NOAA Data Report ERL PMEL-

THE 10 JUNE 1996 ANDREANOV TSUNAMI DATABASE

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Preface

This work is part of the Early Detection and Forecast of Tsunamis (EDFT) project initiated in 1996 and funded by the Defense Advanced Research Projects Agency (DARPA) to complement the mission of the Pacific Disaster Center (PDC). The primary purpose of this project is to develop an improved tsunami forecasting capability for the Hawaiian Islands for use by the PDC and the Tsunami Warning Centers (TWC). The EDFT project is comprised of three parts: 1) instrumentation, 2) numerical modeling, and 3) database development.

The instrumentation phase focuses on the development, testing, and deployment of a real-time, deep-ocean tsunami detection system designed to measure a tsunami in the open ocean away from the effects of local bathymetry and topography (Milburn *et al.*, 1996). Duplicates of this system will eventually be deployed in areas of likely tsunamigenic generation; e.g., off the Alaska-Aleutian Seismic Zone (AASZ), and the Cascadia Subduction Zone (CSZ). Numerical modeling activities concentrate on developing an integrated, state-of-the-art simulation capability for the three primary phases of tsunami evolution: generation, propagation, and inundation (Titov, 1996). The database development phase of EDFT consists of several efforts to improve the body of readily available, rapidly sampled sea level records of tsunamis. Acquisition and assembly of such data sets are essential for verifying and improving the numerical models on which future forecasting algorithms will be based.

This report describes the first such comprehensive data set, a collection of time series of the tsunami generated by the 10 June 1996 Andreanov Islands earthquake. The measurements were made at deep-ocean, offshore, and coastal stations maintained by the National Ocean Service (NOS) of the National Oceanic and Atmospheric Administration (NOAA), NOAA's Pacific Tsunami Warning Center (PTWC), and Pacific Marine Environmental Laboratory (PMEL), the Japanese Meteorological Agency (JMA), the University of Hawaii Sea Level Center (UHSLC), and the United States Army Corps of Engineers (USACE).

The database is currently maintained on-line at the NOAA/PMEL web site and is available to interested researchers. Maintenance responsibility will be transferred to the NOAA National Geophysical Data Center after a short experimental period. Researchers with additional records of this event are encouraged to contribute them to the on-line database to make it as complete as possible.

To access the on-line database, and to learn more about the organizations and projects mentioned here, go to URL http://www.pmel.noaa.gov/tsunami/ and follow the appropriate links.

CONTENTS

Figures

Tables

The 10 June 1996 Andreanov Tsunami Database

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1. Introduction

A magnitude 7.7 Mw earthquake occurred along the Aleutian Island Archipelago in the Andreanov Islands 50 miles SW of Adak, Alaska on 10 June 1996 at 0404 UTC. The earthquake epicenter was located at 50.6°N latitude, 177.7°W longitude. A second earthquake of magnitude 7.2 Mw occurred 30 miles SW of Adak, Alaska (51.5°N latitude, 176.9°W longitude) at 1525 UTC on 10 June 1996. Both earthquakes generated a tsunami. Data from 127 separate tide gauge and bottom pressure stations during the initial magnitude 7.7 earthquake and subsequent tsunami are presented in this report.

Figure 1 shows the location of the earthquake epicenter and of each station for which a record was obtained, and also indicates whether or not a tsunami was discernible in the record. A number of agencies have contributed to the database, resulting in comprehensive geographical coverage. Individual stations within the Japanese and Hawaiian regions are indistinguishable from one another, in Fig. 1, due to the high density of stations present. Figures 2 and 3 provide expanded maps of stations within these regions.

A regionally ordered list of stations beginning with stations grouped within the Japanese region and following a clockwise pattern appears in Table 1. They include 71 records from NOAA, 58 from JMA, 33 from UH, and 4 from USACE. For convenience, Table 2 provides the same information sorted alphabetically. The tsunami is evident at 46 of these stations, not present at another 46 stations, and uncertain at 32 stations. The remaining three stations are characterized by bad or missing data. Tsunami records at selected stations within the seven major regions are shown in Fig. 4. Maximum peak-to-trough recorded tsunami wave heights at selected stations are given in Table 3, as estimated by the Alaska Tsunami Warning Center (see URL http://www.alaska.net/~atwc/tsunami.html).

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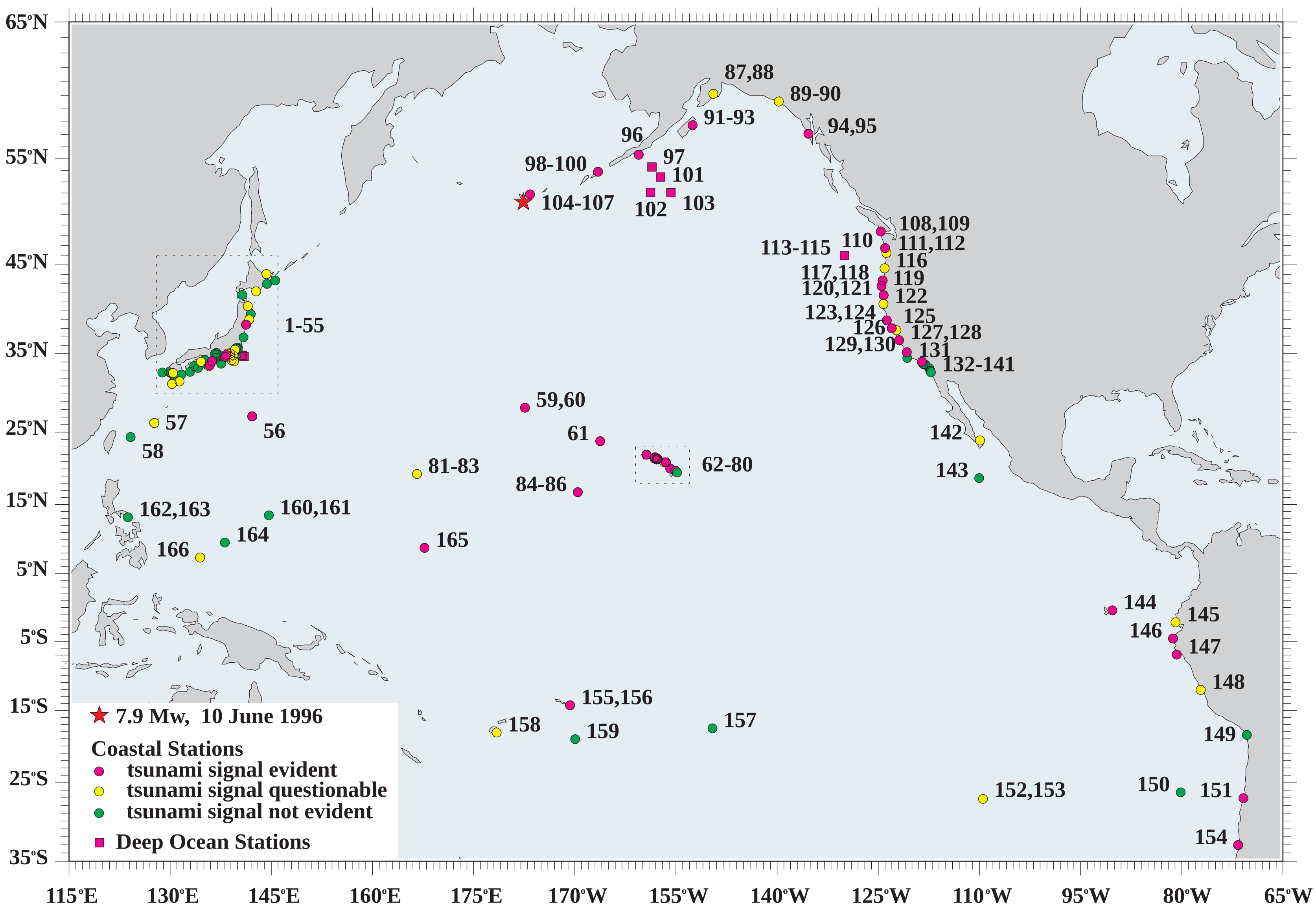

Fig. 1. Tsunami station summary map showing the location of the 10 June 1996 Andreanov Islands earthquake epicenter and each station for which a record was obtained.

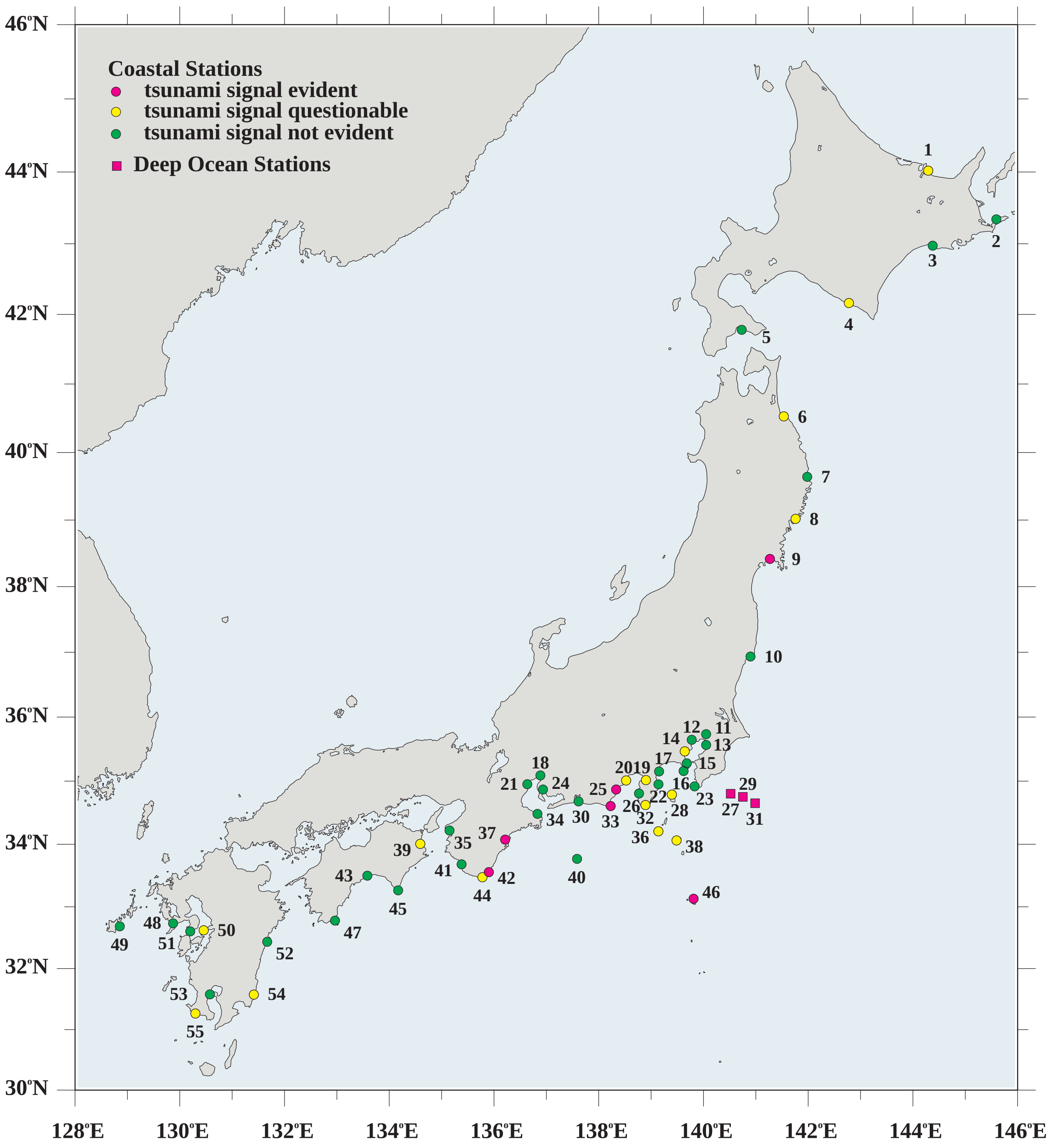

Fig. 2. Expanded map of the densely sampled Japanese region.

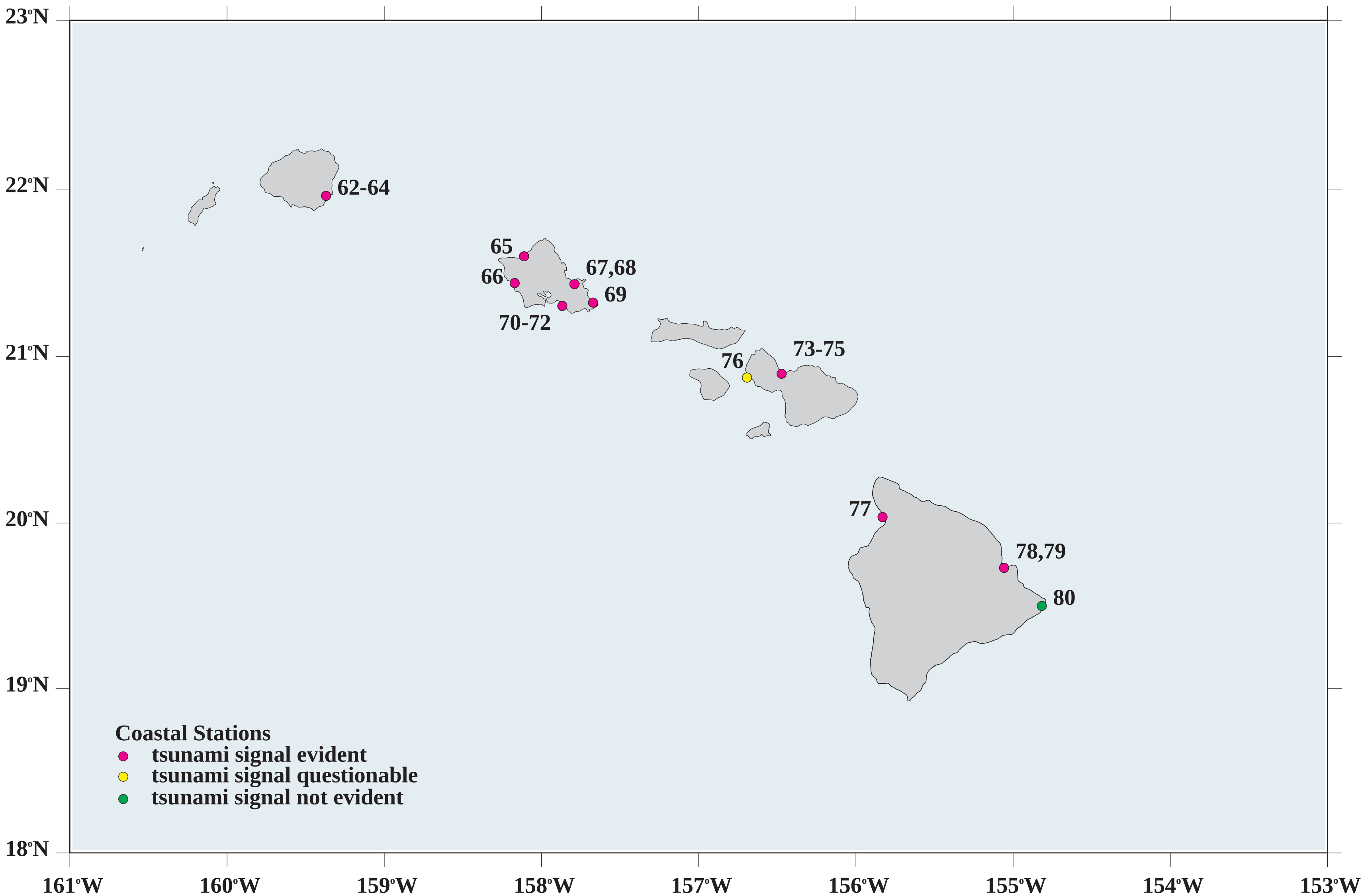

Fig. 3. Expanded map of the densely sampled Hawaiian region.

