

PSMSL Annual Report for 2002

1. Introduction

The Permanent Service for Mean Sea Level (PSMSL) is operated at the Proudman Oceanographic Laboratory (POL), Bidston Observatory and is a member of the Federation of Astronomical and Geophysical Data Analysis Services (FAGS) under the auspices of the International Council for Science (ICSU). The PSMSL reports to the International Association for the Physical Sciences of the Ocean 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/>

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

This year the PSMSL has continued with its primary task of assembly of the global data set of sea level change information and its dissemination to the research community. It has conducted scientific investigations of the data set and related information. It has also contributed strongly to the further development of the Global Sea Level Observing System (GLOSS), and has participated in important international conferences and working groups concerned with sea level and climate change. These and other activities are reviewed briefly in the following report.

2. PSMSL Staff

Two new scientists joined the PSMSL in 2002 following increased funding received from the UK Natural Environment Research Council. The first was Dr. Svetlana Jevrejeva from Tallinn in Estonia, who has published a number of papers on climate variability including studies of sea ice changes in the Baltic related to the North Atlantic Oscillation. The second was Mr. (soon to be Dr.) Simon Holgate from Liverpool University who has a background in sea-level related geology, geography and palaeo-carbon flux studies. Svetlana and Simon will lead the PSMSL data collection in future, with some continued assistance from Mrs. Rose Player.

3. PSMSL Data Receipts for 2002

In the period since the last Annual Report (i.e. since mid-December 2001), almost 800 station-years of data were entered into the PSMSL database which is a little less than the number reported in 2001. Appendix 1 lists countries from which sea level data were obtained, while Figure 1 shows their locations. Most data can be seen to have originated from Europe and North America, with continued major gaps in South America, Africa and parts of Asia which are receiving special attention through the IOC GLOSS programme (see below). A significant number of station-years are in-hand to be entered into the database, including a

large amount of information from Japan and the Arctic coast of Russia, provided to the PSMSL by the Arctic and Antarctic Research Institute via Professor Andrey Proshutinsky. The latter contains data sets covering approximately 70 locations with record lengths of 10-50 years.

4. 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).

4.1 GLOSS Status from a PSMSL Viewpoint (October 2002)

For several years, the PSMSL has provided a summary of the status of the GLOSS Core Network (GCN) from its viewpoint. During 2002, the GCN was redefined slightly, following recommendations made at the 7th Meeting of the GLOSS Group of Experts in 2001, and a review of its status as of October 2002 can be found at:

<http://www.pol.ac.uk/psmsl/programmes/gloss.info.html>

In brief, the status of the programme at the present time is near-identical to that one year ago with GLOSS considered to be approximately two-thirds operational. It is anticipated that a major review of GLOSS needs will be undertaken in 2003.

4.2 GLOSS Training Courses

GLOSS training courses have been held in many countries since the mid-1980s. During 2002, the PSMSL took the lead in planning two training courses for 2003, in Chile and Malaysia during April. Each course will contain lectures from PSMSL staff together with lectures by other invited experts and local specialists.

4.3 Workshop on Vertical Crustal Motion and Sea Level Change

In September, Prof. Mike Bevis (Univ. Hawaii), Dr. C. Le Provost (GRGS, Toulouse) and Dr. Woodworth (PSMSL) organised a study week on vertical crustal motion and sea level change and on the use of GPS at tide gauges in Toulouse, France. The week included the development of the TIGA project at GFZ, Germany which aims to better understand the uncertainties in the use of GPS in this role further. The meeting was held under the auspices of the IGS/PSMSL/IAPSO/IAG/GLOSS CGPS@TG working group.

4.4 IOC Manual 3 and PSMSL Training Web Page

An updated version of the third volume of the IOC Manuals and Guides No.14 on sea level measurement and interpretation was published finally in 2002 and can be down-loaded from the PSMSL training web page:

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

which also contains an extensive set of other sea-level related training information.

