Journal of Natural Disaster Science, Volume 34, Number 2, 2013, pp127-141

Consciousness of Disaster Risk and Tsunami Evacuation: A Questionnaire Survey in Okitsu, Kochi Prefecture

Yingying SUN*
Katsuya YAMORI**
Ryoya TANISAWA*
Seiji KONDO*

*Graduate School of Informatics, Kyoto University
**Disaster Prevention Research Institute, Kyoto University

(Received January 18, 2013 Accepted August 30, 2013)

ABSTRACT

The 2011 Great East Japan Earthquake forced a reevaluation of the effectiveness of disaster management facilities and strategies in coastal communities where damage due to an earthquake and resulting tsunami from the Nankai Trough can be expected. Specific areas subject to reevaluation include (i) individual-level topics in disaster risk management, such as the use of motor vehicles for evacuation, (ii) challenges initiated by government reappraisals of tsunami estimation, such as the safety of existing shelters, and (iii) low tsunami evacuation rates in areas at high risk of tsunami damage, despite evacuation orders issued at the time of the Great East Japan Earthquake. This study discusses the impact of these factors on the consciousness of residents in a community where we performed action research. The results of a questionnaire survey indicate that Okitsu residents have similar problems regarding tsunami evacuation as those revealed in the devastated areas of the Tohoku region. To promote disaster consciousness and improve tsunami evacuation rates, we suggest a new approach to evacuation drills called the single-person drill. This drill changes a community practice into an individual activity that we hope will involve more residents in disaster risk management, and ultimately contribute to their successful tsunami evacuation.

Keyword: Nankai Trough earthquake, Great East Japan Earthquake, disaster consciousness, tsunami evacuation, single-person drill

1. Introduction

This study focuses on disaster risk management implemented in the Okitsu community of Shimanto Town, Kochi Prefecture where we started action research before 2011. This community is at high risk of damage from a tsunami caused by a powerful earthquake originating in the nearby Nankai Trough (hereinafter, Nankai Trough earthquake). After the Great East Japan Earthquake, with the cooperation of the local community, we conducted a questionnaire survey. The survey focused on residents' consciousness

of tsunami evacuation, with the aim of finding problems in disaster mitigation measures such as those that emerged in the Tohoku region. Potential problems include individual topics in disaster risk management, the influence of reevaluating damage estimates, and lack of emergency consciousness toward tsunami evacuation. Based on the survey data and information collected through action research, we discuss the effectiveness of facilities, strategies, and problems that exist in the community. We also consider common issues in huge coastal areas at high risk of devastating damage from the Nankai Trough earthquake.

This study is an action research aiming to seek betterment for local communities. Action research was first elaborated by Lewin (1948) as an intervention that dealt with the improvement of intergroup relations. In this paper, we focus on the conditions and effects of the disaster management co-practiced by various stakeholders, such as pupils, residents, administrators, graduate students, professors, etc., making different contributions according to their abilities, interests, and even relationships with other people.

The first author, for example, might be deemed to be a young lady, who always wanders around the community, or to be a foreigner who can speak fluent Japanese, or to be a disaster researcher who makes earnest efforts to motivate people to conduct evacuation drills. Similarly, the residents, for instance, have different characteristics and usually become teachers of disaster management in the local community, no matter whether they are elderly or young, healthy or disabled. All the stakeholders are co-researchers in this study, and their roles keep changing with their dynamic social actions, which can be seen as the most precious benefits of action research.

So, for illustrative purposes, the pronoun "we" is applied to indicate the authors, while contributions made by others are clearly denoted as "pupils, residents, or administrators," respectively. This is not to separate the intimate relationships among co-researchers; conversely, it is to emphasize their specific roles in action research. In addition, the first author of this article is in charge of the study and decides what methodology should be applied and how related information should be collected through frequent interactions with residents. The other three authors also made a great contribution to the research by participating in community activities occasionally when important events such as questionnaire surveys, disaster education symposiums, or evacuation drills had to be planned or put into practice. The term "disaster experts" in this article especially refers to those who are majoring in disaster research but have not conducted action research with local residents in Okitsu community.

2. Impact of the Great East Japan Earthquake

At this time of writing, one and a half years has passed since the Great East Japan Earthquake. As has been discussed regarding the major problems in disaster management revealed by the extensive damage, attention has been focused onto preparedness for the Nankai Trough earthquake. There is a high probability that such an earthquake will occur in the near future; preparedness should thus be made in each community where damage is expected.

In the Great East Japan Earthquake, over 90% of the approximately 20,000 fatalities (including those still officially listed as "missing") died from drowning, not the earthquake itself (Cabinet Office, 2011). Even in some regions known to be at high risk of tsunami incursion, residents had more than 10 minutes to evacuate before flooding began; also, residents of southern Miyagi Prefecture had almost an hour (Japan Meteorological Agency, 2011). The tremendous damage inflicted provides a clear example of how convincing residents to rapidly evacuate is among the greatest challenges in disaster risk management.

The potential for damage resulting from the Nankai Trough earthquake has been discussed since even before 2011. Many local governments, related organizations, and residents have invested great energy into disaster mitigation measures, such as the construction of hard facilities and the implementation of soft strategies, all of which were based on community-level conditions. However, the huge impact of the Great East Japan Earthquake has forced a reevaluation of the likely effectiveness of these approaches. Specific areas for reevaluation include individual-level topics, government reappraisals of tsunami estimation, and low tsunami evacuation rates despite evacuation orders issued at the time of the Great East Japan Earthquake. This paper discusses each of these problems in detail.

