2

Trends and Problems of Seismological Research in Japan in Light of Two Major

Shozo MATSUMURA
Affiliated Researcher

1 Introduction

The two earthquakes to which the title refers are the 1995 Great Hanshin-Awaji Earthquake (M7.3, 6,437 dead and missing) and the Great East Japan Earthquake (M9.0, approximately 20,000 dead and missing). When we look back on past earthquakes in Japan, including these two, Japan has experienced thirty-one earthquakes that left ten or more dead and missing in the 20th century, occurring at an average interval of 3.2 years. In the first eleven years of the 21st century, Japan was struck by four such earthquakes that indicate the pace is not slowing: the 2004 Chuetsu Earthquake, the 2007 Chuetsu Offshore Earthquake, the 2008 Iwate-Miyagi Inland Earthquake and the 2011 Great East Japan Earthquake. In other words, if a warning had been issued that an earthquake like these would strike somewhere in Japan about once every three years, then it would have been correct. This prediction may or may not be valid in the future. Assuming that it will, its effectiveness would be ironic compared to earthquake predictions for specific areas, which are rarely accurate. This is because while we cannot stop earthquakes from happening, we can act to limit the extent of the damage they cause.

The orientation and structure of Japanese seismological research underwent major change after the Great Hanshin-Awaji Earthquake. Even so, this latest disaster has again instigated change in the field; but in what way?

It just so happens that this shift has been spelled out in the 4th Science and Technology Basic Plan (adopted by a cabinet decision on August 19th, 2011).[1] This document acknowledges that, based on the disaster and nuclear accident, the country's risk management was insufficient and that an issue to tackle will be how to educate the public about science and technology and restore their trust in it. The plan also calls for the promotion of initiatives such as research and development to enhance our ability to respond to natural disasters and keep the public safe.

This paper reflects on the implications the Great East Japan Earthquake has for seismology, while also considering the state of seismological research in Japan in a comparison to the United States that is based on the number of and trends concerning their seismological societies' research presentations.

2 The Great East Japan Earthquake

2-1 An Overview of the Earthquake

At 2:46 p.m. on March 11th, 2011, a massive M9.0 earthquake struck under the Pacific Ocean, affecting an area from Tohoku to Kanto. (The earthquake was officially named the "2011 Earthquake off the Pacific Coast of Tohoku" by the Japan Meteorological Agency). This was the strongest earthquake ever recorded in Japan. There were roughly 20,000 dead and missing due to the seismic intensity and the tsunami that followed.

This earthquake was caused by sliding along the boundary between the Pacific Plate, which is subducting under the Japan Trench, and the continental plate atop which sits the Tohoku region. Figure 1 shows the distribution of slippage on the fault plane, based on an analysis of data from the GEONET ground-based GPS observation network conducted by the Geographical Survey Institute of Japan (GSI) the day after the earthquake.[2] The slippage is centered around the epicenter in the waters off the Miyagi Prefecture. A 500 km x 200 km area around the focal region experienced slippage of up to 24 meters, stretching from off the Iwate Sanriku coast to off the coasts of Miyagi, Fukushima and Ibaraki prefectures.

Whereas the Great Hanshin-Awaji Earthquake occurred along an active fault below an urban area, this latest earthquake struck at a plate boundary along an ocean trench. Thus, two different types of major earthquakes struck in a sixteen-year timeframe.

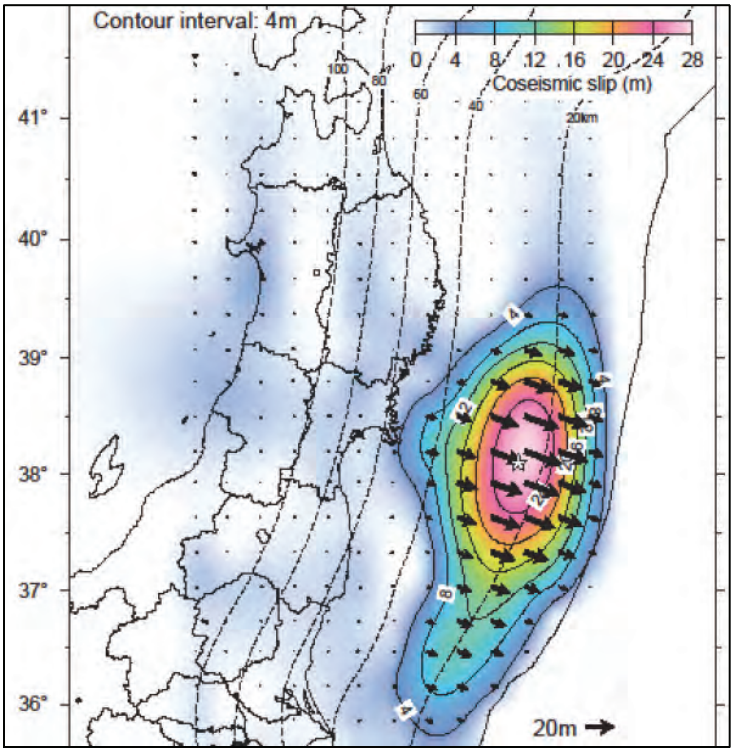

Figure 1 : Distribution of Slippage on Plate Boundary

Source: GSI[2]

2-2 Prior Prediction

The Headquarters for Earthquake Research Promotion (HERP) established by the government after the Great Hanshin-Awaji Earthquake conducted earthquake likelihood assessments off eastern Japan's Pacific coast prior to the Great East Japan Earthquake.[3] Beginning with the assessment report on seismic activity off the coast of Miyagi Prefecture released in November 2000, HERP has divided the area into eight zones (see Figure 2; A: North off-Sanriku, B: Central off-Sanriku, C: Off-Miyagi Prefecture, D: Off-Fukushima Prefecture, E: Off-Ibaraki Prefecture, F: Off-Boso, G: South off-Sanriku Japan Trench Approach, H: North off-Sanriku to off-Boso Japan Trench Approach). Except for zones B and F, HERP released figures on the likelihood of earthquakes occurring over the next thirty years in each zone and their predicted magnitude (referred to as a "characteristic earthquake" if the focal region can be pinned down). Earthquake likelihoods are updated annually. Figure 2 shows thirty-year probabilities as of January 1, 2011.

