Information

■ Information ■

IRIDeS has an exhibition space to introduce our research activities to the public. It is also equipped with the largest 3D screen among Japanese research institutes. Upon request, IRIDeS screens the 3D documentary film “The Great Tsunami in Japan: reflecting on the 2011 disaster” (80min/25min, Japanese/English). The film was produced by NHK Media Technology and supervised by IRIDeS Director and Professor Fumihiko Imamura, to pass on memories and experiences of the Great East Japan Earthquake and Tsunami.

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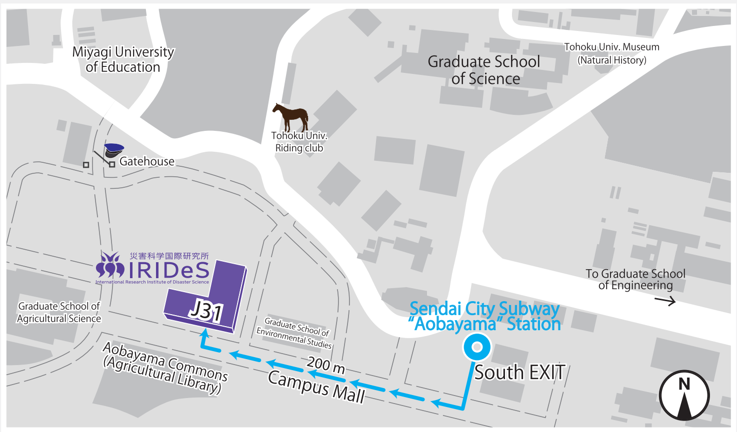

Contact
IRIDeS Public Relations Office
Phone: +81-22-752-2049
Email: koho-office@irides.tohoku.ac.jp

Editor's Note

In 2017, The Graduate School of Agricultural Science moved to the Aobayama New Campus. The Aobayama Commons opened with a library, cafeteria and campus store. The neighborhood of IRIDeS is becoming more and more lively!

(Natsuko Chubachi, IRIDeS Public Relations Office)

Published in March, 2018

Conveying the results of practical disaster prevention research from TOHOKU to the world

IRIDeS NEWS

International Research Institute of Disaster Science Tohoku University

2018

Pick up!

< Feature > The First “World Bosai Forum”

< Academic Research > The Post-seismic Seafloor Deformation Following the 2011 Tohoku-oki Great Earthquake / Collaboration between Tsunami Engineering and Disaster Medical Science

< Feature Photographs > Seven Years of the Areas Affected by the Great East Japan Earthquake

IRIDeS International Research Institute of Disaster Science

Organization
IRIDeS

- Hazard and Risk Evaluation Research Division
- Disaster Medical Science Division
- Human and Social Response Research Division
- Disaster Information Management and Public Collaboration Division
- Regional and Urban Reconstruction Research Division
- Endowed Research Division
- Disaster Science Division
- G-Safety Inter-Graduate School Doctoral Degree Program on Science for Global Safety

Greetings

Director of IRIDeS
Professor Fumihiko Imamura

For a year now, IRIDeS has taken new initiatives: the implementation of a Project Area/Unit System and the hosting of the first "World Bosai Forum." Since the inception of IRIDeS, its researchers have performed academic research work on regional issues and aimed for the study of "practical disaster prevention" through research outcomes that give back to communities. The Project Area/Unit System promotes this objective. Moreover, the World Bosai Forum held last fall invited people from all around the world to discuss their regional problems and take action. Many have high expectations from this—a forum that connects the Tohoku region to the world—and want us to develop it into a cornerstone for Sendai as an international city in the future.

This year, the results of the first World Bosai Forum will be tied to those of the 2018 International Disaster and Risk Conference which is to be held this summer in Davos, Switzerland. I strive to ensure the success of the second World Bosai Forum to be held in 2019 at Sendai.

For its various activities in academia, the arts, and society, IRIDeS has received the 67th Kahoku Culture Award that is given to individuals and organizations that contribute to the development of the Tohoku region. With the expectations inherent in this award, we continue to push forward in fulfilling the responsibilities that we so keenly feel.

July 2018 will mark the 25th anniversary of the Hokkaido Southwest Offshore Earthquake that struck the island of Okushiri. One young researcher who experienced the earthquake as a junior high school student living on the island is now working at IRIDeS. I desire that the younger generation that lived through the Great East Japan Earthquake steps up to help Japan and the world with disaster risk reduction.

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Feature

We Held the First "World Bosai Forum"

What is the World Bosai Forum?

In 2015, at the third UN World Conference on Disaster Risk Reduction held in Sendai, Japan, the "Sendai Framework for Disaster Risk Reduction 2015–2030" was adopted. Japan, who hosted this conference, is expected not only to develop domestic disaster risk reduction policies further but also to strengthen cooperation with the international community, being a strong leader in the implementation of the Sendai Framework for Disaster Risk Reduction.

As part of this plan, the "World Bosai Forum/International Disaster Risk Conference in Sendai" will be held biennially from 2017 onward, in cooperation with the "International Disaster and Risk Conference IDRC Davos" held in Switzerland. Bosai is a traditional Japanese term, indicating a holistic approach to reduce human and economic losses from disasters, which represents activities in all disaster phases, including prevention, mitigation, response and recovery . The World Bosai Forum invites experts from Japan, the international community, and local residents to discuss disaster risk reduction strategies devised by industry, government, academia, and the private sector. The purpose of the forum is to provide an opportunity for people from a wide variety of backgrounds to share the world's latest disaster risk reduction expertise, create specific disaster prevention solutions, and disseminate the lessons learned from the Great East Japan Earthquake to the rest of the world.

World BOSAI Forum
IDRC 2017 in SENDAI

The World Bosai Forum logo is an image of people gathering together and thinking creatively. The 4 colors in the logo symbolize industry, government, academia, and the private sector.

What is the "Sendai Framework for Disaster Risk Reduction"?···It is an agreement indicating the course of action needed to reduce disaster risks worldwide. The United Nations agreed to promote disaster risk reduction according to these international policies from 2015 to 2030. The title of the agreement commemorates "Sendai," the location where the conference was held, by using its name. The specific methods for promoting disaster risk recution efforts were entrusted to all the stakeholders in attendance, with all required to contribute.

How Tohoku University and IRIDeS contributed

Tohoku University and IRIDeS shared responsibility for managing the World Bosai Forum and gave their full-fledged support to organizing the first event. The Director of IRIDeS, Professor Fumihiko Imamura, served as the World Bosai Forum Committee Chairperson, while the President of Tohoku University, Professor Susumu Satomi, served as the Committee President. The World Bosai Forum Secretariat was established within IRIDeS with an IRIDeS Professor Yuichi Ono as the Secretary-General, and they made diligent preparations in cooperation with various related agencies, including the City of Sendai.

