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29

**Catalogue of tide
gauges in the Pacific**

Unesco 1984

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Foreword

Although this catalogue is primarily 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 ocean 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 IGOS 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.

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The International Tsunami Warning System

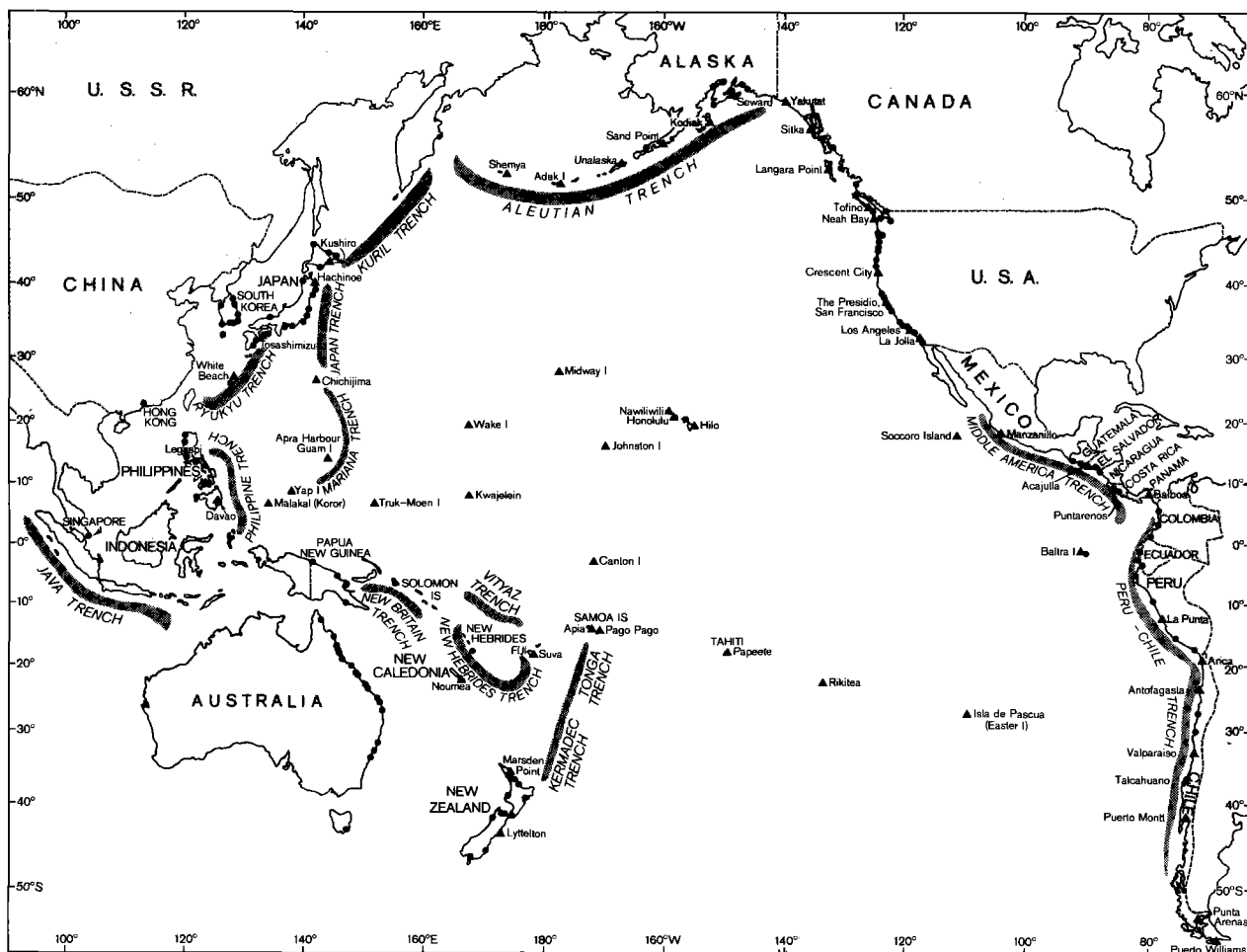
In August 1948, the United States Coast & Geodetic Survey (USC & GS) created a Tsunami Warning System to provide reliable warnings and information to the Hawaiian Islands, to military establishments and to United States of America Trust Territories throughout the Pacific region. The impetus for this 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 successful 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

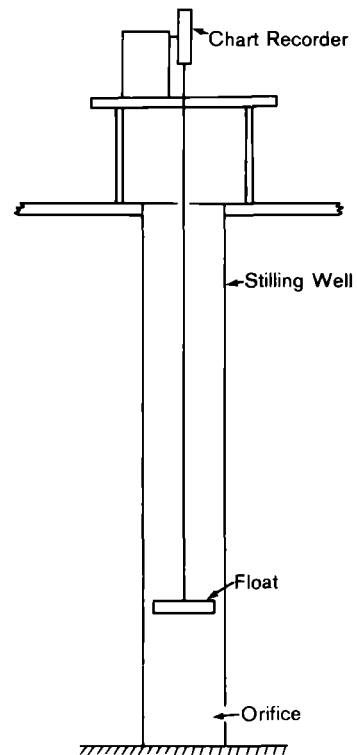
The float-operated tide gauge can be called the traditional tide gauge, since it has been employed for well over 100 years and, even today, it is the most common type of gauge in operation. Thus, of the 319 individual tide gauges listed in this catalogue, 266 (or 84%) are float gauges. (It should be 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 recorders 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 which 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 (Shiple 1963; Cross 1968; Easton 1968; Noye 1968, 1974 a, b, c; Sager and Matthäus 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.

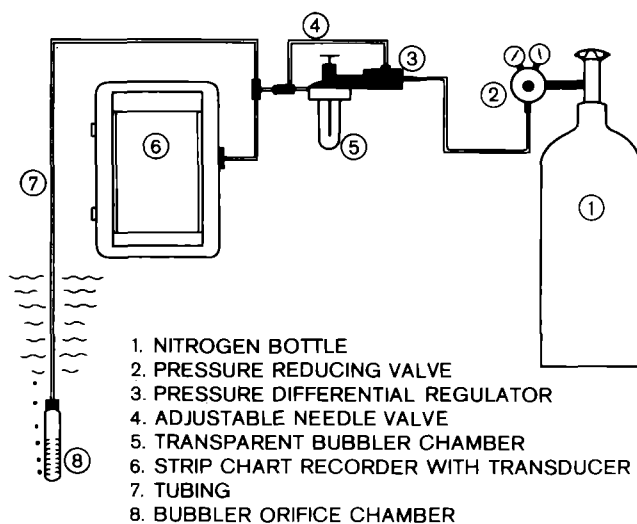
The problems associated with the use of float-operated tide gauges have been widely recognized. For example, the National Ocean Survey (NOS) of the National Oceanic and Atmospheric Administration (NOAA) in the USA has initiated a series of studies designed to examine alternative methods of measuring 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 bubbler 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 trough 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 trough 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 bubbles 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.

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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	AGENCY	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	Gladstone 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

