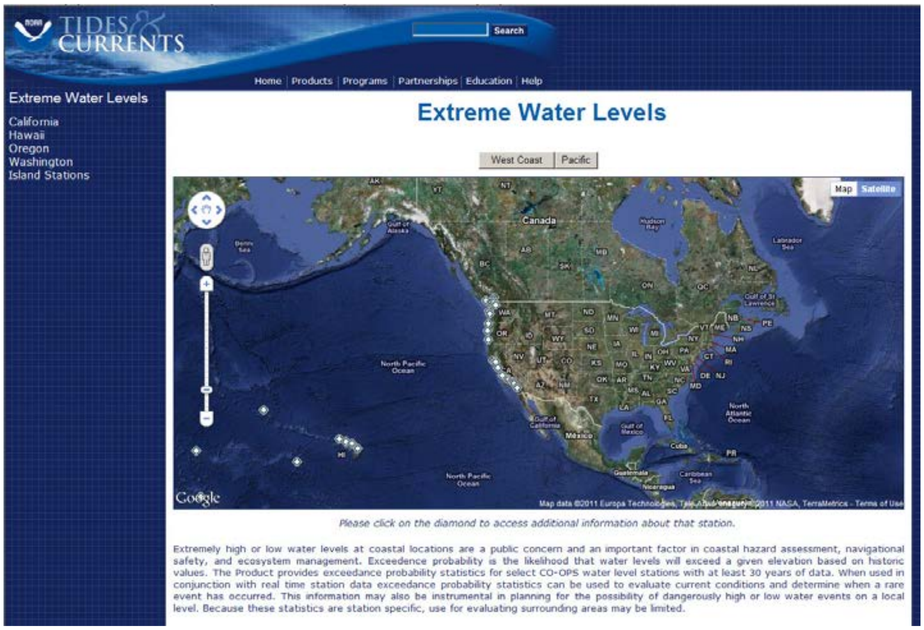

Figure 14: Google Map Interface for Exceedance Probability Statistics on Extreme Water Levels.

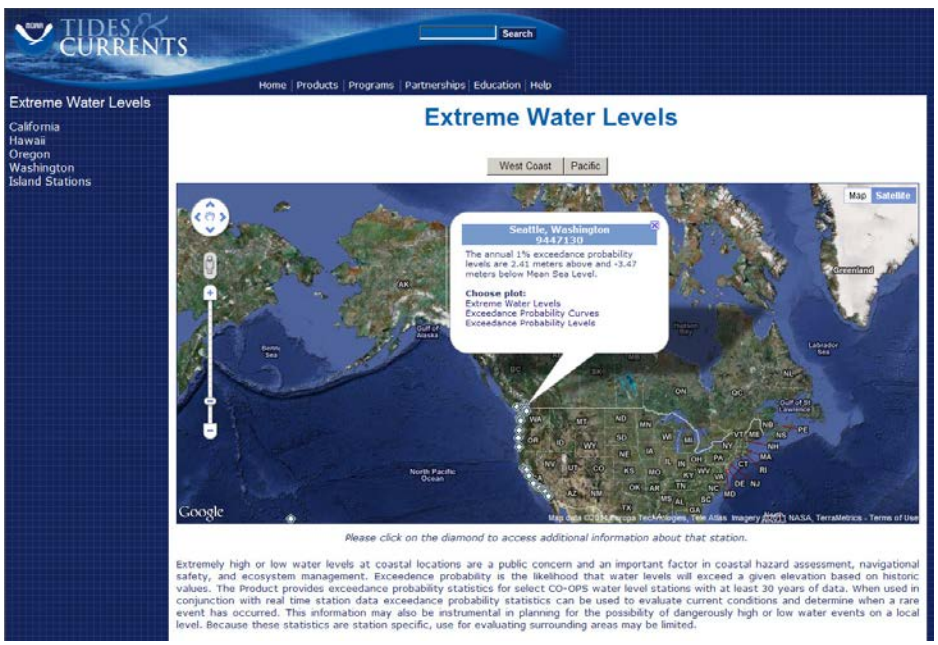

Figure 15: Pop-up menu for example station Seattle 9447130 from which users can select Extreme Water Levels, Exceedance Probability Curves, or Exceedance Probability Levels.