The World Bosai Forum Committee···This committee was comprised of Tohoku University, City of Sendai, Miyagi Prefecture, Kahoku Shimpo Publishing Co., the Tohoku Economic Federation, Global Risk Forum GRF Davos, and the Sendai Chamber of Commerce and Industry.

The first World Bosai Forum ended in a great success

The commemorable first World Bosai Forum was held at the Sendai International Center and the Tohoku University Centennial Hall (Kawauchi Hagi Hall) from November 25 to 28 in 2017. Forty-nine sessions and 27 mini-presentations were held, beginning with the "Pre-World Bosai Forum Festival" as a free event, open to the public, held the day before the main sessions started. In addition, there were 93 poster presentations and 12 exhibition booths. Further, while the forum was being held, there was also a field trip excursion to study the disaster areas.

In total, there were 947 registrants, who traveled to participate in the conference from 42 countries and regions. The forum was a great success, with the final number of participants totaling more than 10,000 people, including citizens and stakeholders attending the "Bosai Kokutai," and "the Bosai Industry Fair."

Feature

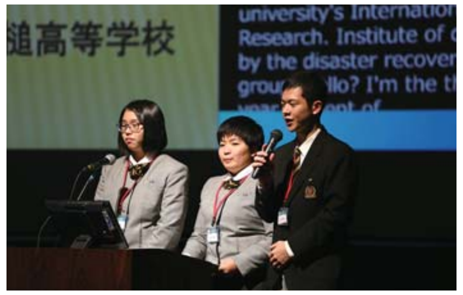
The activities of the first World Bosai Forum and achievements

One of the main characteristics of this World Bosai Forum was the participation of a diverse group of people hoping to gain an understanding of the practical side of disaster risk reduction rather than mere theory. In the section below, the various activities and achievements of the first World Bosai Forum are introduced.

The Pre-World Bosai Forum Festival

Approximately 700 people participated in the opening event "Pre-WBF Festival: Learning from the disaster, bridging to the future" held in partnership with Science Agora. During Part One, the younger generation from Iwate, Miyagi, and Fukushima Prefectures, having experienced disasters, announced serious initiatives aimed at reconstruction and disaster risk reduction. Katsuya Oonishi, the mayor of Kuroshio in Kochi Prefecture, who has advanced their disaster risk reduction strategies preparing for a large Nankai trough earthquake, encouraged the younger generation saying, "Superficial things do not move people. An attitude that is seeking substance brings about the most sympathy and gets the support of others."

Part Two focused on the cultural aspects of reconstruction and disaster risk reduction. There was a demonstration of the gallant traditional art form of the "Namiita Tiger dance," performed by residents of Namiita, Kesennuma (a disaster area), as an expression of gratitude for all the support from within Japan, as well as around the world. The ensemble of the Sendai Philharmonic Orchestra members and a concert by NHK Sendai Boys and Girls Choir impressed everyone with their performances such as "Azure" and "Flowers will Bloom" songs that were filled with hopes of reconstruction.



The left picture
Recovery Study Group students of Iwate Prefctural Otsushi High School

The right picture
The Tiger Dance that empowered people in the reconstruction of disaster areas

Openings

The World Bosai Forum opening ceremony was held separately following the joint opening with "Bosai Kokutai" where the Minister of State for Disaster Management, Hachiro Okonogi, also attended. A university student from Rikuzentakata who had lost her family members due to the Great East Japan Earthquake shared her determination for the future. Thereafter, disaster risk reduction leaders from around the globe gathered, including Robert Glasser, Special Representative of the UN Secretary-General (SRSG) for Disaster Risk Reduction and Head of the United Nations Office for Disaster Risk Reduction. They summarized the state of progress for each of their organizations on the "Sendai Framework for Disaster Risk Reduction." Then they expressed their hopes and expectations of the World Bosai Forum.

Sessions

A wide variety of sessions was held. These sessions included "The knowledge front of disaster risk reduction" (organizer: Elsevier) that clarified the research trends and topics on disaster risk reduction and "Sustainable development thorough DRR Investment" (organizer: JICA) to discuss how to realize pre-investiments for disaster risk recution in developing countries. The kick-off symposium was hosted by Tohoku University as the university has been officially recognized as one of the three designated national universities with its world-class disaster science. In addition, the "The role of ICT in disaster risk Reduction -A session about the envisioned future utilizing Fujitsu's ICT solutions-" (organizer: Fujitsu) talked about how the Global Centre for Disaster Statistics can contribute to the sustainable development goals specified by the UN. Lively discussions about cutting-edge disaster risk reduction topics were held at all of these sessions.

World Bosai Survey

A questionnaire survey related to the Sendai Framework for Disaster Risk Reduction was conducted to participants in the World Bosai Forum, entitled the "World Bosai Survey." The results highlighted some very interesting trends. These included the following: while only 30 percent of the respondents had attended the 3rd UN World Conference on Disaster Risk Reduction, 70 percent of the respondents were aware of the Sendai Framework for Disaster Risk Reduction, and most respondents identified "earthquakes" as the disaster they felt their country was most at risk of experiencing in the future. This survey was conducted to inform global disaster risk reduction policies in the future. It might have been the first disaster risk reduction awareness survey that has ever been conducted on a global level.

The Summary at the Closing Ceremony

Fumihiko Imamura, the World Bosai Forum Committee Chairperson, presented the "Chair's Summary" that compiled the results of the World Bosai Forum. The major talking points were organized into three areas: "science and technology;" "policies and finance;" and "society and culture." In the area of science and technology, major topics discussed were related to cutting-edge scientific technologies for disaster risk reduction, including tsunami simulations, drones, big data analytics, and the application of space technology. Meanwhile, in the area of policies and finance, they discussed the importance of policies and financial supports that are necessary for disaster risk reduction. These were primarily themed around the recovery from the Great East Japan Earthquake, as well as around how to incorporate disaster risk reduction in the sustainable development strategies of developing nations. Finally, in the area of society and culture, topics were discussed such as: the various groups involved in disaster risk reduction activities, their situations, and challenges; the needs of those vulnerable to disasters; and local disaster risk reduction traditions.

Chairperson Fumihiko Imamura pointed out that the simultaneous functioning of these three areas is essential for disaster risk reduction. There is the saying "Disasters strike when they have been forgotten" as recognized by Torahiko Terada. Chairperson Imamura made a pun related to this saying and closed the Forum by stating "As far as we do not forget about disasters, we can handle them."

