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29

# Catalogue of tide gauges in the Pacific

Unesco 1984

This catalogue was prepared by Mr Norman M. Ridgway, ITSU National Contact of New Zealand (Dept. of Scientific and Industrial Research, New Zealand Oceanographic Institute, P.O. Box 12-346, WELLINGTON NORTH, New Zealand) at the request of the Secretary, IOC, to provide a list of sources of tidal data which can be used in post-event studies of tsunamis and in other branches of oceanographic study.

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# Foreword

Although this catalogue is primiraly intended to provide a list of sources for tidal data which can be used in post-event studies of tsunamis, it may also be useful in other branches of oceanographic study, such as tidal prediction, hydrography, coastal geodesy, storm surges, harbour seiches, climatic changes and oceanic circulations. For example, a catalogue of tide gauges in the Southern Ocean (Lutjeharms 1980) arose from an interest in the dynamics of the Antarctic Circumpolar Current–variations in the oceanic circulation being related to mean sea level changes. The value of tidal information in the study of ocen variability and climatic changes was recognized by the joint Intergovernmental Oceanographic Commission of the United Nations Educational Scientific and Cultural Organization (IOC-Unesco) and the World Meteorological Organization (WMO) Working Committee for the Integrated Global Ocean Services System (IOC-WMO/IGOSS) at its Third Session held in Paris, 21 February–2 March, 1983. In Annex IV of its Summary Report is a plan for the establishment of an IGOSS Sea Level Pilot Project in the Pacific (ISLPP). This present compilation may aid in identifying tide gauges that can be incorporated into the ISLPP.

Although the listings are as complete as possible, there will doubtless be some errors and omissions and it would be appreciated if these could be brought to the attention of either the compiler or the Director, International Tsunami Information Center, P.O. Box 50027, Honolulu, Hawaii, USA.

# Summary

Tables with information on tide gauges in the Pacific are compiled in the present catalogue. Tables contain information on the location of tide stations, their types, time of their installation and names of agencies they belong to. In addition to the 58 stations of the tsunami warning system, some 203 other tide gauges are listed herein.

The catalogue contains a description of the types of tide-gauges in operation. Problems associated with the use of different types of tide-gauges are identified and recommendations to overcome some of them are given.

# Contents

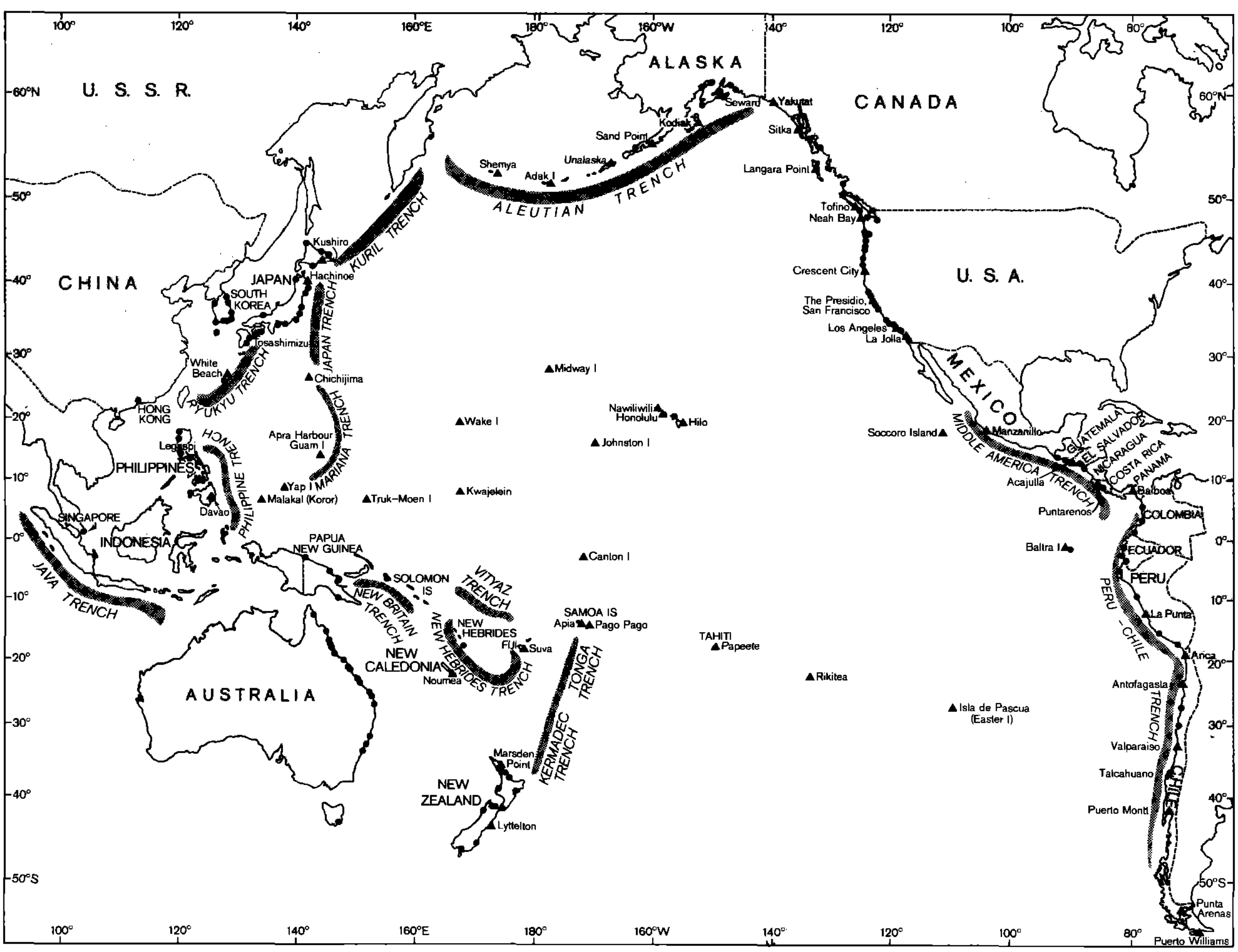
# The International Tsunami Warning System

In August 1948, the United States Coast & Geodetic Survey (USC & GS) created a Tsunami Warning System to provide reliable warnings and information to the Hawaiian Islands, to military establishments and to United States of America Trust Territories throughout the Pacific region. The impetus for this development was the severe damage and heavy casualties (including 173 deaths) which Hawaii experienced following a large tsunami which was generated near the Aleutian Islands on 1 April 1946. The destructive effects were widespread throughout the Pacific Ocean (Iida *et al.* 1967).

Twelve years later, another catastrophic and Pacific-wide tsunami was generated near Chile on 21 May 1960, and this was followed within four years by a similarly destructive tsunami generated near Alaska on 27 March 1964. The incidence of these two major tsunamis drew attention to the urgent need for an international Tsunami Warning System to provide warnings to countries located within the Pacific Basin, where the vast majority of the world's tsunamis occur. To meet this need the United States of America offered to expand its warning system and this offer was accepted by IOC/Unesco. This led to the establishment, in 1965, of the International Tsunami Information Center (ITIC) and the International Co-ordination Group for the International Tsunami Warning System (ICG/ITSU) under the auspices of IOC/Unesco. The Honolulu Observatory, which carried out seismic and magnetic observations, became the operational centre of the Tsunami Warning System (TWS) as the Pacific Tsunami Warning Center (PTWC). Currently, 22 IOC Member States are represented in ICG/ITSU.

Two important elements in the sucessful operation of the system are the seismic and tide station networks. The TWS seismic network in the Pacific consists of 32 stations and the tide network of 58 stations (Fig. 1). Whenever a possibly tsunamigenic seismic event (usually a large-magnitude earthquake) occurs, the TWS tide stations belonging to countries which are nearest to the epicenter are called immediately and asked to closely monitor their tide gauges and to inform PTWC whether or not a tsunami has been recorded. Since it is essential that TWS tide stations are able to provide immediate and reliable data, they must be permanently manned and have reliable communication links with PTWC. In addition to the 58 TWS stations, some 203 other tide stations are listed herein.

***Figure 1:*** *Location of Tsunami Warning System network and the tide network in the Pacific (by N.M. Ridgway)*




• Tide gauge station
▲ TWS seismic station

# Float-operated tide gauges

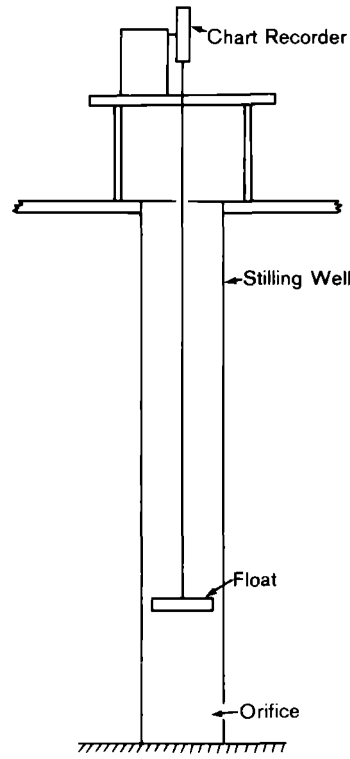
The float-operated tide gauge can be called the traditional tide gauge, since it has been employed for well over 100 years and, even today, it is the most common type of gauge in operation. Thus, of the 319 individual tide gauges listed in this catalogue, 266 (or 84%) are float gauges. (It should be noted that these 319 gauges are represented by 29 different makes and models. It is beyond the scope of this publication to give descriptions of these individual makes. Details of particular models and installations can be obtained from national tidal agencies. Their names and addresses are listed herein.

With this type of gauge (see Fig. 2), a float operates in a vertical cylinder of water–called a stilling well–which is connected to the surrounding water by a small orifice (although some stilling wells may have more than an orifice). This orifice acts as a filtering device since it imposes a time lag in the response of the water inside the well to surface waves which have periods in the order of seconds. The excursions of the float are transmitted to a recorder, via a system of shafts and gears, by a flexible wire. This wire is kept taut by a counter-balance weight, or occasionally by a spring. Most recoders have a clockwork drum to which a paper chart is fitted and upon which the vertical movements of the float with respect to time are traced by a pen, thereby producing an analogue record, usually a weekly or a monthly chart. The advantage of this type of recorder is that it supplies a continuous record of the water level variations; however, subsequent processing of the data is time-consuming and expensive. To overcome this problem, particularly at tide stations operated by the USA, analogue-to-digital recorders (ADRs) have been installed wich convert the analogue signals to discrete values of the water level, typically at six-minute intervals, and record these values on punched paper tape in a machine-readable format.

Float gauges are generally reliable and, being relatively unsophisticated instruments, do not require highly skilled technicians to maintain and service them. However, they can suffer from a number of faults associated with both the recording mechanisms and the stilling wells (Lennon 1969, 1971; Glen 1979; Friske 1981; Shih and Porter 1981).

Faults in the recording mechanisms are often associated with their operation in humid, salt-laden atmospheric conditions which are conducive to metal corrosion and the deterioration of bearing surfaces. This promotes an increase in friction and can result in changes of tension in the float suspension and a lag in the float's response to changes of the well water-level. The paper punching mechanism in ADRs is quite complex, making them more prone to mechanical problems than analogue recorders. Humid atmospheric conditions may also cause the paper charts used in analogues recorders to become distorted and this can lead to recording errors–ADR paper tapes are more stable since they are backed with foil. Recording errors can also arise if the analogue charts are not properly positioned on the chart drum, if the scale lines are not accurately printed, or if the clockwork mechanism is faulty. However, despite these possible sources of error, most recording errors result from the use of stilling wells.

***Figure 2:*** *Typical float gauge system*




Stilling wells are an essential component of float-operated tide gauges since they not only filter out short-period surface waves but also provide physical protection to the float. Ideally, stilling wells should have a linear response so that the well water should always be at the same level as that outside. In practice, however, stilling wells are non-linear devices whose responses depend not only upon such factors as the relative dimensions of the stilling well and orifice (or orifices), the size of the float and the shape of the orifice, but also upon the presence or absence of surface waves, water currents, density differences between the well water and the outside water, and marine fouling and/or siltation around the orifice (Shipley 1963; Cross 1968; Easton 1968; Noye 1968, 1974 a, b, c; Sager and Matthaüs 1970; Braddock 1980; Shih and Porter 1981).

Oscillatory pressure fluctuations in the presence of large surface waves may cause a "pumping down" effect and a lowering of the well water level by as much as 10-15 cm (Cross, 1968; Shih and Porter 1981). Water currents flowing past the stilling well can decrease the water pressure at the orifice and result in a lowering of the well water-level. This is often referred to as the "drawdown" effect. From theoretical considerations, Lennon (1971) calculated that a current flowing at a speed of 1.5ms$^{-1}$ could lower the well water-level by 18 cm.

As the sea ebbs and flows with the tide, the temperature and salinity of near-coastal water can change markedly, particularly near river mouths where there is a large influx of fresh water. The restriction of flow through the stilling well orifice can prevent complete flushing of the well water and result in the stilling well containing low-density water (which has entered at high tide). In this event, the mean density of the well water would be less than that of the outside water and the well water-level. Lennon (1971) stated that, in the River Mersey where the tidal range is 10 m, errors in excess of 6 cm can occur. Marine fouling and siltation around the stilling well orifice and inside the well itself increases the restriction to flow, thus altering the designed filtering characteristics and resulting in a reduced amplitude response.

Despite these possible sources of error, Cross (1968) concluded that the frequency response of float gauges was adequate for the recording of tsunamis, except for those of large amplitude and short period. The response of a float gauge to a tsunami was also examined by Braddock (1980). He found that, on the arrival of a tsunami, there was an initial period of transient response during which the gauge was adjusting to the new wave climate. This initial period may last for up to one tsunami wave period and can result in errors in recording both the phase and amplitude of the initial wave.

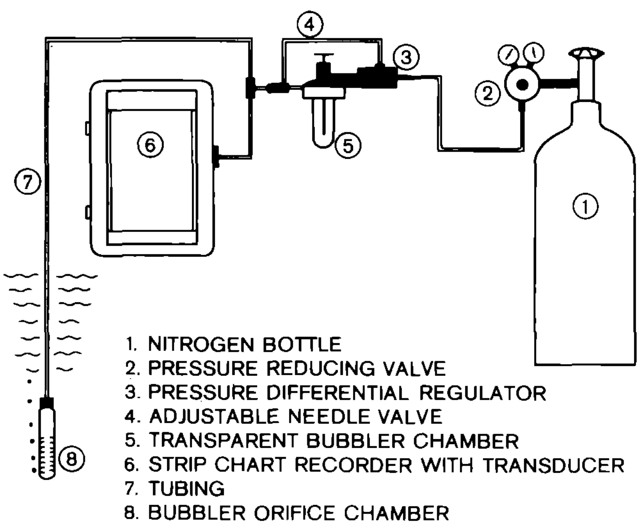
The problems associated with the use of float-operated tide gauges have been widely recognized. For example, the National Ocean Survey (NOS) of the National Oceanic and Atmospheric Administration (NOAA) in the USA has initiated a series of studies designed to examine alternative methods of measuring and recording tides and water levels (Beckers *et al.* 1981; Friske 1981; Lobecker *et al.* 1981;) and improved systems will almost certainly be developed and be in common use at some future date. However, the fact remains that float gauges are the most widely used type of tide gauge, as they have been for many decades, and it seems likely that their use will continue for a number of years to come. In order to ensure that they provide the best possible data, it is essential that tidal agencies are aware of the errors to which they are subject, and that they ensure their gauges are well maintained and operated by competent personnel.

## Pressure-operated tide gauges

Some sites are not suitable for the installation of float gauges because they lack any vertical structure upon which the stilling well can be mounted. Furthermore, because they are expensive to install in terms of both time and money, float gauges are unsuitable for temporary use (Pugh 1972). Under these circumstances pressure-operated tide gauges are particularly useful, since they can be installed at a relatively cheap cost. A number of different methods of measuring pressure variations can be employed. Of the 53 pressure tide gauges listed in this catalogue, 43 are bubbler gauges, 6 are electric strain-gauges, 3 are quartz crystal gauges and one is a pneumatic gauge.

The bubbler tide gauge consists of an underwater orifice chamber (about 15 cm in length and 2 cm in diameter with a small opening at the bottom end) which is fixed rigidly in position and is connected to a source of compressed gas, usually nitrogen, by a small diameter plastic tube which may be up to 800 m in length. A recorder and gas control gauges complete the system, as illustrated in Fig. 3. The gas pressure throughout the tube is approximately equal to the water pressure at the orifice chamber, and changes in the water elevation result in changes in the gas pressure. In practice, since the gas is set to flow through the tube and bubble out into the water via the orifice, the gas pressure is slightly higher than the water pressure at the outlet and prevents water from rising up the tube. The pressure differential is maintained at a constant level by means of a control gauge. Although bubller gauges are not subject to the problems inherent with the use of stilling wells, errors associated with their use can arise, mainly from the effects of surface waves, water-density variations and friction of the gas flow.

