Tide Gauge Data Rescue

Mr. Patrick C. Caldwell
Manager, Joint Archive for Sea Level, National Oceanographic Data Center (NODC),
Patrick.caldwell@noaa.gov

Abstract
Historical, non-digitized tide-gauge records are potentially of great value to the oceanographic research community as they can extend existing sea-level time series as far back as possible in order to understand more completely the time scales of sea-level change, and in particular, sea-level rise associated with climate change. At the 12th session of the Global Sea Level Observing System (GLOSS) Group of Experts (GLOSS GE XII, 7-11 November, 2011, United Nations Educational, Scientific and Cultural Organization, Paris), the topic of rescue of tide-gauge data in non-computer form (charts, tabulations, etc.) was discussed. The GLOSS GE acknowledged that a large amount of historical data remain in paper form and noted that there have been recent findings in non-oceanographic facilities such as the United States National Archives and Records Administration and the archives of the French territorial divisions. To learn more of the holdings of tide-gauge records worldwide, a questionnaire was developed and sent to national focal points for GLOSS and also to national hydrographic agencies identified via the International Hydrographic Organization. The questionnaire sought specific details on locations, time spans, sampling frequencies, and media type, volume, and quality. The responses were compiled in an inventory of the Committee for Data in Science and Technology Data-at-Risk Task Group, which seeks to assess the availability and quality of historical records from a wide spectrum of scientific and technological fields, with the long-term goal of identifying funding sources and means for transferring the old records into computer-ready format(s). This paper describes the accomplishments of the 2012 GLOSS questionnaire.

Author
Mr. Patrick Caldwell received a Bachelor's and Master's degree in meteorology from Florida State University in 1982 and 1984, respectively. He supported climate data rescue within the Marine and Environmental Protection Agency of Saudi Arabia from 1985-1986. He joined National Oceanic and Atmospheric Administration in 1987 as manager for the Joint Archive for Sea Level based at the University of Hawaii Sea Level Center.

1. Background

Objective measurements and observations are essential to the advancement of science. Within natural sciences, hypotheses on temporal and spatial variability of a given process are tested with objective theories and validated through *in situ* data. Various entities, such as national and international environmental data centers, support scientific research by maintaining large archives of readily-available, scientifically-valid, computer-ready measurements and observations. Long-lived entities, such as select museums, libraries, academic departments, non-governmental organizations, private environmental and engineering companies, and others within all branches of governmental agencies from local to federal levels, have collected and stored *in situ* environmental records. In some cases, data may be stored but are may risk loss owing to deterioration of media - or simply get forgotten. Determining what records exists can be just as daunting as the actual transformation into digital, science-ready form.

Since 2011, the International Council for Science: Committee on Data for Science and Technology (CODATA) has supported a Data-at-Risk Task Group (DARTG), whose purpose is to rescue scientific data. The international members of DARTG include data specialists in a wide range of natural and information sciences; each team member, upon whom DARTG may call, is an expert within a select discipline. The first phase is to gather information about data at risk. The collected information is placed into an on-line DARTG inventory (www.ibiblio.org/data-at-risk/items/browse/1). The motivation is to alert scientists to the existence of these valuable historical records. That awareness should facilitate funding solicitations by keenly interested researchers who seek to salvage safely the measurements and observations from their original media to contemporary electronic formats.

The author of this paper is a member of DARTG as well as the Group of Experts (GE) of the Global Sea Level Observing System (GLOSS). GLOSS was established in 1985 by the Intergovernmental Oceanographic Commission (IOC) of the United Nations Educational, Scientific and Cultural Organization (UNESCO). It provides oversight and coordination for regional and global sea-level networks in support of scientific research. The GLOSS GE has identified 290 tide-gauge sites worldwide; they constitute the GLOSS Core Network (GCN).[1] The site selection is based on several criteria; locations with minimal influence of rivers are desired to monitor better the oceanic variations. Preference is given to secure ports, which provide protection both from extreme waves and from vandalism). Sites with existing long time series are given priority.

GLOSS has designated data centers to support the securing of information about, and access to, tide-gauge measurements. Data centers are distinguished by the temporal turnaround from acquisition to on-line access and by the temporal resolution within the time series. Sea-level rescue has been an important focus of the delayed-mode centers: the British Oceanographic Data Centre (BODC), the Joint Archive for Sea Level (JASL) and the Permanent Service for Mean Sea Level (PSMSL). The BODC handles high-frequency series, defined as hourly intervals or less. The JASL, a partnership between the United States (US) National Oceanic and Atmospheric Administration's (NOAA) National Oceanographic Data Center (NODC) and the University of Hawaii Sea Level Center (UHSLC), focuses on data measured or reduced to hourly intervals, from which daily means are produced. The PSMSL is the longest-operating international sea-level repository, and has the largest number of sites and years for monthly mean sea level. All the centers acquire time series beyond the GCN. The centers share in solicitation from regional and national data suppliers, and exchange data and metadata on a regular basis.

Historical tide-gauge records are important for furthering our understanding of sea-level variations over a wide range of temporal and spatial scales. The highest frequency data provide guidance on magnitudes and durations of coastal inundations from extreme events such as tsunamis and storm surges. Regional, long tidal records have been used to study the temporal variation in tidal components.[2] Sea

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[1] IOC, "Global Sea Level Observing System (GLOSS) Implementation Plan – 2012," UNESCO/IOC Technical Series No. 100 (2012), 2-48.