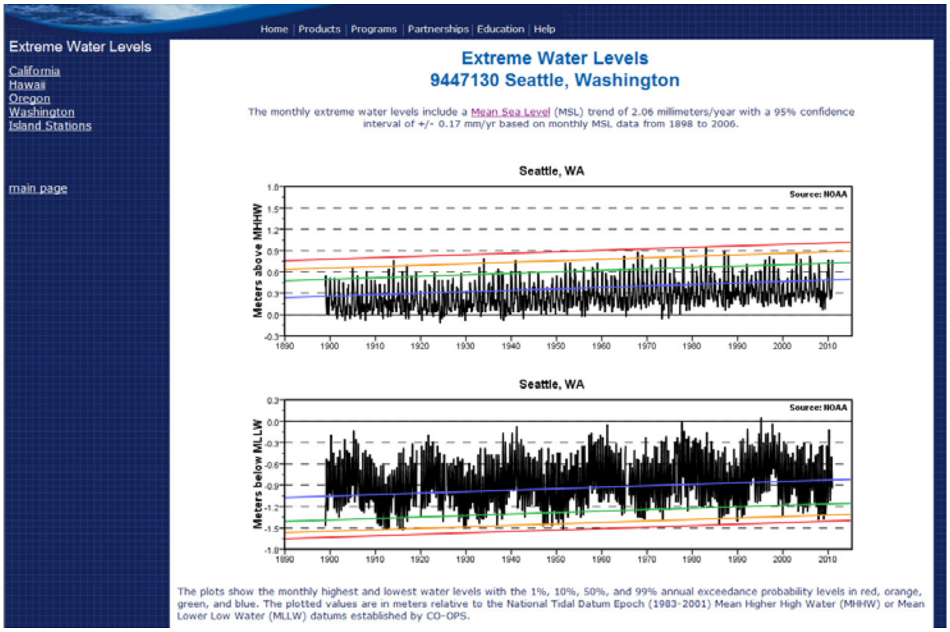

Figure 16: The monthly highest and lowest water levels overlaid by the exceedance probability levels.

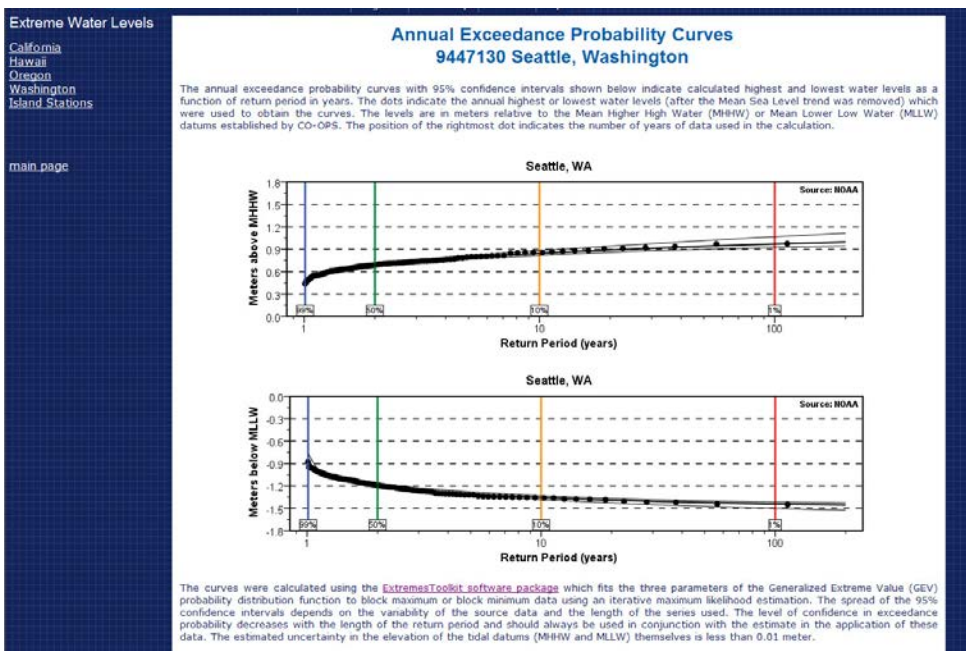

Figure 17: Exceedance Probability Curves relative to Return Periods with 1 year, 2 years, 10 years, and 100 years identified.

