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Original article

Impact of the 2011 Tohoku Earthquake on the Use of Tidal Flats: A Case Study in Inner Tokyo Bay

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Abstract: Coastal areas have recently been revaluated to understand the relationship between ecosystem services and humans. However, devastation from the 2011 earthquake and tsunami in Japan might have limited the use of ecosystem services. Thus, we investigate the effects of the earthquake and tsunami on the use of tidal flats. We used questionnaires to evaluate changes in the number and anxiety of users for each type of use of the Sanbanze tidal flat in the innermost part of Tokyo Bay. We also conducted a field survey to verify the trends.

We found that clamming and walking or jogging were the most common uses in the surveyed area. However, clamming activity decreased after the earthquake as indicated by field observation (73% decrease in spring long holiday season) and questionnaires (64%). Other clamming ground in Tokyo Bay also showed a similar decrease (62%). Many visitors were anxious about the damaged infrastructure. Compared to other types of use such as swimming or total tourism in the tourism statistics, the recovery phase was slower for clamming using the data of other locations. Considering these evidence, the innermost part of Tokyo Bay can be classified as an earthquake-devastated area, from the view point of ecosystem services.

Key Words: behavioral change, tourism industry, Great East Japan Earthquake of 2011, marine leisure use, shellfish gathering, marine ecosystem services

INTRODUCTION

From a historical viewpoint, there has been a close interrelationship between human activity and the natural environment especially in coastal areas. Most large cities were built in coastal areas and humans benefitted from natural resources, including living aquatic species, and water transportation. Although there was no special attention paid to such a human–nature relationship during the era of high economic growth, it has recently been recognized and better understood with the consideration of ecosystem services (Costanza *et al.,* 1997, 2014; Millennium Ecosystem Assessment 2005; Barbier *et al.,* 2011). This relationship (i.e. the use of ecosystem services) helps to maintain and improve human well-being in a rapidly urbanizing world (Brymer *et al.,* 2010; Keniger *et al.,* 2013) and promote human–nature relationships for the sustainable use of ecosystems. Among all ecosystem services, cultural services are considered the most important for the promotion of the sustainable use of ecosystems. This is especially true in the case of education (Kaplan, 2000; Miller, 2005; Soga, and Gaston, 2016; Soga *et al.,* 2016). These relationships were also emphasized in the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES), which was established to mainstream biodiversity conservation and build a sustainable society after the decision of the 10th Conference of Parties of the Convention on Biological Diversity (CBD-COP 10) in 2010 and the 2007 meeting of the G8+5 Environment Ministers in Potsdam, Germany (Barbier *et al.,* 2011; Díaz *et al.,* 2015). Policy supporting tools, scientific evidence and data are also needed

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from scientists to promote the sustainable use of ecosystems (Yamakita *et al.,* 2015a).

For this purpose, it is important to evaluate the recognition and change in cultural ecosystem services. In the discipline of climate change adaptation, the resilience of ecosystem services are often evaluated as dependent on the changes to ecosystems (supply side) and less so in terms of social preferences (demand side) (Thomalla *et al.,* 2006). For example, ecosystem services were evaluated as a response variable to changes in human population and the status of ecosystems to future climate change without consideration of the change in demand for ecosystem services (Mitchell *et al.,* 2015). In the case of the Millennium Ecosystem Assessment, changes in the demand of different scenarios were considered but only qualitative evaluation was conducted (Millennium Ecosystem Assessment 2005; Carpenter *et al.,* 2009). In the case of a disaster, the environment (including the disaster itself) affects the demand directly, at least in terms of short-term time scales. In the context of the changes in demand for ecosystem service, we need to evaluate how much and which types of cultural services are affected by a disaster (McDonald, 2009; Burkhard *et al.,* 2012). This is the first objective of our research.

