January – March 2011 VOLUME XLIII, NUMBER 1

Intergovernmental Coordination Group for the Pacific Tsunami Warning and Mitigation System

TSUNAMI NEWSLETTER

International Tsunami Information Centre

TABLE OF CONTENTS

Near East Coast of Honshu, Japan, 11 March 2011, UTC 05:46, M_w = 9.0
Great East Japan Earthquake

The 11 March 2011 magnitude 9.0 Great East Japan earthquake, depth 20 km generated a tsunami that was observed all over the Pacific region and caused tremendous devastation locally. Over 19,000 people were killed and missing.

The Japan Meteorological Agency (JMA) earthquake early warning was available starting about 8 seconds after the earthquake, and JMA issued its first national tsunami warning 3 minutes afterward based on a preliminary magnitude 7.9. A "Major Tsunami Warning," the maximum threat level for the region was issued, followed with regular updates. The earthquake faulting, however, ruptured for more than 3 minutes and with later data confirmed that the actual magnitude was 9.0. As observations were received, JMA upgraded and expanded their national warning to the entire country, the first time in its history since its National Tsunami Warning Center (NTWC) began in 1952. Tsunami warnings were in effect 40 hours, and advisories were finally cancelled after 51:12 hours. The highest wave on tide gauges was over 7.3 m, and at least eight coastal gauges ceased operating soon after the 1st wave hit due to sensor malfunction (broken) or communications outages. Runups ranged through 25 m, with maximums of over at 35 m in narrow inlets.

The 11 March 2011 Japan tsunami was the first

...continued p. 4

Tsunami floooding at Rikuzen Takata, Japan, 12 March 2011. Photo courtesy of JMA from the helicopter of Japan Self-Defense Force.

SUMMARY OF EARTHQUAKES
1 JANUARY - 31 MARCH 2011
Reported by: International Tsunami Warning Centres
Compiled by: International Tsunami Information Centre, ITIC

Advisories issued by international tsunami warning centres. The Pacific Tsunami Warning Center (P) issues: Tsunami Information Bulletins (TIB), Fixed and Expanding Regional Warnings (FRW, ERW), and Ocean-wide or Widespread Watch/ Warnings (TWW) for the Pacific; Tsunami Information Bulletins (TIB), Local, Regional, and Ocean-wide Tsunami Watches (LTW, RTW, TW) for the Indian Ocean (IO); Tsunami Information Statements (TIS), Local, Regional, and Ocean-wide Watches (LTW, RTW, TW) for the wider Caribbean (C). The Japan Meteorological Agency (J), issues: Tsunami Advisories (NWPTA) for the Northwestern Pacific; Tsunami Watch Information (TWI) for the Indian Ocean. The West Coast/Alaska Tsunami Warning Center (A) issues: Tsunami Information Statements (TIS), Tsunami Advisories (TA), Tsunami Watch/ Warnings (TWW) for Canada, the US (including Puerto Rico, excluding Hawaii and US-affiliated Pacific Island countries), and the US/British Virgin Islands. Depth (from GCMT solution), epicentre and M_w from the USGS (G), and M_w from PTWC, WC/ATWC, and JMA at action time. Other earthquakes with M_w greater than or equal to 6.5 and a depth no greater than 100 km, as recorded by USGS, have also been included. Wave height and period measurements from sea level gauges (g) reported as amplitude (amp), peak to trough, or greatest value for either flow depth (fd) or runup (r) as indicated.

DATE	TIME (UTC)	LOCATION	EPICENTRE	DEPTH (km)	M_w	PTWC (P), JMA (J) or WC/ATWC (A) ACTION	ACTION TIME (UTC)	TSUNAMI? DAMAGING?	MAXIMUM MEASUREMENT and LOCATION
2-Jan	20:20	Near Coast of Central Chile	38.354° S 73.275° W	20	7.2 (A, P) 7.1 (G)	(P) 01 TIB (A) 01 TIS	20:29 20:30	YES NO	1.5 cm (amp)(g) Talcahuano, Chile
9-Jan	10:04	Vanuatu Islands	19.163° S 168.326° E	12	6.9 (A, P) 6.6 (G)	(P) 01 TIB (A) 01 TIS	10:13 10:14	YES NO	3 cm (amp) (g) Port Vila, Vanuatu
12-Jan	21:32	Bonin Islands, Japan Region	26.98° N 139.87° E	518	6.6 (A, J, P) 6.5 (G)	(P) 01 TIB (J) 01 NWPTA (A) 01 TIS	21:41 21:42 21:44	NO NO	
13-Jan	16:17	Loyalty Islands	20.622° S 168.459° E	13	7.3 (A, P) 7.0 (G)	(P) 01 TIB (A) 01 TIS	16:25 16:27	NO NO	
18-Jan	20:23	Southwestern Pakistan	28.732° N 63.928° E	52	7.4 (P) 7.2 (G)	(P) 01 TIB	20:33	NO NO	
11-Feb	20:05	Near Coast of Central Chile	36.344° S 72.959° W	14	7.0 (A, P) 6.8 (G)	(P) 01 TIB (A) 01 TIS	20:14 20:16	YES NO	17 cm (amp) (g) Talcahuano, Chile
14-Feb	03:40	Off Coast of Central Chile	35.433° S 72.739° W	12	6.6 (A, G, P)	(P) 01 TIB (A) 01 TIS	03:52 03:54	NO NO	
6-Mar	14:33	South Sandwich Island Region	56.387° S 27.019° W	96	6.6 (P) 6.5 (A, G)	(A) 01 TIS (P) 01 TIB	14:45 14:46	NO NO	
7-Mar	00:10	Solomon Islands	10.334° S 160.739° E	34	6.6 (A, G, J, P)	(P) 01 TIB (A) 01 TIS (J) 01 NWPTA	00:21 00:23 00:27	NO NO	
9-Mar	02:45	Off East Coast of Honshu Japan	38.424° N 142.836° E	15	7.3 (J 03 NWPTA) 7.2 (A, G, J, P)	(J) 01 NWPTA (P) 01 TIB (A) 01 TIS (A) 02 TIS (J) 02 NWPTA (P) 02 TIB (J) 03 NWPTA	02:51 02:54 02:55 03:02 03:36 03:57 04:27	YES NO	54 cm (amp) (g) Ofunato, Japan
9-Mar	21:25	New Britain Region P.N.G.	6.022° S 149.659° E	51	6.6 (A, J, P) 6.5 (G)	(P) 01 TIB (A) 01 TIS (J) 01 NWPTA	21:33 21:34 21:45		

Earthquakes, *continued*

DATE	TIME (UTC)	LOCATION	EPICENTRE	DEPTH (km)	M_w	PTWC (P), JMA (J) or WC/ATWC (A) ACTION	ACTION TIME (UTC)	TSUNAMI? DAMAGING?	MAXIMUM MEASUREMENT and LOCATION
10-Mar	17:09	Bali Sea	6.86° S 116.76° E	522	6.5 (A, G, P)	(P) 01 TIB (A) 01 TIS	17:15 17:20	NO NO	
11-Mar	05:46	Near East Coast of Honshu	38.322° N 142.369°E	20	9.0 (G) 8.9 (A 03 TWW, P 04 TWW) 8.8 (J 05 NWPTA, P 02 ERW) 8.4 (J 03 NWPTA) 7.9 (A 01 TIS, P 01 ERW, J 01 NWPTA)	(J) 01 NWPTA (P) 01 ERW (A) 01 TIS (P) 02 ERW (J) 02 NWPTA (J) 03 NWPTA (J) 04 NWPTA (P) 03 TWW (A) 03 TWW (P) 04 TWW (A) 04 TWW (P) 05 TWW (A) 05 TWW (J) 05 NWPTA (P) 06 TWW (A) 06 TWW (J) 06 NWPTA (P) 07 TWW (A) 07 TWW (P) 08 TWW (A) 08 TWW (P) 09 TWW (A) 09 TWW (J) 07 NWPTA (P) 10 TWW (A) 10 TWW (P) 11 TWW (A) 11 TWW (J) 08 NWPTA (P) 12 TWW (A) 12 TWW (P) 13 TWW (A) 13 TWW (P) 14 TWW (A) 14 TWW (P) 15 TWW (P) 16 TWW (A) 15 TWW (P) 17 TWW (A) 16 TWW (P) 18 TWW (J) 09 NWPTA (A) 17 TWW (P) 19 TWW (A) 18 TA (P) 20 TWW (A) 19 TA	05:55 05:55 05:58 06:43 06:44 07:05 07:29 07:30 08:26 08:30 08:51 09:30 09:45 09:51 10:30 10:37 11:13 11:32 11:39 12:30 12:43 13:32 13:46 13:57 14:32 14:47 15:32 15:46 16:07 16:38 16:52 17:32 17:47 18:32 18:46 18:54 19:38 19:45 20:37 20:46 21:38 21:49 21:55 22:39 22:57 23:37 23:57	YES YES	38 m (r) Koborinai fishing port, Miyako City, Japan 7.3 m or more (amp) (g) Soma, Japan. Note: Several gauges damaged and ceased operation.
12-Mar						(P) 21 TWW (A) 20 TA	00:40 00:55		

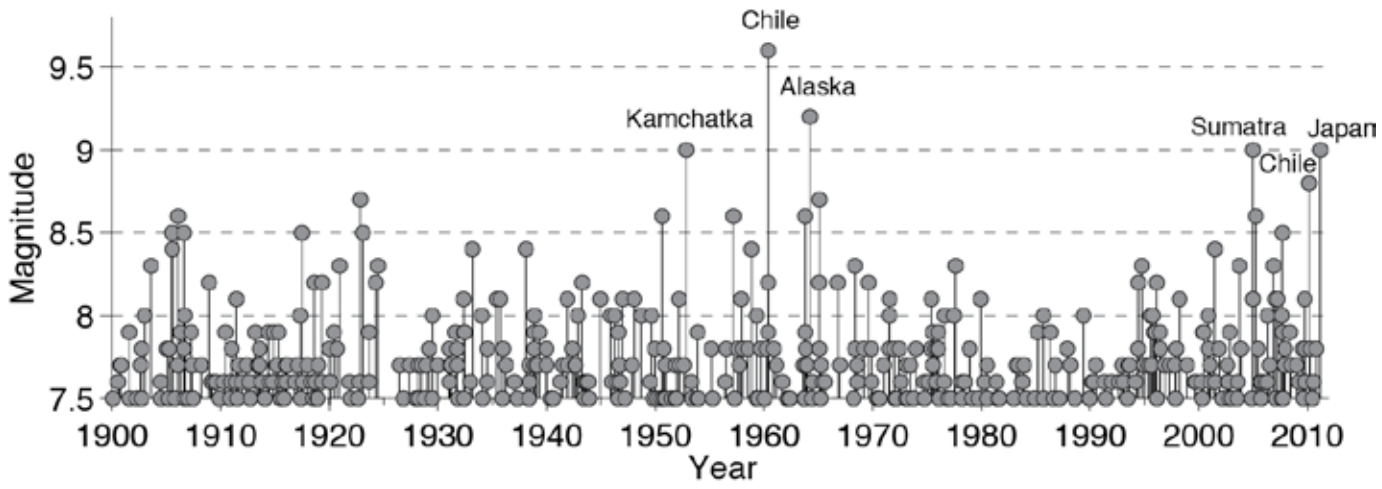
Earthquakes, *continued*

DATE	TIME (UTC)	LOCATION	EPICENTRE	DEPTH (km)	M_w	PTWC (P), JMA (J) or WC/ATWC (A) ACTION	ACTION TIME (UTC)	TSUNAMI? DAMAGING?	MAXIMUM MEASUREMENT and LOCATION
						(P) 22 TWW	01:39		
						(A) 21 TA	02:00		
						(P) 23 TWW	02:39		
						(A) 22 TA	02:49		
						(P) 24 TWW	03:39		
						(A) 23 TA	03:56		
						(P) 25 TWW	04:36		
						(A) 24 TA	04:54		
						(P) 26 TWW	05:40		
						(A) 25 TA	05:52		
						(P) 27 TWW	06:36		
						(A) 26 TA	07:07		
						(A) 27 TA	08:00		
						(A) 28 TA	09:01		
						(A) 29 TA	09:57		
						(A) 30 TA	11:00		
						(A) 31 TA	12:09		
						(A) 32 TA	13:07		
						(A) 33 TA	14:12		
						(A) 34 TA	15:04		
						(A) 35 TWW	16:10		
17-Mar	02:48	Vanuatu Islands	17.339° S 167.743° E	21	6.5 (A, P) 6.3 (G)	(P) 01 TIB (A) 01 TIS	02:56 02:58	NO NO	
22-Mar	07:19	Off East Coast of Honshu Japan	37.249° N 143.956° E	15	6.6 (G, P)	(P) 01 TIB	07:38	NO NO	
24-Mar	13:56	Myanmar	20.705° N 99.949° E	12	6.9 (P) 6.8 (G)	(P) 01 TIB	14:04	NO NO	
27-Mar	22:24	Near East Coast of Honshu Japan	38.40° N 142.10° E	21	6.5 (A, J, P) 6.2 (G)	(P) 01 TIB (A) 01 TIS (J) 01 NWPTA	22:30 22:32 22:35	NO NO	