Beginning with individual-level issues in disaster

mitigation, one issue is that 64.3% of victims in the Great East Japan Earthquake were over 60 years old, and 45.5% were over 70 years old. This result is similar to other recent disasters, in which most of the victims were elderly persons (Ushiyama *et al.*, 2012). Another issue is that before the Great East Japan Earthquake, there were high expectations placed on community-level support under emergency conditions, particularly on local volunteer firefighters. However, 253 volunteer firefighters died while trying to evacuate others. One surviving volunteer firefighter said that "they knew precisely that the tsunami was coming, but they couldn't bring themselves to evacuate while others remained behind" (CeMI, 2011). These poignant words illustrate the limitations of *kyojo*, the Japanese principle of mutual assistance. Although tremendous efforts put into community-level disaster management and relating achievements have been seen, the huge damage motivated us to shift attention from community-level approaches to individual-level ones, such as the tsunami evacuation principle of tsunami *tendenko*. The Great East Japan Earthquake led to a significant renewal of interest in the concept of tsunami *tendenko*, the importance of an "each for themselves" attitude toward escaping tsunami on the one hand, but the complexity of actually implementing such strategies for tsunami evacuation on the other (Yamori, 2012).

Another question pointed out is whether people should use motor vehicles for evacuation. According to the Central Disaster Prevention Council (2012), up to 56% of evacuees reportedly used cars for evacuation. This information indicates that while the importance of walking or running to shelters has long been held as a principle of tsunami evacuation, such rules are not adhered to during emergency conditions. Those who used motor vehicles for evacuation encountered various problems, such as traffic jams, damaged roads, and dysfunctional traffic signals. Indeed, many victims were found drowned in their cars.

A second impact is that the central and local governments have been forced to reappraise damage estimates. The Tohoku disaster was described as "an unprecedented event beyond human conception" because it exceeded all hazard estimates and hugely impacted society. Much of the disaster mitigation infrastructure such as tsunami prevention levees did not function properly and failed to prevent the tsunami from reaching residential areas. Some designated shelters were destroyed as well. According to the Jiji Press (2012), 16% of the 2,023 shelters in 32 metropolitan regions along the Tohoku coast were inundated.

As an immediate response to the disaster, the Cabinet Office (2012) set out to revise estimations of damage from the Nankai Trough. Two new estimates were released in March and August 2012, and many local governments began to reevaluate disaster estimates based on the new figures. For example, the prescribed height and assumed safety of existing shelters were modified, and previous designated shelters lost their designation as new ones replaced them.

Kochi Prefecture, in which the research community is located, received steady support from the governor, who said, "We have done our best, based on the worst-case estimates. Nonetheless, the tragedy of the Tohoku event taught us valuable lessons about the importance of reevaluating existing disaster management strategies." Under the governor's direction, an expert team was established to support Kochi Prefecture's early reappraisal of damage estimates and reformulation of disaster management countermeasures (Asahi Shimbun, 2011).

A final problem for consideration is low evacuation rates. Expectations were that the residents of the Tohoku region had an even higher awareness of tsunami risks than those living in areas likely to be affected by the Nankai Trough earthquake. In the Great East Japan Earthquake, however, only 57% of residents subject to evacuation orders responded quickly after the earthquake (Central Disaster Prevention Council, 2011). A survey conducted by Weathernews Inc. (2011), with a key feature of having one part that sought information about the respondents themselves and a second part that sought information about their friends and family who died, indicated that only 23% of fatalities were among those who evacuated immediately after the earthquake.

On the day of the Great East Japan Earthquake, tsunami warnings accompanied by evacuation orders were issued all along the Pacific coast of central to west Japan. According to a survey by Kyodo News (2011), only 6% of Pacific coast residents evacuated to designated shelters on that day.

The tsunami evacuation problems that emerged in the event provided important lessons for Nankai

Trough earthquake-expected areas. Thus, to investigate the details of the three above-mentioned factors in a certain community would be very helpful for future disaster management. The following sections discuss the consciousness of disaster risks and tsunami evacuation, by focusing on the living conditions, individual needs, and concerns about the disaster management of residents.

3. Overall Situation

This section summarizes the overall situation of the Okitsu community. We begin by focusing on the tsunami risks, and then talk about disaster management strategies that have been promoted in the community. Finally, we discuss the influences of the Great East Japan Earthquake based on the three above-mentioned factors.

3.1 Outline of the Okitsu Community

Okitsu is located in the southwestern coastal area of Shimanto Town in Kochi Prefecture. There are 552 households and a total population of 1,014 in the community, with 47% being male and 53%, female. In addition, 48% of the population is over the age of 65, while teenagers under the age of 15 account for only 7.8% (Shimanto Town, 2012).

The Okitsu community is made up of three subunits: Omuro, Gobun, and Urabun. Omuro has 159 households and 305 residents, who are mainly involved in the fishing industry. Urabun has 199 households and 327 residents, who also primarily make their living from fishery. Gobun is an agricultural area with 194 households and 382 residents, with primary crops that include *myoga* ginger and peppers.

Okitsu has a southern boundary formed by Tosa Bay, famous for its clear waters and beautiful beaches. As shown in figure 1, along Tosa Bay, no roads lead to nearby towns. The only lifeline is Road No. 52, which provides Okitsu residents with access to surrounding areas. Road No. 52 is a narrow mountain road with more than 140 curves along its 8 km length in Okitsu territory, and can easily be shut down by landslides or earthquakes. This road comes out of the long tunnel of Okitsu Hill (394 m) into Okitsu, and then runs down sharply to the community (10 m on average). Without passing through residential areas due to the high density of houses, it goes straight along the sea side and ends up at the intersection of Omuro and Urabun. Obviously, it is difficult for elderly people to drive through the road, so a common concern among residents in this isolated, mountainous area is a major disaster that cuts off ground transport (Sun *et al*., 2012).

