Pure Appl. Geophys. 171 (2014), 3175–3182

DOI 10.1007/s00024-014-0894-8

Pure and Applied Geophysics

Introduction to "Tsunamis in the Pacific Ocean: 2011–2012"

Alexander B. Rabinovich,[1,2] Jose C. Borrero,[3,4] and Hermann M. Fritz[5]

Abstract—With this volume of the Pure and Applied Geophysics (PAGEOPH) topical issue "Tsunamis in the Pacific Ocean: 2011–2012", we are pleased to present 21 new papers discussing tsunami events occurring in this two-year span. Owing to the profound impact resulting from the unique crossover of a natural and nuclear disaster, research into the 11 March 2011 Tohoku, Japan earthquake and tsunami continues; here we present 12 papers related to this event. Three papers report on detailed field survey results and updated analyses of the wave dynamics based on these surveys. Two papers explore the effects of the Tohoku tsunami on the coast of Russia. Three papers discuss the tsunami source mechanism, and four papers deal with tsunami hydrodynamics in the far field or over the wider Pacific basin. In addition, a series of five papers presents studies of four new tsunami and earthquake events occurring over this time period. This includes tsunamis in El Salvador, the Philippines, Japan and the west coast of British Columbia, Canada. Finally, we present four new papers on tsunami science, including discussions on tsunami event duration, tsunami wave amplitude, tsunami energy and tsunami recurrence.

Key words: Tsunami, 2011 Tohoku earthquake, 2012 El Salvador, 2012 Philippines, 2012 Haida Gwaii, December 2012 Japan earthquakes and tsunamis, source parameters, tsunami field survey, PACIFIC Ocean, DART, tsunami records, seiches, tsunami numerical modelling, spectral analysis.

1. *Introduction*

The Tsunami Commission was established within the International Union of Geodesy and Geophysics (IUGG) following the 1960 Chile tsunami, generated by the largest (M_w 9.5) instrumentally recorded earthquake. The 1960 tsunami propagated throughout the entire Pacific Ocean, affecting areas located far from the source, and demonstrated the necessity of international cooperation. As organized, the Tsunami Commission is supported by two International Union of Geodesy and Geophysics (IUGG) associations: the International Association of Seismology and Physics of the Earth's Interior (IASPEI) and the International Association for the Physical Sciences of the Oceans (IAPSO). Since its foundation, the Tsunami Commission has held biannual International Tsunami Symposia and published special volumes of selected tsunami papers (Satake *et al.* 2007, 2011a, b; Cummins *et al.* 2008; 2009).

Two recent volumes (Satake *et al.* 2013a, b) were associated with the 25th International Tsunami Symposium, held in Melbourne, Australia from 1 to 4 July, 2011, just 4 months after the catastrophic Tohoku tsunami of 11 March 2011. This tsunami was generated by the largest instrumentally recorded earthquake (M_w 9.0) in the history of Japan, causing nearly 20,000 tsunami casualties and devastating tsunami damage on the Pacific coast of Honshu and Hokkaido islands. Numerous papers have already been published on the Tohoku earthquake and tsunami, including special issues in *Earth, Planets and Space* (Vol. 63, No.7, Editors: Kanamori and Yomogida 2011), *Geophysical Research Letters* (Vol. 39, No. 7, 2012), *Coastal Engineering Journal* (Vol. 54, No.1, Editor: Sato 2012), *Earthquake Spectra* (Vol. 29, No. S1, Editors: Mori and Eisner 2013), among others. Thus, it was natural that the entire Volume I of the 2013 *PAGEOPH* topical tsunami issue was on the 2011 Tohoku event (Vol. 170, Nos. 6–8, Editor: Satake *et al.* 2013a). However, results from new investigations into the 2011 Tohoku

---

[1] P.P. Shirshov Institute of Oceanology, Russian Academy of Sciences, 36 Nakhimovsky Pr., Moscow 117997, Russia. E-mail: A.B.Rabinovich@gmail.com

[2] Department of Fisheries and Oceans, Institute of Ocean Sciences, 9860 West Saanich Rd., Sidney, BC V8L 4B2, Canada.