Moving toward the next World Bosai Forum

During the first World Bosai Forum, diverse participants shared their cutting-edge disaster prevention technologies, science, and knowledge from around the globe, promoting the "Sendai Framework for Disaster Risk Reduction." The Forum also served as the setting for a rich cultural exchange. The plan is to hold the World Bosai Forum biannually while working in cooperation with the International Disaster and Risk Conference IDRC Davos in Switherland. The hope is that each time this forum is held, it will provide a space to share the latest disaster prevention expertise, passing on the Great East Japan Earthquake experiences to the next generation and rest of the world. The lessons learned from the 2011 disaster should not just fade away.

The "Sendai Framework for Disaster Risk Reduction" has made SENDAI a disaster risk reduction keyword that is recognized worldwide. The World Bosai Forums of the future will aim to develop a safer society by joining forces with citizens and specialists from various fields and spreading BOSAI from SENDAI to the rest of the world.

Elucidating the Post-seismic Seafloor Deformation Following the 2011 Tohoku-oki Great Earthquake

Disaster Science Division Professor Motoyuki Kido

Professor Motoyuki Kido of IRIDeS and his team are the first in the world to elucidate the complex movements of the seafloor after the Tohoku-oki great earthquake.

On March 11, 2011, along the Japan Trench—deep in the off-Miyagi Pacific Ocean floor—the plates (bedrock covering the earth's surface) began to move each other, causing a huge earthquake with a magnitude of 9.0. This earthquake, and the resulting tsunami, caused severe destruction, particularly in the Tohoku region. Experts have named the "2011 Tohoku-oki earthquake" as a genuine natural phenomenon. "The Great East Japan Earthquake" is the name of the disaster that caused damage to people and society.

Due to major movements within the Earth, oceanic plates constantly sink into landward plates around Japan. Moreover, due to the friction between the plates while sinking in, strain is built up within the plates; therefore, from time to time, earthquakes occur to release this strain by rupturing the fault. Although the 2011 Tohoku-oki Eq. was also based on this principle, the rupture area of the fault was extremely large ever observed in Japan's history.

The research team of IRIDeS, including Prof. Motoyuki Kido, and Prof. Ryota Hino of the Graduate School of Science, Tohoku University (IRIDeS concurrent faculty) used a special instrument to observe the huge movements at the time of the earthquake. In addition, over the course of four years from 2012 after the earthquake, they expanded the geodetic network and continued to investigate the seafloor crustal movement across the entire area of offshore Tohoku. That is to say, the team explored aftermath of the 2011 Tohoku earthquake. Prof. Kido and his team were the first in the world to elucidate the complex movement of the seafloor after the great earthquake. This was published as a paper in 2017*1, causing a great stir both domestically and internationally.

*1: Tomita, F., M. Kido, Y. Ohta, T. Iinuma, and R. Hino, "Along-trench variation in seafloor displacements after the 2011 Tohoku earthquake," Science Advances, 3, e1700113, doi:10.1126/sciadv.1700113, 2017.

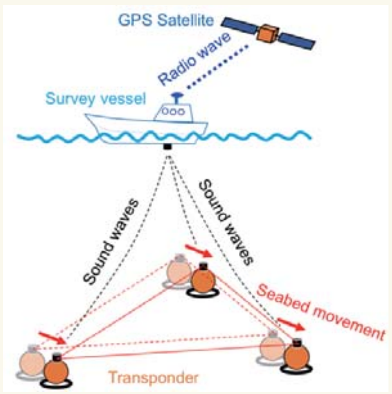
Seafloor survey for which advanced technology is required

How is it possible to investigate deep seafloor movements? For land positioning survey, measurements over ground were performed in the past; however, in recent years, with the development of global positioning systems (GPS) using artificial satellites, this investigation can be conducted in an accurate, simple, and economic way using radio waves. Changes over time, in a particular point location, can be continuously monitored, making it possible to accurately ascertain the extent of crustal movements over a specific period. In contrast, as radio waves do not reach points under the sea, a GPS cannot be used on sea floor. The area around the Japan Trench is far from the land and located at a depth of 5000 m or more from the surface of the water. It has been extremely difficult to gauge, over many years, the detailed movements of a deep seabed that is inaccessible to humans.

However, to elucidate the mechanism of an earthquake occurring beneath the seabed, it was essential not only to make observations from land that is far away but also to collect data from positions close to the seabed. Prof. Kido and the team had already realized the importance of this and were tackling this issue since the early years of the 21st Century. In cooperation with the Japan Coast Guard, they developed and deployed a seafloor geodetic observation system, particularly focusing on the off-Miyagi earthquakes that occurred periodically. Therefore, the system was in use for observing geodetic fluctuations already in 2010, just before the Tohoku-oki Eq. occurred.

The equipment used by Prof. Kido and his team to measure the movements of the seabed is called a "seafloor precision transponder" [Figure 1]. With one set containing three or more seafloor precision transponders, these sets were deployed in the seabed in advance, and sound waves were sent from a sea vessel whose position was monitored by GPS [Figure 2]. The time taken for the response to come back from each transponder was measured, and by correcting for influences on the speed of the sound in ocean, due to seawater temperature change, the position of the transponder was obtained. This measurement was conducted regularly to investigate the extent to which the transponder deployed into the seabed had moved since the previous investigation and to clarify the distance and direction of the crustal movement. Fundamentally, this was the principle involved for the continuous and accurate investigation of the positional changes of the transponder, and although it seems simple, it involved water depths of 5000 m. At this depth, extremely sophisticated equipment is required to accurately grasp movements that occur in the order of centimeters.

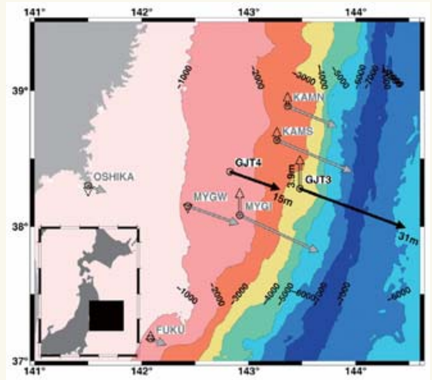
[Figure 1]
Operation to install seafloor precision transponders deploying into the sea



[Figure 2]
Sending sound waves to the transponder from a vessel
(vessel position measured by GPS)

The 2011 Tohoku-oki Eq. was completely unexpected, in terms of its scale and the area covered, compared to the expected off-Miyagi earthquakes. Nonetheless, as the seafloor geodetic observation system was already in operation, the world was able to grasp for the first time that—as a result of this earthquake—the landward plates had shifted east by up to 31 meters*2. Until this point, the maximum shift observed on land had been a mere 5 meters near the Oshika Peninsula, positioned on the ocean side [Figure 3]. If this observation system had not been in place, we would not have been able to capture this major shift in the seabed.