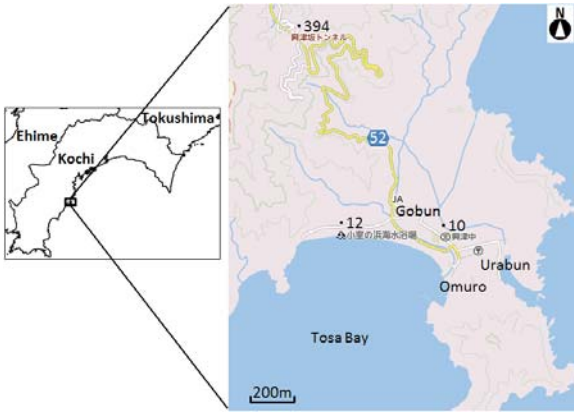

Fig.1. Location of Okitsu

Before the Great East Japan Earthquake, disaster experts predicted that a 12 m tsunami would arrive within 18 minutes after an 8.4 magnitude Nankai Trough earthquake (Kochi Prefecture, 2005). According to historical records, at least 11 earthquakes with magnitudes greater than 7.0 have hit the area. In recent years, the 1946 Showa Nankai Earthquake of 8.0 magnitude caused severe damage, including destruction of farmland, sluice gates, and tsunami prevention levees (Editorial Committee of the History of Kubokawa, 2005). Thus, the priority of disaster management in Okitsu is how to help people survive tsunami and isolation.

3.2 Disaster Risk Management

The Okitsu community is known for its advanced disaster risk management, thanks in large part to disaster education efforts by Okitsu Elementary School. In 2005, Okitsu Elementary School received a directive to "create and develop safe communities with the cooperation of school and community" from the Ministry of Education, Culture, Sports, Science and Technology (MEXT). The goal of this initiative is to enhance student consciousness of disaster risks by involving residents' cooperation. After reflecting on the future achievements of disaster education in the community, the school principal and community leaders established the Okitsu Disaster Education Com-

mittee (hereinafter, Okitsu DEC) in October 2005.

Since then, students have engaged in activities such as issuing disaster management newsletters, disaster mapping, community cooking, etc. During disaster mapping, students discovered many problems related to disaster mitigation. For example, they observed that bridge piers were in disrepair, despite being important routes to shelters. They also observed that evacuation routes were difficult for older people and would easily be destroyed in the event of a major earthquake. The kindergarten and daycare center were located very close to the coast, despite principal users being vulnerable under emergency conditions. Such discoveries have been sincerely accepted and discussed by residents, and some issues were brought to the attention of local government. For example, in February 2010, the kindergarten and the daycare center were relocated together to locations at least 30 m above sea level, becoming a main shelter for Okitsu called the Sakura Kai.

Due to the efforts of students and residents, evacuation facilities in Okitsu can hold 1,582 people, more than the whole population of the community (see figure 2). Sufficient emergency supplies are stored in each facility to allow long-term occupation in the event that Road No. 52 is shut down. Shelters store prefabricated cottages to protect evacuees from rain or wind. Evacuation drills, community cooking, and nighttime camping have been conducted using these facilities.

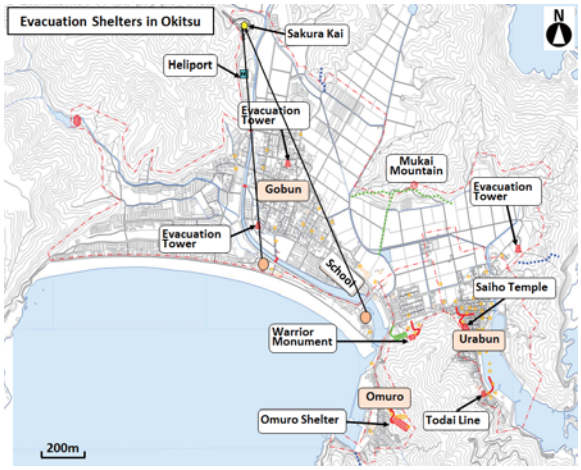

Fig.2. Okitsu evacuation shelters

3.3 Response to the Great East Japan Earthquake

The Great East Japan Earthquake shocked the Okitsu community, and called into question its preparedness for tsunami risks. We, as researchers conducting action research on tsunami management with local residents for several years, felt a greater responsibility for future disaster management. We actively shared our knowledge and the latest information, such as the details of tsunami simulation and damage estimation. We also presented cases of tsunami evacuation, inviting survivors from disaster-affected areas. To ensure residents could make a secondary evacuation from shelters situated 15 m above sea level to higher ground, we suggested that residents build several evacuation roads, as well as repairing existing facilities.

However, cases of failed evacuation of senior citizens in Tohoku caused much anxiety in Okitsu. Opinions collected through the action research, such as "I am over 80 and have back problems, so it is hard for me to get to a shelter," indicate significant individual-level problems. Issues also include the actions of local volunteer firefighters during tsunami evacuation and the pros and cons of using motor vehicles for evacuation. We discuss these issues concretely in the following section.

Local government gave Okitsu tsunami warnings and evacuation orders on March 11, 2012, but only 26.9% evacuated to shelters. This evacuation rate far exceeds the prefecture-wide average of 5.9% (Kyodo News, 2011), which was likely a result of the effectiveness of advanced disaster management in the community; yet a 73% non-evacuation rate under emergency conditions is nonetheless problematic. Thus, it is necessary to investigate residents' consciousness of tsunami evacuation and disaster management to establish appropriate strategies.

4. Questionnaire Survey

We conducted the survey in January 2012 with the cooperation of Okitsu DEC. As three factors of disaster management have been shown to be important in the Great East Japan Earthquake, the main purpose of the survey is to find out what kind of specific problems existed in Okitsu compared to the Tohoku region.

Table 1 shows an outline of the survey, which targeted all the households in Okitsu (552 families on January 1, 2012). We received 225 valid responses (46.2%). Table 2 shows the demographic data of gender and age. It turns out that 46% are male and 54%

are female, almost equal to the gender ratio of the whole population. In addition, nearly 72% of the respondents are above the age of 60. Table 3 shows different response rates in the community. Omuro had the lowest (30.2%), but the rates of the other two were both near 50%.

Table 4 shows the survey details. Based on the three factors described in section 2, we categorized all the questions into individual-level problems (Q5, Q7, and Q8), the reevaluation of damage estimates (Q1 and Q9), and the rate of tsunami evacuation (Q2, Q3, Q4, and Q6). The idea is that problems of disaster management in the Okitsu community somehow revealed similar features to those in the Tohoku region, such as an aging population, the safety of existing shelters, and evacuation rate. So, using these three factors to analyze the survey data can lead to an accurate grasp of the problems in Okitsu.