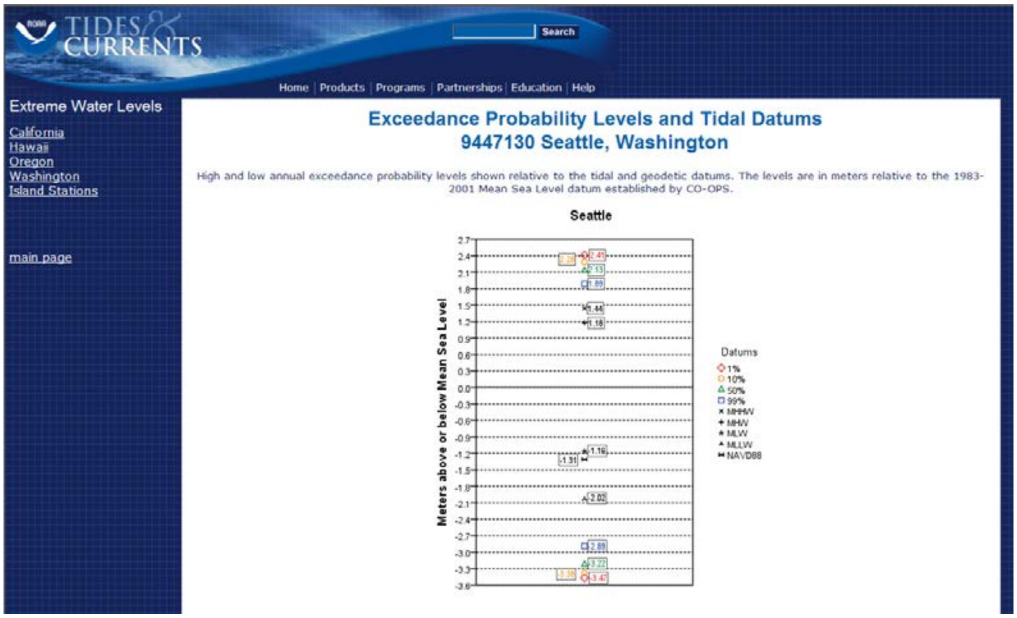

Figure 18: Exceedance probability levels relative to tidal and geodetic datums.

Probabilistic estimates of extreme water level under a changing climate

Probabilistic estimates of extreme still water level events under a changing climate http://www.noaaclimatepacis.org/slr/phase1.php. This site has arisen as a result of activities carried out following the "Towards a Consensus Methodology for Projecting Sea Level Rise and Coastal Inundation in the Pacific Islands Technical Workshop" held January 10-11, 2012 in Honolulu. This workshop brought together government, academic, and other experts to share knowledge and explore our current understanding of information and methods that can be used to project long-term changes in sea level and coastal inundation in the Pacific Islands http://www.noaaideacenter.org/slr/. The guidance and products that can be accessed here represent the results of the first phase of work leading to the development of innovative methodologies and best practices for the formulation of probabilistic estimates of extreme still water level events under a changing climate for specific locations in the Pacific Islands. This work involved non-stationary extreme value analysis that includes changes to mean sea level (MSL) in the form of observed trends as well as projections of future changes based upon model-derived scenarios developed for the USGCRP National Climatic Assessment (NCA). Two models - the Generalized Extreme Value (GEV) Distribution and the Generalized Pareto Distribution (GPD) - were used to compute the extreme value statistical distributions of *static water levels* from historical observations from tide gauges.

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.