[2] Jay, David. A., "Evolution of tidal amplitudes in the eastern Pacific Ocean," Geophysical Research Letters 36 (2009): L04603, accessed August 1, 2012, doi:10.1029/2008GL036185.

level has significant regional inter-annual through inter-decadal variations, such as seen in tide-gauge records from Hawaii.[3] Historical data, through extension of the length of record for a given time series, augment statistical confidence of analysis. Studies of variations on those moderate time and space scales and extension of records further back in time are essential for the task of defining long-term global sea-level rise.[4]

The Global Oceanographic Data Archaeology and Rescue (GODAR) project[5] defines `data archaeology' as the process of seeking out, restoring, evaluating, correcting, and interpreting historical data sets, and `data rescue' as the effort to save data at risk by digitizing manuscript data, copying to electronic media, and archiving these data into an internationally available electronic database. In support of GODAR and GLOSS, several efforts have been made for sea-level data archaeology and rescue over the past two decades. During the 1990s the JASL salvaged 372 years for 34 stations of paper hourly tables, primarily acquired from the NOAA National Ocean Service (NOS) for sites within South and Central America.[6] The BODC led a GLOSS archaeology and rescue project in 2001. Through this recovery effort and the work of individual agencies in digitizing and quality controlling paper records, 91 tide gauge series were extended backwards by 1,411 years of hourly data. The BODC has a substantial archive of approximately 3000 site years of tide-gauge charts and tabulations dating back to the 1850s. Some sites include other parameters. Most sites are within the United Kingdom and are in paper form. For eight of those stations, scanned images of the analog tidal charts for 86 site years were made available, and of those, 45 years have been digitized. Funding has been secured to digitize 160 site years from 22 tide stations and produce scanned images of 500 site years for 14 stations, most of which date from 1890 to 1920.

At the GLOSS GE XII meeting in November 2011, the topic of data rescue was revisited. The primary motivation came from the inquiry of researchers Dr. David Jay and Dr. Stefan Talke of Portland State University (PSU), who have interests in historical records for analyses of tidal and other higher-frequency phenomena.[7] Over the past several years they have inquired about the availability of historical sea-level records in need of rescue for tide-gauge sites within North America and the Pacific Ocean and under various international agencies. It has been determined that a large amount of records exist in non-digital form within the US National Archives and Records Administration (NARA) and the US Federal Records Center (FRC). In addition, Dr. Nicolas Pouvreau has recorded that large holdings also exist within the archives of the French territorial divisions.[8] The GLOSS GE XII therefore decided to carry out a new inventory exercise about international holdings of sea-level data at risk, by issuing of a questionnaire to all GLOSS focal points and member representatives of the International Hydrographic Organization (IHO).

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[3] Firing, Yvonne. L., Mark A. Merrifield, Thomas. A. Schroeder, and Bo. Qiu, "Interdecadal sea level Fluctuations at Hawaii," Journal of Physical Oceanography 34 (2004): 2514-2524.
[4] Church, John. A. and Neil. J. White, "A 20th century acceleration in global sea-level rise," Geophysical Research Letters 33(2006): L01602, accessed August 1, 2012, doi:10.1029/2005GL024826.
[5] Levitus, Sydney, "The UNESCO-IOC-IODE "Global Oceanographic Data Archaeology and Rescue" (GODAR) Project and "World Ocean Database" Projects," Data Science Journal 11 (2012): 1-26.
[6] Caldwell, Patrick, "NOAA Support for Global Sea Level Data Rescue," NOAA Earth System Monitor 14-3 (2003): 1-8.
[7] Talke, Stephen, David A. Jay, Patrick Caldwell, and Mark Merrifield, "Historical Tide Measurements in North America and the Pacific," poster (2011), Civil and Environmental Engineering Department, Portland State University, Portland, Oregon, USA.
[8] Pouvreau, Nicolas. "Three Centuries of Tide Gauge Measurements in France: Tools, Methods and Tendencies of Components of Sea Level in the Port of Brest" (Ph.D. diss., University of Rochelle, France, 2008).

2. The Questionnaire and Responses

The questionnaire was crafted through guidance of GLOSS GE and DARTG. It was sent out in early January 2012 with a deadline for May 1, 2012 (later extended to August 1, 2012). The purpose was to build an inventory of information about sea-level data in need of rescue. The primary desired information were where records reside, for what stations and dates, on which type of media, and in what condition in terms of readability and risk of loss. Specifics were also sought about the types, makes and models of the tide gauges, the recording mechanisms, clocks, data reduction, calibration, geodetic leveling, measurement of ancillary environmental parameters at the tide station, and the availability of technical, maintenance and processing notes. It is important to learn if the historical benchmarks can be linked to the existing geodetic network for a given station. A rough estimate of the volume of the physical storage media was requested. Additional questions concerned the original purpose of collecting the data, and whether copies reside in other repositories. Inquiries were also made about possible plans by the data holders to digitize the records in the near future, and if not, whether there would be scope for collaboration with other agencies/institutions to inventory and possibly rescue the data.

There was a total of 18 replies from 14 countries. Not all replies resulted in the discovery of historical data, though several mentioned that further investigations are ongoing. From the responses, nine repositories were identified as holding historical records: the Canadian Hydrographic Service (CHS), Danmarks Meteorologiske Institut (DMI), FRC, Instituto Geografico Nacional de Espana (IGN), Land Information New Zealand (LINZ), NARA, Rijkswaterstaat Waterdienst Netherlands (RWS), Servicio de Hidrografia Naval Argentina (SHN), and United Kingdom Hydrographic Office (UKHO). There is a total of 169 tide gauge stations (Figure 1, Appendix A) holding hourly or higher-frequency data at risk, and of those, 23 are within the GCN (Table 1 and Figure 2). The extensive historical sea-level data holdings identified in French repositories by Dr. Pouvreau are not included in this summary, since they are already well documented. The Tbilisi State University (TSU) also reported data holdings from three sites in the Black Sea, with a total of 126 years of monthly mean sea level. (High-frequency data are generally preferred as they allow for a greater degree of quality control and a wider range of applications).

The largest concentrations of stations are in Europe, North America and New Zealand, with a sprinkling of sites in Africa, Asia, Pacific Islands and the Caribbean. Only one site was identified in South America. The total time-span of those records adds up to 4,103 years, though excluding known gaps reduces the total to 3,259 years. (It is likely that there are additional gaps, so that number is still biased high). Data from some of those years have already been rescued and reside in GLOSS data centers. If digitized and quality controlled, these historical records could add 2,824 years of hourly data to the JASL, and 1,897 years of monthly mean sea-level data to the PSMSL. For GCN sites, they would add 324 years to the JASL and 270 years to the PSMSL.