By comparing Figures 1 and 2, we see that the recent earthquake was due to sudden slippage in six of the eight zones (B, C, D, E, G and H inside the oval in Figure 2). Looking at the historical record, we find no past combination of an earthquake and tsunami in this area like this one. The focal region of the Meiji-Sanriku Tsunami Earthquake that struck in June 1896 (M8.2) was off the coasts of Iwate and Miyagi prefectures, near the Japan Trench, which corresponds to Zone H in Figure 2. The maximum run-up height of this earthquake's tsunami was estimated at 38.2 meters and it killed 22,000 people. Although this earthquake was not as strong as the M9.0 Great East Japan Earthquake, the tsunami magnitude (Mt) was of comparable scale, measured at the maximum value of 9.0.[4] Furthermore, there was a series of M7-M8 seismic events in zones E, H, C and G (in that order) during a year-and-a-half period in 1896 and 1897, before and after the Meiji-Sanriku Tsunami Earthquake. This was caused by slippage occurring over a relatively short period of time, much of which had a focal region over the edge of the Pacific Plate.

So can we say that the Great East Japan Earthquake is a recurrence of what happened 120 years before? From a seismological point of view, the successive slippage in each zone's focal region occurring 120 years ago is completely different from the simultaneous slippage that happened within a few minutes this time. The total moment magnitude (Mw) (the simple arithmetic sum of the energy released) of these characteristic earthquakes, etc. is only Mw8.4, whereas the Great East Japan Earthquake's was M9.0, or about ten times more energy. Furthermore, if the Pacific Plate subducts at a speed of around 8 cm a year, then it cannot amass slippage of more than 24

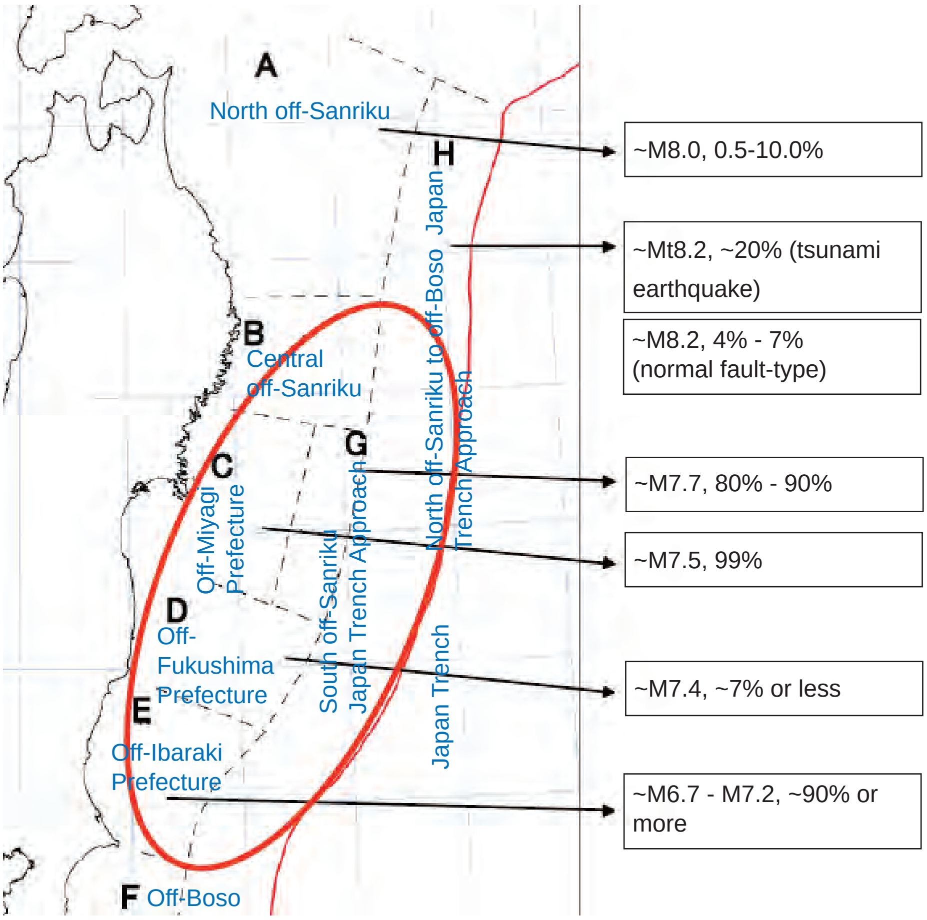

Figure 2 : Seismic Zones and Earthquake Likelihood Predictions Released by HERP
Figure shows predicted magnitudes and 30-year likelihoods.

Compiled by STFC based on HERP materials[3]

meters over 120 years. Accordingly, it is incorrect to view this earthquake merely as one of a series of "interconnected earthquakes" shown in Figure 2. Thus, we are forced to rethink how earthquakes in this area occur.