Table 1. Survey overview

Target	All households
Distribution	Time: January 10, 2012 Method: local postal service Number: 552 packages
Collection	Time: January 11 to 25, 2012 Method: 10 kinds (returned to the following locations: students in Okitsu Elementary School and Okitsu Junior High School; top leaders of each subunit; Okitsu Elementary School or Okitsu Junior High School; local administrative office; fishermen's union; kindergarten; local office of Japan Agriculture; local assembly hall) Respondents: 225 households response rate: 46.2%

Table 2. Age and gender

Age	Male	Female	Total
0~19	0.0%	0.4%	0.4%
20~29	0.9%	0.4%	1.3%
30~39	0.9%	5.5%	6.4%
40~49	2.1%	4.7%	6.8%
50~59	7.7%	5.5%	13.2%
60~69	12.8%	15.7%	28.5%
70~79	15.3%	12.3%	27.7%
above 80	6.4%	9.4%	15.7%
Total	46.0%	54.0%	100.0%
Respondents	108	127	235

Table 3. Response rates

	Omuro	Gobun	Urabun	Total
Respondents	48	100	96	255
Households	159	199	194	552
Response rate	30.2%	50.3%	49.5%	46.2%

Table 4. Survey item

Q1. What do you think about the damage estimates for the expected Nankai Trough earthquake and tsunami?
Q2. What would urge you to make an evacuation? (Select 3 of 7 options.)
Q3. Which shelter would be your first choice?
Q4. How long would it take before you can evacuate to a shelter?
Q5. How would you evacuate?
Q6. Which would be your second-choice shelter?
Q7. (Dilemma of family evacuation) Would you pick up your child at school before evacuating when an earthquake occurred?
Q8. (Dilemma of local volunteer firefighter evacuation) In the event of a tsunami, do you think local volunteer firefighters should help others evacuate before evacuating themselves?
Q9. Which of the following tsunami management measures do you anticipate in the future? (Select 3 of 8 options in decreasing order of importance.)
Q10. (Open-ended question) Do you have any comments regarding disaster risk management in Okitsu?
Demographic items: Location, Age, Gender, Occupation.

4.1 Individual-level Problems

This section discusses survey results related to individual-level problems associated with Q5 (methods of evacuation), Q7 (dilemma of family evacuation), and Q8 (dilemma of local volunteer firefighter evacuation).

Responses to Q5 as shown in table 5 indicate that more than 80% of residents would evacuate on foot. Note that the main Gobun shelter is the Sakura Kai, which is located 1.5 km from residential areas, so almost 20% of residents reported they would use a car or motorcycle. Of the three subunits, residents of Gobun seem to have an advantage in using motor vehicles for evacuation, because Gobun is closest to

Road No. 52, which leads to the Sakura Kai and nearby towns. However, there are also many narrow roads built between old brick walls that would easily collapse in a large earthquake. Using motor vehicles for evacuation requires consideration of local residents' needs, road conditions, and driving rules in an emergency situation. This calls for special and individual approaches such as the "single-person drill," discussed later.

Table 5. Evacuation methods

	Omuro	Gobun	Urabun	Total
Walking	89.1%	72.4%	89.1%	82.2%
Bicycle	6.5%	5.1%	2.2%	4.2%
Motorcycle	0.0%	3.1%	0.0%	1.3%
Car	4.3%	15.3%	7.6%	10.2%
Others	0.0%	4.1%	1.1%	2.1%
Total	100%	100%	100%	100%
Respondents	46	98	92	236

Q7 (dilemma of family evacuation) and Q8 (dilemma of local volunteer firefighter evacuation) are designed based on the "crossroad" style, a tool for disaster education proposed by Yamori *et al.* (2005). Q7 asks: "Suppose a big earthquake occurs while your child is at school and you are at home. The community radio announces an emergency evacuation. Would you go to pick up your child or evacuate first?" Answer: (i) I would pick up my child first; (ii) I would evacuate first. Q8 asks: "Suppose a large tsunami will arrive within 20 minutes. In this situation, what do you think local volunteer firefighters should do first: help others evacuate first, or evacuate themselves?" Answer: (i) They should help others evacuate first; (ii) They should evacuate themselves first.

For Q7, more than 40% of respondents answered that they would pick up their children before evacuating (see figure 3). In Omuro in particular, over 50% of residents would go to pick up children. This indicates that the importance of tsunami *tendenko* has not been completely understood and accepted in Okitsu, despite demonstration of its importance in the Great East Japan Earthquake. Moreover, as the percentage of teenagers in the community is lower than 8%, but almost 72% of respondents are above the age of 60, the "pick up children" result could be largely based on a hypothetical child instead of a real one. From this survey result, it stands to reason that many people would similarly choose to help an elderly relative to evacuate, rather than evacuate themselves first. If this is the case, the implications are serious for Okitsu, where much of the population is elderly. There are many reports of delayed evacuations in the Tohoku event (e.g., Weathernews Inc., 2011; Survey Research Center Co. Ltd., 2011). In many cases, people who had evacuated to a safe location returned to a dangerous place out of concern for relatives, an act that often led to avoidable tragedy. In Okitsu, the fact that up to 40% of residents resist tsunami *tendenko* cannot be ignored.

Responses to Q8 (see figure 4) indicate that opinions toward volunteer firefighters' responsibilities during emergency conditions vary. While 70% of respondents think that local volunteer firefighters should evacuate first, more than 30% believe that they should help others first. Disaster risks in the Okitsu community are such that if volunteer firefighters took the time to assist in evacuation efforts, they would likely fail to evacuate themselves and might be engulfed by the tsunami. The problem of varied opinions on the topic of volunteer firefighters' evacuation should thus be considered seriously.