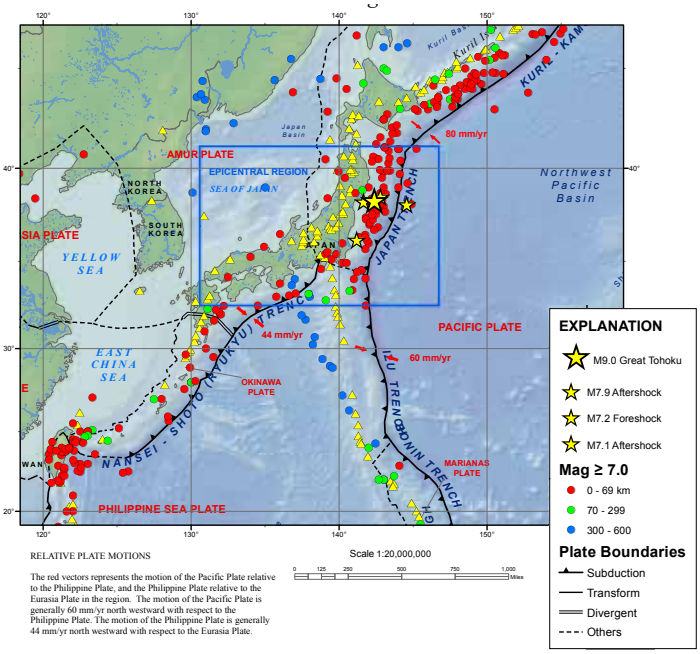
Great East Japan Earthquake, *continued*

A History of Large Earthquakes (1900-2011)

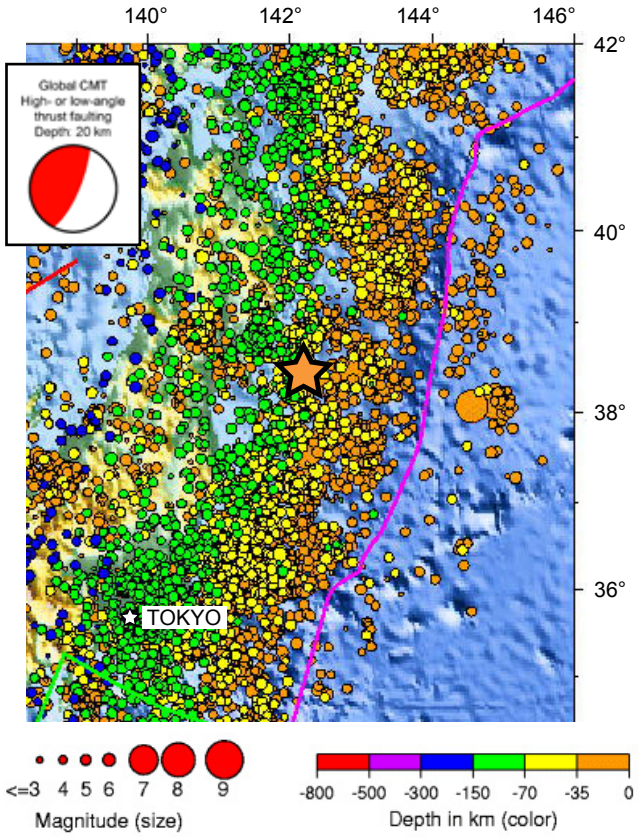
Source/Data courtesy: USGS



Great East Japan Earthquake, *continued*



Relative plate motions and boundaries of the Pacific Plate, Philippines Plate, Eurasia Plate. Map courtesy of USGS.



Historic regional seismicity. 11 March 2011 epicentre location marked by an orange star. Map courtesy of USGS National Earthquake Information Center (NEIC).

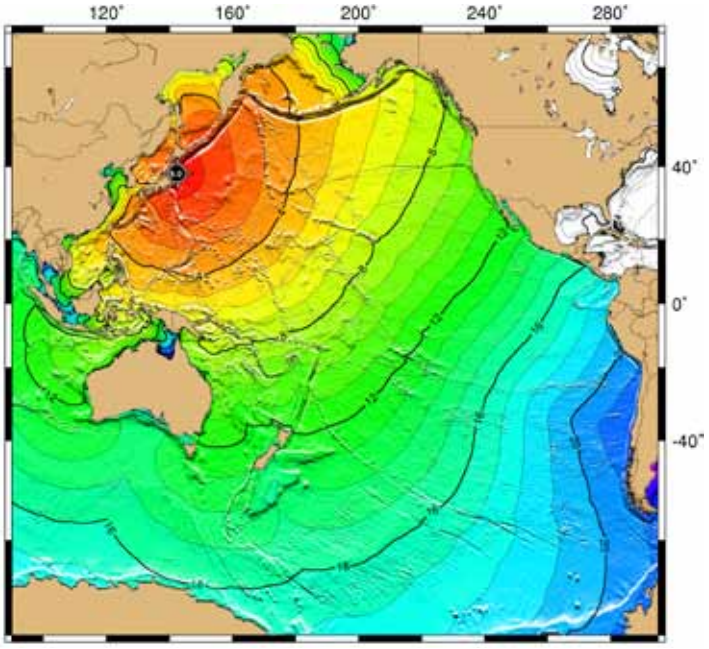
to cause deaths in Japan since the 1993 Sea of Japan magnitude 7.7 earthquake and tsunami caused 231 deaths. According to the NOAA National Geophysics Center / World Data Center for Marine Geology and Geophysics / (http://www.ngdc.noaa.gov/hazard/) Global Historical Event databases, 263 confirmed tsunamis have been generated near Japan since 684 A.D. Of these, 68 (27%) caused deaths. The majority of Japanese tsunamis were generated by earthquakes (94%), with the remainder caused by volcanic eruptions (6%).

The tsunami also propagated across the entire Pacific Ocean. In Hawaii, USA, PTWC issued a Warning at 07:28 UTC, downgraded to an Advisory at 17:31 UTC, and issued final Advisory at 15:39 UTC, 12 March. Waves traveled to Hanalei, Kauai in 7 hours and 8 minutes, with 1.7 m maximum amplitude at Kahului, Maui. The maximum Hawaii runup was up to 5 m, inundation up to 115 m, with over $30 million in damage to harbors in addition to hotels and buildings along the east coast of Hawaii island.

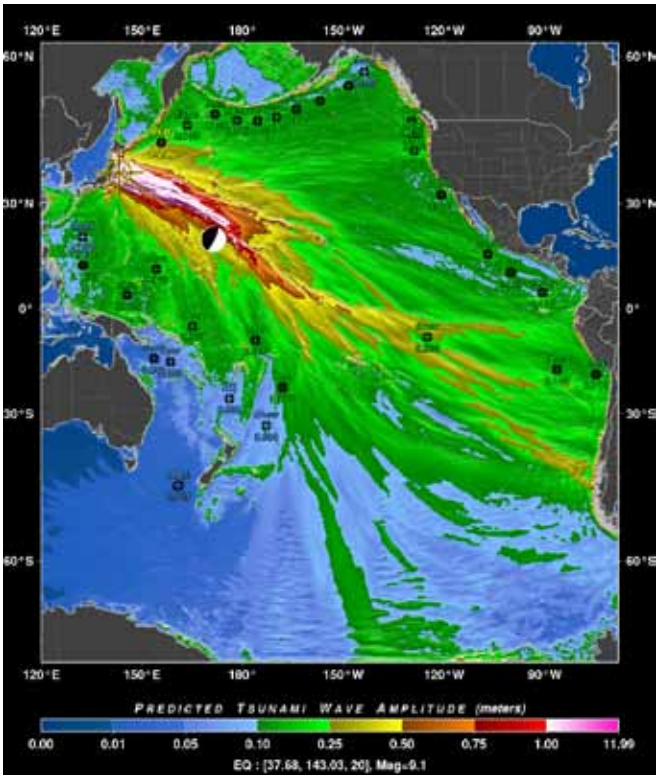
Along western North America, the West Coast/ Alaska Tsunami Warning Center (WC/ATWC) issued a Warning for California and Oregon at 08:51 UTC, downgraded to an Advisory at 22:57 UTC, and then cancelled at 16:10 UTC, 12 March. At Crescent City, California, USA, waves arrived in 9 hours and 48 minutes. The Crescent City sea level gauge measured over 2 m amplitude. Maximum California runup was up to 3 m and over $60 million in damage occurred. In British Columbia, Canada, an Advisory was issued at 08:26 UTC, and then cancelled at 02:49 UTC, 12 March.

Waves arrived at Iquique, Chile in 21 hours and 15 minutes. A national warning by Chile's national tsunami warning centre (SHOA) was maintained after the PTWC widespread warning was cancelled, and government authorities ordered precautionary evacuations of coastal communities that had a high probability of being flooded. Damaging waves over 2 m amplitude were measured in Arica and Constitucion. Runups measured up to 4 m, inundations up to 200 m, and over $6 million in damage occurred. Outside of Japan, 1 person died in Oregon, USA trying to eyewitness the tsunami, and 1 person died in Papua, Indonesia awaiting assistance.

Great East Japan Earthquake, *continued*

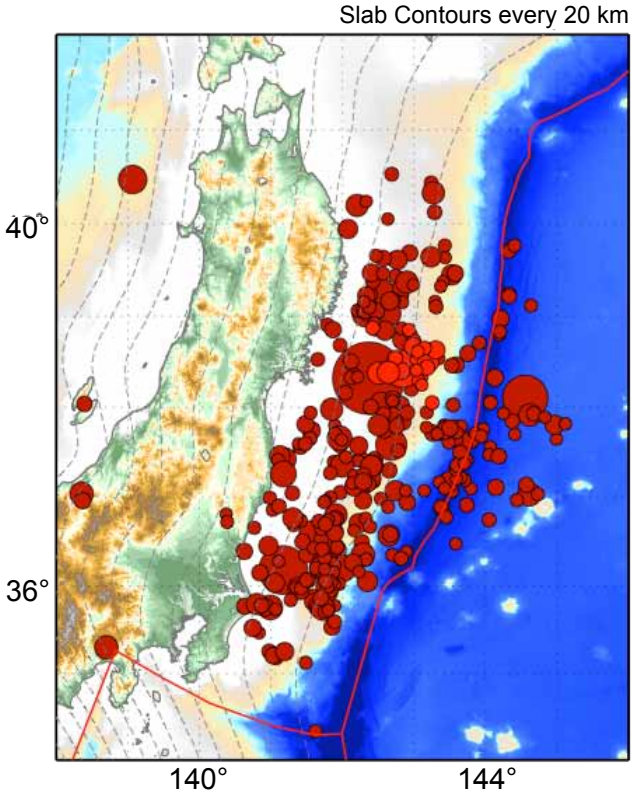


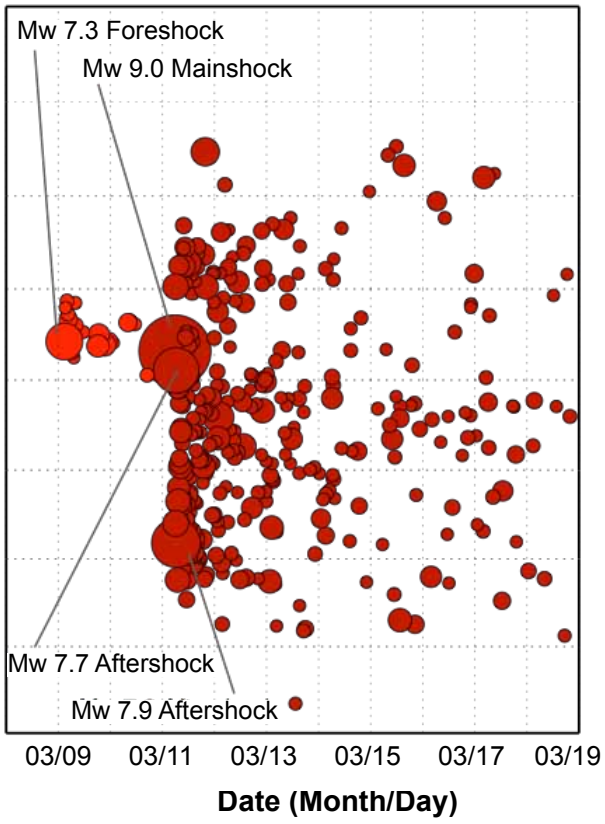
Above: Tsunami travel map using M9.0 Great East Japan Earthquake as the tsunami source. Contour lines and color bands in 1-hour intervals. Map courtesy of ITIC.



Above: PTWC Real-Time International Forecasting Tsunami (RIFT) model forecast showing tsunami energy distribution and predicted tsunami wave amplitude as computed during the event using a M9.1 near vertical/ shallow-dipping fault source. Map courtesy of PTWC.

Below Left & Right: 11 March 2011 Great East Japan earthquake and aftershocks. Maps courtesy of USGS.