Prior predictions had assumed an M7 or M8 earthquake would hit off the coast of Miyagi Prefecture in the near-future. However, it was not thought that an M9 earthquake would occur in this area. The basis for this was taken from the conjecture in "Comparative Study of Subduction" as pointed out by Shimazaki(2011)[5]. Ruff and Kanamori (1983)[6] provided two parameters for earthquake size in a subduction zone: subduction speed and plate age. Applying this theory, we can estimate that the typical magnitude of earthquakes occurring off the Sanriku coast is around M8.1. Sumatra was similar. However, both the 2004 Sumatra-Andaman Earthquake and the Great East Japan Earthquake were actually M9. We can now say that there is a problem with the hypothesis.

There is nothing odd about testing whether a theory's hypothesis corresponds to reality and then switching to another theory. Five M9 earthquakes have occurred along the Pacific Rim in the past half-century. Thus, a cool-headed analysis would find an M9 earthquake hitting the coast of Japan as unsurprising. In a sense, the problem now is that a leading theory deprived us of the freedom to come up with other ideas. It is perfectly normal in science to weed out any number of hypotheses as we make scientific advances. However, seismology has another dimension in that it has the worrying problem of its hypotheses being directly related to people lives. Although we should avoid coming to fast conclusions, the public needs to recognize or prepare to accept the fact that, to say the least, the researchers' work does not always have beneficial effects.

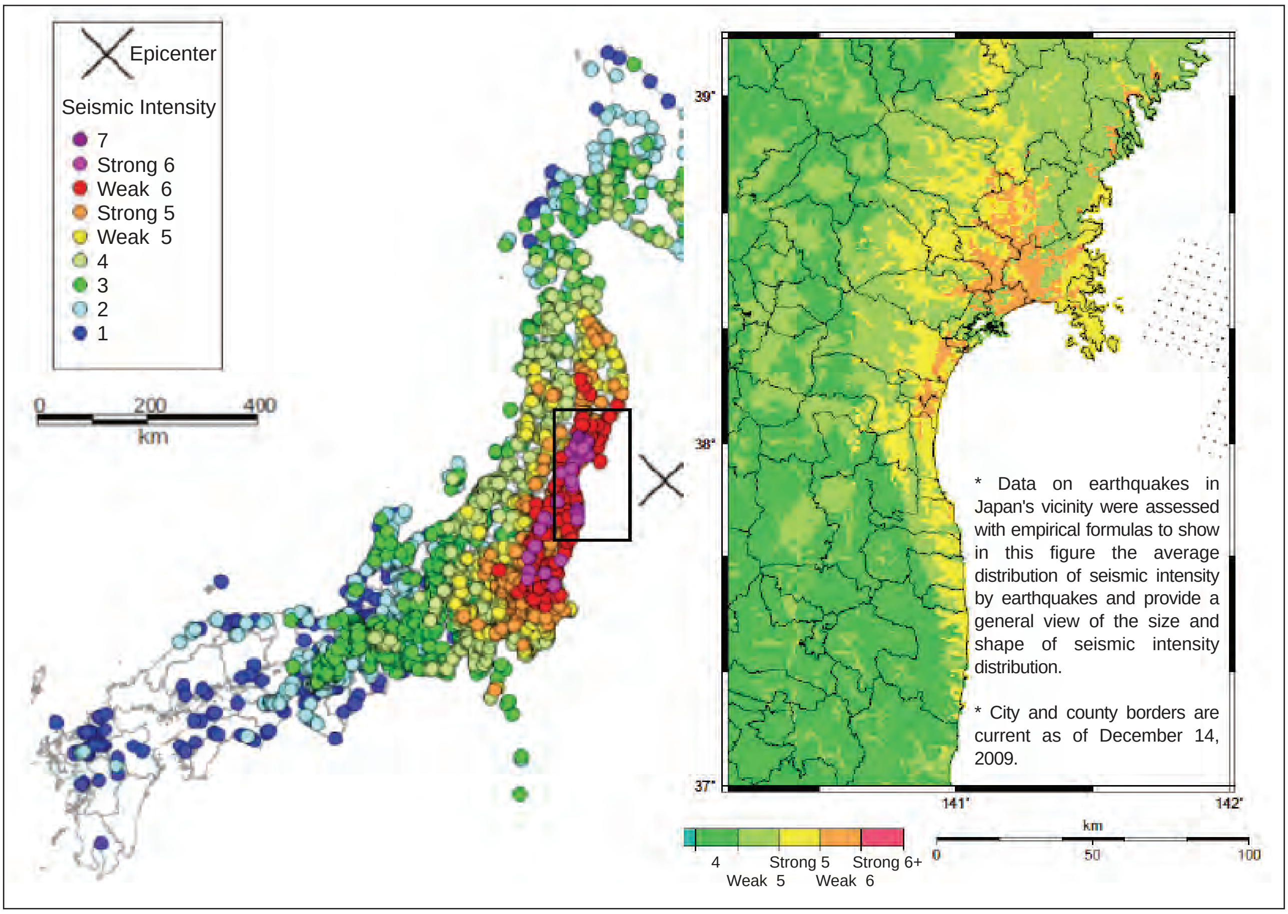

Figure 3 : Distribution of Seismic Intensity from Great East Japan Earthquake (left) and Predicted Distribution along Miyagi Prefecture Coast (right)

Sources: HERP[7], Association for the Development of Earthquake Prediction

2-3 Research on Off Miyagi Prefecture Earthquakes

Figure 3 compares the distribution of HERP's[7] seismic intensity predictions for earthquakes off the coast of Miyagi Prefecture (Zones C and G from Figure 2; right side of figure) and the distribution of observed seismic intensity from actual earthquakes (left side of figure; based on data from the Association for the Development of Earthquake Prediction). While the left side of the figure shows a wide area around Miyagi Prefecture experiencing seismic intensity of at least 6-lower, the hazard map on the right only labels an area with seismic intensity of at least 6-lower on part of the Kitakamigawa watershed and the coast of Sendai Bay, demonstrating a major discrepancy between assumptions explained in the previous section and reality.