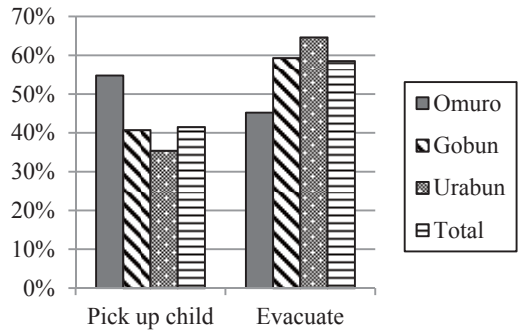

Fig. 3. Pick up child or evacuate? (N=212)

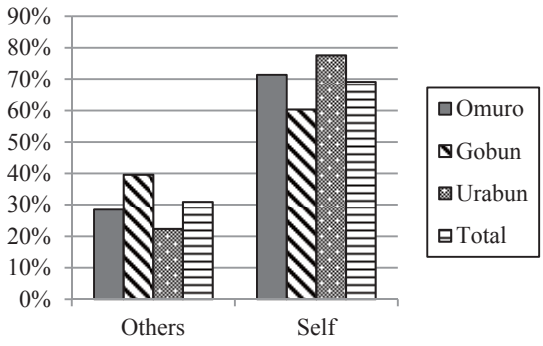

Fig. 4. Evacuate self or others? (N = 223)

Various opinions are also reflected in the qualitative data collected through action research. For example, one of the local volunteer firefighters told us that after the Great East Japan Earthquake, two new principles of tsunami management were notified by the local government. One is, "Do not go to close the water gate after a big earthquake." The other is, "Support evacuation efforts only while evacuating yourself." However, when we asked whether residents were aware of these policies, the volunteer firefighter was slightly embarrassed and replied, "They might, but I'm not sure."

Opinions also vary in responses to the open-ended question. The opinion from a local volunteer firefighter was: "Question 8 bothered me for a long time. As a volunteer firefighter, I strongly feel that I should put others before myself. But I also know that there are circumstances where I have to protect myself first. Balancing both is difficult, so I can only hope to find the best way to protect myself and others from a tsunami." However, one aged person responded, "I can't imagine that volunteer firefighters would give elderly people a hand under emergency conditions."

To resolve this dilemma, approaches should be introduced such as investigating the distribution of volunteer firefighter residences in each subunit to plan evacuation routes that maximize the effectiveness of "supporting evacuation efforts while evacuating oneself" (Yamori *et al.*, 2012).

4.2 Reappraisal of Disaster Estimation

This section describes the results of Q1 (tsunami estimation) and Q9 (anticipated tsunami prevention management), which measure the influence of the reevaluation of damage estimates.

Table 6 shows residents' thoughts regarding an expected Nankai Trough earthquake. A total of 76.7% of residents answered that the scale of the resulting tsunami might exceed current estimates. As previously noted, revised damage estimates had not yet been released when this survey was conducted, so these data demonstrate the discomposure of residents caused by the Great East Japan Earthquake. An alternative view is that residents have allowed for another "unprecedented event beyond human conception" by not completely trusting disaster experts and government officials. Events following the Great East Japan Earthquake, such as the evacuation of school children in Kamaishi City (described as "the miracle of Kamaishi") have also reinforced suspicion against official estimates. This is because Prof. Katada of Gunma University, who for many years taught emergency evacuation techniques, emphasized three evacuation principles that form the core issues of disaster education. One of the three principles that facilitated the above-mentioned "miracle of Kamaishi" was "*Sotei ni torawareru na*" (literally, "do not completely trust any kind of disaster estimate") (Katada, 2012). Therefore, it is necessary for Okitsu residents to understand the importance as well as the limitations of tsunami predictions.

Table 6. Opinion of tsunami scale

	Omuro	Gobun	Urabun	Total
Larger than estimation	87.5%	73.7%	74.2%	76.7%
Same as estimation	6.3%	20.0%	18.3%	16.5%
Smaller than estimation	6.3%	6.3%	7.5%	6.8%
Total	100%	100%	100%	100%
Respondents	48	95	93	236

Q9 (anticipated tsunami prevention management) asks respondents to select three out of eight options in order of importance. To focus on the most compelling needs of residents, we only discuss the results of the highest-ranked option. Table 7 shows that almost 50% of residents thought that provision of shelters and evacuation roads were the most urgent aspects of tsunami management in Okitsu.

Table 7. Anticipated tsunami risk management

	Omuro	Gobun	Urabun	Total
Disaster drill	31.1%	23.2%	33.3%	28.6%
Disaster education symposium	0.0%	1.1%	3.4%	1.8%
Road and shelter expansion	37.8%	56.8%	41.4%	47.1%
Information distribution equipment	11.1%	3.2%	3.4%	4.8%
Increased evacuation tools	0.0%	3.2%	2.3%	2.2%
Supply stocks	13.3%	8.4%	6.9%	8.8%
Strengthened sea walls	6.7%	2.1%	4.6%	4.0%
Other	0.0%	2.1%	4.6%	2.6%
Total	100%	100%	100%	100%
Respondents	45	95	87	227

We mentioned above that shelter capacities already exceed the population of Okitsu. The results of Q9 indicate that the influence of the Great East Japan Earthquake has caused significant anxiety about the reevaluation of damage estimates and distrust in the

safety of existing shelters, most of which are 15 m above sea level in the light of the old tsunami estimation of 12 m. Opinions from the open-ended question, such as "The primary Urabun shelter seems too low when considering the inundated shelters in the Tohoku region. I hope the government will relocate it at least 10 m higher," and "More evacuation roads should be constructed. Bridges leading to shelters must be repaired as soon as possible. After I heard about the horrible experiences in the Tohoku region, I keenly felt that our shelters should be reevaluated," verify the survey data.

Sun *et al.* (2013a) pointed out that several factors contributed to the extreme anxiety regarding shelters in Okitsu, including an insufficient understanding of the efforts made by Okitsu Elementary School and Okitsu DEC, as well as dependence on a number of residents who are leaders in promoting disaster management. In the future, key persons in Okitsu should encourage the majority of residents to become masters in disaster management.