4.5 New WOCE Sea Level Data DVD

A new version of the WOCE Sea Level Data Set is now available on DVD, produced for the final conference of the WOCE programme in San Antonio in November. In addition to the 'Fast-delivery' and 'Delayed-mode' WOCE sea level data sets, the DVD contains tidal constants from the WOCE sea level data set, PSMSL monthly and annual mean sea level data set, and the GLOSS Station Handbook. The DVDs also contain data sets of other ocean parameters collected during WOCE. Copies are available from PSMSL, British Oceanographic Data Centre (BODC) or the University of Hawaii Sea Level Center, and an on-line version is available at the US NODC (www.nodc.noaa.gov/woce_v3).

4.6 GLOSS/IODE Sea Level Data Archaeology Project

In 2001, the International Ocean Data Exchange (IODE) Committee of IOC and GLOSS embarked in a project to assess how much paper-based sea level exists around the world in the form of charts, paper tape etc. and which can be potentially converted to computer-readable form. The project was led by Dr. Lesley Rickards and conclusions from the first stage of the project can be inspected via the GLOSS web page given above.

4.7 Maps of Holocene Sea Level Changes

During 2002, the PSMSL with some support from GLOSS funded the production of maps of sea level change through the Holocene period (last 10,000 years), showing the changes in coastlines which resulted. The maps form part of the PSMSL and GLOSS training materials and have been produced by Dr. Glenn Milne and colleagues at the University of Durham. They will go onto the web in early 2003.

4.8 Eighth Meeting of the GLOSS Group of Experts

Meetings of the GLOSS Group of Experts (GE) usually take place at intervals of two years. The last (GE7) took place at the University of Hawaii during April 2001 and included a scientific workshop entitled 'The Klaus Wyrтки Workshop: Observations and Integrations' concentrating on sea level science in the Pacific and held in honour of Professor Wyrтки, a further workshop concerning sea level aspects of the Asia-Pacific Space Geodynamic Project (APSG), and a workshop on GPS at tide gauges. Two reports are available via:

<http://www.pol.ac.uk/psmsl/training/gloss.pub.html>

The eight meeting (GE8) will be held at IOC headquarters in Paris in October 2003. As for previous GE meetings, the week will include several workshops, including one on the new tide gauge, GPS etc. techniques now becoming available.

5. PSMSL-Related Scientific Meetings and Study Groups

The following important meetings and study groups were attended during the year:

- Workshop on Space Gravity in Bern, Switzerland in March attended by Drs. Hughes and

Woodworth.

- First meeting of the JCOMM Observations Panel in San Diego, USA in April attended by Dr. Gary Mitchum (Univ. of South Florida) on behalf of the PSMSL.
- Opening of the Centre for Terrestrial Carbon Dynamics in Sheffield, UK in April attended by Dr. Woodworth.
- Kick-off meeting of the UK Foresight Programme on Flood and Coastal Defence at the Royal Society, London in June attended by Dr. Woodworth.
- Annual Tyndall Assembly (UK Climate Change Conference) at Manchester, UK in September attended by Dr. Woodworth.
- InterGeo2002 during Frankfurt Geodesy Week at Frankfurt, Germany in October attended by Dr. Woodworth.
- Final conference of the World Ocean Circulation Experiment at San Antonio, USA in November attended by Drs. Rickards and Hughes.
- Working group towards the Integrated Global Geodetic Observing System (IGGOS) in Munich, Germany in November attended by Dr. Woodworth.
- First meeting of the European Sea Level Service (ESEAS) in Istanbul, Turkey in November attended by Drs. Jevrejeva, Rickards, Flather and Woodworth.

Plans are already underway for PSMSL attendance at important conferences in 2003, including the four-yearly International Union of Geodesy and Geophysics (IUGG) conference in Japan in June-July at which the PSMSL will organise two important sea-level related sessions.

6. PSMSL Forum

Mr. Philip Knight of POL has written a newsgroup type software called the PSMSL Forum which allows discussion via emails of matters of importance to the PSMSL, such as developments in tide gauge technology or sea level research. The software is presently being tested by volunteers and will be released generally in 2003.