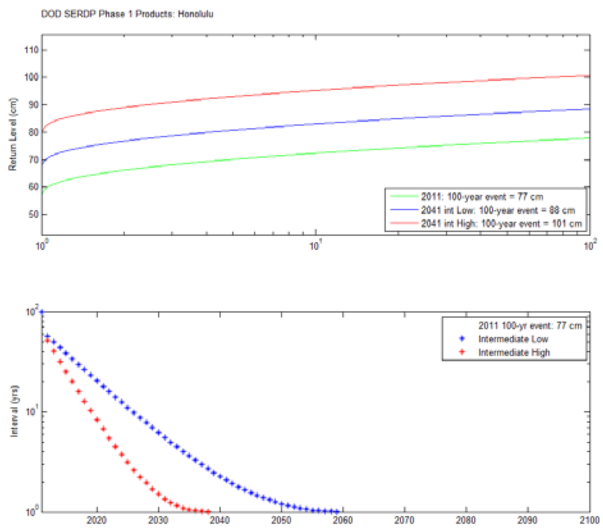

Figure 19. (Top) Exceedance probability curves (return level elevations), for recent year (green) and 30 years from most recent year under US National Climate Assessment (NCA) SLR Intermediate Low (blue) and High (red) scenarios. The Intermediate Low and High scenarios correspond to 0.5m:1.64 feet and 1.2m:3.94 feet by 2100 respectively. (Bottom) Recurrence interval decay curves, showing change in return level interval associated with the most recent year's 100-yr return level elevation under NCA SLR Intermediate Low (blue) and High (red) scenarios.

Water Level Outlooks

As part of a joint effort by NOAA NESDIS/NCDC & NOS/CO-OPS and UHSLC, 'Seasonal Water Level and Storminess Outlook' products are being developed for the Atlantic Coast and Pacific Islands. These products are specifically tailored for coastal flooding/erosion risk warning. The 'outlooks' aim to project the potential for elevated water levels at the shoreline due to: 1) regional changes in mean sea level associated with ENSO and other modes of natural variability; 2) tropical and extra-tropical storms; and 3) unusually high tides. The outlooks respond to a need from community planners, resource managers, and other decision-makers for information about the potential for coastal flooding and erosion to threaten coastal structures and property, groundwater reservoirs, harbor operations, waste water systems, sandy beaches, coral reef ecosystems, and other social and economic concerns. Currently, information of this type is limited in scope and not well integrated.

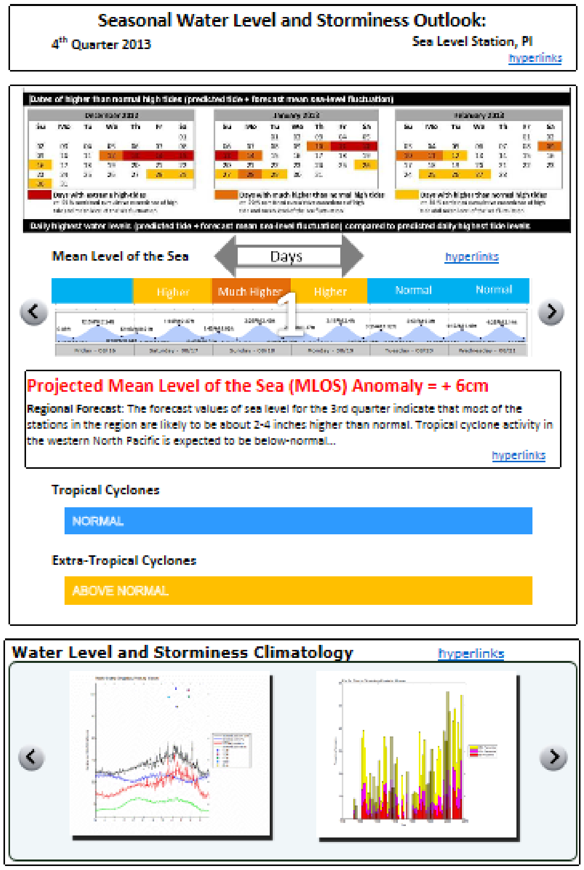

Figure 20. Example of a Seasonal Outlook for a Pacific Island showing times of higher than normal tides, outlooks of expected *storminess* shown relative to climatological patterns