[3] eCoast Ltd., Box 151, Raglan 3225, New Zealand. E-mail: jose@ecoast.co.nz

[4] Department of Civil and Environmental Engineering, University of Southern California, Los Angeles, CA, USA. E-mail: jborrero@usc.edu

[5] School of Civil and Environmental Engineering, Georgia Institute of Technology, Atlanta, GA 30332, USA. E-mail: fritz@gatech.edu

Birkhäuser

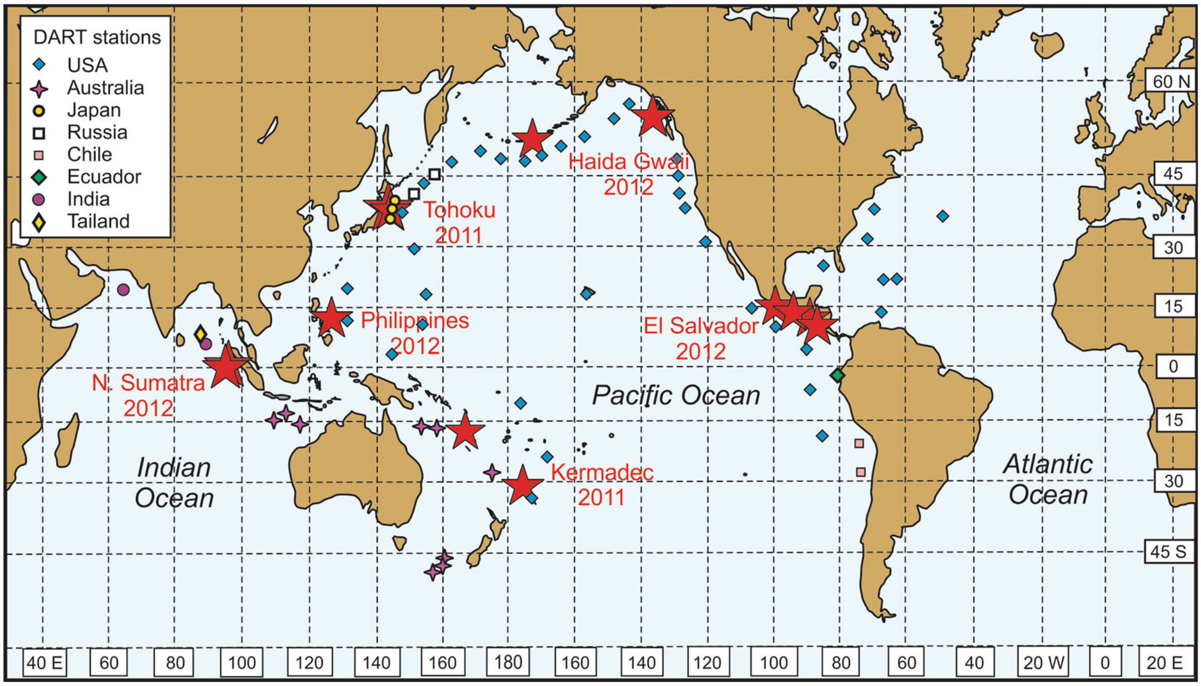

Figure 1
Red stars show the epicenter locations of tsunamigenic earthquakes occurring in 2011 and 2012; green diamonds show the locations of open ocean DART tsunameters

followed, requiring additional publication outlets. Additionally, in the remainder of 2011 through 2012 several other tsunami events occurred (Fig. 1). While these tsunamis were not as strong or devastating as the 2011 Tohoku event, they were nevertheless scientifically interesting and societally important.

These days, we are living in a new, "instrumental" era of tsunami science with ever more detailed (and sometimes overwhelming!) amounts of data available after each event. The types of data include precise seismological data from broadband IRIS and open-ocean bottom seismographs, GPS measurements of ground deformations on land, hydroacoustic and satellite altimetry data, not to mention the results of tsunami field surveys and high-resolution coastal tide gauge records. Most importantly, however, deep-ocean "tsunameters" now routinely provide direct measurements of tsunami waves in the open ocean, significantly improving our understanding of tsunami physics, the quality of tsunami modelling and the reliability and accuracy of tsunami warnings (Mofjeld 2009; Titov 2009; Rabinovich 2014). When a tsunami in the open ocean was first recorded (Filloux 1982; Dykhan *et al.* 1983), it was a scientific sensation. Nowadays, DART[1] stations located throughout the Pacific, Indian and Atlantic Oceans (Fig. 1) record every tsunami no matter how small. The low level of background noise in the deep ocean and the high precision of DART instruments enable us to reliably identify and examine tsunamis with wave heights of only a few millimeters. Moreover, in recent years, Japan has developed a dense and effective network of cable tsunameters comprised of scores of stations (Kawaguchi *et al.* 2012; Rabinovich 2014). These stations provide invaluable information about tsunamis generated by earthquakes in this region (e.g., Matsumoto and Kaneda 2013; Satake *et al.* 2013c). Similarly, in Canada, the University of Victoria, BC, established in 2009 the NEPTUNE-Canada[2] geophysical observatory on the southwestern shelf of Vancouver Island, which has already

---

[1] DART = Deep-ocean Assessment and Reporting of Tsunami.