***Figure 3:*** *Typical bubbler pressure tide gauge system (after Barbee 1965)*




When large surface waves are present, the water pressure at the orifice is constantly changing. When a wave through passes over the sensor, the water pressure is reduced and the gas bubbles out quickly from the orifice. Conversely, when a wave crest passes over, the water pressure increases and there may be a slight delay before the gas pressure adjusts to this increase. If the next wave through arrives before this adjustment is made, the gas again bubbles out freely and the cumulative effect can result in the recorded water-level being less than it should be. The errors due to large surface waves are compensated for to some extent by designing the orifice chamber so that its volume is comparable to the volume of the tube. However, bubbler gauges are more effective if they are installed at sites which are sheltered from large waves (Glen 1979).

Since the water-levels measured by bubbler gauges are a function of the water pressures at the orifice, variations in the local water density can lead to errors. As stated earlier, such density variations are most pronounced at sites located near river mouths. In general, density–related errors are small and are usually less than the reading accuracy of the recorder. If necessary, in extreme cases, corrections can be applied from specific gravity measurements (Poling and Butler 1963).

Friction which results from the gas flowing through the tube is another possible source of error. The magnitude of this error depends upon the rate of flow of the gas, the bore diameter of the tube, and the tube length. A 0.3 cm diameter tube, 800 m in length and with a flow rate of 60 rubbles per minute, has an error of about 3 cm. If a very long length of tube is required at a particular location, the friction error can be offset by the use of two separate tubes, one to supply the gas to the orifice chamber and the other to transmit pressure to the recorder.

Pneumatic tide gauges employ an air-filled metal chamber, fitted with a flexible diaphragm of synthetic rubber, as the pressure sensor. Water level changes cause corresponding air pressure changes in the diaphragm chamber, and these pressure changes are transmitted to a pen recorder by a length of pipe. Air friction effects can cause recording errors and thus the tube length is restricted to about 50 m. This type of gauge, which is accurate to about 0.03 m at best, is rarely used for permanent installation.

Electric strain-gauge tide gauges make use of the fact that, when a conductor or semi-conductor is subjected to a mechanical strain, its resistance changes. Modern gauges employ a silicon semi-conductor mounted on a diaphragm. As the diaphragm flexes in response to changes in the water level, the semi-conductor experiences deformations and corresponding changes in its resistance. The potentiometric output is amplified, filtered electronically to remove short-period surface waves, and recorded in terms of water level in either analogue or digital form.

In quartz-crystal tide gauges, water levels are recorded by measuring changes in the resonant frequency of a vibrating quartz crystal. The frequency of vibration depends upon the pressure applied to the crystal, and changes of the vibrational frequency which result from water level changes are detected using an electronic oscillator circuit (Wearn and Larson 1980). Quartz-crystal pressure sensors are able to make precise measurements of the water pressure and are often used in deep-sea gauges, since they are capable of resolving water level variations in the order of millimetres in water depths of several hundred metres. The output is recorded in binary form on magnetic tape.

Both electric-strain and quartz-crystal tide gauges require compensations to be made for variations in the barometric pressure and density of the water before the recorded pressures can be converted into water levels. Only nine of these gauges are currently installed at permanent tide stations. Their maintenance and calibration requirements are much more demanding than is the case with older types of gauges, and they require the services of experienced and well-qualified electronics personnel. They have not been in use for a sufficiently long period of time to establish their long-term reliability.


# Acknowledgements

The writer is grateful to the Intergovernmental Oceanographic Commission of Unesco, who sponsored this project, and expresses his particular and sincere thanks to the following–Ltd (i.g.) Marianne Douthit; NOAA Corps (National Weather Service–Pacific Region); Dr. G. Pararas-Camayannis, (Director, ITIC); Mr G.C. Dohler, (Chairman, IGC/ITSU) and the many national tidal agencies for their co-operation, advice and criticism.

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# Tables of tide gauges and maps showing their location

**Table 1: Tide gauges of Australia** (see Fig. 4)

COUNTRY: AUSTRALIA — STATE: QUEENSLAND

| No. | STATION NAME | LATITUDE South | | LONGITUDE East | | GAUGE | INSTALLED | AGENGY | COMMENTS |
|---|---|---|---|---|---|---|---|---|---|
| | | Deg | Min | Deg | Min | | | | |
| 1 | WEIPA (Evans Landing) | 12 | 40 | 151 | 52 | OTT | Jan 1965 | DHM | |
| – | WEIPA (Humbug Point) | 12 | 40 | 151 | 52 | LS | | BPA | |
| – | WEIPA (Lorim Point) | 12 | 40 | 151 | 52 | RWM | Oct 1977 | DHM | |
| 2 | COCKTOWN | 15 | 27 | 145 | 15 | LS | Jul 1977 | BPA | |
| 3 | CAIRNS | 16 | 56 | 145 | 47 | AMS | 1933 | CHB | |
| – | CAIRNS | 16 | 56 | 145 | 47 | LS | Feb 1975 | BPA | |
| 4 | MOURILYAN | 17 | 35 | 146 | 05 | RWN | Feb 1962 | DHM | |
| – | MOURILYAN | 17 | 35 | 146 | 05 | LS | Apr 1975 | BPA | |
| 5 | CLUMP POINT | 17 | 51 | 146 | 07 | LS | Jul 1976 | BPA | |
| 6 | LUCINDA | 18 | 31 | 146 | 20 | LS | Aug 1975 | BPA | |
| – | LUCINDA | 18 | 31 | 146 | 20 | RWM | Jan 1965 | DHM | |
| 6 | TOWNSVILLE | 19 | 15 | 146 | 50 | AMS | 1945 | THB | |
| – | TOWNSVILLE | 19 | 15 | 146 | 50 | LS | Mar 1975 | BPA | |
| 8 | BOWEN | 20 | 01 | 148 | 15 | LS | Mar 1975 | BPA | |
| 9 | MACKAY | 21 | 07 | 149 | 14 | AMS | 1948 | MHB | |
| – | MACKAY | 21 | 07 | 149 | 14 | LS | Jun 1975 | BPA | |
| 10 | HAY POINT | 21 | 16 | 149 | 19 | RWM | Jul 1971 | HPS | |
| – | HAY POINT | 21 | 16 | 149 | 19 | LS | | BPA | |
| 11 | SHUTE HARBOUR | 21 | 18 | 148 | 48 | LS | Jul 1976 | BPA | |
| 12 | PORT ALMA | 23 | 35 | 150 | 52 | LS | Jul 1976 | BPA | |
| 13 | GLADSTONE | 23 | 50 | 151 | 15 | RWN | | GHB | |
| – | GLADSTONE | 23 | 51 | 151 | 19 | LS | Apr 1978 | BPA | |
| 14 | MOOLOOABA | 26 | 41 | 153 | 08 | RWM | Sep 1970 | DHM | |
| 15 | CALOUNDRA HEAD | 26 | 48 | 153 | 09 | NYP | Dec 1976 | DHM | |
| 16 | BRISBANE | 27 | 22 | 153 | 10 | RWM | Feb 1966 | DHM | |
| **STATE:** | | | | | | | | **NEW SOUTH WALES** | |
| 17 | CROWDY HEAD | 31 | 50 | 152 | 45 | LS | Feb 1977 | CSIRO | |
| 18 | NEWCASTLE (Pilot Station) | 32 | 56 | 151 | 47 | GTS | 1959 | MSB | |
| – | NEWCASTLE (Dockyard No. 2) | 32 | 56 | 151 | 47 | ESD | 1971 | MSB | |
| 19 | SYDNEY (Fort Dennison) | 33 | 51 | 151 | 13 | HAR | | MSB | |
| – | SYDNEY (Camp Cove) | 33 | 50 | 151 | 17 | HAR | | MSB | |
| **STATE:** | | | | | | | | | **TASMANIA** |
| 20 | HOBART | 42 | 53 | 147 | 20 | GK | Feb 1960 | MBS | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |

## AUSTRALIA

TIDE GAUGE ABBREVIATIONS

| | |
|---|---|
| AMS | Amsler: Float operated |
| ESD | Esdaile & Sons, Sydney: Float operated |
| GK | George Kent Ltd: Float operated |
| GTS | Gents of England: Float operated |
| HAR | Harrison & Sons, England: Float operated |
| LS | Leupold & Stevens: Float operated |
| NYP | Neypric: Float operated |
| OTT | Ott: Float operated |
| RWM | R.W. Munro: Float operated |

AGENCY ABBREVIATIONS

| | |
|---|---|
| BPA | Beach Protection Agency, GPO Box 2195, Brisbane, Queensland 4001 |
| CHB | Cairns Harbour Board, PO Box 594, Cairns, Queensland 4870 |
| CSI | CSIRO Division of Oceanography & Fisheries, PO Box 21, Cronulla, N.S.W. 2230 |
| DHM | Department of Harbours & Marine, GPO Box 2185, Brisbane, Queensland 4001 |
| GHB | Gladstoje Harbour Board, PO Box 259, Gladstone, Queensland 4680 |
| HPS | Hay Point Services, Mail Service 283, Mackay, Queensland 4740 |
| MBH | Marine Board of Hobart, Hobart, Tasmania |
| MHB | Mackay Harbour Board, PO Box 96, Mackay, Queensland 4740 |
| MSB | Maritime Services Board of N.S.W., Newcomen & Scott Streets, Newcastle, N.S.W. 2300 |
| THB | Townsville Harbour Board, PO Box 1031, Townsville, Queensland 4810 |

NOTE

The L&S gauges operated by the Beach Protection Authority are installed mainly for the purpose of recording cyclonic storm surges. Records are in the form of continuous rolls covering a period of 6 months.

*Figure 4: Distribution of tide gauges of Australia*

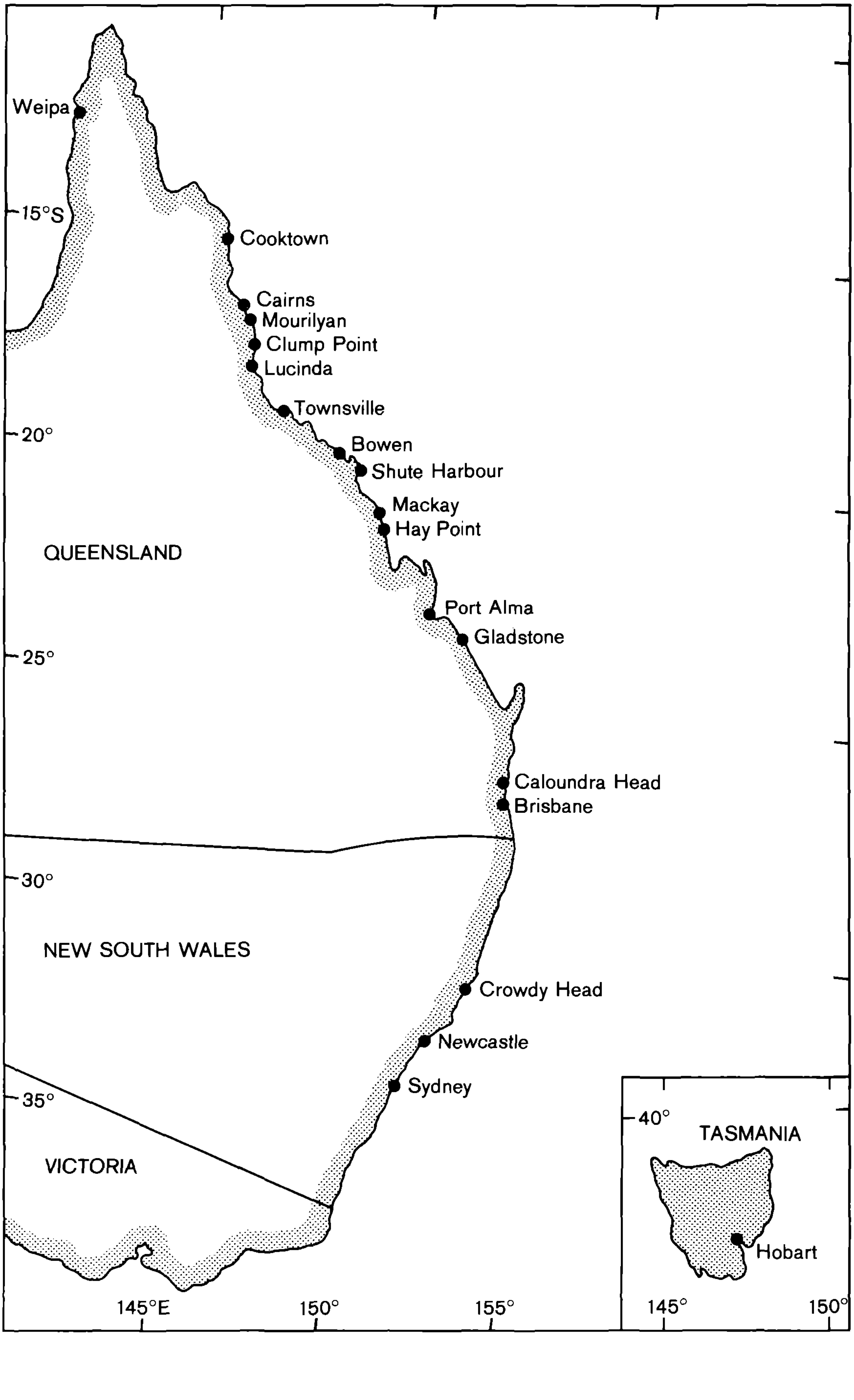

**Table 2: Tide gauges of Canada** (see Fig. 5)

COUNTRY: CANADA

STATE: BRITISH COLUMBIA

| No. | STATION NAME | LATITUDE North | | LONGITUDE West | | GAUGE | INSTALLED | AGENGY | COMMENTS |
|---|---|---|---|---|---|---|---|---|---|
| | | Deg | Min | Deg | Min | | | | |
| 1 | SOOKE | 48 | 42 | 123 | 44 | OTT | Mar 1958 | CHS | |
| 2 | VICTORIA | 48 | 25 | 123 | 22 | HWK | Feb 1895 | – | |
| 3 | ESQUIMALT HARBOUR | 48 | 26 | 123 | 27 | HWK | Feb 1976 | – | |
| 4 | ESQUIMALT LAGOON | 48 | 26 | 123 | 38 | HWK | Feb 1976 | – | |
| 5 | PORT RENFREW | 48 | 33 | 124 | 25 | OTT | Feb 1968 | – | |
| 6 | PATRICIA BAY | 48 | 39 | 123 | 37 | OTT | Jun 1976 | – | |
| 7 | BAMFIELD | 48 | 50 | 125 | 08 | OTT | Oct 1969 | – | |
| 8 | FULFORD HARBOUR | 48 | 46 | 123 | 27 | OTT | Nov 1952 | – | |
| 9 | STEVESTON | 49 | 08 | 123 | 12 | OTT | 1919 | – | |
| 10 | TOFINO | 49 | 09 | 125 | 55 | HWK | Aug 1905 | – | TWS GAUGE |
| 11 | NEW WESTMINSTER | 49 | 12 | 122 | 54 | OTT | 1922 | – | |
| 12 | PORT ALBERNI | 49 | 14 | 124 | 49 | OTT | Dec 1970 | – | |
| 13 | VANCOUVER | 49 | 17 | 123 | 07 | OTT | Apr 1981 | – | |
| 14 | WINCHELSEA HARBOUR | 49 | 18 | 124 | 04 | HWK | Jan 1971 | – | |
| 15 | POINT ATKINSON | 49 | 20 | 123 | 15 | HWK | Jan 1930 | – | |
| 16 | GOLD RIVER | 49 | 11 | 126 | 07 | OTT | Jul 1980 | – | |
| 17 | LITTLE RIVER | 49 | 44 | 124 | 54 | HWK | Jan 1971 | – | |
| 18 | ZEALLOS | 49 | 59 | 126 | 51 | OTT | Jul 1980 | – | |
| 19 | CAMPBELL RIVER | 50 | 01 | 125 | 14 | OTT | May 1965 | – | |
| 20 | PORT HARDY | 50 | 43 | 127 | 29 | OTT | Jun 1964 | – | |
| 21 | BELLA BELLA | 52 | 10 | 128 | 08 | OTT | Jul 1961 | – | |
| 22 | QUEEN CHARLOTTE CITY | 53 | 15 | 132 | 04 | OTT | Apr 1981 | – | |
| 23 | LANGARA POINT | 54 | 15 | 133 | 03 | HAG | Feb 1973 | – | TWS GAUGE |
| 24 | PRINCE RUPERT | 54 | 19 | 130 | 20 | HWK | May 1906 | – | |
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**CANADA**

TIDE GAUGE ABBREVIATIONS

HAG Hagenuk: Float operated
HWK Hydr. Werkstatten: Float operated
OTT Ott: Float operated

AGENCY ABBREVIATION

CHS Canadian Hydrographic Service, Department of Fisheries and Oceans, Ottawa, 615 Booth Street, Canada KIA OE6

## NOTES

Further information on the Tsunami Warning System Gauges operated in Canada can be found in the Proceedings of the International Symposium on Tsunamis and Tsunami Research, Honolulu, Hawaii, 7-10 October 1969. (Tsunamis in the Pacific edited by W.M. Adams, East-West Center Press, Honolulu). For details of new developments contact the Canadian Hydrographic Service.