4.3 Issues Regarding Tsunami Evacuation

This section discusses issues related to tsunami evacuation, based on the results of Q2 (reason for starting to evacuate), Q3 and Q6 (evacuation destination), and Q4 (expected tsunami evacuation time).

In Okitsu, 81.1% of residents report that they would evacuate quickly after a big earthquake (table 8). This is a much higher rate than the survey data regarding tsunami evacuation in the Great East Japan Earthquake, and is thus indicative of the effectiveness of disaster risk management in the community. Nonetheless, actual rates have not been verified in a real disaster, and reported potential actions may not translate into actual behavior. Risks in Okitsu are such that immediate evacuation following a large earthquake is vital, yet 10.9% of residents reportedly will not evacuate without hearing an evacuation recommendation or order. Worse yet, 6.3% of residents would wait to hear such information on the community warning alarms. It is rational to want to collect information regarding earthquakes and tsunamis, but "waiting for more information in lieu of making a quick evacuation" (Katada, 2005; Yamori, 2010) would be a serious problem in Okitsu.

Table 8. What would prompt you to evacuate?

	Omuro	Gobun	Urabun	Total
Earthquake	87.2%	78.4%	80.9%	81.1%
Tsunami warning	8.5%	14.4%	8.5%	10.9%
Community alarm	4.3%	6.2%	7.4%	6.3%
Neighbor calling	0.0%	0.0%	2.1%	0.8%
Others evacuating	0.0%	1.0%	0.0%	0.4%
Tsunami	0.0%	0.0%	0.0%	0.0%
Others	0.0%	0.0%	1.1%	0.4%
Total	100%	100%	100%	100%
Respondents	47	97	94	238

We posed Q3 (first choice of shelter) and Q6 (second choice of shelter) because 23% of Tohoku survivors reported that the first place they evacuated to was inundated by the tsunami (Weathernews Inc., 2011). Figure 2 and table 9 indicate that most residents selected shelters in their own residential areas ("other" always indicates high ground near the respondent's house). In particular, 80% of Omuro residents selected the primary Omuro shelter or Warrior Monument. More than 70% of Gobun residents selected the Sakura Kai. More than 70% of Urabun residents selected Saiho Temple or the Todai Line. Because of the location and the balanced construction of shelters in the three subunits, most residents know exactly where to evacuate to, which deserves high praise.

Table 9. First-choice evacuation shelter

	Omuro	Gobun	Urabun	Total
Warrior Monument	44.4%	2.0%	0.0%	9.4%
1st Omuro Shelter	35.6%	0.0%	1.1%	7.3%
Saiho Temple	0.0%	0.0%	56.0%	21.8%
Todai Line	0.0%	0.0%	14.3%	5.6%
Sakura Kai	2.2%	71.4%	8.8%	33.8%
Mukai Mountain	2.2%	14.3%	4.4%	8.1%
Evacuation Tower	2.2%	8.2%	2.2%	4.7%
Other	13.3%	4.1%	13.2%	9.4%
Total	100%	100%	100%	100%
Respondents	45	98	91	234

Earlier, we pointed out the difference in response rates among the three subunits (the rate in Omuro is much lower than the other two). We think there are two reasons that could explain this phenomenon. One is that the leader of Omuro also serves as the leader of the organization of local volunteer firefighters, and is in charge of disaster management. The other is that

multitudinous shelters reduce residents' vigilance and consciousness of disaster risks. In fact, the two shelters in Omuro were constructed earlier than the others, which contribute to their high recognition among residents.

As shown in figure 2, several evacuation shelters in Okitsu were constructed according to the residential conditions and the population in each unit. However, people would probably not be at home, or evacuation roads leading to their first-choice shelters would be blocked by collapsed walls. So, we strongly suggest that residents be familiar with more than one shelter to ensure successful escape from a tsunami. Table 10 shows various ways to deal with inaccessibility to first-choice shelters. Almost 50% of residents selected evacuation towers at 15 m above sea level, or "other" (high ground near their houses). This indicates that even evacuation towers cannot enable people to evacuate to a higher place, but can serve as a second evacuation shelter when a tsunami is actually flooding in. That is to say, towers are "a subordinate method of tsunami evacuation" (Yamori *et al.*, 2012). Local residents considered more available shelters besides the designated ones, which was admirable. Moreover, responses to the open-ended question, such as "Evacuation shelters cannot fit everyone's need. More evacuation roads should be constructed to allow quick evacuation to high ground," indicate a proactive attitude. Nonetheless, from the perspective of safety, it is necessary to test whether non-designated places could be used as shelters.

Table 10. Second-choice evacuation shelter

	Omuro	Gobun	Urabun	Total
Warrior Monument	15.4%	3.3%	8.5%	7.5%
1st Omuro Shelter	12.8%	0.0%	0.0%	2.4%
Saiho Temple	20.5%	1.1%	22.0%	12.7%
Todai Line	0.0%	0.0%	17.1%	6.6%
Sakura Kai	7.7%	16.5%	2.4%	9.4%
Mukai Mountain	5.1%	15.4%	17.1%	14.2%
Evacuation Tower	10.3%	47.3%	12.2%	26.9%
Other	28.2%	16.5%	20.7%	20.3%
Total	100%	100%	100%	100%
Respondents	39	91	82	212

Finally, we discuss the results of Q4 (expected tsunami evacuation time). A tsunami is expected to hit Okitsu soon after an earthquake, so the time required to evacuate to shelters is one of the most important issues in disaster management. Q4 asks respondents to guess their estimated evacuation time, rather than selecting options. When the survey was conducted in Okitsu, there were no official reports on tsunami reappraisal, but lots of information released through TV broadcasts and newspapers suggest that a ferocious tsunami would come even within 3-5 minutes. Considering the then-current disaster estimates that a tsunami would arrive within 18 minutes, even several seconds of evacuation time would be a matter of life or death. So, we classified the results of Q4 into five categories, which are 0-3 minutes, 4-5 minutes, 6-10 minutes, 11-18 minutes, and over 18 minutes, though unevenly.