[2] NEPTUNE-Canada = Canadian North-East Pacific Underwater Networked Experiments.

recorded more than ten tsunami events (Thomson *et al*. 2011; Rabinovich *et al*. 2013).

In general, we can say that the tools available for tsunami research have dramatically improved over the last 35 years. While the 1980s were rife with scientific ideas and theories about tsunami waves, there was very little empirical data; now we have an abundance of observational data, but sometimes not enough ideas to explain the new findings! In any case, the ongoing publication of high-quality scientific results is very important, and for that reason, the IUGG Tsunami Commission decided to prepare the additional, "inter-symposium" topical tsunami issue presented here. Altogether, 30 papers were submitted with 21 selected for publication.

2. *The 2011 Tohoku Tsunami*

This volume presents 12 new papers discussing the 2011 Tohoku tsunami: three papers deal with field data including previously unpublished data from surveys in the Fukushima exclusion zone, three papers investigate the seismic source, two papers deal with tsunami data recorded off the coast of Russia and four papers look at the tsunami waves recorded in the far-field (Marshall Islands, Hawaii, California and basin-wide).

Starting the group of field survey papers, Tsuji *et al.* (2014) compare the results from the Tohoku post-tsunami field surveys to runup and inundation data from past great earthquakes along the Honshu coast. They show that along the Sanriku coast, tsunami heights from the 2011 event were positively correlated with the previous Sanriku tsunamis, indicating that for near-field tsunamis, local variations in tsunami height resulting from the irregular coastline may be more dominant than the earthquake location, type, or magnitude. Along that coast, correlations to heights from the far-field Chilean tsunamis (1960, 2010) were less significant due to differences between the local and trans-Pacific tsunamis. However, along the Ibaraki and Chiba coasts, wave heights from the 2011 Tohoku and the Chilean tsunamis are positively correlated, showing a general decrease toward the south with small local variations such as large heights near peninsulas.

Shimonzono *et al.* (2014) next describe in detail the maximum runup height of nearly 40 m measured in a funneling coastal valley of the Aneyoshi district north of the entrance to Yamada Bay. Wave records from offshore GPS-buoys are introduced in a numerical model to analyze the measured localized runup amplification. The results indicated that a spectral component with a relatively short dominant period of 4–5 min in the leading wave plays a key role in the tsunami runup amplification by local bathymetry and topography. A final field survey paper by Sato *et al.* (2014) reports on detailed field data collected from inside the former 20-km exclusion zone around the Fukushima Dai-ichi nuclear power plant (NPP). The field surveys in the exclusion zone were delayed for more than a year due to elevated radiation levels caused by the multiple meltdowns at the NPP. Detailed distributions of the measured tsunami heights are presented in combination with observed infrastructure damage. Large tsunami heights exceeding 10 m were limited to areas within 500 m from the shoreline, while onshore profiles of the maximum inundation levels were dependent on inland topography. Tsunami flood levels in the coastal plains were affected by the extent of seawall damage, and remnant seawalls that survived the tsunami overflow provide valuable design lessons.

Next, we present two papers dealing with the seismological and wave generation aspects of the 2011 earthquake. First Rodkin and Tikhonov (2014) use data from the Japan Meteorological Agency (JMA) to examine the recent historical seismicity of the Tohoku earthquake source region. They find that this earthquake occurred in a region where over the previous 7 years (2005–2011), there was a considerable decrease in the number of earthquakes and associated *b*-values. The authors then describe some short-term (20 days) precursor anomalies of the Tohoku earthquake, in particular, an increase in the number of earthquakes and a decrease in hypocentral depths in a 120 km radius around the epicenter of the 2011 mega event. The unexpectedly high tsunami waves associated with a rather small rupture area of the Tohoku earthquake demonstrate that similar events could occur in some other subduction zones where such cases had previously been considered impossible.

This is followed by a review paper by Pararas-Carayannis (2014), who revisits the earthquake and tsunami source mechanism of the great Tohoku-Oki earthquake of 11 March 2011. An examination of the source mechanism determined that the great tsunami resulted from a combination of crustal deformations of the ocean floor due to up-thrust tectonic motions augmented by additional uplift due to the quake's slow and long rupturing process, as well as to large coseismic lateral movements that compressed and deformed the compacted sediments along the accretionary prism of the overriding plate. The author suggests that as with the 1896 Sanriku tsunami, additional ocean floor deformation and uplift of the sediments was responsible for the higher waves generated by the 2011 earthquake.