***Figure 5:*** *Distribution of tide gauges of Canada*

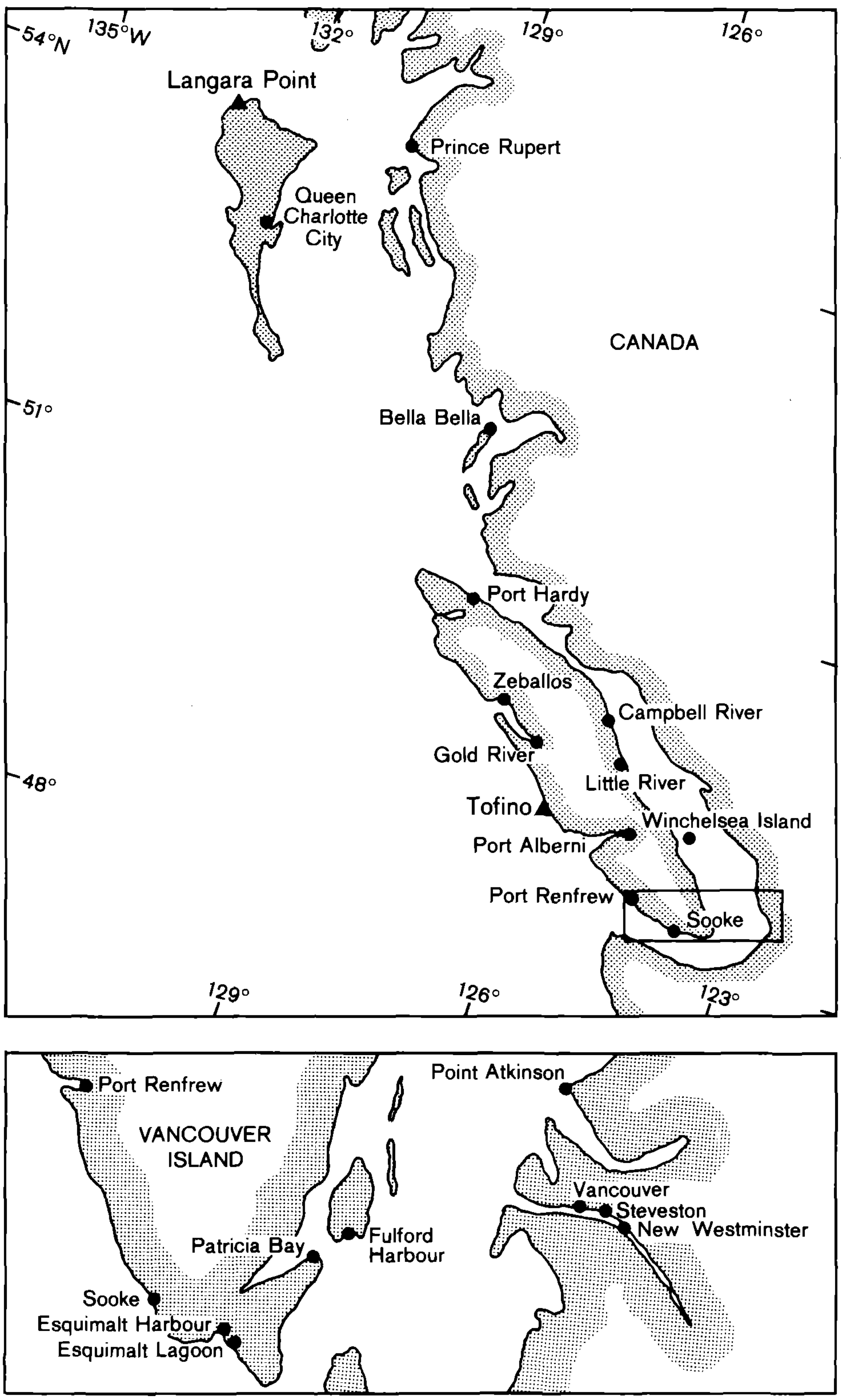

**Table 3: Tide gauges of Central America** (see Fig. 6)

AREA: CENTRAL AMERICA COUNTRIES: PANAMA/COSTA RICA/NICARAGUA/EL SALVADOR/GUATEMALA

| No. | STATION NAME | LATITUDE North | | LONGITUDE West | | GAUGE | INSTALLED | AGENGY | COMMENTS |
|---|---|---|---|---|---|---|---|---|---|
| | | Deg | Min | Deg | Min | | | | |
| | **PANAMA** | | | | | | | | |
| 1 | ARMUELLES | 08 | 16 | 082 | 52 | STD | | IGNTD | |
| 2 | BALBAO | 08 | 58 | 079 | 34 | BRI | | NOAA | TWS GAUGE |
| | **COSTA RICA** | | | | | | | | |
| 3 | QUEPOS | 09 | 24 | 084 | 10 | STD | Jun 1957 | IGN | |
| 4 | PUNTARENAS | 09 | 59 | 084 | 50 | STD | Apr 1941 | IGN | TWS GAUGE |
| | **NICARAGUA** | | | | | | | | |
| 5 | CORINTO | 12 | 29 | 087 | 10 | | | | |
| | **EL SALVADOR** | | | | | | | | |
| 6 | LA UNION | 13 | 20 | 087 | 49 | STD | | CEPA | |
| 7 | ACAJUTLA | 13 | 35 | 089 | 50 | STD | Feb 1968 | CEPA | TWS GAUGE |
| | **GUATEMALA** | | | | | | | | |
| 8 | SAN JOSE | 13 | 55 | 090 | 50 | STD | Feb 1949 | INS | |
| 9 | CHAMPERICO | 14 | 18 | 091 | 55 | STD | May 1963 | INS | |
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## CENTRAL AMERICA

TIDE GAUGE ABBREVIATIONS

BRI Bristol: Float operated
STD Standard: Float operated

AGENCY ABBREVIATION

IGN Instituto Geográfico Nacional, San José, Costa Rica
INS INSIVUMEH, 7A avenida 14 - 57, Zona 13, Guatemala
CEPA Comisión Ejecutiva Portuaria Autónoma, Instituto Georgráfico Nacional, Apartado Postal n.° 247, Avenida Juan Bertis n.° 79 - Delgado, San Salvador, El Salador
IGNTD Instituto Geográfico Nacional Tommy Guardia, Departmento de Estudios Especiales, Apartado Postal n.° 5262, Panamá 5, República de Panamá
NOAA National Weather Service, NOAA, PO Box 50027, Honolulu, Hawaii 96850

NOTE

The gauges at San Jose and Champerico, Guatemala, have been out of service since September and June 1975 respectively.

*Figure 6:* *Distribution of tide gauges of Central America*

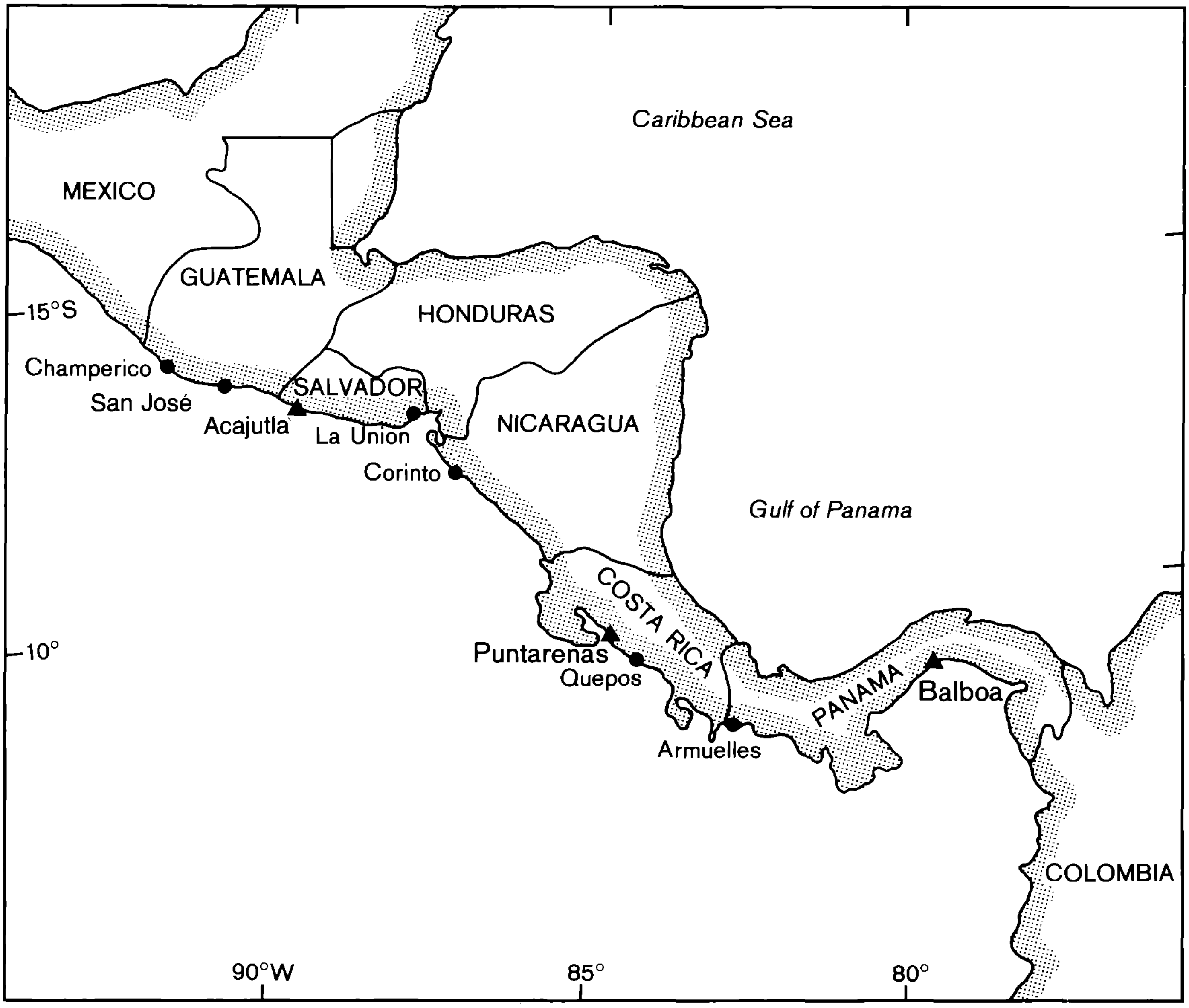

**Table 4: Tide gauges of Japan** (see Fig. 7)

COUNTRY: JAPAN

| No. | STATION NAME | LATITUDE North | | LONGITUDE East | | GAUGE | INSTALLED | AGENGY | COMMENTS |
|---|---|---|---|---|---|---|---|---|---|
| | | Deg | Min | Deg | Min | | | | |
| 1 | NAHA | 26 | 13 | 127 | 40 | FUE | Aug 1966 | JMA | |
| 2 | CHICHIJIMA | 27 | 06 | 142 | 11 | – | Apr 1980 | – | TWS GAUGE |
| 3 | ABURATSU | 31 | 34 | 131 | 25 | – | Mar 1928 | – | |
| 4 | TOSASHIMIZU | 32 | 47 | 132 | 58 | – | Jun 1931 | – | TWS GAUGE |
| 5 | MUROTOMISAKI | 33 | 16 | 134 | 10 | – | Jul 1966 | – | |
| 6 | KUSHIMOTO | 33 | 28 | 135 | 47 | – | Jun 1896 | – | |
| 7 | TOBA | 34 | 29 | 136 | 50 | – | Jan 1925 | – | |
| 8 | OMAEZAKI | 34 | 36 | 138 | 14 | – | Jun 1958 | – | |
| 9 | MERA | 34 | 55 | 139 | 50 | – | May 1927 | – | |
| 10 | MAIZURU | 35 | 28 | 135 | 23 | – | May 1968 | – | |
| 11 | CHOSI | 35 | 44 | 140 | 52 | – | Jan 1916 | – | |
| 12 | ONAHAMA | 36 | 56 | 140 | 54 | – | Jan 1951 | – | |
| 13 | AYUKAWA | 38 | 18 | 141 | 31 | – | Jun 1894 | – | |
| 14 | FUNATO | 39 | 01 | 141 | 45 | – | Aug 1963 | – | |
| 15 | MIYAKO | 39 | 38 | 141 | 59 | – | Apr 1919 | – | |
| 16 | HACHINOHE | 40 | 32 | 141 | 32 | – | Aug 1936 | – | TWS GAUGE |
| 17 | FUKAURA | 40 | 39 | 139 | 56 | – | Apr 1972 | – | |
| 18 | URAKAWA | 42 | 10 | 142 | 46 | – | Apr 1983 | – | To be installed |
| 19 | KUSHIRO | 42 | 58 | 144 | 23 | – | Jan 1947 | – | TWS GAUGE |
| 20 | HANASAKI (Nemuro) | 43 | 17 | 145 | 34 | – | Aug 1953 | – | |
| 21 | ABASHIRI | 44 | 01 | 144 | 18 | – | Jan 1956 | – | |
| 22 | WAKKANAI | 45 | 25 | 141 | 41 | – | Jan 1955 | – | |
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**JAPAN**

TIDE GAUGE ABBREVIATIONS

FUE Fuess: Float operated

AGENCY ABBREVIATION

JMA Japan Meteorological Agency, Ote-Machi, Chiyoda-Ku, Tokyo, Japan 100

NOTE

Tidal records prior to 1950 are not generally available. Records for the period 1950-1956 are on microfilm and are held at JMA. It is planned to microfilm records from 1956 onwards.

*figure 7:* Distribution of tide gauges of Japan

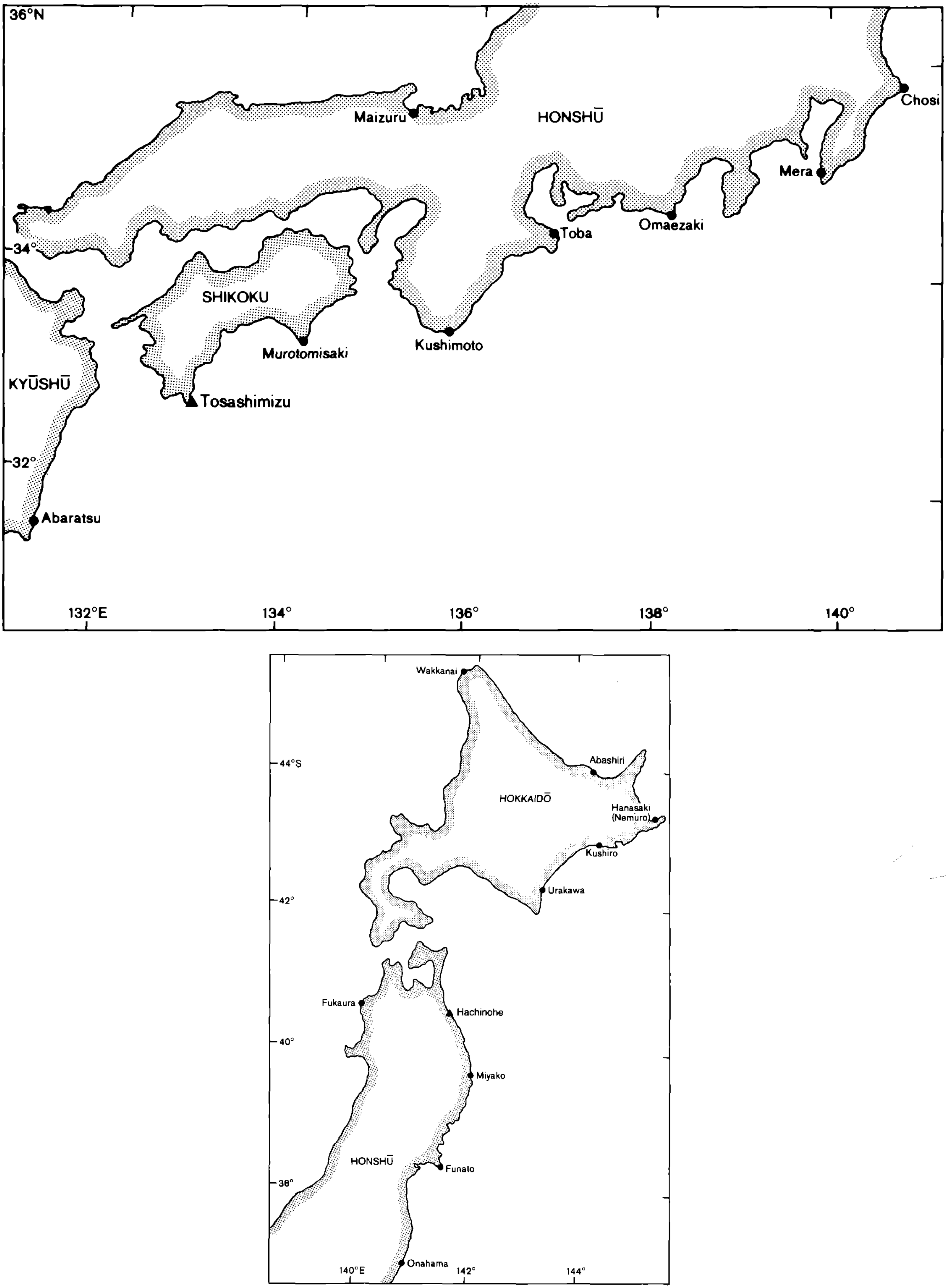

**Table 5: Tide gauges of Korea** (See Fig. 8)

COUNTRY: KOREA

| No. | STATION NAME | LATITUDE North | | LONGITUDE East | | GAUGE | INSTALLED | AGENGY | COMMENTS |
|---|---|---|---|---|---|---|---|---|---|
| | | Deg | Min | Deg | Min | | | | |
| 1 | JEJU | 33 | 34 | 126 | 32 | OTT | Dec 1963 | MOT | |
| 2 | YEOSU | 34 | 45 | 127 | 46 | FUE | Feb 1965 | – | |
| 3 | MOGPO | 34 | 47 | 126 | 24 | FUE | Aug 1952 | – | |
| 4 | CHUNGMU | 34 | 49 | 128 | 26 | FUE | Jan 1976 | – | |
| 5 | BUSAN | 35 | 06 | 129 | 02 | FUE | Feb 1955 | – | |
| 6 | ULSAN | 35 | 31 | 129 | 23 | FUE | Sep 1962 | – | |
| 7 | GUNSAN | 35 | 59 | 126 | 43 | OTT | Dec 1959 | – | |
| 8 | POHANG | 36 | 01 | 129 | 24 | FUE | Jan 1971 | – | |
| 9 | INCHON | 37 | 28 | 126 | 36 | OTT | May 1959 | – | |
| 10 | MUGHO | 37 | 33 | 129 | 07 | FUE | Feb 1965 | – | |
| 11 | SOGCHO | 38 | 12 | 128 | 36 | FUE | Nov 1973 | – | |
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**KOREA**