Great East Japan Earthquake - Tsunami Event Timeline: PTWC, JMA (national), JMA NWPTAC (international), WC/ATWC

Source/Data courtesy: IOC

Type of Tsunami Bulletin		Estimated Tsunami Height
Tsunami Warning	Major Tsunami	"3m", "4m", "6m", "8m", "over 10m"
	Tsunami	"1m", "2m"
Tsunami Advisory		"0.5m"

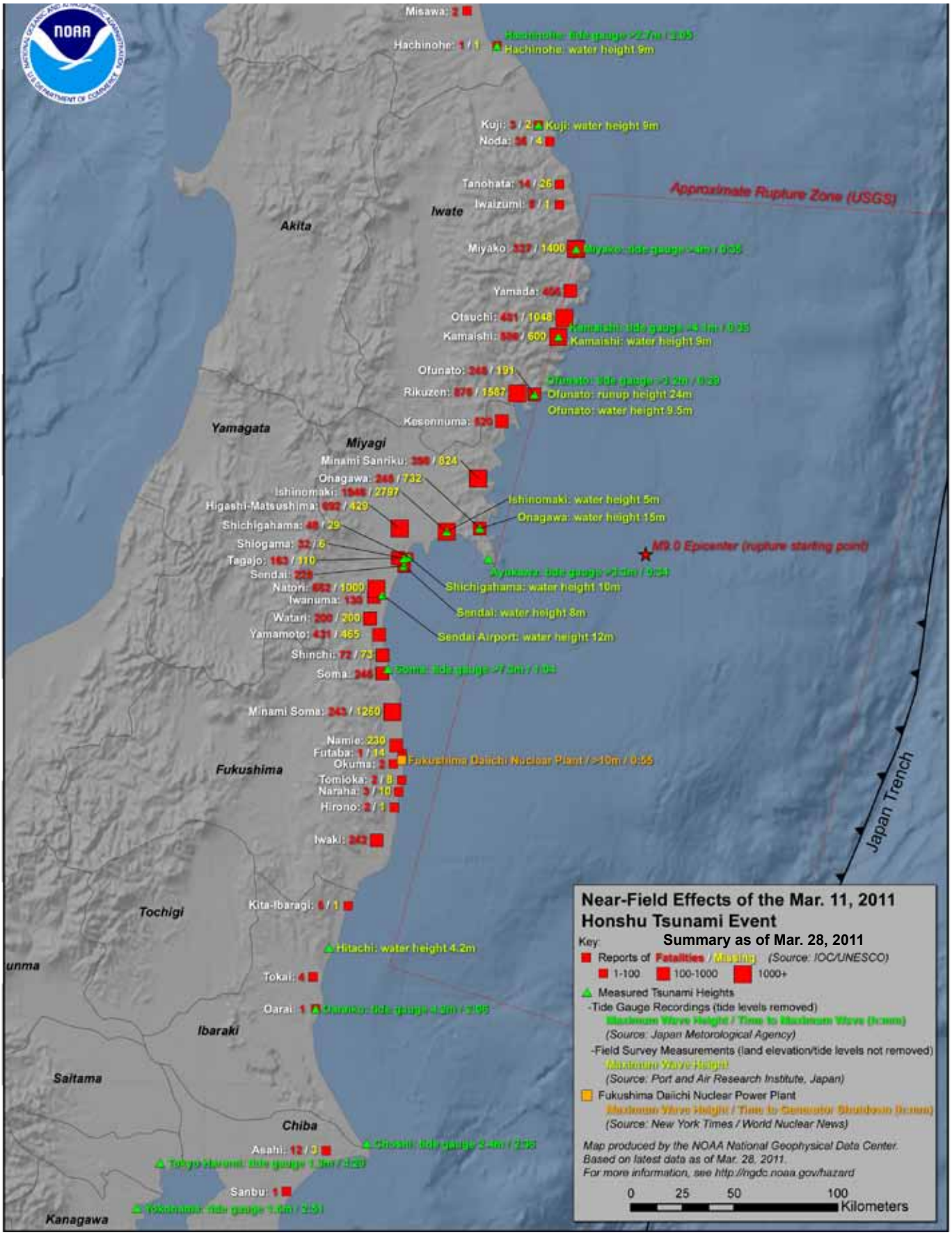
Time (UTC)	Elapsed Time since Earthquake (hr)	Source	Action
11 Mar 2011 05:46		NEIC	OT: 05:46:23 UTC M_w: 9.0 (Local time: 14:46) 38.322°N, 142.369°E, dep: 32 km 129km E of Sendai, Japan
05:49	00:03	JMA	**Major Tsunami Warning:** 3 Prefectures (Iwate, Miyagi, Fukushima) **Tsunami warning:** 5 zones Advisory: 15 zones
05:50	00:04	JMA	Tsunami Information on Expected tsunami arrival time and height
05:50	00:04	JMA	Tsunami Information on Time of high tide
05:55	00:09	NWPTAC (JMA)	38.0N, 142.9E, M: 7.9, Expected Tsunami height; Marshall Is.: 1 meter, Micronesia: 1 meter, Jayapula, Indonesia: 0.5 meter, Papua New Guines: 0.5 meter Mariana Is: 0.5 meter
05:55	00:09	PTWC	**Warning** for Japan, Russia, Marcus Is., N. Marianas, Guam, Wake Is., Taiwan **Watch** for Yap, Philippines, Marshall Is., Belau, Midway Is., Pohnpei, Chuuk, Kosrae, Indonesia, Papua New Guinea, Nauru, Johnston Is., Solomon Is., Kiribati, Hawaii 36.0N 142.9E,10Km M:7.9
05:59	00:13	JMA	Tsunami Information on Observed tsunami height
06:01	00:15	JMA	Tsunami Information on Observed tsunami height
06:10	00:24	JMA	Tsunami Information on Observed tsunami height
06:14	00:28	JMA	**Tsunami Warning is extended** **Major Tsunami Warning:** 6 Prefectures (Iwate, Miyagi, Fukushima, Aomori, Ibaragi, Chiba) **Tsunami warning:** 7 zones Advisory: 23 zones
06:43	00:57	PTWC	Warning for Japan, Russia, Marcus Is., N. Marianas Watch for Guam, Wake Is., Taiwan, Yap, Philippines, Marshall Is., Belau, Midway Is., Pohnpei, Chuuk, Kosrae, Indonesia, Papua New Guinea, Nauru, Hawaii 38.2N, 142.5E, 10km, M:8.8
07:05	01:19	NWPTAC (JMA)	38.1N 142.9E M: 8.4 Expected Tsunami height; Marshall Is.: 2 meter, Micronesia: 2 meter, Jayapula, Indonesia: 1 meter, Papua New Guines: 1 meter, Mariana Is: 1 meter etc
07:08	01:22	JMA	38.1N, 142.9E h: 20km **M: 8.4** **Tsunami Warning is extended** **Major Tsunami Warning: 17 zones** **Tsunami warning:** 19 zones Advisory: 17 zones
07:20	01:34	JMA	**JMA named as " The 2011 Tohoku Earthquake off the Pacific coast"**
07:30	01:44	PTWC	38.2N, 142.5E, 10km, M:8.8 WARNING for Japan, Russia, Marcus Is., N. Marianas Guam, Wake Is., Taiwan, Yap, Philippines, Marshall Is., Belau, Midway Is., Pohnpei, Chuuk, Kosrae, Indonesia, Papua New Guinea, Nauru, Johnston Is., Solomon Is., Kiribati, Howland-Baker,Hawaii, Tuvalu, Cook Is., Niue, Australia, Fiji, New Caledonia, Tonga, Mexico, Kermadec Is., FR. Polynesia, New Zealand, Pitcairn, Guatemala, El Salvador, Costa Rica, Nicaragua, Antarctica, Panama, Honduras, Chile, Ecuador, Colombia, Peru
08:30	02:44	PTWC	38.3N, 142.4E, 24km, M:8.9 (Note: updated) WARNING for Japan, Russia, Marcus Is., N. Marianas Guam, Wake Is., Taiwan, Yap, Philippines, Marshall Is., Belau, Midway Is., Pohnpei, Chuuk, Kosrae, Indonesia, Papua New Guinea, Nauru, Johnston Is., Solomon Is., Kiribati, Howland-Baker,Hawaii, Tuvalu, Cook Is., Niue, Australia, Fiji, New Caledonia, Tonga, Mexico, Kermadec Is., FR. Polynesia, New Zealand, Pitcairn, Guatemala, El Salvador, Costa Rica, Nicaragua, Antarctica, Panama, Honduras, Chile, Ecuador, Colombia, Peru
08:48	03:02	JMA	38.1N, 142.9E h: 20km **M: 8.8**

Event Timeline, *continued*

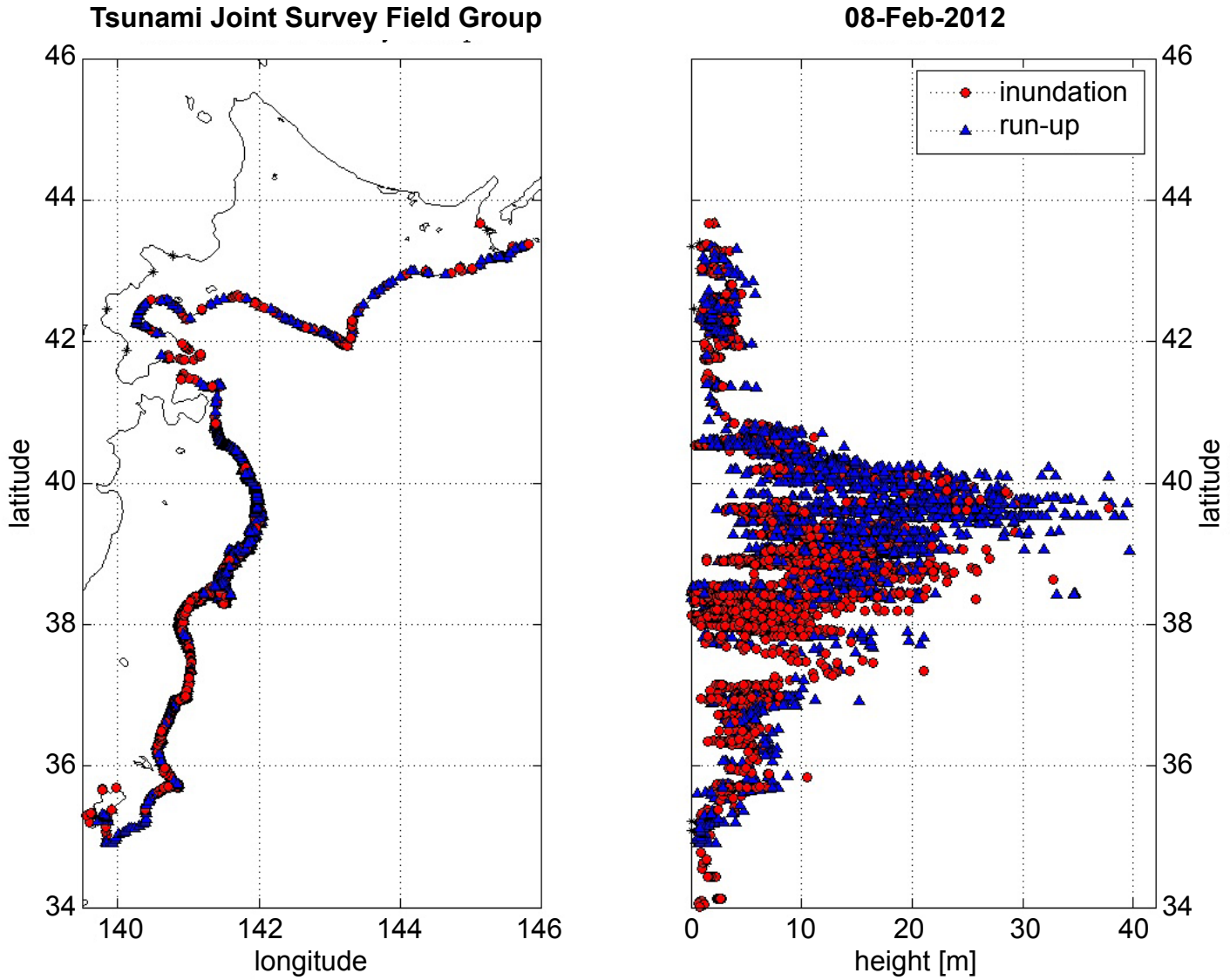
Time (UTC)	Elapsed Time since Earthquake (hr)	Source	Action
09:30	03:44	PTWC No. 5	Warning area is reduced; Australia and New Zealand are deleted from warning area. WARNING for Japan, Russia, Marcus Is., N. Marianas Guam, Wake Is., Taiwan, Yap, Philippines, Marshall Is., Belau, Midway Is., Pohnpei, Chuuk, Kosrae, Indonesia, Papua New Guinea, Nauru, Johnston Is., Solomon Is., Kiribati, Howland-Baker, Hawaii, Tuvalu, Cook Is., Niue, Fiji, New Caledonia, Tonga, Mexico, Kermadec Is., FR. Polynesia, Pitcairn, Guatemala, El Salvador, Costa Rica, Nicaragua, Antarctica, Panama, Honduras, Chile, Ecuador, Colombia, Peru
09:51	04:05	NWPTAC (JMA) No. 5	Expected tsunami height Kamchatsk: 3 m, Urup, Kuril: 3 m, Papua New Guinea: 1 – 4 m, Solomon: 2 – 3 m etc
10:05	04:19	WCATWC	Warning: California and Oregon Warning: Alaska (Amchitka to Attu) Advisory:
12:35	06:49	JMA	**Tsunami Warning is extended** **Major Tsunami Warning:** 17 zones (Iwate, Miyagi, Fukushima, Aomori, Ibaragi, Chiba etc) **Tsunami warning:** 22 zones Advisory: 19 zones
13:53	08:07	JMA	**Tsunami Warning is extended** **Major Tsunami Warning:** 18 zones **Tsunami warning:** 21 zones Advisory: 19 zones
16:52	11:06	WCATWC	Tsunami Warning in the Western Aleutians has been downgraded to an Advisory. Warning continues in effect for the coastal areas of California and Oregon from point conception California to the Oregon-Washington border.
18:20	12:34	JMA	**Tsunami Warning is extended** **Major Tsunami Warning:** 18 zones **Tsunami warning:** 21 zones Advisory: 27 zones (Total: all coastal zones)
12 Mar 2012 03:39	21:53	PTWC	Warning area is reduced; Australia and New Zealand are deleted from warning area. WARNING for Japan, Mexico, Antarctica, Chile, Ecuador, Colombia, Peru
04:50	23:04	JMA	Warning area is reduced **Major Tsunami Warning:** 4 zones (Iwate, Miyagi, Fukushima, Aomori) **Tsunami warning:** 11 zones Advisory: 26 zones
04:54	23:08	WCATWC No.24	Advisory continues for California and Oregon, and Alaska (Chignik to Attu) Advisory cancelled from Cascade head Oregon to Douglas lane county line Oregon.
06:36	24:50	PTWC No. 27	Tsunami warning and/or Watch issued by PTWC is now cancelled.
11:00	29:14	WCATWC No.30	Advisory continues for California and Oregon Cancelled Alaska Advisory Status
11:20	29:34	JMA	Warning area is reduced **Tsunami Warning:** 4 zones Advisory: 21 zones
12:09	30:23	WCATWC No.31	Advisory continues for California Cancelled Oregon Advisory Status
16:10	34:24	WCATWC No.35	Cancelled California Advisory Status *(Note: no more Advisory exist)*
22:30	40:44	JMA	No Warning; only Advisory Advisory: 15 zones
13 Mar 2012 08:58	51:12	JMA	All Advisories are cancelled 38.1N, 142.9E h: 20km **M: 9.0**
16 Mar 2012 03:00		JMA	1. Probability of a earthquake (expected seismic intensity is more than 5-upper JMA scale; correspond 8 – 9 of MMI scale) within 3 days from 03Z, 16 Mar. is 40 % 2. Probability of a earthquake (expected seismic intensity is more than 5-upper JMA scale) within 3 days from 03Z, 19 Mar. is 20 %