One of the most critical issues relevant to tsunami forecasting, and tsunami modeling in general, is the characterization of the tsunami source. A tsunami source can be modeled based on data from seismometers, GPS measurements of crustal deformation, deep-ocean tsunameters, and other advanced instruments that provide near real-time information. Using data from the 2011 Tohoku earthquake, Wei *et al.* (2014) applied several different source models, based on different data sources, to simulate the generation, propagation and inundation of tsunami waves in the near field. They compare their results to measured data, including inundation extents and water level records from nearby tsunameters. Their results highlight the critical role these deep-ocean tsunami measurements play in the rapid determination of an approximate tsunami source suitable for issuing reliable and accurate forecasts. They also show that results from tsunameter-derived source models are compatible with results based on other real-time geodetic data, and may also provide a more nuanced understanding of tsunami generation from both tectonic and, non-seismic processes such as submarine landslides.

Our last cluster of papers on the 2011 Tohoku tsunami highlights the findings of researchers who studied tsunami records from various locations around the Pacific. Two papers from the Russian coast give a regional perspective, while four other papers examine tsunami waves at far-field locations or over the Pacific basin as a whole. This group of papers starts with the work of Razjigaeva *et al.* (2014), who examined tsunami sedimentation in the bays of the southernmost group of the Kuril Islands (the Lesser Kuril Islands). They report on the unusual situation where the sea during the tsunami was covered with ice, and describe changes in the erosional capacity of the tsunami due to ice fragments carried along with the waves. Their paper is a continuation of their previous work (Razjigaeva *et al.* 2013), which was based on the direct post-event studies. Their newer studies showed well-preserved tsunami deposits, evident one-and-a-half years after the event. A comparative analysis between tsunami deposits in the Kuril Islands relative to near-field (Honshu Island) sites indicated that differences in runup heights contributed to considerable differences in erosion, sedimentation, distribution of tsunami deposits, the formation of sedimentary structures, grain-size composition, and diatom and foraminifera assemblages. On the coasts of the Lesser Kuril Islands, the mud layers in sections of coastal lowlands in closed bays contained the grain-size composition of the 2011 mud, and preserved detailed geological records of paleotsunamis.

This is followed by the contribution of Shevchenko *et al.* (2014), who examine deep-water and coastal observations and data of the 2011 tsunami along the Far East coast of Russia. Key findings from their study show that tsunami waves reached up to 2.5 m along the Kuril Islands and that tsunami waves affecting the region northeast of the source exhibited much longer periods than waves propagating directly to the east. The authors estimated the major characteristics of the recorded waves and compared the observed tsunami series to the results from numerical models. In contrast to the open-ocean stations where the first waves were the highest, at Russian coastal sites, the highest waves occurred several hours after the arrival of the first tsunami wave.

Heidarzadeh and Satake (2014a) present evidence that extremely long modes of the Pacific Ocean were excited by the 11 March 2011 Tohoku tsunami. A numerical approach was employed to calculate the basin-wide modes of the Pacific Ocean, resulting in 49 modes in the range of 2–48 h. Spectral analysis of tide-gauge records showed that some of the calculated basin-wide modes were indeed excited by the

Tohoku tsunami. The tide gauge signals were classified into three groups: (1) basin-wide modes (>1.5 h), (2) the tsunami source periods (20–90 min), and (3) local bathymetric effects ($<$20 min). The average contributions to the total tsunami energy were 6.4 % for the basin-wide mode, 64.1 % for the tsunami source, and 29.5 % for the local bathymetry. Simulations suggest that the amount of contribution of basin effects to the total tsunami energy depends on the location of the tsunami source.

Next, Ford *et al.* (2014) report on an interesting mid-basin data set of tsunami waves from the 2011 Tohoku event. In their study, tide gauge data and numerical simulations supplement a serendipitous recording of the tsunami on an array of bottom-mounted pressure sensors at Majuro and Kwajalein Atolls in the Republic of the Marshall Islands. They show that tsunami oscillations in the lagoon were substantially more energetic and longer lasting than observed on the reefs or modeled in the deep ocean, and that the tsunami excited the normal modes of the atoll lagoons. They also showed that the propagation of the tsunami across the reef flats is tidally dependent, with amplitudes increasing/decreasing shoreward at high/low tide. Most importantly, from a hazard management viewpoint, they showed that while the peak wave heights in the Marshall Islands coincided with low tide, the observed amplitudes could have caused inundation had they coincided with a higher tide stage.

In the far field, Zhou *et al.* (2014) and Admire *et al.* (2014) investigate both tsunami wave heights and currents. Firstly, Zhou *et al.* (2014), examine the effects of frequency dispersion on tsunami waves and currents from the 2011 Tohoku event. In a series of numerical experiments, they compare the trans-oceanic propagation and tsunami dynamics in the vicinity of the Hawaiian Islands using both a weakly dispersive Boussinesq model and a shallow-water model that neglects dispersion effects. The model results indicate that dispersion effects generally result in reduced amplitudes of the leading tsunami waves. They also show that a model neglecting dispersion effects could underestimate wave heights and current speeds of the trailing waves developing in coastal waters.