7. 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, now called GLOUP (Global Undersea Pressures), and has been managed by Dr. Chris Hughes and can be inspected at:

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

8. Publications

Appendix 2 provides a list of relevant papers published in 2001 and 2002 which have made use of PSMSL and related data. Of particular note, the Journal of Coastal Research will publish shortly an update on the work of the PSMSL.

9. Outreach

In January, Dr. Woodworth gave a presentation on monitoring and predicting sea level changes to the UK Association for Science Education which consists of most secondary school science teachers. In March, Dr. Woodworth gave a similar presentation to the Humber branch of the UK Nautical Society. In June, he was interviewed by South of England local radio on the topic of storms and sea level changes. In September, he gave a short interview on FR3 television during the CGPS@TG week in Toulouse.

10. Visitors to the PSMSL in 2002

Visitors to the PSMSL during the year included Dr. Alan Wall and Mr. Paul Hughes (Liverpool John Moores University), Dr. David Pugh (Southampton Oceanography Centre), Drs. Paul Leonard and Linda Aucott (Department for Environment, Food and Rural Affairs), Prof. Julian Orford (Queen's University Belfast), Drs. Frank Farquharson and Frank Law (Centre for Ecology and Hydrology), Dr. Ronan Le Roy (SHOM, France), Mr. Derek Flynn (UK Office of Science and Technology), Commodore Stevenson (DNSOM, Royal Navy) and First Lt. Hasan Yildiz (General Command of Mapping, Turkey).

11. Relocation of POL to Liverpool University

Plans have advanced for POL's relocation from Bidston Observatory to a new building on the campus of Liverpool University in summer 2003. This will include the relocation of the PSMSL. Our new postal address and phone and fax numbers will be advertised on the PSMSL web pages as soon as possible but our email and web addresses will be unchanged. We expect that any disruption to the work of the PSMSL will be temporary.

Summary

It can be seen that 2002 has been a further active year with regard to important workshops, international conferences and working groups. Scientific outputs, represented by the number of POL publications in sea level and related fields, are as high as ever.

Particular thanks as usual go to PSMSL staff and to colleagues at the Proudman Oceanographic Laboratory (Bidston Observatory) who contribute part of their time to PSMSL activities.

P.L.Woodworth (December 2002)

Appendix 1: Number of station-years entered into the databank for each country or coastline in the period mid-December 2001 to mid-December 2002 (797 total).

ICELAND	1	CAROLINE IS.	3
FAEROE ISLANDS	4	PALAU ISLANDS	1
SPITSBERGEN	2	NAURU	3
RUSSIAN FEDERATION (ARCTIC)	1	MARSHALL ISLANDS	5
NORWAY	21	KIRIBATI	3
SWEDEN	10	TUVALU	3
FINLAND	48	SOLOMON ISLANDS	3
GERMANY (FORMER DDR) BALTIC	32	NEW CALEDONIA	1
GERMANY (FORMER FRG) BALTIC	16	VANUATU	1
GERMANY (NORTH SEA)	3	FIJI	2
NETHERLANDS	11	TONGA	1
UNITED KINGDOM	43	AMERICAN SAMOA	1
IRELAND	1	WESTERN SAMOA	1
CHANNEL ISLANDS	1	PHOENIX ISLANDS (KIRIBATI)	1
FRANCE (ATLANTIC)	12	HAWAIIAN ISLANDS	8
SPAIN (ATLANTIC)	62	LINE ISLANDS	1
SPAIN (MEDITERRANEAN)	13	PENRHYN ISLAND	1
SPAIN (BALEARIC ISLANDS)	3	ILES DE LA SOCIETE	1
FRANCE (MEDITERRANEAN)	4	COOK ISLANDS	3
ITALY (ADRIATIC)	1	GAMBIER ISLAND	1
SLOVENIA	1	USA (ALEUTIAN ISLANDS)	2
GREECE	18	USA (ALASKA)	15
RUSSIAN FEDERATION (BLACK SEA)	1	USA (PACIFIC COAST)	20
GEORGIA	1	MEXICO (PACIFIC)	2
TURKEY	9	EL SALVADOR	2
SPANISH N. AFRICA	3	PANAMA (PACIFIC)	3
SPAIN (CANARY ISLANDS)	9	ECUADOR	3
CAPE VERDE ISLANDS	1	ARGENTINA	6
ASCENSION	2	FALKLAND ISLANDS (MALVINAS)	2
ST. HELENA	2	BRAZIL	8
NAMIBIA	1	TRINIDAD & TOBAGO	3
MOZAMBIQUE	2	GUADELOUPE	2
MAURITIUS	2	CUBA	3
CHAGOS ARCHIPELAGO	1	CAYMAN ISLANDS	5
MALDIVES	3	PUERTO RICO	2
TANZANIA	1	VIRGIN ISLANDS	9
KENYA	2	USA (GULF)	20
GULF	26	BAHAMAS	1
MUSCAT & OMAN	2	USA (ATLANTIC)	35
PAKISTAN	9	CANADA (ATLANTIC AND ARCTIC)	69
INDIA	6	GREENLAND	20
BANGLADESH	18	ANTARCTICA	7
MALAYSIA	24		
VIET NAM	20		
HONG KONG, CHINA	6		
RUSSIAN FED. (PACIFIC)	2		
JAPAN (HONSHU-PACIFIC)	6		
JAPAN (AMAMI GUNTO)	6		
SARAWAK	3		
SABAH	12		
PAPUA NEW GUINEA	1		
AUSTRALIA	16		
NORTHERN MARIANA ISLANDS	8		
GUAM			