TIDE GAUGE ABBREVIATIONS

FUE Fuess: Float operated
OTT Ott: Float operated

AGENCY ABBREVIATION

MOT Hydrographic Office, Ministry of Transportation, Daewang Building (7th Floor), 355 Junglimdong Chung-Ku Seoul, 110 Korea

*Figure 8: Distribution of tide gauges of Korea*

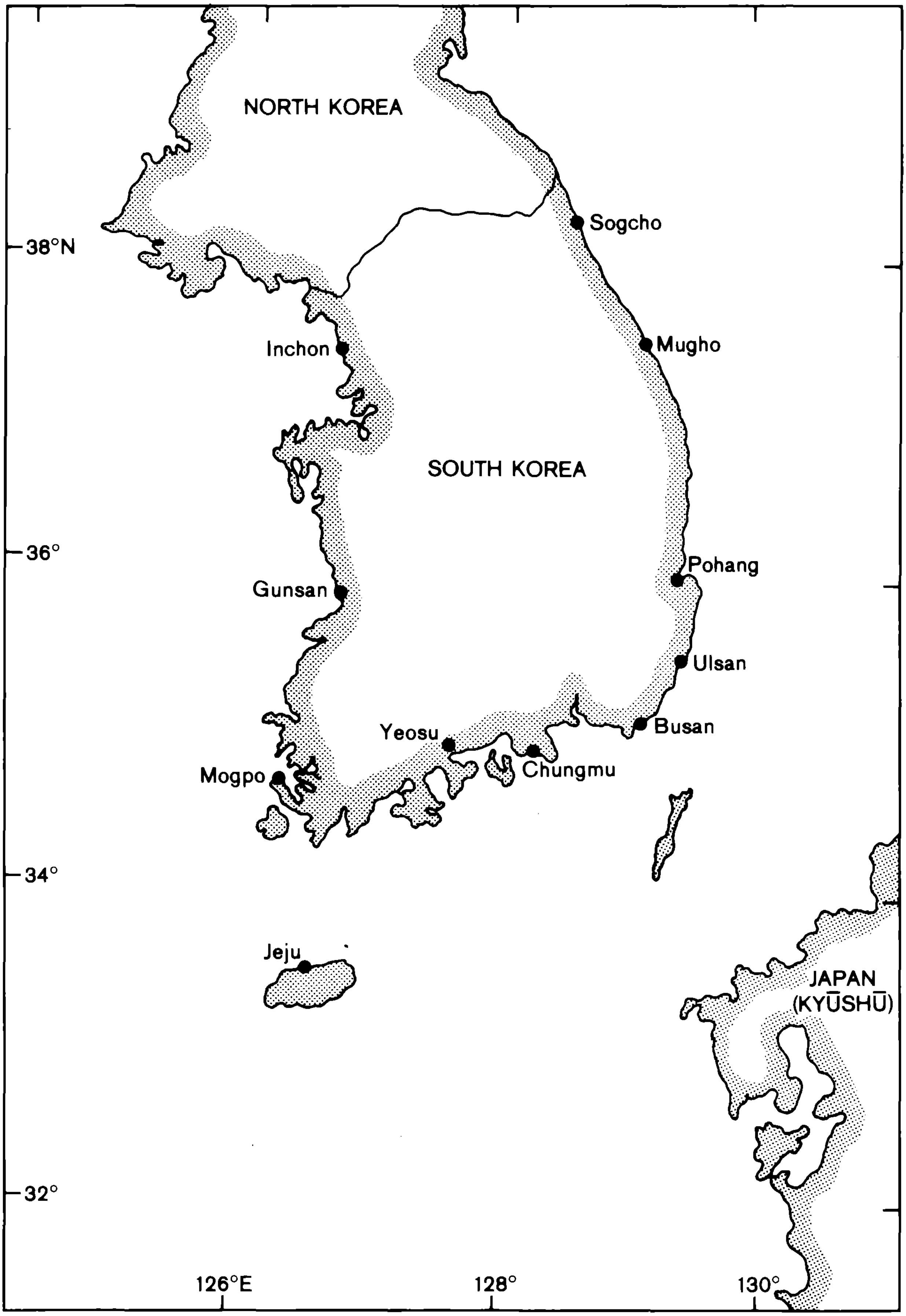

**Table 6: Tide gauges of Mexico** (see Fig. 9)

COUNTRY: MEXICO

| No. | STATION NAME | LATITUDE North | | LONGITUDE East | | GAUGE | INSTALLED | AGENGY | COMMENTS |
|---|---|---|---|---|---|---|---|---|---|
| | | Deg | Min | Deg | Min | | | | |
| 1 | SOCORRO ISLAND | 18 | 43 | 110 | 57 | STD | | DGO | TWS GAUGE |
| 2 | MANZANILLO | 19 | 03 | 104 | 20 | STD | | DGO | TWS GAUGE |
| | | | | | | | | | |
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**MEXICO**

TIDE GAUGE ABBREVIATION
STD Standard; Float operated

AGENCY ABBREVIATION

DGO Dirección General de Oceanografía, Departamento de Hidrografía, Av. Coyoacán 131, México 12, D.F.

***Figure 9 :*** *Distribution of tide gauges of Mexico*

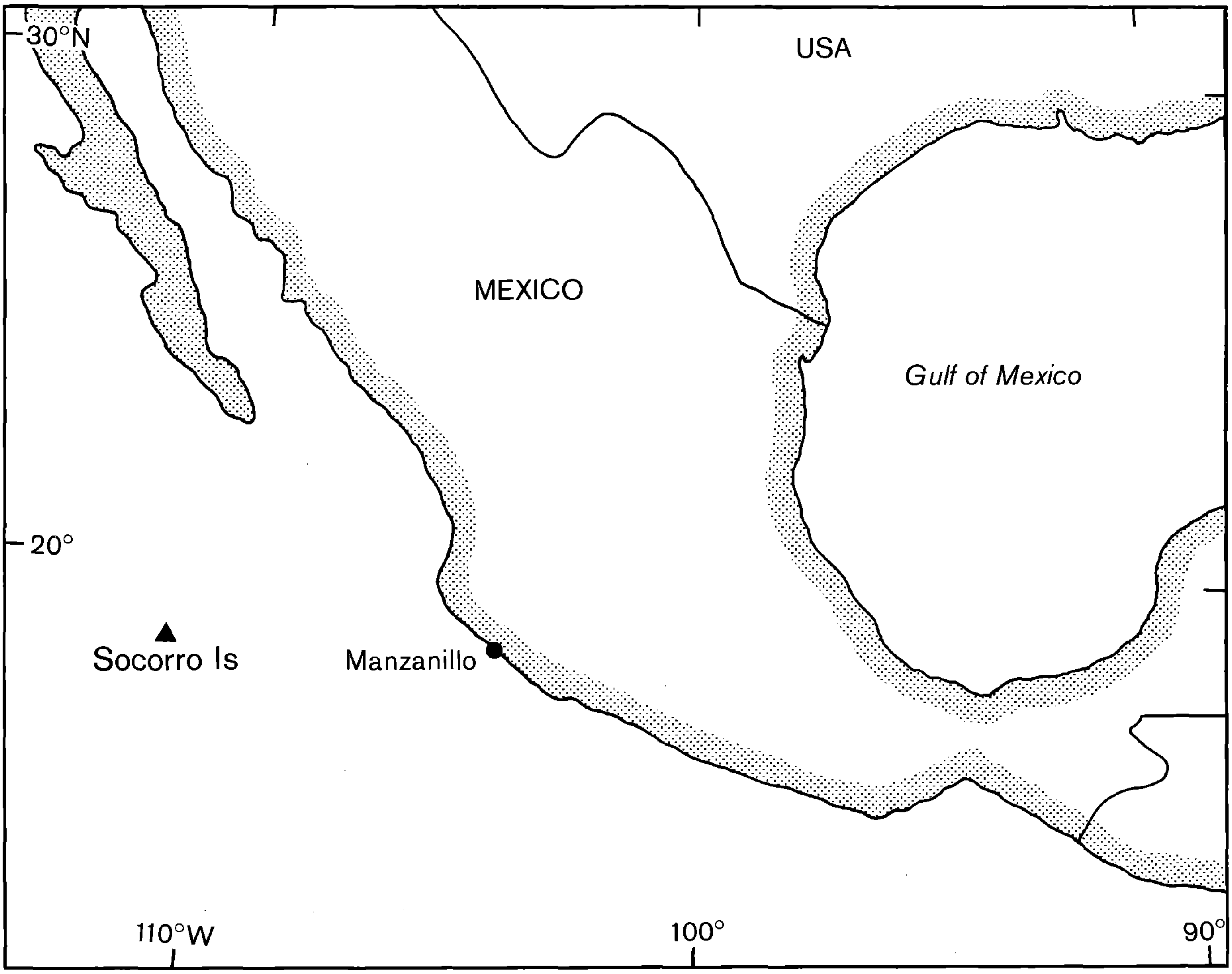

**Table 7: Tide gauges of New Zealand** (see Fig. 10)

COUNTRY: NEW ZEALAND

| No. | STATION NAME | LATITUDE South | | LONGITUDE East | | GAUGE | INSTALLED | AGENGY | COMMENTS |
|---|---|---|---|---|---|---|---|---|---|
| | | Deg | Min | Deg | Min | | | | |
| 1 | WHANGAREI | 35 | 46 | 174 | 21 | RWM | Nov 1963 | NHB | |
| 2 | MARSDEN POINT | 35 | 50 | 174 | 29 | RWM | Nov 1963 | HHB | TWS GAUGE |
| 3 | AUCKLAND | 36 | 51 | 174 | 46 | RWM | 1959 | AHB | |
| 4 | ONEHUNGA | 36 | 56 | 174 | 47 | RWM | 1959 | AHB | |
| 5 | GISBORNE | 38 | 41 | 178 | 02 | PHI | May 1983 | GHB | |
| 6 | NEW PLYMOUTH | 39 | 04 | 174 | 02 | G&K | 1931 | THB | |
| 7 | NAPIER | 39 | 29 | 176 | 55 | G&K | 1939 | HBHB | |
| 8 | NELSON | 41 | 16 | 173 | 16 | PHI | Jul 1982 | NeHB | |
| 9 | PICTON | 41 | 17 | 174 | 00 | FOX | 1962 | MHB | |
| 10 | WELLINGTON | 41 | 17 | 174 | 47 | EVE | 1891 | WHB | |
| 11 | WESTPORT | 41 | 45 | 171 | 36 | DRU | Dec 1982 | WeHB | |
| 12 | GREYMOUTH | 42 | 27 | 171 | 12 | E&V | Nov 1959 | GrHB | |
| 13 | LYTTELTON | 43 | 36 | 172 | 43 | E&V | Jun 1955 | LHB | TWS GAUGE |
| 14 | TIMARU | 44 | 24 | 171 | 15 | E&V | 1963 | TiHB | |
| 15 | DUNEDIN | 45 | 53 | 170 | 30 | EVE | oct 1963 | OHB | |
| 16 | BLUFF | 46 | 36 | 168 | 21 | POR | Pre-1920 | SHB | |
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## NEW ZEALAND

TIDE GAUGE ABBREVIATIONS

| | |
|---|---|
| DRU | Druck electric strain: Pressure operated |
| E&V | Evershed & Vignoles: Float operated |
| EVE | Evershed ER 8: Float operated |
| FOX | Foxboro pneumatic: Pressure operated |
| G&K | Glenfield & Kennedy: Float operated |
| PHI | Phillips electric strain: Pressure operated |
| POR | Porter: Float operated |
| REC | Record, Series 140SA: Float operated |
| RWM | R.W. Munro: Float operated |

AGENCY ABBREVIATIONS

| | |
|---|---|
| AHB | Auckland Harbour Board, PO Box 1259, Auckland |
| GHB | Gisborne Harbour Board, PO Box 549, Gisborne |
| GrHB | Greymouth Harbour Board, PO Box 76, Greymouth |
| HBHB | Hawke's Bay Harbour Board, Private Bag, Napier |
| LHB | Lyttelton Harbour Board, PO Box 2108, Lyttelton |
| MHB | Marlborough Harbour Board, PO Box 84, Picton |
| NeHB | Nelson Harbour Board, PO Box 1003, Nelson |

| | |
|---|---|
| NHB | Northland Harbour Board, Private Bag, Whangarei |
| OHB | Otago Harbour Board, PO Box 1, Dunedin |
| SHB | Southland Harbour Board, PO Box 1, Bluff |
| THB | Taranaki Harbour Board, PO Box 348, New Plymouth |
| TiHB | Timaru Harbour Board, PO Box 76, Timaru |
| WeHB | Westport Harbour, Westport |
| WHB | Wellington Harbour Board, PO Box 893, Wellington |

PREVIOUS RECORDS

Auckland: From 1918-1959 a Negretti and Zambra float-operated gauge was in operation
Nelson: From 1952-1974 an Evershed & Vignoles float-operated gauge was in operation
New Plymouth: From 1956-1966 a Foxboro pneumatic pressure-operated gauge was in operation
Onehunga: From 1924-1959 a Negretti & Zambra float-operated gauge was in operation
Westport: From 1952-1982 an Evershed float-operated gauge was in operation

***Figure 10:*** *Distribution of tide gauges of New Zealand*

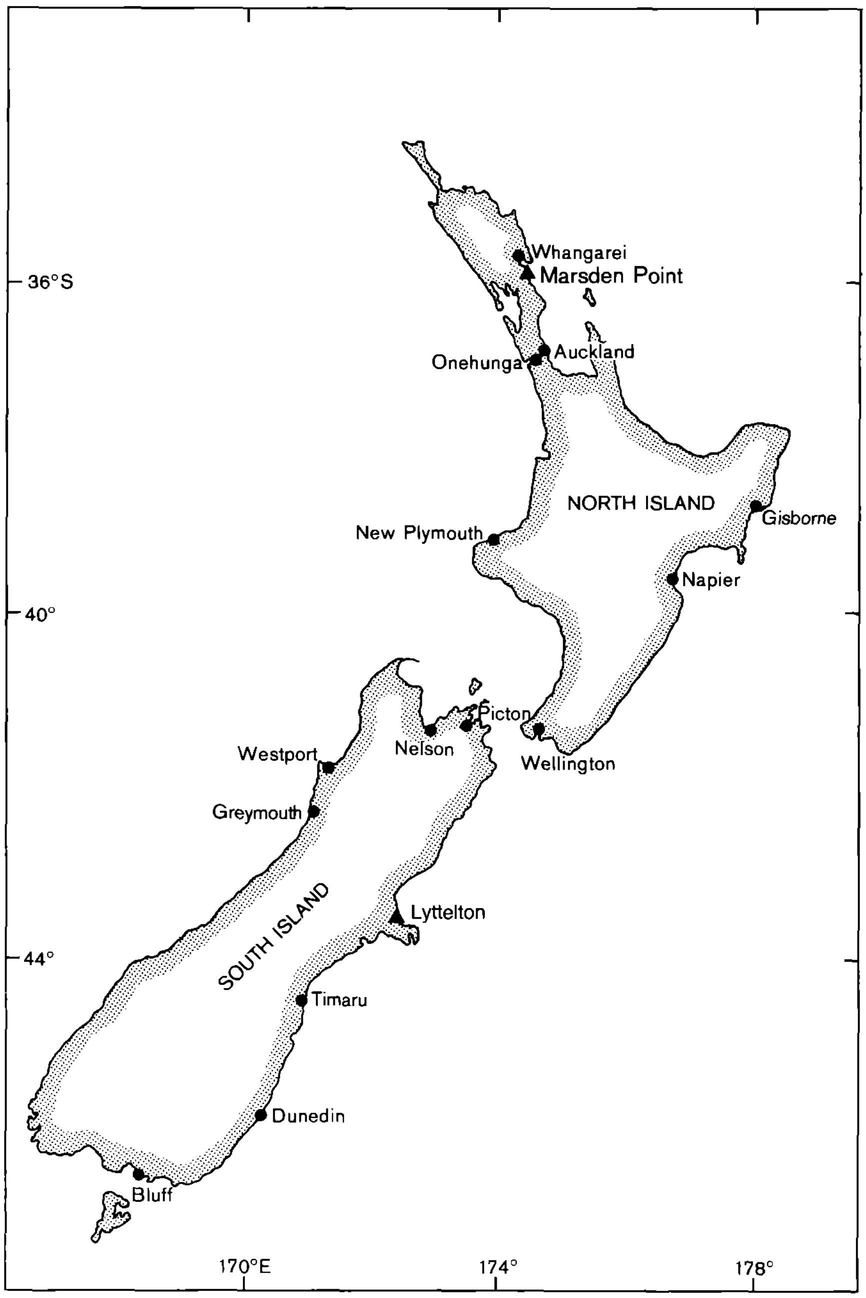

**Table 8: Tide gauges of the North Pacific Islands** (see Fig. 11)

NORTH PACIFIC ISLANDS

| No. | STATION NAME | LATITUDE North | | LONGITUDE East | | GAUGE | INSTALLED | AGENGY | COMMENTS |
|---|---|---|---|---|---|---|---|---|---|
| | | Deg | Min | Deg | Min | | | | |
| 1 | MALAKAL (Palau Is., Koro) | 07 | 20 | 134 | 28 | FP/BMF | May 1969 | NOAA | TWS GAUGE |
| 2 | TRUK (Moen Is) | 07 | 26 | 151 | 51 | FP/BMF | Mar 1979 | – | TWS GAUGE |
| 3 | KWAJELEIN (Marshall Is.) | 08 | 44 | 167 | 44 | FP/BMF | 1977 | – | TWS GAUGE |
| 4 | YAP I. (West Caroline Is.) | 09 | 31 | 138 | 08 | FP/BMF | May 1969 | – | TWS GAUGE |
| 5 | APRA (Guam I.) | 13 | 27 | 144 | 39 | FP/BMF | 1950 | – | TWS GAUGE |
| 6 | WAKE I. | 19 | 17 | 166 | 37 | | 1950 | – | TWS GAUGE |
| 7 | WHITE BEACH (Okinawa) | 26 | 18 | 127 | 55 | BMF | 1975 | – | TWS GAUGE |
| | | North | | West | | | | | |
| 8 | JOHNSTON I. | 16 | 45 | 169 | 31 | FP/BMF | Apr 1970 | – | TWS GAUGE |
| 9 | MIDWAY I. | 28 | 13 | 177 | 22 | FP/BMF | Feb 1979 | – | TWS GAUGE |
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**NORTH PACIFIC ISLANDS**

