

# ***PSMSL Report for GE/GLOSS-X***

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## **1. Introduction**

The Permanent Service for Mean Sea Level (PSMSL) is based at the Proudman Oceanographic Laboratory (POL) on the campus of Liverpool University. It is a member of the Federation of Astronomical and Geophysical Data Analysis Services (FAGS) and operates under the auspices of the International Council for Science (ICSU).

During 2006, the PSMSL helped to organize one of the most important sea level conferences in recent years on "Understanding Sea-Level Rise and Variability". It continued to provide strong support to the Global Sea Level Observing System (GLOSS) and to related projects such as the Ocean Data and Information Network for Africa (ODINAFRICA). It provided advice and assistance to a large number of people with interests in Sea Level Science, thereby fulfilling its overall obligations as a FAGS Service. Finally, and most importantly, it redoubled its efforts in its primary aim of providing the global data bank for long term sea level information from tide gauges.

The PSMSL has been based at POL (which was located at Bidston Observatory until December 2004, on the other side of the River Mersey from its present position in Liverpool) for many years, having been established in 1933 by Joseph Proudman who became its first Secretary. The functions provided by the PSMSL are in as much demand as ever, and plans are already in place to celebrate the 75th anniversary of the Service in 2008, when Liverpool will itself be celebrating its recognition as European Capital of Culture.

## **2. Staffing and funding**

The main PSMSL scientific staff concerned with the collection and analysis of monthly MSL data are Philip Woodworth, Simon Holgate and Svetlana Jevrejeva. They were joined in 2005 by Kathy Gordon whose responsibility is sea level data management. Alongside the monthly MSL collection, the PSMSL together with BODC, is responsible for an archive of delayed-mode higher-frequency sea level data (e.g. hourly values) from the GLOSS network. This activity has so far included Lesley Rickards, Elizabeth Bradshaw and other colleagues. In 2006, proposals were accepted for the merger, so far as possible, of these two delayed-mode Liverpool-based sea level activities. As a consequence, Lesley Rickards took over the Directorship of an enlarged PSMSL in April 2007.

The stimulus for this merger was the PSMSL application in 2005 to the UK Natural Environment Research Council (the parent body of POL and BODC) for continued and modestly expanded funding for the period 2007-2012 under a process called 'Oceans2025'. The proposal was graded as 'alpha-5', the highest possible, which provides a clear way forward. The PSMSL has since been able to recruit a scientist (Mark Tamisiea) with an established international reputation in geophysics and geodesy. Mark will expand the range of Sea Level Science undertaken at POL and will be able to help the PSMSL play a more active role in activities such as the Global Geodetic Observing System (GGOS). Trevor Baker retired from POL in 2005. Trevor represented the PSMSL on many occasions, and lectured at GLOSS training courses, and his expertise continues to be available on an informal basis.

## **2. PSMSL Data Receipts for 2006**

In 2006 almost 2000 station-years of data were entered into the PSMSL database, increasing the total PSMSL data holdings to over 55000 station-years. This annual increase is significantly in excess of the norm in recent years, while the geographical coverage of the data received is much wider than

normal. This reflects to some extent the enhanced levels of communication that PSMSL has been able to establish with data suppliers.

Appendix 1 lists countries from which sea level data were obtained, while Figure 1 shows their locations. Most data originated from Europe and North America. However, large data sets were also obtained from Asia, Australasia and southern Africa. Major gaps in data receipts persist in other parts of Africa which are receiving special attention through ODINAFRICA (see section 4.4 below).

