6. SEA LEVEL CENTRES

Sea level data have been collected for many years and historically, in some cases, data may have been archived at a national level, albeit in a rather ad hoc fashion, with little or no uniformity between one centre and the next. The one exception to this nationally based system is the Permanent Service for Mean Sea Level (PSMSL), an international sea level centre, responsible for monthly and annual mean sea levels, which is described in more detail below in section 6.3. More recently there has been a need for sea level measurements to be made available as part of large scale science programmes, for example the Tropical Ocean Global Atmosphere (TOGA) Programme and the World Ocean Circulation Experiment (WOCE).

The advantages of maintaining data in a recognised centre include the protection of the long term value of the data by storing them in a professionally managed archive, making value added products available - and high quality data will be available to a wide user community. Interactions between scientists, data collectors and data centres will result in data banks of benefit to the scientific community. In addition to the above, research workers will be encouraged to edit and document their data. The data will be available in a single format rather than in a multiplicity of formats.

To be fully effective, a sea level data bank must be more than simply a collection of numerical values; these must also be qualified by additional information concerning methods of measurement and subsequent data processing. The accompanying information needed is given in Table 6.1. A certain amount of validation and quality control will be carried out on the data by the data centre. This may vary depending on the function of the data centre, but should include checking data values for spikes, gaps and physically unreasonable values. For hourly values the residuals produced by tidal analysis of the data can be screened to check for datum shifts, timing problems and other errors. Data from adjacent stations may be compared to check out unusual signals. Qualifying information accompanying the data can also be checked.

Science programmes like TOGA and WOCE bring with them their own special needs - for example, there is a demand for quality controlled data, easy access for researchers to the data and for the data to be made available on a reasonable time scale. Perhaps more importantly, scientific experiments have a finite lifetime, and so at the end of a project, the data must be passed on to a long term archive to protect both the data and the investment in effort and money in the collection of the data.

Moreover, it is becoming increasingly important to have access to long time series of data for studies relating to climate change. The length of sea level records is a unique asset here with some records extending back 100 years or more. As more science turns to look at long term trends these interdecadal data sets will assume even greater importance. Thus it is essential that these valuable data sets are maintained.

In addition to compiling a high quality bank of sea level data these data must be made readily available to users in a suitable form. This may be a magnetic tape in the IOC standard format GF3 of sea level data series or it may be some other value added product - for example, the IGOSS Sea Level Programme in the Pacific (ISLP-Pac) produces monthly mean sea level

Each data series should include entries for the following :

- Country and organisation responsible for data collection and processing
- Originator's identifier for the series (e.g. site name and year)
- Geographical location (latitude and longitude)
- Dates and times of the start and end of the data series

Sufficient plain language documentation should accompany the data so as to ensure that they are adequately qualified and may therefore be used with confidence by a secondary user.

- Instrument
  a) Instrument description, manufacturer, model, principle of measurement, method of recording - refer to publication or briefly describe
  b) Instrument modifications and their effect on the data
  c) Method and times of calibration, to include calibration factors
  d) Frequency of cleaning, control of biological fouling
  e) Operational history
  f) Pertinent instrument characteristics; for example, for a conventional stilling well, information should include well diameter, orifice depth below mean water level and orifice height above sea bed; for a bubbler gauge - tube length, tube diameter, orifice diameter, density value used to convert to elevation, acceleration due to gravity and the formula used to compensate for tube length.
- Site
  a) Brief description of location of tide gauge
  b) Description of tide gauge benchmarks
  c) Datum relationships
  d) Datum history
- Data sampling/processing

  Brief description of processing procedures used to obtain final data values including:
  a) Sampling scheme e.g. continuous recording, instantaneous, averaged
  b) Interval between samples and duration of individual samples (raw data)
  c) Number of raw data samples
  d) Nominal interval of processed data
  e) Gaps in the data record
  f) Timing and/or datum corrections applied
  g) De-spiking/smoothing/interpolating methods and editing procedures

Report any additional item or event that may have affected the data, or have a bearing on the subsequent use of the data.

TABLE 6.1: Information required to accompany the data

anomaly maps. These are distributed as hard copy maps, but additionally, the data that goes to make up the maps are available over computer networks.

A brief description is given below of a selection of the major sea level centres currently in existence showing the variety of work in progress. Contact names and addresses are given in Appendix 2.