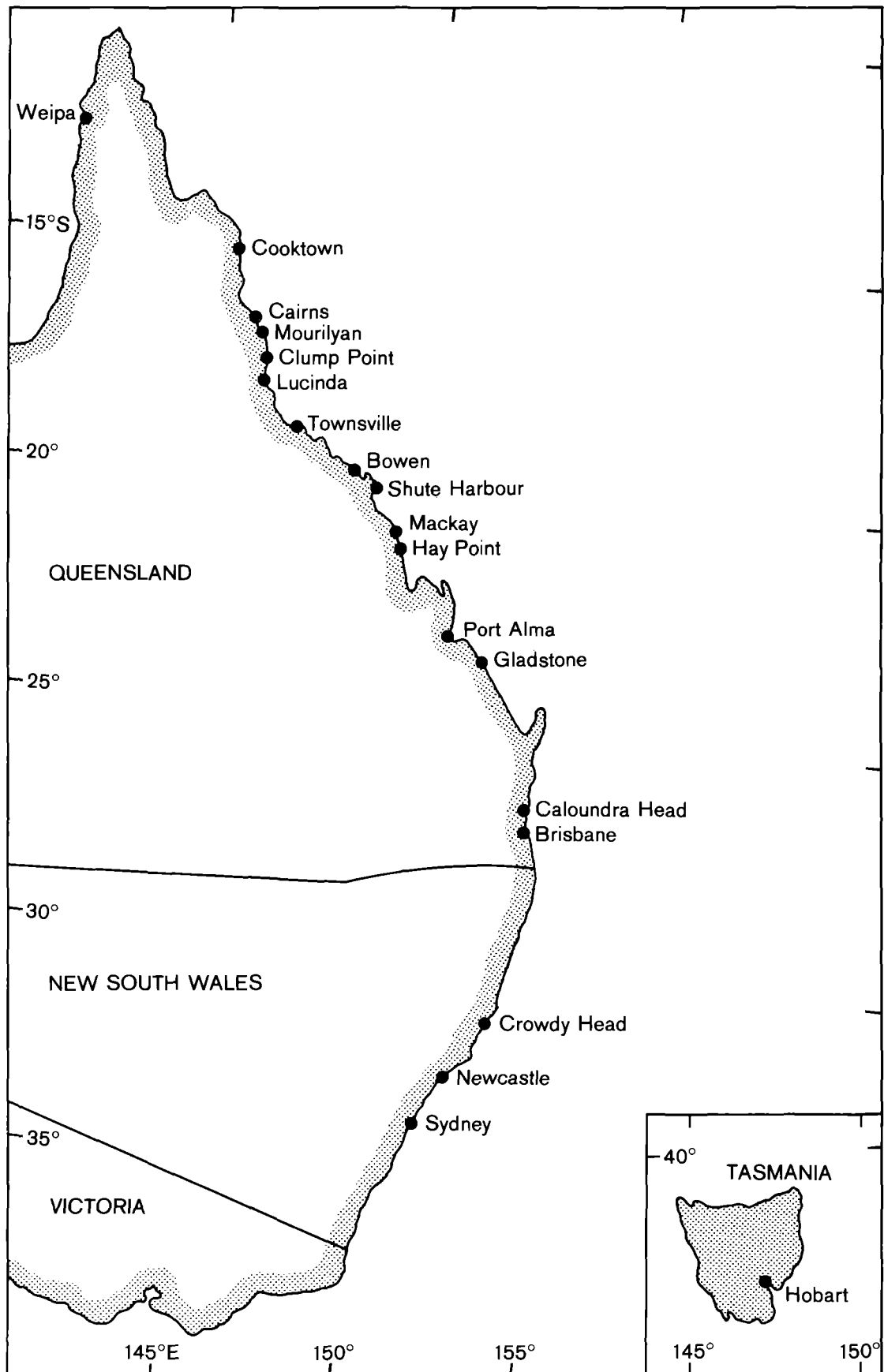


Table 2: Tide gauges of Canada (see Fig. 5)

COUNTRY: CANADA

STATE: BRITISH COLUMBIA

No.	STATION NAME	LATITUDE North		LONGITUDE West		GAUGE	INSTALLED	AGENCY	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	STEVESON	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	—	

CANADA

TIDE GAUGE ABBREVIATIONS

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

AGENCY ABBREVIATION

CHS Canadian Hydrographic Service, Department of Fisheries and Oceans, Ottawa, 615 Booth Street,
 Canada K1A 0E6

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

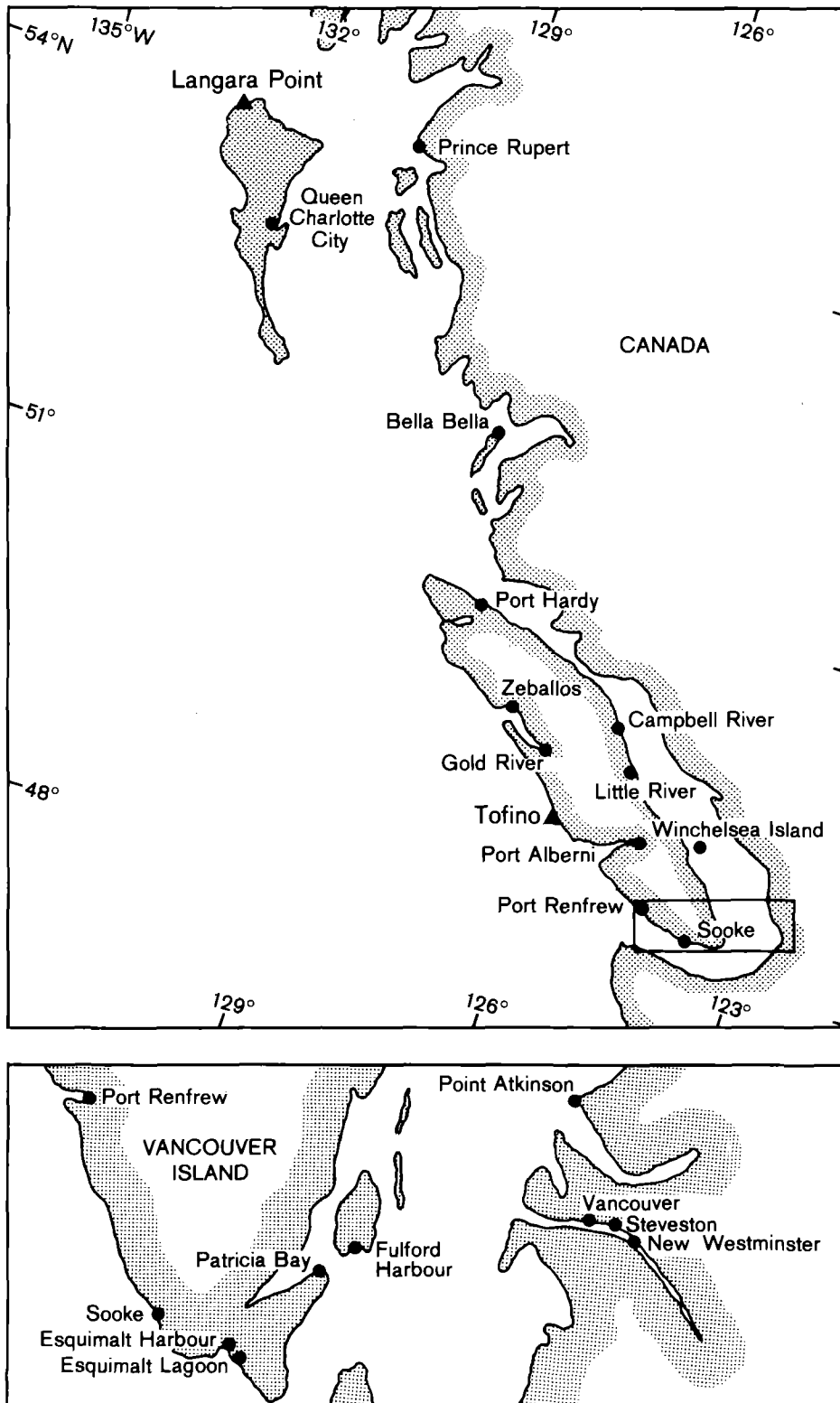


Table 3: Tide gauges of Central America (see Fig. 6)

AREA: CENTRAL AMERICA

COUNTRIES: PANAMA/COSTA RICA/NICARAGUA/EL SALVADOR/GUATEMALA

No.	STATION NAME	LATITUDE North		LONGITUDE West		GAUGE	INSTALLED	AGENCY	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	

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 Geográfico Nacional, Apartado Postal n.º 247, Avenida Juan Bertis n.º 79 - Delgado, San Salvador, El Salvador
IGNTD Instituto Geográfico Nacional Tommy Guardia, Departamento de Estudios Especiales, Apartado Postal n.º 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

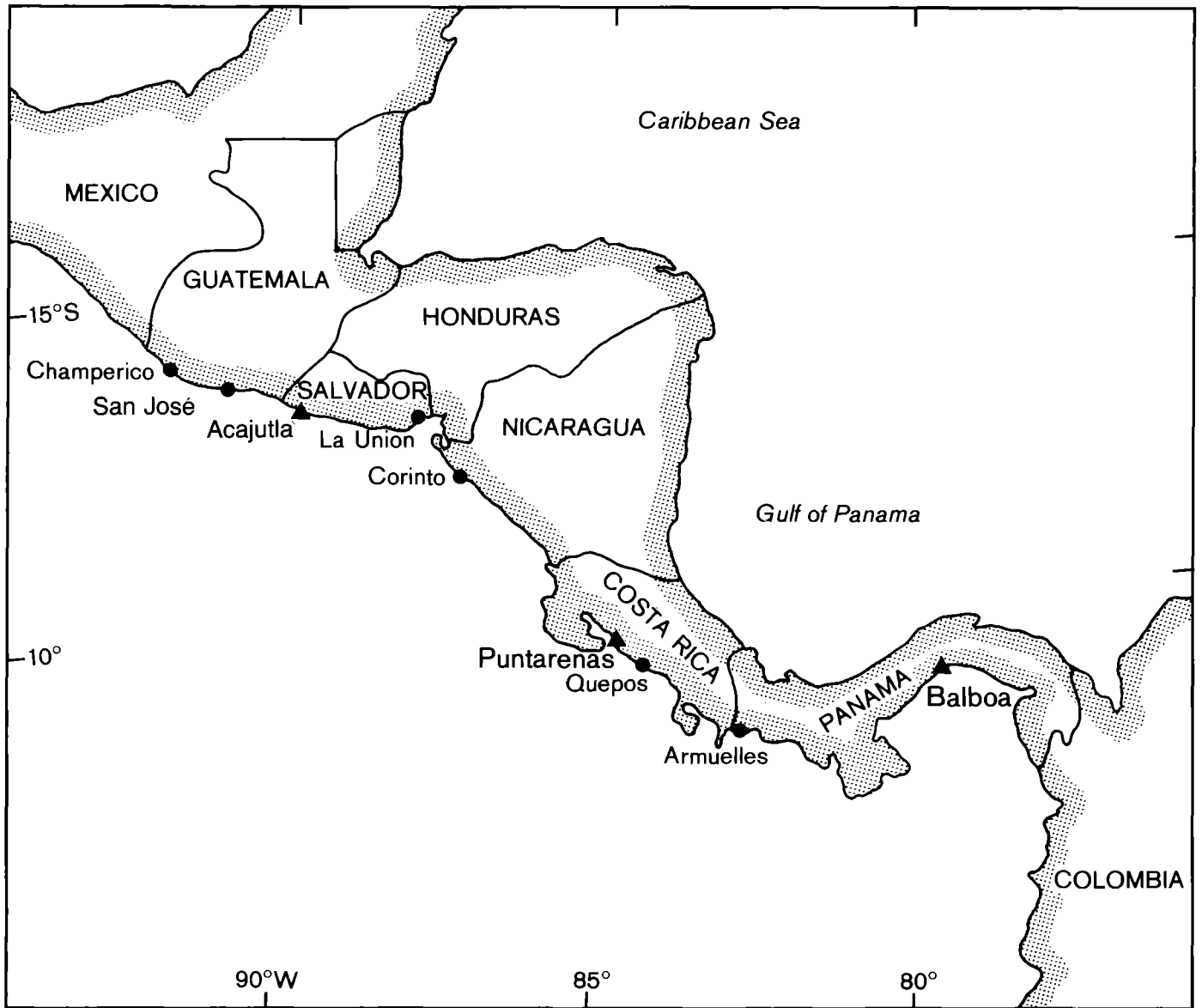


Table 4: Tide gauges of Japan (see Fig. 7)