The available non-digital records are of varying time spans (Table 2 and Figures 3 and 4). The time spans for the seven Danish sites are more than 80 years, though the degree of missing spans has not been determined. The FRC holdings for lengths greater than 30 years are most likely to have major gaps. The number of sites with newly identified series lengths greater than 30 years is 40, which represents 24% of the total, and of those, 35 series could be added to the JASL and 24 to the PSMSL. For GCN sites, rescuing those records could add spans longer than 30 years for 5 series to the JASL and 3 to the PSMSL.

The questionnaire included a number of items that could provide general technical information about the historical records (Table 3). The majority of the available historical records are in the form of analog traces. Such pen traces are also referred to as marigrams, tide graphs or tidal charts. Only about 30% of the records have already been tabulated to numerical form as hourly or high/low-tide values. The vast majority of the media used is paper; only one station used film. The media and readability are good for 40% of the sites and of varying quality for 52%, while only 2 sites were described as poor. There were no confirmations that hard copies of the records were stored in other locations. The tide-gauge type was the standard float and stilling well for 42% ; only 4% used pressure or siphon gauges. The rest had an unconfirmed gauge type, though it was assumed most were of the float/well type. Station maintenance notes were documented for 45% of the sites; only one site was without any, but the rest were unconfirmed. Ancillary parameters of temperature, atmospheric pressure, and wind were taken at three sites; 15 sets did not having other measurements, and the rest gave no information. The inquiry as to why the data were originally collected gave the main motivation as being hydrography for port operation, including tide predictions and determinations of mean sea level to define data for navigational charts. Others noted geodesy in general, which could apply to near shore or land-based applications such as defining regional or national data. For the Danish sites, the need for knowledge about extreme water levels was also noted as a motivation.

Linking the gauge data to a vertical reference level is essential for most scientific applications. Daily visual tide pole or staff readings were historically the primary means of calibration. The tide staffs are linked to a network of land-based benchmarks through periodic geodetic surveys to determine any vertical movement of the station platform and to link the tide data to regional or national geodetic data, which could be tied to the same benchmarks. Tide-pole readings were confirmed for 46% of the sites, and only one site was noted as having only some sets available; no sites were declared void of readings. For the unconfirmed set, it is assumed that most have such readings since it has always been standard practice. Benchmark maps are available for 31% of the sites, though the rest were unconfirmed except for one. Historical geodetic surveys taken at the time of data collection were reported as being available for 40% of the stations, with only one confirming that none was available; the rest were unconfirmed. For 45% of the sites, the historical data can be tied into the present geodetic network, though most were unconfirmed. All of the agencies confirmed their support to GLOSS for access to these historical records.

3. Concluding Remarks

The GLOSS 2012 data archaeology and rescue questionnaire determined that a vast amount of historical tide gauge measurements exist in non-electronic form. Those measurements augment the large summary identified in French repositories and documented by Dr. Pouvreau. However, it is also recognized that participation in the questionnaire was only moderate, considering the large number of national contacts representing GLOSS and IHO. Among the replies, several contacts mentioned that an investigation is pending. Part of the reason is that the records for a given nation probably reside in disparate locations which are not readily near the GLOSS or IHO contacts. Thus, one conclusion from this effort is that additional searches of repositories need to be undertaken; that would require support or funding from national or international entities, plus willing national scientific/hydrographic/historical champions to perform the task.

One possible avenue for enlarging the effort could be to coordinate with other international groups that have similar goals, such as the Atmospheric Circulation Reconstructions over the Earth (ACRE) program. It is likely that many of the repositories holding data of interest to ACRE could also have sea level records. Thus, for example, if an individual searching for atmospheric data came across sea-level data, then a note could be made, and vice-versa. Other lessons learned in data archaeology and upcoming plans of ACRE could be shared with GLOSS through collaborations. It is expected that a representative of the GLOSS GE will participate in the ACRE workshop in November 2012 (Toulouse, France).

The GLOSS questionnaire revealed that 24% of these discovered records are for time series with lengths greater than 30 years. Recovery of those data into scientifically-valid forms would add substantial lengths of record for many series. Such data could enhance the confidence in assessment of long-term global sea-level rise. Many other applications are possible for shorter times and/or more regional space scales, such as case studies of extreme events. The information from the GLOSS questionnaire will be made public through the GLOSS communication channels and the DARTG inventory. The inventory will be updated as new discoveries are made or if more detailed information is made available regarding missing years, such as in the case of the unknown gaps in the Danish and FRC sites. This study represents only the first stage of discovery of potential sources. It is hoped that this information will fuel the interest of researchers willing to seek funding and support for salvaging these records into computer-ready, high-quality data.

Acknowledgments

Thanks are due to Philip Woodworth, Lesley Rickards, Guy Woppelmann, Thorkild Aarup, David Jay, Stefan Talke, Sydney Levitus and Elizabeth Griffin for helpful comments during the preparation of the questionnaire and for constructive reviews of a draft of this paper. Stephen Shipman (IHO) is recognized for his support in sending the questionnaire to IHO national hydrographic contact points. Thanks are also due to the individuals and agencies that replied and provided information to the survey: Stefan Talke and David Jay (PSU, US), Shigalla Mahongo (Tanzania Fisheries Research Institute), Koos Doekes (RWI, Netherlands), Maria Jesus Garcia Fernandez (Spanish Oceanographic Institute), Puyol Montserrat Bernat (IGN, Spain), Afranio Mesquito (University of Sao Paulo, Brazil), Cesar Borba (Naval Center for Hydrography, Brazil), Juan Fierro (Hydrographic and Oceanographic Service of the Chilean Navy), Giorgi Metreveli (TSU, Georgia), Christoph Blasi (German Federal Institute of Hydrography), Palle Bo Nielsen (DMI, Denmark), June Thompson (UKHO, United Kingdom), Anne Ballantyne (CHS, Canada), David Wyatt (IHO, Monaco), Glen Rowe (LINZ, New Zealand), Angora Aman (University of Cocody, Cote d'Ivoire). Finally, thanks are given to NOAA and UHSLC for providing daily support for the author.

