

# ***Report by the Permanent Service for Mean Sea Level (PSMSL) for the Period 2003-2007 to the XXIV General Assembly of the IUGG, Perugia, Italy, July 2007***

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## **1. Introduction**

This report reviews briefly the work of the Permanent Service for Mean Sea Level (PSMSL) during 2003-2007. In this period, the PSMSL has continued with its main duty, of data banking of sea level information for the scientific community. In addition, it has taken a major role in the development of the Global Sea Level Observing System (GLOSS), and has contributed to important international working groups and conferences on climate change and geophysics.

The PSMSL is operated at the Proudman Oceanographic Laboratory (POL) under the auspices of the International Council for Science (ICSU), and is a member of the Federation of Astronomical and Geophysical Data Analysis Services (FAGS). In December 2004 the PSMSL (together with other groups in POL and the British Oceanographic Data Centre, BODC) relocated from Bidston Observatory to a new building on the campus of Liverpool University with minimal disruption to normal work.

The PSMSL reports to the International Association for the Physical Sciences of the Oceans Commission on Mean Sea Level and Tides (IAPSO/CMSLT) and has an Advisory Board consisting of scientists expert in each area of sea level research. Annual reports on the work of the PSMSL are circulated each year to the International Association of Geodesy (IAG), the Intergovernmental Oceanographic Commission (IOC), IAPSO, FAGS, and other relevant bodies and are available publicly via the web at:

<http://www.pol.ac.uk/psmsl/>

This same web page also serves as a source of PSMSL data and ancillary information.

## **2. PSMSL Staff and Funding**

The main PSMSL scientific staff concerned with the collection and analysis of monthly MSL data include 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.

### **3. PSMSL MSL Data Receipts for 2003-2007**

On average, approximately 1500 station-years of MSL data were entered into the PSMSL database during each year of the period. This compares well to rates obtained in previous years. Most data originated from Europe, North America and Japan, but all regions are represented in the receipts at some level. Important data gaps in South America, Africa and parts of Asia are receiving special attention as part of the GLOSS and ODINAFRICA programmes (see below). Figure 1 indicates the locations from which data were received during 2003-2007.

### **4. PSMSL DM HF Data Receipts for 2003-2007**

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 Odin Africa 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.

### **5. GLOSS Activities**

The Global Sea Level Observing System (GLOSS) is a project of the Joint Commission for Oceanography and Marine Meteorology (JCOMM) of the Intergovernmental Oceanographic Commission (IOC) and World Meteorological Organisation (WMO). One of the main aims of GLOSS is to improve the quality and quantity of data supplied to the PSMSL. GLOSS has been one of the first components of the Global Ocean Observing System (GOOS). GLOSS network status as perceived by the PSMSL is reviewed each year and can be found at <http://www.gloss-sealevel.org>. Status reports are also presented to meetings of the GLOSS Group of Experts, which is the management committee for the programme. These meetings are held approximately every two years with the latest held in June 2007 alongside a workshop on new tide gauge technology.

GLOSS training courses have been held in many countries since the mid-1980s. In 2003, a most successful course was held at the Hydrographic and Oceanographic Service of the Navy (SHOA) in Valparaiso, Chile in which the Philip Woodworth gave several lectures on sea level science and technology. In 2004, another excellent course was held in Malaysia organized by the Department of Survey and Mapping, in which the PSMSL was represented by Simon Williams from POL. He presented a set of lectures on tides and sea and land level changes, and gave instructions in tidal analysis software packages.

Two courses were held in 2006. The first was in Tokyo, Japan and was attended by Simon Holgate. It included background information provided by the PSMSL. The second course, which the PSMSL took a lead in organizing, was at the IOC facility in Oostende, 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. A less formal course focused on Africa was held at POL in mid-2007. In addition, several African tide gauge specialists have received individual training at POL during the past four years.

### **6. Tide Gauge Network Building**

During the period, the PSMSL took the lead in the technical specification of new gauges to be installed in Africa and the western Indian Ocean as part of the Ocean Data and Information Network for Africa (ODINAFRICA) initiative of the Government of Flanders and IOC, and of Indian Ocean Tsunami Warning System developments. Following the Sumatra tsunami of December 2004 and the Katrina floods of August 2005, there is a recognition that all new gauges must be capable of real-time reporting and be able to serve operational requirements as well as scientific ones. New gauges have been provided through PSMSL for installation in Mozambique, Pakistan, Mauritania, Ghana, Cameroon, Congo, Djibouti and Yemen with up to 6 others planned in 2007-8.