Table 1. Regionally ordered tsunami station summary table. A table key follows.

plot number	Latitude [°N]	Longitude [°E]	Station	Id	Sensor	dt [sec]	T	ETA [hrs]	file Start UTC June 1996	file End UTC June 1996	record length	Mean [m]	Contact
1	44.0172	144.2897	Abashiri	JMA		60	?	4.4431	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	0.681	Y.Tanioka
2	43.3417	145.5900	Nemuro	JMA		60	N	4.4444	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	0.957	Y.Tanioka
3	42.9722	144.3750	Kushiro	JMA		60	N	4.1014	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	0.866	Y.Tanioka
4	42.1617	142.7750	Urakawa	JMA		60	?	4.1275	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	0.858	Y.Tanioka
5	41.7792	140.7283	Hakodate	JMA		60	N	4.1275	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	0.471	Y.Tanioka
6	40.5289	141.5314	Hachinohe	JMA		60	?	4.5111	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	0.826	Y.Tanioka
7	39.6408	141.9789	Miyako	JMA		60	N	4.4178	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	0.822	Y.Tanioka
8	39.0167	141.7572	Ofunato	JMA		60	?	4.4178	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	0.842	Y.Tanioka
9	38.4167	141.2667	Ishinomaki	JMA		60	Y	4.4389	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	0.874	Y.Tanioka
10	36.9339	140.8953	Onahama	JMA		60	N	4.4497	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	0.750	Y.Tanioka
11	35.7333	140.0483	Cyoshi	JMA		60	N	5.8458	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	0.791	Y.Tanioka
12	35.6456	139.7733	Tokyo	JMA		60	N	5.8458	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	1.093	Y.Tanioka
13	35.5650	140.0483	Chiba	JMA		60	N	5.8458	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	1.072	Y.Tanioka
14	35.4650	139.6403	Yokohama	JMA		60	?	5.8458	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	1.018	Y.Tanioka
15	35.2778	139.6797	Yokosuka	JMA		60	N	5.0444	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	1.019	Y.Tanioka
16	35.1567	139.6183	Aburatsubo			60	N	5.8458	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	1.803	Y.Tanioka
17	35.1500	139.1500	Manazuru			60	N	5.3053	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	2.547	Y.Tanioka
18	35.0881	136.8839	Nagoya	JMA		60	N	5.8417	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	1.338	Y.Tanioka
19	35.0142	138.8986	Uchiura	JMA		60	?	5.3053	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	0.896	Y.Tanioka
20	35.0086	138.5208	Shimizuko	JMA		60	?	5.3053	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	0.873	Y.Tanioka
21	34.9500	136.6333	Yokkaichi	JMA		60	N	5.6111	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	1.402	Y.Tanioka
22	34.9483	139.1383	Ito	JMA		60	N	5.3053	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	2.213	Y.Tanioka
23	34.9156	139.8281	Tateyama	JMA		60	N	5.0444	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	0.861	Y.Tanioka
24	34.8667	136.9333	Taketoyo	JMA		60	N	5.6111	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	1.272	Y.Tanioka
25	34.8667	138.3300	Yaizu	JMA		60	Y	5.5761	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	3.134	Y.Tanioka
26	34.8033	138.7667	Tago			60	N	5.3053	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	2.445	Y.Tanioka
27	34.8000	140.5167	Boso-Obs3			60	?	5.3053	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	-2.917	Y.Tanioka
28	34.7861	139.3944	Oshima	JMA		60	?	5.3053	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	0.810	Y.Tanioka
29	34.7500	140.7500	Boso-Obs2			60	N	4.8236	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	14.499	Y.Tanioka
30	34.6789	137.6119	Maisaka	JMA		60	N	5.5761	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	0.646	Y.Tanioka
31	34.6500	140.9833	Boso-Obs1			60	N	4.8236	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	-6.846	Y.Tanioka
32	34.6217	138.8900	Minamiizu			60	?	5.3053	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	2.705	Y.Tanioka
33	34.6053	138.2250	Omaezaki	JMA		60	Y	5.5761	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	0.935	Y.Tanioka
34	34.4819	136.8275	Toba	JMA		60	N	5.6525	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	1.154	Y.Tanioka
35	34.2186	135.1483	Wakayama	JMA		60	N	6.1250	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	1.173	Y.Tanioka
36	34.2050	139.1367	Kozujima	JMA		60	?	5.3053	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	1.276	Y.Tanioka
37	34.0733	136.2103	Owase	JMA		60	Y	5.6111	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	0.945	Y.Tanioka
38	34.0600	139.4833	Miyakejima	JMA		60	?	5.0444	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	2.322	Y.Tanioka
39	34.0058	134.5900	Komatsujima	JMA		60	?	5.9194	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	1.079	Y.Tanioka
40	33.7667	137.5833	Tokai-Obs			60	N	5.4528	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	6.476	Y.Tanioka
41	33.6800	135.3786	Shirahama	JMA		60	N	6.1250	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	1.131	Y.Tanioka
42	33.5547	135.8989	Uragami	JMA		60	Y	5.8222	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	0.962	Y.Tanioka
43	33.4975	133.5786	Kochi	JMA		60	N	6.1178	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	1.179	Y.Tanioka
44	33.4725	135.7761	Shionomisaki	JMA		60	?	5.8222	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	1.112	Y.Tanioka

Table 1. (continued)

plot number	Latitude [°N]	Longitude [°E]	Station	Id	Sensor	dt [sec]	T	ETA [hrs]	file Start UTC June 1996	file End UTC June 1996	record length	Mean [m]	Contact
45	33.2631	134.1672	Murotomisaki	JMA		60	N	6.1178	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	1.245	Y.Tanioka
46	33.1278	139.8083	Hachijyohima	JMA		60	Y	5.1222	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	1.020	Y.Tanioka
47	32.7758	132.9614	Tosashimizu	JMA		60	N	6.3692	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	1.251	Y.Tanioka
48	32.7311	129.8689	Nagasaki	JMA		60	N	8.8889	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	1.725	Y.Tanioka
49	32.6833	128.8519	Fukue	JMA		60	N	9.1219	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	1.655	Y.Tanioka
50	32.6197	130.4539	Misumi	JMA		60	?	8.8889	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	2.302	Y.Tanioka
51	32.6019	130.1969	Kuchinotsu	JMA		60	N	8.8889	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	2.015	Y.Tanioka
52	32.4333	131.6667	Hyugashirahama			60	N	6.3692	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	1.152	Y.Tanioka
53	31.5775	130.5728	Kagoshima	JMA		60	N	6.6319	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	1.589	Y.Tanioka
54	31.5733	131.4114	Aburatsu	JMA		60	?	8.1361	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	1.208	Y.Tanioka
55	31.2642	130.2953	Makurazaki	JMA		60	?	7.9025	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	1.501	Y.Tanioka
56	27.0911	142.1914	Chichijima	JMA		60	Y	5.4139	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	0.504	Y.Tanioka
57	26.2089	127.6675	Naha	JMA		60	?	7.3775	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	1.272	Y.Tanioka
58	24.3317	124.1558	Ishigakijima	JMA		60	N	8.0611	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	1.197	Y.Tanioka
59	28.2117	-177.3600	Midway	NOS 16199108	Druck	15	Y	3.1500	08 07:08:20=160.297454	13 23:29:50=165.979051	32727	1.769	J.Wendland
60	28.2010	-177.3510	Midway, Hawaii	PTWC	BUB	120	Y	3.1650	09 00:00:00=161.000000	13 22:58:00=165.956944	3570	1.495	B.Kilonsky
61	23.7830	-166.2170	Tern, Fr. Frigate, Hawaii	UHSLC	BUB	120	Y	4.1900	08 23:29:00=160.978472	13 23:27:00=165.977083	3600	0.768	B.Kilonsky
62	21.9600	-159.3700	Nawiliwili, Kauai, Hawaii	PTWC	ENC	120	Y	4.7125	08 22:06:00=160.920834	10 22:00:00=162.916667	1438	0.097	B.Kilonsky
63	21.9550	-159.3567	Nawiliwili	NOS 16114008	Druck	15	Y	4.5333	08 06:40:20=160.278009	13 23:01:50=165.959606	32727	1.547	J.Wendland
64	21.9550	-159.3567	Nawiliwili	NOS 16114001	Aquatrak	60	Y	4.5333	09 03:19:00=161.138194	15 23:18:00=167.970833	9840	0.972	J.Wendland
65	21.6000	-158.1100	Haleiwa, Oahu, Hawaii	PTWC	ENC	120	Y	4.7344	09 01:26:00=161.059723	11 01:16:00=163.052779	1436	0.060	B.Kilonsky
66	21.4400	-158.1700	Waianae, Oahu, Hawaii	PTWC	ENC	120	Y	4.7344	09 02:10:00=161.090278	11 02:00:00=163.083334	1436	0.166	B.Kilonsky
67	21.4333	-157.7900	Mokuoloe	NOS 16124808	Druck	15	Y	4.7333	08 06:10:21=160.257187	13 22:31:51=165.938784	32727	1.473	J.Wendland
68	21.4333	-157.7900	Mokuoloe	NOS 16124801	Aquatrak	60	Y	4.7333	09 03:52:00=161.161111	16 21:51:00=168.910417	11160	1.153	J.Wendland
69	21.3232	-157.6715	Makapu`u, Oahu, Hawaii	PTWC	ENC	120	Y	4.7344	09 00:42:00=161.029167	11 00:32:00=163.022223	1436	0.276	B.Kilonsky
70	21.3040	-157.8670	Honolulu, Oahu, Hawaii	PTWC	PTW	120	?	4.7344	09 03:18:00=161.137500	11 03:08:00=163.130556	1436	0.188	B.Kilonsky
71	21.3033	-157.8650	Honolulu	NOS 16123408	Druck	15	Y	4.7333	09 01:08:05=161.047280	14 17:29:35=166.728877	32727	1.120	J.Wendland
72	21.3033	-157.8650	Honolulu	NOS 16123401	Aquatrak	60	Y	4.7333	09 02:44:00=161.113889	15 18:13:00=167.759028	9570	1.329	J.Wendland
73	20.8980	-156.4720	Kahului, Maui, Hawaii	PTWC	ENC	120	Y	4.9958	09 01:02:00=161.043056	11 00:52:00=163.036112	1436	-0.168	B.Kilonsky
74	20.8950	-156.4683	Kahului	NOS 16156808	Druck	15	Y	5.0000	08 08:33:05=160.356308	14 00:54:35=166.037905	32727	1.832	J.Wendland
75	20.8950	-156.4683	Kahului	NOS 16156801	Aquatrak	60	Y	5.0000	09 01:33:00=161.064583	17 09:32:00=169.397222	12000	1.059	J.Wendland
76	20.8750	-156.6920	Lahaina, Maui, Hawaii	PTWC	PTW	120	?	4.9917	09 03:04:00=161.127778	11 02:54:00=163.120834	1436	0.232	B.Kilonsky
77	20.0367	-155.8300	Kawaihae	NOS 16174331	Druck	60	Y	5.0000	09 00:06:00=161.004167	15 21:05:00=167.878473	9900	1.044	J.Wendland
78	19.7300	-155.0567	Hilo	NOS 16177608	Druck	15	Y	5.4167	08 00:25:35=160.017766	13 16:46:50=165.699190	32726	2.500	J.Wendland
79	19.7300	-155.0567	Hilo	NOS 16177601	Aquatrak	60	Y	5.4167	09 02:39:00=161.110417	14 16:38:00=166.693056	8040	1.544	J.Wendland
80	19.5000	-154.8170	Kapoho, Hawaii, Hawaii	PTWC	ENC	120	N	5.1833	09 02:36:00=161.108334	11 02:26:00=163.101390	1436	0.398	B.Kilonsky
81	19.2900	166.6183	Wake	NOS 18900008	Druck	15	?	4.7500	08 09:07:20=160.380093	14 01:28:50=166.061690	32727	2.777	J.Wendland
82	19.2900	166.6183	Wake	NOS 18900001	Aquatrak	60	?	4.7500	09 00:45:00=161.031250	15 20:44:00=167.863889	9840	1.523	J.Wendland
83	19.2892	166.6213	Wake, Territory	PTWC	BUB	120	?	4.7483	08 23:54:00=160.995833	13 23:52:00=165.994444	3600	1.185	B.Kilonsky
84	16.7390	-169.5233	Johnston, Territory	PTWC	BUB	120	?	5.1192	08 23:36:00=160.983333	13 23:34:00=165.981944	3600	2.022	B.Kilonsky
85	16.7383	-169.5300	Johnston Island	NOS 16190008	Druck	15	?	5.1167	08 01:52:20=160.078009	13 18:13:50=165.759606	32727	1.819	J.Wendland
86	16.7383	-169.5300	Johnston Island	NOS 16190001	Aquatrak	60	Y	5.1167	09 02:09:00=161.089583	15 19:08:00=167.797222	9660	0.939	J.Wendland
87	60.1200	-149.4267	Seward	NOS 94550908	IMO	15	?	4.1833	08 23:12:36=160.967083	14 15:33:51=166.648507	32726	3.428	J.Wendland
88	60.1200	-149.4267	Seward	NOS 94550901	Aquatrak	60	?	4.1833	09 02:52:00=161.119444	16 08:51:00=168.368750	10440	3.463	J.Wendland

Table 1. (continued)