List of Tables

Table 1. A summary of GCN sites for recently identified non-digital sea level records.

Source	GLOSS ID	Station Name	Country	Time Span	# Yrs	Exist JASL 2012	Yrs to JASL
UKHO	0246	Cascais	Portugal	1905	1	1959-2005	1
UKHO	0248	GIBRALTAR	Gibraltar	1961-99	38	1961-2000	0
UKHO	0066	Honiara	Solomon Islands	1957–1961,1965-1968	9	1974-2009	9
UKHO	0259	Lagos Bar	Nigeria	1940-1949,51-53,69-70	15	1961-70,90-96	13
UKHO	0229	Reykjavik	Iceland	1956-63(part)	8	1984-1999	8
UKHO	0258	Tema	Ghana	1963 – 1964	2		2
IGN	0243	A Coruna	Spain	1950-1983	34	1943-2008	0
FRC	0290	Newport, RI	USA	1844-46,92-95	7	1930-2011	7
FRC	0220	Atlantic City, NJ	USA	1911-1939	29	1911-2011	0
FRC	0216	Key West, FL	USA	1847,50-52,57-59,1903	8	1913-2011	8
FRC	0289	Fort Pulaski,GA	USA	1851-52,89-92	6	1935-2011	6
FRC	0288	Pensacola	USA	1890-1939	50	1923-2011	34
FRC	0217	Galveston, TX	USA	1852-1939	88	1904-2011	52
FRC	0159	La Jolla, CA	USA	1924-1939	16	1924-2011	0
FRC	0158	San Francisco, CA	USA	1853	1	1897-2011	1
NARA	0154	Sitka, AK	USA	1893-97,1924-25	7	1938-2011	7
NARA	0206	San Juan, PR	USA	1892-1897,99	7	1977-2011	7
NARA	0073	Manila	Philippines	1901-1940	40	1984-2008	40
NARA	0116	Truk, Caroline Is.	Fed. St. Micronesia	1948-1949	2	1963-1991	2
NARA	0108	Honolulu, HI	USA	1877-1884,1892-1905	20	1877-1892,1905-2011	7
LINZ	0101	Wellington	New Zealand	1887-1944	58	1944-2010	57
LINZ	0127	Auckland	New Zealand	1899-1902	4	1984-1988	4
CHS	0156	Tofino, BC	Canada	1905-1908,1917-1948	35	1963-2010	35
CHS	0155	Prince Rupert, BC	Canada	1906-08, 1919-1942	26	1910-1918;1963-2010	26

Table 2. (A) A summary of the site counts (#) and percent of total (%) as a function of series length. The length excludes gaps. "All" pertains to the cumulative discovery of records. "JASL" refers to sites and years that potentially could be added to the JASL and similar for "PSMSL". (B) This table follows the same theme though exclusively for GCN sites.

(A)		**<=5 yr**		**5>yr<=15**		**15>yr<=30**		**30>yr<=60**		**>60 yr**	
	sites	#	%	#	%	#	%	#	%	#	%
All	169	52	31	52	31	25	15	27	16	13	8
JASL	159	54	34	48	30	22	14	24	16	11	7
PSMSL	134	51	38	46	34	13	10	20	16	4	3
(B)		**<=5 yr**		**5>yr<=15**		**15>yr<=30**		**30>yr<=60**		**>60 yr**	
	sites	#	%	#	%	#	%	#	%	#	%
All	24	5	21	8	33	4	17	6	25	1	4
JASL	20	5	25	8	45	1	5	5	25	0	0
PSMSL	15	4	27	7	47	1	7	3	20	0	0

Table 3. Summary of questionnaire responses, as site counts.

Form of Data	**Analog Trace**	**Tabulated**		
	118	51		
Storage Media	**Paper**	**Film**		
	168	1		
Media Quality	**Good**	**Varies**	**Poor**	**Unconfirmed**
	67	88	2	18
Stored Elsewhere	**No**	**Unconfirmed**		
	80	89		
Gauge Type	**Float/Well**	**Pressure/Siphon**	**Unconfirmed**	
	71	7	91	
Tide Pole Readings	**Yes**	**Some**	**Unconfirmed**	
	77	1	91	
	Yes	**No**	**Unconfirmed**	
Maintenance Notes	76	1	92	
Ancillary Data	3	15	151	
BM Maps	53	1	115	
Historic Geodetic Surveys	67	1	101	
Link to Present BM	76	1	92	
Cooperate GLOSS	169	0	0	

List of Figures

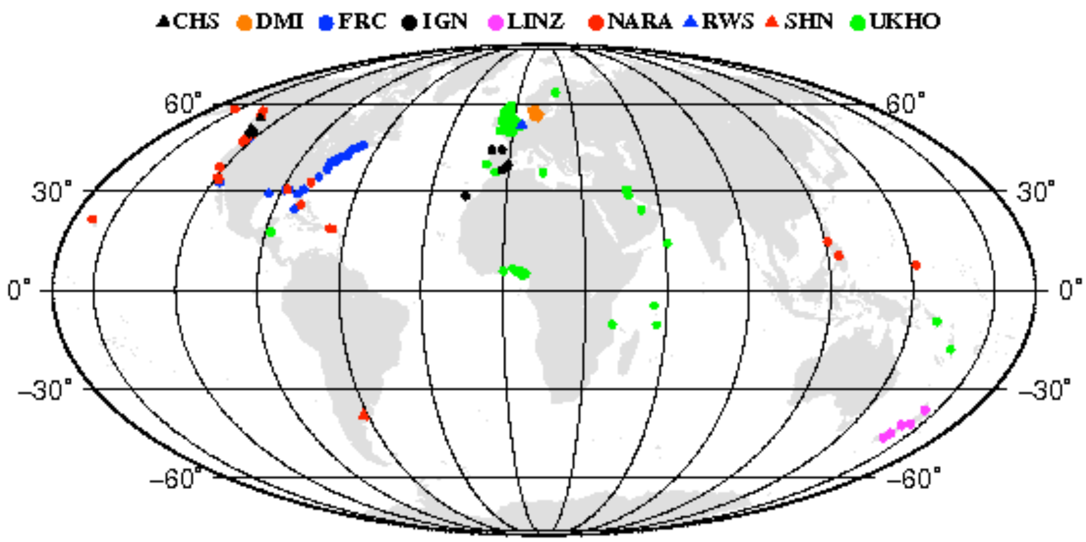

Figure 1. Plot of the station locations by repository for identified historical data in need of rescue.