An important component of the network building was a 4<sup>th</sup> edition of the IOC Manual on Sea Level Measurement and Interpretation, which was finally published in 2006 and can be obtained in electronic form from the PSMSL training web pages. Of equal importance to the tide gauge hardware itself is the form of

telemetry employed to send data to centres. The PSMSL and IOC have taken a major interest 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. BGAN-enabled tide gauges similar to those described above for ODINAFRICA should be installed in late-2007.

## **7. International Polar Year**

The PSMSL took the lead during 2005 in the preparation of a proposal for sea level measurements in the Arctic and Antarctic as part of the International Polar Year activities. The proposal was accepted enthusiastically by the international programme and has formed the basis for national bids for funding by GLOSS partners.

## **8. Altimetry and Gravity Field Activities**

Participation has continued in European and US altimeter working groups during the period. Philip Woodworth is a Principal Investigator for the US/French altimeter missions (TOPEX/POSEIDON and JASON-1) and of particular interest to the PSMSL is the symbiosis between altimetry and tide gauge measurements with gauges being used extensively by the project to calibrate the altimeter data set. Philip Woodworth and Chris Hughes of POL have during the period been members of the Mission Advisory Group (MAG) of the European Space Agency (ESA) Gravity Field and Steady State Ocean Circulation Experiment (GOCE) mission which is planned for launch at the end of 2007. This is a major development for ocean circulation and sea level studies in the next decade. POL scientists are also involved in the use of data from the US-German Gravity Recovery And Climate Experiment (GRACE).

## **9. Geodetic Fixing of Tide Gauge Benchmarks**

For the last two decades the PSMSL and the International GNSS Service (IGS) have led workshops and facilitated reports on the subject of operating GPS receivers at tide gauges in order to decouple land and sea level change. This led to the establishment of the TIDE GAUGE (TIGA) pilot project of the IGS which has the aim of studying the particular problems of operating receivers at gauge sites. The state of the art in this topic was reviewed in the Royal Society meeting referred to below. As part of what is called 'CGPS@TG' work, regular surveys have been conducted on behalf of the PSMSL and other organisations on the availability of permanent GPS stations near to tide gauges by Guy Wöppelmann of the University of La Rochelle.

## **10. 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, 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.

## 11. 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>

## 12. Publicity

The opportunity has been taken whenever possible to publicise the work of the PSMSL in newspapers and on radio and TV. Presentations were given in the period in all three media in several countries and details can be found in the PSMSL Annual Reports.

### Summary

It can be seen that 2003-2007 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 75<sup>th</sup> 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 also to the staff of POL and BODC who help us to provide the community with an extended Service.

Lesley Rickards and Philip Woodworth (July 2007)