This is followed by Admire *et al.* (2014), who present some relatively rare tsunami current speed data from northern California, including instrumental data from the 2010 Chile and 2011 Tohoku tsunamis in Humboldt Bay and current speeds derived from video camera footage at the entrance to Crescent City Harbor during the 2011 Tohoku tsunami. During the 2011 event, the tsunami signal was evident for more than 40 h in Humboldt Bay, with a peak current speed of 0.8 m/s occurring approximately 1 h after arrival. At Crescent City, within the first 3 h of tsunami activity, peak surface currents were estimated to have exceeded 4.5 m/s on one wave cycle and 3 m/s on six others, and were the cause of most of the damage experienced there. Their study also presents numerical model results in an effort to calibrate to measured data.

3. *New Tsunami Events*

Four new tsunami events occurred in 2012, and in this volume we present papers describing aspects of each. In August 2012, tsunamis occurred in El Salvador and Nicaragua on August 27 and in the Philippines on August 31. Borrero *et al.* (2014) conducted a post-tsunami reconnaissance survey of the El Salvador event and measured tsunami heights of up to 6 m with a maximum inundation distance of over 300 m. This is an important finding in that the causative earthquake for this event was relatively small, with a moment magnitude of only 7.3. Seismological analyses of the earthquake showed that it was a ‘slow’ or ‘tsunami’ earthquake (Kanamori 1972), making it the second such event in this region in 20 years—an important consideration when assessing tsunami hazards for this region. Heidarzadeh and Satake (2014b) also investigated aspects of the El Salvador tsunami as well as the August 31 Philippines tsunami. In their study, they focused on the far-field signature of these events as recorded on coastal tide gauges and deep-water tsunameters. They performed a detailed spectral analysis (using Fourier and wavelet techniques), and showed that the spectral content of the tsunami signal is related to the location of the recording station relative to the orientation of the tsunami source.

On 27 October 2012, a relatively large (M_w 7.7) earthquake occurred off the west coast of Haida Gwaii in the Canadian province of British Columbia. Cassidy *et al*. (2014) provide an overview of the seismotectonics of the fault region and put this event in context. They explain that although the earthquake source region is predominantly a strike-slip transform fault boundary, there is a component of oblique convergence between the Pacific and North America plates off Haida Gwaii. The October earthquake, the second largest instrumentally recorded earthquake in that region, had a primarily thrust mechanism and was responsible for generating a tsunami that caused significant local runup. Leonard and Bednarski (2014) specifically examined the near-field effects of the 2012 Haida Gwaii tsunami. Despite a lack of evidence suggesting damaging waves along the coast of British Columbia (largest amplitudes of ~0.5–1 m were measured in Hawaii), field surveys conducted in the weeks and months following the earthquake revealed that much of the unpopulated and un-instrumented coastline of western Haida Gwaii was impacted by significant tsunami waves reaching a maximum height of 13 m with runup exceeding 3 m along 200 km of the coastline. The greatest impacts were evident at the heads of narrow inlets and bays on western Moresby Island, where natural and anthropogenic debris was found on the forest floor and caught in tree branches, suggesting flow depths up to 2.5 m. The authors indicate that lessons learned from their study of the impacts of the Haida Gwaii tsunami may prove useful to future post-tsunami and paleotsunami surveys.

Finally, Bernard *et al.* (2014), report on a small tsunami produced by a M_W 7.3 earthquake offshore of Japan, adjacent to the source region for the 2011 Tohoku event. They present the deep-water tsunameter data from this event, recorded on instruments that were deployed just 2 weeks before the causative earthquake. They show that the data recorded by these two instruments helped to improve the speed and accuracy of tsunami forecasts for the coast of Japan and the Pacific Ocean in general.

4. *Tsunami Science*

Four papers in this issue relate to general topics in tsunami science, warning and hazard mitigation, and use examples from recent events to provide new insights or answers. In particular, Kim and Whitmore (2014) examined the relationship between tsunami maximum amplitude and signal duration based on 89 historical data sets from 13 tsunamis occurring between 1952 and 2011. The problem of event duration is quite important for effective tsunami warnings, hazard assessment and emergency response. They evaluated the tsunami sea level time series and used a linear least squares fit to get a quantitative estimate of amplitude decay function for their study region. The confidence interval was found to be roughly 20 h over the range of maximum tsunami amplitudes; this relatively large interval likely resulted from local resonance, late-arriving reflections, and other effects.