Table 11 shows that almost 90% of residents said they could make a successful evacuation within 18 minutes, and nearly 30% answered that they could evacuate within 5 minutes. Meanwhile, the results of each subunit show that residents living in Gobun require more time than the other two, with 18.4% of residents requiring more than 18 minutes. This is likely because the Sakura Kai is somewhat far from residential areas.

Table 11. Evacuation time

	Omuro	Gobun	Urabun	Total
0-3 min	10.9%	2.0%	8.8%	6.4%
4-5 min	28.3%	15.3%	24.2%	21.3%
6-10 min	30.4%	36.7%	39.6%	36.6%
11-18 min	19.6%	27.6%	19.8%	23.0%
>18 min	10.9%	18.4%	7.7%	12.8%
Total	100%	100%	100%	100%
Respondents	46	98	91	235

According to survey reports, residents in the Tohoku region spent almost 30 minutes to evacuate to shelters, including the time period before and during evacuation (Ministry of Land, Infrastructure, Transport and Tourism, 2011). Thus, the Okitsu data underestimate the required evacuation time, because it was a supposed one. Tsunami evacuation time is important for Okitsu and other coastal regions, so finding out what elements determine it is important.

4.4 Further Analysis of Tsunami Evacuation Time

To further discuss the evacuation time, we set Q4 (expected tsunami evacuation time) as the explained variable and all the other questions except the open-

ended question as explanatory variables, and applied CATDAP, a categorical data analysis program package for analyzing cross-classified data. CATDAP automates the search for optimal combinations of predictors (explanatory variables) on which a specific response variable (the explained variable) has the strongest dependence.

Specifically, CATDAP calculates Akaike's information criterion (AIC), which ranges from small to large order in the form of cross-classified data on explanatory variables (Sakamoto, 1985). Recognition as a significant category of data occurs when AIC is less than -1 (Terado *et al.*, 2004). If the explanatory variables have more than three items or if they are continuous, CATDAP will auto-categorize them into groups giving the smallest AIC. For example, the items "strongly agree, agree, disagree, and strongly disagree" might be categorized into two groups, such as one group of "strongly agree" and another of "agree, disagree, and strongly disagree."

Table 12 shows the top-five AIC values, ranked from low to high scores of explanatory variables when Q4 is the explained variable. The corresponding cross-classified data are shown in tables 13-16. Because we have discussed the relationship between L (location) and Q4 (expected tsunami evacuation time), here, we limit our discussion to other items, namely, shelter (Sakura Kai and other), gender, reason for evacuating (earthquake and other), and anticipated tsunami risk management (disaster drills and other).

Table 12. Items of explanatory variables

Rank	Explanatory variables	Categories of explanatory variables	AIC
1	Q3 (shelter)	2	-15.61
2	G (gender)	2	-7.02
3	L (location)	2	-6.24
4	Q2 (reason for evacuating)	2	-5.42
5	Q9 (anticipated tsunami management)	2	-3.25

To begin with, we discuss the relationship between tsunami evacuation time and shelter shown in table 13. The auto-categorized results for shelters are grouped into the Sakura Kai and other, where "other" indicates all other shelters (see figure 2). This result can be explained that the location of the Sakura Kai is far from the residential areas.

Table 13. Cross-table of Q4 and Q3

Q3 / Q4	0-3 min	4-5 min	6-10 min	11-18 min	>18 min	Total	Respondents
Sakura Kai	0.0%	15.0%	33.7%	28.7%	22.5%	100%	80
Other	7.7%	23.8%	43.1%	20.0%	5.4%	100%	130

Next, we discuss the relationship between tsunami evacuation time and gender. Since the questionnaire survey packages were allocated to every household but not the individuals, a gender bias of respondents can be considered. Nonetheless, amazingly, the gender ratio of respondents (46% male to 54% female) is pretty close to that of the whole population (47% to 53%), which indicates that the result of the questionnaire survey best represents the gender characteristics in the Okitsu community. Table 14 shows that 12.1% of males suppose that they can evacuate within 3 minutes, compared to only 1.7% of females. Twice as many women as men claim they need more than 10 minutes to evacuate.

Table 14. Cross-table of Q4 and G

G / Q4	0-3 min	4-5 min	6-10 min	11-18 min	>18 min	Total	Respondents
Male	12.1%	22.4%	39.3%	17.8%	8.4%	100%	107
Female	1.7%	21.5%	35.5%	24.8%	16.5%	100%	121

It is difficult to explain the difference using only the survey results, so we suggest the following as possible reasons. Ikeda (2010) noted that compared with men, women usually have less physical strength and lower coping capacity under emergency situations. Also, in most cases, the behavior of women is determined by extrinsic factors, for example, in the collection of disaster information or decision-making. When we discussed this issue with residents in Okitsu, one female said, "When I go out without taking the bankbook with me, I'm anxious about the future livelihood of my family should an earthquake strike." This indicates that different expected actions between men and women might lead to delayed evacuation among women.

Table 15 shows the relationship between expected tsunami evacuation time and reason for evacuating. The term "other" includes tsunami warning, community warning alarms, neighbors calling, others evacuating, tsunami, and other factors except the earthquake. We find that people who claim they can evacuate within 3 minutes all considered evacuating immediately after an earthquake. In contrast, 26.8% of residents who need more than 18 minutes will not

evacuate even after a big earthquake (in fact, they decide to evacuate because of other motivations).

Table 15. Cross-table of Q4 and Q2

Q2 / Q4	0-3 min	4-5 min	6-10 min	11-18 min	>18 min	Total	Respondents
Earthquake	7.4%	21.6%	40.7%	21.1%	9.3%	100%	204
Other	0.0%	22.9%	20.0%	31.4%	25.7%	100%	35

In those areas where a tsunami will hit shortly after an expected Nankai Trough earthquake strikes (such as Okitsu), reducing the number of casualties requires that residents take earthquake tremors as the sign to evacuate. Some Okitsu residents told us that they remember the 1946 Showa Nankai Earthquake and learned the importance of quick evacuation after an earthquake strikes. One respondent said, "I keep my purse near my pillow in case an earthquake occurs in the night." Such valuable experiences of residents should be taken seriously and spread to the population at large.