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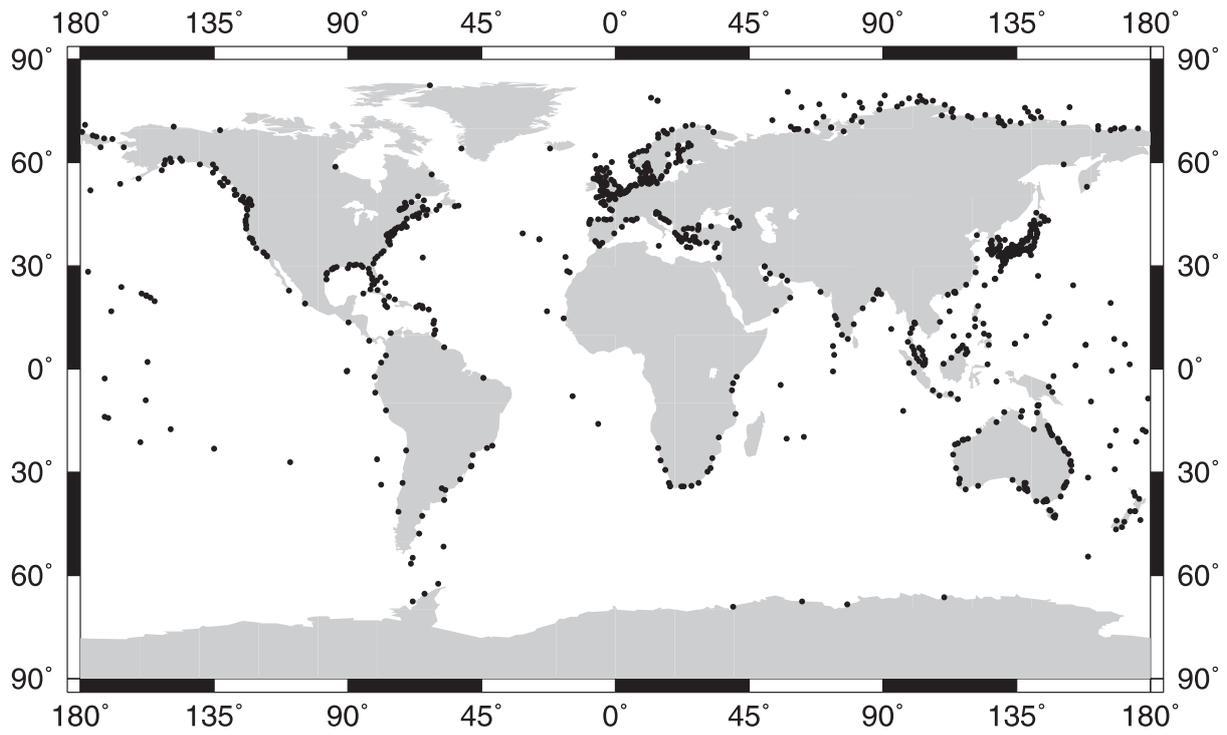
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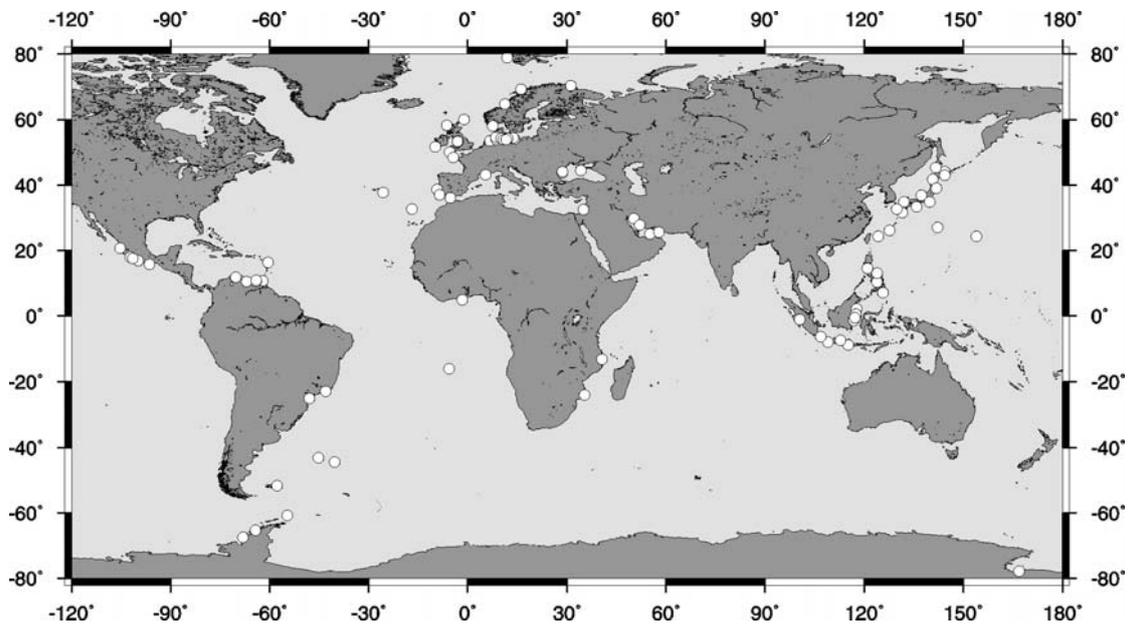
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**Figure 1: New PSMSL MSL Data 2003-2007**



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