plot number	Latitude [°N]	Longitude [°E]	Station	Id	Sensor	dt [sec]	T	ETA [hrs]	file Start UTC June 1996	file End UTC June 1996	record length	Mean [m]	Contact
89	59.5483	-139.7350	Yakutat	NOS 94532208	IMO	15	?	4.0333	08 06:33:20=160.273148	13 22:41:05=165.945197	32672	5.235	J.Wendland
90	59.5483	-139.7350	Yakutat	NOS 94532201	Aquatrak	60	?	4.0333	08 16:41:00=160.695139	11 20:40:00=163.861111	4560	2.222	J.Wendland
91	57.7317	-152.5117	Kodiak	NOS 94572928	IMO	15	Y	2.7333	08 09:07:20=160.380093	14 01:28:50=166.061690	32727	2.777	J.Wendland
92	57.7317	-152.5117	Kodiak	NOS 94572921	Aquatrak	60	Y	2.7333	09 04:06:00=161.170833	15 22:44:00=167.947222	9759	9.160	J.Wendland
93	57.4400	-152.2900	Kodiak, Alaska	PTWC	BUB	120	Y	2.7372	08 23:34:00=160.981944	13 23:32:00=165.980555	3600	2.528	B.Kilonsky
94	57.0517	-135.3417	Sitka	NOS 94516008	Druck	15	Y	4.3333	08 19:00:35=160.792072	14 11:22:05=166.473669	32727	3.850	J.Wendland
95	57.0517	-135.3417	Sitka	NOS 94516001	Aquatrak	60	Y	4.3333	09 03:25:00=161.142361	16 02:17:00=168.095139	10013	2.933	J.Wendland
96	55.3333	-160.5017	Sand Point	NOS 94594501	Aquatrak	60	Y	2.3333	09 03:04:00=161.127778	16 12:03:00=168.502084	10620	10.330	J.Wendland
97	54.2902	-158.5470	AK70	PMEL	BPR	15	Y	2.0667	09 00:00:00=161.000000	14 00:00:00=166.000000	28801	1751.928	M. Eble
98	53.8800	-166.5383	Dutch Hbr,Unalaska	NOS 94626208	IMO	15	Y	1.6167	08 08:56:20=160.372454	14 01:17:50=166.054051	32727	2.901	J.Wendland
99	53.8800	-166.5383	Dutch Hbr,Unalaska	NOS 94626201	Aquatrak	60	Y	1.6167	09 01:57:00=161.081250	16 00:56:00=168.038889	10020	1.265	J.Wendland
100	53.5300	-166.3200	Dutch Hbr,Unalaska, Alaska	PTWC	BUB	120	?	1.4056	08 23:33:00=160.981250	13 22:31:00=165.938194	3570	2.530	B.Kilonsky
101	53.4233	-157.2777	AK71	PMEL	BPR	15	Y	2.0333	09 00:00:00=161.000000	14 00:00:00=166.000000	28801	4831.798	M. Eble
102	52.0392	-158.7513	AK72	PMEL	BPR	15	Y	1.8167	09 00:00:00=161.000000	14 00:00:00=166.000000	28801	4943.092	M. Eble
103	52.0182	-155.7235	AK73	PMEL	BPR	15	Y	2.0667	09 00:00:00=161.000000	14 00:00:00=166.000000	28801	4872.032	M. Eble
104	51.8633	-176.6317	Adak	NOS 94613808	Druck	15	Y	0.1500	08 08:16:20=160.344676	14 00:37:50=166.026273	32727	2.535	J.Wendland
105	51.8633	-176.6317	Adak	NOS 94613801	Aquatrak	60	Y	0.1500	09 03:24:00=161.141667	15 19:09:00=167.797917	9586	1.468	J.Wendland
106	51.5200	-176.3800	Adak, Alaska	PTWC	ADR	120	Y	0.2972	08 23:32:00=160.980556	13 23:30:00=165.979167	3600	2.231	B.Kilonsky
107	51.5200	-176.3800	Adak, Alaska	PTWC	BUB	120	Y	0.2972	08 23:32:00=160.980556	13 23:30:00=165.979167	3600	2.231	B.Kilonsky
108	48.3667	-124.6117	Neah Bay	NOS 94430908	Druck	15	Y	5.4500	09 01:27:51=161.061007	14 17:49:21=166.742604	32727	3.496	J.Wendland
109	48.3667	-124.6117	Neah Bay	NOS 94430901	Aquatrak	60	Y	5.4500	09 00:25:00=161.017361	15 18:24:00=167.766667	9720	1.702	J.Wendland
110	46.7083	-123.9650	Toke Point	NOS 94409101	Aquatrak	60	Y	5.8000	09 04:06:00=161.170833	17 17:55:00=169.746527	12350	2.567	J.Wendland
111	46.2083	-123.7667	Astoria	NOS 94390408	Druck	15	?	5.8000	08 03:23:35=160.141377	13 19:45:05=165.822974	32727	2.965	J.Wendland
112	46.2083	-123.7667	Astoria	NOS 94390401	Aquatrak	60	N	5.8000	09 04:43:00=161.196528	15 20:42:00=167.862500	9600	1.964	J.Wendland
113	45.96	-130.00	WC68	PMEL	BPR	15	Y	5.0000	09 00:00:00=161.000000	14 00:00:00=166.000000	28801	1578.740	M. Eble
114	45.9333	-129.9805	WC67	PMEL	BPR	15	Y	5.0000	09 00:00:00=161.000000	14 00:00:00=166.000000	28801	1564.938	M. Eble
115	45.93	-129.98	WC69	PMEL	BPR	15	Y	5.0000	09 00:00:00=161.000000	14 00:00:00=166.000000	28801	1558.564	M. Eble
116	44.6250	-124.0433	South Beach	NOS 94353808	IMO	15	?	5.9920	07 02:20:30=159.097569	12 18:42:00=164.779166	32727	3.794	J.Wendland
117	43.3450	-124.3217	Charleston	NOS 94327808	IMO	15	Y	6.0833	08 01:04:06=160.044514	13 17:25:21=165.725938	32726	3.007	J.Wendland
118	43.3450	-124.3217	Charleston	NOS 94327801	Aquatrak	60	?	6.0833	09 03:41:00=161.153472	16 06:17:00=168.261805	10237	2.206	J.Wendland
119	42.7400	-124.4967	Port Orford	NOS 94316471	Aquatrak	60	Y	5.9000	09 03:14:00=161.134722	16 06:13:00=168.259028	10260	8.013	J.Wendland
120	41.7450	-124.1833	Crescent City	NOS 94197508	IMO	15	Y	6.2167	08 07:49:35=160.326100	14 00:11:05=166.007697	32727	3.141	J.Wendland
121	41.7450	-124.1833	Crescent City	NOS 94197501	Aquatrak	60	Y	6.2167	09 02:35:00=161.107639	16 16:34:00=168.690278	10920	2.094	J.Wendland
122	40.7667	-124.2167	No.Spit	NOS 94187678	IMO	15	?	6.2833	06 06:00:51=158.250590	11 22:22:21=163.932187	32727	3.728	J.Wendland
123	38.9150	-123.7117	Arena Cove	NOS 94168418	IMO	15	Y	6.2333	08 05:38:20=160.234954	13 21:59:50=165.916551	32727	3.075	J.Wendland
124	38.9150	-123.7117	Arena Cove	NOS 94168411	Aquatrak	60	Y	6.2333	09 04:22:00=161.181944	17 21:31:00=169.896527	12550	9.654	J.Wendland
125	37.9967	-122.9750	Point Reyes	NOS 94150201	Aquatrak	60	Y	6.4167	09 03:02:00=161.126389	15 07:01:00=167.292361	8880	2.068	J.Wendland
126	37.7717	-122.2983	Alameda	NOS 94147508	IMO	15	?	6.6667	08 09:14:20=160.384954	14 01:35:50=166.066551	32727	3.569	J.Wendland
127	36.6050	-121.8883	Monterey Harbor	NOS 94134508	IMO	15	?	6.0667	08 05:39:05=160.235475	13 22:00:35=165.917072	32727	3.681	J.Wendland
128	36.6050	-121.8883	Monterey Harbor	NOS 94134501	Aquatrak	60	Y	6.0667	09 03:14:00=161.134722	17 22:13:00=169.925694	12660	1.794	J.Wendland
129	35.1683	-120.7533	Port San Luis	NOS 94121108	IMO	15	Y	6.8667	08 04:01:20=160.167593	13 20:22:50=165.849190	32727	2.890	J.Wendland
130	35.1683	-120.7533	Port San Luis	NOS 94121101	Aquatrak	60	N	6.8667	09 03:23:00=161.140972	17 03:22:00=169.140278	11520	1.563	J.Wendland
131	34.4700	-120.6817	Harvest Platform, Ca	COE 63.1		15	N	6.8750	08 06:14:52=160.260324	17 18:34:52=169.774213	54801	15.74387	M. Eble
132	34.0083	-118.5000	Santa Monica	NOS 94108408	IMO	15	Y	7.7000	08 07:49:35=160.326100	14 00:11:05=166.007697	32727	3.141	J.Wendland

Table 1. (continued)

plot number	Latitude [°N]	Longitude [°E]	Station	Id	Sensor	dt [sec]	T	ETA [hrs]	file Start UTC June 1996	file End UTC June 1996	record length	Mean [m]	Contact
133	34.0083	-118.5000	Santa Monica	NOS 94108401	Aquatrak	60	N	7.7000	09 04:07:00=161.171528	15 20:06:00=167.837500	9600	1.560	J.Wendland
134	33.7200	-118.2550	Los Angeles	NOS 94106608	IMO	15	N	7.7000	08 08:36:20=160.358565	14 00:57:50=166.040162	32727	3.436	J.Wendland
135	33.7200	-118.2550	Los Angeles	NOS 94106601	Aquatrak	60	N	7.7000	08 21:11:00=160.882639	16 06:10:00=168.256945	10620	2.013	J.Wendland
136	33.6317	-117.9783	Huntington Beach, CA	COE 72.1		15	N	7.7069	08 06:10:46=160.257477	18 01:22:31=170.057303	56448	10.63984	M. Eble
137	33.2050	-117.3883	Oceanside O Dock, CA	COE 69.1		15		7.7069	08 06:01:43=160.251192	17 21:09:28=169.881574	55472	4.94947	M. Eble
138	32.8667	-117.2583	La Jolla	NOS 94102308	IMO	15	N	7.7833	07 23:18:06=159.970903	13 15:39:36=165.652500	32727	4.694	J.Wendland
139	32.8667	-117.2583	La Jolla	NOS 94102301	Aquatrak	60	N	7.7833	09 02:56:00=161.122222	16 16:55:00=168.704861	10920	2.111	J.Wendland
140	32.8667	-117.2567	Scripps Pier, Ca	COE 3.1		15	N	7.7903	08 05:53:43=160.245637	17 17:06:58=169.713172	54534	4.88873	M. Eble
141	32.7133	-117.1733	San Diego	NOS 94101701	Aquatrak	60	N	7.7833	09 03:40:00=161.152778	15 21:39:00=167.902084	9720	2.005	J.Wendland
142	23.8830	-109.9000	Cabo San Lucas Mexico	UHSLC	ENC	120	?	9.1875	08 23:18:00=160.970833	13 23:16:00=165.969444	3600	10.034	B.Kilonsky
143	18.7170	-110.0170	Socorro Mexico	PTWC	BUB	120	N	9.6539	08 23:19:00=160.971528	13 23:17:00=165.970139	3600	1.878	B.Kilonsky
144	-0.4330	-90.2830	Baltra, Galapagos Ecuador	UHSLC	ENC	120	Y	14.7344	08 23:32:00=160.980556	13 23:30:00=165.979167	3600	9.338	B.Kilonsky
145	-2.2090	-80.9020	La Libertad Ecuador	PTWC	ENC	120	?	16.1650	08 23:26:00=160.976389	13 23:24:00=165.975000	3600	2.656	B.Kilonsky
146	-4.5833	-81.2833	Talara Peru	PTWC	ENC	120	Y	16.1483	08 23:22:00=160.973611	13 23:20:00=165.972222	3600	0.756	B.Kilonsky
147	-6.9350	-80.7200	Lobos de Afuera Peru	PTWC	ENC	120	Y	16.1747	08 23:20:00=160.972222	13 23:18:00=165.970833	3600	1.468	B.Kilonsky
148	-12.0710	-77.1740	Callao, La-Punta Peru	PTWC	ENC	120	?	17.0764	08 23:32:00=160.980556	13 23:30:00=165.979167	3600	3.813	B.Kilonsky
149	-18.4720	-70.3350	Arica Chile	PTWC	BUB	120	N	18.7792	08 23:34:00=160.981944	13 23:32:00=165.980555	3600	1.946	B.Kilonsky
150	-26.2833	-80.1333	San Felix Chile	PTWC	BUB	120		17.5706	08 23:32:00=160.980556	13 23:30:00=165.979167	3600	1.197	B.Kilonsky
151	-27.0580	-70.8340	Caldera Chile	PTWC	BUB	120	Y	18.7983	08 23:56:00=160.997222	13 23:54:00=165.995833	3600	3.189	B.Kilonsky
152	-27.1500	-109.4483	Easter Island	NOS 99624208	IMO	15		14.8667	14 05:45:53=166.240197	15 16:59:38=167.708079	8456	1.620	J.Wendland
153	-27.1530	-109.4480	Easter Chile	PTWC	BUB	120	?	14.8736	08 23:56:00=160.997222	13 23:54:00=165.995833	3600	1.438	B.Kilonsky
154	-33.0330	-71.6170	Valparaiso Chile	PTWC	BUB	120	Y	19.0344	08 23:24:00=160.975000	13 23:22:00=165.973611	3600	1.449	B.Kilonsky
155	-14.2800	-170.6900	Pago Pago	NOS 17700008	Druck	15	Y	9.3833	07 06:22:35=159.265683	12 22:44:05=164.947280	32727	2.216	J.Wendland
156	-14.2800	-170.6900	Pago Pago	NOS 17700001	Digibub	60	Y	9.3833	09 02:51:00=161.118750	15 19:08:00=167.797222	9618	2.087	J.Wendland
157	-17.5350	-149.5717	Papeete	NOS 17324178	IMO	15	N	10.5667	08 01:58:20=160.082176	13 18:19:50=165.763773	32727	2.640	J.Wendland
158	-18.1367	178.4250	Suva Fiji	NOS 19100001	Aquatrak	60	?	10.3833	09 02:37:00=161.109028	14 21:36:00=166.900000	8340	11.585	J.Wendland
159	-19.0525	-169.9214	Niue Niue	PTWC	BUB	120		10.0706	08 23:29:00=160.978472	13 23:27:00=165.977083	3600	-0.060	B.Kilonsky
160	13.4417	144.6533	Guam	NOS 16300008	Druck	15	N	6.7667	08 04:26:20=160.184954	13 20:47:50=165.866551	32727	5.670	J.Wendland
161	13.4417	144.6533	Guam	NOS 16300001	Aquatrak	60	N	6.7667	09 04:23:00=161.182639	15 18:22:00=167.765278	9480	0.993	J.Wendland
162	13.1611	123.7578	Legaspi Philippines	PTWC	ENC	120	N	8.4622	08 23:06:00=160.962500	13 23:04:00=165.961111	3600	4.576	B.Kilonsky
163	13.1611	123.7578	Legaspi Philippines	PTWC	PRS	120	N	8.4622	08 23:06:00=160.962500	13 23:04:00=165.961111	3600	2.085	B.Kilonsky
164	9.5120	138.1280	Yap Fed States Micro	UHSLC	ENC	120	N	7.7944	08 23:04:00=160.961111	13 23:02:00=165.959722	3600	9.482	B.Kilonsky
165	8.7367	167.7383	Kwajalein	NOS 18200001	Aquatrak	60	Y	6.3333	09 02:30:00=161.104167	15 19:29:00=167.811806	9660	1.545	J.Wendland
166	7.3320	134.4640	Malakal, Koror Palau	PTWC	ENC	120	?	8.3069	08 23:02:00=160.959722	13 23:00:00=165.958333	3600	7.040	B.Kilonsky

Table 1. Key.

Id - Owners / Station Identification:

COE: US Army Corps of Engineers
JMA: Japanese Meteorological Agency
NOS: National Ocean Service, NOAA
PMEL: Pacific Marine Environmental Laboratory, NOAA
PTWC: Pacific Tsunami Warning Center, NWS
UHSLC: University of Hawaii Sea Level Center
blank: Owners of individually maintained Japanese stations not available at this time.

T - Tsunami Visible?:

Y: Indicates tsunami signal is evident above noise levels.
?: Indicates tsunami signal is questionable, but might be evident with more processing.
N: Indicates tsunami signal is not evident above noise levels.

Sensors:

ADR: Data from a punch paper tape transmitted via satellite
Aquatrak: Data from AQUATRAK sensor transmitted via satellite
BPR: Data from PAROSCIENTIFIC sensor
Druck: Data from DRUCK Sensor stored on 64K RAM pack
IMO: Data from IMO Sensor stored on 64K RAM pack
BUB: Data from BUBBLER gauge transmitted via satellite
ENC: DATA from HANDAR ENCODER transmitted via satellite
PRS: Data from NOS PRESSURE TRANSDUCER transmitted via satellite
PTW: Data from NOS PRIMARY WATER LEVEL transmitted via satellite
blank: not available at this time.

ETA - Estimated Time of Arrival:

Tsunami arrival time at each station, relative to the main earthquake shock (June 10, 1996 at 0404 UTC), estimated by means of a modified PTWC travel time code.

Mean:

Mean sea level value removed from data records.

Table 2. Alphabetically ordered tsunami station summary table. A table key follows.

