Report by the Permanent Service for Mean Sea Level (PSMSL) for the Period 1999-2001 to the IAG Scientific Assembly, Budapest, September 2001

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1. Introduction

This report reviews briefly the work of the Permanent Service for Mean Sea Level (PSMSL) from mid-1999 to mid-2001. In this period, 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 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 and geophysics.

The PSMSL is operated at the Proudman Oceanographic Laboratory (POL), Bidston Observatory 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). 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/

This same web page also serves as a source of PSMSL data and ancillary information. Copies of PSMSL data can also be provided on CD-ROM and via other media.

2. PSMSL Data Receipts for 1999-2001

Approximately 2200 station-years of data were entered into the PSMSL database during this period from the locations shown in Figure 1. This is slightly lower rate of receipts than in previous years (see the PSMSL Report to the IUGG/IAPSO/IAG for the period 1995-99). Data receipts are expected to return to previous levels during 2001. Most data can be seen to have originated from Europe, North America, Japan, Australia and the Pacific, with major gaps in South America, Africa and parts of Asia which require special attention. To some extent, the regional gaps can be considered to be a fluctuation, as data have been received from some stations in these regions in previous years. In addition, data from several stations are awaiting checking prior to entry into the data base. Nevertheless, there is clearly a long-standing problem with the availability of data from these regions which will require investment both nationally and internationally (e.g. through GLOSS, see below).

3. GLOSS Activities

The Global Sea Level Observing System (GLOSS) is an IOC project, one of the aims of which is to improve the quality and quantity of data supplied to the PSMSL. GLOSS can be considered as one of the first components of the Global Ocean Observing System (GOOS) with the PSMSL taking the lead role in its development. A major GLOSS Experts meeting (in Honolulu, Hawaii, USA in April 2001) was organised during the period with several other smaller related meetings organised on an *ad hoc* basis. The GLOSS programme is now operated under the auspices of the new Joint Commission for Oceanography and Marine Meteorology (JCOMM) of IOC and the World Meteorological Organisation (WMO), rather than the IOC alone, following major changes to the organisational structures of the programmes of both organisations.

3.1 GLOSS Status

Each year the PSMSL has provided a summary of the status of GLOSS from its viewpoint, the most recent of which can be inspected via the above web page. The status of the programme at the present time is near-

identical to that two years ago. GLOSS can be considered approximately two-thirds operational, if one uses data receipts by the PSMSL as a guide to operational status, or somewhat better if one considers several factors discussed in detail in the PSMSL 1999 Annual Report. However, these status summaries hide major problems in several regions, with expenditure in new tide gauge equipment in a number of countries, and the network improvements which result, balanced against the fact that many GLOSS stations in other countries are being terminated or require major upgrades. In addition, the investments made in gauges for international programmes (notably WOCE) are unlikely to be repeated in future. Consequently, it is possible that GLOSS status, measured in terms of PSMSL receipts, may have reached a plateau.

This pessimism is contradicted to some extent by the stated requirements for investment in regional networks of coastal tide gauges by, for example, the IOC GOOS COOP (Coastal Oceans Observations Panel). Therefore, GLOSS status may receive a boost in the long term from 'coastal', rather than 'climate' or 'oceanographic', applications. Whatever the scientific emphasis, investment in equipment and training is a priority in many countries. During the past year, the PSMSL has been working closely with the IOC GLOSS Technical Secretary (Dr. Thorkild Aarup) to investigate possibilities for obtaining additional funding for the programme.

3.2 GLOSS-Related Reports

The PSMSL maintains a list of reports relevant to the development of GLOSS at the above web page. During the past year, many of these reports have become available in PDF (Acrobat) format down-loadable from the IOC and/or UNESCO electronic libraries. See the above web file for which reports are available this way.

3.3 GLOSS Handbook

Sea level researchers will be familiar with the GLOSS Handbook product available on the above web page. This product is edited by Dr. Lesley Rickards of the British Oceanographic Data Centre (BODC). Lesley has now commenced major updates towards a 2001 version. GLOSS Contacts can be expected to be asked to provide information.

3.4 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 has been completed and can be down-loaded from the PSMSL training web page which also contains an extensive set of other sea-level related information.

3.5 New WOCE Sea Level Data CD-ROM

Version 2.0 of the WOCE Sea Level Data set is now available. In addition to the 'Fast-delivery' and 'Delayed-mode' WOCE sea level data sets, the CD-ROM contains tidal constants from the WOCE sea level data set, PSMSL monthly and annual mean sea level data set, and the GLOSS Station Handbook (Version 4.1). Copies are available from PSMSL, BODC or the University of Hawaii Sea Level Center. The Sea Level CD-ROM is a contribution to the WOCE Global Data (Version 2.0) CD-ROM set (15 CDs). Copies of the complete set are available from the US National Oceanographic Data Center, Silver Spring, USA.

3.6 Proposal for a Sea Level Data Archaeology Project

At the 2000 IOC International Oceanographic Data and Information Exchange (IODE) XVI Committee meeting several extensions to the Global Ocean Data Archaeology and Rescue (GODAR) project were suggested. The PSMSL proposed a data archaeology project for historical sea level records with the aim of extending existing time series and gaining access to observations which are not in digital form. In many countries there are considerable amounts of historical sea level data in paper form such as charts or tabulations. These need to be computerised to provide electronic access, as backup for data security, and so that they can be subject to modern quality control and analysis. The original records would not be destroyed, as they may contain further information which is not captured by the computerised version (for example, charts digitised to hourly values might miss tsunami or seiche information) and also, in some cases, they are historic documents. The IODE Committee supported the proposal and recommended that the sea level archaeology project should be co-ordinated by GLOSS, with the GODAR Project Leader acting as advisor to the project. The GLOSS Secretariat will now encourage all countries to assess their holdings of historical tide gauge data which can potentially be rescued and convey that information to the PSMSL, which will act as a contact point. Following on from this,

IOC/GLOSS will aim to put countries in touch with each other and with sea level organisations with regard to collaborative data rescue.