*2: Kido, M., Y. Osada, H. Fujimoto, R. Hino, and Y. Ito, "Trench-normal variation in observed seafloor displacements associated with the 2011 Tohoku-Oki earthquake," Geophys. Res. Lett., 38, L24303, doi:10.1029/2011GL050057, 2011.



[Figure 3]
Movement of the seabed due to the 2011 Tohoku-oki earthquake
(Kido et al., 2011, GRL)

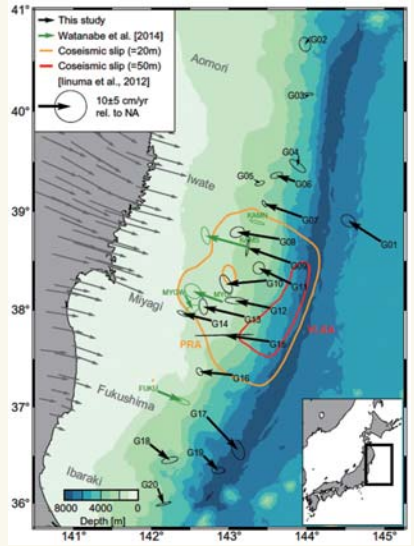
The significance of the research of Professor Kido and the team

The achievement of Prof. Kido's research team on this occasion was elucidating the "four-year seafloor movements following the 2011 Tohoku-oki Eq." According to their research, at the time the earthquake occurred, a huge fault slip occurred off the coast of Miyagi Prefecture, which resulted in the plates continued to move to the west. In contrast, in the Fukushima-offshore further south, the opposite movement to the east was observed [Figure 4]. The fact that the crustal movements differ according to the region presents complex issues. The research team pointed out that while the cause of the off-Miyagi fluctuations could be explained as "visco-elastic relaxation," for the Fukushima-oki fluctuations, the enduring area at the time of the giant earthquake is currently moving slowly, which can be considered as an "after-slip" occurring subsequently to the great earthquake.

Why is it important to determine what happens after a giant earthquake? This is "because it is important to understand not only the instant at which it occurred but also its continuous cycle before and after the occurrence," Prof. Kido explains. "Particularly, when a giant earthquake occurs, the 'clean-up' movements occur for many years after the earthquake itself. Movements related to the 2011 Tohoku-oki Eq. are continuing even now. The rapid movements seen immediately after the earthquake are weakening now, but it will take decades to return to the state it was in before the earthquake."

To accurately grasp movements in the earth's crust after an earthquake, it is vital to understand how strain is released or how strain is further accumulated within the plates; this is extremely important when considering how these factors are connected to earthquakes that may occur in the future. It is not scientifically possible, at present, to accurately predict the date of an occurrence or the magnitude of an earthquake. Nevertheless, this type of elucidation of fluctuations in crustal movements may be important reference material for evaluating the risk of earthquakes and setting up a disaster risk reduction plan.

"Plates near the Japan trench that had not moved since the Jogan Earthquake (869) are thought to have shifted considerably in 2011." Scientific data of giant earthquakes in a cycle ranging from several hundred to a thousand years did not exist in the past. When considering the frequency of giant earthquakes, unless observation is conducted at the current timing, we will lose the opportunity to gain information for several hundred years in the future. It can be said that the research of Prof. Kido and his team—that elucidates the movement of the seabed, which is not easy to survey, as well as the effects of extremely rare giant earthquakes—is highly significant.



[Figure 4]
Complex movements of the seabed over four years after the 2011 Tohoku-oki earthquake
(Tomita et al., 2017, Science Adv.)

Future research

Phenomena called "slow-slips" are often observed in the area around the occurrence of a giant earthquake. They are intermittent and slow ruptures, emitting no seismic waves, and are so to speak "slow motion earthquakes." They affect the accumulation and release of strain in the same way as other earthquakes and can also be a trigger for giant earthquakes. In recent years, "slow-slips" have been confirmed around the world, and Prof. Kido and his team plan to continue this research moving forward. Much more frequent observations are required to monitor seafloor displacement due to slow-slips for which movements occur in monthly units. The current method, in which these are measured each time by boarding a vessel and travelling to an area near the trench, limits the frequency of observations and involves a huge cost. Moving forward, Prof. Kido states that he wants to forge ahead using automated measurements with unmanned vessels. Furthermore, despite the fact that giant earthquakes have occurred in the past in the Ryukyu Island and Kuril Island offing, there are regions that do not have observation systems, and extending the offshore geodetic network is a major issue. In the future, Prof. Kido will continue his advance in his exploratory research, elucidating the mechanisms of earthquake occurrence, in the deep sea that is the final frontier.

Life-saving Efforts: Collaboration between Tsunami Engineering and Disaster Medical Science

(from left)

Hazard and Risk Evaluation Research Division Associate Professor Erick Mas and Professor Shunichi Koshimura
Disaster Medical Science Division Professor Shinichi Egawa and Assistant Professor Hiroyuki Sasaki

Introduction

In the fiscal year 2017, Prof. Shunichi Koshimura's research team started a large-scale, five-year study to combine a wide-area-damage-grasping technology and disaster medical science. The purpose of this study was to establish a mechanism to quickly grasp the state of human and property damage from tsunamis that affect a wide area immediately and then estimate the healthcare and relief needs for better response. There will be an overwhelming shortage of medical resources when a large Nankai Trough earthquake/tsunami occurs. The study aims to create a system to assist the health responders including Disaster Medical Assistance Team (DMAT) as quick as possible to coordinate the whole health sector to save as many lives as possible.

Research origin

Immediately following the Great East Japan Earthquake in 2011, Prof. Koshimura, as a researcher, had a bitter experience of not being able to obtain disaster information and confirm the situation of the disaster area because the communications network was cut off. This became his research impetus, which led to develop technologies to grasp the extent of the damage, and to obtain a general picture of the disaster area within a short period of time using computer simulation techniques and remote-sensing technology that employs satellites and unmanned aircrafts. For instance, a real-time simulation technology, leaded by Prof. Koshimura, goes into operation immediately following a tsunami. This system has been adopted by the Japanese Cabinet Office allowing the government to estimate the damage within 30 minutes.

However, as Prof. Koshimura pursued those studies, he felt that "while it is important to forecast and grasp the damage, it is not enough to save people's lives. The current studies designed to grasp the extent of the damage are quite 'passive' in dealing with natural disasters, and I want to expand my research so it can save people."