### **3. Delayed Mode High Frequency (DM HF) Data Receipts for 2003-2007**

Alongside the monthly MSL collection, the PSMSL together with BODC, is responsible for an archive of delayed-mode higher-frequency sea level data (e.g. hourly values) from the GLOSS network. Approximately 686 site years of high-frequency delayed-mode were received during the period 2003-2007. Data have been added from new tide gauge installations in poor coverage areas, such as the data from the ODINAFRICA tide gauges. There have also been important datasets received from other data sparse regions, such as Indonesia, and South America (a large amount of data was submitted for Venezuela). Significant historic datasets have also been included. Data have been received from Norway, extending back to 1927 in one case, from the gauge at Tregde. Long time series have also been acquired for two of the French GLOSS sites, with the record from Brest beginning in 1860. Figure 2 provides an overview of DM HF received.

### **4. GLOUP**

The PSMSL is responsible to the IAPSO Commission on Mean Sea Level and Tides for the maintenance of the data base of pelagic (bottom pressure recorder) information. This data base, called GLOUP (Global Undersea Pressures), was maintained during the period by Chris Hughes and will receive a major update in the near future. It can be inspected at:

<http://www.pol.ac.uk/psmslh/gloup/gloup.html>

### **5. GLOSS Activities**

#### **5.1 New GLOSS and PSMSL Web Sites**

During 2005, the decision was made by the PSMSL and by the Chairman of GLOSS (Prof. Mark Merrifield, University of Hawaii Sea Level Center) and the GLOSS Technical Secretary (Dr. Thorkild Aarup, IOC) to separate the PSMSL and GLOSS web pages, thereby enabling the separate functions and organizational backgrounds of the two services to be more clearly identified. Therefore, during 2006 a dedicated GLOSS web site was established with the name:

<http://www.gloss-sealevel.org>

This web site contains an updated version of the GLOSS Handbook and revised information pages. It will continue to be maintained by the PSMSL and British Oceanographic Data Centre (BODC) on behalf of GLOSS.

The PSMSL web site will remain at <http://www.pol.ac.uk/psmsl> but will receive a fresh look in 2007.

#### **5.2 GLOSS Status from a PSMSL Viewpoint (October 2006)**

For several years, the PSMSL has provided a summary of the status of the GLOSS Core Network (GCN) from its viewpoint. A review of its status as of October 2006 can be found at the above GLOSS web site. In brief, the overall status of the programme at the present time is modestly improved compared to that a year ago, and one expects that the improvements to the network (some originating from infrastructure installed following the Sumatra earthquake and tsunami) will feed through to status improvement during the next year.

### **5.3 GLOSS Training Courses**

GLOSS training courses have been held in many countries since the mid-1980s. During 2006, two courses were held. The first was in Tokyo, Japan during May and included background information provided by the PSMSL. The second course, which the PSMSL took a lead in organizing, was in November at the IOC Project Office for IODE in Ostend, Belgium. This course was attended by participants from African countries, several of whom are to receive new tide gauges as part of GLOSS development or the ODINAFRICA programme. Training was provided in the technology of tide gauges, the software used for tidal analysis, and in the science of sea level change. Another course focusing on Africa will be held in mid-2007. PSMSL also organised a short training course at POL for technicians from Egypt, Germany and Iran in May 2007.

### **5.4 New GLOSS and ODINAFRICA Tide Gauges**

Two tide gauges from the GLOSS-Africa and ODINAFRICA initiatives have already been provided by IOC through PSMSL/POL for installation in Mozambique with a third at Karachi, Pakistan. Gauges have also been installed in Nouakchott, Djibouti and Takoradi. Others will be installed in the near future in Cameroon, Congo and Yemen, with up to 6 more following in 2007-2008, again with expert assistance from PSMSL/POL. The tide gauge stations in this set consist of a radar gauge, two pressure sensors, data logger and satellite communication equipment. A dual-use approach has been adopted such that the equipment can be used for tsunami monitoring as well for sea level studies.

In May, the PSMSL hosted Lt. Cdr. Taufeeque Rauf from the Pakistan Hydrographic Department so as to provide training prior to installation of the new GLOSS tide gauge at Karachi.