COUNTRY: JAPAN

No.	STATION NAME	LATITUDE North		LONGITUDE East		GAUGE	INSTALLED	AGENCY	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	MEHA	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	—	

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

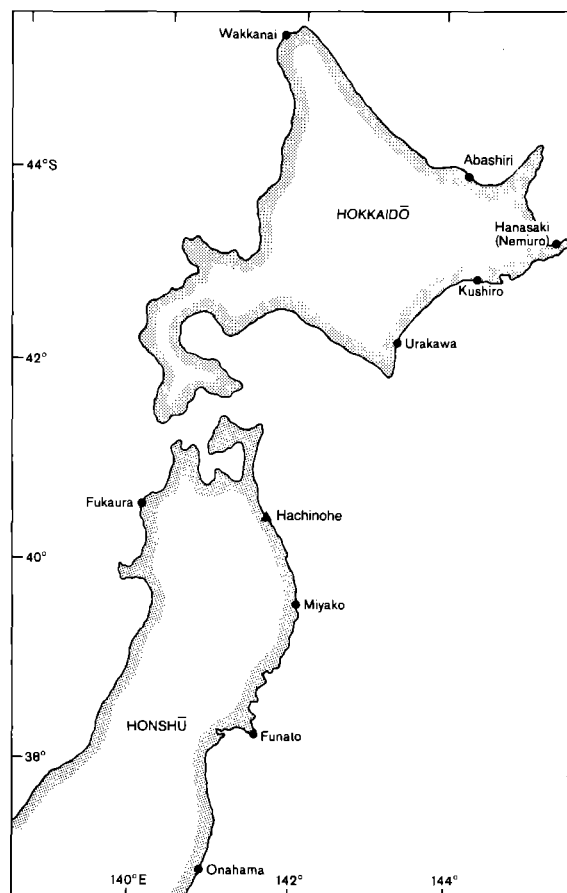
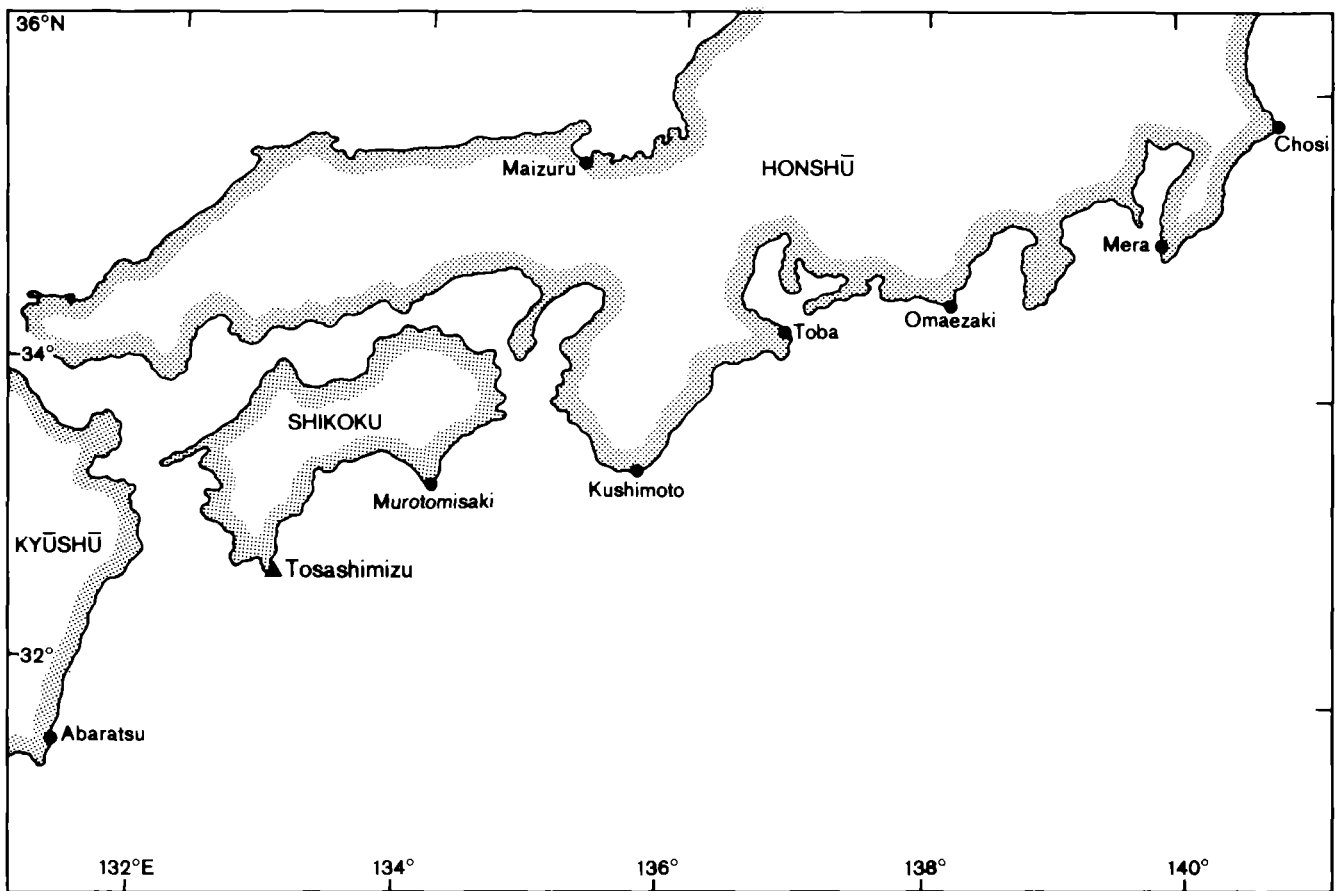


Table 5: Tide gauges of Korea (See Fig. 8)

COUNTRY: KOREA

No.	STATION NAME	LATITUDE North		LONGITUDE East		GAUGE	INSTALLED	AGENCY	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	—	