When Prof. Koshimura was considering what kind of research would be able to save peoples' lives, Prof. Shinichi Egawa and Assist. Prof. Hiroyuki Sasaki in IRIDeS Disaster Medical Science Division gave him an opportunity to get the detailed understanding of the activities of DMAT. DMAT consists of members including doctors, nurses, and operation coordinators who receive training so that they will be able to enter the disaster area, save the lives of victims, and take actions to reduce the number of preventable disaster deaths* as much as possible. Assist. Prof. Sasaki has a DMAT certification, and during the 2016 Kumamoto earthquake, he conducted medical activities in the disaster areas.

There has been no collaboration between tsunami engineering and medical science in the past. However, Prof. Koshimura believed that such collaboration could make it possible to conduct a study that reduces the number of preventable disaster deaths. So, he proposed a joint research project to researchers in disaster medical science. His association with IRIDeS, an interdisciplinary disaster research institute, helped him come up with this idea. He won the support of researchers in disaster medical science and started a research team consisting of 12 people, both within and outside IRIDeS in a wide variety of fields, such as a DMAT supervisor, researchers in disaster science and spatial information engineering.

*: preventable disaster death is defined as a death that could have been prevented if the person was treated in an ordinary life and medical environment.

Characteristics

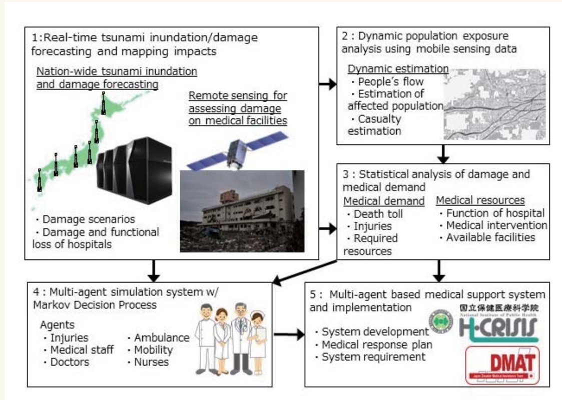
The aims of this study are as follows. (1) After a disaster occurs, the damage will be promptly assessed. The extent of damage suffered by people and medical institutions will be estimated based on the physical damage to the disaster area. (2) Then, an estimate will be made regarding the number of casualties, the number of hospital beds that are needed, the number of people needing transport, and the medical resources required. (3) DMAT members dispatched to the forefront of the disaster area will be provided with information obtained through the wide-area-damage-grasping technology so that their medical care activities will be supported. (4) At the same time, a simulation will be conducted to analyze how the DMAT should allocate its limited medical and human resources and how it should operate to save as many lives as possible. Then, the system that allows DMAT to operate most efficiently will be suggested. (5) Forecasts and support information will be updated in real time as the situation changes, such as the state of the damage and the supply of materials. [Figure 1]

One of the most notable features of this study is that DMAT members who work on the front lines of disaster medical care have been taking part in the project since the research phase. They will incorporate on-site activities into the study and determine whether their study is workable.

The final aim is to have the results of the research used when DMAT is actually operating in the field.

Immediately after a disaster, DMAT tries to reach the disaster area as quickly as possible even when only very limited information is available, because the more time is wasted, the more people could die. Until now, DMAT had to collect specific information about the disaster area, for instance, "whether or not this road is passable," while being in the field, and they often had to conduct their medical activities while adding data to the map. However, if the results of this research make it possible for DMAT to quickly obtain disaster information about a large area, DMAT will be able to significantly increase the efficiency of its activities and concentrate on the original task of saving lives.

Furthermore, this research aims not only to provide DMAT with information about the disaster area but also to work out "what action is desirable under the current circumstances" based on the analysis of the simulation model of DMAT's operations and propose this course of action to DMAT.



[Figure 1] Research system

Current progress

After starting this study, Prof. Koshimura's group first started working on building a model to estimate the damage to hospitals based on the damage from a tsunami. The tsunami damage and the damage to hospitals were classified into several levels, such as "can be immediately restored," "can re-open in one week or one month," and "needs to be evacuated," and then preparations were made to clarify the correlation between the tsunami level and the level of damage done to the hospitals.

In January 2018, in order to work on modeling DMAT operations, the research team participated in DMAT training in Tokushima Prefecture to study the disaster medical response activities. When a large disaster strikes, many people, such as police officers, firefighters, self-defense forces, the Japan Coast Guard personnel, doctors, nurses, rescue workers, logistical personnel, and officials at prefectural disaster headquarters start performing their duties. These people are positioned as "agents" in the simulation. The plan is to construct a "multi-agent simulation model" that accurately grasps how each agent operates, how these agents are related to one other, and what interactions happen among them.

"By participating in the DMAT training, I understood the complex activities that happen in the field which I could not have grasped by simply reading documents," Koshimura said. The plan for this agent simulation is to incorporate facts and realities about medical response activities in the disaster field, such as the decision-making of various officials, the discovery of injured and sick persons, triage, treatments, and transportation to unaffected areas. Initially, the aim is to simulate the current course of actions including problems. Next, the study will figure out how the problems can be solved and how actions can be taken efficiently. "On the front lines of disaster medical science, there are a variety of decisions being made in the field and at the various headquarters by many different people in many different occupations like rescue workers, firefighters, medical personnel, and administrators. The simulation will calculate this myriad of combinations. It will take into account the variations in their operations, and by running hundreds and thousands of trials, a picture of what the average looks like will come into focus. It will allow us to determine when failures occur, how to avoid these failures, and how people can operate more efficiently."

DMAT has accumulated expertise through its experience handling a variety of disasters. Until now, when only a limited amount of information is obtained after a disaster, where the situation changes constantly, DMAT makes decisions, relying on pieces of information collected at each disaster zone and on the team's accumulated experiences. However, the research by Prof. Koshimura's group could give a scientific basis to DMAT's activities, provide proposals of better strategies and systems for taking action, and make DMAT's operations significantly easier.

Multi-disciplinary health cluster response training
in Tokushima Prefectural Headquarter

Plan for the future

This study has only just begun and the goal of the research team is to sequentially combine DMAT's simulation model and the disaster model and to have this combined model start operating in five years. Prof. Koshimura stated, "I want to elevate the research that has been done until now on analyzing and understanding the situation into research that reduces the number of preventable disaster deaths. By working together with experts who have actually engaged in disaster medical activities, I am seriously aiming for something that will be usable for future disasters."

The DMAT system has made important progress after the Great Hanshin-Awaji Earthquake in 1995, in which many preventable deaths took place because prompt medical care could not be provided in the disaster areas. As mentioned above, the impetus for Prof. Koshimura's wide-area-damage-grasping technology was the 2011 Great East Japan Earthquake. In Japan, a nation with many natural disasters, efforts are underway to learn from the past disasters and create solutions for future disasters.