### **5.5 IOC Manual 4**

The 4th edition of the IOC Manual on Sea Level Measurement and Interpretation, which the PSMSL played a major part in writing, was finally published in 2006. Paper copies can be obtained from IOC while electronic copies can be obtained from the PSMSL training web pages.

## **6. BGAN Satellite Transmission**

The PSMSL and POL took a major interest in 2006 in the use of the Inmarsat BGAN (Broadband Global Area Network) system for real-time transmission of tide gauge data from remote stations, and especially for data of interest for tsunami warning. This telemetry enables always-on broadband internet connections to tide gauges, providing higher bandwidth and reduced latency in data transfer than available at present by systems such as Meteosat. Inmarsat were very helpful in providing test equipment, with the result that BGAN-enabled tide gauges similar to those described above for ODINAFRICA should become available in 2007. Two papers have been submitted for publication to scientific and technical journals based on our experience with the BGAN technology.

## **7. Publications**

The PSMSL has a responsibility to not only collect and redistribute sea level information, but also to analyse data and publish scientific results. The main papers published each year are listed in PSMSL Annual Reports. However, three important ones may be mentioned here. The first is the Fourth Assessment Report (4AR) of the Intergovernmental Panel on Climate Change (IPCC) which was published during 2007 with a chapter on ocean and sea level changes with Philip Woodworth as a Contributing Author.

The second follows the World Climate Research Programme workshop on Understanding Sea-Level Rise and Variability, held at UNESCO in Paris, France during 6-9 June 2006, co-organised by Philip Woodworth, John Church (CSIRO, Australia), Stan Wilson (NOAA, USA) and Thorkild Aarup (IOC). This major event attracted over 150 attendees and reviewed the entire field of past and future sea level changes (including extreme sea level as well as mean sea level), together with the reasons for change, and with methods for better monitoring and modelling them. A book is near completion with chapters

based on position papers written before the workshop and on the presentations and discussions during it.

In February 2004, the PSMSL helped to organize a two day 'Celebration of UK Sea Level Science' at the Royal Society in London, which was attended by approximately 100 UK scientists. This meeting marked the establishment of the UK National Tidal and Sea Level Facility. A Theme Volume of Philosophical Transactions of the Royal Society, containing papers based on presentations at the meeting, was published in 2006. The meeting was attended by Christian Le Provost, a long-standing friend of PSMSL and Chairman of the GLOSS Group of Experts. Christian died shortly after the Royal Society meeting and the Theme Volume was published in his memory.