The year after CBD-COP 10, the Great East Japan Earthquake of 2011 occurred off the Pacific coast of Tohoku on 11 March. The magnitude 9.0 earthquake caused strong and sustained shaking over a wide range on the east side of Japan. In addition, the accompanying tsunami caused serious damage in most of the eastern regions along the Pacific Ocean especially in Tohoku. The tsunami destroyed a huge seawall over 10 m high, and reached 40.1 m in height at its maximum. Houses, bridges, and buildings were swept into the ocean (Yamakita *et al.,* 2015b). Even in areas not affected by the tsunami, there were frequent after-shocks in a large area of eastern Japan. Video recordings of the tsunami were repeatedly broadcast by the mass media (Ishigaki *et al.,* 2013). The planned power outages impacted industry and traffic (Akamatsu *et al.,* 2013). And radioactive materials were released from the Fukushima Daiichi nuclear power plants. These incidents sparked confusion and anxiety among many residents.

As a response to this situation, the psychological damage from the earthquake and tsunami in the devastated area was measured (Ishigaki *et al.,* 2013; Shultz *et al.,* 2013). For example, more than 40% of the inhabitants of the tsunami-devastated area showed mental problems, categorized as more than moderate (Yokoyama *et al.,* 2014). In general, the effect of the disaster decreased by distance from the epicenter and elapsed time. Remote areas, not exposed to the disaster, were expected to have limited or transient psychological damages (Bonanno *et al.,* 2010). The psychological damage consisted of two phases: the crisis phase and the recovery phase. In the recovery phase, the path to recovery depended on the impact to the system (Masten, 2010). However there are not many quantitative data to evaluate the recovery phase (Chang, 2010).

From the above point of view, we can investigate whether there is a strong and long staying as seen in the disaster devastated areas even in the ecosystem services in distant places which have little survey but extend large area. For this purpose it is important to show both the impact of this huge earthquake on people's attitudes to nature in areas far from the epicenter and temporal changes of people's attitudes to nature quantitatively, by way of randomly sampled questionnaires and field observations. In addition, we propose that not only spatial and temporal factors but also different types of use contribute to the differences in impact and recovery. We focused on the demand of ecosystem services in the Tokyo Bay area, because it is far from the epicenter (over 200 km) and because there were no fatal damages in this area (i.e. expectation of quick recovery in theory). As a second question, we state whether this remote area can be considered a non-exposed area by considering spatial, temporal, usage type differences of the tidal flat.

The intertidal and shallow Sanbanze wetland (hereafter we call tidal flat in broad sense) located in the innermost part of Tokyo Bay is a suitable area for this study (Sanbanze Restoration Planning Board 2004). There are some records of discussions and surveys about the use and impressions of this tidal flat by local communities as a result of conservation activities. For example, educational activities and stakeholder meetings were carried out in this area after a landfill plan was halted in 2001. Some of these interviews were conducted before the earthquake (Urayasu whole-NatureEXPlorers 2014).

After the earthquake, this area was affected not only by the planned power outages and after-shocks, which affected most of the Tokyo metropolitan population, but also by liquefaction, which caused damage to houses, roads, and other infrastructure (Unjoh *et al.,* 2012; Yasuda *et al.,* 2012). In addition, some intertidal areas became subtidal because of liquefaction, subsidence, and the fast flow from the tsunami (Chiba prefeture 2012). Therefore, we thought that both the psychological and physical effects of the tsunami could affect people's relationship to the tidal flat and their attitudes toward its use and conservation.

In order to show the effects of the earthquake and tsunami on the use of the tidal flat and its cultural ecosystem services, we used questionnaires to evaluate changes in the number of users for each tidal flat usage. For clamming, which has a high economic value (873 USD (91000 yen)/ha·year)[1)], we used field surveys to evaluate the number of users and compared the results with those of the questionnaires. We evaluated the cause of these changes by comparing travel statistics for other regions in the Chiba Prefecture with visitorship to the Sanbanze wetland as well as the results from the questionnaire about the drivers of changed impressions.

1. METHODS

1.1 Study site

Among the peripheral areas of the Sanbanze wetland, we conducted our survey near Urayasu City, which is the closest residential area to the wetland (the Hinode area; Fig. 1). We have interview data about local impressions of the wetland from before the earthquake (Urayasu whole-NatureEXPlolers 2014). We expect people in this area to have similar responses, because they moved to the area around the same time, following construction of the condominium apartments in the landfill area.