New Active Fault Confirmed in Sendai Plain

Academic Research 3

Disaster Science Division Assistant Professor Shinsuke Okada

Approximately 2,000 active faults are found in Japan. Each active fault may move only once in thousands or tens of thousands of years to cause inland earthquakes. However, longer active faults comprise large active fault planes and store huge amounts of accumulated energy and consequently tend to cause major earthquakes during fault movements.

The Nagamachi-Rifu active fault zone lies at the boundary between the plains and hills of the Sendai region, directly below a densely populated area of Sendai City. No significant seismic activity along this active fault zone has been recorded in history. However, M7.0 to 7.5 earthquakes can occur in the Nagamachi-Rifu active fault; therefore, residents in this region need to be prepared for a major future earthquake.

The presence of the Nagamachi-Rifu active fault is evident; however, there are faults that also dives underground and are therefore difficult to discern (active blind faults). The Nigatake fault, which extends over 8-km underground to the east of the Nagamachi-Rifu active fault, is one of such active blind faults. Recently, Assist. Prof. Shinsuke Okada of IRIDeS Disaster Science Division and his research team discovered the presence of a previously unknown active blind fault in this region.

The area of Medeshima in the city of Natori, located in the southern reaches of Sendai Plain, is built near a hilly region that follows a scarp and is almost 2.5-km long. It has been previously speculated that this scarp might represent the partial exposure of an active fault; however, no scientific evidence to support this speculation had previously been produced. If it were a true active fault, the fault would be longer than the 2.5-km-long scarp, with the rest of its length hidden beneath the surface.

Assist. Prof. Okada and his team tackled a number of questions: "Is this really an active fault? If so, how far does the fault continue?" Initially, Okada's team conducted a seismic reflection survey, in which sound waves were transmitted underground and their reflections were used to determine the structure of the geology through which they traveled. The team moved gradually in an eastward direction across Sendai Plain during their investigation. They found that the underground geological features had undergone deformations, and these deformations were not limited to the immediate Medeshima area; the deformations extended into the region fairly far to the south. Strata that were initially horizontal had repeatedly been pushed upwards; in other words, these deformations are believed to be the evidence of an active fault. To analyze the underground density structure, the team also conducted a gravity survey using minute differences in gravity from the internal structure of the earth. The results supported those of the seismic reflection survey and suggested that the area is indeed home to an active blind fault (Figs. 1 and 2). It was also confirmed that the north end of this active blind fault disappears in the northeast of the Medeshima Hills. Assist. Prof. Okada's team presented this study at the Japanese Society for Active Fault Studies 2014 Fall Congress (J. Seismol. Soc. Japan 2nd ser. 70 2017).

This study aimed to confirm the presence of this previously undetected active fault in Sendai Plain and to clarify its position and features; however, the times during which this fault had experienced movement were not examined. The fact that this fault could ultimately lead to earthquakes is a concern for the future, but Assist. Prof. Okada says, "Looking at the region of this active fault, there does not appear to be any large gaps in the strata. It does not appear as a clear geomorphological feature at the surface, so it can be considered to be low-activity and does not present a great risk." If it were connected to the Nigatake fault to the north, it would have the potential to cause a large earthquake. However, this study has also confirmed that this newly confirmed active fault breaks off to the north; therefore, it is viewed as separate from the Nigatake fault.

This series of studies by Assist. Prof. Okada and his team revealed another aspect of the active fault system in Sendai Plain. Assist. Prof. Okada explains: "While we have located the northern end of this fault, we do not yet know how far it extends to the south. That is a topic for future research."

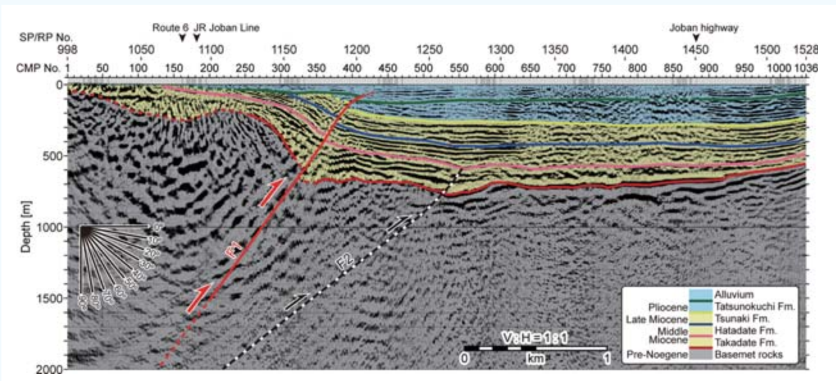


Fig.1 Cross-section from seismic reflection survey showing underground structure. The F1 line denotes the active blind fault. The strata to the left of the line (to the west) are greatly inclined, deformed by the active fault. (Revised from Okada et al., 2017, J. Seismol. Soc. Japan 2nd ser. (Zisin), 70, 109–124)

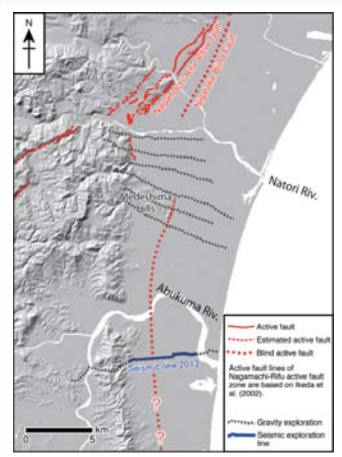


Fig.2 The newly confirmed active blind fault (dotted red line south of Medeshima hills)

Scientific Verification of the Damage that Tsunamis Cause to Seaweed Beds

Academic Research 4

Endowed Research Division
Assistant Professor Kei Yamashita

Hazard and Risk Evaluation Research Division
Associate Professor Anawat Suppasri

Seaweed beds are regions in shallow water where seaweed grows. Eelgrass (*Zostera marina*) is one of the species in these beds that purifies water and provides a habitat in which fry can grow and thrive. Seaweed species such as brown seaweed (*Undaria pinnatifida*) and kelp (*Laminariaceae*) are an essential part of the Japanese diet and are also a food source for abalone and sea urchins. Seaweed beds also harbor a wide variety of sea life. Although most people do not see them on a daily basis because they are under the water surface, seaweed species are extremely important to humans from the perspectives of ecosystems, aquaculture, and economics.