6.1 TOGA SEA LEVEL CENTRE

Through interest in ocean-atmosphere coupling and the predictability of climate changes from months to years, the World Climate Research Programme initiated the Tropical Ocean Global Atmosphere (TOGA) Programme, a ten-year programme that began in 1985 and continues until 1995. One of the key observational components of the TOGA programme is the sea level. In 1985, the TOGA Sea Level Centre (SLC) was created at the University of Hawaii (UH) to concentrate the efforts of acquiring, processing, and archiving sea level data from the tropics.

The data are received at the TOGA SLC from the sea-level stations located in tropical and sub-tropical zones of the World's Oceans.

The TOGA programme requires daily sea level values from sites identified in the implementation plan (International TOGA Programme Office, 1987). However, requests are made for hourly heights, which have proven necessary for thorough quality control.

As the quantity of data collected by the TOGA SLC increased, expertise in data management was provided by the National Oceanographic Data Centre (NODC) with the establishment of the Joint Archive for Sea Level (JASL) at UH in 1987. The JASL supports the TOGA SLC in the collection, quality assurance, management, and dissemination of the data.

The TOGA SLC prepares scientifically valid, well-documented, standardised sea level data sets of hourly, daily, and monthly values. As of July 1993, 239 stations (Figure 6.1) with 2650 station-years of quality assured data from the tropical oceans have been passed to PSMSL and the World Data Centre-A for Oceanography, which ensures wide spread advertisement of the data availability and allows easy access for the scientific and public communities (TOGA Sea Level Centre: Annual Report for the year ending July 1993. Data Report No. 11).

6.2 WOCE SEA LEVEL DATA ASSEMBLY CENTRES

The international WOCE programme is establishing two sea level data assembly centres, responsibility for this has been vested jointly in the University of Hawaii and the British Oceanographic Data Centre. The first goal of WOCE requires sea level data for joint use with satellite altimetry data and for geostrophic computations of specific currents, for example, through straits. Sea level data will also serve as a check on the validity of numerical model outputs. The second goal of WOCE, determining the representativeness of the WOCE data set for the long term behaviour of the ocean, will be addressed by comparing by comparing sea level measurements made during WOCE with those held by the Permanent Service for Mean Sea Level. The University of Hawaii will build upon its experience gained in the TOGA experiment and will make higher frequency (i.e. hourly) data available in a more timely way. The sea level data set for WOCE must be not only delivered more quickly, but also must have