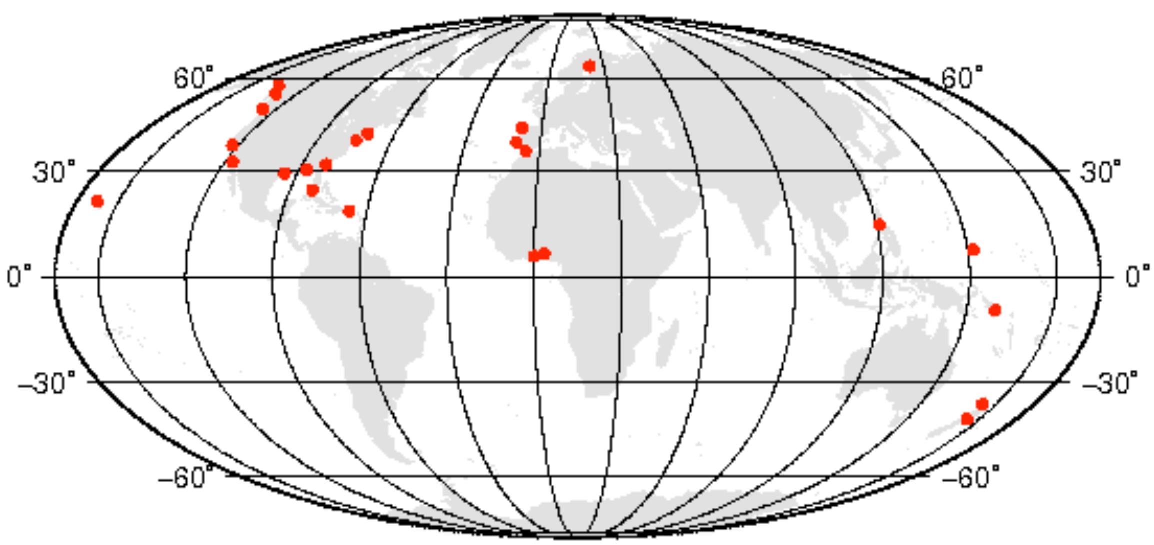

Figure 2. Map showing the locations of GCN sites with identified historical sea level data.

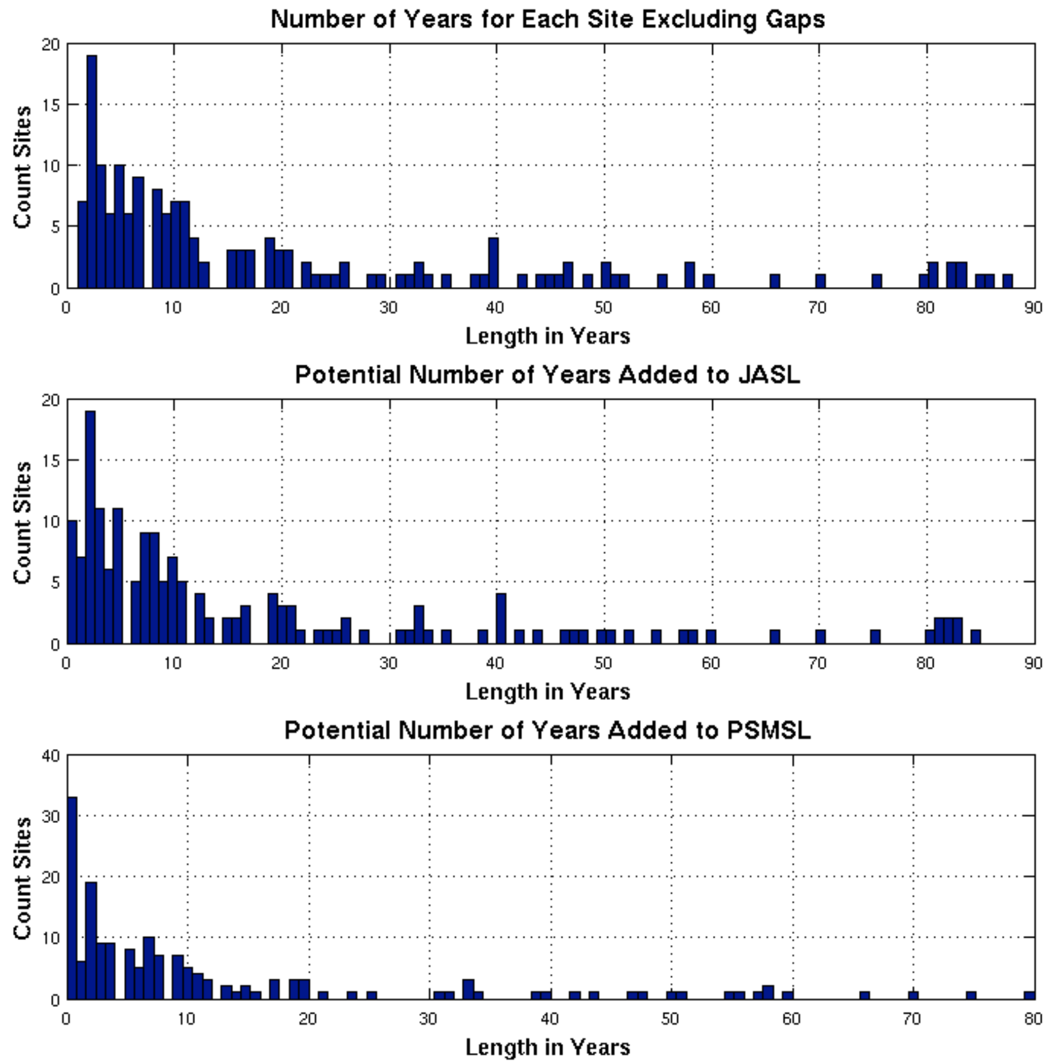

Figure 3. The site counts as a function of record length for the entire set excluding gaps, for the potential additions to the JASL, and same for PSMSL.