TIDE GAUGE ABBREVIATIONS

BMF Bristol Metameter: Float operated
BMP Bristol Metameter: Pressure operated
FP Fischer-Porter: Float operated

AGENCY ABBREVIATION

NOAA National Weather Service, NOAA, PO Box 50027, Honolulu, Hawaii 96850

NOTE

The Bristol recorders are chain driven off the FP gauges and are located in the Communication Offices for use in the Tsunami Warning System.

Each tide station listed in the North Pacific is equipped with a back-up Metercraft bubbler gauge in addition to those indicated.

*Figure 11: Distribution of tide gauges of the North Pacific Islands*

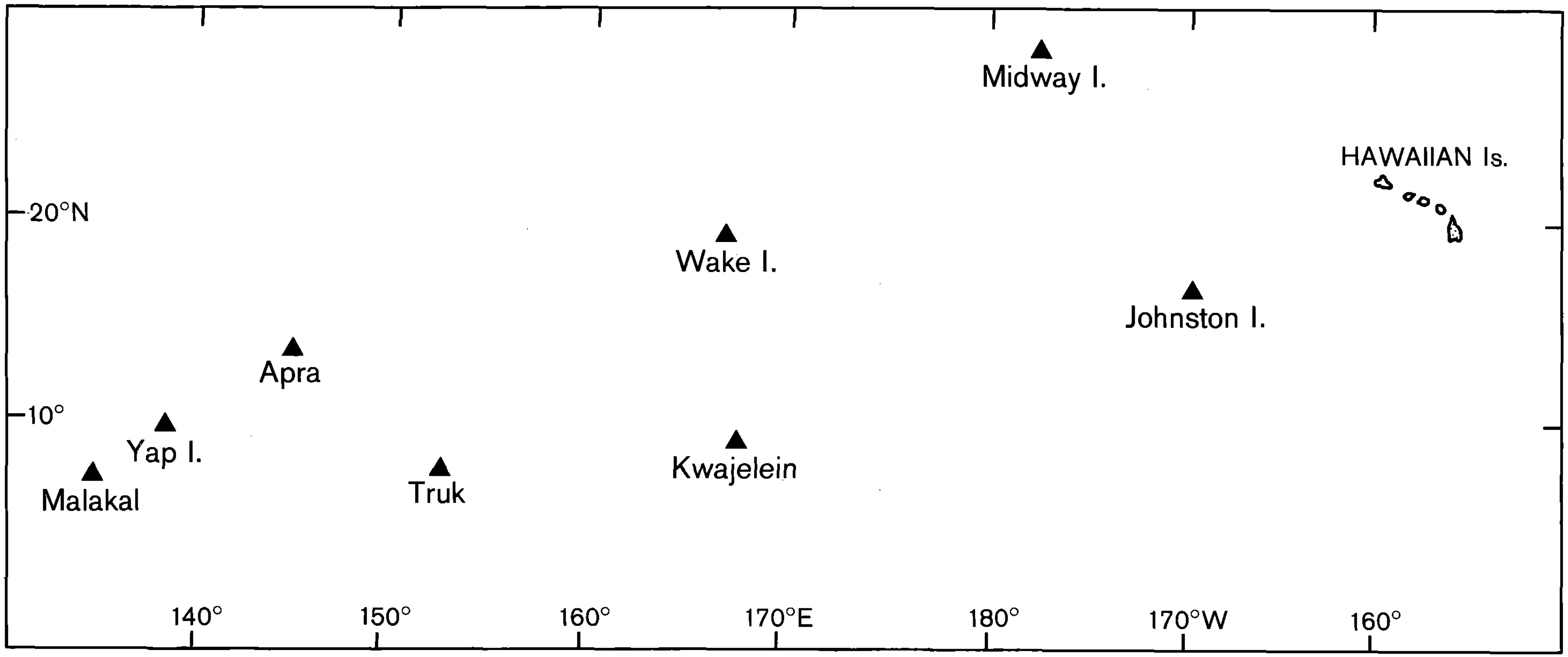

**Table 9: Tide gauges of Papua New Guinea** (see Fig. 12)

COUNTRY: PAPUA NEW GUINEA

| No. | STATION NAME | LATITUDE South | | LONGITUDE East | | GAUGE | INSTALLED | AGENGY | COMMENTS |
|---|---|---|---|---|---|---|---|---|---|
| | | Deg | Min | Deg | Min | | | | |
| 1 | VANIMO | 02 | 41 | 141 | 18 | LS | 1978 | DTCA | |
| 2 | MADANG | 05 | 13 | 145 | 50 | LS | | DTCA | |
| 3 | LAE | 06 | 44 | 147 | 59 | LS | | DTCA | |
| 4 | PORT MORESBY | 10 | 29 | 147 | 08 | LS | | DTCA | |
| | | | | | | | | | |
| | **BOUGAINVILLE ISLAND** | | | | | | | | |
| 5 | ANEWA BAY | 06 | 11 | 155 | 33 | LS | | BCL | |
| 6 | MAGINI ISLAND | 06 | 16 | 155 | 07 | HS/LS | | BCL | |
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**PAPUA NEW GUINEA**

TIDE GAUGE ABBREVIATIONS

L&S Leupold & Stevens: Float operated
HS/L&S Hydrological Services Bubbler Type with I & S recorder

AGENCY ABBREVIATIONS

DTCA Department of Transport & Civil Aviation, Division of Marine, P.O. Box 2457, Konedobu, Papua New Guinea
BCL Bougainville Copper Ltd., Panguana, Bougainville, Papua New Guinea

*Figure 12: Distribution of tide gauges of Papua New Guinea*

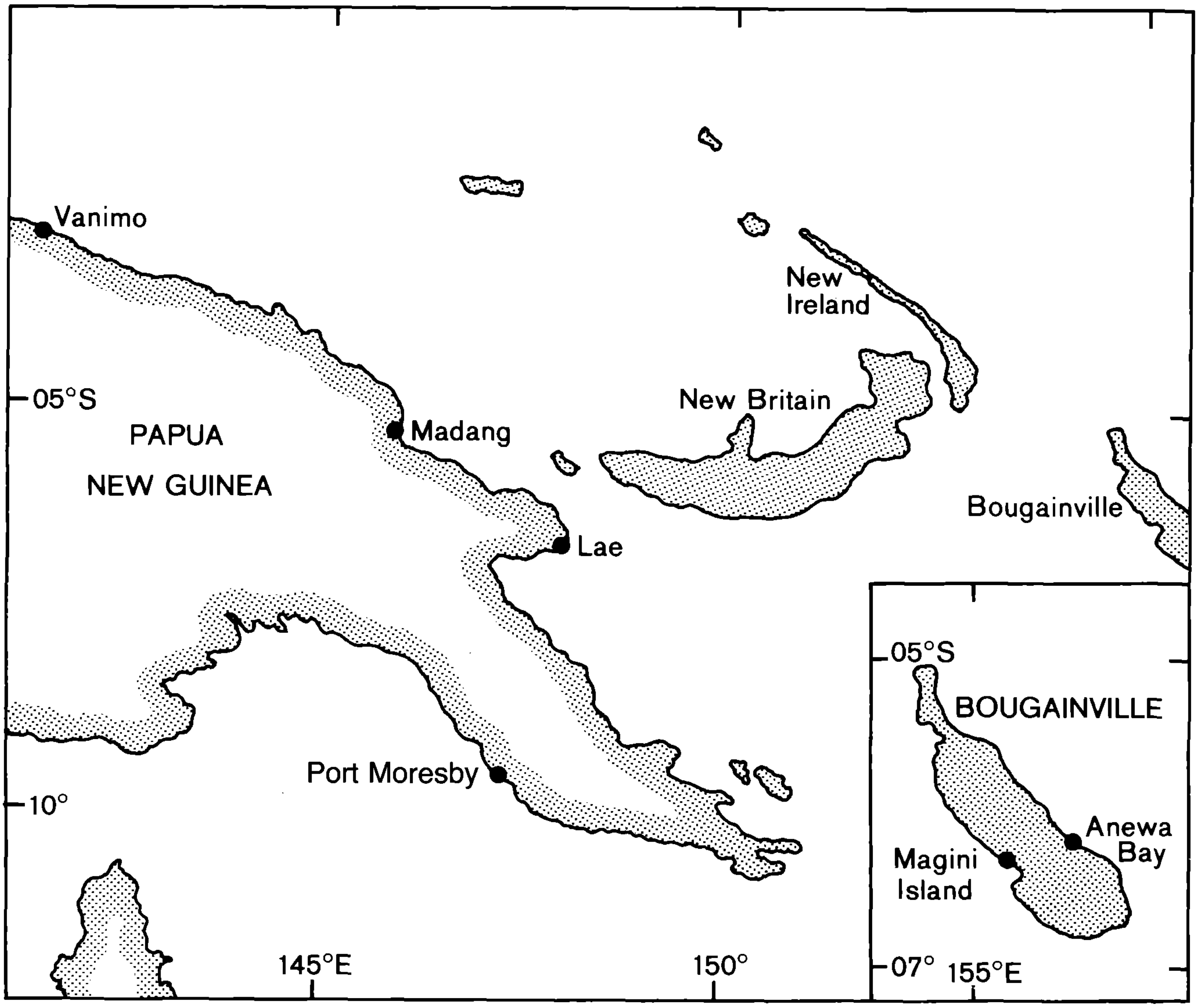

**Table 10: Tide gauges of the Philippines** (see Fig. 13)

COUNTRY: PHILIPPINES

| No. | STATION NAME | LATITUDE North | | LONGITUDE East | | GAUGE | INSTALLED | AGENGY | COMMENTS |
|---|---|---|---|---|---|---|---|---|---|
| | | Deg | Min | Deg | Min | | | | |
| 1 | JOLO | 06 | 04 | 121 | 00 | STD | 1947 | BCGS | |
| 2 | DAVAO | 07 | 05 | 125 | 38 | STD | 1947 | BCGS | TWS GAUGE |
| 3 | CEBU | 10 | 18 | 123 | 54 | STD | 1935 | BCGS | |
| 4 | LEGASPI | 13 | 09 | 123 | 14 | STD | 1947 | BCGS | TWS GAYGE |
| 5 | PARACALE | 14 | 17 | 122 | 47 | STD | 1982 | PAGA | |
| 6 | MANILA (South Harbour) | 14 | 35 | 120 | 58 | STD | 1901 | BCGS | |
| 7 | SOLVEC | 17 | 27 | 120 | 27 | STD | 1982 | PAGA | |
| 8 | CURRIMAO | 18 | 01 | 120 | 29 | STD | 1980 | PAGA | |
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**PHILIPPINES**

TIDE GAUGE ABBREVIATION

STD Standard: Float operated

AGENCY ABBREVIATIONS

BCGS Bureau of Coast & Geodetic Survey, 421 Barraca St., San Nicolas, Manila
PAGA Philippine National Atmospheric, Geophysical & Astronomical Service Administration, 1424 Quezon Boulevard Extension, Quezon City

*Figure 13:* *Distribution of tide gauges of the Philippines*

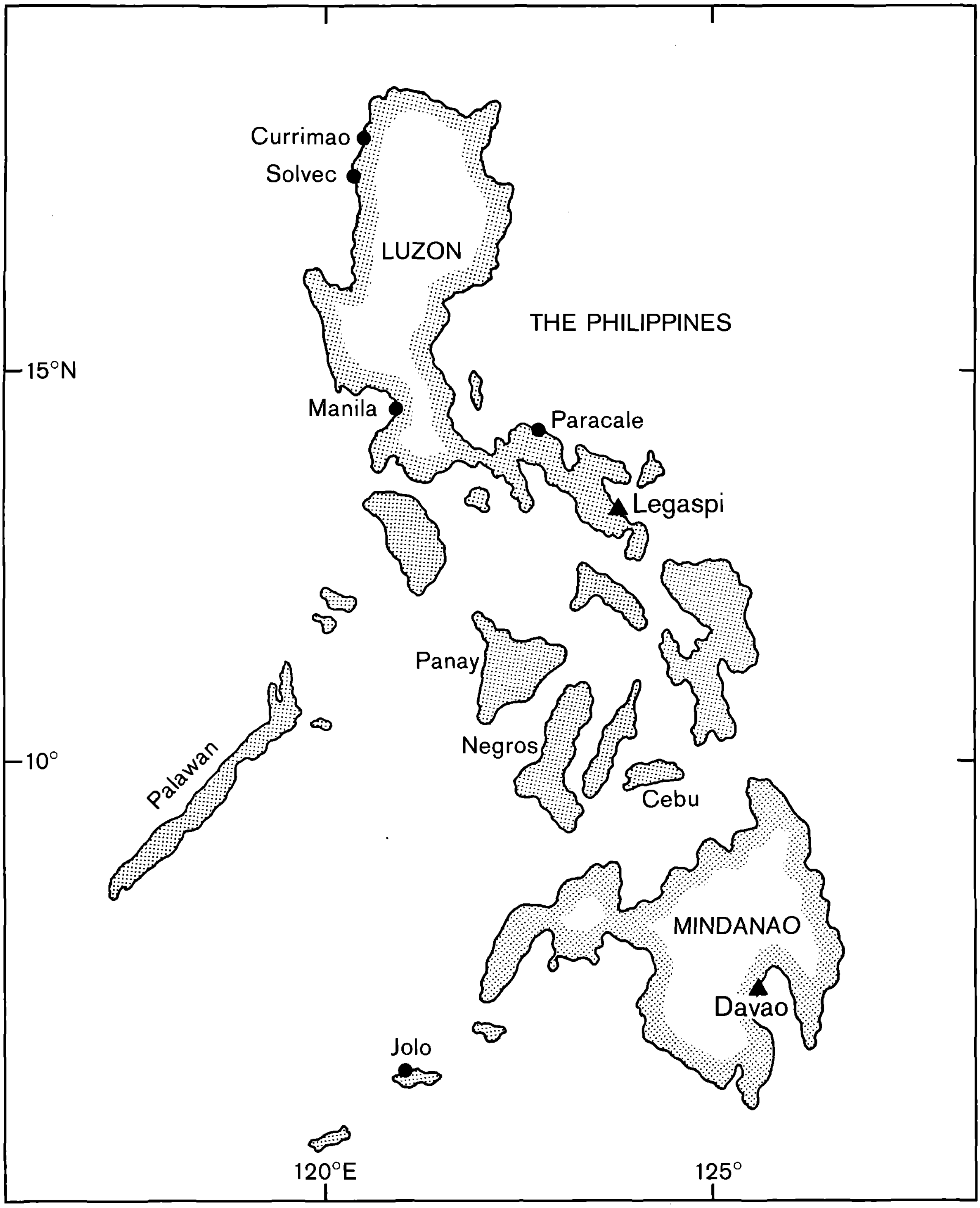

**Table 11: Tide gauges of Singapore** (see Fig. 14)

COUNTRY: SINGAPORE

| No. | STATION NAME | LATITUDE North | | LONGITUDE East | | GAUGE | INSTALLED | AGENGY | COMMENTS |
|---|---|---|---|---|---|---|---|---|---|
| | | Deg | Min | Deg | Min | | | | |
| 1 | RAFFLES LIGHTHOUSE | 01 | 09.6 | 103 | 44.6 | OTT | Jul 1973 | PSA | |
| 2 | BUKOM BESEIR | 01 | 13.8 | 103 | 46.7 | OTT | Oct 1979 | – | |
| 3 | SULTAN SHOAL LIGHTHOUSE | 01 | 14.4 | 103 | 39.0 | OTT | 1972 | – | |
| 4 | WORLD TRADE CENTRE | 01 | 15.8 | 103 | 49.3 | OTT | Aug 1981 | – | |
| 5 | SLAVE II (Ajax Shoal) | 01 | 17.0 | 103 | 36.5 | OTT | Jun 1981 | – | |
| 6 | KALLANG RIVER | 01 | 18.2 | 103 | 52.3 | OTT | Dec 1980 | – | |
| 7 | JURONG WHARF | 01 | 18.4 | 103 | 43.2 | OTT | May 1970 | – | |
| 8 | SLAVE I (Angler Bank) | 01 | 20.7 | 104 | 01.8 | OTT | Feb 1976 | – | |
| 9 | PU TEKONG BESAR | 01 | 24.8 | 104 | 05.2 | OTT | Feb 1982 | – | |
| 10 | PUNGGOL BN. | 01 | 25.3 | 103 | 54.8 | OTT | Apr 1972 | – | |
| 11 | SEMBEWANG | 01 | 28.0 | 103 | 50.0 | RWM | | – | |
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**SINGAPORE**