However, this does not mean that HERP's assumptions were meaningless. At the least they created a sense of danger over an imminent major earthquake off the coast of Miyagi Prefecture. It is not easy to examine to what extent these assumptions reduced the actual damage caused by the Great East Japan Earthquake, but because of them, earthquake resistance measures were promoted in and around the City of Sendai. It would be hard not to imagine that these efforts paid off.

In addition, HERP started up a priority survey and observation project, the "Priority Survey and Observation of Off-Miyagi Prefecture Earthquakes,"which involved five years of comprehensive surveys and analysis from 2005 to 2009. The project was conducted by up to fifty-nine researchers and produced a lengthy 411-page final report. A notable part of the report is one that lists three major tsunamis: the 869 Jogan Tsunami, the 1611 Keicho Tsunami and the 1793 Kansei Tsunami. The report states that giant tsunamis like these reoccur every 450 to 800 years or so. Considering that most of the casualties as well as the problems caused by the nuclear power plant accident were caused by the tsunami, it is truly unfortunate that the timely insight obtained through this project was not adequately utilized before the disaster.

Although the timing of this major disaster was unfortunate, the policy and research project conducted by HERP, a government organization established as a response to the Great Hanshin-Awaji Earthquake,

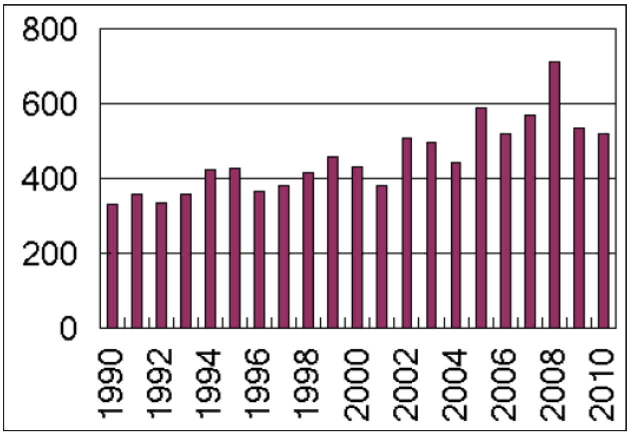

Figure 4 : Number of Presentations at SSJ Fall Meetings
Compiled by STFC

is fundamentally "mission-oriented" research with clearly defined goals. So just what path did the orientation of the scientists' research take after the Great Hanshin-Awaji Earthquake?

3 Trends in Japanese and U.S. Seismological Societies

This chapter examines seismological societies in Japan and the United States to compare the orientation of research conducted by scientists from each. First, we will look at seismological research trends by focusing on papers presented by the Seismological Society of Japan (SSJ). Although the SSJ does not provide a view of the field in its entirety, most Japanese seismologists are members, making it valid as the most comprehensive place relating, at the least, to seismological research as physical science in Japan.

An important point about the SSJ is that while it is a single society, there is no substantive force holding its membership together. In other words, individual society members decide what papers to present; the orientation these papers take does not reflect any particular intent of the society. However, as a result of this, the publications provide an objective look at the field's overall research trends at the time.

The SSJ normally announces papers semiannually at its spring and fall meetings, but since 1990 the spring meeting has been a joint event with other geophysical societies: the Society of Geomagnetism and Earth, Planetary and Space Sciences (SGEPSS) and the Volcanological Society of Japan (VSJ). Thus, only the fall meetings were the subject of the below research.

3-1 Japanese Seismological Research Before and After the Great Hanshin-Awaji Earthquake

The deaths of more than 6,400 people killed by the Great Hanshin-Awaji Earthquake in 1995 were a powerful shock to the entire field of seismology at the time. The Headquarters for Earthquake Prediction Promotion, a group within the Science and Technology Agency, (now the Ministry of Education, Culture, Sports, Science and Technology) was reorganized into the Headquarters for Earthquake Research Promotion, drawing up seismic intensity hazard maps for all of Japan as reported earlier in Science & Technology Trends.[8] Seismological societies corrected what had been an excessive importance placed on studying earthquake prediction and directed the basic focus of research on applying physical science to reveal earthquake mechanisms.

Figure 4 shows the number of paper presentations at the fall meeting over the past twenty years. Since the number of presentations permitted for each member per meeting is limited, we can consider these figures as being roughly proportionate to the total number of researchers. Although there was not a sudden increase due to the Great Hanshin-Awaji Earthquake, we can surmise that there has been a steady rise in the number of seismologists (including university students). It should be noted that the sudden protrusion in 2008 was due to a joint meeting with an international society.