KOREA

TIDE GAUGE ABBREVIATIONS

FUE Fues: 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

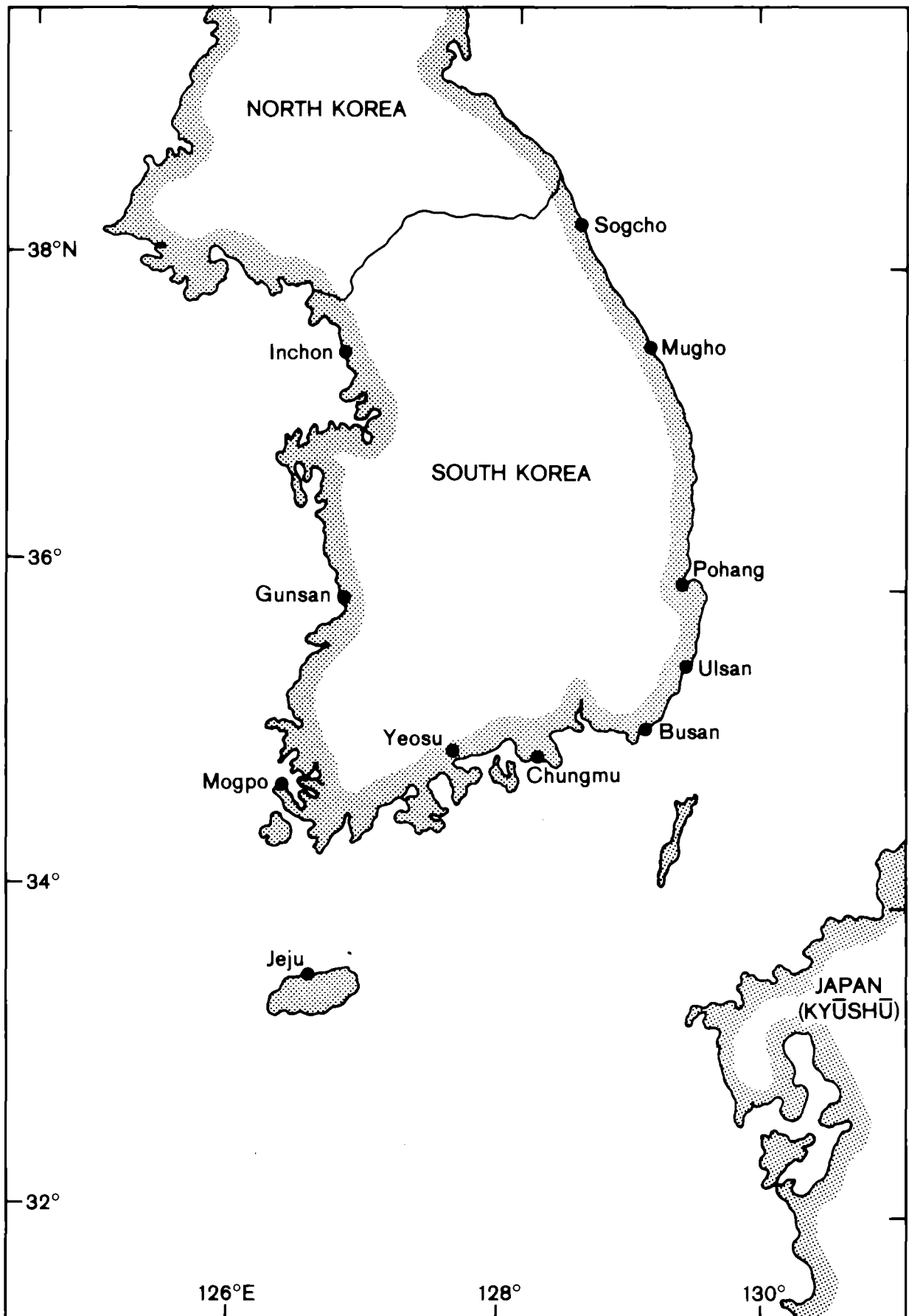


Table 6: Tide gauges of Mexico (see Fig. 9)

COUNTRY: MEXICO

No.	STATION NAME	LATITUDE North		LONGITUDE East		GAUGE	INSTALLED	AGENCY	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

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*

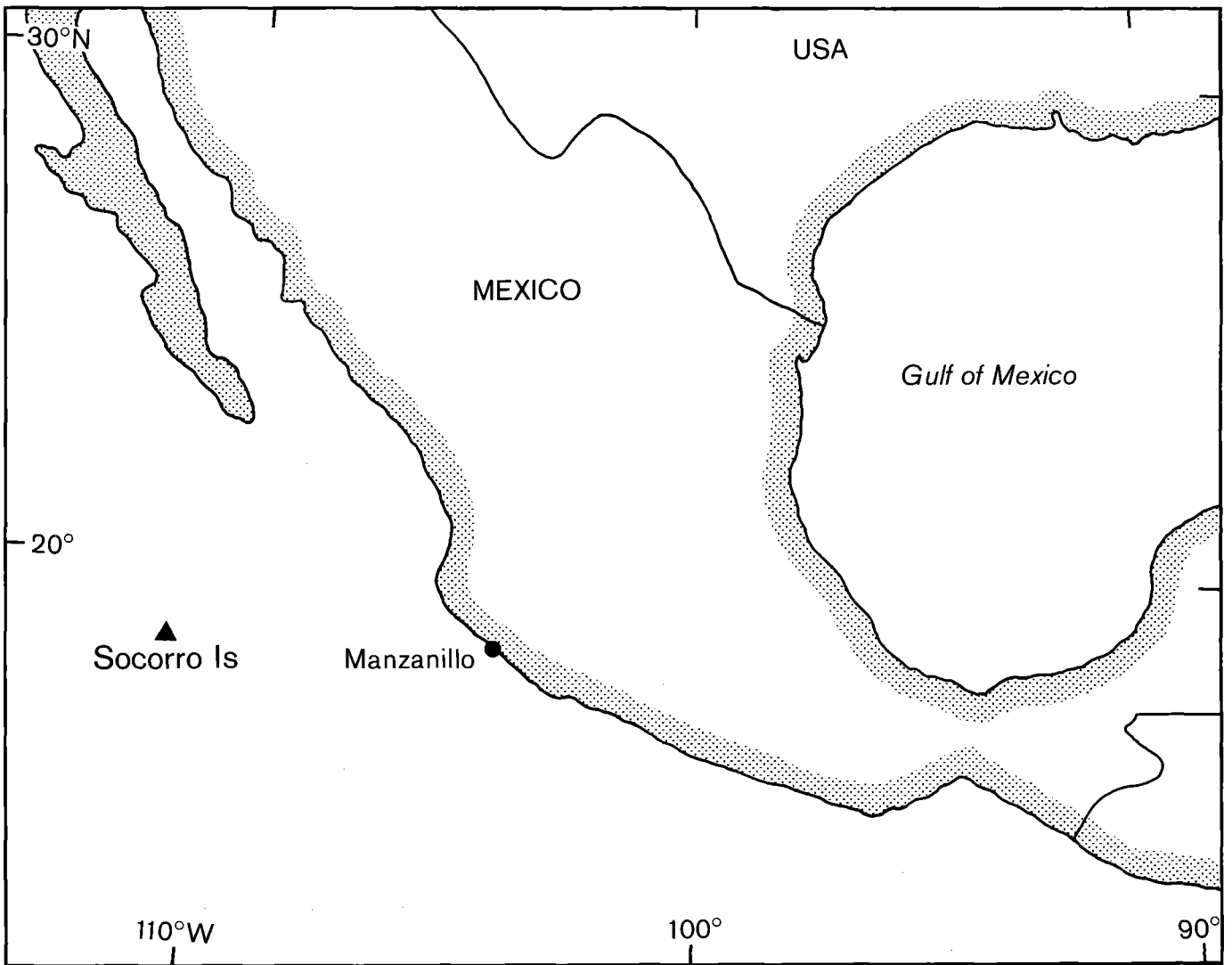


Table 7: Tide gauges of New Zealand (see Fig. 10)

COUNTRY: NEW ZEALAND

No.	STATION NAME	LATITUDE South		LONGITUDE East		GAUGE	INSTALLED	AGENCY	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	LYTTTELTON	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	

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

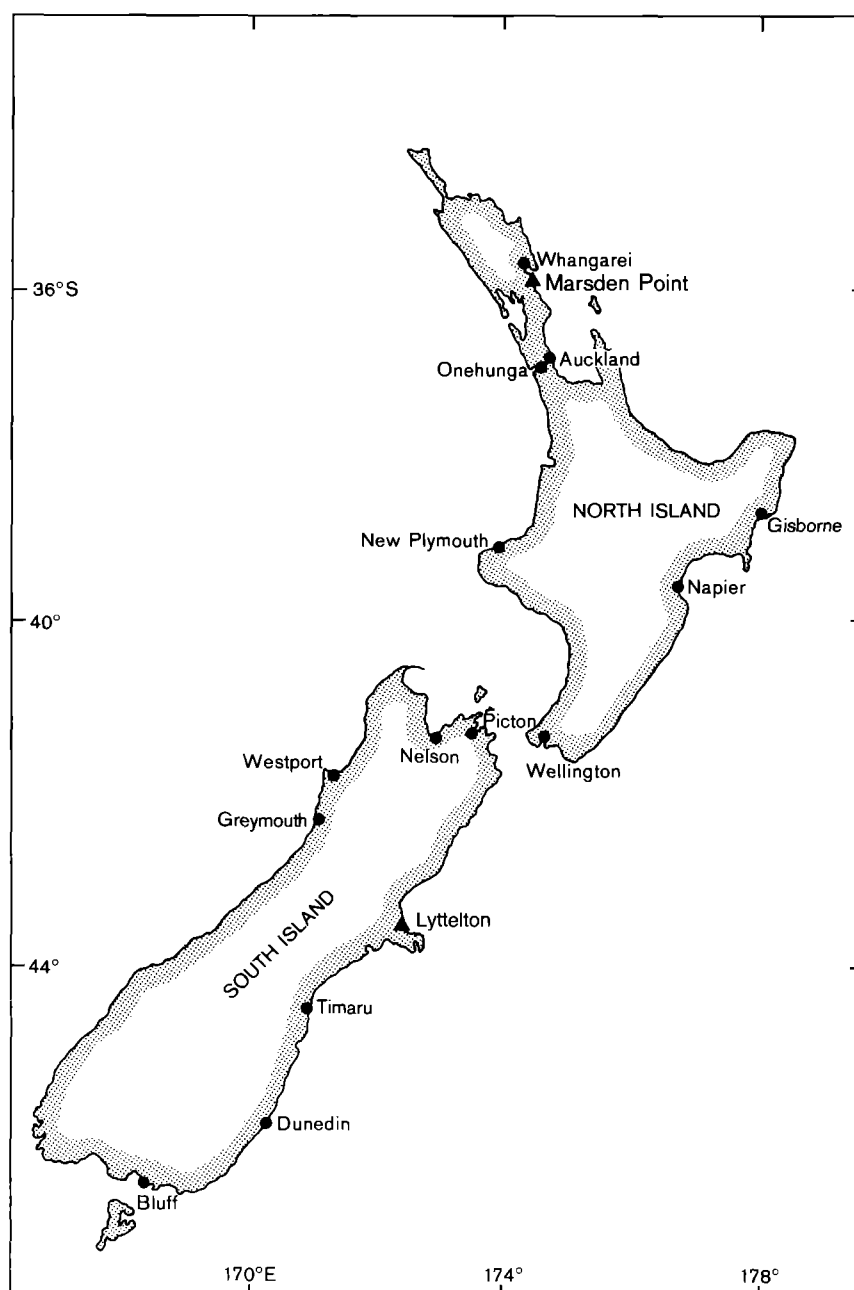


Table 8: Tide gauges of the North Pacific Islands (see Fig. 11)