TIDE GAUGE ABBREVIATIONS

RWM R.W. Munro: Float operated
OTT Ott: Float operated

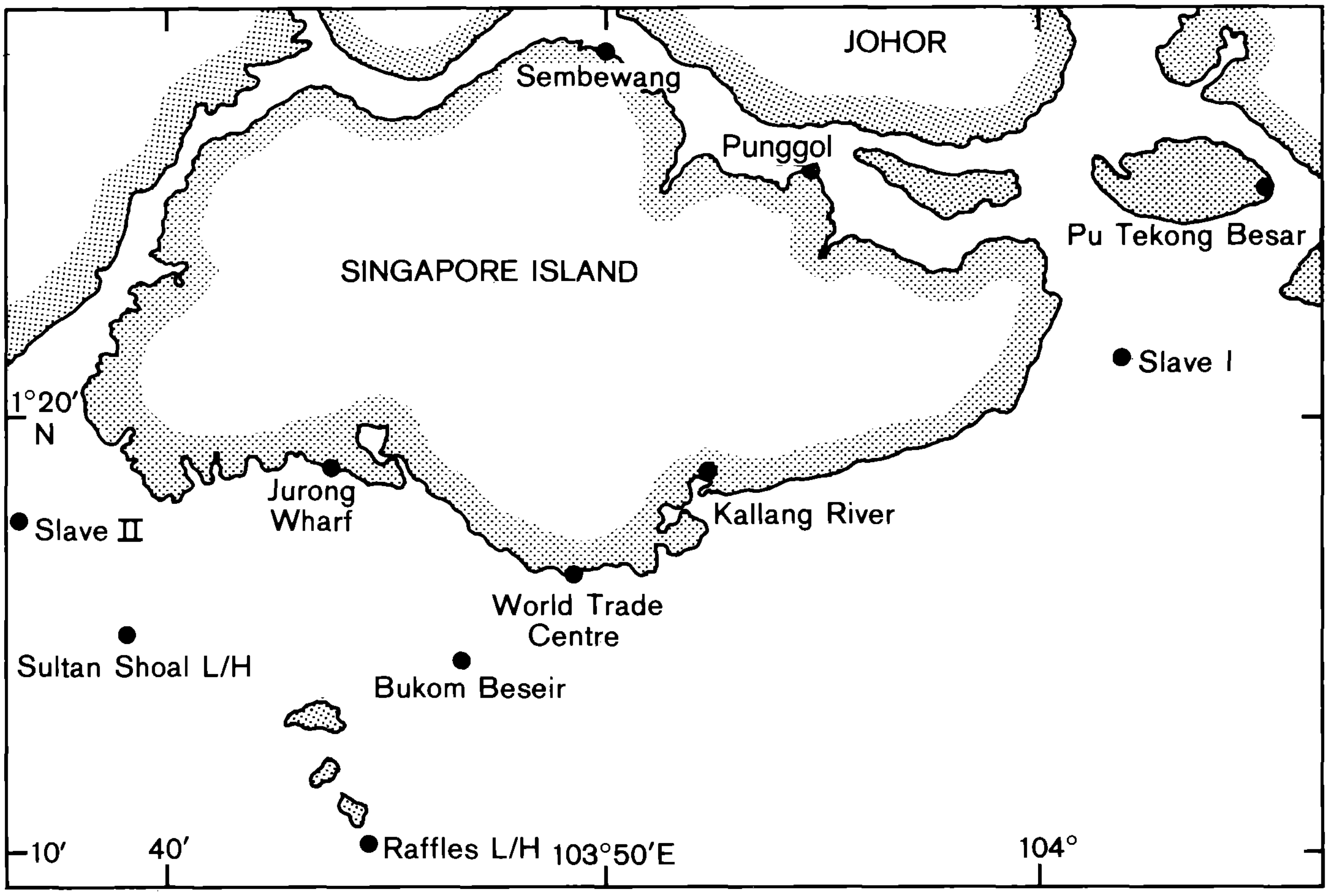
AGENCY ABBREVIATION

PSA Port of Singapore Authority, Hydrographic Department, 12th Floor Tanjong Pagar Complex, Tanjong Pagar Road, Singapore 0208

NOTE

The tide gauge at the World Trade Centre was previously installed at Victoria Dock (01 16'N, 103 16.5'E) from April 1972 to August 1981

***Figure 14:*** *Distribution of tide gauges of Singapore*



## **Table 12: Tide gauges of South America** (Fig. 15)

AREA: SOUTH AMERICA COUNTRIES: COLOMBIA/ECUADOR/PERU/CHILE

| No. | STATION NAME | LATITUDE North | | LONGITUDE West | | GAUGE | INSTALLED | AGENGY | COMMENTS |
|---|---|---|---|---|---|---|---|---|---|
| | | Deg | Min | Deg | Min | | | | |
| | **COLOMBIA** | | | | | | | | |
| 1 | TUMACO | 01 | 50 | 078 | 44 | | | | |
| 2 | BUENAVENTURA | 03 | 54 | 077 | 05 | | | | |
| 3 | BAHIA DE SOLANO | 06 | 14 | 077 | 24 | | | | |
| | **ECUADOR** | South | | West | | | | | |
| 4 | BALTRA ISLAND | 00 | 26 | 090 | 17 | STD | Feb 1968 | INOCAR | TWS GAUGE |
| 5 | SAN CRISTOBAL (Galapagos Is.) | 00 | 54 | 089 | 34 | STD | | INOCAR | |
| 6 | MANTA | 00 | 56 | 080 | 43 | STD | Jun 1971 | INOCAR | |
| 7 | LA LIBERTAD | 02 | 13 | 080 | 55 | STD | Oct 1968 | INOCAR | |
| 8 | PTO. BOLIVAR | 03 | 18 | 080 | 00 | STD | Aug 1973 | INOCAR | |
| | **PERU** | | | | | | | | |
| 9 | EL SALTO | 03 | 25 | 080 | 18 | STD | Jul 1979 | DHN | |
| 10 | TALARA | 04 | 35 | 081 | 17 | STD | Mar 1942 | – | |
| 11 | PAITA | 05 | 05 | 081 | 07 | DIG | Mar 1982 | – | |
| 12 | I. LOBOS DE AFUERA | 06 | 56 | 080 | 43 | STD | Apr 1978 | – | |
| 13 | PIMENTEL | 06 | 50 | 079 | 56 | DIG/SRD | Apr 1978 | – | |
| 14 | CHIMBOTE | 09 | 05 | 078 | 38 | DIG/STD | Oct 1954 | – | |
| 15 | LA PUNTA (Callao) | 12 | 04 | 077 | 10 | STD | Jan 1954 | – | TWS GAUGE |
| 16 | SAN JUAN | 15 | 21 | 075 | 09 | STD | Jul 1975 | DHN | |
| 17 | MATARANI | 17 | 00 | 072 | 07 | STD | Apr 1941 | – | |
| | **CHILE** | | | | | | | | |
| 18 | ARICA | 18 | 29 | 070 | 19 | STD | Nov 1950 | IHA | TWS GAUGE |
| 19 | ANTOFAGASTA | 23 | 39 | 070 | 25 | STD | Dec 1945 | – | TWS GAUGE |
| 20 | CALDERA | 27 | 07 | 070 | 50 | STD | Nov 1950 | – | |
| 21 | ISLA DE PASCUA (Easter Island) | 27 | 09 | 109 | 27 | BRI | Jan 1957 | – | TWS GAUGE |
| 22 | COQUIMBO | 29 | 56 | 071 | 21 | BRI | Apr 1960 | – | |
| 23 | VALPARAISO | 33 | 02 | 071 | 38 | MC | Mar 1941 | – | TWS GAUGE |
| 24 | TALCAHUANO | 36 | 41 | 073 | 06 | STD | Jun 1949 | – | TWS GAUGE |
| 25 | PUERTO MONTT | 41 | 29 | 072 | 58 | MC | Jan 1942 | – | TWS GAUGE |
| 26 | PUNTA ARENAS | 53 | 10 | 070 | 54 | BRI | Jan 1942 | – | TWS GAUGE |
| 27 | PUERTO WILLIAMS | 54 | 56 | 067 | 37 | STD | Nov 1964 | – | TWS GAUGE |
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## SOUTH AMERICA

TIDE GAUGE ABBREVIATIONS

| | |
|---|---|
| BRI | Bristol:Float operated |
| DIG | Digital gauge |
| MC | Metercraft bubbler: Pressure operated |
| STD | Standard: Float operated |

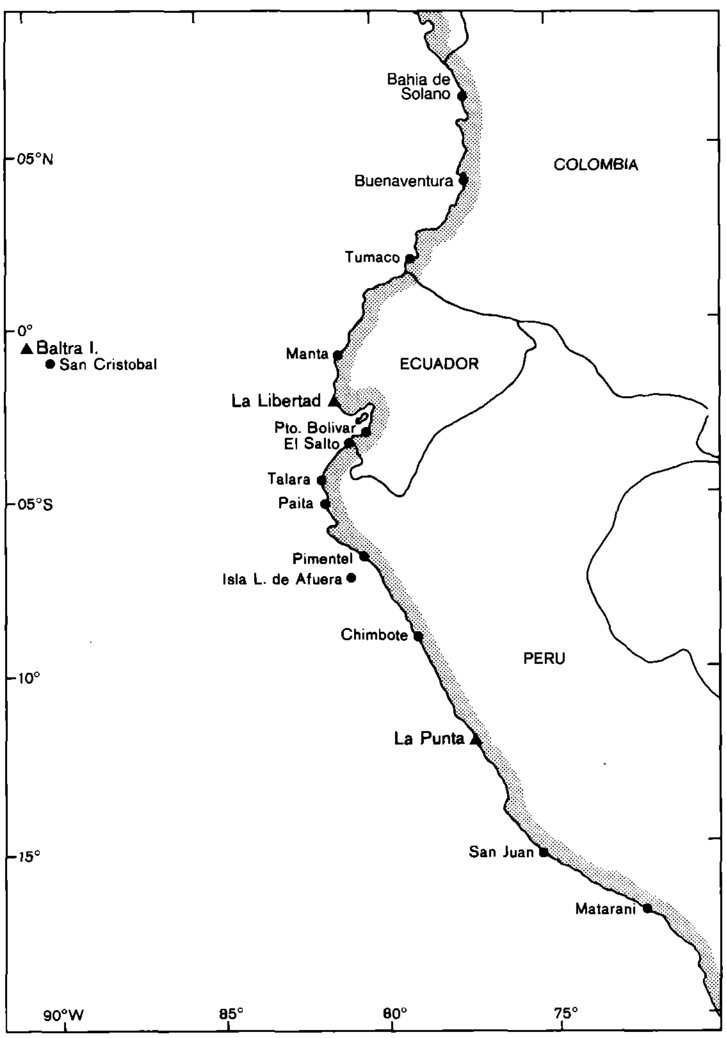
AGENCY ABBREVIATION

| | |
|---|---|
| DHN | Dirección de Hidrografía y Navegación de la Marina, Casilla Postal 80, La Punta, Callao, Perú |
| IHA | Instituto Hydrográfico de la Armada, Casilla 324, Valparaíso, Chile |
| INOCAR | Instituto Oceanográfico de la Armada, P.O. Box 5940, Guayaquil, Ecuador |

NOTE

The digital gauges listed under 'Peru' were installed by the University of Oregon, USA.

***Figure 15:*** *Distribution of tide gauges of South America*



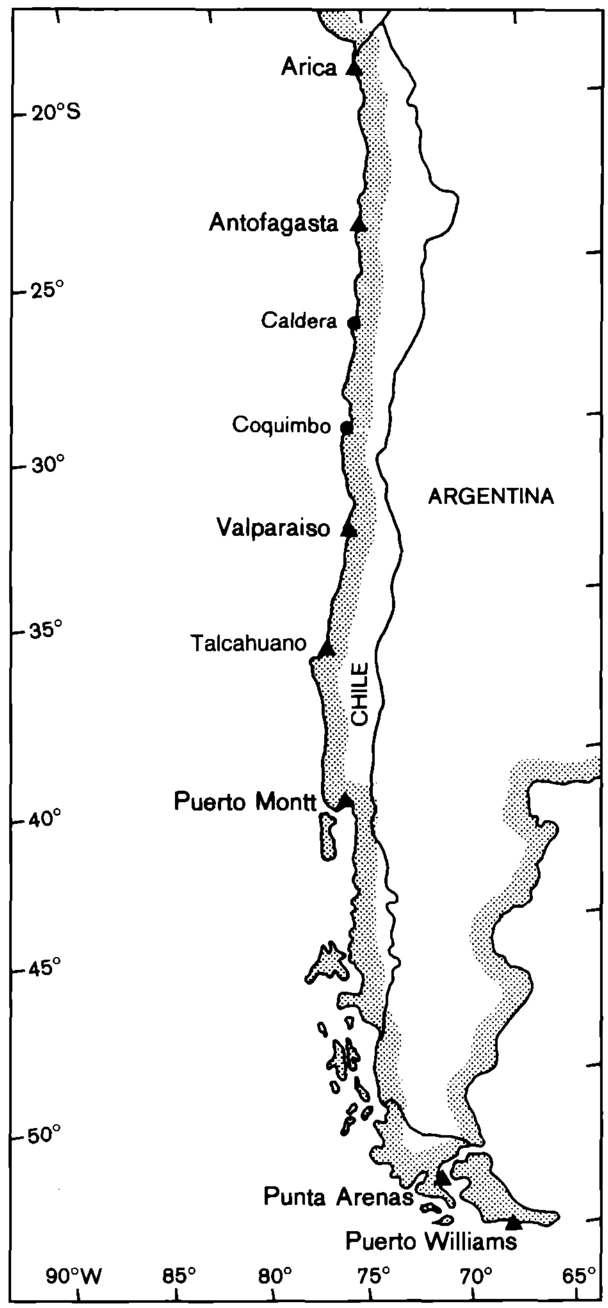



**Table 13: Tide gauges of the South Pacific Islands** (see Fig. 16)

SOUTH PACIFIC ISLANDS

| No. | STATION NAME | LATITUDE South | | LONGITUDE East | | GAUGE | INSTALLED | AGENGY | COMMENTS |
|---|---|---|---|---|---|---|---|---|---|
| | | Deg | Min | Deg | Min | | | | |
| 1 | PORT VILA (New Hebrides) | 17 | 45 | 168 | 15 | BEL | Jun 1979 | | |
| 2 | SUVA (Fiji) | 18 | 08 | 178 | 26 | BMF | Mar 1970 | FMD | TWS GAUGE |
| 3 | NOUMEA (New Caledonia) | 22 | 17 | 166 | 26 | OTT | Mar 1968 | MOP | TWS GAUGE |
| | | South | | West | | | | | |
| 4 | CANTON ISLAND | 02 | 49 | 171 | 43 | BRI/FP | May 1972 | NOAA | TWS GAUGE |
| 5 | APIA (Western Samoa) | 13 | 50 | 171 | 45 | BRI | Oct 1970 | AO | TWS GAUGE |
| 6 | PAGO PAGO (American Samoa) | 14 | 16 | 170 | 41 | LS/MC | Mar 1979 | NOAA | TWS GAUGE |
| 7 | PAPEETE (Tahiti) | 17 | 32 | 149 | 34 | STD | Mar 1969 | MOP | TWS GAUGE |
| 8 | RIKITEA (Mangareva Island) | 23 | 08 | 134 | 57 | BRI | Oct 1969 | MOP | TWS GAUGE |
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**SOUTH PACIFIC ISLANDS**