The issue is not how many papers there are, but what they are about and their orientation. The author has tried categorizing the papers based on their titles, as he believes that one can figure out the research's orientation from the title. Figure 5 is a comparison of the meeting prior to the Great Hanshin-Awaji Earthquake (fall 1994)[9] and the fall 2010 meeting[10] sixteen years later. The figure gives the name of each meeting session and the number of papers presented. Other than the special sessions in the lower part of each list, many names of sessions in the two academic years have not changed at all. Of course, the content of each kind of research develops year-by-year while surely some sessions adopt very different styles. However, the point here is not how much seismology has changed scientifically, but whether the orientation of individual scientists' research is incorporating the mission since the Great Hanshin-Awaji Earthquake and whether this indicates that the trend within the society as a whole is changing direction. To discuss

1994 (Fukuoka)	
Crustal and Ground Structures	23
Crustal Movements	17
Seismic Activity and Earthquakes in General	44
Focal Mechanisms	34
Seismic Waves and Theory	16
Ground Movement and Earthquake Damage	25
Historical Earthquakes	7
Tectonics and Seismotectonics	30
Earthquake Prediction	11
Geochemistry and Underground Water	5
Active Faults, Gravity and Planets	18
Rock Failure and Stress	8
Inner Earth Structures, Physical Properties and Thermology	24
Tsunami and Magnitude	12
Measurement and Processing Systems	19
Numerical Waves and Strong Motions	46
Inland Earthquakes	33
Volcanic Tremors	25
The Unzen Volcano	13
Bolivian Deep Earthquakes	14
Total	424

2010 (Hiroshima)	
Crustal Structures	37
Crustal Movements, GPS and Gravity	44
Seismic Activity	35
Earthquakes in General, etc.	13
Earthquake Theory and Analytical Methods	21
Ground Structures and Movements	32
Geothermics	1
Tectonics	8
Earthquake Prediction	17
Geochemistry and Underground Water	2
Active Faults and Historical Earthquakes	15
Rock Experiments and Ground Stress	9
Deep Structures and Physical Properties of the Earth and Other Planets	16
Tsunami	17
Earthquake Measurement and Processing Systems	12
Strong Motions and Earthquake Damage	48
Various Earthquake-related Phenomena	4
New Seismic Waveform Anatomy	49
The Physics of Earthquake Occurences	54
Challenges in Studying Changing Topography: From Active Faults to Seismic Motions	13
Towards the Construction of Earthquake Prediction Systems Based on Seismic Activity Assessments	21
The Philippine Sea Plate and the Japanese Archipelago: From Earthquakes and Volcanoes to Land Formation Theory	40
Memorial Lectures	3
Earthquake Education and the History of Seismology	7
Total	518

Figure 5 : Session Names and Number of Presentations at SSJ Fall Meetings (1994 & 2010)

Compiled by STFC

them the author has, albeit somewhat arbitrarily, inferred the research topics from individual paper titles and classified them into four categories (1: academic and physical science research on the structure of the Earth's crust, earthquake mechanisms, etc.; 2: earthquake prediction/forecasting; 3: seismic intensity assessment and damage prediction; 4: other). These categories are no more than comparative classifications based on the author's impressions. In addition, these categories were made with the following section's comparison with American seismological societies in mind.

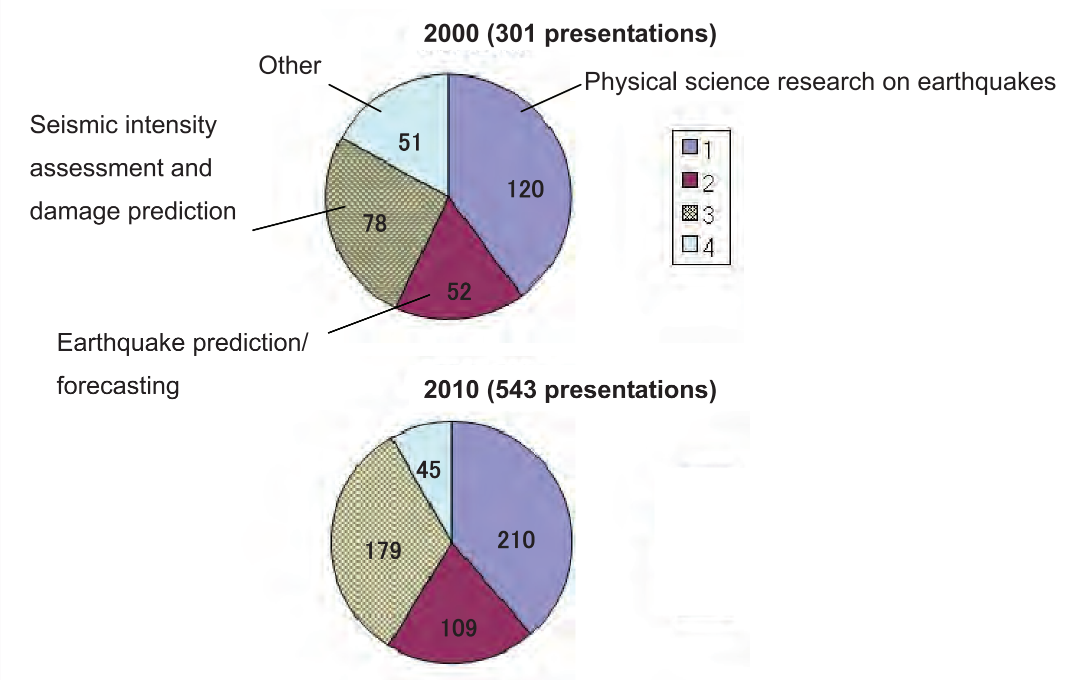

Figure6 : SSJ Presentation Themes Based on Presentation Titles
Figures are number of presentations