V. Regional Activities

A. Pacific Islands Integrated Water Level Service

Regional partners including the US NOAA, NZ NIWA and Met Service, and Australian CSIRO and BOM among others are coordinating on the creation and distribution of climate-related sea level products. This group has identified the development and distribution of actionable information related to high waves and water levels at a seasonal scale as an area of mutual interest (see above). Joint efforts in this area constitute path-finding activities directed towards aligning complementary interests and activities, sponsoring joint projects, and leveraging funding as a way to minimize duplication of effort and maximize the use of agency resources in the Pacific. It represents a center of action within a broader effort to support regional collaboration in the areas of data and observations, applied research and analysis, product development, and outreach and training and demonstrate the value of regionally integrated water level-related products and services.

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 IOC also assisted at the same time with the development Early Warning Systems for tsunami and other coastal hazards in both the Caribbean (CARIBE EWS) andthe Mediterranean and Northeast Atlantic Ocean (NEAMTWS). These TWSs, all continue to be coordinated by the IOC, are supported by the Member States which 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 contributes data to the Tsunami Warning Centers. It was temporarily removed in 2013 due to pier reconstruction and dredging, but is planned to be re-established in 2014. The sustainable nature of the construction of this station as a long-term station makes it an ideal site for a Caribbean GLOSS station.

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. At the moment of this report one of the stations (Penuelas) is in the process of being relocated to another site off southern Puerto Rico. 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
YABUCOA	PR	3366B5CA	6 min	975-422B	18.06 N	65.84 W
ISLA CAJA DE MUERTOS	PR					

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 wind sensors were upgraded to meet the specification of the WMO. 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. One of the stations, Mayagüez, has a collocated GPS.

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. In 2012-2013 it assisted with the upgrading of the Road Town, Tortola, British Virgin Islands station and also installed a tsunami ready tide gauge in the Dominican Republic, in the south province of Barahona. The data from these stations are available thru the PRSN website, as well as the IOC Sea Level Monitoring Facility.

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). Every month it provides a report of sea level data availability at different centers, including the IOC Sea Level Monitoring Facility, the PRSN and the University of Hawaii Sea Level Center. As of September 2013 the CARIBE EWS station inventory included 111 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 55 coastal sea level stations are contributing data over GOES or FTP, most at least every 6 minutes (60% increase over 2011 when there were 34 just 34 coastal sea level station). Currently with funding provided thru UNESCO tsunami and GLOSS compliant stations are to be installed by the end of 2013 in Guatemala, Grand Cayman Islands, Haiti (2), St. Nevis and St. Vincent. Thru UNAVCO (US GPS Consortium), funding was secured for an additional two stations with collocated high rate GPS in 2 additional sites. Several other countries also have plans for new installations and stations. For other locations, funds are required for new installations or upgrades to the current facilities.

The CTWP, thru initiatives with NOAA, US State Department and the Tsunami Unit is maintaining discussions with the Caribbean and international stakeholders 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 which is being executed by the Caribbean Tsunami Warning Program.

In addition to maintaining an inventory of sea level stations in the Caribbean and Western Atlantic basin, the CTWP helped organize the 3rd regional GLOSS-CARIBE EWS sea level network operator's workshop **"Strengthening Sea Level Observation Network and Coordination Activities in the Caribbean"** in June 2012 in Merida, Mexico. The course was organized within the framework of the US WMO Voluntary Contributions Project "Strengthening sea-level observation network and coordination activities in the Caribbean", the Intergovernmental Oceanographic Commission IOC of UNESCO (GLOSS, IOCARIBE and Tsunami), the US National Oceanic and Atmospheric Administration (NOAA) and the National Mareographic Service of the Universidad Autónoma de Mexico (UNAM). The purpose of the course was to provide the sea level station operators and data analysts in the region lectures and hands on training on the science and operations of sea level stations for tsunami and other coastal hazards warning purposes. The workshop included 4 days of lectures, presentations and exercises and two field trips to stations operated by the UNAM. 37 sea level station professionals from the Caribbean, Central America, northern South America, Mexico, US Mainland, Puerto Rico and Hawaii participated in the training activity. The Puerto Rico Seismic Network is trying to identify a source of funding to host a 4th course in 2014.