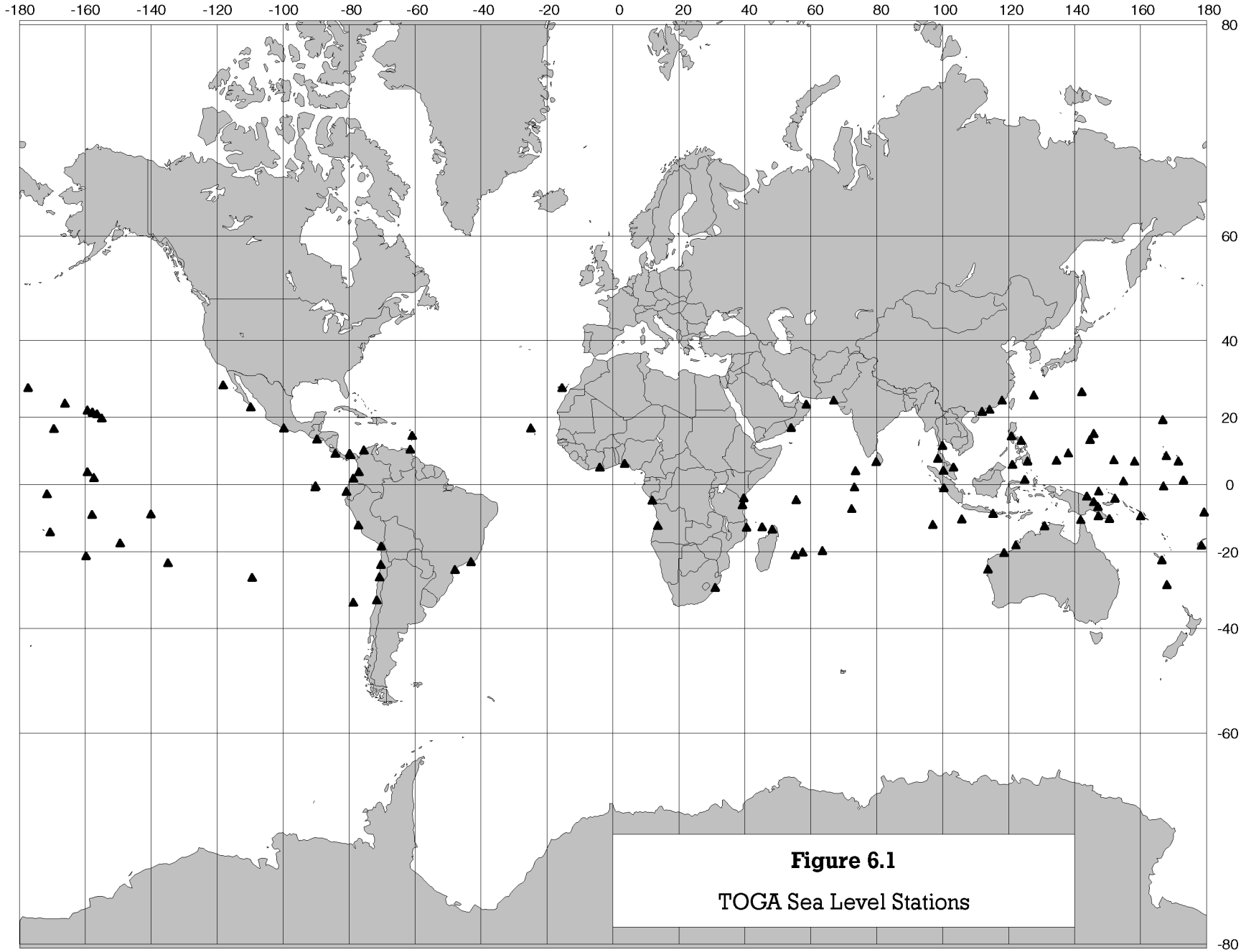

Figure 6.1

TOGA Sea Level Stations

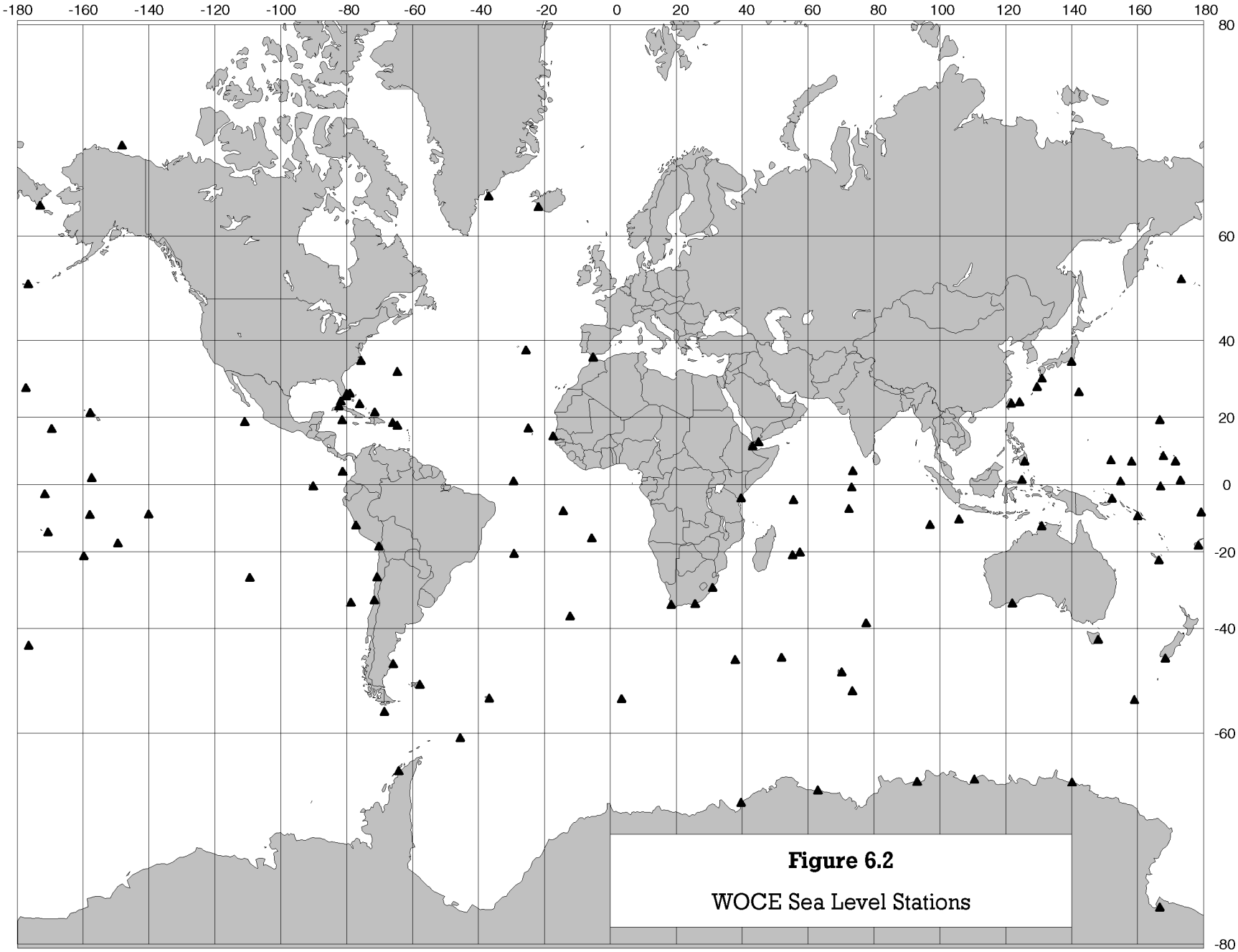

Figure 6.2

WOCE Sea Level Stations

a good global distribution to be of maximum use for the global altimetry data sets. Data will primarily be from gauges transmitting data by satellite, but will also include other data which can be rapidly supplied. Between 40 and 100 gauges will be included in the network. The data processing and distribution system will be improved to enable processed data to be available within 2-3 months of collection, that is, on a similar timescale to the satellite altimetry data.

BODC will assemble, distribute and supply sea level data to the full extent of quality control possible covering all of the 100 or so gauges (Figure 6.2) in the WOCE network. WOCE requires that the elevations should be accurate to 1cm, the timing to 2 minutes and the atmospheric pressure measurements to 1 mbar. Quality control will include checking for reasonable values, tidal analysis to remove tidal variation to enable screening of the residuals as a diagnostic for datum shifts and timing errors. Unusual signals will be compared against adjacent stations. Regular summaries of the data available are being produced for the scientific community. Close collaboration will be maintained between the scientists, BODC, TOGA centre and the PSMSL. Distribution of the data to the scientific community should be possible within 18 - 24 months after data collection. BODC will also ensure archival of the sea level data as a WOCE data set in the World Data Centre system.