Compiled by STFC

3-2 Comparison between Japan and U.S. Seismological Societies

The author also used the categories to make a comparison with the Seismological Society of America (SSA). The U.S. west coast experienced a series of medium-strength earthquakes around twenty years ago: the Loma Prieta Earthquake in 1989 (M6.9, sixty-three dead), the Landers Earthquake in 1992 (M7.3, 400 hurt) and the Northridge Earthquake in 1994 (M6.7, fifty-seven dead). The author examined papers presented thereafter in 2000[11] and 2010[12] at regular meetings. The number of papers was 301 and 543, respectively, displaying a large increase that fairly rivals Japan's in recent years. Furthermore, the session names are listed in Figures 7 and 8. The author made literal Japanese translations of the titles himself in the original Japanese version of this paper. The SSA uses long session names and never uses a name more than once. In the U.S., one feels that session names have a “mission orientation” to clarify the goals and meaning of the research.

It is impossible to clearly judge from session names and presentation titles alone whether there is a mission orientation extending to the substance of the research. Rather, perhaps it is commonly thought that there are no national or other differences in the way that fundamental research is conducted. However, although these are differences on the surface, we cannot dismiss the impression that there are differences in research orientation and attitude.

Figure 9 is the result of a comparison of presentation titles, categorized by subject area, between 2000 and 2010. Although the classification is simple and subjective, there is a clear difference between Japan and the U.S. when we compare it to Figure 6. In the U.S., the second and third subject areas together make up around 50% of the total. Figure 10 contains excerpts from each seismological society’s website stating the purpose or intent for their establishment. Keeping in mind the analysis and results presented in this section, as we read them we notice that the American society expresses more strongly how its intentions relate to the wider society.

3-3 The Meaning Expressed by “Implication”

The results of the comparison between session names and presentation titles by the Japanese and American seismological societies show that there is a weak sense of mission in research by Japanese scientists. In fact, the author has one more reason for having this impression. Non-Japanese papers frequently use the term “implication” in their titles and introductions. The dictionary definition in Japanese is gan’i, a word that Japanese find somewhat difficult to use. However, this word does more than simply accurately convey the content and results of research; it emphasizes the

2000 SSA Meeting (San Diego, California)	
Recent Topical Earthquakes	25
The Interface between Engineers and Seismologists	14
Earthquakes in General	11
CTBT Monitoring and the Global Seismic Network	40
3D Imaging of the Earth's Crust	20
Accounting for Site Effects in Probabilistic Seismic Hazard Analysis	36
Near-surface Geophysical Imaging	14
Seismology in Education	13
Seismology and the NSF Earthscope Initiative	14
"Terra Scale" Computing and Earthquake Science	10
Interfacing Seismology with Other Geophysical Disciplines	9
Combined Use of Seismic and Geodetic Data	19
Seismic Arrays of the Future: "Zero Maintenance" Stations/New Technology and Telemetry	16
Seismic Events through the Ages	26
Seismology and Volcanoes	6
Seismic Structures, Big and Small	11
Strong Motions and Probabilistic Seismic Hazards	17
Total	301

Figure 7 : SSA Session Names and Number of Presentations (2000)

Compiled by STFC

2010 SSA Meeting (Portland, Oregon)	
Building Code Uses of Seismic Hazard Data	10
Monitoring for Nuclear Explosions	34
Characterizing the Next Cascadia Earthquake and Tsunami	17
Magnitude Scaling and Regional Variation of Ground Motion (jointly sponsored by the European Seismological Commission)	24
Advances in Seismic Hazard Mapping	23
The Evolution of Slow Slip and Tremor in Time and Space	21
Seismic Imaging: Recent Advancement and Future Directions	19
Engaging Students and Teachers in Seismology: In Memory of John Lahr	11
Joint Inversion of Multiple Geophysical Data Sets for Seismic Structure	6
Ground Motion: Observations and Theory	4
Seismological Methods: Techniques and Theory	8
Numerical Prediction of Earthquake Ground Motion	37
The Seismo-Acoustic Wavefield: Fusion of Seismic and Infrasound Data	21
Operational Earthquake Forecasting	18
Near-Surface Deformation Associated with Active Faults	27
Quantification and Treatment of Uncertainty and Correlations in Seismic Hazard and Risk Assessments	15
Earthquake Debates	12
Seismic Structure and Geodynamics of the High Lava Plains and Greater Pacific Northwest	16
Deterministic Simulated Ground Motion Records under ASCE 7-10 as a Bridge Between Geotechnical and Structural Engineering Industry	12
Recent Advances in Source Parameters and Earthquake Magnitude Estimations	24
Local Observations of the January 12, 2010 Haiti Earthquake (Mw7.0)	1
The January/February 2010 Earthquakes in Haiti, Offshore Northern California, and Chile: Origins, Impacts and Lessons Learned	38
Volcanic Plumbing Systems: Results, Interpretations and Implications for Monitoring	19
Subsurface Imaging for Urban Seismic Hazards at the Engineering Scale	23
State of Stress in Intraplate Regions	19
Statistics of Earthquakes	15
Seismology of the Atmosphere, Oceans, and Cryosphere	12
At the Interface Between Earthquake Sciences and Earthquake Engineering in the Pacific Northwest	9
Seismicity and Seismotectonics	18
Time Reversal in Geophysics	11
Seismic Hazard Mitigation Policy Development and Implementation	7
Seismic Networks, Analysis Tools, and Instrumentation	12
Total	543

Figure 8 : SSA Session Names and Number of Presentations (2010)