** Major Tsunami Warning: Tsunami height is estimated to be 3 m or more*
*** Tsunami Warning: Tsunami height is estimated to be up to 2 m*

Great East Japan Earthquake, *continued*



Great East Japan Earthquake, *continued*

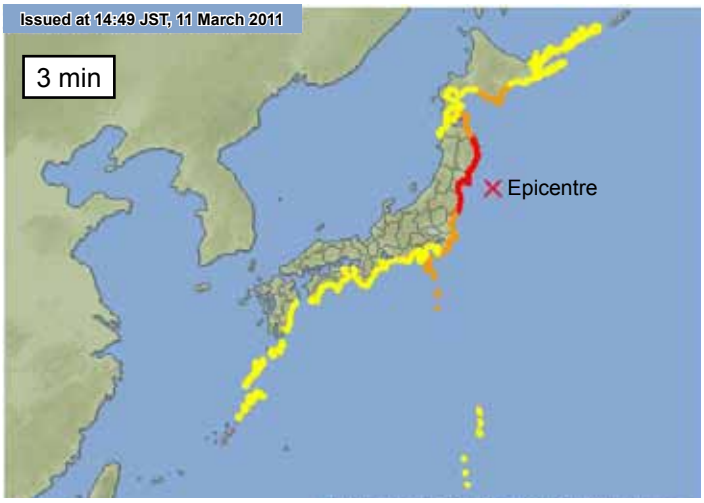


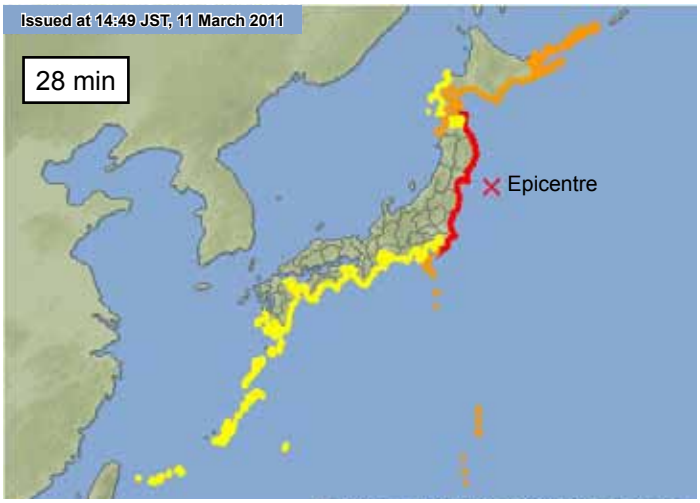
Distribution of Measured Tsunami Heights of the 2011 Great East Japan Tsunami. Red circles and blue triangles indicate coastal inundation heights and run up heights, respectively, in meters. Courtesy of the Tsunami Joint Survey Field Group.

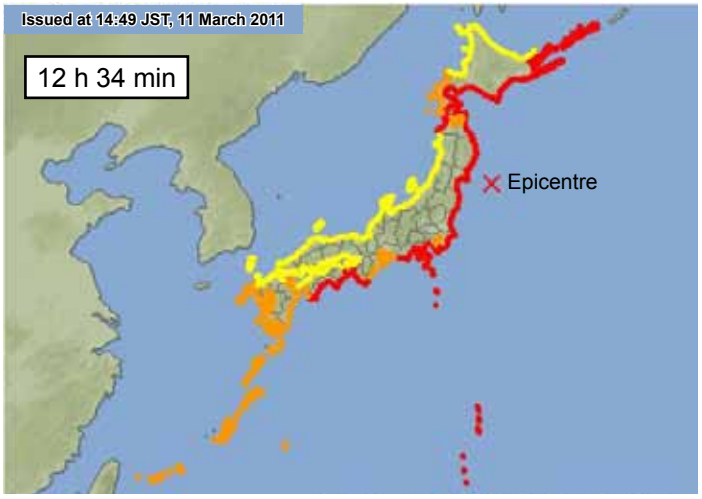
Panorama view of destruction in Ofunato, Japan from the Tohoku tsunami. Photo courtesy of L. Kong.

Great East Japan Earthquake, *continued*

National Tsunami Warnings issued for Japan
Source/Data courtesy: JMA



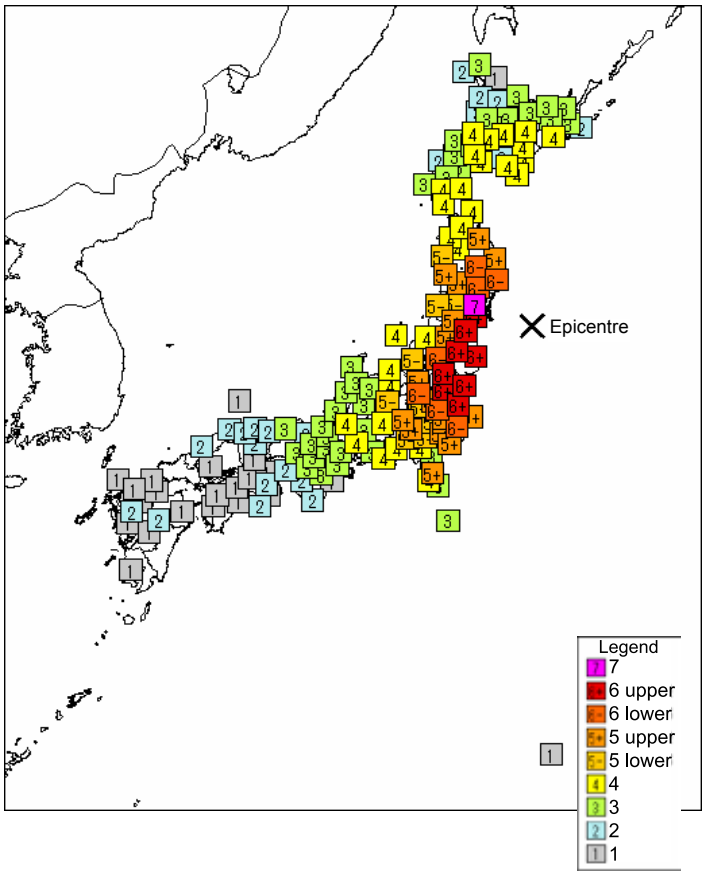




Type of Tsunami Bulletin		Estimated Tsunami Height
Tsunami Warning	Major Tsunami	"3m", "4m", "6m", "8m", "over 10m"
	Tsunami	"1m", "2m"
Tsunami Advisory		"0.5m"

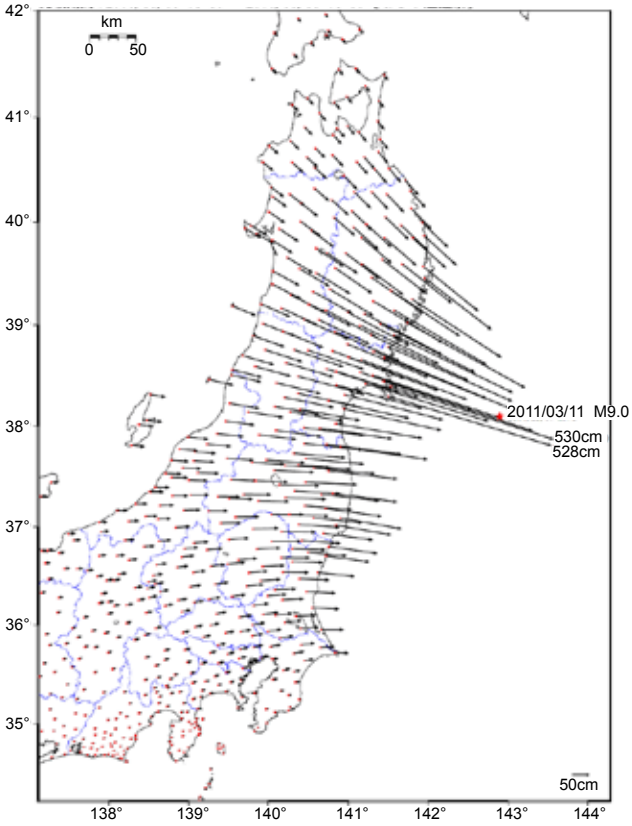
Legend above is for the 3 images on left, National Tsunami Warnings issued for Japan 3 min, 28 min and 12h 34 min after the earthquake. Courtesy of Japan Meteorological Agency (JMA).

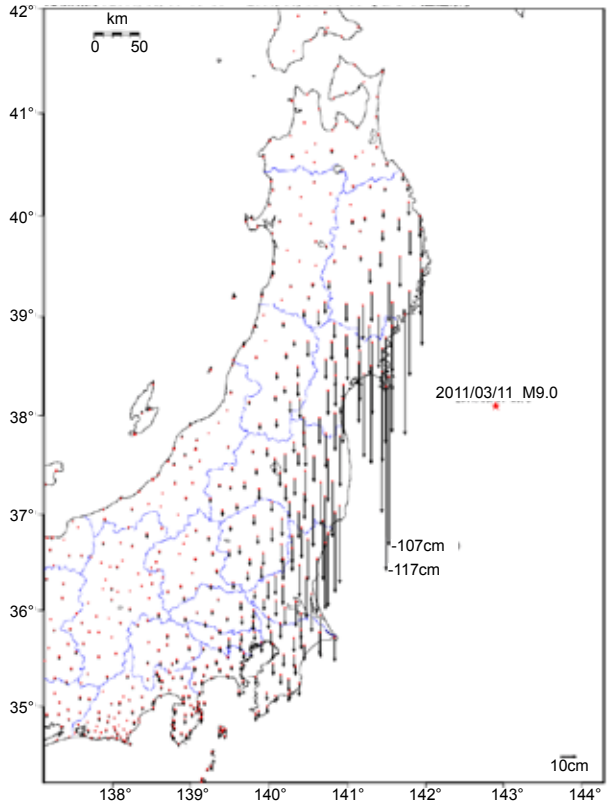
Distribution of JMA Seismic Intensity
Source/Data courtesy: JMA



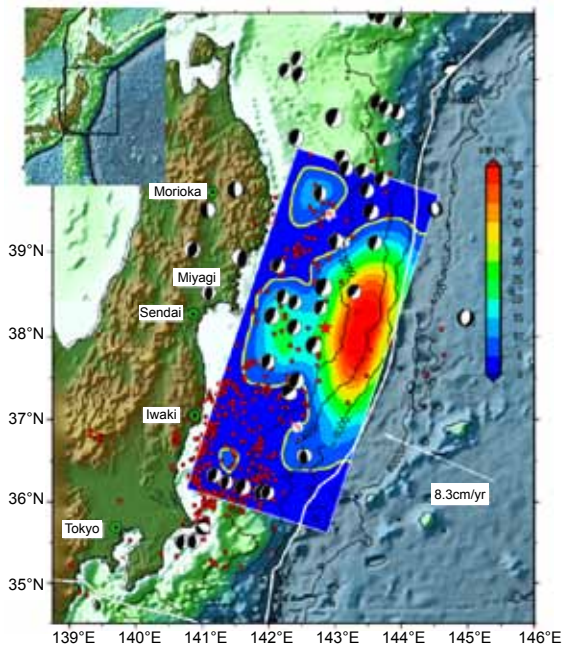
Japan seismic ground shaking intensity map measured by seismic intensity meters. People feel a mild shake at scale 1. Buildings are damaged in 5 upper and above range.. Courtesy of Japan Meteorological Agency (JMA).

Great East Japan Earthquake, *continued*

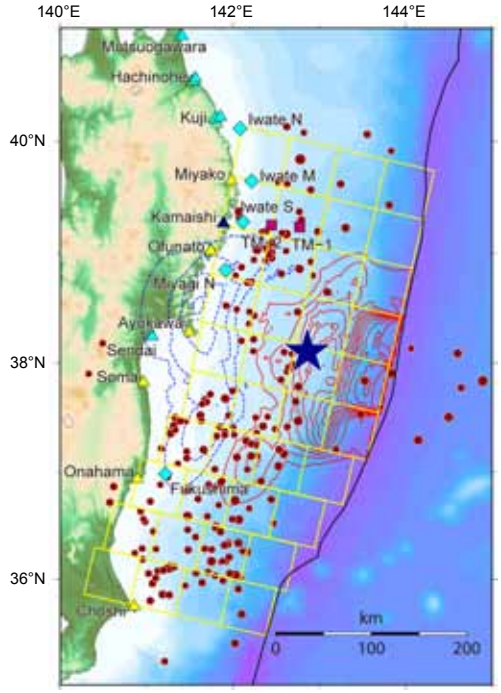




Left & Right: GPS horizontal and vertical vector ground displacement measurements. Courtesy of Geospatial Information Authority of Japan and USGS.