6.3 THE PERMANENT SERVICE FOR MEAN SEA LEVEL (PSMSL)

Established at Bidston Observatory, Birkenhead, U.K. in 1933, PSMSL acts as an international repository for mean sea level information. PSMSL also acts as a global mean sea level assembly centre for GLOSS. PSMSL is a member of the Federation of Astronomical and Geophysical Data Services (FAGS) of the International Council of Scientific Unions (ICSU). Under the aegis of the International Association of the Physical Sciences of the Ocean (IAPSO), the PSMSL is charged with the collection, dissemination and analysis of mean sea level data. The activities of the PSMSL are supported through FAGS, through the IOC, and by the United Kingdom Natural Environment Research Council (NERC). Monthly and annual mean values of sea level are sent to PSMSL by national authorities, together with details of gauge location, missing days of data and a definition of the datum to which the measurements are referred. Received data are checked for consistency. If possible values are reduced to Revised Local Reference (RLR); this involves the identification of a stable permanent benchmark close to the tide gauge and the reduction of all data to a single datum which is referred to this benchmark. This ensures continuity with subsequent data. Records of monthly and annual values of mean sea level have been assembled from over 1500 sea level stations in more than 100 countries (Figure 6.3). There are 518 stations for which the PSMSL has at least 20 years of data and 115 stations have data from before 1900. In addition from 1991, geodetic measurements are being data banked at PSMSL.