Nyland and Huang (2014) discussed specific problems related to tsunami warnings and advisories based on the West Coast and Alaska Tsunami Warning Center (WCATWC) experience during the 2011 Tohoku tsunami event. Specifically, they looked at the problem of how long a tsunami warning or advisory should be in place. To address this issue, the WCATWC developed a technique to estimate the amplitude decay of tsunami waves recorded at tide stations within the WCATWC Area of Responsibility (AOR). Based on an analysis of the real-time tide gauge records, they estimated exponential decay curves, which were then combined with an average West Coast decay function to provide an initial tsunami amplitude-duration forecast.

Nosov *et al*. (2014) used detailed slip distribution data from recent earthquakes and the Okada (1985) formulae to calculate the vector fields of coseismic sea-floor deformations, the displaced water volume and the gravitational potential energy of the tsunami source. They suggest that in many cases, the horizontal components of the bottom deformation provide an additional contribution to the displaced water volume without reducing the contribution of the vertical component. This increase varies from 0.07 to 55 % with an average increase of 14 %. The authors go on to examine measures of a tsunami's initial energy as functions of the moment magnitude, and show that a tsunami captures from 0.001 to 0.34 % of the earthquake energy, and on average 0.04 %.

And finally, closing this volume, Kaistrenko (2014) describes a Poissonian probability model for tsunami runup heights, with emphasis on a tsunami recurrence function. He shows that a general tsunami recurrence function contains at least two important scaling parameters: (1) the asymptotic frequency of big tsunamis f at a study site, and (2) a characteristic tsunami height H^* for that site. These parameters and their variations are statistically evaluated using observational data from tsunami catalogues. The author also considers theoretical and applied problems related to tsunami recurrence, shows an example of a two-parameter tsunami hazard map, and discusses issues related to probabilistic tsunami hazard estimation.

Acknowledgments

We, the guest editors, would like to thank Dr. Renata Dmovska, Editor-in-Chief of PAGEOPH for arranging and supporting the continued production of these topical volumes on tsunamis. We feel very strongly that they provide an important outlet for many high-quality research articles related to all aspects of tsunami science. We would also like to thank Ms. Priyanka Ganesh in the Springer Journals Editorial Office for her timely editorial assistance. Finally, we thank each of the authors for their excellent contributions and hard work in making this volume a success.

REFERENCES

Admire, A., Dengler, L., Crawford, G., Uslu, B., Borrero, J., Greer, D., Montoya, J., and Wilson, R. (2014), *Observed and modeled currents from the Tohoku-oki, Japan and other recent tsunamis in northern California*, Pure Appl. Geophys., *171* (this issue); doi:10.1007/s00024-014-0797-8.

Bernard, E., Tang, L., Wei, Y., and Titov, V. (2014), *Impact of near-field, deep-ocean tsunami observations on forecasting the December 7, 2012 Japanese tsunami*, Pure Appl. Geophys., *171* (this issue); doi:10.1007/s00024-013-0720-8.

Borrero, J., Kalligeris, N., Lynett, P.J., Fritz, H.M., Newman, A.V., and Convers, J.A. (2014), *Observations and modeling of the August 27, 2012 earthquake and tsunami affecting El Salvador and Nicaragua*, Pure Appl. Geophys. (this issue); doi:10.1007/s00024-014-0782-2.

Cassidy, J.F., Rogers, G.C., and Hyndman, R.D. (2014), *An overview of the October 28, 2012 Mw 7.7 earthquake in Haida Gwaii, Canada: A tsunamigenic thrust event along a predominantly strike-slip margin*, Pure Appl. Geophys. (this issue); doi:10.1007/s00024-014-0775-1.

Cummins, P.R., Kong, L.S.L., and Satake, K. (2008), *Tsunami Science Four Years after the 2004 Indian Ocean Tsunami. Part I: Modelling and Hazard Assessment*, Pure Appl. Geophys. *165*, Topical Issue.

Cummins, P.R., Kong, L.S.L., and Satake, K. (2009), *Tsunami Science Four Years after the 2004 Indian Ocean Tsunami. Part II: Observation and Data Analysis*, Pure Appl. Geophys. *166*, Topical Issue.

Dykhan, B.D., Jaque, V.M., Kulikov, E.A. et al. (1983), *Registration of tsunamis in the open ocean,* Marine Geodesy, *6*, 303–310.

Filloux, J.H. (1982), *Tsunami recorded on the open ocean floor*, Geophys. Res. Lett., *9* (1), 25–28.