Seaweed beds along Japan's northeastern coastline were devastated by the 2011 Great East Japan Earthquake and Tsunami. The loss of eelgrass from Shizugawa Bay in the town of Minami Sanriku in Miyagi Prefecture was particularly severe. However, to date, there have been few efforts to elucidate the scientific mechanism by which tsunamis cause damage to seaweed beds.

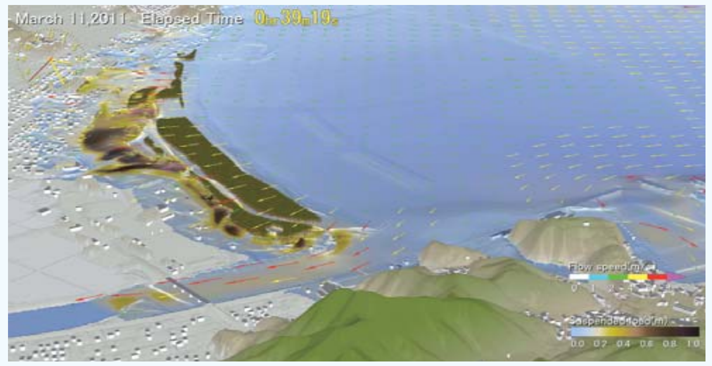
Therefore, Assist. Prof. Kei Yamashita (who specializes in tsunami engineering) and others at IRIDeS have commenced research to clarify the damage that tsunamis cause to eelgrass beds, specifically in Miyagi Prefecture. Using expertise they gained from their prior research regarding tsunami-induced sediment transport, they first deduced that the sediment transport and flow velocity associated with tsunamis were likely to be important factors in the damage to the eelgrass beds. They also hypothesized that the tsunami causes damage by several mechanisms: eelgrass is uprooted due to the erosion of the seabed sediment and deposition of sand, brown seaweed is torn off rocks in the strong currents, and brown seaweed is damaged by sediment deposited by the currents flowing over the rocks. Then, they evaluated the state of damage to the seaweed beds and assessed whether it matched the state of damage that was predicted by a simulation of the sediment transport associated with a tsunami. In their investigation of the Shizugawa Bay, in particular, the researchers were able to verify that the tsunami-induced sediment transport and flow velocity are correlated with the damage to the eelgrass beds. For example, several places where sand erosion was predicted were consistent with the places in which eelgrass damage was observed.

Eelgrass (Photo by Miyagi Prefecture Fisheries Technology Institute, from an official website of Miyagi Prefectural Government)

Then, Assist. Prof. Yamashita delved further into this matter in collaboration with Assoc. Prof. Anawat Suppasri and others from IRIDeS. The researchers decided to conduct a study to quantitatively verify the relationship between the force of a tsunami and the level of damage to the eelgrass beds. Specifically, they investigated the correlation between the flow velocity caused by a tsunami and the damage to the eelgrass beds in Lake Mangokuura of Ishinomaki City in Miyagi Prefecture. The results of this investigation were recently published*. For example, they found that when the tsunami flow velocity was 1 m^3/s, approximately half of the eelgrass was damaged, but when the flow velocity increased to 3 m/s, 90% of eelgrass was lost. In the future, they plan on incorporating sediment transport into their investigation.

Up until now, research has been conducted on seaweed beds in the field of ecology, or on the mechanism by which typhoons damage seaweed beds. Few studies, however, have shown the correlation between tsunamis and seaweed bed damage. The researchers hope that by scientifically elucidating the details of the mechanism by which tsunamis destroy seaweed beds, they may be able to identify the locations of seaweed beds that are less prone to tsunami damage. Assist. Prof. Yamashita aims to provide the necessary knowledge to prevent future seabed damage to protect the livelihood of people in coastal areas. He also hopes to expand the scope of his research to be able to predict which areas will be at risk for damage from a tsunami caused by a potential earthquake in the Nankai Trough.

＊: Suppasri, A., Fukui, K., Yamashita, K., Leelawat, N., Hiroyuki, O. and Imamura, F. (2018) Developing fragility functions for aquaculture rafts and eelgrass in the case of the 2011 Great East Japan tsunami, Natural Hazards and Earth System Sciences, 18, 145-155.



An image from a simulation of the sediment transfer associated with a tsunami, which is from the research Assistant Professor Yamashita was involved

Activities

Activity 01

How to Utilize Uncertain Scientific Information to Mitigate Disaster:
Exploration of "The Study Group for Countermeasures on the Forecast of Nankai Trough Earthquakes"

The "Nankai Trough" is a groove in the deep-ocean formed by plate subduction, which extends from off the coast of Shizuoka to off the coast of Miyazaki. In the vicinity of this area, large earthquakes have occurred quite frequently. Historically, there were cases in which Tonankai and Nankai earthqakes occurred consecutively, resulting in great disasters, such as the Ansei Earthquakes (1854) and Showa Earthquakes (1944 and 1946). In Japan, following the Great East Japan Earthquake, re-examination of earthquake long-term evaluation has taken place. In 2012, the Cabinet Office announced a new estimation based on experts' opinions: if a gigantic earthquake would occur around the Nankai Trough in the future, it is possible that, in the worst case scenario, the earthquake could be maximum M9 class and the number of deaths could reach as large as 320,000 or even more.

In IRIDeS, young researchers volunteered to create a study group on the Nankai Trough earthquake and have been organizing monthly meetings by inviting experts of various fields to study and discuss pertinent isues. The central theme, above all, is how we can utilize uncertain forecast information to mitigate disasters. We cannot predict eartquakes in our current knowledge. However, seafloor observation networks have rapidly improved in recent years and have made it possible to capture oceanic plate movements and other phenomena, slow slips for example, that possibly trigger large earthquakes. Currently, in the Nankai Trough area, "the world's best observation network" that can acquire real-time data is in place.

With our current knowledge on earthquake physics, it is difficult to know if abnormal signals captured in the observation data indicate an impending earthquake. But we may know, albeit with a large uncertainty, if the probability of an earthquake has increased or not. Can this type of information be utilized for disaster mitigation by allowing precautionary measures? Discussions have been going on among researchers, whose backgrounds are in different disciplines such as science, engineering, psychology, and volcanology, local government officials who have been taking part in disaster risk reduction plans in the Nankai Trough area, and journalists who have been involved in disaster reporting. Yo Fukushima, an associate professor of the Disaster Science Division in IRIDeS and the head of the study group organizers, states that "by continuing seminars and discussions for more than a year, we have been able to consider the problem from various aspects. We hope to continue working deeper on this theme through multidisciplinary discussions."

Researchers can well analyze the past and present if data are available, but they cannot accurately predict the future. Yet, can we utilize available scientific information to build a better future, to mitigate the risk of Nankai Trough earthquakes? The researchers' pursuit continues.