plot number	Latitude [°N]	Longitude [°E]	Station	Id	Sensor	dt [sec]	T	ETA [hrs]	file Start UTC June 1996	file End UTC June 1996	record length	Mean [m]	Contact
1	44.0172	144.2897	Abashiri	JMA		60	?	4.4431	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	0.681	Y.Tanioka
54	31.5733	131.4114	Aburatsu	JMA		60	?	8.1361	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	1.208	Y.Tanioka
16	35.1567	139.6183	Aburatsubo			60	N	5.8458	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	1.803	Y.Tanioka
104	51.8633	-176.6317	Adak	NOS 94613808	Druck	15	Y	0.1500	08 08:16:20=160.344676	14 00:37:50=166.026273	32727	2.535	J.Wendland
105	51.8633	-176.6317	Adak	NOS 94613801	Aquatrak	60	Y	0.1500	09 03:24:00=161.141667	15 19:09:00=167.797917	9586	1.468	J.Wendland
106	51.5200	-176.3800	Adak, Alaska	PTWC	ADR	120	Y	0.2972	08 23:32:00=160.980556	13 23:30:00=165.979167	3600	2.231	B.Kilonsky
107	51.5200	-176.3800	Adak, Alaska	PTWC	BUB	120	Y	0.2972	08 23:32:00=160.980556	13 23:30:00=165.979167	3600	2.231	B.Kilonsky
97	54.2902	-158.5470	AK70	PMEL	BPR	15	Y	2.0667	09 00:00:00=161.000000	14 00:00:00=166.000000	28801	1751.928	M. Eble
101	53.4233	-157.2777	AK71	PMEL	BPR	15	Y	2.0333	09 00:00:00=161.000000	14 00:00:00=166.000000	28801	4831.798	M. Eble
102	52.0392	-158.7513	AK72	PMEL	BPR	15	Y	1.8167	09 00:00:00=161.000000	14 00:00:00=166.000000	28801	4943.092	M. Eble
103	52.0182	-155.7235	AK73	PMEL	BPR	15	Y	2.0667	09 00:00:00=161.000000	14 00:00:00=166.000000	28801	4872.032	M. Eble
126	37.7717	-122.2983	Alameda	NOS 94147508	IMO	15	?	6.6667	08 09:14:20=160.384954	14 01:35:50=166.066551	32727	3.569	J.Wendland
123	38.9150	-123.7117	Arena Cove	NOS 94168418	IMO	15	Y	6.2333	08 05:38:20=160.234954	13 21:59:50=165.916551	32727	3.075	J.Wendland
124	38.9150	-123.7117	Arena Cove	NOS 94168411	Aquatrak	60	Y	6.2333	09 04:22:00=161.181944	17 21:31:00=169.896527	12550	9.654	J.Wendland
149	-18.4720	-70.3350	Arica Chile	PTWC	BUB	120	N	18.7792	08 23:34:00=160.981944	13 23:32:00=165.980555	3600	1.946	B.Kilonsky
111	46.2083	-123.7667	Astoria	NOS 94390408	Druck	15	?	5.8000	08 03:23:35=160.141377	13 19:45:05=165.822974	32727	2.965	J.Wendland
112	46.2083	-123.7667	Astoria	NOS 94390401	Aquatrak	60	N	5.8000	09 04:43:00=161.196528	15 20:42:00=167.862500	9600	1.964	J.Wendland
144	-0.4330	-90.2830	Baltra, Galapagos Ecuador	UHSLC	ENC	120	Y	14.7344	08 23:32:00=160.980556	13 23:30:00=165.979167	3600	9.338	B.Kilonsky
31	34.6500	140.9833	Boso-Obs1			60	N	4.8236	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	-6.846	Y.Tanioka
29	34.7500	140.7500	Boso-Obs2			60	N	4.8236	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	14.499	Y.Tanioka
27	34.8000	140.5167	Boso-Obs3			60	?	5.3053	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	-2.917	Y.Tanioka
142	23.8830	-109.9000	Cabo San Lucas Mexico	UHSLC	ENC	120	?	9.1875	08 23:18:00=160.970833	13 23:16:00=165.969444	3600	10.034	B.Kilonsky
151	-27.0580	-70.8340	Caldera Chile	PTWC	BUB	120	Y	18.7983	08 23:56:00=160.997222	13 23:54:00=165.995833	3600	3.189	B.Kilonsky
148	-12.0710	-77.1740	Callao, La-Punta Peru	PTWC	ENC	120	?	17.0764	08 23:32:00=160.980556	13 23:30:00=165.979167	3600	3.813	B.Kilonsky
117	43.3450	-124.3217	Charleston	NOS 94327808	IMO	15	Y	6.0833	08 01:04:06=160.044514	13 17:25:21=165.725938	32726	3.007	J.Wendland
118	43.3450	-124.3217	Charleston	NOS 94327801	Aquatrak	60	?	6.0833	09 03:41:00=161.153472	16 06:17:00=168.261805	10237	2.206	J.Wendland
13	35.5650	140.0483	Chiba	JMA		60	N	5.8458	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	1.072	Y.Tanioka
56	27.0911	142.1914	Chichijima	JMA		60	Y	5.4139	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	0.504	Y.Tanioka
120	41.7450	-124.1833	Crescent City	NOS 94197508	IMO	15	Y	6.2167	08 07:49:35=160.326100	14 00:11:05=166.007697	32727	3.141	J.Wendland
121	41.7450	-124.1833	Crescent City	NOS 94197501	Aquatrak	60	Y	6.2167	09 02:35:00=161.107639	16 16:34:00=168.690278	10920	2.094	J.Wendland
11	35.7333	140.0483	Cyoshi	JMA		60	N	5.8458	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	0.791	Y.Tanioka
98	53.8800	-166.5383	Dutch Hbr,Unalaska	NOS 94626208	IMO	15	Y	1.6167	08 08:56:20=160.372454	14 01:17:50=166.054051	32727	2.901	J.Wendland
99	53.8800	-166.5383	Dutch Hbr,Unalaska	NOS 94626201	Aquatrak	60	Y	1.6167	09 01:57:00=161.081250	16 00:56:00=168.038889	10020	1.265	J.Wendland
100	53.5300	-166.3200	Dutch Hbr,Unalaska, Alaska	PTWC	BUB	120	?	1.4056	08 23:33:00=160.981250	13 22:31:00=165.938194	3570	2.530	B.Kilonsky
153	-27.1530	-109.4480	Easter Chile	PTWC	BUB	120	?	14.8736	08 23:56:00=160.997222	13 23:54:00=165.995833	3600	1.438	B.Kilonsky
152	-27.1500	-109.4483	Easter Island	NOS 99624208	IMO	15		14.8667	14 05:45:53=166.240197	15 16:59:38=167.708079	8456	1.620	J.Wendland
49	32.6833	128.8519	Fukue	JMA		60	N	9.1219	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	1.655	Y.Tanioka
160	13.4417	144.6533	Guam	NOS 16300008	Druck	15	N	6.7667	08 04:26:20=160.184954	13 20:47:50=165.866551	32727	5.670	J.Wendland
161	13.4417	144.6533	Guam	NOS 16300001	Aquatrak	60	N	6.7667	09 04:23:00=161.182639	15 18:22:00=167.765278	9480	0.993	J.Wendland
46	33.1278	139.8083	Hachijyohima	JMA		60	Y	5.1222	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	1.020	Y.Tanioka
6	40.5289	141.5314	Hachinohe	JMA		60	?	4.5111	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	0.826	Y.Tanioka
5	41.7792	140.7283	Hakodate	JMA		60	N	4.1275	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	0.471	Y.Tanioka
65	21.6000	-158.1100	Haleiwa, Oahu, Hawaii	PTWC	ENC	120	Y	4.7344	09 01:26:00=161.059723	11 01:16:00=163.052779	1436	0.060	B.Kilonsky
131	34.4700	-120.6817	Harvest Platform, Ca	COE 63.1		15	N	6.8750	08 06:14:52=160.260324	17 18:34:52=169.774213	54801	15.74387	M. Eble

Table 2. (continued)

plot number	Latitude [°N]	Longitude [°E]	Station	Id	Sensor	dt [sec]	T	ETA [hrs]	file Start UTC June 1996	file End UTC June 1996	record length	Mean [m]	Contact
78	19.7300	-155.0567	Hilo	NOS 16177608	Druck	15	Y	5.4167	08 00:25:35=160.017766	13 16:46:50=165.699190	32726	2.500	J.Wendland
79	19.7300	-155.0567	Hilo	NOS 16177601	Aquatrak	60	Y	5.4167	09 02:39:00=161.110417	14 16:38:00=166.693056	8040	1.544	J.Wendland
71	21.3033	-157.8650	Honolulu	NOS 16123408	Druck	15	Y	4.7333	09 01:08:05=161.047280	14 17:29:35=166.728877	32727	1.120	J.Wendland
72	21.3033	-157.8650	Honolulu	NOS 16123401	Aquatrak	60	Y	4.7333	09 02:44:00=161.113889	15 18:13:00=167.759028	9570	1.329	J.Wendland
70	21.3040	-157.8670	Honolulu, Oahu, Hawaii	PTWC	PTW	120	?	4.7344	09 03:18:00=161.137500	11 03:08:00=163.130556	1436	0.188	B.Kilonsky
136	33.6317	-117.9783	Huntington Beach, CA	COE 72.1		15	N	7.7069	08 06:10:46=160.257477	18 01:22:31=170.057303	56448	10.63984	M. Eble
52	32.4333	131.6667	Hyugashirahama			60	N	6.3692	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	1.152	Y.Tanioka
58	24.3317	124.1558	Ishigakijima	JMA		60	N	8.0611	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	1.197	Y.Tanioka
9	38.4167	141.2667	Ishinomaki	JMA		60	Y	4.4389	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	0.874	Y.Tanioka
22	34.9483	139.1383	Ito	JMA		60	N	5.3053	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	2.213	Y.Tanioka
85	16.7383	-169.5300	Johnston Island	NOS 16190008	Druck	15	?	5.1167	08 01:52:20=160.078009	13 18:13:50=165.759606	32727	1.819	J.Wendland
86	16.7383	-169.5300	Johnston Island	NOS 16190001	Aquatrak	60	Y	5.1167	09 02:09:00=161.089583	15 19:08:00=167.797222	9660	0.939	J.Wendland
84	16.7390	-169.5233	Johnston, Territory	PTWC	BUB	120	?	5.1192	08 23:36:00=160.983333	13 23:34:00=165.981944	3600	2.022	B.Kilonsky
53	31.5775	130.5728	Kagoshima	JMA		60	N	6.6319	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	1.589	Y.Tanioka
74	20.8950	-156.4683	Kahului	NOS 16156808	Druck	15	Y	5.0000	08 08:33:05=160.356308	14 00:54:35=166.037905	32727	1.832	J.Wendland
75	20.8950	-156.4683	Kahului	NOS 16156801	Aquatrak	60	Y	5.0000	09 01:33:00=161.064583	17 09:32:00=169.397222	12000	1.059	J.Wendland
73	20.8980	-156.4720	Kahului, Maui, Hawaii	PTWC	ENC	120	Y	4.9958	09 01:02:00=161.043056	11 00:52:00=163.036112	1436	-0.168	B.Kilonsky
80	19.5000	-154.8170	Kapoho, Hawaii, Hawaii	PTWC	ENC	120	N	5.1833	09 02:36:00=161.108334	11 02:26:00=163.101390	1436	0.398	B.Kilonsky
77	20.0367	-155.8300	Kawaihae	NOS 16174331	Druck	60	Y	5.0000	09 00:06:00=161.004167	15 21:05:00=167.878473	9900	1.044	J.Wendland
43	33.4975	133.5786	Kochi	JMA		60	N	6.1178	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	1.179	Y.Tanioka
91	57.7317	-152.5117	Kodiak	NOS 94572928	IMO	15	Y	2.7333	08 09:07:20=160.380093	14 01:28:50=166.061690	32727	2.777	J.Wendland
92	57.7317	-152.5117	Kodiak	NOS 94572921	Aquatrak	60	Y	2.7333	09 04:06:00=161.170833	15 22:44:00=167.947222	9759	9.160	J.Wendland
93	57.4400	-152.2900	Kodiak, Alaska	PTWC	BUB	120	Y	2.7372	08 23:34:00=160.981944	13 23:32:00=165.980555	3600	2.528	B.Kilonsky
39	34.0058	134.5900	Komatsujima	JMA		60	?	5.9194	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	1.079	Y.Tanioka
36	34.2050	139.1367	Kozujima	JMA		60	?	5.3053	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	1.276	Y.Tanioka
51	32.6019	130.1969	Kuchinotsu	JMA		60	N	8.8889	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	2.015	Y.Tanioka
3	42.9722	144.3750	Kushiro	JMA		60	N	4.1014	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	0.866	Y.Tanioka
165	8.7367	167.7383	Kwajalein	NOS 18200001	Aquatrak	60	Y	6.3333	09 02:30:00=161.104167	15 19:29:00=167.811806	9660	1.545	J.Wendland
138	32.8667	-117.2583	La Jolla	NOS 94102308	IMO	15	N	7.7833	07 23:18:06=159.970903	13 15:39:36=165.652500	32727	4.694	J.Wendland
139	32.8667	-117.2583	La Jolla	NOS 94102301	Aquatrak	60	N	7.7833	09 02:56:00=161.122222	16 16:55:00=168.704861	10920	2.111	J.Wendland
145	-2.2090	-80.9020	La Libertad Ecuador	PTWC	ENC	120	?	16.1650	08 23:26:00=160.976389	13 23:24:00=165.975000	3600	2.656	B.Kilonsky
76	20.8750	-156.6920	Lahaina, Maui, Hawaii	PTWC	PTW	120	?	4.9917	09 03:04:00=161.127778	11 02:54:00=163.120834	1436	0.232	B.Kilonsky
162	13.1611	123.7578	Legaspi Philippines	PTWC	ENC	120	N	8.4622	08 23:06:00=160.962500	13 23:04:00=165.961111	3600	4.576	B.Kilonsky
163	13.1611	123.7578	Legaspi Philippines	PTWC	PRS	120	N	8.4622	08 23:06:00=160.962500	13 23:04:00=165.961111	3600	2.085	B.Kilonsky
147	-6.9350	-80.7200	Lobos de Afuera Peru	PTWC	ENC	120	Y	16.1747	08 23:20:00=160.972222	13 23:18:00=165.970833	3600	1.468	B.Kilonsky
134	33.7200	-118.2550	Los Angeles	NOS 94106608	IMO	15	N	7.7000	08 08:36:20=160.358565	14 00:57:50=166.040162	32727	3.436	J.Wendland
135	33.7200	-118.2550	Los Angeles	NOS 94106601	Aquatrak	60	N	7.7000	08 21:11:00=160.882639	16 06:10:00=168.256945	10620	2.013	J.Wendland
30	34.6789	137.6119	Maisaka	JMA		60	N	5.5761	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	0.646	Y.Tanioka
69	21.3232	-157.6715	Makapu`u, Oahu, Hawaii	PTWC	ENC	120	Y	4.7344	09 00:42:00=161.029167	11 00:32:00=163.022223	1436	0.276	B.Kilonsky
55	31.2642	130.2953	Makurazaki	JMA		60	?	7.9025	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	1.501	Y.Tanioka
166	7.3320	134.4640	Malakal, Koror Palau	PTWC	ENC	120	?	8.3069	08 23:02:00=160.959722	13 23:00:00=165.958333	3600	7.040	B.Kilonsky
17	35.1500	139.1500	Manazuru			60	N	5.3053	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	2.547	Y.Tanioka
59	28.2117	-177.3600	Midway	NOS 16199108	Druck	15	Y	3.1500	08 07:08:20=160.297454	13 23:29:50=165.979051	32727	1.769	J.Wendland
60	28.2010	-177.3510	Midway, Hawaii	PTWC	BUB	120	Y	3.1650	09 00:00:00=161.000000	13 22:58:00=165.956944	3570	1.495	B.Kilonsky

Table 2. (continued)