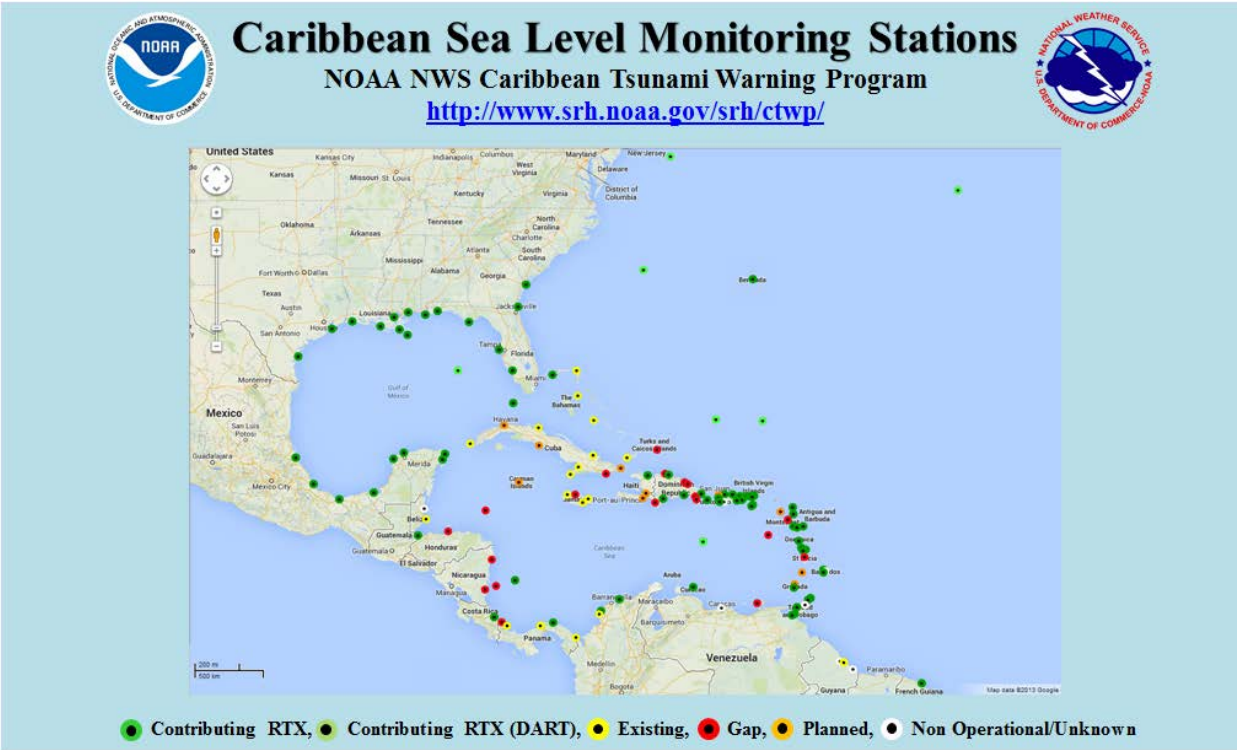

Figure 21. Current status of sea level stations in the Caribbean.