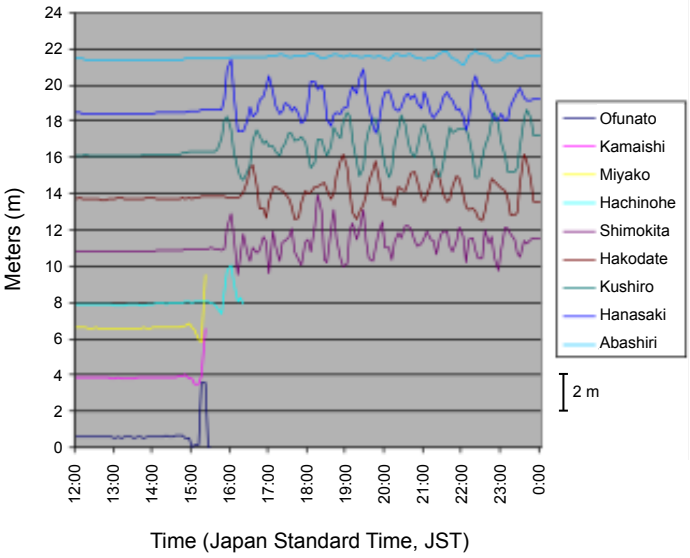
Earthquake finite fault model showing slip distribution as determined by the joint inversion of seismic body & surface waves. Slip in excess of 55 m was estimated. Centroid moment tensor solutions of aftershocks are also shown. The Pacific Plate is subducting at a rate of 8.3 cm/yr at the Japan Trench. Figure courtesy of G. Shao, U. California, Santa Barbara.



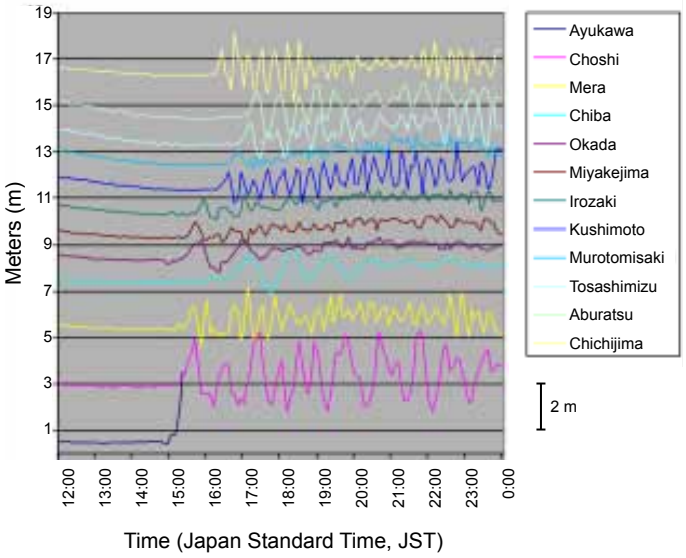
Slip distribution estimated from the inversion of tsunami waveforms as measured on the 2 offshore bottom-pressure gauges (square), 5 GPS surface gauges (diamond), and 33 coastal tide gauges (triangles). Star shows main earthquake and circles aftershocks within 1 day. Slip up to 40 m along the trench axis was calculated. Figure courtesy of Y. Fujii, IISEE.

Great East Japan Earthquake, *continued*

Tsunami Marigrams at Japan Stations (Japan Standard Time)
Sample Interval 5 Minutes
Source/Data courtesy: JMA

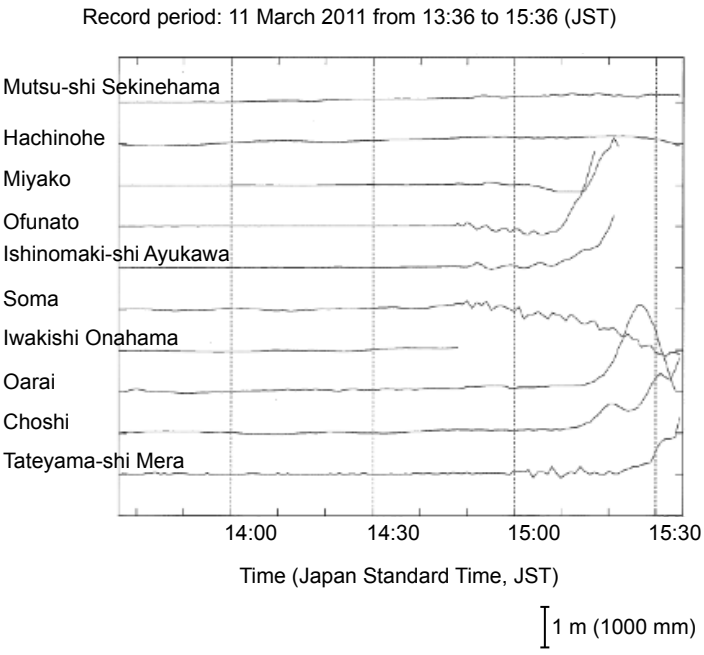


Eastern stations from Ofunato, Iwate Prefecture.



Western stations from Ayukawa, Miyagi Prefecture.

Tsunami Marigrams at Japan Stations
Source/Data courtesy: JMA



Scale: Bar length bottom right is 1 m, but 4 m for Miyako, Ofunato and Ishinomaki-shi Ayukawa.

Damage to Minami Sanriku Disaster Management Office from the Tohoku tsunami. Photo ourtesy of L. Kong.

Great East Japan Earthquake, *continued*

Tsunami Wave Heights along Japan Coast
(Coastal Sea Level Stations with max amplitude > 1 m)
Source: JMA

Coastal Sea Level Station	Initial Tsunami arrival time (UTC) 11 Mar 2011	Amplitude of initial motion (m)	Direction of the first motion (+ = up, i = down)	Maximum Arrival Time (UTC), 11 March 2011	Max amplitude (zero to peak, m)	Elapsed time to Max Wave (hr)
Kamaishi * *	5:45	0.1	(-)	6:21	> 4.1	0:35
Ofunato * *	5:46	0.2	(-)	6:15	> 3.2	0:29
Ishinomaki-shi Ayukawa * *	5:46	0.1	(+)	6:20	> 3.3	0:34
Miyako * *	5:48	0.2	(+)	6:21	> 4.0	0:35
Soma * *	5:55	0.3	(+)	6:50	> 7.3	1:04
Choshi *	6:13	0.5	(+)	8:22	2.4	2:36
Oarai *	6:15	1.8	(+)	7:52	4.2	2:06
Erimo-cho Shoya	6:18	0.1	(-)	6:44	3.5	0:58
Urakawa	6:19	0.2	(-)	7:42	2.7	1:56
Mutsu-shi Sekinehama *	6:20	0.1	(-)	9:16	2.9	3:30
Hachinohe * *	6:22	0.8	(-)	7:51	> 2.7	2:05
Tokachi-ko *	6:26	0.2	(-)	6:57	> 2.8	1:11
Hamanaka-cho Kiritappu-ko	6:27	Slight	(-)	13:19	2.6	7:33
Tateyama-shi Mera *	6:29	1.3	(+)	8:05	1.6	2:19
Kushiro *	6:34	2	(+)	14:39	2.1	8:53
Nemuro-shi Hanasaki *	6:34	Slight	(-)	6:57	2.8	1:11
Hachijojima Kaminato	6:35	1.2	(+)	6:45	1.2	0:59
Tomakomai-nishiko	6:37	0.2	(-)	8:30	2.1	2:44
Tomakomai-higashiko *	6:40	0.2	(-)	7:17	> 2.5	1:31
Shiraoi-ko	6:40	0.1	(-)	7:01	1.8	1:15
Hachijojima Yaene	6:40	1.4	(+)	6:48	1.4	1:02
Yokosuka	6:52	0.9	(+)	8:16	1.6	2:30
Oshima Mori-ko	6:56	Slight	(-)	10:37	1.8	4:51
Muroran-ko	6:56	Slight	(-)	11:06	1	5:20
Numazu-shi Uchiura	7:01	1.4	(+)	7:16	1.4	1:30
Omaezaki	7:03	1	(+)	8:18	1.4	2:32
Yokohama	7:09	0.8	(+)	8:37	1.6	2:51
Hakodate *	7:11	1.9	(+)	14:35	2.4	8:49
Kumano-shi Yuki	7:12	0.7	(+)	7:28	0.7	1:42
Chichijima Futami	7:14	1	(+)	7:46	1.8	2:00
Nachi-katsuura-cho Uragami	7:14	0.9	(+)	9:06	1.3	3:20
Kushimoto-cho Fukuro-ko	7:16	0.7	(+)	16:32	1.4	10:46

Great East Japan Earthquake, *continued*

Coastal Sea Level Station	Initial Tsunami arrival time (UTC) 11 Mar 2011	Amplitude of initial motion (m)	Direction of the first motion (+ = up, i = down)	Maximum Arrival Time (UTC), 11 March 2011	Max amplitude (zero to peak, m)	Elapsed time to Max Wave (hr)
Owase	7:17	1	(+)	8:12	1.7	2:26
Tahara-shi Akabane	7:21	1.1	(+)	8:32	1.6	2:46
Toba	7:34	0.5	(+)	10:13	1.8	4:27
Shirahama-cho Katata	7:34	0.9	(+)	15:35	1	9:49
Gobo-shi Haraido	7:35	0.7	(+)	8:57	1.1	3:11
Tokyo Harumi	7:37	0.8	(+)	10:15	1.3	4:29
Tokushima Yuki	7:37	1	(+)	11:27	1.1	5:41
Tanegashima Kumano	7:52	0.8	(+)	18:23	1.5	12:37
Tosa-shimizu	7:56	0.9	(+)	16:58	1.3	11:12
Susaki-ko	8:00	1.4	(+)	11:59	2.6	6:13
Amami-shi Kominato	8:01	0.1	(-)	16:48	1.2	11:02
Nichinan-shi Aburatsu *	8:05	1	(+)	15:12	1.1	9:26
Miyazaki-ko	8:06	1.4	(+)	18:33	1.6	12:47
Shibushi-ko	8:12	1.1	(+)	8:39	1.1	2:53
Nagoya	8:43	0.7	(+)	10:36	1	4:50

* *Stations ceased operation*
* *Marigram sea level record shown on page 13*

The Pacific Tsunami Warning Center's Response to the Great East Japan Earthquake and Tsunami

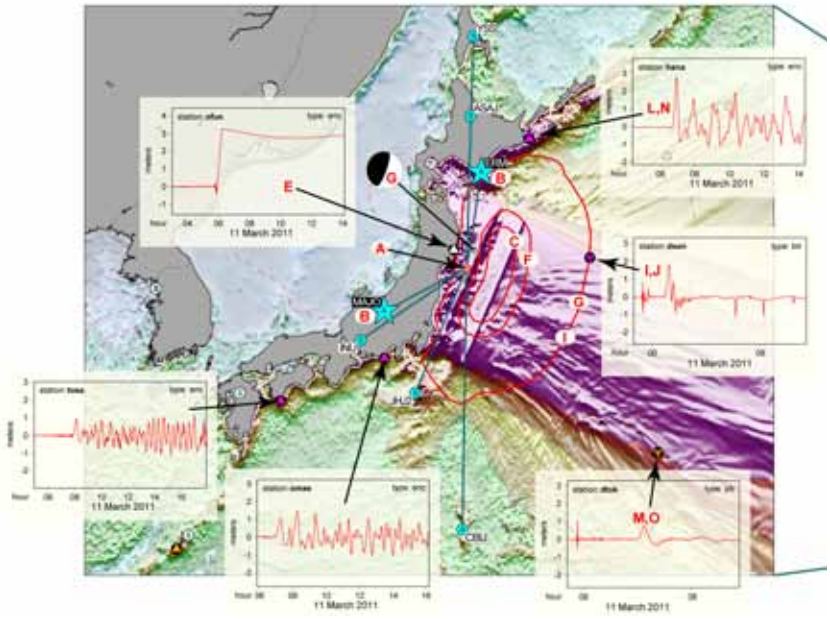
Excerpt from: S.A. Weinstein, N.C. Becker, B. Shiro, K.K. Koyanagi, V. Sardina, D. Walsh, D. Wang, C.S. McCreery, G.J. Fryer, R.K. Cessaro, B.F. Hirshorn, and V. Hsu, Poster 53D-0075, presented at 2011 Fall American Geophysical Union (AGU) Meeting.

The largest Pacific basin earthquake in 47 years, and also the largest magnitude earthquake since the Sumatra 2004 earthquake, struck off of the east coast of the Tohoku region of Honshu, Japan at 5:46 UTC on 11 March 2011. The Tohoku earthquake (M_w 9.0) generated a massive tsunami with runups of up to 40m along the Tohoku coast. The tsunami waves crossed the Pacific Ocean causing significant damage as far away as Hawaii, California, and Chile, thereby becoming the largest, most destructive tsunami in the Pacific Basin since 1960.

Coastal sea walls and harbor break sea walls in Taro, Japan were overtopped and portions destroyed with waves flooding to the 3rd story of this hotel. While Taro, Japan was well prepared, the tsunami that hit was much bigger than expected. Photo courtesy of L. Kong.