TIDE GAUGE ABBREVIATIONS

BEL Belfort: Float operated
BMF Bristol Metameter: Float operated
BRI Bristol: Float operated
FP Fischer-Porter: Float operated
MC Metercraft bubbler: Pressure operated
OTT Ott: Float operated
STD Standard: Float operated

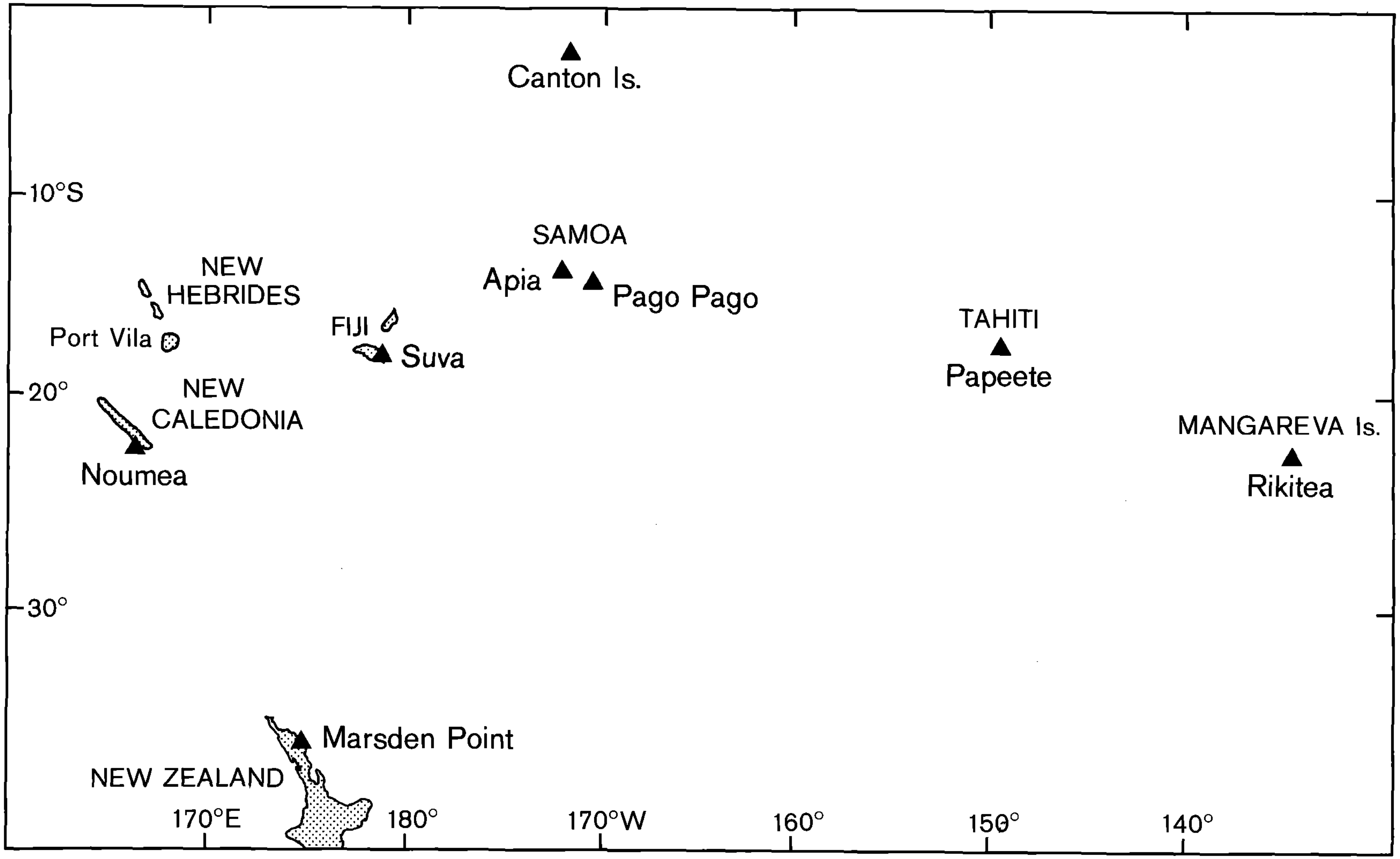
AGENCY ABBREVIATIONS

AO Apia Observatory, Private Bag, Apia, Western Samoa
FMD Fiji Marine Department, P.O. Box 326, Suva, Fiji
GMR Geology, Mines and Rural Water Supplies, New Hebrides Government, Port Vila, New Hebrides
MOP Mission Océanographique du Pacifique, BP 38, Nouméa, New Caledonia
NOAA National Weather Service, NOAA, P.O. Box 50027, Honolulu, Hawaii 96850

NOTE

The gauge at Port Vila, New Hebrides, has been installed as part of an ongoing research programme. There is no assurance that the gauge will be retained after 1984.

***Figure 16:*** *Distribution of tide gauges of the South Pacific Islands*



## Table 14: Tide gauges of the United Kingdom - Hong Kong (see Fig. 17)

COUNTRY: UNITED KINGDOM - HONG KONG

| No. | STATION NAME | LATITUDE North | | LONGITUDE East | | GAUGE | INSTALLED | AGENGY | COMMENTS |
|---|---|---|---|---|---|---|---|---|---|
| | | Deg | Min | Deg | Min | | | | |
| 1 | WAGLAN ISLAND | 22 | 11 | 114 | 18 | ESS | Sep 1976 | RO | |
| 2 | CHI MA WAN | 22 | 14 | 114 | 00 | RWM | Jun 1960 | PWD | |
| 3 | NORTH POINT | 22 | 18 | 114 | 12 | RWM | Dec 1953 | PWD | |
| 4 | TAI PO KAU | 22 | 27 | 114 | 11 | RWM | Aug 1962 | PWD | |
| 5 | TSIM BEI TSUI | 22 | 29 | 114 | 01 | RWM | Apr 1974 | PWD | |
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**UNITED KINGDOM - HONG KONG**

TIDE GAUGE ABBREVIATIONS

ESS Essdaile: Float operated
RWM R.W. Munro: Float operated

AGENCY ABBREVIATION

RO Royal Observatory,Nathan Road, Kowloon, Hong Kong

***Figure 17:*** *Distribution of tide gauges of the United Kingdom–Hong Kong*

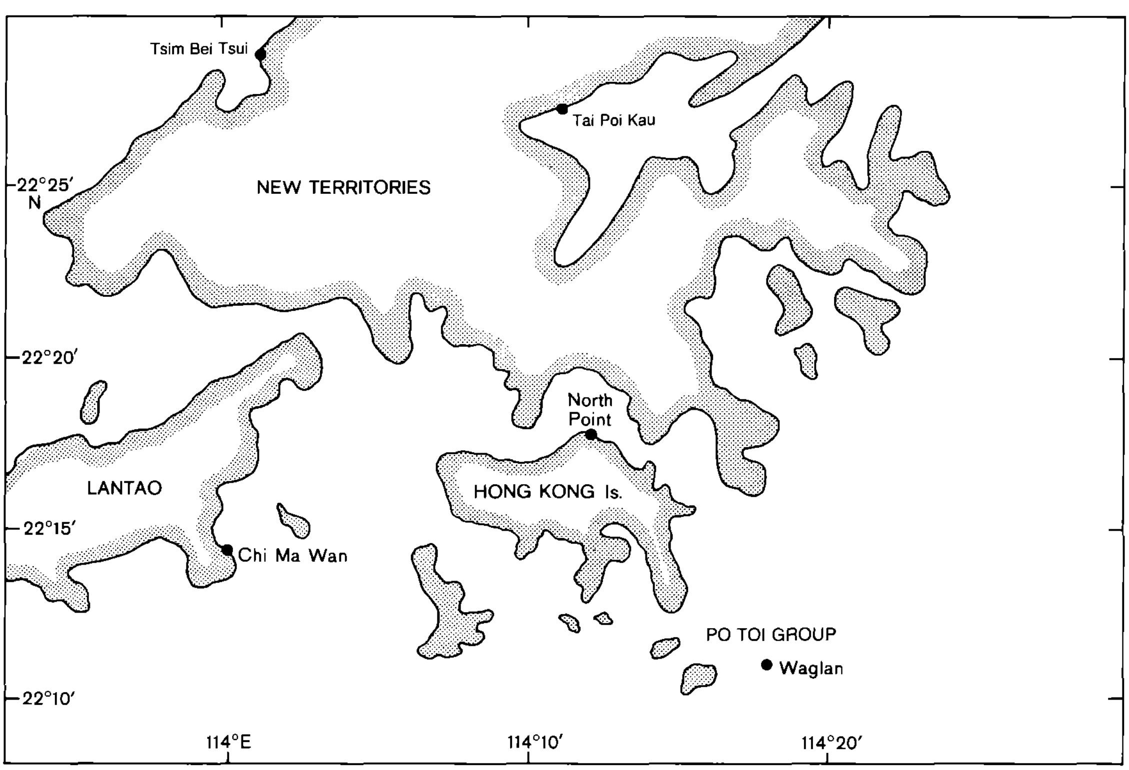

**Table 15: Tide gauges of the United States of America** (see Fig. 18)

COUNTRY: UNITED STATES OF AMERICA — STATE: ALASKA

| No. | STATION NAME | LATITUDE North | | LONGITUDE West | | GAUGE | INSTALLED | AGENGY | COMMENTS |
|---|---|---|---|---|---|---|---|---|---|
| | | Deg | Min | Deg | Min | | | | |
| 1 | ADAK ISLAND | 51 | 52 | 176 | 38 | L&S/BMP | Jul 1972 | NOAA | TWS GAUGE |
| 2 | SHEMYA | 52 | 44 | 174 | 04 | BMP | Oct 1976 | – | TWS GAUGE |
| 3 | UNALASKA (Fox Island) | 53 | 53 | 166 | 32 | L&S/BMP | 1955 | – | TWS GAUGE |
| 4 | COLD BAY | 55 | 13 | 162 | 42 | BRI | Jul 1971 | – | |
| 5 | KETCHIKAN | 55 | 20 | 131 | 37 | L&S/MC | 1919 | – | |
| 6 | SAND POINT | 55 | 20 | 160 | 30 | FP/MC | 1972 | – | TWS GAUGE |
| 7 | SITKA (Baranoff Island) | 57 | 03 | 135 | 20 | L&S/MC | 1938 | – | TWS GAUGE |
| 8 | KODIAK ISLAND | 57 | 45 | 152 | 29 | BRI | 1949 | – | TWS GAUGE |
| 9 | JUNEAU | 58 | 18 | 134 | 25 | FP | 1936 | – | |
| 10 | SELDOVIA | 59 | 26 | 151 | 23 | L&S/MC | 1964 | – | |
| 11 | YAKUTAT | 59 | 33 | 139 | 44 | L&S/MC | 1940 | – | TWS GAUGE |
| 12 | SEWARD | 60 | 07 | 149 | 26 | L&S/MC | 1923 | – | TWS GAUGE |
| 13 | CORDOVA | 60 | 33 | 145 | 45 | L&S/MC | 1949 | – | |
| 14 | NIKISKI | 60 | 41 | 151 | 24 | BRI | 1971 | – | |
| 15 | VALDEZ | 61 | 07 | 146 | 22 | L&S/MC | 1966 | – | |
| 16 | ANCHORAGE | 61 | 14 | 149 | 53 | BRI | 1964 | – | |
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## Table 15: continued

COUNTRY: UNITED STATES OF AMERICA — STATE: CALIFORNIA

| No. | STATION NAME | LATITUDE North | | LONGITUDE West | | GAUGE | INSTALLED | AGENGY | COMMENTS |
|---|---|---|---|---|---|---|---|---|---|
| | | Deg | Min | Deg | Min | | | | |
| 1 | SAN DIEGO BAY | 32 | 43 | 177 | 10 | L&S/MC | Jul 1946 | NOAA | |
| 2 | LA JOLLA (Scripps Institution) | 32 | 52 | 117 | 15 | L&S/MC | 1924 | – | TWS GAUGE |
| 3 | NEWPORT BAY ENTRANCE | 33 | 36 | 117 | 53 | L&S/MC | 1955 | – | |
| 4 | SAN PEDRO (Los Angeles) | 33 | 43 | 118 | 16 | L&S/MC | Apr 1939 | – | TWS GAUGE |
| 5 | LONG BEACH (Terminal Island) | 33 | 45 | 118 | 14 | L&S/MC | 1963 | – | |
| 6 | SANTA MONICA | 34 | 00 | 118 | 30 | L&S/MC | 1936 | – | |
| 7 | RINCON ISLAND | 34 | 21 | 119 | 27 | L&S | 1962 | – | |
| 8 | PORT SAN LUIS (Avila Beach) | 35 | 10 | 120 | 45 | L&S/MC | 1945 | – | |
| 9 | MONTEREY HARBOR | 36 | 35 | 121 | 53 | L&S/MC | 1974 | – | |
| 10 | SAN MATEO | 37 | 35 | 122 | 15 | L&S/MC | Dec 1980 | – | |
| 11 | ALAMEDA (San Francisco Bay) | 37 | 36 | 122 | 18 | L&S/MC | 1939 | – | |
| 12 | ARENA COVE | 37 | 47 | 122 | 18 | L&S/MC | Dec 1977 | – | |
| 13 | THE PRESIDIO (San francisco) | 37 | 48 | 122 | 28 | L&S/MC | 1854 | – | TSW GAUGE |
| 14 | POINT REYES | 38 | 00 | 122 | 58 | L&S/MC | 1973 | – | |
| 15 | PORT CHICAGO | 38 | 03 | 120 | 02 | L&S/MC | Feb 1977 | – | |
| 16 | NORTH SPIT (Humbolt Bay) | 40 | 46 | 124 | 13 | L&S/MC | Aug 1981 | – | |
| 17 | TRINIDAD | 41 | 03 | 124 | 09 | L&S/MC | 1982 | – | |
| 18 | CRESCENT CITY | 41 | 11 | 124 | 11 | L&S/MC | Nov 1981 | – | TWS GAUGE |
| | | | | | | | | | |

COUNTRY: UNITED STATES OF AMERICA — STATE: HAWAII

| No. | STATION NAME | LATITUDE North | | LONGITUDE West | | GAUGE | INSTALLED | AGENGY | COMMENTS |
|---|---|---|---|---|---|---|---|---|---|
| | | Deg | Min | Deg | Min | | | | |
| 1 | HONUAPO (Hawaii) | 19 | 06 | 156 | 43 | BMP | 1975 | NOAA | TWS GAUGE |
| 2 | KAILUA KONA (Hawaii) | 19 | 38 | 156 | 00 | MSP | | – | TWS GAUGE |
| 3 | HILO (Havai) | 19 | 44 | 155 | 04 | MSP | | – | TWS GAUGE |
| 4 | MAHU KONA (Hawaii) | 20 | 11 | 155 | 54 | MSP | 1982 | – | TWS GAUGE |
| 5 | KAHULUI (Maui) | 20 | 54 | 156 | 28 | BMF | 1979 | – | |
| 6 | HONOLULU (Oahu) | 21 | 18 | 159 | 21 | BMF | 1973 | – | TWS GAUGE |
| 7 | PUULOA (Oahu) | 21 | 20 | 157 | 58 | BMP | Jun 1982 | – | |
| 8 | NAWILIWILI (Kauai) | 21 | 57 | 159 | 21 | BMF | 1954 | – | |
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**Table 15: continued**

COUNTRY: UNITED STATES OF AMERICA — STATE: WASHINGTON/OREGON

| No. | STATION NAME | LATITUDE North | | LONGITUDE West | | GAUGE | INSTALLED | AGENGY | COMMENTS |
|---|---|---|---|---|---|---|---|---|---|
| | | Deg | Min | Deg | Min | | | | |
| | **WASHINGTON** | | | | | | | | |
| 1 | PORT TOWNSEND | 46 | 07 | 122 | 45 | L&S | 1972 | NOAA | |
| 2 | TOKE POINT | 46 | 42 | 123 | 58 | L&S | 1935 | – | |
| 3 | SEATTLE | 47 | 36 | 122 | 20 | L&S/MC | 1929 | – | |
| 4 | POULSBO | 47 | 44 | 122 | 38 | FP/MC | | – | |
| 5 | PORT ANGELES | 48 | 07 | 122 | 26 | L&S | 1975 | – | |
| 6 | NEAH BAY | 48 | 22 | 124 | 37 | L&S/MC | 1934 | – | TWS GAUGE |
| 7 | FRIDAY HARBOR | 48 | 33 | 123 | 01 | L&S/MC | 1934 | – | |
| 8 | CHERRY POINT | 48 | 52 | 122 | 45 | L&S/MC | 1971 | – | |
| | **OREGON** | | | | | | | | |
| 9 | PORT ORFORD | 42 | 44 | 124 | 30 | L&S/MC | 1929 | – | |
| 10 | CHARLESTON (Coos Bay) | 43 | 21 | 124 | 19 | L&S | 1972 | – | |
| 11 | NEWPORT (South Beach) | 44 | 37 | 124 | 03 | L&S | 1962 | – | |
| 12 | DEPOE BAY | 44 | 49 | 124 | 04 | L&S | 1962 | – | |
| 13 | ASTORIA | 46 | 12 | 123 | 46 | L&S/MC | 1925 | – | |
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## UNITED STATES OF AMERICA