plot number	Latitude [°N]	Longitude [°E]	Station	Id	Sensor	dt [sec]	T	ETA [hrs]	file Start UTC June 1996	file End UTC June 1996	record length	Mean [m]	Contact
32	34.6217	138.8900	Minamiizu			60	?	5.3053	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	2.705	Y.Tanioka
50	32.6197	130.4539	Misumi	JMA		60	?	8.8889	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	2.302	Y.Tanioka
38	34.0600	139.4833	Miyakejima	JMA		60	?	5.0444	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	2.322	Y.Tanioka
7	39.6408	141.9789	Miyako	JMA		60	N	4.4178	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	0.822	Y.Tanioka
67	21.4333	-157.7900	Mokuoloe	NOS 16124808	Druck	15	Y	4.7333	08 06:10:21=160.257187	13 22:31:51=165.938784	32727	1.473	J.Wendland
68	21.4333	-157.7900	Mokuoloe	NOS 16124801	Aquatrak	60	Y	4.7333	09 03:52:00=161.161111	16 21:51:00=168.910417	11160	1.153	J.Wendland
127	36.6050	-121.8883	Monterey Harbor	NOS 94134508	IMO	15	?	6.0667	08 05:39:05=160.235475	13 22:00:35=165.917072	32727	3.681	J.Wendland
128	36.6050	-121.8883	Monterey Harbor	NOS 94134501	Aquatrak	60	Y	6.0667	09 03:14:00=161.134722	17 22:13:00=169.925694	12660	1.794	J.Wendland
45	33.2631	134.1672	Murotomisaki	JMA		60	N	6.1178	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	1.245	Y.Tanioka
48	32.7311	129.8689	Nagasaki	JMA		60	N	8.8889	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	1.725	Y.Tanioka
18	35.0881	136.8839	Nagoya	JMA		60	N	5.8417	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	1.338	Y.Tanioka
57	26.2089	127.6675	Naha	JMA		60	?	7.3775	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	1.272	Y.Tanioka
63	21.9550	-159.3567	Nawiliwili	NOS 16114008	Druck	15	Y	4.5333	08 06:40:20=160.278009	13 23:01:50=165.959606	32727	1.547	J.Wendland
64	21.9550	-159.3567	Nawiliwili	NOS 16114001	Aquatrak	60	Y	4.5333	09 03:19:00=161.138194	15 23:18:00=167.970833	9840	0.972	J.Wendland
62	21.9600	-159.3700	Nawiliwili, Kauai, Hawaii	PTWC	ENC	120	Y	4.7125	08 22:06:00=160.920834	10 22:00:00=162.916667	1438	0.097	B.Kilonsky
108	48.3667	-124.6117	Neah Bay	NOS 94430908	Druck	15	Y	5.4500	09 01:27:51=161.061007	14 17:49:21=166.742604	32727	3.496	J.Wendland
109	48.3667	-124.6117	Neah Bay	NOS 94430901	Aquatrak	60	Y	5.4500	09 00:25:00=161.017361	15 18:24:00=167.766667	9720	1.702	J.Wendland
2	43.3417	145.5900	Nemuro	JMA		60	N	4.4444	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	0.957	Y.Tanioka
159	-19.0525	-169.9214	Niue Niue	PTWC	BUB	120		10.0706	08 23:29:00=160.978472	13 23:27:00=165.977083	3600	-0.060	B.Kilonsky
122	40.7667	-124.2167	No.Spit	NOS 94187678	IMO	15	?	6.2833	06 06:00:51=158.250590	11 22:22:21=163.932187	32727	3.728	J.Wendland
137	33.2050	-117.3883	Oceanside O Dock, CA	COE 69.1		15		7.7069	08 06:01:43=160.251192	17 21:09:28=169.881574	55472	4.94947	M. Eble
8	39.0167	141.7572	Ofunato	JMA		60	?	4.4178	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	0.842	Y.Tanioka
33	34.6053	138.2250	Omaezaki	JMA		60	Y	5.5761	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	0.935	Y.Tanioka
10	36.9339	140.8953	Onahama	JMA		60	N	4.4497	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	0.750	Y.Tanioka
28	34.7861	139.3944	Oshima	JMA		60	?	5.3053	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	0.810	Y.Tanioka
37	34.0733	136.2103	Owase	JMA		60	Y	5.6111	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	0.945	Y.Tanioka
155	-14.2800	-170.6900	Pago Pago	NOS 17700008	Druck	15	Y	9.3833	07 06:22:35=159.265683	12 22:44:05=164.947280	32727	2.216	J.Wendland
156	-14.2800	-170.6900	Pago Pago	NOS 17700001	Digibub	60	Y	9.3833	09 02:51:00=161.118750	15 19:08:00=167.797222	9618	2.087	J.Wendland
157	-17.5350	-149.5717	Papeete	NOS 17324178	IMO	15	N	10.5667	08 01:58:20=160.082176	13 18:19:50=165.763773	32727	2.640	J.Wendland
125	37.9967	-122.9750	Point Reyes	NOS 94150201	Aquatrak	60	Y	6.4167	09 03:02:00=161.126389	15 07:01:00=167.292361	8880	2.068	J.Wendland
119	42.7400	-124.4967	Port Orford	NOS 94316471	Aquatrak	60	Y	5.9000	09 03:14:00=161.134722	16 06:13:00=168.259028	10260	8.013	J.Wendland
129	35.1683	-120.7533	Port San Luis	NOS 94121108	IMO	15	Y	6.8667	08 04:01:20=160.167593	13 20:22:50=165.849190	32727	2.890	J.Wendland
130	35.1683	-120.7533	Port San Luis	NOS 94121101	Aquatrak	60	N	6.8667	09 03:23:00=161.140972	17 03:22:00=169.140278	11520	1.563	J.Wendland
141	32.7133	-117.1733	San Diego	NOS 94101701	Aquatrak	60	N	7.7833	09 03:40:00=161.152778	15 21:39:00=167.902084	9720	2.005	J.Wendland
150	-26.2833	-80.1333	San Felix Chile	PTWC	BUB	120		17.5706	08 23:32:00=160.980556	13 23:30:00=165.979167	3600	1.197	B.Kilonsky
96	55.3333	-160.5017	Sand Point	NOS 94594501	Aquatrak	60	Y	2.3333	09 03:04:00=161.127778	16 12:03:00=168.502084	10620	10.330	J.Wendland
132	34.0083	-118.5000	Santa Monica	NOS 94108408	IMO	15	Y	7.7000	08 07:49:35=160.326100	14 00:11:05=166.007697	32727	3.141	J.Wendland
133	34.0083	-118.5000	Santa Monica	NOS 94108401	Aquatrak	60	N	7.7000	09 04:07:00=161.171528	15 20:06:00=167.837500	9600	1.560	J.Wendland
140	32.8667	-117.2567	Scripps Pier, Ca	COE 3.1		15	N	7.7903	08 05:53:43=160.245637	17 17:06:58=169.713172	54534	4.88873	M. Eble
87	60.1200	-149.4267	Seward	NOS 94550908	IMO	15	?	4.1833	08 23:12:36=160.967083	14 15:33:51=166.648507	32726	3.428	J.Wendland
88	60.1200	-149.4267	Seward	NOS 94550901	Aquatrak	60	?	4.1833	09 02:52:00=161.119444	16 08:51:00=168.368750	10440	3.463	J.Wendland
20	35.0086	138.5208	Shimizuko	JMA		60	?	5.3053	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	0.873	Y.Tanioka
44	33.4725	135.7761	Shionomisaki	JMA		60	?	5.8222	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	1.112	Y.Tanioka
41	33.6800	135.3786	Shirahama	JMA		60	N	6.1250	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	1.131	Y.Tanioka

Table 2. (continued)

plot number	Latitude [°N]	Longitude [°E]	Station	Id	Sensor	dt [sec]	T	ETA [hrs]	file Start UTC June 1996	file End UTC June 1996	record length	Mean [m]	Contact
94	57.0517	-135.3417	Sitka	NOS 94516008	Druck	15	Y	4.3333	08 19:00:35=160.792072	14 11:22:05=166.473669	32727	3.850	J.Wendland
95	57.0517	-135.3417	Sitka	NOS 94516001	Aquatrak	60	Y	4.3333	09 03:25:00=161.142361	16 02:17:00=168.095139	10013	2.933	J.Wendland
143	18.7170	-110.0170	Socorro Mexico	PTWC	BUB	120	N	9.6539	08 23:19:00=160.971528	13 23:17:00=165.970139	3600	1.878	B.Kilonsky
116	44.6250	-124.0433	South Beach	NOS 94353808	IMO	15	?	5.9920	07 02:20:30=159.097569	12 18:42:00=164.779166	32727	3.794	J.Wendland
158	-18.1367	178.4250	Suva Fiji	NOS 19100001	Aquatrak	60	?	10.3833	09 02:37:00=161.109028	14 21:36:00=166.900000	8340	11.585	J.Wendland
26	34.8033	138.7667	Tago			60	N	5.3053	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	2.445	Y.Tanioka
24	34.8667	136.9333	Taketoyo	JMA		60	N	5.6111	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	1.272	Y.Tanioka
146	-4.5833	-81.2833	Talara Peru	PTWC	ENC	120	Y	16.1483	08 23:22:00=160.973611	13 23:20:00=165.972222	3600	0.756	B.Kilonsky
23	34.9156	139.8281	Tateyama	JMA		60	N	5.0444	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	0.861	Y.Tanioka
61	23.7830	-166.2170	Tern, Fr. Frigate, Hawaii	UHSLC	BUB	120	Y	4.1900	08 23:29:00=160.978472	13 23:27:00=165.977083	3600	0.768	B.Kilonsky
34	34.4819	136.8275	Toba	JMA		60	N	5.6525	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	1.154	Y.Tanioka
40	33.7667	137.5833	Tokai-Obs			60	N	5.4528	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	6.476	Y.Tanioka
110	46.7083	-123.9650	Toke Point	NOS 94409101	Aquatrak	60	Y	5.8000	09 04:06:00=161.170833	17 17:55:00=169.746527	12350	2.567	J.Wendland
12	35.6456	139.7733	Tokyo	JMA		60	N	5.8458	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	1.093	Y.Tanioka
47	32.7758	132.9614	Tosashimizu	JMA		60	N	6.3692	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	1.251	Y.Tanioka
19	35.0142	138.8986	Uchiura	JMA		60	?	5.3053	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	0.896	Y.Tanioka
42	33.5547	135.8989	Uragami	JMA		60	Y	5.8222	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	0.962	Y.Tanioka
4	42.1617	142.7750	Urakawa	JMA		60	?	4.1275	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	0.858	Y.Tanioka
154	-33.0330	-71.6170	Valparaiso Chile	PTWC	BUB	120	Y	19.0344	08 23:24:00=160.975000	13 23:22:00=165.973611	3600	1.449	B.Kilonsky
66	21.4400	-158.1700	Waianae, Oahu, Hawaii	PTWC	ENC	120	Y	4.7344	09 02:10:00=161.090278	11 02:00:00=163.083334	1436	0.166	B.Kilonsky
35	34.2186	135.1483	Wakayama	JMA		60	N	6.1250	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	1.173	Y.Tanioka
81	19.2900	166.6183	Wake	NOS 18900008	Druck	15	?	4.7500	08 09:07:20=160.380093	14 01:28:50=166.061690	32727	2.777	J.Wendland
82	19.2900	166.6183	Wake	NOS 18900001	Aquatrak	60	?	4.7500	09 00:45:00=161.031250	15 20:44:00=167.863889	9840	1.523	J.Wendland
83	19.2892	166.6213	Wake, Territory	PTWC	BUB	120	?	4.7483	08 23:54:00=160.995833	13 23:52:00=165.994444	3600	1.185	B.Kilonsky
114	45.9333	-129.9805	WC67	PMEL	BPR	15	Y	5.0000	09 00:00:00=161.000000	14 00:00:00=166.000000	28801	1564.938	M. Eble
113	45.96	-130.00	WC68	PMEL	BPR	15	Y	5.0000	09 00:00:00=161.000000	14 00:00:00=166.000000	28801	1578.740	M. Eble
115	45.93	-129.98	WC69	PMEL	BPR	15	Y	5.0000	09 00:00:00=161.000000	14 00:00:00=166.000000	28801	1558.564	M. Eble
25	34.8667	138.3300	Yaizu	JMA		60	Y	5.5761	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	3.134	Y.Tanioka
89	59.5483	-139.7350	Yakutat	NOS 94532208	IMO	15	?	4.0333	08 06:33:20=160.273148	13 22:41:05=165.945197	32672	5.235	J.Wendland
90	59.5483	-139.7350	Yakutat	NOS 94532201	Aquatrak	60	?	4.0333	08 16:41:00=160.695139	11 20:40:00=163.861111	4560	2.222	J.Wendland
164	9.5120	138.1280	Yap Fed States Micro	UHSLC	ENC	120	N	7.7944	08 23:04:00=160.961111	13 23:02:00=165.959722	3600	9.482	B.Kilonsky
21	34.9500	136.6333	Yokkaichi	JMA		60	N	5.6111	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	1.402	Y.Tanioka
14	35.4650	139.6403	Yokohama	JMA		60	?	5.8458	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	1.018	Y.Tanioka
15	35.2778	139.6797	Yokosuka	JMA		60	N	5.0444	08 00:00:00=160.000000	13 00:00:00=165.000000	7201	1.019	Y.Tanioka

Table 2. Key.

Id - Owners / Station Identification:

COE: US Army Corps of Engineers
JMA: Japanese Meteorological Agency
NOS: National Ocean Service, NOAA
PMEL: Pacific Marine Environmental Laboratory, NOAA
PTWC: Pacific Tsunami Warning Center, NWS
UHSLC: University of Hawaii Sea Level Center
blank: Owners of individually maintained Japanese stations not available at this time.

T - Tsunami Visible?:

Y: Indicates tsunami signal is evident above noise levels.
?: Indicates tsunami signal is questionable, but might be evident with more processing.
N: Indicates tsunami signal is not evident above noise levels.

Sensors:

ADR: Data from a punch paper tape transmitted via satellite
Aquatrak: Data from AQUATRAK sensor transmitted via satellite
BPR: Data from PAROSCIENTIFIC sensor
Druck: Data from DRUCK Sensor stored on 64K RAM pack
IMO: Data from IMO Sensor stored on 64K RAM pack
BUB: Data from BUBBLER gauge transmitted via satellite
ENC: DATA from HANDAR ENCODER transmitted via satellite
PRS: Data from NOS PRESSURE TRANSDUCER transmitted via satellite
PTW: Data from NOS PRIMARY WATER LEVEL transmitted via satellite
blank: not available at this time.

ETA - Estimated Time of Arrival:

Tsunami arrival time at each station, relative to the main earthquake shock (June 10, 1996 at 0404 UTC), estimated by means of a modified PTWC travel time code.

Mean:

Mean sea level value removed from data records.

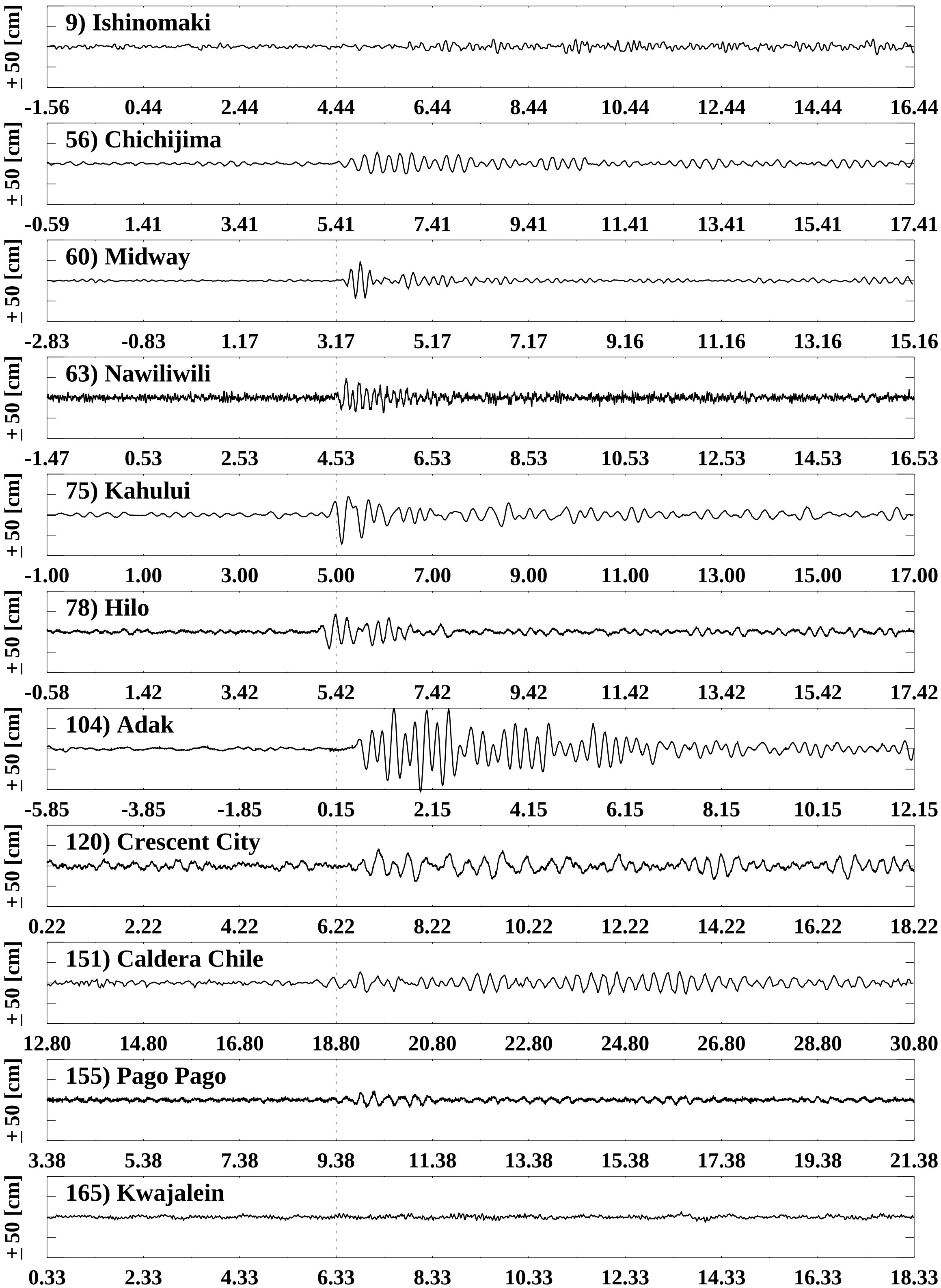

Fig. 4. Tsunami records at selected stations within the seven geographical regions. Time is referred to the main shock, at 0404 UTC on 10 June 1996, and vertical dashed lines indicate the theoretically computed arrival time.

Table 3. Maximum peak-to-trough (double-amplitude) recorded tsunami wave heights at selected stations, as estimated by the Alaska Tsunami Warning Center (see URL http://www.alaska.net/~atwc/ tsunami.html).