PTWC Response, *continued*

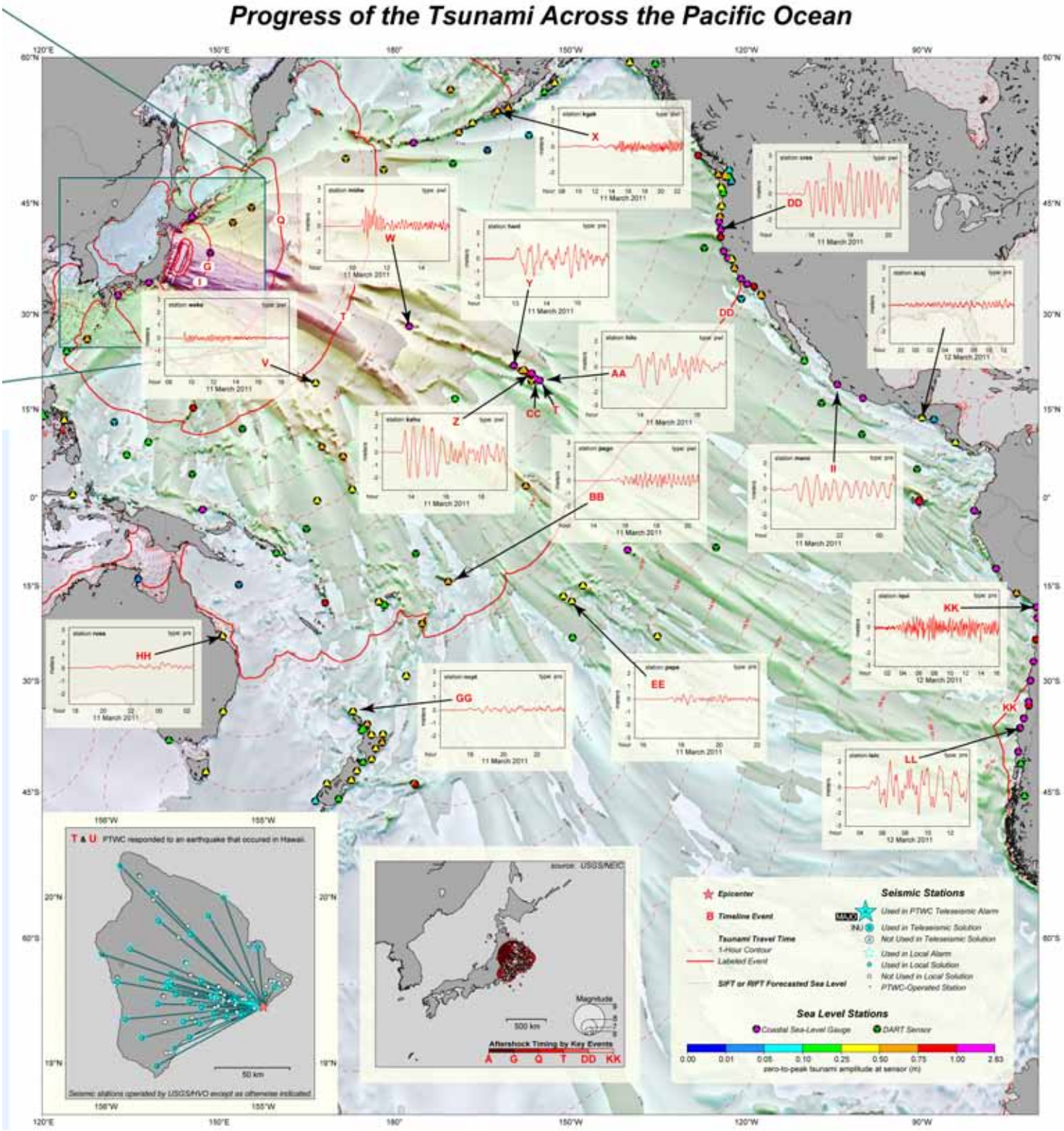
Triggers on the seismic stations at Erimo, Hokkaido (ERM) and Matsushiro, Honshu (MAJO), alerted Pacific Tsunami Warning Center (PTWC) scientists 90 seconds after the earthquake began. Four minutes after its origin, and about one minute after the earthquake's rupture ended, PTWC issued an observatory message reporting a preliminary magnitude of 7.5. Eight minutes after origin time, the Japan Meteorological Agency (JMA) issued its first international tsunami message in its capacity as the Northwest Pacific Tsunami Advisory Center. In accordance with international tsunami warning system protocols, PTWC then followed with its first international tsunami warning message using JMA's earthquake parameters, including an M_w of 7.9. Additional M_{wp}, mantle wave, and W-phase magnitude estimations based on the analysis of later-arriving seismic data at PTWC revealed that the earthquake magnitude reached at least 8.8, and that a destructive tsunami would likely be crossing the Pacific Ocean. The earthquake damaged the nearest coastal sea-level station located 90 km from the epicentre in Ofunato, Japan. The NOAA DART sensor situated 600 km off the coast of Sendai, Japan, at a depth of 5.6 km recorded a tsunami wave amplitude of nearly two meters, making it by far the largest tsunami wave ever recorded by a DART sensor. Thirty minutes later, a coastal sea-level station at Hanasaki, Japan, 600 km from the epicentre, recorded a tsunami wave amplitude of nearly three meters. The evacuation of Hawaii's coastlines commenced at 7:31 UTC. Concurrent with this tsunami event, a widely-felt M_w 4.6 earthquake occurred beneath the island of Hawai`i at 8:58 UTC. PTWC responded within three minutes of origin time with a Tsunami Information Statement stating that the Hawaii earthquake would not generate a tsunami. After issuing 27 international tsunami bulletins to Pacific basin countries, and 16 messages to the State of Hawaii during a period of 25 hours after the event began, PTWC concluded its role during the Tohoku tsunami event with the issuance of the corresponding warning cancellation message at 6:36 UTC on 12 March 2011. During the following weeks, however, the PTWC continued to respond to dozens of aftershocks related to the earthquake.



PTWC Response to the Tohoku Earthquake and Tsunami. Japan region sea level records as received by PTWC on 11 March 2011. *See more on page 17.*

Damage in Onagawa, Japan from the Tohoku tsunami. Photo courtesy of Y. Takata.

PTWC Response, *continued*

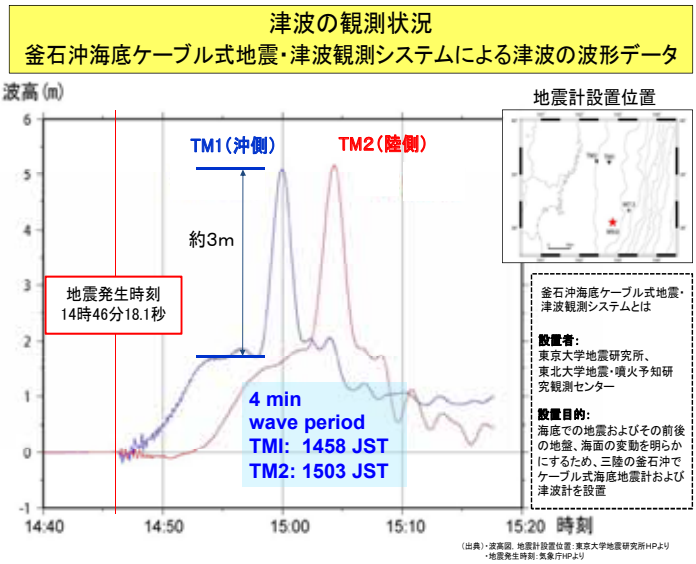


PTWC Response to the Tohoku Earthquake and Tsunami. Selected sea level records (V-X) and (AA - LL) across the Pacific as received by PTWC over a 25-hour time period starting from 05:46 UTC on 11 March 2011. The results of PTWC's RIFT (Real-Time Initial Forecasts of Tsunamis) tsunami forecast model are superimposed on the ocean. Bottom centre map shows Tohoku aftershocks timing. Bottom left map shows Hawaii Island earthquake that required PTWC simultaneous attention during the 25-hour warning.

See WC/ATWC website for more sea level gauge data. http://wcatwc.arh.noaa.gov/about/tsunamimain.php

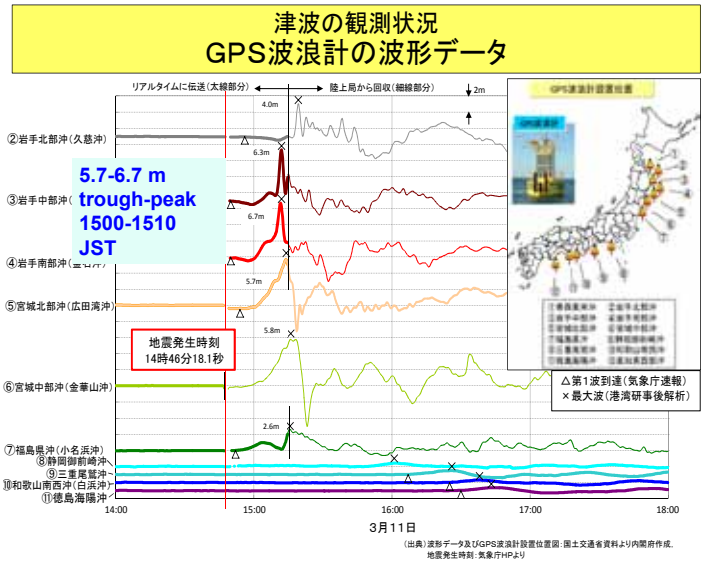
Great East Japan Earthquake, *continued*

Tsunami Measured on Cabled Bottom Pressure Sensor
Source/Data courtesy: U/Tokyo



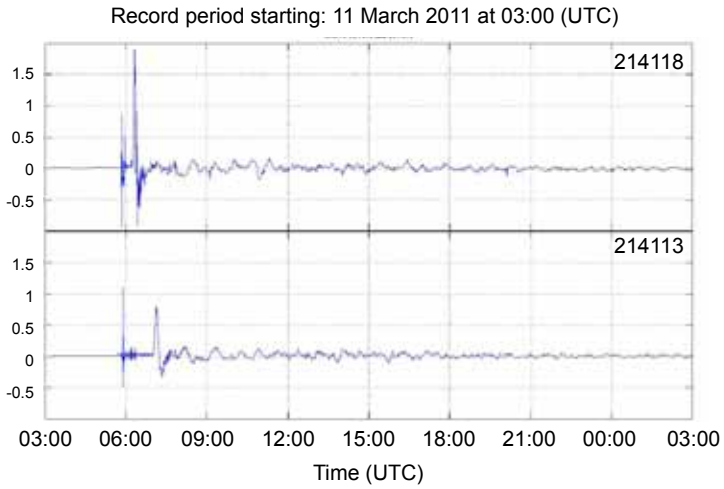
Cabled Ocean Bottom Pressure Sensors acted as tsunami detectors, installed off Sanriku coast, measured maximum sea surface change of 3 meters with 4-5 minute wave periods. Courtesy of Earthquake Research Institute, University of Tokyo. (U/Tokyo)

Tsunami Observed on GPS Surface Buoy
Source/Data courtesy: PARI



GPS Surface Buoys measured varying 5.7-6.7 meter, trough to peak tsunami marigram signals over a 10 minute sampling period. Waveform data and location of other GPS surface buoys also displayed. Courtesy of Japan Port and Airport Research Institute (PARI).

Tsunami Marigrams at DART Stations
DARTs #21413 and #21418
Source/Data courtesy: NOAA



Tsunami arrivals at the two closest DART stations. A maximum amplitude of nearly 2 m was observed on DART 21418 and over 1 m at DART 21413. The 1st high frequency arrival on each time series is the earthquake signal. Courtesy of NOAA.

Vertical Evacuation Building Signage in background guided people to refuge in Minami, Sanriku. Photo courtesy of L. Kong.

Great East Japan Earthquake, *continued*

Tsunami Wave Heights around the Pacific

Source/Data courtesy: NOAA National Geophysical Data Center and WDS/MGG-Tsunamis from various sources, including PTWC, JMA, WC/ATWC, and others