### **8. Visitors to the PSMSL in 2006**

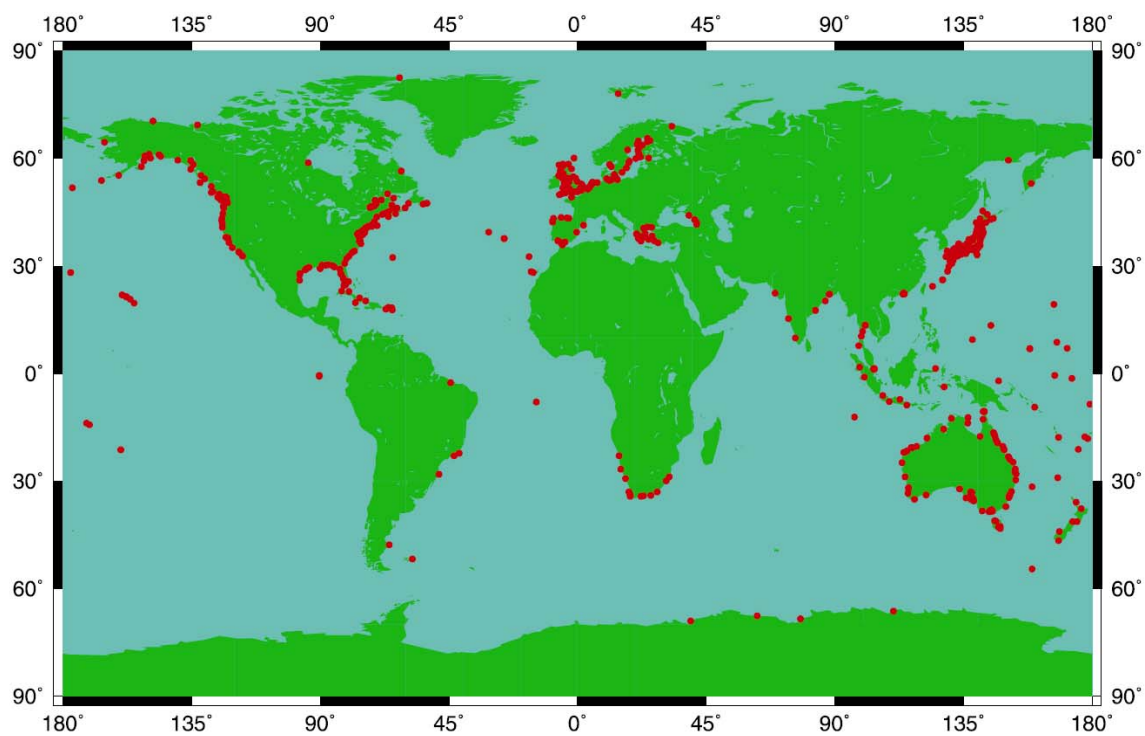
Visitors welcomed to the PSMSL during the year included Dr. Marek Ziebart (University College, London), Ross Hibbins and Gary Marshall (Bureau of Meteorology, Australia), Drs. Bob Gatliff, John Ludden and Peter Balson (British Geological Survey), Drs. Glenn Nolan and Guy Westbrook (Marine Institute, Ireland), Dr. Mark Tamisiea (Harvard-Smithsonian Centre for Astrophysics, USA), Prof. Keith Tinkler (Brock University, Canada), Mr. Graham Alcock (Auckland, New Zealand), Mr. Simon Wills (OTT UK Ltd.), Dr. Thorkild Aarup (IOC) and Dr. Brian Iddon, MP.

### **Summary**

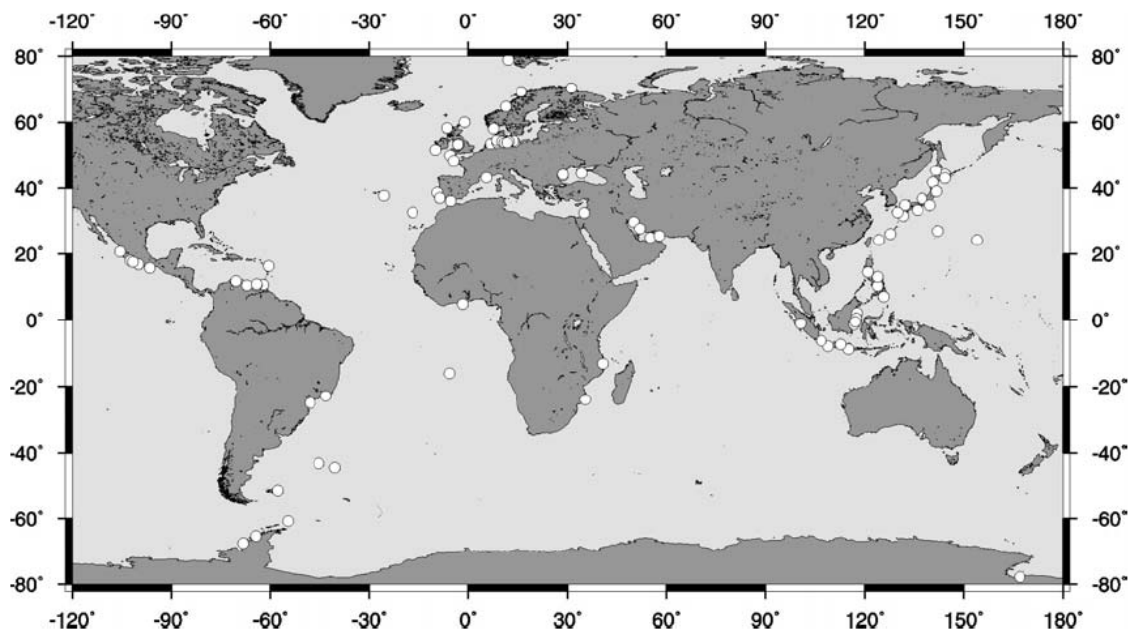
It can be seen that the period since GE/GLOSS-IX has been a further active period with regard to important workshops and conferences, and a busy one with regard to data acquisition and analysis. The functions provided by the PSMSL are in as much demand as ever, and plans are already in place to celebrate the 75th anniversary of the Service in 2008, when Liverpool will itself be celebrating its recognition as European Capital of Culture. Particular thanks as usual go to PSMSL staff and to colleagues at the Proudman Oceanographic Laboratory and British Oceanographic Data Centre who contribute part of their time to PSMSL activities.