Appendix 2: Some Relevant Reports dated 2001-2002

Dated 2001

Mathers, E.L. and Woodworth, P.L. 2001. Departures from the local inverse barometer model observed in altimeter and tide gauge data and in a global barotropic numerical model. *Journal of Geophysical Research*, 106(C4), 6957-6972.

Church, J.A., Gregory, J.M., Huybrechts, P., Kuhn, M., Lambeck, K., Nhuan, M.T., Qin, D. and Woodworth, P.L. 2001. Changes in sea level. In, *Climate Change 2001: The Scientific Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change.* (eds. J.T. Houghton, Y. Ding, D.J. Griggs, M. Noguer, P.J. van der Linden, X. Dai, K. Maskell and C.A. Johnson). Cambridge: Cambridge University Press. 881pp.

Johannessen, J.A., Le Provost, C., Drange, H., Srokosz, M., Woodworth, P., Schlüssel, P., Le Grand, P., Kerr, Y., Wingham, D. and Rebhan, H. 2001. Observing the Ocean from Space: Emerging Capabilities in Europe. pp.198-208 in, *Observing the Oceans in the 21st Century*, C.J. Koblinsky and N.R. Smith (eds), Bureau of Meteorology, Melbourne, Australia. 604pp.

Mitchum, G.T., Cheney, R., Fu, L-L., Le Provost, C., Menard, Y. and Woodworth, P. 2001. The future of sea surface height observations. pp.120-136 in, *Observing the Oceans in the 21st Century*, C.J. Koblinsky and N.R. Smith (eds), Bureau of Meteorology, Melbourne, Australia. 604pp.

Shum, C.K., Zhao, C.Y., Tseng, H.Z. and Woodworth, P. 2001. Twentieth century sea level change in the Pacific basin. pp.83-88 in, *Proceedings of the Pacific Islands Conference on Climate Change, Climate Variability and Sea Level Rise*, 3-7 April, 2000, National Auditorium, Rarotonga, Cook Islands. (eds. M.Grzechnik and J.Chittleborough). Adelaide: National Tidal Facility Australia. 88pp.

Baker, T.F., Blackman, D.L., Flather, R.A., Vassie, J.M. and Woodworth, P.L. 2001. Integrated effects of climate change on coastal extreme sea levels. *Proceedings of the 36th DEFRA Conference of River and Coastal Engineers*, Keele University, 20-22 June 2001, O3.4.1-O3.4.12.

Flather, R.A., Baker, T.F., Woodworth, P.L., Vassie, I.M. and Blackman, D.L. 2001. Integrated

effects of climate change on coastal extreme sea levels. POL Internal Document No.140. pp.20.