Compiled by STFC

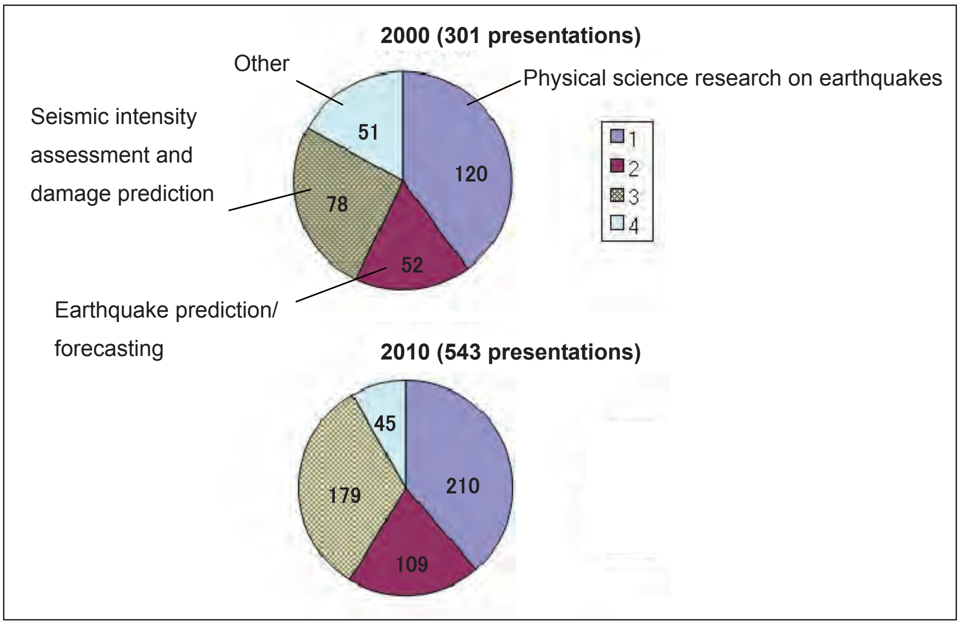

Figure 9 : SSA Presentation Themes Based on Presentation Titles
Figures are number of presentations

Compiled by STFC

SSJ's Mission Statement:	The objective of the SSJ is the development and expansion of seismology and to contribute to the growth of scholarship in Japan through partnerships with related academic societies in Japan and abroad as well as the exchange of knowledge and publication of research on science and practical uses concerning seismology (SSJ homepage[13]).
SSA's Mission Statement:	The Seismological Society of America (SSA) is an international scientific society devoted to the advancement of seismology and its applications in understanding and mitigating earthquake hazards and in imaging the structure of the earth (SSA homepage[14]).

Figure10 : Japan and U.S. Seismological Society Mission Statements

Source: References[13,14]

tenor that conveys the strong intent of the author. If Japanese people use the term "implication" in few of their research presentations, is it simply a difference in vocabulary usage? But the author would dare to say, in recognition of the risks involved in making sweeping generalizations, that when selecting topics for research presentation, Japanese researchers do not have a strong-willed attitude on the position that they want their research to promote: what the purpose is, what they want to emphasize.

After the Great East Japan Earthquake, the Asahi Shimbun[15] newspaper printed the following critique: "[Japanese] seismologists put all their effort in examining the epicenter." One could dismiss this as a careless generalization, but in fact, the author feels the same way. There is no mistake that analyzing the characteristics of the epicenter is a basic part of seismological research, and that it certainly opens the way to follow-up research on earthquake disaster prevention. However, on the other hand, one often wants to press the question, "I see. Now we have a good understanding of the epicenter's characteristics... So, with that information, what does that tell us about what do next?" Presenters may not give thought to stating the purpose of their research, but it is not always obvious to the audience.

4 Observations

From a layman's point of view, seismology is more than just a field within earth science: it is a way to confront the threats that nature poses to our lives. This means that we should think of seismology's goal as being earthquake and earthquake damage prediction – the second and third categories discussed in the preceding chapter. The end goal of the first category, academic and physical science research, has always been earthquake prediction. There was nothing mistaken about shifting from an overemphasis on phenomenological earthquake prediction research, which was popular until the Great Hanshin-Awaji Earthquake, to a return to basics by using physical science to reveal earthquake mechanisms, and this line of thought is still valid. However, no matter how much we discover about their mechanisms and make advances in earthquake-related physical science, that alone will not automatically help us prevent damage caused by actual earthquakes. To take this point a step further, if we study nature through physical science, there is a tendency to become fixated on the study itself. Considering only the current situation, it is difficult to say the effects that major earthquakes have had on seismology have resulted in aligning its orientation with the public's expectations.

Since the Great Hanshin-Awaji Earthquake, Japan has constructed a nationwide network for making basic observations of earthquakes and seismic activity and has started up numerous special research projects. The result has been that much seismology has been conducted by joining in project research based on data from this basic observation network. This sort of research was already in a position that needed a sense of mission. But if in spite of this the result has been that SSJ research trends have not experienced significant change following major earthquakes, then what is the reason for this?

The author does not believe that there is a substantive difference between the quality of Japanese and American researchers or in their research ambitions. Furthermore, the author does not doubt that researchers are primarily motivated to study by their strong curiosity about natural phenomena, supported by a sense of mission that tells them to use the results to improve people's lives. However, at the same time the author does very much perceive that professional researchers live in a research setting that establishes their identity. We cannot expect researchers not to care about how their research is evaluated and how those evaluations will affect their futures. In the end, even if they have a sense of mission, the biggest reason why individual researchers take different directions is the way they are evaluated. For example, the study of earthquakes can largely be divided into two kinds of analysis: spatial structure and temporal variation. Since the latter requires the patient accumulation of data over a long span, it is difficult to produce results in a short time. Therefore, the result may be that young researchers distance themselves from research on temporal variation.