Location	Maximum Double-Amplitude
Adak, AK	102 cm
Shemya, AK	15 cm
Unalaska, AK	12.25 cm
Sand Point, AK	10.2 cm
Kodiak, AK	12.5 cm
Kawaihae, HI	15 cm
Kahului, HI	55 cm
Nawiliwili, HI	33 cm
Hilo, HI	38 cm
Honolulu, HI	10 cm
Port Allen, HI	20 cm
Johnston Island	3 cm
Port Angeles, WA	10 cm
Crescent City, CA	30 cm

The NOAA/PMEL deep ocean BPR records are of particular interest. Four constitute an array located south of the Shumagin Islands in the Aleutian Island chain, approximately 1400 km from the earthquake epicenter. Three more stations were located off the United States Washington-Oregon coast, approximately 3500 km from the earthquake epicenter. These three stations are effectively a single tsunami monitoring station because they are in close proximity to one another; they recorded very nearly the same signal, as shown in Fig. 5. The Alaskan array BPRs, shown in Fig. 6, recorded the seismic Rayleigh wave as well as the tsunami. In the case of the seismic waves, the vertical scale is not an indication of the Rayleigh wave amplitude; rather, the scale reflects an apparent pressure change that is actually due to the vertical acceleration of the BPR and overlying water column induced by passage of the seismic wave (Filloux, 1982).

2. Data Collection and Processing

All data were edited to remove values that exceeded reasonable bounds. Outliers were replaced with linearly interpolated values from adjacent data points. Duplicate data were eliminated, and gaps were filled with a flag. All data are dominated by local tidal fluctuations. Since the tides mask any recorded low-magnitude tsunami signal present in the data record, they are removed from each record by high-pass filtering the edited data records.

2.1 Tide Gauge

Tide gauge data were provided by the Japanese Meteorological Agency (JMA), the University of Hawaii (UH), the Pacific Tsunami Warning Center (PTWC), and the National Ocean Service (NOS). All tide gauge data were transferred over the World Wide Web from their respective source

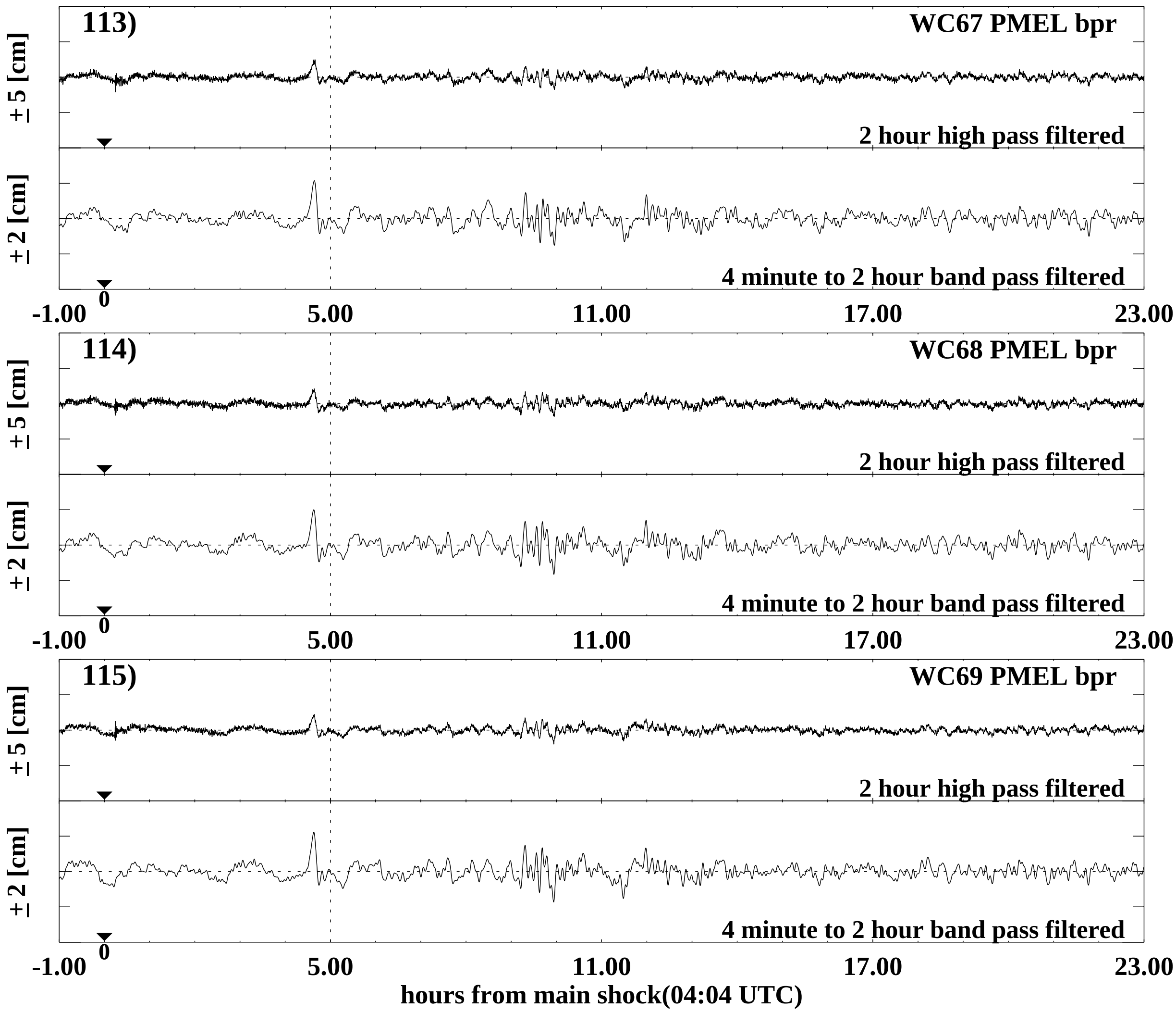

Fig. 5. NOAA/PMEL observations of bottom pressure at deep-ocean stations located off the United States Washington-Oregon coast approximately 3500 km from the earthquake epicenter. Time is referred to the main shock, at 0404 UTC on 10 June 1996, and vertical dashed lines indicate the theoretically computed arrival time.

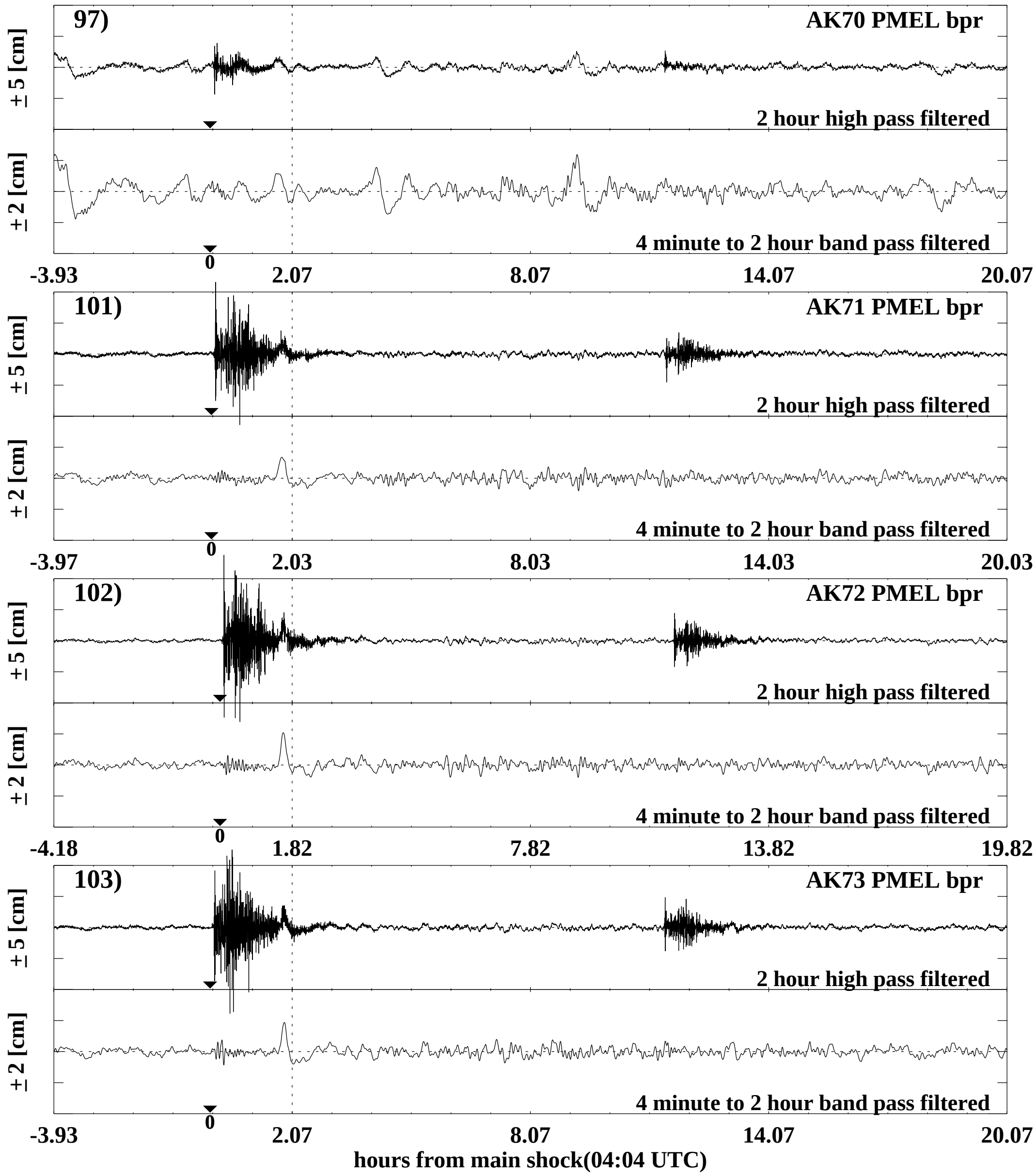

Fig. 6. NOAA/PMEL observations of bottom pressure at each of the four deep-ocean stations comprising the NOAA Alaskan array. Time is referred to the main shock, at 0404 UTC on 10 June 1996, and vertical dashed lines indicate the theoretically computed arrival time.

locations to NOAA/PMEL for processing. Sampling rates for JMA, PTWC, and UH data are 1 minute, 2 minutes, and 2 minutes, respectively. NOS data were sampled at either 15-second or 1-minute intervals.

2.1.1 JMA and Affiliate Data

Data provided by the Japan Meteorological Agency (JMA) were recorded at 54 tide gauges (44 operated by JMA, five operated by Geographical Survey Institute (GSI), and 5 operated by the Maritime Safety Agency (MSA)), and four ocean bottom pressure gauges operated by JMA. The ocean bottom pressure gauge consists of a quartz pressure transducer with 0.5 mm resolution (see Okada, 1995). All data are obtained by a telemetry system, a part of the Earthquake Phenomena Observation System (EPOS) (Uchike and Hosono, 1995) at the JMA.

Original data at different gauges have varied sampling intervals: 1.0–3.0 second interval for tide gauges, 20-second interval for ocean bottom pressure gauges. Each second, the system searches for new data from all gauges; when new data are not available, the previous data are stored. The quasi-1-second-sampled data are re-sampled to produce 1-minute intervals by averaging 1 minute of the data between 0 and 59 seconds. The time provided here for each data point refers to the center of the 1-minute averaging interval.

2.1.2 NOS

Data are provided by the National Ocean Service (NOS) Ocean and Lake Levels Division (OLLD). OLLD operates and maintains approximately 200 continuously sampling tide gauges along the entire U.S. coastline (Gonzalez *et al.*, 1993). In almost every case the stations are comprised of two separate units: the primary water level sensor (1-minute data), and a backup sensor (15-second data). All NOS 1-minute data platforms are accessed via modem connection and downloaded for processing and analysis at PMEL. The 15-second data RAM Pack is removed onsite (data is not available via a modem connection), and mailed to the Pacific Operations Section office in Seattle, Washington for decoding. Decoding is performed by a Sutron 8202 RAM Pack reader, which expands the compressed 15-second data to an ASCII format. After a time conversion, the data is then processed in the same way as the 1-minute data.

The primary water level sensor is the Sutron 9000. This sensor is comprised of a data collection platform with an acoustic water level measurement sensor. The actual acoustic unit (Aquatrak) operates by pinging down a small sounding tube that is mounted in a protective well. The 9000 takes water level readings every second, and averages 58 values over 1 minute. The Pago Pago station in Samoa is equipped with a Paroscientific Digi-Bubbler system. This system feeds nitrogen to two orifices hard mounted at known water depths (geodetic levels), resulting in extremely accurate water density and water level measurement. The Digi-Bubbler system samples once every 5 seconds, and over each minute 11 of these values are averaged. Using either the Aquatrack or the Digi-

Bubbler a total of just over 22 days worth of data (32,762 values) are continuously read to a buffer on a first-in, first-out basis, and can be downloaded for processing via a modem connection.

The backup meter is the Sutron 8200 and operates by measuring the pressure of nitrogen purged out of an orifice hard mounted to a determined depth in the water, effectively measuring the height of the water column above the orifice level. The 8200 is equipped with a removable 64K RAM Pack that is continuously written to on a first-in, first-out basis. The 8200 averages 15 samples every 10 seconds and records that value for every 15-second period. The RAM Pack contains the latest 5 days' 16 hours worth of data (32,725 data points), and is continuously overwritten until removed.

2.1.3 UH and PTWC

Both the UH and PTWC use float-type gauges with standard stilling wells as the primary sensor. The sea level gauges are placed in harbors and on piers in lagoons where the installations are protected. Other site criteria stipulate that the water be sufficiently deep, the station be away from heavy ship activity, and the location be convenient for the tide observer and technicians and thus less costly to maintain. The use of shallow water pressure gauges is generally avoided for several reasons. They cannot be easily referred to bench marks and the pressure transducers drift, requiring costly calibration trips. In those few locations where a well installation was not feasible, bubbler gauges have been successfully installed.

Presently, the UH and PTWC stations are most commonly fitted with two or more redundant sensors to reduce data gaps, a data collection platform (DCP) with telemetry capabilities, electric power sources, and a weather-proof enclosure (Kilonsky, 1982). The hub of each satellite-transmitting sea level station is the DCP, which manages the logging and transmission of the data from the various gauges. In addition, all stations include a tide staff and an automated reference level switch, which are linked by surveying with local bench marks, and used to align the gauge measurements with a common zero reference level. The different types of gauges installed within the UH and PTWC Networks include analog-to-digital recorders, magnetic incremental shaft encoders, pneumatic devices (bubblers) and pressure transducers. Wyrtki *et al.* (1988) provides a detailed discussion of the components and operation of a station.

The DCPs at remote sites transmit sea level data at precisely timed intervals (with occasional special tsunami broadcasts) via NOAA's Geostationary Operational Environmental Satellite (GOES) Data Collection System (DCS), Japan's Geostationary Meteorological Satellite (GMS) DCS, and the European Organization for the Exploitation of Meteorological Satellites (EUMETSAT) Meteorological Satellite (METEOSAT) DCS. At the programmed transmit time, the DCP radio is activated and the stored sensor data is phase encoded into a UHF carrier. The data is received by the satellite transponder and retransmitted in the S band to the downlink site, for the GOES system, the National Environmental Satellite, Data, and Information Service (NESDIS) Command and Acquisition Facility at Wallops Island, Virginia. After demodulation, the platform messages are relayed to the National Weather Service (NWS) Telecommunication Gateway and routed to the UH and PTWC over NWS telecommunication lines where they are logged on dedicated microcomputers. Although message formats vary among stations, they usually include at least two channels of sea level height, reference level switch information, and battery voltages and other DCP engineering information. Collection and processing steps are separated into daily and monthly routines. Data messages are normally received in Hawaii 3 to 5 minutes after transmission from the DCP.

Currently, data from over 100 satellite-transmitting stations are received and processed at the UH Sea Level Center. Sampling rates for these stations vary from 2 minutes for UH and PTWC locations to 6 minutes for NOS sites. Typically, each station has at least two separate data paths. One is real time via satellite, and the other, a delayed mode using on-site data loggers. The satellite data are received on an hourly cycle, arriving at the UH within minutes of transmission. Data logged locally at stations are forwarded, along with tide staff information, to the UH Sea Level Center on a monthly cycle. The UH stations and some PTWC stations also provide additional leveling information from the specially designed switches that are surveyed to the tide staff. These reference level switches measure the exact time the sea level passes the switch, and are used to determine the vertical location of the sensor. As the data arrive at the UH, they are logged onto a network of computers. A daily review of the satellite data is conducted, and any transmission or instrument problems are identified. Queries are made to the data originators when appropriate. For each station, a file is created that contains all redundant data (each separate source of data at a station is called a data channel) and the predicted tides. It also contains reference level information for each channel, and serves as the merging point for the near real-time and delayed mode data.