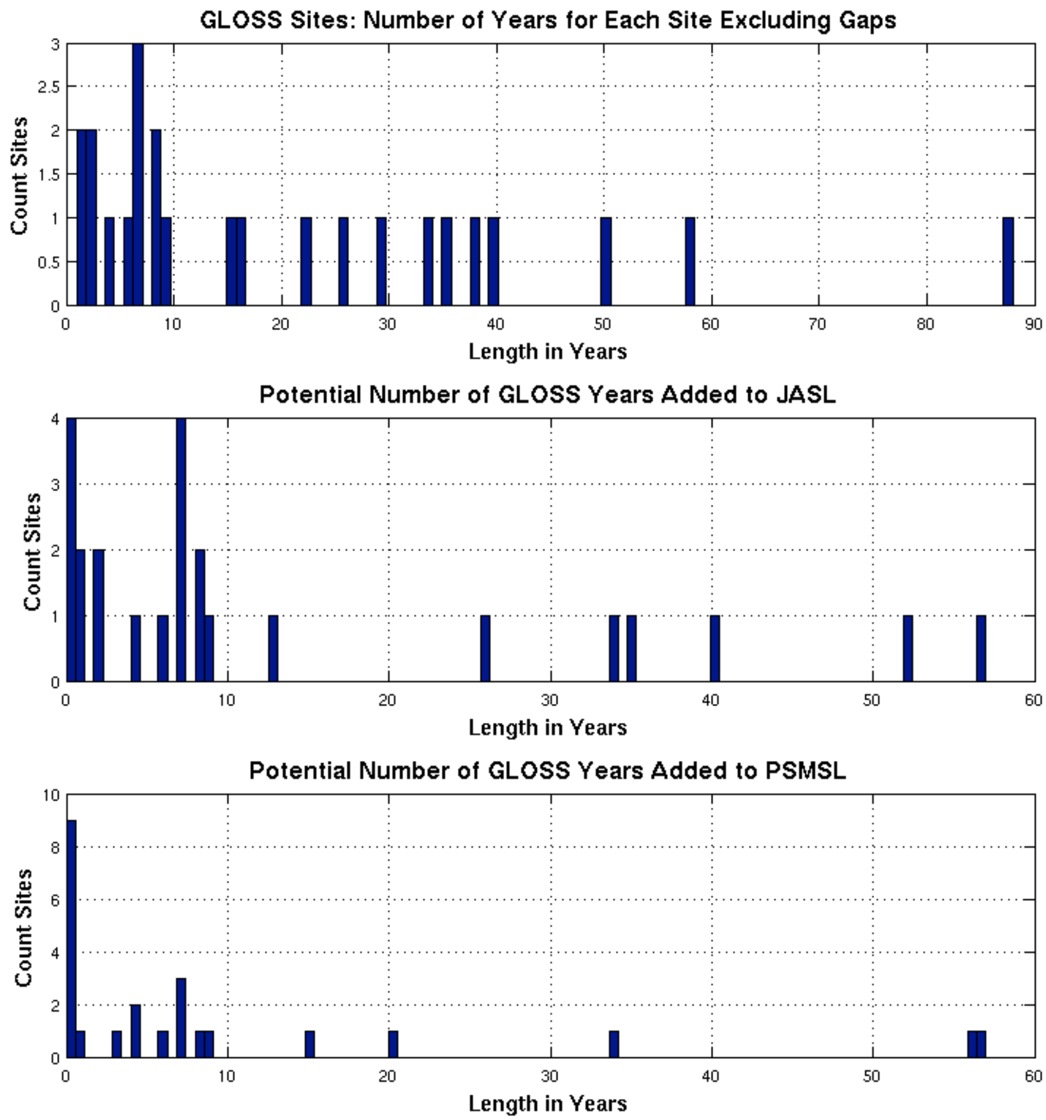

Figure 4. As for Figure 3, but exclusively for GCN sites.

Appendix A

Tide-gauge stations identified by the 2012 GLOSS questionnaire as having data at risk. The large quantity of data records in French repositories, as identified by Dr. Pouvreau, are not included.