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 2012 • JASL (055A) data to 2013 • CRN station
206	San Juan, PR	• Ongoing, currently using an acoustic gauge with pressure gauge backup – with redundant DCP • PSMSL data through 2012 • JASL (245A) data to 2013
221	Bermuda	• Ongoing, currently using an acoustic gauge with pressure gauge backup – with redundant DCP • PSMSL data through 2012 • JASL (259A) data to 2013 • CRN station
302	Adak, AK	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2012 • JASL (040A) data to 2013
149	Apra Harbor, Guam	• Ongoing, currently using a digital/pressure bubbler gauge – with redundant DCP • PSMSL data through 2012 • JASL (053A) data to 2013 • CRN station
219	Duck Pier, NC	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2012 • JASL (260A) data to 2013
289	Fort Pulaski, GA	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2012 • JASL (752A) data through 2005
217	Galveston Pier 21, TX	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2012 • JASL (775A) data to 2013
287	Hilo, HI	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2012 • JASL (060A) data to 2013
108	Honolulu. HI	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2012 • JASL (057B) data to 2013

GLOSS ID	Location	Status
		• CRN station
109	Johnston Island	No longer operated by NOAA as of 2003 – operated by UHSLC since 2004 • PSMSL data through 2003 • JASL (052A) data to 2013
216	Key West, FL	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2012 • JASL (242A) data to 2013 • CRN station
159	La Jolla, CA	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2012 • JASL (554A) data to 2013 • 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
332	Miami (Virginia Key), FL	• Ongoing, currently using an acoustic gauge with pressure gauge backup – station is not connected to datum at Miami. • PSMSL data through 2012 • JASL (755A) Virginia Key data 1996 to 2013
106	Midway Island	• Ongoing, currently using an acoustic gauge with pressure gauge backup – with redundant DCP • PSMSL data through 2012 • JASL (050A) data to 2013
290	Newport, RI	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2012 • JASL (253A) data to 2013
74	Nome, AK	• Ongoing, currently using a dual orifice digital/bubbler system • PSMSL data through 2012 • JASL (0595A) data to 2013
144	Pago Pago, AS	• Ongoing, currently using an acoustic gauge with pressure gauge backup – with redundant DCP • PSMSL data through 2012 • JASL (056A) data to 2013
288	Pensacola, FL	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2012 • JASL (762A) data to 2013 • 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 2012

GLOSS ID	Location	Status
		• JASL (579A) data to 2013
158	San Francisco, CA	• Ongoing, currently using a dual orifice digital/bubbler system PSMSL data through 2012 • JASL (551A) data to 2013 • CRN station
100	Sand Point, AK	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2012 • JASL (574A) data to 2013
150	Seward, AK	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2012 • JASL (560C) data to 2013
154	Sitka, AK	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2012 • JASL (559A) data to 2013
157	South Beach, OR	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2012 • JASL (592A) data to 2013
102	Unalaska (Dutch Harbor), AK	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2012 • JASL (041B) data to 2013
220	Atlantic City, NJ	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2012 • JASL (264A) data to 2013 • CRN station
105	Wake Island	• Ongoing, currently using an acoustic gauge with pressure gauge backup – with redundant DCP • PSMSL data through 2012 • JASL (051A) data to 2013

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 2012 • JASL data to 2013
058A	Nawiliwili, HI	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2012 • JASL data to 2013
059A	Kahului, HI	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2012 • JASL data to 2013
061A	Mokuoloe, HI	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2012 • JASL data through 2013
552A	Kawaihae, HI	• Ongoing, currently using an acoustic gauge with pressure gauge backup • JASL data through 2013
555A	Monterey, CA	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2012 • JASL data through 2012
556A	Crescent City, CA	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2012 • JASL data to 2013 • CRN station
557A	Port Orford, OR	• Ongoing, currently using a dual orifice digital/bubbler system • PSMSL data through 2012 • JASL data through 2012
558A	Neah Bay, WA	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2012 • JASL data to 2013 • CRN station
561A	Seldovia, AK	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2012 • JASL data through 2012
562A	Valdez. AK	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2012