TIDE GAUGE ABBREVIATIONS

BMF Bristol Metameter: Float operated
BMP Bristol Metameter: Pressure operated
BRI Bristol: Float operated
FP Fischer-Porter: Float operated: Digital recorder at 15 minute intervals.
L&S Leupold & Stevens: Float operated; Analogue to digital recorder.
MC Metercraft bubbler: Pressure operated
MSP Metercraft electric strain: pressure operated

AGENCY ABBREVIATION

NOAA National Oceanographic and Atmospheric Administration, National Weather Service,
P.O. Box 50027, Honolulu, Hawaii 96850

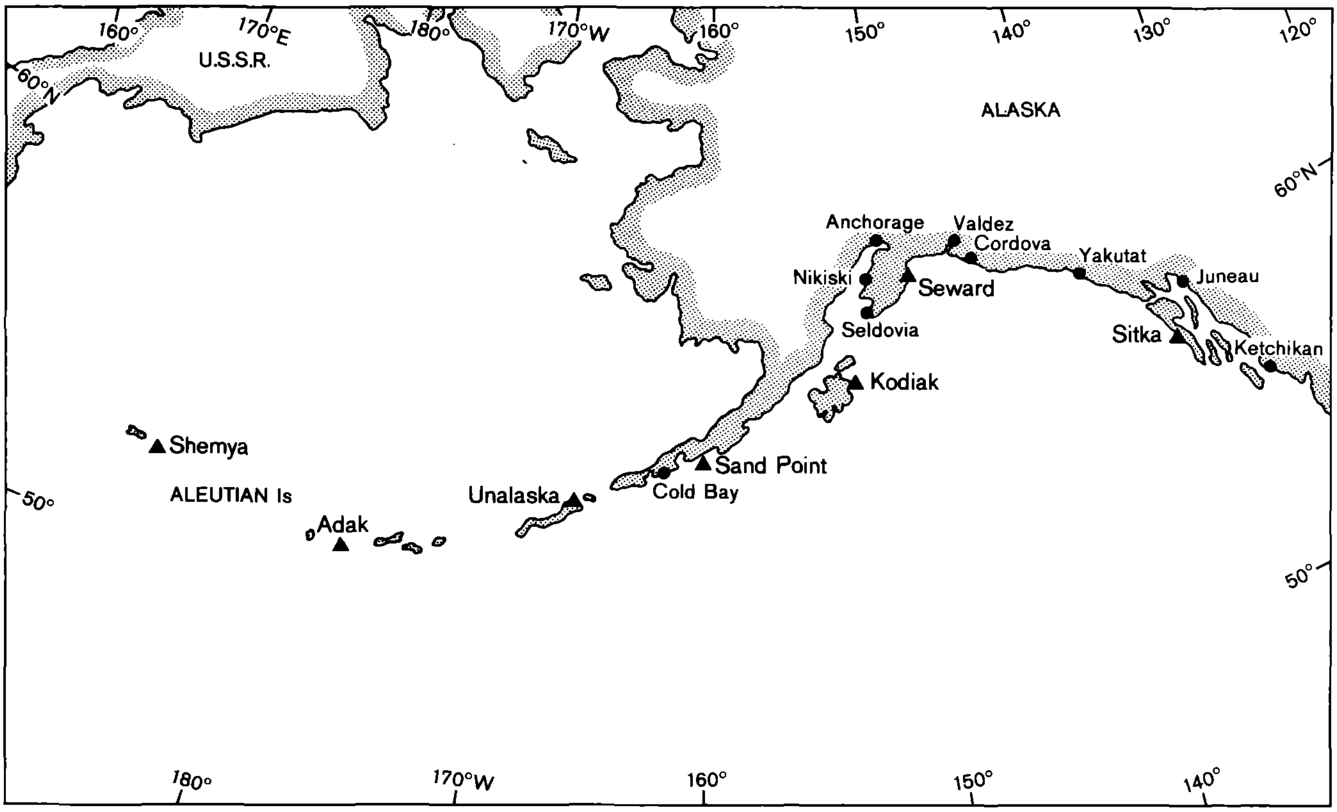
NOTES

NOAA will replace their Bristol Metameter Gauges in the Tsunami Warning System within the next two years with Metercraft bubbler (pressure) gauges. These Metercraft gauges will be telemetered.

The Leupold & Stevens gauges may drive a Bristol Metameter recorder.

The tide station at Poulsbo, Washington, is operative only between September and June of each year.

***Figure 18:*** *Distribution of tide gauges of the United States of America*



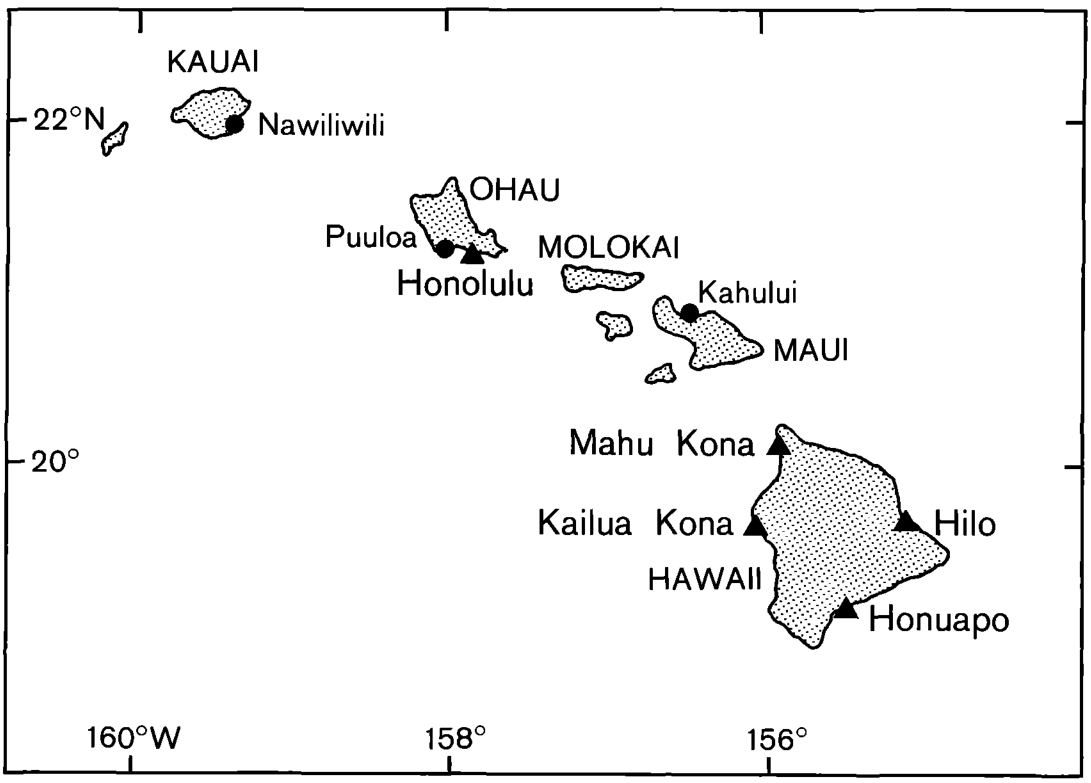



*figure 18: contd.*

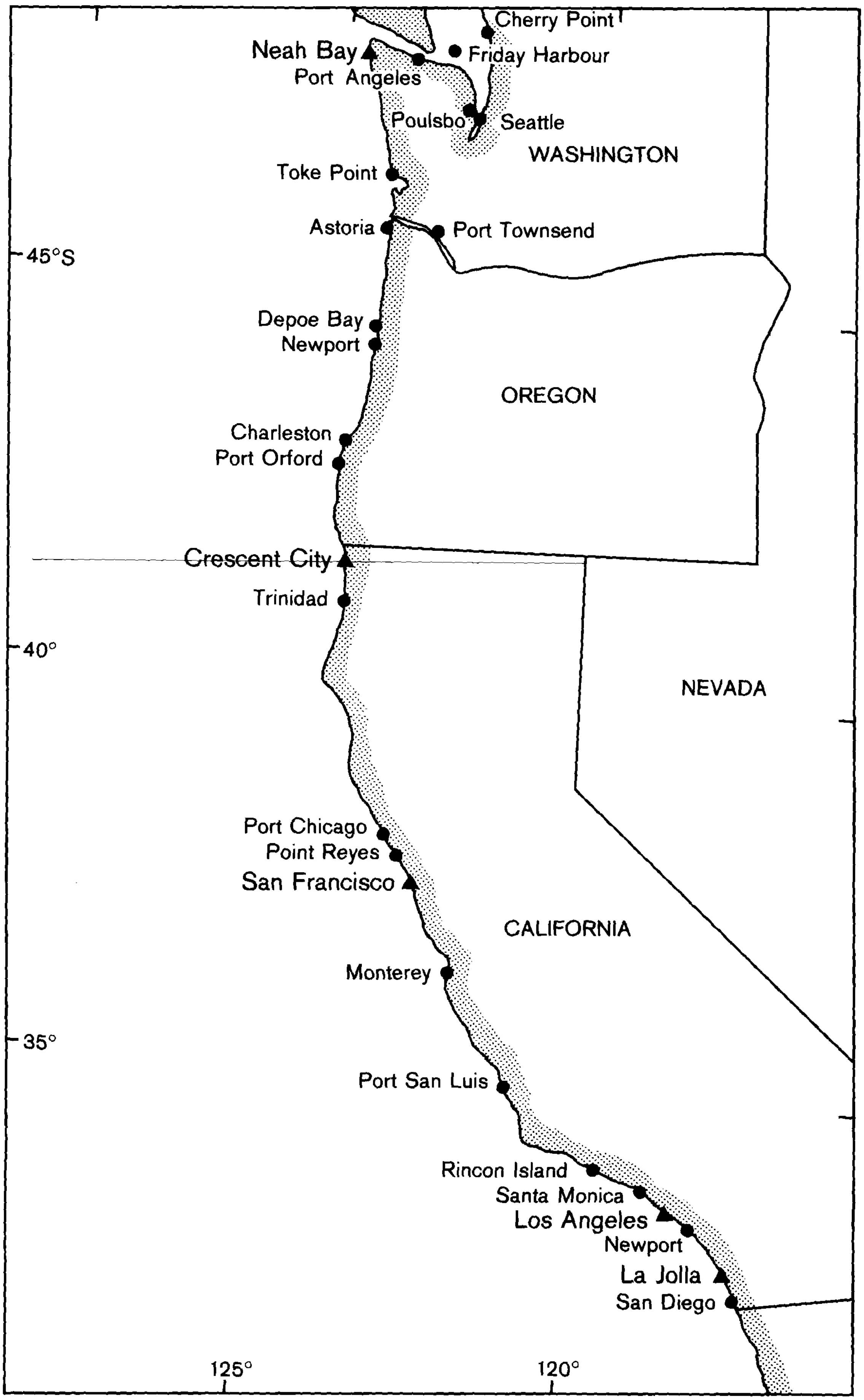


**Table 16: Tide gauges of the Department of Oceanography, University of Hawaii** (see Fig. 19)

DEPARTMENT OF OCEANOGRAPHY, UNIVERSITY OF HAWAII

| No. | STATION NAME | LATITUDE North | | LONGITUDE East | | GAUGE | INSTALLED | AGENGY | COMMENTS |
|---|---|---|---|---|---|---|---|---|---|
| | | Deg | Min | Deg | Min | | | | |
| 1 | SAIPAN (North Mariana Islands) | 15 | 13.6 | 145 | 44.5 | ADR | Sep 1978 | | |
| 2 | YAP (Caroline Islands) | 09 | 30.5 | 138 | 07.7 | ADR* | Aug 1974 | | |
| 3 | MALAKAL (Palau Islands) | 07 | 19.8 | 134 | 27.8 | ADR* | Aug 1974 | | |
| 4 | MAJURO (Marshall Islands) | 07 | 06.4 | 171 | 22.4 | ADR | Apr 1974 | | |
| 5 | PONAPE (Caroline Islands) | 06 | 59.2 | 158 | 14.6 | ADR | Apr 1974 | | |
| 6 | TARAWA (Betio, Kiribati) | 01 | 21.5 | 172 | 56.1 | ADR | May 1974 | | |
| 7 | TARAWA (Bairiki, Kiribati) | 01 | 11.9 | 173 | 00.8 | ADR | July 1982 | | |
| 8 | KAPINGAMAPANGI ISLAND | 01 | 05.9 | 154 | 46.6 | ADR | Sep 1978 | | |
| | | North | | West | | | | | |
| 9 | FRENCH FRIGATE SHOALS (Hawaii) | 23 | 52.0 | 166 | 17.4 | ADR | Sep 1975 | | |
| 10 | KEWALO (Oahu, Hawaii) | 21 | 17.7 | 157 | 51.7 | ADR | Jan 1978 | | |
| 11 | PALMYRA ISLAND | 05 | 53 | 162 | 05 | AAN | Jul 1978 | | |
| 12 | FANNING (Kiribati) | 03 | 54.4 | 159 | 23.2 | ADR | Jan 1975 | | |
| 13 | CHRISTMAS ISLAND (Kiribati) | 01 | 59.1 | 157 | 28.6 | ADR | Jan 1975 | | |
| | | South | | East | | | | | |
| 14 | NOUMEA (New Caledonia) | 22 | 17.7 | 166 | 26.0 | ADR | Nov 1975 | | |
| 15 | SUVA (Fiji) | 18 | 08.2 | 178 | 25.6 | ADR | Oct 1975 | | |
| 16 | HONIARA (Solomon Islands) | 09 | 25.5 | 159 | 57.4 | ADR | Nov 1974 | | |
| 17 | FUNAFUTI | 08 | 31.5 | 179 | 12.5 | ADR | Oct 1977 | | |
| 18 | ANEWA BAY (Bougainville Is.) | 06 | 13.2 | 155 | 38.2 | STD | May 1969 | | |
| 19 | RABAUL (Papua New Guinea) | 04 | 12.0 | 152 | 10.5 | ADR | Dec 1974 | | |
| 20 | NAURU (Kiribati) | 00 | 31.7 | 166 | 54.3 | ADR** | May 1974 | | |
| | | | | | | | | | |
| | | | | | | | | | |

**Table 16: continued**

DEPARTMENT OF OCEANOGRAPHY, UNIVERSITY OF HAWAII

| No. | STATION NAME | LATITUDE South | | LONGITUDE West | | GAUGE | INSTALLED | AGENGY | COMMENTS |
|---|---|---|---|---|---|---|---|---|---|
| | | Deg | Min | Deg | Min | | | | |
| 21 | JUAN FERNANDEZ Is. (Chile) | 33 | 37.3 | 078 | 50.0 | ADR | Jan 1977 | | |
| 22 | EASTER ISLAND (Chile) | 27 | 09.0 | 109 | 26.9 | ADR | Mar 1977 | | |
| 23 | RIKITEA (Mangareva Island) | 23 | 07.5 | 134 | 57.2 | ADR* | Jun 1975 | | |
| 24 | RAROTONGA (Cook Islands) | 21 | 11.9 | 159 | 46.2 | ADR | Apr 1977 | | |
| 25 | PAPEETE (Tahiti) | 17 | 31.5 | 149 | 34.0 | ADR* | Jun 1975 | | |
| 26 | PENRHYN (Cook Islands) | 09 | 00.8 | 158 | 03.7 | ADR | Apr 1977 | | |
| 27 | NUKU HIVA (Marquesas Islands) | 08 | 55.8 | 140 | 04.9 | ADR | Mar 1982 | | |
| 28 | MALDEN ISLAND | 04 | 03 | 154 | 59 | AAN | Oct 1976 | | |
| 29 | CANTON (Kiribati) | 02 | 48.6 | 171 | 43.1 | ADR | Feb 1975 | | |
| 30 | SANTA CRUZ (Galapagos Is.) | 00 | 45.2 | 090 | 18.7 | ADR** | Oct 1978 | | |
| 31 | JARVIS ISLAND | 00 | 23 | 160 | 02 | AAN | Oct 1977 | | |
| | **DISCONTINUED STATIONS** | North | | East | | | | | |
| 32 | BALTRA | 00 | 26.1 | 090 | 17.1 | ADR | Aug. 1974 | | |
| 33 | ENEWETOK | 11 | 25.8 | 162 | 23.2 | ADR | Aug. 1974 | | |
| 34 | ENEWETOK 'B' | 11 | 21.6 | 162 | 21.1 | ADR | Jun 1978 | | |
| 35 | MARCUS | 24 | 17.9 | 153 | 58.0 | BUBBLER | Sep 1976 | | |
| 36 | PAGAN | 18 | 08 | 145 | 46 | AAN | Sep 1977 | | |
| | | South | | West | | | | | |
| 37 | HIVA OA | 09 | 48.6 | 139 | 01.6 | ADR | Oct 1975 | | |
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**UNIVERSITY OF HAWAII**

TIDE GAUGE ABBREVIATIONS

AAN Aanderaa: Pressure operated.
ADR Analogue to digital recorder: Float operated: Records every 15 minutes.
ADR* ADR connected to analogue recorder.
ADR** ADR with bubbler gauge separately installed.
STD Standard: Float operated.

AGENCY

Prof. Klaus Wyrtki
Department of Oceanography
University of Hawaii
2525 Correa Road
Honolulu
HAWAII 96822

*Figure 19:* *Distribution of tide gauges of the Department of Oceanography, University of Hawaii (by K. Wyrtki)*