Analyses produced from the mean sea level data bank include statistics of local and global trends and seasonal variations. They also include the identification of anomalously high or low levels which may occur in particular areas. The aim is to produce summaries which may be used for direct comparison with data from other scientific studies, such as climatology, ocean circulation variability and vertical land movements.

In 1991 PSMSL produced a report 'Data Holdings of the PSMSL' which contains an updated catalogue of their data holdings together with addresses of national sea level authorities. Data

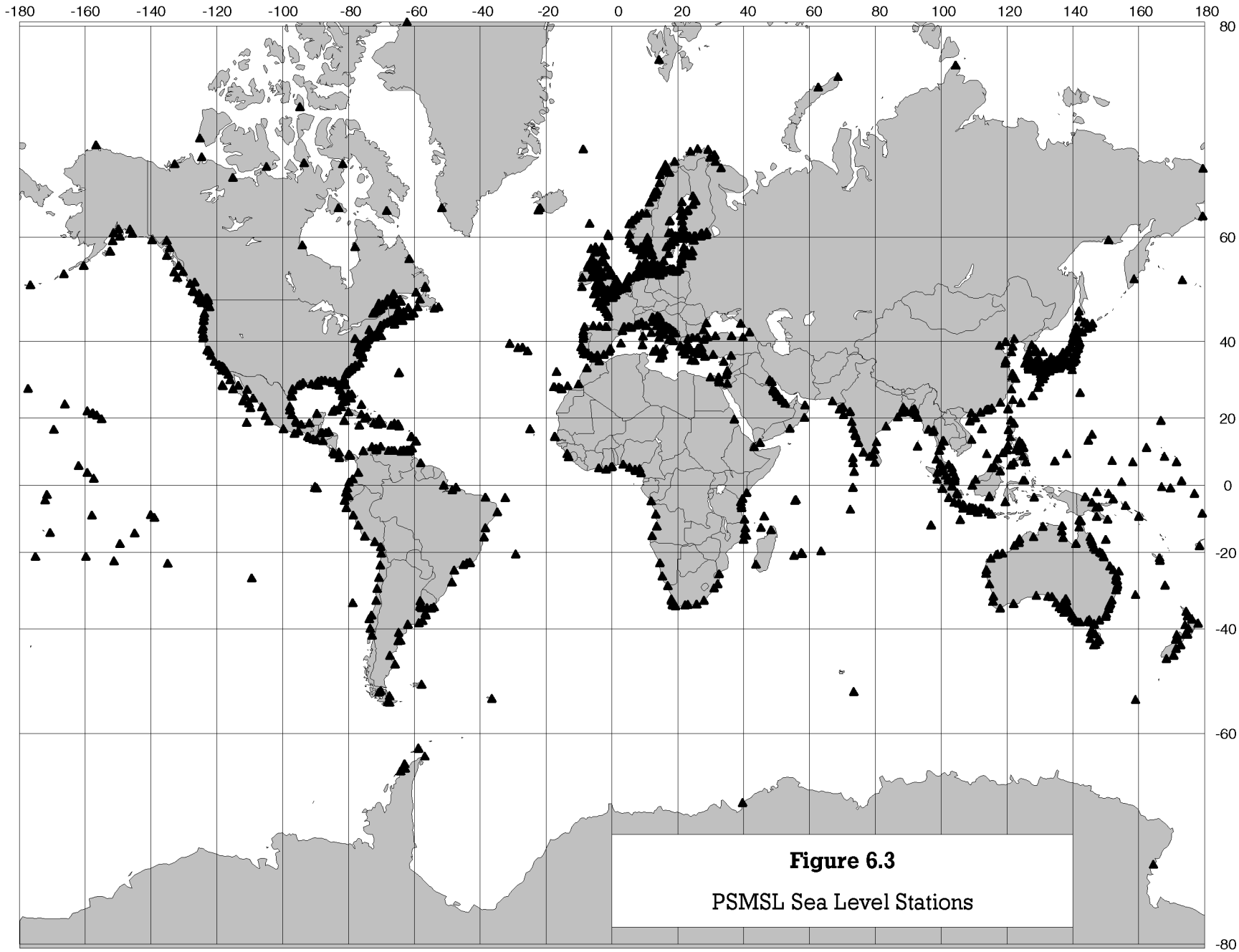

Figure 6.3

PSMSL Sea Level Stations

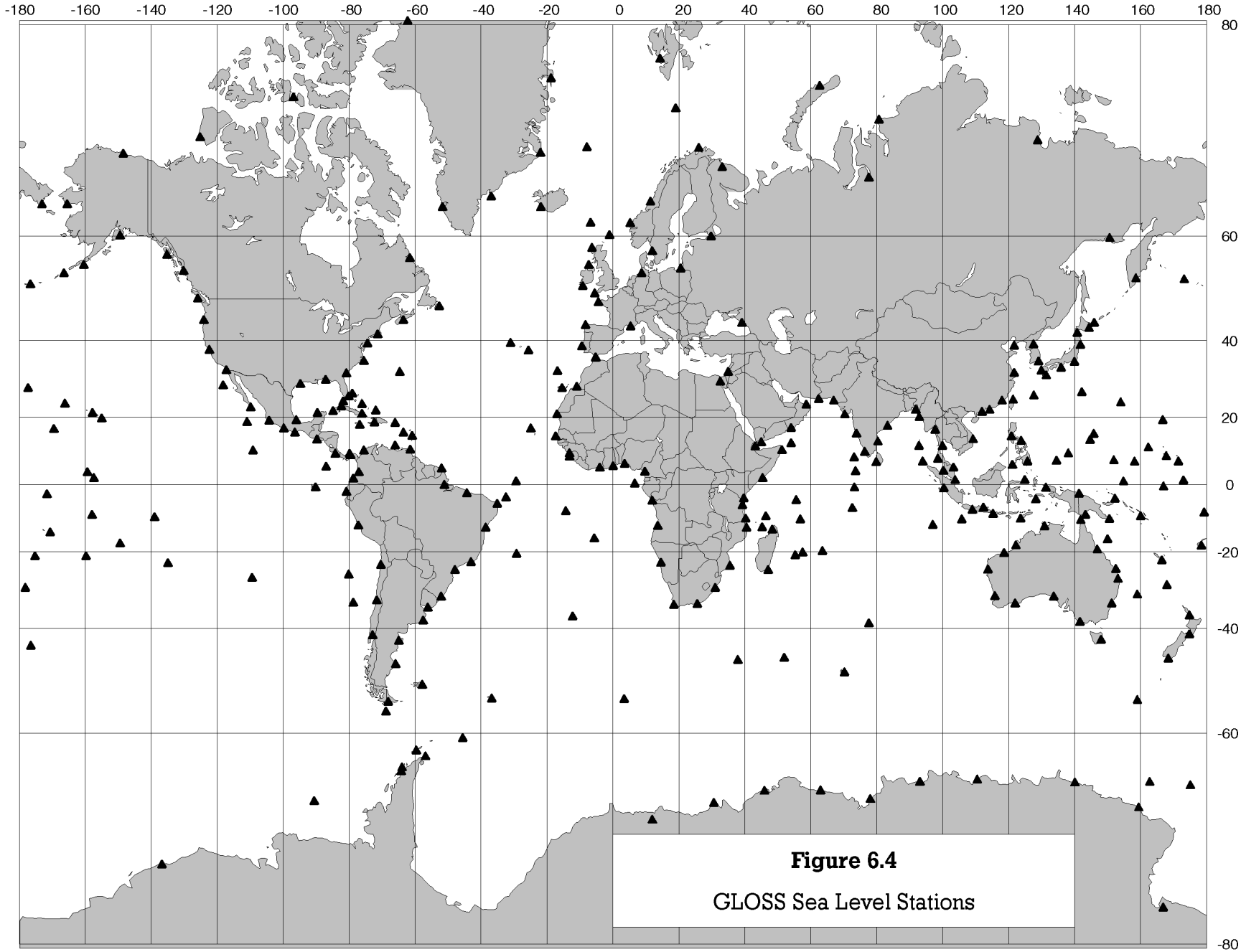

Figure 6.4

GLOSS Sea Level Stations

are available from them either across Internet, or on magnetic tape in GF3 format, or, for small selections of data, on floppy disk or as hardcopy listings. PSMSL can also provide copies of the GLOSS Handbook, a PC package giving details and site maps of each gauge (Figure 6.4) within the GLOSS network.