JASL ID	Location	Status
		• JASL data through 2012
564A	Willapa Bay (Toke Point), WA	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2012 • JASL data through 2012
565A	Port San Luis, CA	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2012 • JASL data through 2012
567A	Los Angeles, CA	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2012 • JASL data through 2012
570A	Yakutat, AK	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2012 • JASL data to 2013
571A	Ketchikan, AK	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2012 • JASL data to 2013 • CRN station
572A	Astoria, OR	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2012 • JASL data through 2012
573A	Arena Cove, CA	• Ongoing, currently using an acoustic gauge with pressure gauge backup • JASL data through 2012
575A	Charleston, OR	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2012 • JASL data through 2012
576A	Humboldt Bay (North Spit), CA	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2012 • JASL data through 2012
578A	Santa Monica, CA	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2012 • JASL data through 2012
583B	Cordova, AK	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2012 • JASL data through 2012
594A	Platform Harvest, CA	• Ongoing, currently two DCP's with paroscientific pressure digital bubbler sensors • JASL data 1995 through 1999

JASL ID	Location	Status
246A	Magueyes Island, PR	• Ongoing, currently using an acoustic gauge with pressure gauge backup – with redundant DCP • PSMSL data through 2012 • JASL data through 2012
261A	Charleston, SC	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2012 • JASL data to 2013 • CRN station
240A	Fernandina Beach, FL	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2012 • JASL data through 2012 • CRN station
252A	Portland, ME	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2012 • JASL data through 2012 • CRN station
254A	Lime Tree bay, VI	• Ongoing, currently using an acoustic gauge with pressure gauge backup – with redundant DCP • PSMSL data through 2012 • JASL data through 2012
255A	Charlotte Amalie, VI	• Ongoing, currently using an acoustic gauge with pressure gauge backup – with redundant DCP • PSMSL data through 2012 • JASL data through 2012
279A	Montauk, NY	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2012 • JASL data through 2012
740A	Eastport, ME	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2012 • JASL data through 2012
741A	Boston, MA	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2012 • JASL data through 2012 • CRN station
742A	Woods Hole. MA	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2012 • JASL data through 2012
743A	Nantucket, MA	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2012 • JASL data through 2012

JASL ID	Location	Status
744A	New London, CT	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2012 • JASL data through 2012
745A	New York (The Battery), NY	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2012 • JASL data through 2012 • CRN station
746A	Cape May, NJ	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2012 • JASL data through 2012
747A	Lewes, DE	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2012 • JASL data through 2012
749A	Chesapeake BBT, VA	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2012 • JASL data through 2012
750A	Wilmington, NC	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2012 • JASL data through 2012
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 2012 • JASL data through 2012
759A	St. Petersburg, FL	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2012 • JASL data through 2012
760A	Apalachicola, FL	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2012 • JASL data through 2012
761A	Panama City Beach, FL	• Removed in 2012, used an acoustic gauge with pressure gauge backup • JASL data through 2012
763A	Dauphin Island, AL	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2012 • JASL data through 2012

JASL ID	Location	Status
765A	Grand Isle, LA	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2012 • JASL data through 2012
766A	Sabine Pass, TX	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL through 2012 • JASL data through 2012
767A	Galveston Pleasure Pier, TX	• Removed in 2011, used an acoustic gauge with pressure gauge backup. Replaced with Galveston, North Jetty. • PSMSL data through 2012 • JASL data through 2012
769A	Rockport, TX	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2012 • JASL data through 2012
770A	Corpus Christi, TX	• Ongoing, currently using an acoustic gauge with pressure gauge backup • JASL data 1992 through 2012
772A	Port Isabel, TX	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2012 • JASL data through 2012
773A	Clearwater Beach, FL	• Ongoing, currently using an acoustic gauge with pressure gauge backup • PSMSL data through 2012 • JASL data through 2012
774A	Port Canaveral (Trident Pier), FL	• Ongoing, currently using an acoustic gauge with pressure gauge backup • JASL data through 2012

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
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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
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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
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089A Pxxx xxx Manta-A Ecuador 00-57S 080-44W 1979-1981 100 INOCAR
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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
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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.
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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
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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
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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
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341A Pxxx xxx Keelung Rep. of China 25-09N 121-45E 1980-2010 85 Central Weather Bureau
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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
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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
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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.
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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
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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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