4. Geodetic Fixing of Tide Gauge Benchmarks

In April 2001, a meeting on tide gauge benchmark fixing using GPS and absolute gravity was held at the University of Hawaii prior to the meeting of the GLOSS Experts. This meeting was organised under the auspices of the joint working group of the IGS, PSMSL, IAPSO/CMSLT, IAG (SC8 of Section V, Sea level and ice sheets) and IOC/GLOSS and was the latest meeting in a series which commenced at the Jet Propulsion Laboratory in 1997. A web document on 'How to Operate GPS at Gauges' edited by Prof. Mike Bevis is available via:

http://www.soest.hawaii.edu/cgps_tg

Surveys have been conducted on behalf of the PSMSL, EUREF and other organisations on the availability of permanent GPS stations near to tide gauges. They was undertaken by Dr. Guy Woppelmann of SHOM, France and results can be found via:

http://sonel.ensg.ign.fr/stations/cgps/cgps_survey.html

This web page also contains a mechanism by which the community should be able to keep the information up-to-date as a 'living document'.

5. Intergovernmental Panel on Climate Change (IPCC) Third Assessment Report

The Third Assessment Report (TAR) of the Intergovernmental Panel on Climate Change (IPCC) has continued under development in 1999-2001 with Chapter 11 on sea level changes led by Dr. J. Church (Australia) and Dr. J. Gregory (UK) and with Dr. Woodworth as a Lead Author. Chapter meetings took place in New Zealand in February 2000 and Canada in July 2000 with final publication of the TAR in January 2001.

6. Altimetry and Gravity Field Activities

Participation has continued in US and European altimeter working groups during the period. Dr. Woodworth is a Principal Investigator for the TOPEX/POSEIDON and JASON-1 missions and a Co-Investigator for the ERS and Envisat missions. Of particular interest to the PSMSL is the symbiosis between altimetry and tide gauge measurements with gauges being used extensively by the projects to calibrate the altimeter data sets. In December 2000, Dr. Xiaojun Dong from the Shanghai Astronomical Observatory joined the sea level group at POL through a Fellowship from the Royal Society, with the object of researching the best methods for ongoing altimeter calibration using tide gauge data. Interest has also continued in upcoming space gravity missions including the Gravity Recovery And Climate Experiment (GRACE) mission and the Gravity Field and Steady State Ocean Circulation Experiment (GOCE) mission. Drs. Hughes and Woodworth are closely involved in both these projects.

7. European and Arctic Projects

For the past four years, the European Union (EU) EOSS project has aimed to enhance sea level (tide gauges) and land level (GPS) monitoring, and associated data exchange in Europe, primarily by sets of bilateral (i.e. no new cost) agreements. The project (chaired by Prof. H-P. Plag from Norway) ends in September 2001 with an international conference in Dubrovnik, Croatia. A position paper on the status of sea level recording in Europe can be obtained from the PSMSL. At the time of writing, the first Call for Participation is being issued for a new European Sea Level Service (ESEAS) which it is hoped will continue and extend the work of EOSS, and put the provision of sea and land level information from Europe on a sounder basis. A report on the status of sea level recording in the Arctic has also been completed by Prof. Hans-Peter Plag and may also be obtained from the PSMSL.

10. Publicity

The PSMSL has endeavoured to publicise sea level data and their use as often as possible through brochures, web pages, newspaper and TV articles, seminars etc. Open Days took place at POL (including PSMSL) on

several occasions during the period, attended by approximately 2000 members of the public on each occasion, as well as local dignitaries and Members of Parliament.

11. PSMSL Staffing

Mrs. Elaine Spencer, who had been PSMSL Technical Secretary since 1974, left the PSMSL in 1999. Elaine was awarded an MBE in the 2001 UK New Year's Honours List for her 25 years of work with the PSMSL. Elaine's duties have been taken over by Mrs. Rose Player. Later in 1999, Mrs. Sally Dowell departed PSMSL/WOCE Centre after several years at POL. Her role has been filled in the short term by a temporary contract position. Dr. Philip Axe left PSMSL in August 2000, after completing his PhD, to take up an oceanographic position in Sweden. Phil had played major roles in data provision from the South Atlantic and Europe. Also in August, Mr. Graham Alcock took early retirement. Graham was closely involved in PSMSL and GLOSS matters for over 20 years, being the main organiser of over 10 GLOSS training courses at POL, having represented PSMSL and GLOSS at many international meetings, and having authored several important GLOSS reports. Graham is presently combining retirement activities with sea-level consultancy and may be contacted through the PSMSL. It will be appreciated that, with the departure of several people closely involved in international sea level work at POL, priorities have had to be reassessed. This means that while some activities will continue as before (e.g. the maintenance of the PSMSL data set), some others (e.g. hosting of GLOSS training courses at POL) will not be possible in the short term.

On more positive notes, Dr. Simon Williams was appointed to the GPS and absolute gravity group at POL in 1999 which will benefit the land movement studies discussed above. In addition, the appointment of Dr. Thorkild Aarup to the post of GLOSS Technical Secretary at IOC in 1999 has been a major boost to GLOSS coordination.

12. More Information?

For further information on the above points or others, please consult the PSMSL web pages or email psmsl@pol.ac.uk.

Figure 1 New PSMSL Data