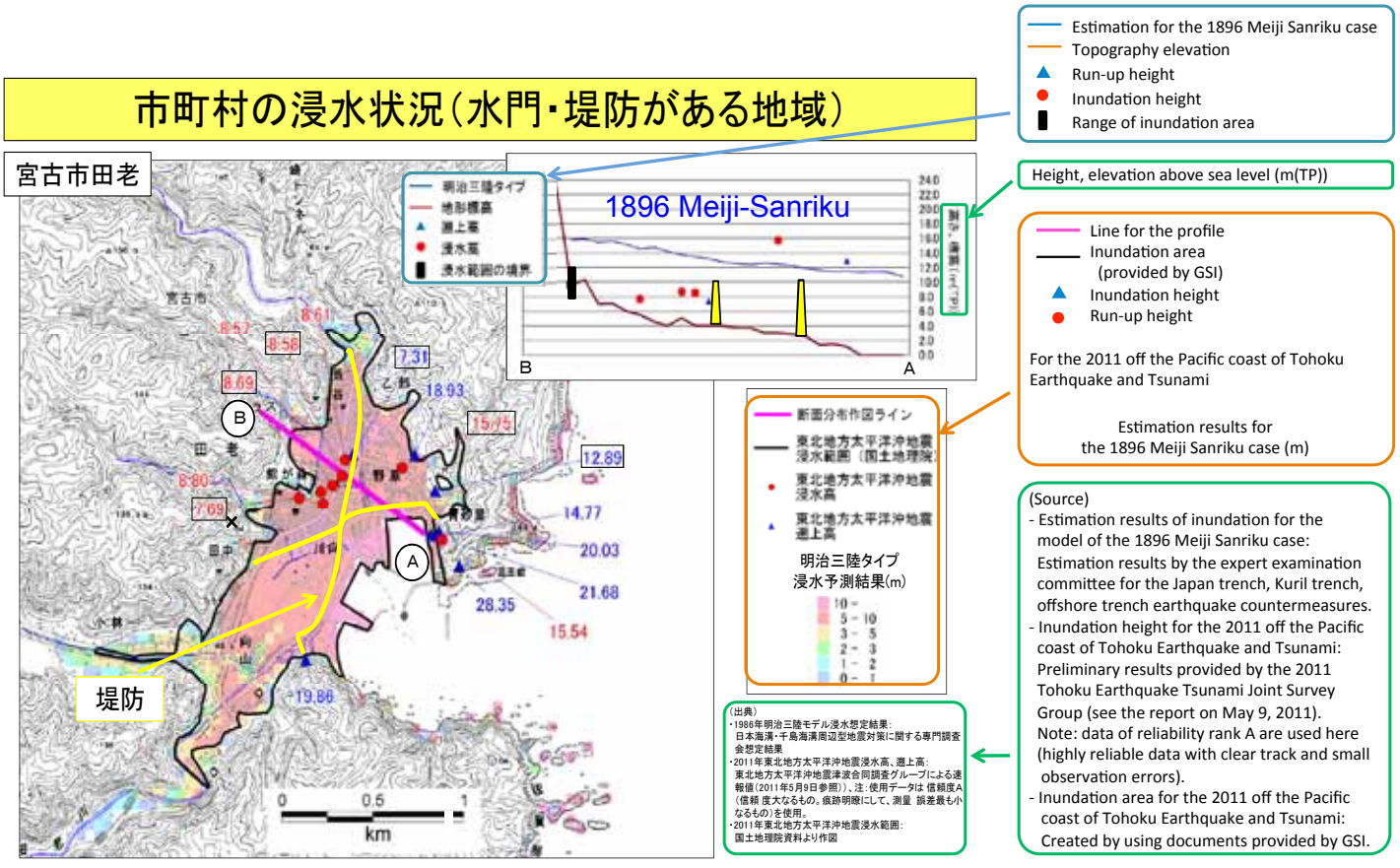
Coastal Sea Level Station or DART Instrument	Country	Amplitude (m)	Distance from Epicentre (km)
Ofunato	Japan	3.25	94
Boso	Japan	0.75	416
DART D21418 BPR, NE Tokyo, Japan	Japan	1.08	550
Omaezaki	Japan	1.42	555
Hanasaki	Japan	2.79	614
Tokai	Japan	0.23	661
Yuzhno-Kuril'sk, Kunashir Island	Russia	1.99	699
Malokuril'skaya Bay, Shikotan	Russia	3.00	720
Burevestnik, Iturup I., Kurilskiye	Russia	2.00	847
Cape Krilon	Russia	0.19	850
Rudnaya	Russia	0.32	859
Korsakov, Sakhalin	Russia	0.23	924
Nevelsk, Sakhalin	Russia	0.06	931
Kholmsk	Russia	0.07	969
DART D21401 BPR, 250 NM SE of Itirup Is	Russia	0.67	987
Starodubskoe	Russia	0.16	1,012
Tosa-Shimizu	Japan	0.94	1,049
Iturup, Kurilskiye	Russia	0.53	1,102
Poronaysk	Russia	0.20	1,213
DART D21413 BPR, SE Tokyo, Japan	Japan	0.76	1,242
DART D21419 BPR, 209 NM S of Kuril Is	Russia	0.40	1,305
Naha	Japan	0.25	1,925
Petropavlovsk, Kamchatka	Russia	0.18	2,064
Semjachik, Kamchatka	Russia	0.68	2,064
Nikolskoe, Bering Is.	Russia	0.24	2,575
Saipan, Northern Mariana Islands	USA	0.65	2,589
DART D21415 BPR, 175 NM S of Attu, AK	USA	0.27	2,667
Shemya Island, AK	USA	1.56	2,910
Wake Island	USA	0.39	3,155
DART D52402 BPR - 790 NM NW of Kwajalein	USA	0.29	3,213
Yap Island, Caroline Islands	Micronesia, Fed. States Of	0.15	3,232
Legaspi	Philippines	0.25	3,349
Subic Bay	Philippines	0.07	3,396
Adak, Sweeper Cove, AK	USA	0.35	3,495
Midway Islands	USA	1.27	3,878
St. Paul Island, AK	USA	0.61	4,001
Nikolski, AK	USA	0.27	4,031

Great East Japan Earthquake, *continued*

Coastal Sea Level Station or DART Instrument	Country	Amplitude (m)	Distance from Epicentre (km)
Kwajalein, Marshall Islands	USA	0.55	4,155
Unalaska, Dutch Harbor, AK	USA	0.51	4,192
King Cove, AK	USA	0.64	4,470
Lombrum, Admiralty Islands	Papua New Guinea	1.04	4,515
Manus Island, Admiralty Islands	Papua New Guinea	0.93	4,515
Bitung	Indonesia	0.26	4,568
Sand Point, AK	USA	0.38	4,585
DART D46403 BPR, SE OF Shumagin Is, AK	USA	0.09	4,833
Nauru	Nauru	0.20	4,998
French Frigate Shoals, HI	USA	0.38	5,078
Betio, Tarawa	Kiribati	0.21	5,156
Johnston Island	USA	0.20	5,243
Honiara, Guadalcanal	Solomon Islands	0.26	5,616
Nawiliwili, Kauai, HI	USA	0.76	5,792
Barbers Point, Oahu, HI	USA	0.70	5,942
Honolulu, Oahu, HI	USA	0.71	5,962
Kaumalapau, Lanai, HI	USA	0.91	6,071
Kahului, Maui, HI	USA	1.74	6,108
Port Alexander, AK	USA	0.32	6,155
DART D51407 BPR, SE of Honolulu, HI	USA	0.15	6,182
Kawaihae, Hawaii, HI	USA	1.22	6,217
Hilo, Hawaii, HI	USA	1.41	6,302
Langara Island	Canada	0.23	6,326
Vanuatu Islands	Vanuatu	0.69	6,403
Luganville	Vanuatu	0.54	6,523
Kanton Island, Phoenix Islands	Kiribati	0.05	6,565
Winter Harbor, British Columbia	Canada	0.47	6,805
Neah Bay, WA	USA	0.17	7,135
La Push, WA	USA	0.53	7,159
Lautoka	Fiji	0.33	7,216
Westport, WA	USA	0.26	7,249
Christmas Island, Line Islands	Kiribati	0.56	7,307
South Beach, OR	USA	0.22	7,383
Charleston, OR	USA	0.49	7,447
Port Orford, OR	USA	0.52	7,462
Crescent City, CA	USA	2.02	7,542
North Spit, Humboldt Bay, CA	USA	0.54	7,598
Pago Bay, Guam	USA	0.34	7,622
Pago Pago, American Samoa	USA	0.34	7,623
Arena Cove, CA	USA	0.82	7,747

Great East Japan Earthquake, *continued*

Coastal Sea Level Station or DART Instrument	Country	Amplitude (m)	Distance from Epicentre (km)
San Francisco, CA	USA	0.49	7,906
Monterey, CA	USA	0.72	8,024
Port San Luis, CA	USA	1.88	8,194
Santa Barbara, CA	USA	0.76	8,328
Raoul Island, Boat Cove	New Zealand	0.09	8,579
North Cape	New Zealand	0.23	8,684
Rarotonga	Cook Islands	0.29	8,953
Lottin Pt	New Zealand	0.23	9,208
Papeete, Tahiti	French Polynesia	0.39	9,414
Nuku Hiva Island, Marquesas Islands	French Polynesia	1.48	9,555
Nukualofa (Nuku'alofa)	Tonga	0.37	9,555
Cabo San Lucas	Mexico	0.22	9,875
Manzanillo	Mexico	0.76	10,589
Rikitea, Mangareva Island	French Polynesia	0.21	10,975
Acapulco	Mexico	0.65	11,101



Comparison of the 1896 Meiji-Sanriku tsunami inundation and the 2011 Tohoku tsunami in Taro Town with vertical land height elevation profile above mean sea level, measured along a line between points A (coastline) and B (inland). Courtesy of GSIJ. English translation by JMA.

Great East Japan Earthquake, *continued*

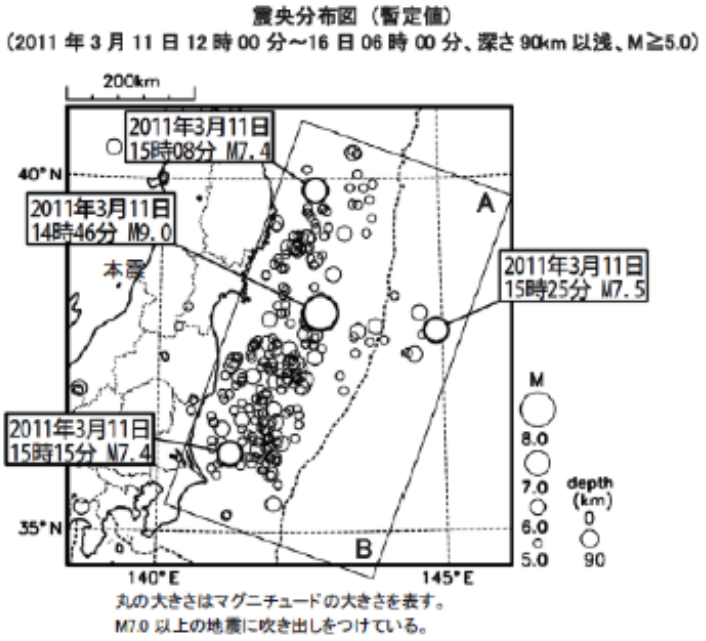
Flooded Taro Town with over toppedsea walls overview, looking northeast. Photo courtesy Geospatial Information Authority of Japan (GSIJ).

Taro looking north from harbor. After waves overtopped the sea wall, only one steel-reinforced building and several concrete one-story structures are left standing. Photo courtesy Geospatial Information Authority of Japan (GSIJ).

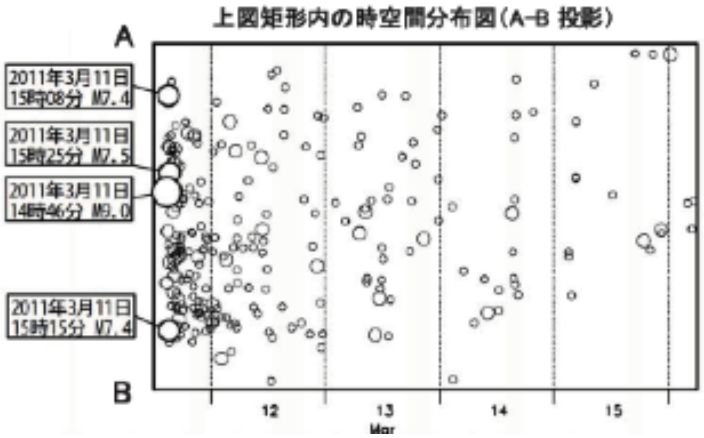
Taro Water Gate – looking southwest (located harbor-side of blue roofs) in above photo. Photo courtesy Geospatial Information Authority of Japan (GSIJ).

Earthquake Aftershock Distribution: 1200 JST 11 March to 0600 JST 16 March 2011

Source/Data courtesy: JMA

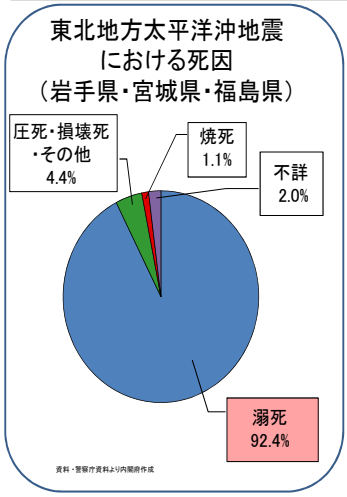


Seismicity Map showing locations of M_{JMA} 5.0+ earthquakes over a 500 km x 200 km rectangular area.

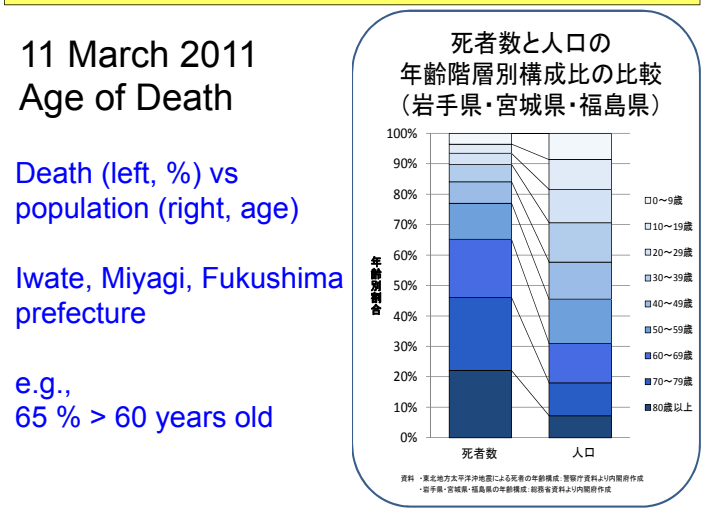


Seismicity magnitude aftershock distribution (over same above rectangular region), with horizontal date scale.