A study meeting with an invited guest, Mr. Naoshi Kitagawa, a former trustee of Kochi Prefecture. (Photo taken on January 22, 2018)

Activity 02

Excursion around Iwaizumi, Disaster Area in 2016 Typhoon No.10

On August 30, 2016, Typhoon No. 10 struck Iwaizumi-cho in Iwate Prefecture, causing major destruction due to the heavy rain and flooding of the Omoto River. Just a little more than a year since the typhoon, on October 21, 2017, IRIDeS researchers, including Assoc. Prof. of history Yuichi Ebina and Assoc. Prof. Shuji Moriguchi who specializes in landslides, visited the site, with local disaster expert Toshimasa Morita and Yumiko Washizuka of local radio station FM Iwate's Iwaizumi bureau, who was responsible for reporting on Typhoon No. 10, and others.

Associate Professors Ebina and Moriguchi considered the information obtained from an analysis on river flooding (provided by Shuichi Kure, Assoc. Prof. at Toyama Prefectural University) and an old map of Iwaizumi and compared them to the shape of the local terrain and the testimonials of locals. The results suggest that the Omoto River flooded as a result of the massive rain concentrated in a short period of time and driftwood that acted as a dam and that previously, the river flowed to a road in which overflowing water ran. Assoc. Prof. Ebina pointed out, "Further detailed analysis must be done to arrive at a conclusion, but this is perhaps an example of how the remains of old land use have an impact in a disaster, even after land use has changed due to human action."

Moreover, IRIDeS researchers, Washizuka, and Morita exchanged opinions on current disaster reporting and issues with disaster prevention countermeasures. With regard to a landslide countermeasures booklet created by disaster prevention expert Morita based on individual investigative visits, Assoc. Prof. Moriguchi stated, "This has a lot of information, such as what dangers lurk in our homes and what escape routes to use in times of disaster, which will help us understand disasters as personal events. It is very advanced and will be a fantastic reference on disaster risk reduction in the future." This collaboration between IRIDeS arts and science partnership researchers, media personalities who know their community, and a disaster prevention expert provided an opportunity for a number of discoveries and useful findings.

The Omoto River, with its river wall still in a crumbling state (Ogawa District)

Associate Professors Ebina and Moriguchi, disaster prevention expert Morita, and FM Iwate's Washizuka exchange opinions (both photos were taken October 21, 2017)

Activity 03

"World Tsunami Museum Conference" Held in Ishigaki

In December 2015, a general assembly of the United Nations created a "World Tsunami Awareness Day." November 5, 2017 was the second such "World Tsunami Awareness Day," and the United Nations International Strategy for Disaster Reduction, Japan's Ministry of Foreign Affairs, and the Japan International Cooperation Agency, with the cooperation of IRIDeS, sponsored a "World Tsunami Museum Conference" in the city of Ishigaki, Okinawa Prefecture.

The island of Ishigaki is thought to have been struck by tsunamis numerous times in the past, with historical records showing major damage from the Meiwa Tsunami of 1771. In addition, it is well-known that tsunamis have carried many large "tsunami boulders" inland on the island.

At the World Tsunami Museum Conference, representatives of museums for tsunami or disaster prevention, such as Wakayama Prefecture's "Inamura-no-Hi no Yakata," gathered from places such as Indonesia, Thailand, Sri Lanka, Portugal, and Turkey to share museum activities and issues. Prof. Shuichi Kawashima and Assoc. Prof. Kazuhisa Goto of IRIDeS lectured the group on tsunami boulders from the perspectives of folklore and geology. In addition, the gathering screened the 3D documentary "O-tsunami 3.11 Mirai e no Kioku" [The Great Tsunami of 3/11: Memories for the Future] (produced by NHK Media Technology, supervised by Prof. Fumihiko Imamura, director at the IRIDeS), which provides a record of the Great East Japan Earthquake and subsequent rebuilding. While increasing their understanding of tsunami, conference attendees shared the current state of tsunami museums around the world as well as the issues they face, ensuring that for those working in tsunami museums and in disaster prevention, the conference was a valuable opportunity to reaffirm the importance of global partnerships.

Associate Professor Goto explains "tsunami boulders" on a tour of Ishigaki Island prior to the conference

Representatives of tsunami museums from around the world engage in discussion

Featured Photographs

The Great East Japan Earthquake: Seven Years of the Tsunami - Devastated Areas as Seen from Photos

(Photos & captions by Michihiro Chikata, Visiting Professor, Disaster Information Management and Public Collaboration Division)

1 Taro District, Miyako City, Iwate Prefecture

This photo was taken just about one month after the earthquake. Surrounded by double seawalls known as the "Great Wall," in 2003 the town of Taro at that time had declared that it was "tsunami-proof..." (photo taken April 8, 2011)

The landside seawall that had been submerged was raised ten meters above sea level. (the rightmost white portion was then added). The mountains in the background were leveled and construction for relocation to a higher location began. (photo taken April 23, 2014)

While many homes and stores had lined the center of the Taro area, it has now become a baseball field, with the shouts of junior high school students echoing around the town. (photo taken June 19, 2016)

This is the Taro-Sanno district, relocated to a higher land area. The Taro police box of the Miyako police department, fire station, nursery school, and health clinic have also been relocated here. (photo taken September 15, 2017)

2 Rikuzentakata City, Iwate Prefecture

The center of Rikuzen Takata City: devastated by a 15 meter high tsunami. More than 1,500 people lost their lives in the disaster. (photo taken April 10, 2011)

Even with more than two years having passed since the disaster, many volunteers were still coming from across the country to help clean up the debris. (photo taken August 3, 2013)

The city center: where the post-disaster reconstruction is progressing. The straight line extending from the mountain is a giant conveyor belt to carry gravel to raise the land of the city center. (photo taken April 25, 2014)

The "Abasse Takata" commercial complex opened its doors in the center of town. It features a supermarket, a bookstore, restaurants and others. A municipal library also opened in July. (photo taken September 17, 2017)

3 Shishiori District, Kesennuma City, Miyagi Prefecture

This ship, the 18th Kyotoku-maru, used for large scale net fishing, was swept away more than 700 meters from the port as far as JR Shishiorikarakuwa Station. (photo taken April 10, 2011)

As the nearby rubble is cleared away, only the 18th Kyotoku-maru remains. Some asserted it should be left in place as a reminder of the disaster, but it was taken apart and removed this October (photo taken August 4, 2013)

These disaster recovery public housing units are under construction and enmeshed in blue netting. A gas station has started its operation. (photo taken April 23, 2016)

The Shishiori district was swept up in flames on the night of the disaster, now construction of permanent houses has finally begun (September 17, 2017)