Harmonic constituents from a routinely updated data base are used to calculate predicted tides, which are subtracted from the observations to form residuals. Residuals between different channels are also analyzed for possible problems. Plots of these residuals are a primary quality control tool. They are inspected by an experienced data processor to correct or flag erroneous features in the observed data. The high frequency gauge data are then available for use. These de-tided data have not been included in the electronic database, but may be obtained by contacting caldwell@soest.hawaii.edu.

2.2 Pressure Data

2.2.1 U.S. Army Corps of Engineers

The Coastal Data Information Program (CDIP) is operated by the Ocean Engineering Research Group (OERG) of the Center for Coastal Studies (CCS) at the Scripps Institution of Oceanography (SIO). CDIP’s mission is the measurement, analysis, archiving, and dissemination of coastal environment data for use by coastal engineers, planners, and managers as well as scientists and mariners (O’Reilly *et al.*, 1993; Seymour *et al.*, 1993).

Close to shore, in-water depths of 30 to 60 feet, waves are measured using pressure sensors mounted near the bottom. These instruments measure pressure fluctuations, or the changing height of the water column, associated with passing waves. These pressure time series can be converted to sea surface elevations and wave frequency spectra. Arrays of four pressure sensors placed in a 6 m square configuration provide directional information similar to that acquired by directional buoys.

Sensotec's Model TJE (Sensotec, Inc., 1990), and Paroscientific pressure transducers (Wearn, 1985; Well-Test Instruments, Inc., 1984) are used for CDIP. TJE's are designed with four-arm 350-ohm strain gage bridges and have welded stainless steel construction. Gage pressure units are built using Sensotec's proprietary "True Gage," design which utilizes a second welded diaphragm that hermetically seals the strain gage circuitry while allowing the transducer to reference atmospheric pressure.

All of the instruments at a particular site are connected to a shore station, either by cable, cellular phone or radio link. The shore stations store data continuously in digital memory. They are interrogated automatically several times daily by a central computer at SIO and archived on computer disks for CDIP client access.

Unprocessed, 1-second data in blocks of 2.25 hours were downloaded from the CDIP FTP site. The data blocks were sequentially merged, eliminating overlaps and filling any gaps with a constant flag outside of expected pressures. Outliers were replaced with values linearly interpolated from adjacent valid data. Tides are removed from each record by high-pass filtering the edited data records.

2.2.2 Pacific Marine Environmental Laboratory

In 1986, NOAA initiated the Pacific Tsunami Observation Program (PacTOP) in the northeast Pacific Ocean dedicated to collecting high-quality deep-water data during a tsunami (Gonzalez *et al.*, 1987). Five permanent deep-ocean BPR observational sites are maintained to monitor the seismically active Alaska-Aleutian Seismic Zone because of the potential threat to United States coastal regions, including Hawaii, the United States west coast, and the Alaskan coast (Eble and Gonzalez, 1991). Since PacTOPs inception, typical BPR deployment and recovery cycles of 11–15 months have been made. Data are recorded on a disk and downloaded to a computer for processing after BPR recovery.

The sensor in the BPR is a Paroscientific model 410K-017 digiquartz pressure transducer, which has a range of 0–10,000 psi (absolute) (~0–6900 m) (Eble *et al.*, 1989). The transducer design utilizes an oscillating quartz-crystal beam that is piezoelectrically induced to vibrate in its lowest resonant, flexural mode (Wearn and Larson, 1980, 1982). Changes in fluid pressure are converted into a change in the axial compressive load on the beam via a Bourdon tube and lever arm arrangement. In turn, the change in the axial load alters the natural vibrational frequency of the beam. The output frequency of the associated oscillator circuit is a measure of the applied external pressure; typical unloaded transducer frequencies are on the order of 40,000 Hz. To improve resolution, frequency multipliers have been used to increase this unloaded frequency to approximately 1 MHz. Since the frequency of transducer oscillation is a function of temperature as well as pressure, accurate temperature measurements are made inside of the pressure transducer cavity housing the quartz crystal. A quartz-crystal clock controls the averaging period of all measurements. Both pressure and temperature data are continuous time averages recorded every 15 seconds. Pressure sensitivity of better than 1 mm is achieved.

The BPR electronics are housed in a cylindrical, anodized aluminum pressure case. The BPR unit and separate acoustic release are mounted on a circular platform with an aluminum tripod. A typical ~1-year deployment BPR mooring configuration is shown in Fig. 7.

3. Report Organization

The data are presented in seven major sections, one for each region of coverage. Each section consists of a map of the study area, and plots of edited and 2-hour high-pass filtered data for each station record. Minimal editing was performed on these data to remove outliers, but a number of time series presented here retain errors and artifacts attributable to instrumentation limitations.

Edited data 24 hours prior to the time of the earthquake's main shock and 120 hours after, for a total of 144 hours or 6 days, are plotted. A 24-hour subsection of the edited series has been 2-hour high-pass filtered to better reveal a tsunami signal, if present, and is plotted directly below the edited time series. The plotted subsection is the time spanned between the two vertical coarse dashed lines on each edited plot. An estimated tsunami arrival time is shown on each plot as a fine dashed line to provide a general arrival time reference. The times are rough estimates obtained by computing paths of minimum propagation time (Braddock, 1969) on a 1° × 1° bathymetric grid. These coarse grid computations can be in error by as much as 30 minutes, and are only provided as guidance.

4. Acknowledgments

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5. References

Braddock, R.D. (1969): On tsunami propagation. *J. Geophys. Res., 74*, 1952–1957.

Eble, M.C., F.I. Gonzalez, D.M. Mattens and H.B. Milburn (1989): Instrumentation, field operations, and data processing for PMEL deep-ocean bottom pressure measurements. NOAA Technical Memorandum ERL PMEL-89, (NTIS PB90-114018), 71 pp.

Eble, M.C., and F.I. Gonzalez (1991): Deep-ocean bottom pressure measurements in the northeast Pacific. *J. Atmos. Oceanic Tech., 8*(2), 221–233.

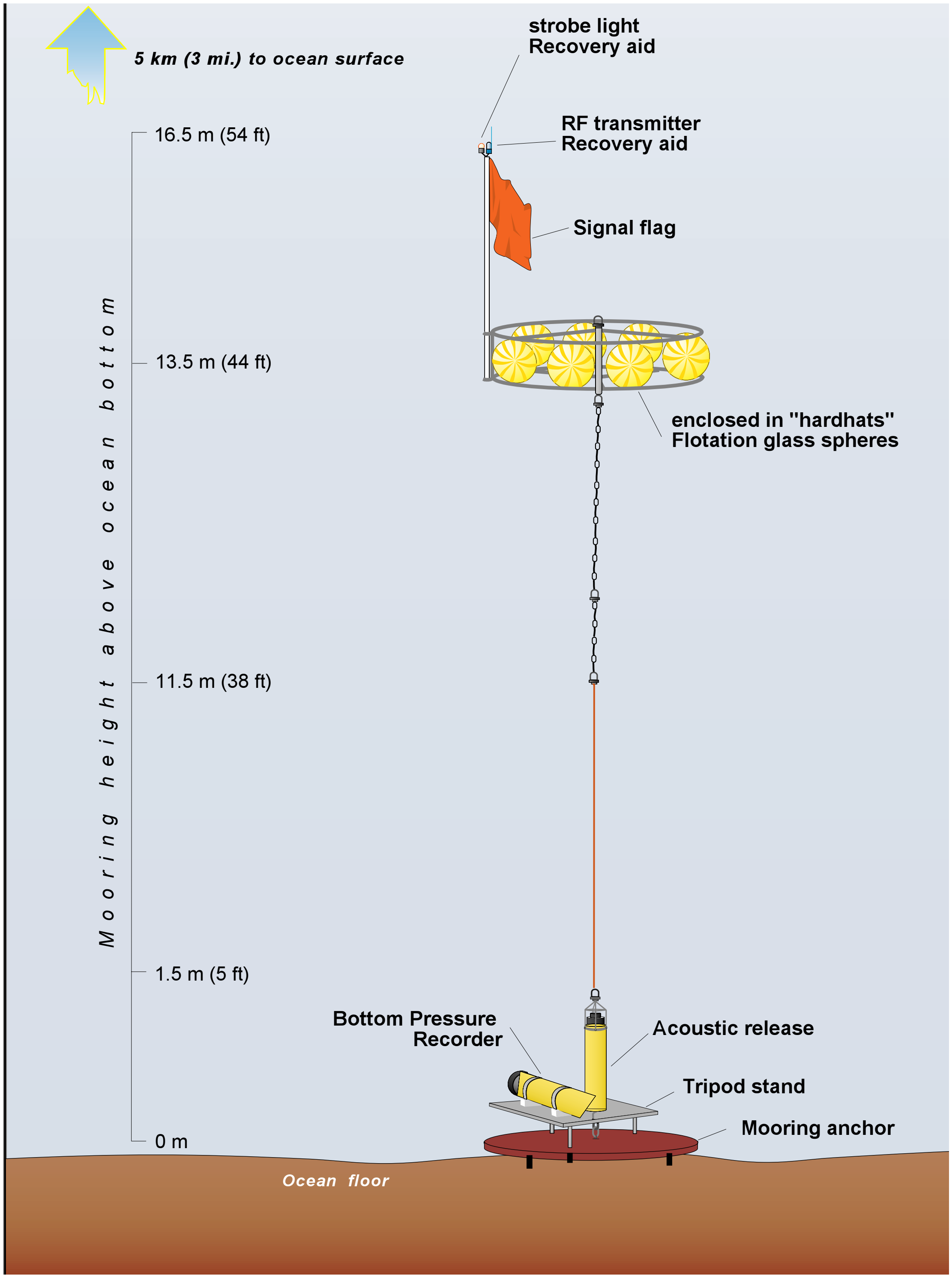


Fig. 7. BPR mooring configuration for long-term deployments.

Filloux, J.H. (1982): Tsunami recorded on the open ocean floor. *Geophys. Res. Lett., 9*, 25–28.

Gonzalez, F.I., E.N. Bernard, H.B. Milburn, D. Castel, J. Thomas, and J.M. Hemsley (1987): The Pacific Tsunami Observation Program (PacTOP). Proceedings of the International Tsunami Symposium, Vancouver, British Columbia, Canada, August 18-19, 1987, International Union of Geodesy and Geophysics, ERL Special Report (PB89-100895), 3–19.

Gonzalez, F.I., T. Mero, and D. Castel (1993): U.S. Tsunami measurements capabilities. Proceedings, Third UJNR Tsunami Workshop, 27 August 1993, Osaka, Japan, 46–49.

Kilonsky, B. (1984): Satellite-transmitted sea level stations—1983. Ref. HIG-84-2, University of Hawaii, Honolulu, 40 pp.

Okada, M. (1995): Tsunami observation by ocean bottom pressure gauge. In *Tsunami: Progress in Prediction, Disaster Prevention and Warning*, Y. Tsuchuya and N. Shuto, eds., 287–303.

O'Reilly, W.C., R.J. Seymour, R.T. Guza, and D. Castel (1993): Wave monitoring in the Southern California Bight. Waterways, Port, Coastal and Ocean Engineering Proceedings, ASCE, 449–457.

Milburn, H.B., A.I. Nakamura, and F.I. Gonzalez (1996): Real-time tsunami reporting from the deep ocean. Proceedings of the Oceans 96 MTS/IEEE Conference, 23–26 September 1996, Fort Lauderdale, FL, 390–394.

Sensotec, Inc. (1990): Catalog #8000 9/90. Copyright 1988, Sensotec Inc.

Seymour, R.J., D. Castel, D. McGehee, J. Thomas, and W. O’Reilly (1993): New technology in coastal wave monitoring. In *Port, Coastal and Ocean Engineering Proceedings*, ASCE, 105–123.

Titov, V.V., and C.E. Synolakis (1996): Numerical modeling Of 3-D long wave runup using VTCS-3. In *Long Wave Runup Models*, World Scientific Publishing Co. Pte. Ltd., Singapore, 242–248.

Uchike, H., and K. Hosono (1995): Japan tsunami warning system; present status and future plan, In *Tsunami: Progress in Prediction, Disaster Prevention and Warning*, Y. Tsuchuya and N. Shuto, Kluwer Academic Publishers, 305–322.

Wearn, R.B., Jr. (1985a): Year long stability measurements on Paroscientific atmospheric pressure transducers. Tech. Note, Paroscientific, Inc., 6 pp.

Wearn, R.B., Jr. (1985b): 15 July 1985 Technical Update. Well-Test Instruments, Inc., 15 pp.

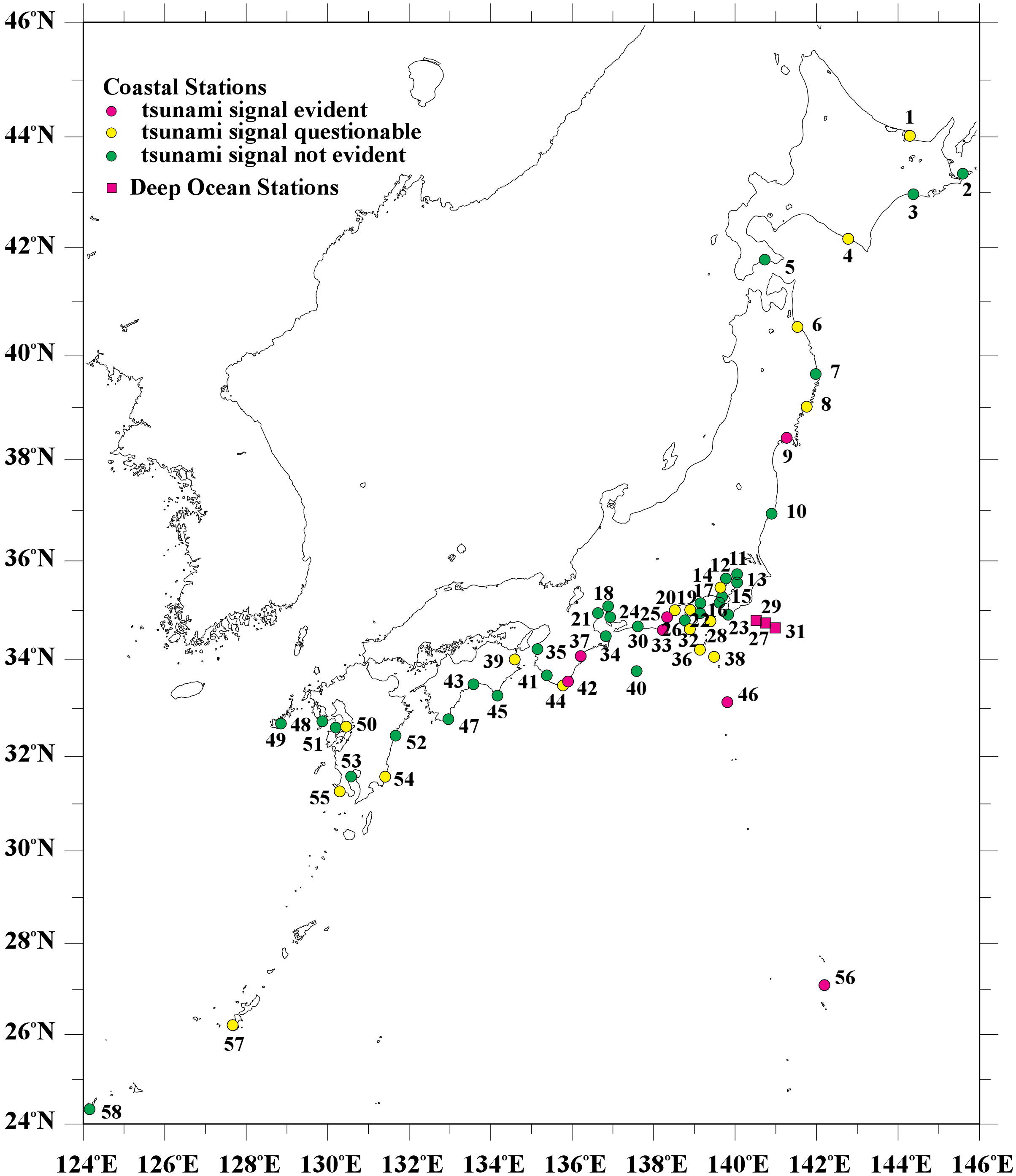
Wearn, R.B., Jr., and N.G. Larson (1980): The Paroscientific pressure transducer, measurement of its sensitivities and drift. APL-UW 8011, 64 pp.