Based on the lessons from the Great East Japan Earthquake, HERP will likely take the lead in beginning new mission-oriented research projects at universities and independent administrative institutions. Of course, such new projects have to provide a clear mission to receive funding. However, if the project merely advertises its mission for self-promotion, then that feeling will not automatically be shared by the individual researchers involved. The worry is that if we compare today's SSJ presentations with those given ten years from now, they may produce the same results as today's research. If we require projects to truly have missions, then we will need to consider how to evaluate individual researchers, as well as of course the projects themselves. That is to say, the problem is related to the ability of the people managing research and the task at hand is to ask them to display true leadership.

5 Conclusion

After the Great Hanshin-Awaji Earthquake, Japanese seismology defined its goal as revealing earthquake mechanisms based on physical science. In a sense it can be said that this was a valid goal to set. However, considering the present situation, the result seems to be a divergence opening up between the research's orientation and what the public expects from seismology.

This paper has attempted to speculate on seismological trends in Japan by comparing the differences in how papers are presented in the Japanese and American seismological societies. This research has depended on a good deal of arbitrary and subjective impressions, but it does in fact seem that there is some sort of disparity in researcher attitude and direction in each country and the author has concluded that it is due to the different degree to which they feel a sense of mission. In normal times, the author would also simply regard this as a difference in research culture, and the author is not arguing that Japanese seismology should take on the mission orientation of America's research culture. Be that as it may, the Great East Japan Earthquake is a very serious, abnormal situation, for all of seismology. The author believes that we can no longer allow researchers to stay secluded within their field as they decide on seismology's goals and how to conduct research.

When the 2009 L'Aquila Earthquake (M6.3) struck Italy, the media reported that the authorities accused a local seismologist of not releasing appropriate predictions. This was a symbolic incident showing what seismologists' motivation and intentions are regarding their research as well as the fact that they cannot avoid the direct relationship seismology has on real people's lives.[16] This news also shook the field of Japanese seismology. The excitement pushed the SSJ to issue a statement of protest to the Italian authorities, as Japan's national character makes it difficult for Japanese researchers to imagine such an incident occurring in the first place. However, the author cannot erase his concern over how far the Japanese people will tolerate spending tens of billions of yen every year[17] on earthquake research without producing results that benefit the public. All researchers engaged in seismology should take a second look at their research and consider what the "implications" are.

References

[1] 4th Science and Technology Basic Plan: http://www8.cao.go.jp/cstp/kihonkeikaku/4honbun.pdf

[2] Geographical Survey Institute of Japan homepage: http://www.gsi.go.jp/common/000060400.pdf

[3] Headquarters for Earthquake Research Promotion homepage, Long-Term Ocean Trench Earthquake Evaluation: http://www.jishin.go.jp/main/p_hyoka02_kaiko.html,
Results of Long-Term Active Fault and Ocean Trench Earthquake Evaluations (Calculated on Jan. 1, 2011): http://www.jishin.go.jp/main/choukihyoka/ichiran_past/ichiran20110111.pdf

[4] Katsuyuki Abe, Gekkan Chikyu, Vol.25, No.5, 337-342, 2003.

[5] Kunihiko Shimazaki, Science, May 2011.

[6] Ruff, L. and H. Kanamori, Tectonophysics, 99, 99-117, 1983.

[7] Headquarters for Earthquake Research Promotion homepage:
http://www.jishin.go.jp/main/oshirase/201103111446sanriku-oki.gif
http://www.jishin.go.jp/main/kyoshindo/pdf/20051214miyagi.pdf

[8] Science & Technology Trends, Oct. 2008, No.91, 25-39:
http://www.nistep.go.jp/achiev/ftx/jpn/stfc/stt091j/0810_03_featurearticles/0810fa02/200810_fa02.html

[9] Seismological Society of Japan, 1994 Fall Meeting Lecture Proceedings.

[10] Seismological Society of Japan, 2010 Fall Meeting Lecture Proceedings.

[11] Program for 2000 SSA Annual Meeting: http://www.seismosoc.org/meetings/ssa2000_program.html

[12] Program for 2010 SSA Annual Meeting: http://www.seismosoc.org/meetings/2010/SSA2010ProgramSchedule.pdf

[13] Seismological Society of Japan, "A brief introduction to SSJ" http://www.zisin.jp/modules/pico/index.php?content_id=104

[14] Seismological Society of America homepage: http://www.seismosoc.org/

[15] Asahi Shimbun, Jun. 2, 2011, morning edition.

[16] Koshun Yamaoka, Seismological Society of Japan Newsletter, Vol.23, No.3, 26-29, 2011.

[17] Headquarters for Earthquake Research Promotion News, Feb. 2011: http://www.jishin.go.jp/main/herpnews/2011/feb/herpnews2011feb.pdf

Profile

Shozo MATSUMURA
Affiliated Fellow, NISTEP
Ph. D.

Dr. Matsumura specializes in seismology. His aim is to detect precursory phenomena preceding major earthquakes by observing microearthquakes. He is particularly interested in understanding the conditions of stress redistribution generated by slow slips and quasi-static slips from changes in patterns of seismic activity, with a focus on Tokai earthquakes. He is an Expert Member of the Headquarters for Earthquake Research Promotion.

(Original Japanese version : published in November, December 2011)