NORTH PACIFIC ISLANDS

No.	STATION NAME	LATITUDE North		LONGITUDE East		GAUGE	INSTALLED	AGENCY	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

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

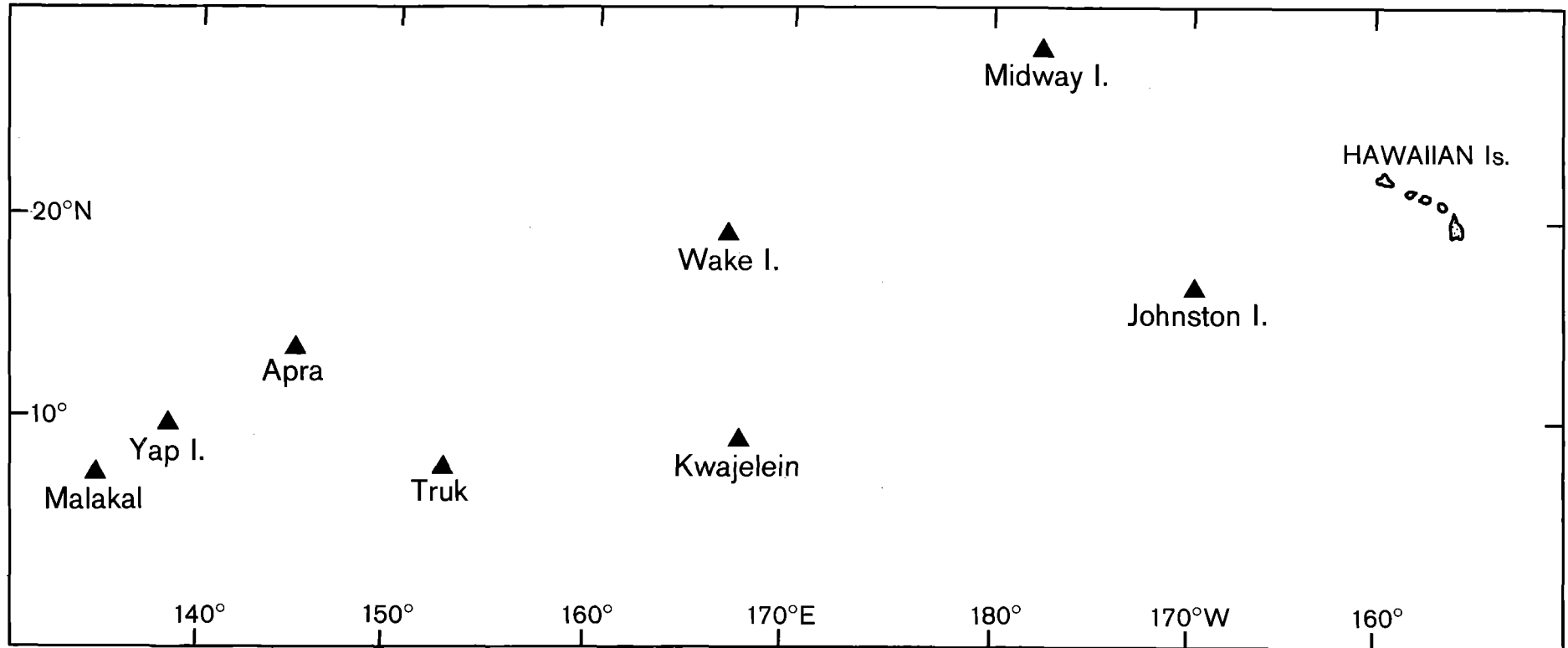


Table 9: Tide gauges of Papua New Guinea (see Fig. 12)

COUNTRY: PAPUA NEW GUINEA

No.	STATION NAME	LATITUDE South		LONGITUDE East		GAUGE	INSTALLED	AGENCY	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	

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

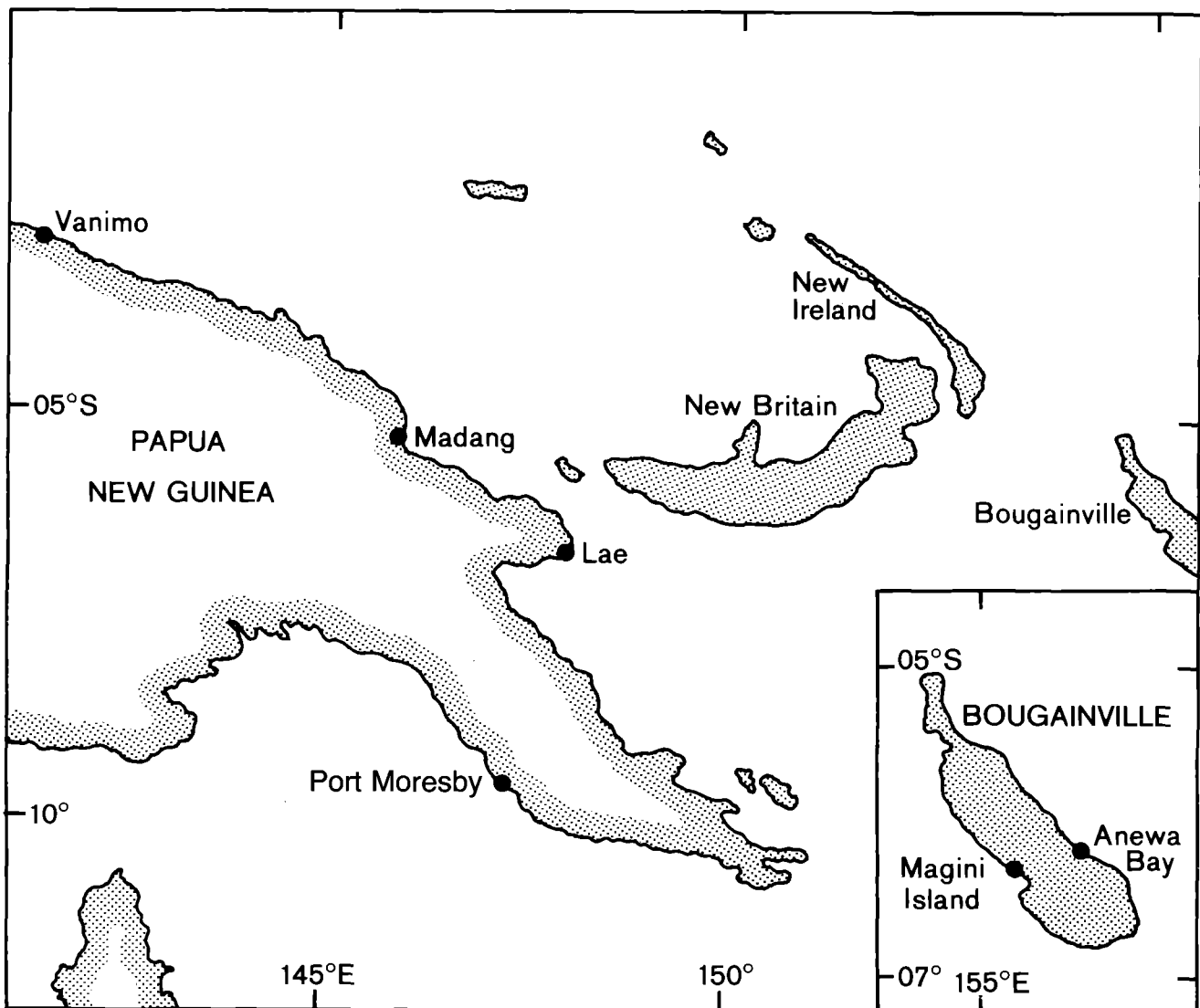


Table 10: Tide gauges of the Philippines (see Fig. 13)

COUNTRY: PHILIPPINES

No.	STATION NAME	LATITUDE North		LONGITUDE East		GAUGE	INSTALLED	AGENCY	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	