Appendix 1: Number of station-years entered into the databank for each country or coastline in the period mid-December 2005 to mid-December 2006 (1970 total).

SPITSBERGEN	2	JAPAN (AMAMI GUNTO)	26
RUSSIAN FEDERATION (ARCTIC)	2	JAPAN (HONSHU-JAPAN SEA)	120
SWEDEN	10	PAPUA NEW GUINEA	1
FINLAND	33	AUSTRALIA	84
GERMANY (FORMER DDR) BALTIC	8	NEW ZEALAND	83
GERMANY (FORMER FRG) BALTIC	4	GUAM	2
NETHERLANDS	22	CAROLINE IS (FED. STATES OF MICRONESIA)	5
UNITED KINGDOM	42	NAURU	1
CHANNEL ISLANDS	1	MARSHALL ISLANDS	4
SPAIN (ATLANTIC)	12	KIRIBATI	1
GIBRALTAR	1	TUVALU	1
SPAIN (MEDITERRANEAN)	70	SOLOMON ISLANDS	1
GREECE	40	VANUATU	1
RUSSIAN FED. (BLACK SEA)	2	FIJI	2
GEORGIA	62	TONGA	1
SPANISH N. AFRICA	62	AMERICAN SAMOA	2
PORTUGAL (AZORES)	43	WESTERN SAMOA	1
PORTUGAL (MADEIRA)	29	HAWAIIAN ISLANDS	12
SPAIN (CANARY ISLANDS)	4	COOK ISLANDS	1
ASCENSION	2	USA (ALEUTIAN ISLANDS)	4
NAMIBIA	2	USA (ALASKA)	30
SOUTH AFRICA	56	CANADA (PACIFIC COAST)	61
INDIA	9	USA (PACIFIC COAST)	42
THAILAND (ANDAMAN SEA)	1	ECUADOR	3
SINGAPORE	28	ARGENTINA	3
INDONESIA	97	FALKLAND ISLANDS (MALVINAS)	2
SULAWESI	10	BRAZIL	51
MALUKU	10	CUBA	21
THAILAND (GULF OF THAILAND)	4	PUERTO RICO	4
HONG KONG, CHINA	6	VIRGIN ISLANDS	4
RUSSIAN FED. (PACIFIC OCEAN)	4	USA (GULF)	39
JAPAN (HOKKAIDO)	74	BERMUDA	2
JAPAN (HONSHU-PACIFIC)	171	USA (ATLANTIC)	70
JAPAN (HONSHU-INLAND SEA)	57	CANADA (ATLANTIC AND ARCTIC)	156
JAPAN (SHIKOKU)	27	ANTARCTICA	10
JAPAN (KYUSHU)	112		



**Figure 1: New PSMSL Data for 2006**



**Figure 2: New HF DM Data 2003-2007**