Source	Station Name	Country	Time Span	# Yrs	Exist 2012	JASL	Yrs to JASL
UKHO	Abadan	Iran	1931-1936	4			4
UKHO	Agalega Islands	Mauritius Group	1962	1			1
UKHO	Al Basrah	Iraq	1923-1930, 1932	9			9
UKHO	BARROW (RAMSDEN DOCK)	England	1849-55,74-75,82-91	17			17
UKHO	Barrow (Halfway Shoal)	England	1992-1996	5			5
UKHO	Barrow (Roa Island)	England	1992-1996	5			5
UKHO	BELFAST	Northern Ireland	1992-1993	2			2
UKHO	Belize City	Belize	?				
UKHO	Blacktoft	England	1991-1992	2			2
UKHO	BONNY TOWN	Nigeria	1963-1967	5			5
UKHO	Bournemouth	England	1974-1990	17			17
UKHO	Burnham-On-Crouch	England	1987, 1988	2			2
UKHO	Calabar	Nigeria	1961-1970	10			10
UKHO	Cascais	Portugal	1905	1	1959-2005		1
UKHO	Castries	Windward Islands	?				
UKHO	Chatham (Lock Approaches)	England	1968-74,76-79,80-87	19			19
UKHO	Coryton	England	1989-1996	8			8
UKHO	DOVER	England	1976-1985	10			10
UKHO	DUBLIN (NORTH WALL)	Ireland	1991-1993	3			3
UKHO	Dunbar	Scotland	1969-1979	11			11
UKHO	FISHGUARD	Wales	1983-1984,1986	3			3
UKHO	Fleetwood	England	1992	1			1
UKHO	GIBRALTAR	Gibraltar	1961-1999	38	1961-2000		0
UKHO	Goole	England	1994-1996	3			3
UKHO	Gorleston-On-Sea	England	1991-1993	3			3
UKHO	Gourock	Scotland	1966.68-85	19			19
UKHO	GREENOCK	Scotland	1972-84,86-89	17			17
UKHO	Haws Point	England	1982	1			1
UKHO	Heysham	England	1986-88	3			3
UKHO	HOLYHEAD	Wales	1979-88	10			10
UKHO	Honiara	Solomon Islands	1957-61,1965-68	9	1974-2009		9
UKHO	Humber Bridge	England	1991-1992	2			2
UKHO	Ilfracombe	England	1970-71	2			2
UKHO	IMMINGHAM	England	1991	1			1
UKHO	INVERGORDON	Scotland	1915-18,59-67,69-	21			21

			86			
UKHO	Inverness	Scotland	1995	1		1
UKHO	Jabal Az Zannah	United Arab Emirates	1968-1980	13		13
UKHO	Lagos Bar	Nigeria	1940-49,51-53,69-70	15	1961-70,1990-96	13
UKHO	LARNE	Northern Ireland	1968 - 1969	2		2
UKHO	LE HAVRE	France	Various			
UKHO	LEITH	Scotland	1980-1988	9		9
UKHO	Liverpool (Alfred Dock)	England	1992-1993	2		2
UKHO	MILFORD HAVEN	Wales	1980-84	5		5
UKHO	Millport	Scotland	1987-1998	12		12
UKHO	MINA AZ ZAWR (MINA SAUD)	Kuwait	1966-1967	2		2
UKHO	Mtwara Bay	Tanzania	1954-1962	9		9
UKHO	Nab Tower	England	1934-1935	2		2
UKHO	North Woolwich	England	1989-1996	8		8
UKHO	OBAN	Scotland	1910-13,1970-72	7		7
UKHO	Ogidigbe	Nigeria	1961-1962	2		2
UKHO	Oostende	Belgium	1918,1940-44	6		6
UKHO	PLYMOUTH (DEVONPORT)	England	1953-1998	46		46
UKHO	POOLE HARBOUR	England	1957-1961	3		3
UKHO	Port Harcourt	Nigeria	1963-1967	5		5
UKHO	PORT VICTORIA	Seychelles	1962-1968	7	1977-82,1986-92	7
UKHO	PORT VILA	Vanuatu	1967-1968	3	1977-82,1993-2009	3
UKHO	PORTLAND	England	1923-28,73-84,85,87	20		20
UKHO	PORTSMOUTH	England	1936-37,39-58,61-96	58		58
UKHO	Ramsgate	England	1990-1991	3		3
UKHO	REYKJAVIK	Iceland	1956-1963	8	1984-1999	8
UKHO	ROSYTH	Scotland	1912-20,1945-89	40		40
UKHO	Sapele	Nigeria	1962-1969	8		8
UKHO	Scarborough	England	1958-1967	10		10
UKHO	Scrabster	Scotland	1966-1976	11		11
UKHO	SHEERNESS	England	1978-1987	10		10
UKHO	SHOREHAM	England	1965-70,88-97	16		16
UKHO	St. Mary's	England	1987-1988	2		2
UKHO	ST. PETER PORT	Channel Islands	1989-1995	7		7
UKHO	Stromness	Scotland	1910-1912	3		3
UKHO	Tema	Ghana	1963-1964	2		2
UKHO	TILBURY	England	1991-1993	3		3
UKHO	Tobermory	Scotland	1977-1978	2		2
UKHO	ULLAPOOL	Scotland	1981-1985	5		5
UKHO	Valletta	Malta	1870,1880,1903-26	25		25

UKHO	VLISSINGEN (FLUSHING)	Netherlands	1917-1918	2		2
UKHO	Warri	Nigeria	1915-1926	12		12
UKHO	WICK	Scotland	1979-1989	11		11
UKHO	Wicklow	Ireland	1968-1969	2		2
UKHO	ZEEBRUGGE	Belgium	1940-1944,1973	5		5
SHN	Puerto Belgrano	Argentina	unconfirmed	10		10
TSI	Gagra, Georgia, Black Sea	Russia	1926-1985	60		
TSI	Gudauta, Georgia	Russia	1928-1960	33		
TSI	Ochamchira, Georgia	Russia	1928-1960	33		
DMI	Rodbyhavn	Denmark	1955-1980	26		26
DMI	Kobehavn	Denmark	1890-1974	85		85
DMI	Korsor	Denmark	1890-1972	83		83
DMI	Slipshavn	Denmark	1890-1971	82		82
DMI	Flynshavn/Mommark	Denmark	1923-1969	20		20
DMI	Fredericia	Denmark	1890-1972	83		83
DMI	Aarhus	Denmark	1890-1970	81		81
DMI	Frederikshavn	Denmark	1890-1970	81		81
DMI	Hirtshals	Denmark	1890-1971	82		82
DMI	Hanstholm	Denmark	1950-1968	19		19
RWS	Hoek van Holland	Netherlands	1911-1931	21		21
IGN	Alicante I	Spain	1870-1874,1874-1924	55		55
IGN	Almeria	Spain	1977-1998	22		22
IGN	Cartagena	Spain	1927-28,1977-89	15		15
IGN	A Coruna	Spain	1950-1983	34	1943-2008	0
IGN	Santander	Spain	1876-1924,20-28,62-73	70		0
IGN	Tenerife	Spain	1926-1975	51	1992-2009	51
FRC	Eastport, ME	USA	1860-64,1918	6	1929-2011	6
FRC	Portland, ME	USA	1852-53,64-66,1910-11	7	1910-2011	5
FRC	Pulpit Harbor, ME	USA	1870-1888	19		19
FRC	Portsmouth, NH	USA	1926-1935	10		10
FRC	Boston, MA	USA	1847-77,1903-11	39	1921-2011	39
FRC	Newport, RI	USA	1844-46,92-95	7	1930-2011	7
FRC	Providence, RI	USA	1872-92	21		21
FRC	Fort Hamilton, NY	USA	1893-1936	44		44
FRC	Governor's Is., NY	USA	1837-1886	50		50
FRC	Willet's Point, NY	USA	1885,1890-96	8		8
FRC	The Battery, NYC, NY	USA	1920-1935	16	1958-2011	16
FRC	Sandy Hook, NJ	USA	1835-1939	105		105
FRC	Atlantic City, NJ	USA	1911-1939	29	1911-2011	0
FRC	Philadelphia, PA	USA	1890-1937	47		0
FRC	Baltimore, MD	USA	1845,53-56,63,66,76,86,98-99	11		0
FRC	Annapolis, MD	USA	1844-47,53,70	6		0
FRC	Old Point Comfort,	USA	1844-79,1906-10,	42		42