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

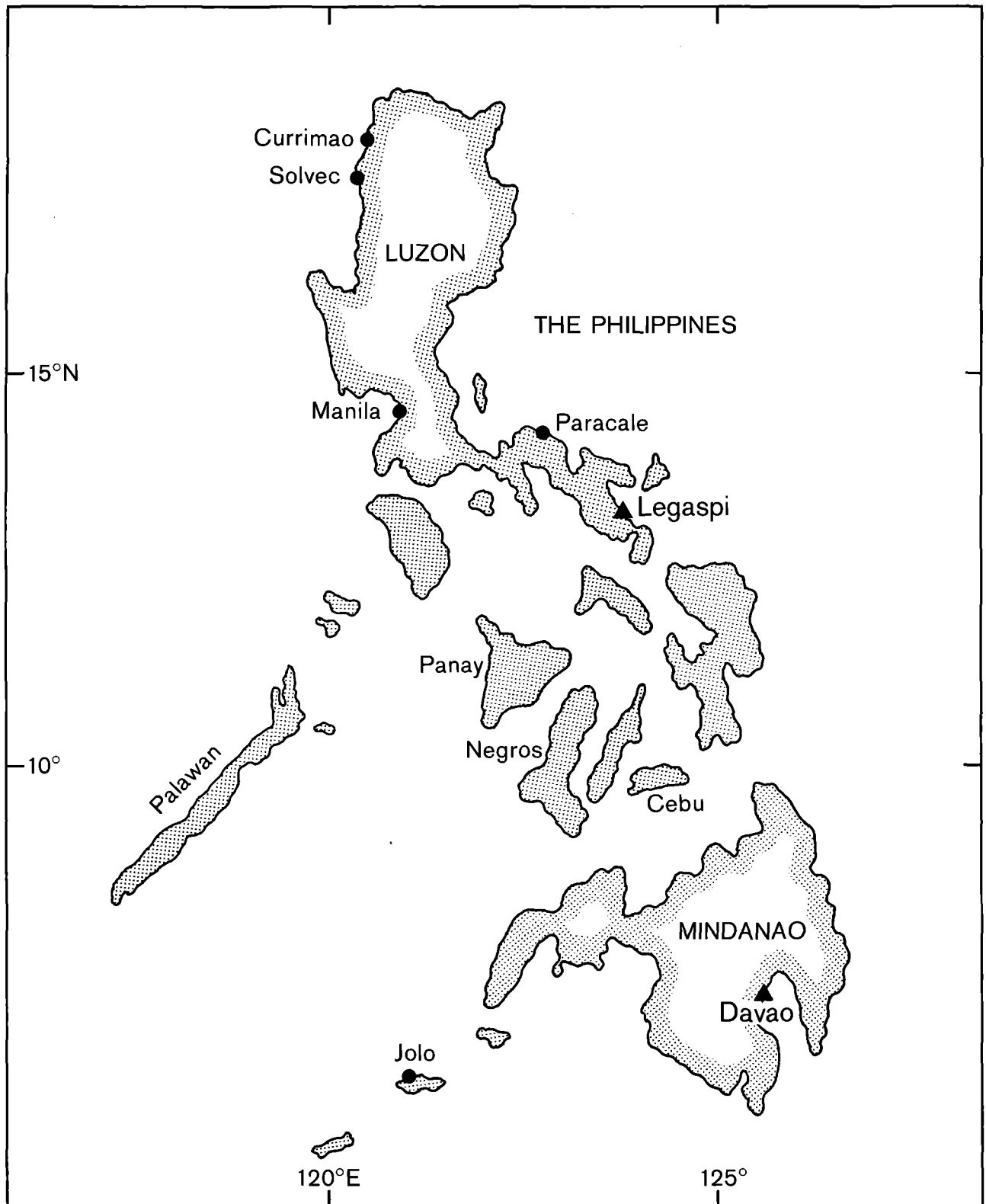


Table 11: Tide gauges of Singapore (see Fig. 14)

COUNTRY: SINGAPORE

No.	STATION NAME	LATITUDE North		LONGITUDE East		GAUGE	INSTALLED	AGENCY	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		–	

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

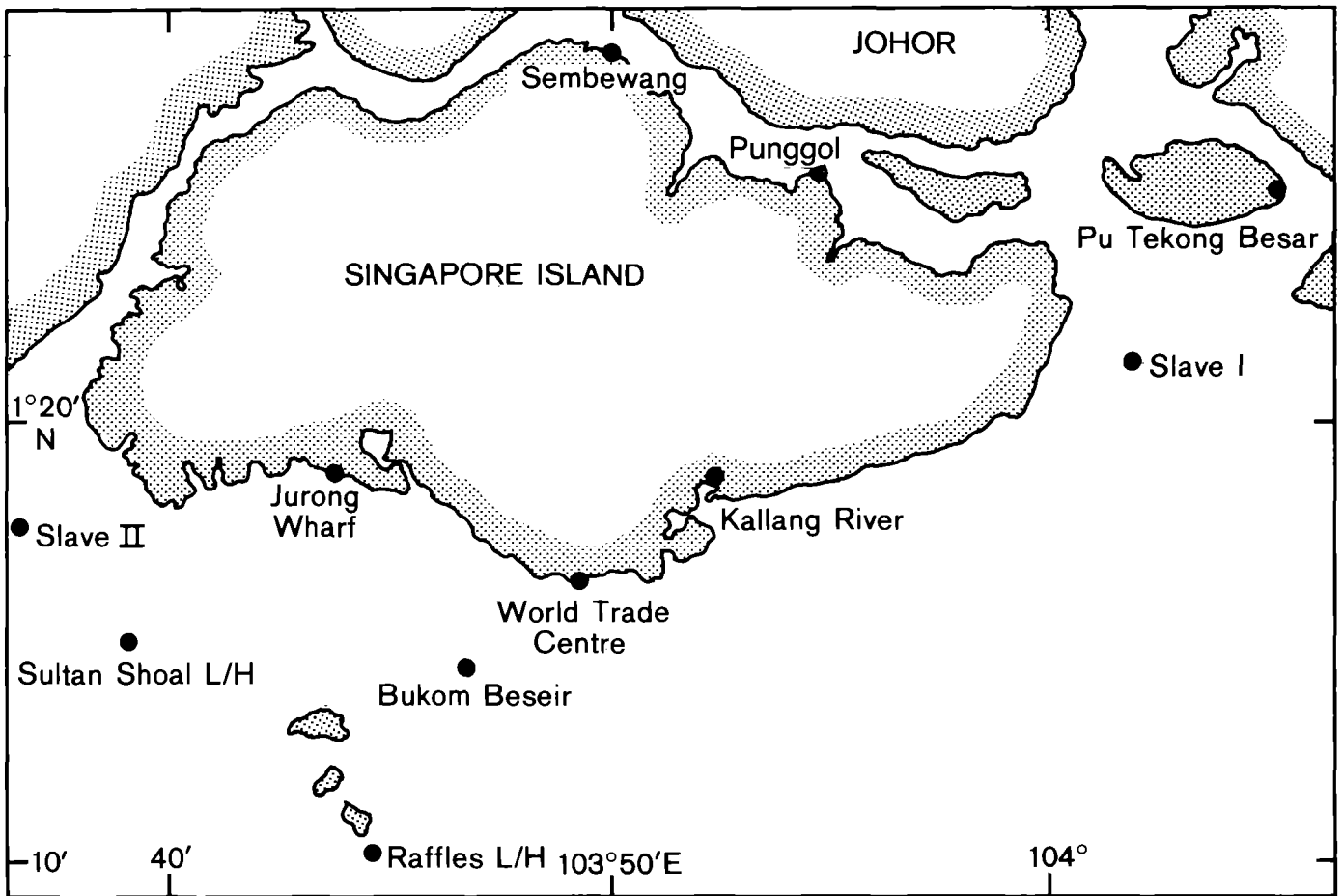


Table 12: Tide gauges of South America (Fig. 15)

AREA: SOUTH AMERICA

COUNTRIES: COLOMBIA/ECUADOR/PERU/CHILE

No.	STATION NAME	LATITUDE North		LONGITUDE West		GAUGE	INSTALLED	AGENCY	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

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

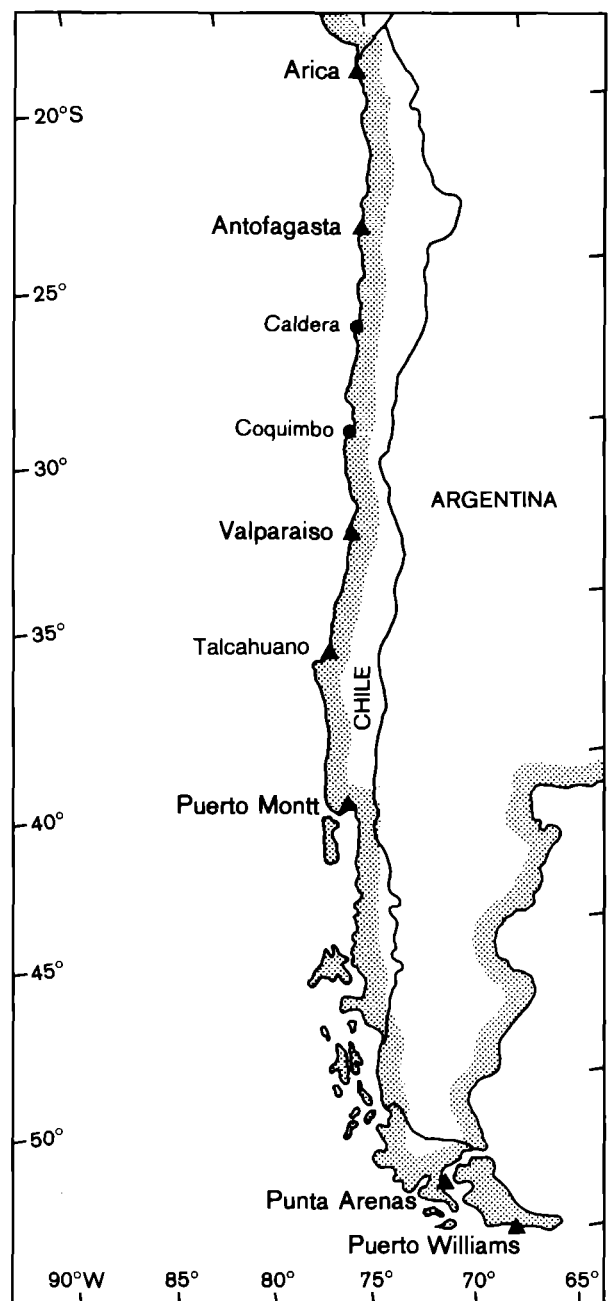


Table 13: Tide gauges of the South Pacific Islands (see Fig. 16)