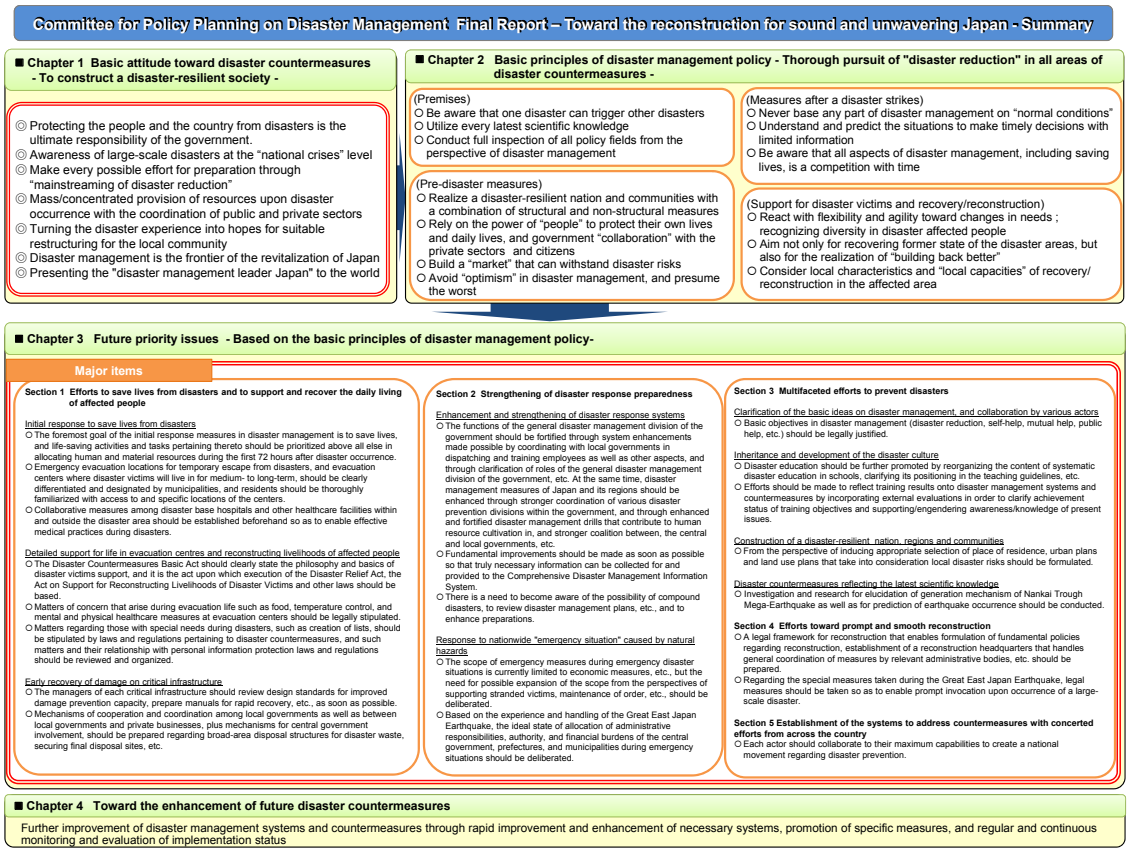
Great East Japan Earthquake, *continued*



Summary causes of death from the Great East Japan Tsunami. Courtesy of the Japan-UNESCO-UNU Symposium on the Great East Japan Tsunami on 11 March 2011 and Tsunami Warning Systems: Policy Perspectives 16-17 February 2012. UNESCO/IOC 2012.



The majority of deaths occurred to senior citizens greater than 60 years old in three impacted prefectures from the Great East Japan Tsunami. Courtesy of the Japan-UNESCO-UNU Symposium on the Great East Japan Tsunami on 11 March 2011 and Tsunami Warning Systems: Policy Perspectives 16-17 February 2012. UNESCO/IOC 2012.



Summary Recommendations of the Japan Committee on Policy Planning and Disaster Management. Courtesy of the Central Disaster Management Council Committee for Policy Planning on Disaster Management. 31 July 2012. http://www.preventionweb.net/english/professional/publications/v.php?id=31851

IOC NEWS

IOC-coordinated Tsunami Warning System Plays Key Role in 11 March 2011 Tsunami

The Pacific Tsunami Warning and Mitigation System, which has been coordinated by the IOC of UNESCO with cooperation from other UN agencies and dozens of nations since 1965, was called into action by the 11 March 2011 great earthquake and subsequent destructive tsunami. Within three minutes of the earthquake, the Japan Meteorological Agency (JMA) issued a National Major Tsunami Warning. Six minutes later international warnings or watches were issued for islands from the South Pacific to Hawaii, as well as Japan and Russia, by JMA's Northwest Pacific Tsunami Advisory Center (NWPTAC) and the Pacific Tsunami Warning Center (PTWC). Ocean-wide warnings were in effect for the Pacific for nearly 25 hours. In Japan, national advisories were finally cancelled after more than 51 hours (2 days). During this time, the JMA monitored and reported tsunami wave heights from its national sea level network and PTWC.

The March earthquake generated both a destructive local tsunami that reached the coast of Japan and a distant tsunami that spread across the Pacific Ocean. Tsunami wave amplitudes greater than 7.3 meters were observed on JMA coastal sea level gauge in Soma, south of Sendai. This tsunami had devastating consequences in the region of Sendai and northern Honshu. The tsunami also caused damage in Hawaii, the US West Coast, and South America, including Chile which had just been hit by a local tsunami the year before in February 2010. See ITIC Newsletter Vol. 42, No. 1.

Based on wave forecasts provided by PTWC and its own calculations, Chile's national tsunami warning centre (SHOA) maintained a national warning and government authorities ordered precautionary evacuations of coastal communities that had a high probability of being flooded.

The International Tsunami Warning Centres (ITWC) work in close cooperation with national agencies. The IOC is primarily concerned with international coordination among nations, while the operational duties of the centres reside with national agencies. For instance in the Pacific, the JMA, PTWC, and the West Coast/Alaska Tsunami Warning Centre (WC/ATWC) have operational responsibility for issuing international advisories to country national authorities. The three TWCs coordinate with each other prior to bulletin issuance. Since the Indian Ocean tsunami of 2004, the UN has designated the IOC to lead in the coordination of regional Tsunami Warning and Mitigation Systems in the Indian Ocean, the Caribbean, and the North-eastern Atlantic and Mediterranean.

Tsunami early warning systems are based on observation networks of seismometers and sea level measuring stations, which send real time data to national and regional tsunami warning centres (TWCs). Based on these observations, TWCs are able to evaluate the potential for a given earthquake to generate a tsunami, and confirm or cancel a tsunami warning advisory. When a potentially destructive tsunami is detected, national authorities decide if a tsunami warning and an evacuation order must be issued to their public.

Sophisticated ocean wave models forecast the tsunami wave's coastal impact. These models are used to assess the potential threat and guide warnings and advisories. For local tsunamis, however, where the wave arrives in minutes, it may be very difficult for TWCs to issue alerts in time, so everyone must recognize a tsunami's natural warning signs and act immediately to save their lives by moving to higher ground. The priority of the IOC programmes is to reduce tsunami risk, by encouraging countries and their communities to implement effective preventive and preparedness measures.

WORKSHOP AND MEETING SUMMARIES

PTWS Working Group 2 Meeting – Tsunami Detection, Warning and Dissemination, 28 February - 4 March 2011, Wellington, New Zealand

The New Zealand Ministry of Civil Defense and Emergency Management (MCDEM) hosted the PTWS Working Group Two and Task Teams meetings from 28 February – 4 March 2011 at their Wellington office just over a week after their country was struck by a destructive earthquake. The 21 February 2011, M6.1 Christchurch earthquake, 190 miles south of Wellington, killed at least 181 people and damaged or destroyed about 100,000 buildings in the central business district.

During the week, the PTWS Southwest Pacific Seismic Data Sharing Task Team, Exercises (PacWave11) Task Team, Enhancing Tsunami Warning Products Task Team, and Pacific Emergency Communications Task Teams met in order to provide status and reporting to PTWS Working Group 2. A summary of WG 2's report made to ICG/PTWS-XXIV is provided below.

Opening

Nora Gale, chair of ICG/PTWS WG2, opened the meeting and welcomed the 24 participants from 14 PTWS Member States

Review of WG2 Actions in PTWS Implementation Plan

Nora Gale introduced the agenda item and the group discussed the action items: Detection, Warning and Dissemination in detail.

Secretariat/ITIC actions:

- It was suggested that the PTWS Implementation Plan needs a glossary to ensure a self-contained document (IOC Secretariat).
- Add the actual TNC and TWFP contact details to the ICG/PTWS session invitation for Beijing for each individual Member State and ask to revise the contact information (Secretariat).
- ITIC will provide a listing of recently conducted trainings for the ICG session in Beijing.

Priority Action Items – Working Group 2

The Group reviewed the priority action items to assess the activity status.

Participants to ICG/PTWS WG 2 meeting, Wellington, New Zealand. From left to right: Nora Gale, Chair, New Zealand; Dr. Garry Rogers, Canada; Sionetasi Pulehetoa, Niue; Dr. Rosaidi Bin Che Abas, Malaysia; Rennie Vaiomounga, Tonga; Esline Garaebiti, Vanuatu. Back: Matthew Moihoi, Papua New Guinea. Photo courtesy of L. Kong.

PTWS Working Group 2 Meeting, *continued*

PTWS Priority Actions in Detection, Warning, and Dissemination

1. In an ongoing process the Secretariat shall secure that all PTWS countries have formally defined their TWFP and TNC and/or reviewed and updated their TWFP and TNC details. TWFP information should be forwarded to PTWC, NWPTAC, and WC/ATWC.

2. Detection: Address operational limitations of PTWS warning centres as indicated in the PTWS Operational Users Guide with specific focus on improving seismic data availability for monitoring and more quickly evaluating earthquakes, especially to be able warn against local tsunamis. Priority stations identified through sensitivity and gap analysis.

3. Detection: Address operational limitations of PTWS warning centres as indicated in the PTWS Operational Users Guide with specific focus on improving seismic source characterization techniques to more quickly evaluate the tsunamigenic potential of large earthquakes.

4. Detection: Address operational limitations of PTWS warning centres as indicated in the PTWS Operational Users Guide with specific focus on improving sea level data availability for monitoring and more quickly evaluating the tsunami threat. Priority stations identified through sensitivity and gap analysis.

5. Warning and dissemination: Enhance tsunami advisory products to improve their clarity, understanding and speed of dissemination, and to ensure consistency with products and terminology used globally. Reference Recommendation PTWS-XXIII.1.

6. Dissemination: In coordination with the PTWS Technical Secretariat, establish a reliable and secure mechanism for Member States to regularly review and update their TWFP and report to the IOC. (Reference Recommendation PTWS-XXIII.3). Implement similar or the same mechanism for use in the regular communication tests conducted by PTWC, NWPTAC, and WC/ATWC.

7. Dissemination: Establish and recommend reliable mechanisms for Member States to receive information from the regional to the national tsunami warning centres, e.g. from PTWC, NWPTAC, and WC/ATWC to TWFPs according to recommendations in the PTWS Operational Users Guide. (Ref. Recommendation PTWS-XXIII.8).

8. Dissemination: Identify and recommend the most reliable mechanisms of the available operational technologies for Member States to disseminate information from national authorities to the general public (Ref. Recomm. PTWS-XXIII.8).

9. Training: MS in collaboration with the Technical Secretariat, ITIC and other appropriate regional organisations provide opportunities for training and building in-country capacity in earthquake and tsunami detection, warning, and alert dissemination. Such training could include, but is not limited to, the development of national Standard Operational Procedures (SOPs) for tsunami warning.

Bernie Kilonsky, University of Hawaii Sea Level Center, suggested that a sea-level user's workshop after Caribbean Workshop for the PTWS would be useful. An outcome would be better understanding on the process for assigning and implementing satellite frequencies in the Pacific.

The creation of a PTWS Sea Level Task Team was suggested by New Zealand and seconded by ITIC.

Decisions and Actions of WG 2 to the ICG/PTWS:

1. A Task Team on Sea Level Monitoring for Tsunami Detection and Warning was established with the following Terms of Reference:

   a. Review the PTWS Medium Term Strategy and make recommendations for upgrading and improvements relating to sea-level measurements, in coordination with GLOSS

   b. Review and recommend changes to the ICG/PTWS Implementation Plan in relation to sea-level monitoring

   c. Review and suggest changes to the procedures for assigning transmission slots for sea-level station data to meteorological geostationary satellites

PTWS Working Group 2 Meeting, *continued*

d. Review existing training documents and coordinate the organisation of a training workshop for sea-level instrument operators and users in 2011

2. The Task Team on PTWS Exercises will report on progress to date at the ICG.

3. The Task Team on Seismic Data Sharing agreed on:

a. The need for follow-up training in the configuration and use of seismic monitoring and analysis systems for Member States in the SW Pacific.

b. Confirming the seismic technical specifications of the Vanuatu meeting of the Seismic Data Sharing Task Team.

c. That relevant national seismic data should be shared through IRIS.

d. The necessity of coordination among donor countries with respect to installation, training & sharing of seismic data for sustainable national seismic networks.

e. To collate documents on site selection, data centre setup by ITIC through an interim email list until other technologies are made available to meet the Task Team requirements. A List Serve has been set up by ITIC with Task Team members.

f. That SeisComp3 is the de-facto the regional earthquake analysis system.

Recommendations of WG2 to the ICG/PTWS:

1. WG2 recommends that the ICG approve the PTWC proposed enhanced products as described in the report to the ICG on the Task Team on Enhancing Tsunami Warning Products. This will include that the PTWC use numerical tsunami forecast to enhance the PTWC products, that the PTWC applies a lower magnitude for local tsunami threat, subject to a study on historical records and numerical models of local tsunami, and that the PTWC elaborate on the implementation process.

2. Requests the Secretariat to seek funds for the follow-up training in the configuration and use of seismic monitoring and analysis systems for Member States in the SW Pacific.

Located in Honolulu, the International Tsunami Information Centre (ITIC) was established on 12 November 1965 by the Intergovernmental Oceanographic Commission (IOC) of the United Nations Educational, Scientific, and Cultural Organization (UNESCO). In 1968, the IOC first convened the International Coordination Group for the Tsunami Warning System in the Pacific (ITSU). In 2005, ITSU became the Intergovernmental Coordination Group for the Pacific Tsunami Warning and Mitigation System (ICG/PTWS) so as to better convey the comprehensive approach required to reduce tsunami risks.

The 35 Member States with Tsunami National Contacts and Tsunami Warning Focal Points are: Australia, Canada, Chile, China, Colombia, Cook Islands, Costa Rica, Democratic People's Republic of Korea, Ecuador, El Salvador, Fiji, France, Guatemala, Indonesia, Japan, Malaysia, Mexico, New Zealand, Nicaragua, Niue, Panama, Papua New Guinea, Peru, Republic of the Philippines, Republic of Korea, Russian Federation, Samoa, Singapore, Solomons, Thailand, Tonga, Tuvalu, U.S.A., Vanuatu and Vietnam.

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