Heilmann, J., Aarup, T. and Woodworth, P.L. 2001. The Global Sea Level Observing System. *Ports and Harbors* (Newsletter of the Association of Ports and Harbors), 46(10), December 2001, 9-11.

Aarup, T., Adekoya, A., Aman, A., Brundrit, G., Magori, C. and Woodworth, P.L. 2001. Position Paper on the Status of GLOSS in Africa. Contributed to the GOOS-AFRICA Meeting, 19-23 November 2001, Nairobi, Kenya. Intergovernmental Oceanographic Commission, report IOC/INF-1165.

Dated 2002

Rummel, R., Balmino, G., Johannessen, J.A., Visser, P. and Woodworth, P. 2002. Dedicated gravity field missions - principles and aims. *Journal of Geodynamics*, 33, 3-20.

Woodworth, P.L., Le Provost, C., Rickards, L.J., Mitchum, G.T. and Merrifield, M. 2002. A review of sea-level research from tide gauges during the World Ocean Circulation Experiment. *Oceanography and Marine Biology: An Annual Review*, 40, 1-35.

Woodworth, P.L. and Blackman, D.L. 2002. Changes in extreme high waters at Liverpool since 1768. *International Journal of Climatology*, 22, 697-714.

Dong, X., Woodworth, P.L., Moore, P. and Bingley, R. 2002. Absolute calibration of the TOPEX/POSEIDON altimeters using UK tide gauges, GPS and precise, local geoid-differences. *Marine Geodesy*, 25, 189-204.

Woodworth, P.L. and Gregory, J.M. 2002. Benefits of GRACE and GOCE to sea level studies. *Space Science Reviews* (in press).

Woodworth, P.L. and Player, R. 2002. The Permanent Service for Mean Sea Level: an update to the 21st century. *Journal of Coastal Research* (in press).

Woodworth, P.L. 2002. Some comments on the long sea level records from the northern Mediterranean. *Journal of Coastal Research* (in press).

Woodworth, P.L. 2002. Three Georges and one Richard Holden: the Liverpool tide table makers.

Transactions of the Historical Society of Lancashire and Cheshire (in press).

Visser, P.N.A.M., Rummel, R., Balmino, G., Sunkel, H., Johannessen, J., Aguirre, M., Woodworth, P.L., Le Provost, C., Tscherning, C.C. and Sabadini, R. 2002. The European Earth Explorer Mission GOCE: impact for the geosciences. pp.95-107 in, Ice Sheets, Sea Level and the Dynamic Earth. Geodynamics Series 29, American Geophysical Union, eds. J. Mitrovica and L.L.A. Vermeersen.

IOC. 2002. (Woodworth, P.L. contributor to) MedGLOSS workshop and coordination meeting for the pilot monitoring network system of systematic sea level measurements in the Mediterranean and Black Seas. Report of meeting 15-17 May 2000, Haifa, Israel. Intergovernmental Oceanographic Commission Workshop Report No. 176.

Aarup, T., Merrifield, M., Shum, C.K. and Woodworth, P.L. 2002. Abstracts of presentations at workshops during the 7th session of the IOC Group of Experts on the Global Sea Level Observing System (GLOSS). Intergovernmental Oceanographic Commission, workshop report No. 180.

Woodworth, P.L. (ed.) 2002. Manual on sea-level measurement and interpretation. Volume III: Reappraisals and recommendations as of the year 2000. Intergovernmental Oceanographic Commission, Manuals & Guides, No 14, 47pp. & appendices.

Aarup, T. and Woodworth, P. 2002. The Global Sea Level Observing System. IALA Bulletin (Magazine of the International Association of Marine Aids to Navigation and Lighthouse Authorities) No. 2002/3, 6-9.

Woodworth, P.L., Hughes, C.W., Whitworth, T. and Pyne, A. 2002. Coherence of sub-surface pressure variability around Antarctica. Abstract for the International WOCE Conference, Texas, November 2002.

Figure 1 New PSMSL Data 2002