SOUTH PACIFIC ISLANDS

No.	STATION NAME	LATITUDE South		LONGITUDE East		GAUGE	INSTALLED	AGENCY	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

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

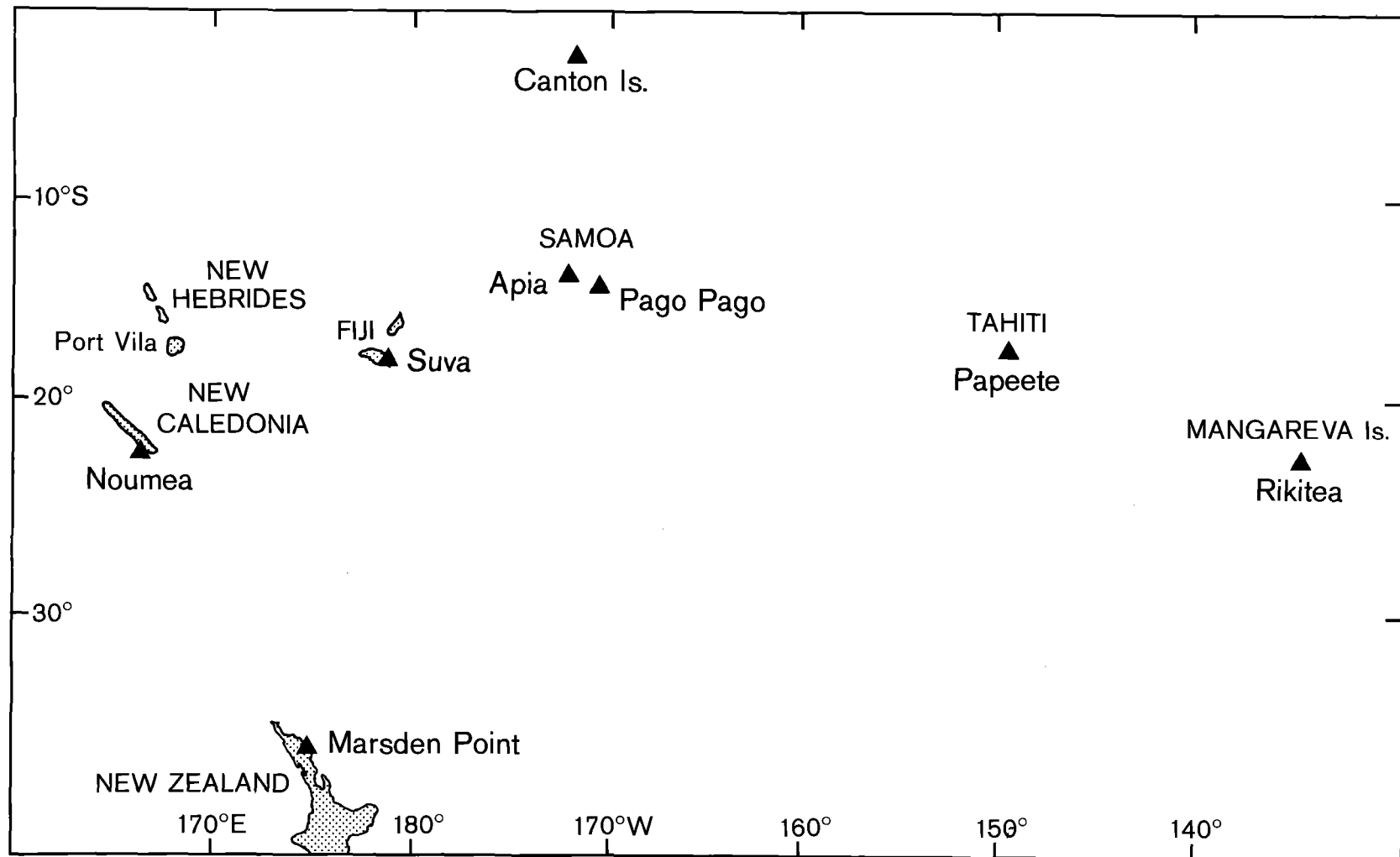


Table 14: Tide gauges of the United Kingdom - Hong Kong (see Fig. 17)

COUNTRY: UNITED KINGDOM - HONG KONG

No.	STATION NAME	LATITUDE North		LONGITUDE East		GAUGE	INSTALLED	AGENCY	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	

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

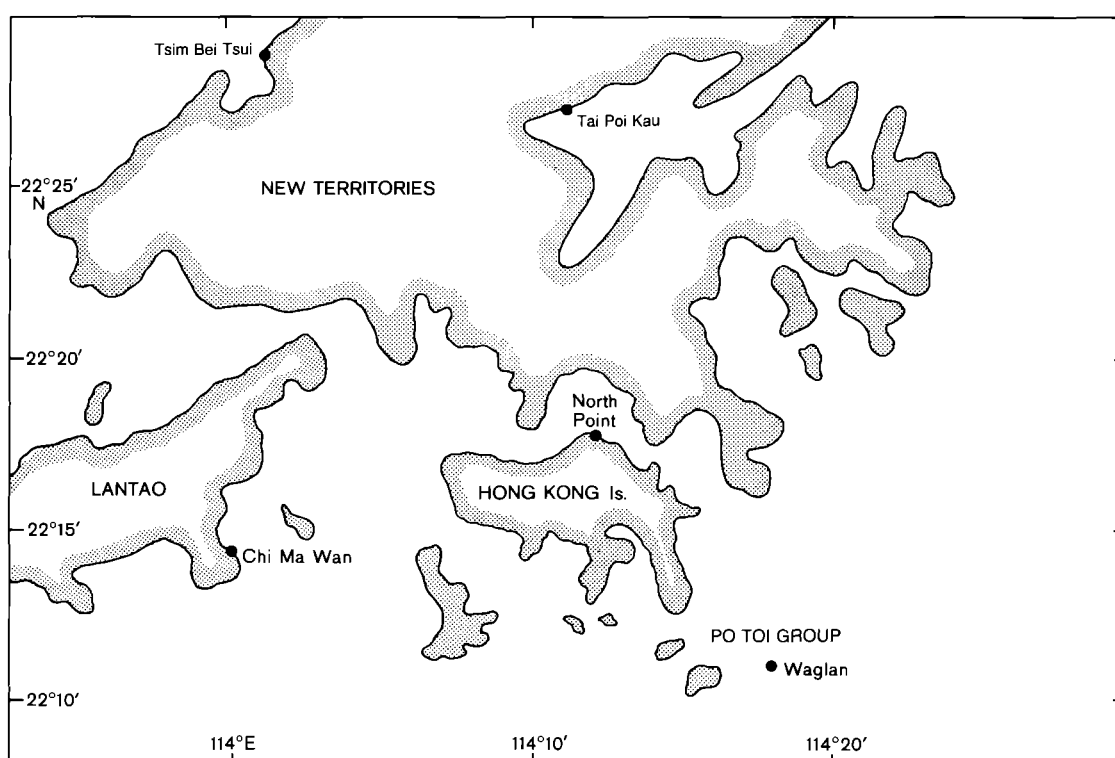


Table 15: Tide gauges of the United States of America (see Fig. 18)

COUNTRY: UNITED STATES OF AMERICA

STATE: ALASKA

No.	STATION NAME	LATITUDE North		LONGITUDE West		GAUGE	INSTALLED	AGENCY	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	—	

Table 15: continued

COUNTRY: UNITED STATES OF AMERICA

STATE: CALIFORNIA

No.	STATION NAME	LATITUDE North		LONGITUDE West		GAUGE	INSTALLED	AGENCY	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	AGENCY	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 (Hawaii)	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	—	

Table 15: continued

COUNTRY: UNITED STATES OF AMERICA

STATE: WASHINGTON/OREGON

No.	STATION NAME	LATITUDE North		LONGITUDE West		GAUGE	INSTALLED	AGENCY	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	—	