Finally, we discuss the relationship between tsunami evacuation time and anticipated tsunami prevention management (table 16). Here, the term "other" includes measures such as disaster education symposiums, building shelters and roads, purchasing information distribution equipment, developing evacuation instruments, stocking supplies, and strengthening levees. It is interesting that both those who claim to have the capacity to successfully evacuate within 3 minutes and those who would require more than 18 minutes insist that disaster drills are important. This tendency might be explained in that people who can evacuate quickly realize the function and achievements of disaster drills and thus praise them, while people who suppose they need more time to evacuate intend to participate in disaster drills to enhance their evacuation capabilities. Nevertheless, people who require 3 to 18 minutes to evacuate emphasize the importance of other aspects of disaster risk management. Thus, we have to introduce more appropriate approaches based on the various individual needs, according to their expected tsunami evacuation time.

Table 16. Cross-table of Q4 and Q9

Q9 / Q4	0-3 min	4-5 min	6-10 min	11-18 min	>18 min	Total	Respondents
Disaster drill	10.1%	20.9%	36.4%	17.8%	14.7%	100%	129
Other	1.9%	25.0%	37.0%	26.9%	9.3%	100%	108

5. Conclusion

This paper discussed the results of a questionnaire survey conducted in the Okitsu community, where advanced disaster risk management has been effectively promoted in light of the high risks of an expected Nankai Trough earthquake. Considering the impact of the Great East Japan Earthquake, we investigated issues concerning tsunami evacuation, such as individual-level problems, reevaluation of damage estimates, and tsunami evacuation in detail. In Okitsu, not only have hard facilities been established, but soft strategies such as disaster education have also been carried out. These achievements were verified by the results of the questionnaire survey.

However, as discussed in the above section, numerous issues of disaster risk management remain to be resolved. For example, according to the survey results, evacuation time in Okitsu is largely underestimated when compared to the Tohoku region because nearly 30% of respondents replied that they could get to shelters within 5 minutes, while during the Great East Japan Earthquake, evacuees spent almost 30 minutes. To resolve these problems, we have pointed out that it is necessary to take the situation of individual residents into consideration to plan concrete measures. As further analyzed by using the CATDAP method, differences in evacuation time among the three subunits, evacuation motivation, and attitudes toward future tsunami management provided specific information for considering disaster risk management based on concrete individual-level issues.

As researchers conducting action research in the Okitsu community, we cooperate with Okitsu Elementary School, Okitsu DEC, and the local administration to promote a new approach called the single-person drill (Sun *et al.*, 2013b). Space limitations preclude describing the single-person drill in detail. What we emphasize here instead is that since the questionnaire survey was conducted through our action research, it will not only point out problems and analyze past achievements, but will serve to find further solutions. This is the real significance of conducting action research. Thus, we want to briefly describe what the single-person drill is to show the long-term objectives of the research.

During the single-person drill, someone plays the role of evacuee carrying GPS equipment while travel-

ling from home to a designated evacuation shelter. Pupils record the evacuation process as a lesson in disaster education. Two pupils use video cameras to record the evacuee's behavior from different angles. One also measures how long the evacuation takes, and the other writes down any interesting observations during the evacuation, such as paths that might be too steep for elderly persons, or bridges that would collapse in an actual emergency condition. The evacuation route as recorded by the GPS sensor is shown on a GIS map with an overlaid tsunami inundation simulation graphic, so that the survivability of the simulated evacuation route can be seen easily.

Pupils can further participate in the single-person drill by creating a video record to promote disaster education. For these video records, a television production company assists with creating a multi-screen video where the screen is divided into four parts. One part shows the first student's video, and the diagonally opposite part shows the second student's video. The third part shows the pupils' comments, and the fourth part shows the GIS map. A clock in the middle shows the time elapsed, and the entire simulated evacuation is time-synced. This approach compactly collects individual-level problems related to tsunami evacuation, in a form similar to clinical records.

According to Sun *et al.* (2013b), the single-person drill aims at overcoming the difficulties described in this paper, by shifting tsunami evacuation from a general, non-urgent condition to a specific, concrete task that can be accomplished by an individual resident. The drill also greatly contributes to the improvement of existing evacuation facilities, because the actual experience of evacuating provides a chance to understand both the strengths and weaknesses of the facilities. It also promotes co-learning of tsunami risks by intergenerational participants, such as elderly evacuees and young collaborators. It is important that the single-person drill combines both the active intervention of researchers in the local community and the neutral research activity of data collection, such as data on the evacuation behavior of residents or data for checking the effectiveness of existing facilities.

With information on every resident's evacuation accumulated through the single-person drill, we can establish databases of disaster management in Okitsu. Also, to have qualitative data on the single-person drill quantified, we can easily compare them with other data, such as the results of the questionnaire survey analyzed in this paper, or data from other communities, to discuss the differences and similarities between them, and to assimilate precious experience from both practice and surveys. In this way, it will not only have a great influence on the practice in Okitsu and other regions, but on academic researches as well.

As the need for disaster risk management of an expected Nankai Trough earthquake increases, core issues of damage mitigation and coping capacities based on special and individual conditions are indispensable. The research in this paper is an initial step toward meeting the requirement for action research. The final purpose of the single-person drill is to motivate individual residents to actively participate in their own disaster risk management. So the research does not just retain the position of finding out problems, but pursues betterment for the research community.

Acknowledgements

The authors thank the staff of Okitsu Elementary School and the Headquarter Office of Disaster Risk Management of Shimanto Town for their assistance and support, especially members of the Okitsu Disaster Education Committee, for their generous cooperation and valuable input.

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