Ford, M., Becker, J.M., Merrifield, M.A. and Song, Y.T. (2014), *Marshall Islands fringing reef and atoll lagoon observations of the Tohoku tsunami*, Pure Appl. Geophys. (this issue); doi:10.1007/s00024-013-0757-8.

Heidarzadeh, M., and Satake, K. (2014a), *Excitation of basin-wide modes of the Pacific Ocean following the 11 March 2011 Tohoku tsunami*, Pure Appl. Geophys. (this issue); doi:10.1007/s00024-013-0731-5.

Heidarzadeh, M., and Satake, K. (2014b), *The El Salvador and Philippines tsunamis of August 2012: insights from sea level data analysis and numerical modeling*, Pure Appl. Geophys. (this issue); doi:10.1007/s00024-014-0790-2.

Kaistrenko, V. (2014), *Tsunami recurrence function: structure, methods of creation, and application for tsunami hazard estimates*, Pure Appl. Geophys. (this issue); doi:10.1007/s00024-014-0791-1.

Kanamori, H. (1972), *Mechanism of tsunami earthquakes*, Phys. Earth Planet. Inter., *6*, 346–359.

Kanamori, H. and Yomogida, K. (2011), *First results of the 2011 Off the Pacific Coast of Tohoku earthquake*, Earth, Planets Space, *63*, 511–902.

Kawaguchi, K., Kaneda, Y., Araki, E. et al. (2012), *Reinforcement of seafloor surveillance infrastructure for earthquake and tsunami monitoring in western Japan*, Proceed. Oceans2012 Mts/Ieee Yeosu, May 21–24, 2012. Yeosu, Republic of Korea.

Kim, Y.T. and Whitmore P. (2014), *Relationship between maximum tsunami amplitude and duration of signal*, Pure Appl. Geophys. (this issue); doi:10.1007/s00024-013-0674-x.

Leonard, L. and Bednarski, J. (2014*), Field survey following the 28 October 2012 Haida Gwaii tsunami*, Pure Appl. Geophys. (this issue); doi:10.1007/s00024-014-0792-0.

Matsumoto, H., and Kaneda, Y. (2013), *Some features of bottom pressure records at the 2011 Tohoku earthquake—Interpretation of the far-field DONET data*. Proceed. 11th SEGJ Intern. Symp.

Mofjeld, H.O. (2009), *Tsunami measurements*. In: *The Sea, Vol. 15, Tsunamis*, A.Robinson, E.Bernard (Eds.). USA, Harvard University Press, Cambridge, p.201–235.

Mori, J. and Eisner, R. (2013), *2011 Tohoku-Oki Earthquake and Tsunamis*, Earthquake Spectra, *29*(S1), vii-S499, Special issue.

Nosov, M., Bolshakova, A., and Kolesov, S. (2014), *Displaced water volume, potential energy of initial elevation and tsunami intensity: analysis of recent tsunami events*, Pure Appl. Geophys. (this issue); doi:10.1007/s00024-013-0730-6.

Nyland, D. and Huang, P. (2014), *Forecasting wave amplitudes after the arrival of a tsunami*, Pure Appl. Geophys. (this issue); doi:10.1007/s00024-013-0703-9.

Okada (1985), *Surface deformation due to shear and tensile faults in a half-space*. Bull. Seism Soc. Amer., *75*(4), 1135–1154.

Pararas-Carayannis, G. (2014), *The Great Tohoku-Oki earthquake and tsunami of March 11, 2011 in Japan: A critical review and evaluation of the tsunami source mechanism*, Pure Appl. Geophys. (this issue); doi:10.1007/s00024-013-0677-7.

Rabinovich, A.B. (2014), *Tsunami observations in the open ocean*, Atmosph. Oceanic Physics, *54* (5) (in press).

Rabinovich, A.B., Thomson, R.E., and Fine, I.V. (2013), *The 2010 Chilean tsunami off the west coast of Canada and the northwest coast of the United States*. Pure Appl. Geophys. *170*, 1529–1565; doi:10.1007/s00024-012-0541-1.

Razjigaeva, N.G., Ganzey, L.A., Grebennikova, T.A., Ivanova, E.D., Kharlamov A.A., Kaistrenko, V.M., and Shishkin, A.A. (2013), *Coastal sedimentation associated with the Tohoku tsunami of 11 March 2011 in South Kuril Islands, NW Pacific Ocean,* Pure and Applied Geophysics, *170*, 1081–1102.

Razjigaeva, N.G., Ganzey, L.A., Grebennikova, T.A., Ivanova, E.D., Kharlamov, A.A., Kaistrenko, V.M., Arslanov, Kh.A., and Chernov, S.B. (2014), *The Tohoku tsunami of 11 March 2011: The key event to understand tsunami sedimentation on the coasts of closed bays of the Lesser Kuril Islands*, Pure Appl. Geophys. (this issue); doi:10.1007/s00024-014-0794-y.