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

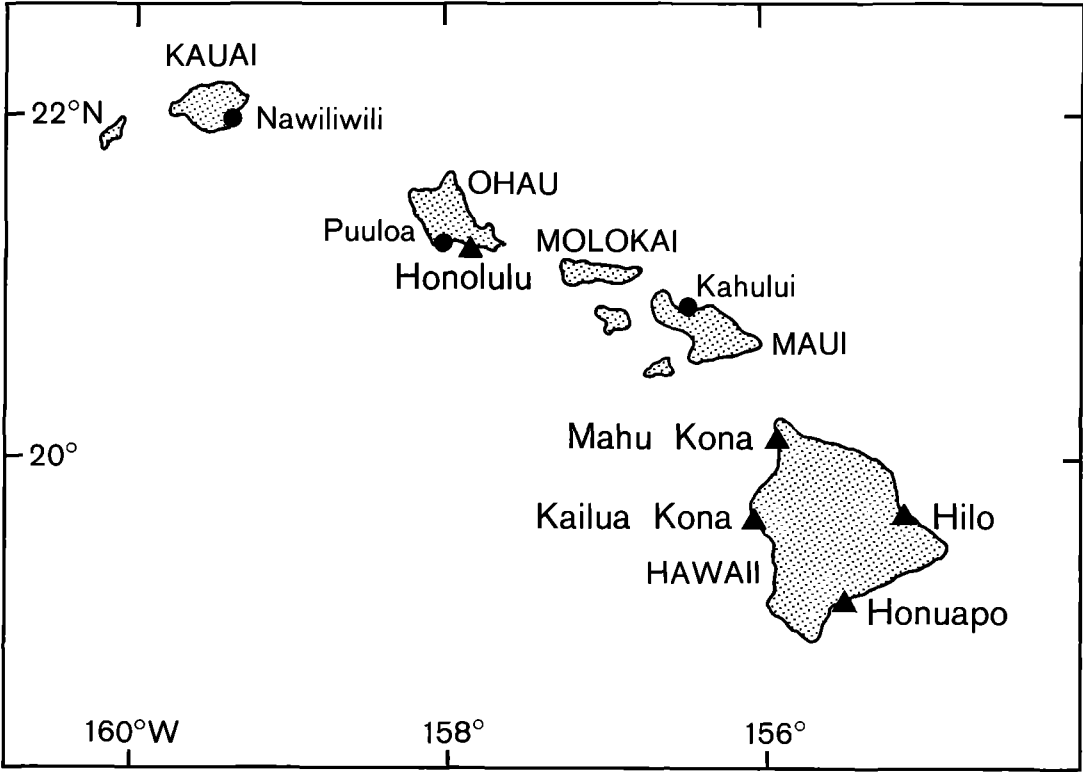
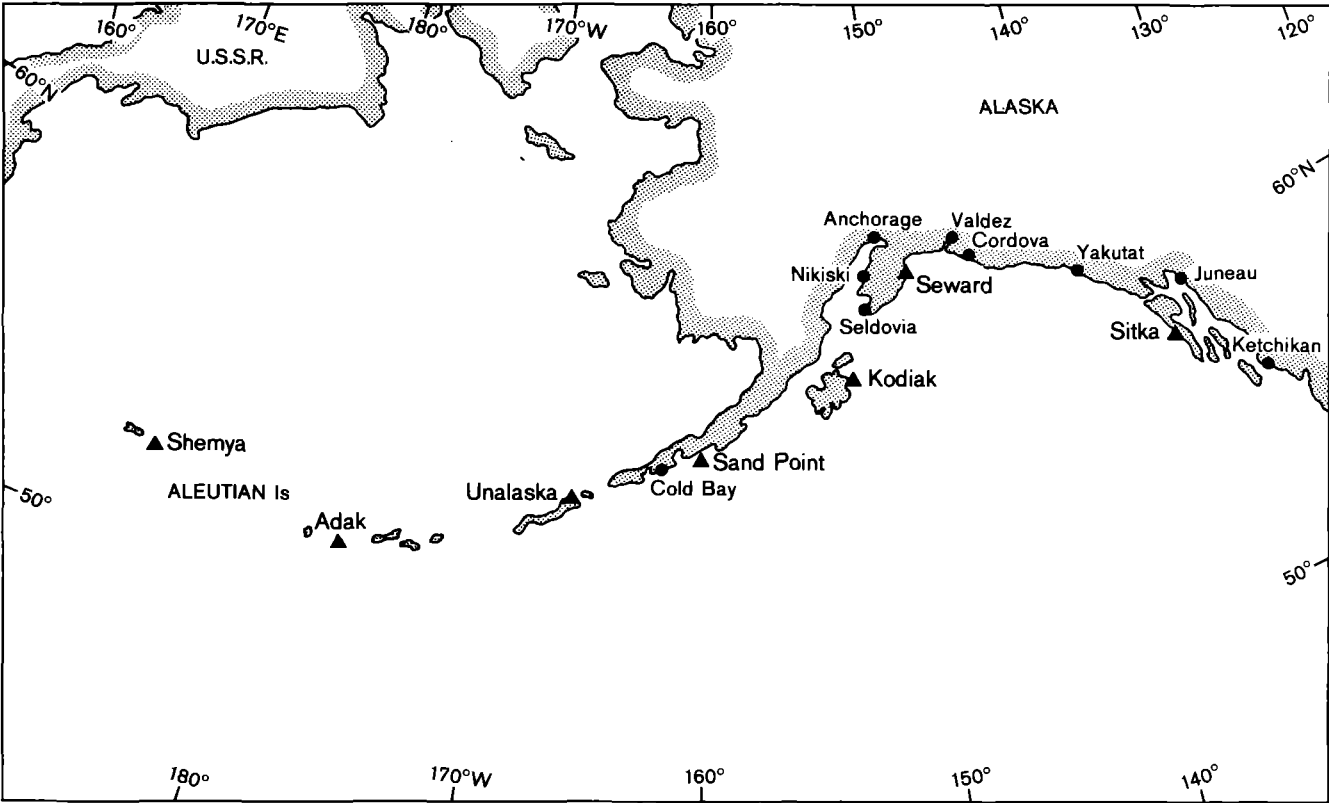


figure 18: contd.

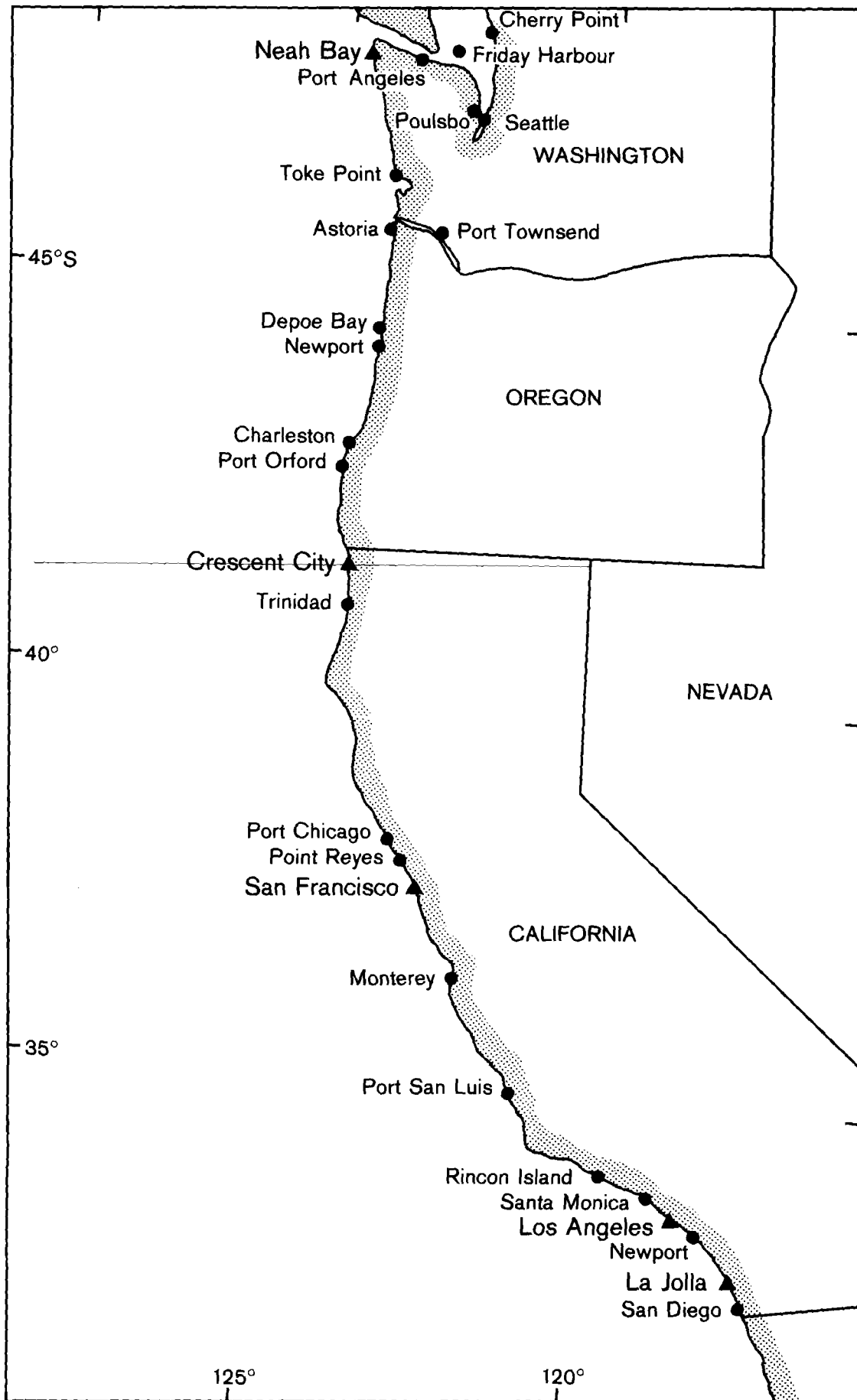


Table 16: Tide gauges of the Department of Oceanography, University of Hawaii (see Fig. 19)

DEPARTMENT OF OCEANOGRAPHY, UNIVERSITY OF HAWAII

No.	STATION NAME	LATITUDE North		LONGITUDE East		GAUGE	INSTALLED	AGENCY	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	AGENCY	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		

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

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