Wearn, R.B., Jr., and N.G. Larson (1982): Measurements of the sensitivities of digiquartz pressure sensors. *Deep-Sea Res., 29*, 111–134.

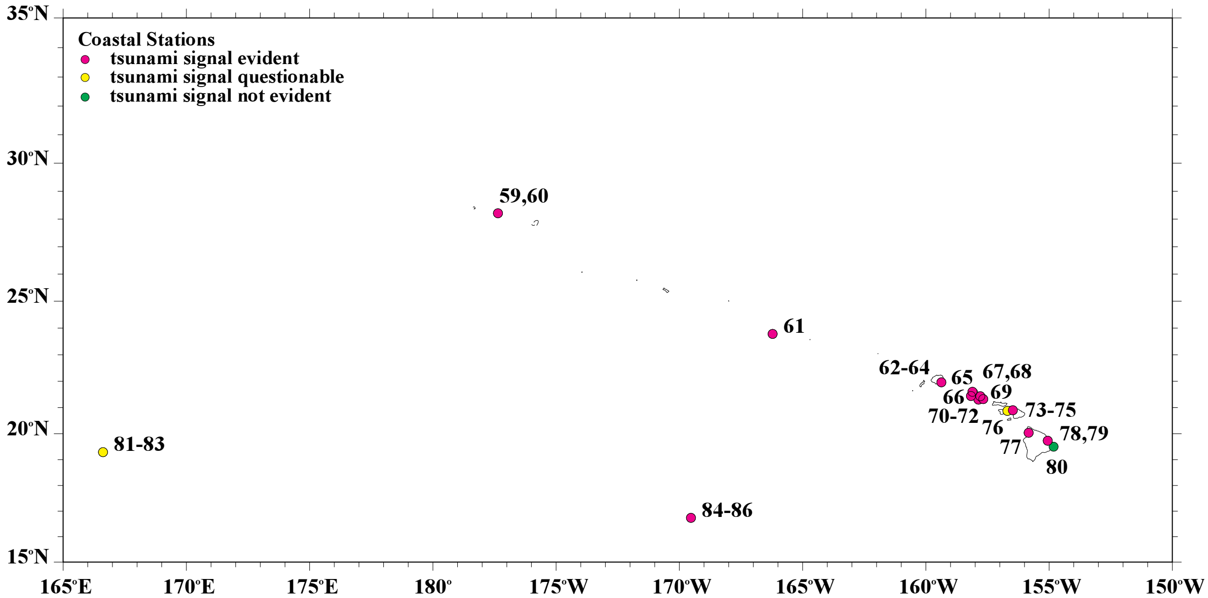
Well-Test Instruments, Inc. (1984): Calibration, test, and characterization of Well-Test Instruments quartz crystal transducers. Document #8062-001, 17 pp.

Wyrtki, K., P. Caldwell, K. Constantine, B. J. Kilonsky, G.T. Mitchum, B. Miyamoto, T. Murphy, and S. Nakahara (1988): The Pacific island sea level network. Univ. of Hawaii, JIMAR 88-0137, 71 pp.

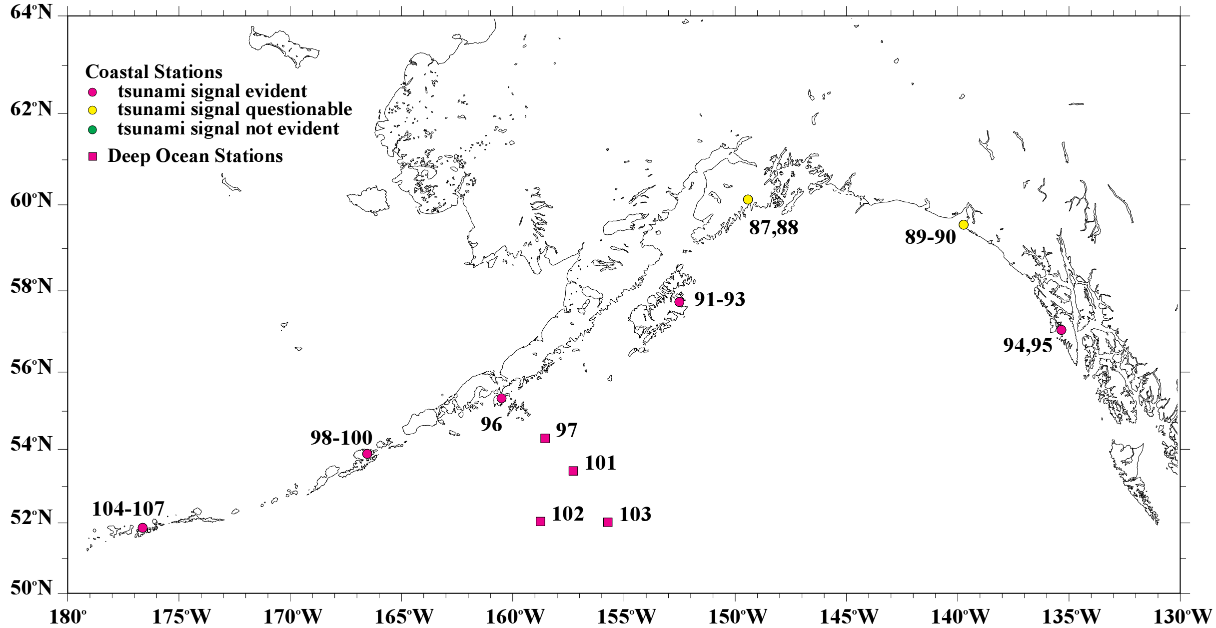
Appendix A
Map of the Japanese region
Click here for plots (see pages 1-20 for plots 1-58)



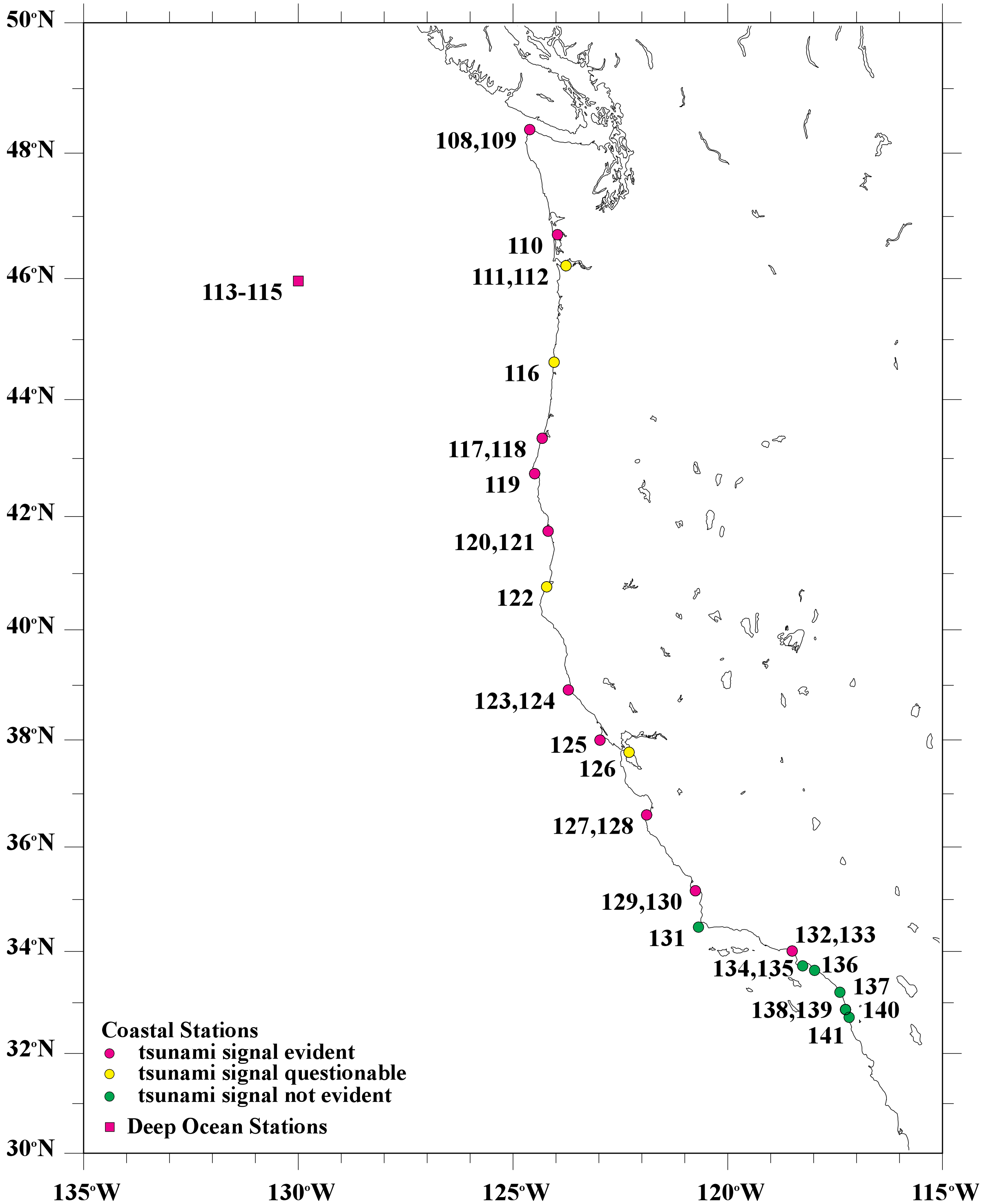
Appendix B
Map of the Hawaiian region
Click here for plots (see pages 20–29 for plots 59–86)



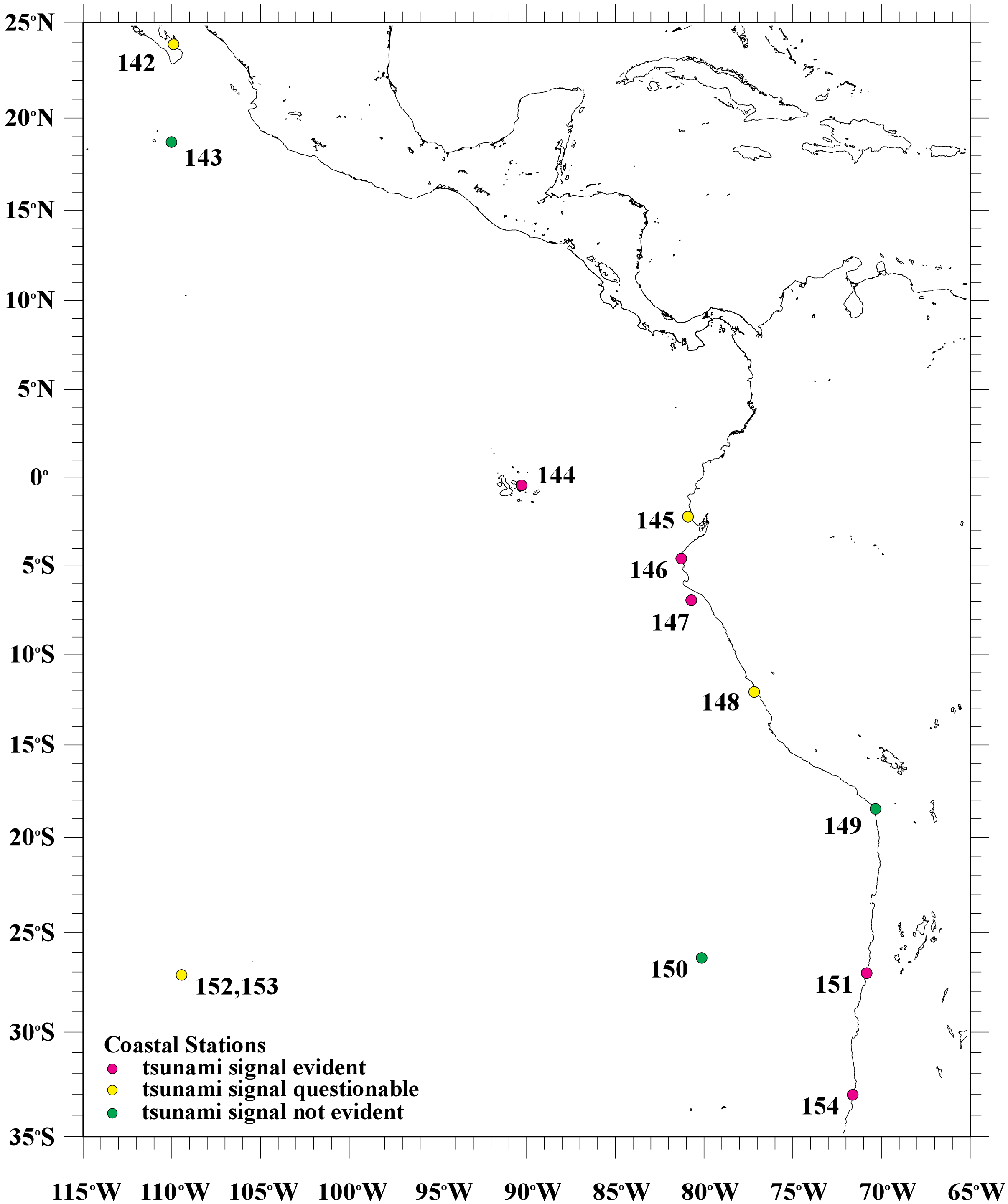
Appendix C
Map of the North Pacific region
Click here for plots (see pages 29-36 for plots 87–107)



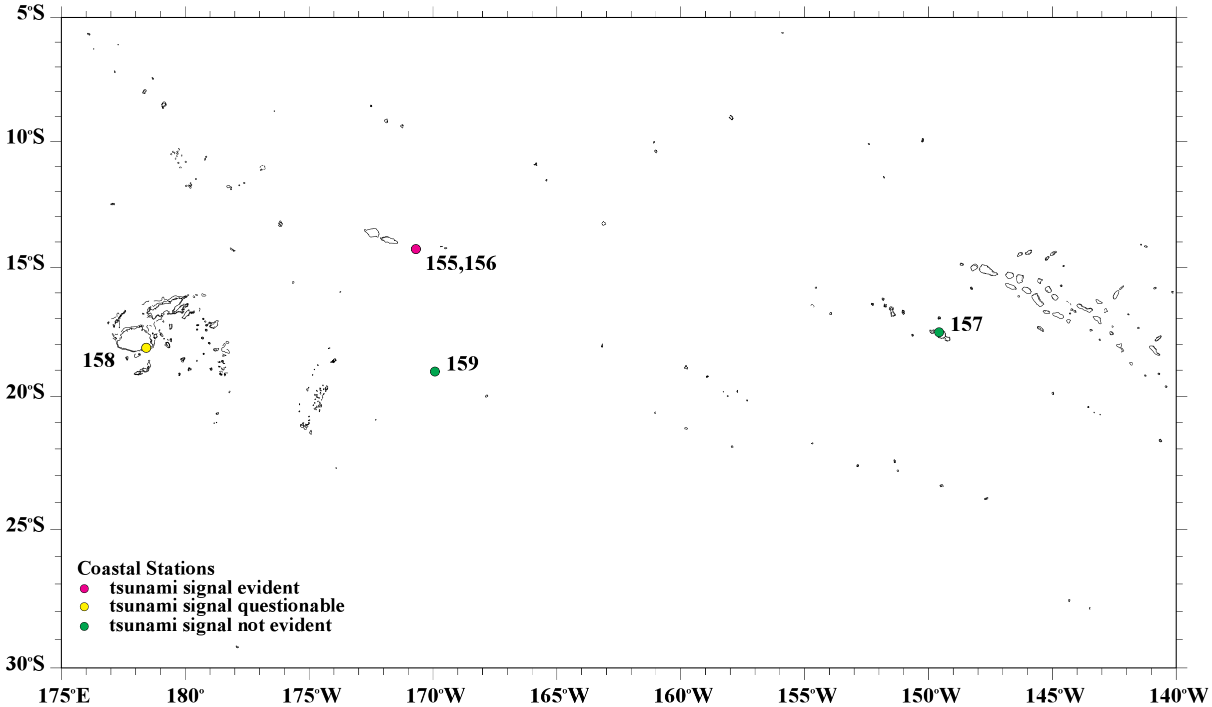
Appendix D
Map of the US West Coast
Click here for plots (see pages 36–47 for plots 108–141)



Appendix E
Map of the South American West Coast
Click here for plots (see pages 48–52 for plots 142–154)



Appendix F
Map of the South Central Pacific region
Click here for plots (see pages 52–53 for plots 155–159)



Appendix G
Map of the Eastern Pacific region
Click here for plots (see pages 54–56 for plots 160–166)