Rodkin, M.V., and Tikhonov, I.N. (2014), *Seismic regime in the vicinity of the 2011 Tohoku mega earthquake (Japan, Mw = 9)*, Pure Appl. Geophys. (this issue); doi:10.1007/s00024-013-0768-5.

Satake, K., Okal, E.A. and Borrero, J.C. (2007), *Tsunami and its Hazards in the Indian and Pacific Oceans*, Pure Appl. Geophys., *164*, Topical Issue.

Satake, K., Rabinovich, A.B., Kânoğlu, U. and Tinti, S. (2011a), *Tsunamis in the World Ocean: Past, Present, and Future. Volume I*, Pure Appl. Geophys., *168* (6-7), Topical Issue.

Satake, K., Rabinovich, A.B., Kânoğlu, U. and Tinti, S. (2011b), *Tsunamis in the World Ocean: Past, Present, and Future. Volume II*, Pure Appl. Geophys., *168* (11), Topical Issue.

Satake, K., Rabinovich, A.B., Dominey-Howes, D., and Borrero, J.C. (2013a), *Historical and Recent Catastrophic Tsunamis in the World: Volume 1. The 2011 Tohoku tsunami*, Pure Appl. Geophys., *170* (6–8), Topical Issue.

Satake, K., Rabinovich, A.B., Dominey-Howes, D., and Borrero, J.C. (2013b), *Historical and Recent Catastrophic Tsunamis in the World: Volume 2. Tsunamis from 1755 to 2010*, Pure Appl. Geophys., *170* (9–10), Topical Issue.

Satake, K., Fujii, Y., Harada, T., and Namegaya, Y. (2013c), *Time and space distribution of coseismic slip of the 2011 Tohoku earthquake as inferred from tsunami waveform data*, Bull. Seism. Soc. Amer., *103*, 1473–1492.

Sato, S. (2012), *Special Anniversary Issue on the 2011 Tohoku earthquake tsunami.* Coastal Engineering Journal, 54 (1).

Sato, S., Okayasu, A., Yeh, H., Fritz, H.M., Tajima, Y., and Shimozono, T. (2014), *Delayed survey of the 2011 Tohoku Tsunami in the former exclusion zone in Minami-Soma, Fukushima Prefecture*, Pure Appl. Geophys. (this issue); doi:10.1007/s00024-014-0809-8.

Shevchenko, G., Ivelskaya, T., and Loskutov, A. (2014), *Characteristics of the 2011 Great Tohoku tsunami on the Russian Far East coast: Deep-water and coastal observations*, Pure Appl. Geophys. (this issue); doi:10.1007/s00024-014-0727-1.

Shimozono, T., Cui, H., Pietrzak, J.D., Fritz, H.M., Okayasu, A., and Hooper. A.J. (2014), *Short wave amplification and extreme runup by the 2011 Tohoku tsunami*, Pure Appl. Geophys. (this issue); doi:10.1007/s00024-014-0803-1.

Thomson, R., Fine, I., Rabinovich, A., Mihály, S., Davis, E., Heesemann, M., and Krassovski, M. (2011), *Observation of the 2009 Samoa tsunami by the NEPTUNE-Canada cabled observatory: Test data for an operational regional tsunami forecast model*, Geophys. Res. Lett., *38*, L11701, doi:10.1029/2011GL046728.

Titov, V.V. (2009), *Tsunami forecasting*. In: *The Sea, Vol.15, Tsunamis*, Eds.: A. Robinson, E. Bernard, Harvard Univ. Press, Cambridge, p. 371–400.

Tsuji, Y., Satake, K., Ishibe, T., Harada, T., Nishiyama, A., and Kusumoto, S. (2014), *Tsunami heights along the Pacific coast of northern Honshu from the 2011 Tohoku and past great earthquakes*, Pure Appl. Geophys. (this issue); doi:10.1007/s00024-014-0779-x.

Wei, Y., Titov, V.V., Newman, A.V., Hayes, G.P., and Tang, L. (2014), *Seismic regime in the vicinity of the 2011 Tohoku mega earthquake (Japan, Mw = 9)*, Pure Appl. Geophys. (this issue); doi:10.1007/s00024-014-0xxxxx.

Zhou, H., Wei, Y., Wright, L., and Titov, V.V. (2014), *Waves and currents in Hawaii waters induced by the dispersive 2011 Tohoku tsunami*, Pure Appl. Geophys. (this issue); doi:10.1007/s00024-014-0781-3.

(Received June 26, 2014, accepted June 27, 2014)