	VA		1918-19			
FRC	Wilmington, NC	USA	1882,87,90-91,1908-11	8	1935-2011	8
FRC	Charleston, SC	USA	1850-61,82-1908,10,13	31	1921-2011	31
FRC	Fort Pulaski,GA	USA	1851-52,89-92	6	1935-2011	6
FRC	Fernandina, FL	USA	1855-61,69-71,78-79	12	1897-2011	12
FRC	Mayport, FL	USA	1895-1939	45	1928-2000	33
FRC	Key West, FL	USA	1847,50-52,57-59,1903	8	1913-2011	8
FRC	Cedar Keys, FL	USA	1858-60,92-93	5		5
FRC	Pensacola	USA	1890-1939	50	1923-2011	34
FRC	Biloxi, MS	USA	1855-1920	66		66
FRC	Fort Morgan, AL	USA	1846-1920	75		75
FRC	Galveston, TX	USA	1852-1939	88	1904-2011	52
FRC	San Diego, CA	USA	1853-1872	20	1906-2011	20
FRC	La Jolla, CA	USA	1924-1939	16	1924-2011	0
FRC	Long Beach, CA	USA	1924-1934	11		11
FRC	Los Angeles, CA	USA	1852-1937	86	1923-2011	70
FRC	San Francisco, CA	USA	1853	1	1897-2011	1
FRC	Sausalito, CA	USA	1851-1897	47		47
FRC	Astoria, Tongue Pt, OR	USA	1853-1876	24	1925-2011	24
FRC	Astoria, Younga Bay, OR	USA	1931-1943	13		0
FRC	Port Townsend, WA	USA	1855,1873-77,1933-5,41,52	11		11
FRC	Seattle, WA	USA	1891-92	2		2
NARA	Fort Sumter, SC	USA	1882-1902,04-08,10,13	28		28
NARA	Presidio, San Francisco, CA	USA	1858,1871,1897-1925	52		0
NARA	Astoria	USA	1853-1858,60,76,1925	9	1925-2011	8
NARA	Olympia, Puget Sd., WA	USA	1916-1924	9		9
NARA	Craig, Prince of Wales Is, AK	USA	1914-1918,1920	6		6
NARA	Ketchikan, AK	USA	1911,1914-15,18-25	11	1918-2011	3
NARA	Kodiak, AK	USA	1880-91,1906-9,18-20,32-39,49-74	48	1975-2010	48
NARA	St. Paul, Kodiak, AK	USA	1880-1891	12		12
NARA	Sitka, AK	USA	1893-97,1924-25	7	1938-2011	7
NARA	San Juan, PR	USA	1892-1897,99	7	1977-2011	7
NARA	St. Thomas, USVI	USA	1872-75,1923-25	7		7
NARA	Manila	Philippines	1901-1940	40	1984-2008	40
NARA	Cebu	Philippines	1935-1938	4	1998-2008	4

NARA	Miami Beach, FL	USA	1931-1938	8		8
NARA	Mobile, AL	USA	1934-1937	4		4
NARA	Long Beach, CA	USA	1935-1936	2		2
NARA	Santa Barbara, CA	USA	1931-1935	4	1996-2011	4
NARA	Santa Monica, CA	USA	1933-1938	6	1973-2011	6
NARA	Friday Harbor, WA	USA	1934-1938	5		5
NARA	Olympia, Puget Sd., WA	USA	1934-1935	2		2
NARA	Toke Pt, Willapa Bay, WA	USA	1935-1938	4	1972-2011	4
NARA	Truk, Caroline Is.	Fed. St. Micronesia	1948-1949	2	1963-1991	2
NARA	Honolulu, HI	USA	1883-84,92-99,1901-4	14	1877-92,1905-2011	7
LINZ	Wellington	New Zealand	1887-1944	58	1944-2010	57
LINZ	Lyttleton	New Zealand	1883-1923	40	1994-2010	40
LINZ	Dunedin	New Zealand	1883-1899	15	1985-2010	15
LINZ	Auckland	New Zealand	1899-1902	4	1984-1988	4
LINZ	West Port	New Zealand	1901-1981	80	1984-1985	80
CHS	Tofino, BC	Canada	1905-1908,1917-1948	35	1963-2010	35
CHS	Point Atkinson, BC	Canada	1922-1961	40		40
CHS	Vancouver, BC	Canada	1901;05-08,1924-1942	23		23
CHS	Prince Rupert, BC	Canada	1906-08, 1919-1942	26	1910-18;1963-2010	26
CHS	Port Hardy, BC	Canada	1905-1909	5		5
CHS	Victoria, BC	Canada	1899-1905	7	1909-2007	7