Since the reclamation plan for the Sanbanze wetland was called off in 2001 following a contentious election, several conservation activities were conducted at multiple levels, from local community organizations to the prefectural government. The Sanbanze restoration planning committee, which was lead by the prefectural governor, committed to full transparency and expected a novel participatory process by adapting the inclusion of multiple stakeholders in the consensus building and planning processes (Kawabe, 2004; Sanbanze Restoration Planning Committee 2004; Yamazaki, and Yamazaki, 2008). Although there was conflicts regarding the conservation engineering plan, a massive 10 year public relations campaign successfully instilled the importance of this tidal flat area and opened people's eyes to the gift of this remaining piece of nature. In the area of the Sanbanze closest to Urayasu City, ongoing beach cleanup activities starting in 1998, a nature observation event

Figure 1. Map of study site and other tidal flats in Tokyo Bay. Darker areas are landfill (reclaimed) areas; several of these suffered land liquefaction after the earthquake.

starting in 2002, and other sporadic events have been held at the community hall and folk museum involving schools and other groups.

For comparing turnout data at these locations, we also used statistics for the number of visitors to each clamming ground (shellfish gathering; SHIO-HI-GARI) and the total number of visitors to bathing beaches in the Chiba prefecture (Fig. 1).

1.2 Study setup

We conducted a survey about usage and impressions of the tidal flat using questionnaires collected by the postal service (Summarized in Table 1). As for the status of usage and impressions before the earthquake, 200 questionnaires including 100 in Hinode were distributed to mailboxes haphazardly in Urayasu City in December 2010. For spreding the mail we decided the street line of populated area and randomly selected houses or building moving by car. At the each of point we picked haphazard amount of the questionnaires and roundomly selected mailbox which did not refuse direct mail. Although sampled numbers are small compare to the population of this city, 26 samples are enough to obtain 0.8 test power for chi sqare test under the condition of p=0.05 df=1 effect size= 0.5 (Large) using power analysis assuming detection of the changes of a single presence absence factor. This survey was originally conducted to gauge the interest of people living near the tidal flat to construction plans for an observatory (Urayasu whole-NatureEXPlolers 2014). After the earthquake, another 100 questionnaires, which included some additional topics relevant to the earthquake disaster, were distributed in the Hinode area in December 2013 in the same manner. All questionnaires were collected by postal mail and surveys with unusual responses were removed. A non-response bias was not evaluated because our interest was present and past usage. The questionnaires consisted of basic respondent profile, marine leisure use (in the both 2010 and 2013), knowledge of the conservation plan (only in the 2010 version), and impact of the earthquake (only in the 2013 version). In the questionnaire cover letter to the respondents, we only mentioned that the surveys were being carried out in order to elucidate uses of the tidal flat and consideration of future situations, and did not add any further information which might affect the results. The following paragraphs describe the details of each topic relevant to the earthquake response.

1.3 Impact of the earthquake and tsunami on attitudes toward the ocean

In the 2013 survey, we asked people about their perception of damage, changes in earthquake-related factors, and changes in their attitude towards the ocean. The respondents were asked about household damages from the earthquake by selecting from the following choices: 1) sediment blowout or inflow, 2) falling or stacking of furniture, 3) interruption of water supply, 4) planned power outages, 5) ground subsidence, 6) complete house collapse, 7) partial house destruction, and 8) others.

To understand changes in their impressions of earthquake-related factors, respondents were asked to indicate their impression, either positively or negatively from the following choices (multiple selections for each were allowed): 1) ocean, 2) landfilled areas, 3) waves, 4) seawall protection, 5) Urayasu, 6) politics, 7) city government, 8) the Self-Defense Forces, 9) civil engineering, and 10) atomic power. Information about changed impressions of the

Table 1. Graphical abstract of the questionnaire. Numbers correspond with the section numbers.

Study site (Section 1.2)	Hinode	Entire city of Urayasu
2010	○	○
2013	○	-

Questions	Material& Methods	Results
Basic profile	1.2	2.11)
Damage by the earthquake (only 2013)	1.3	2.12)
Impression of earthquake related elements (only 2013)	1.3	2.13)
Usage types in past, demand (only 2010) and their change (only 2013)	1.4	2.2

ocean was used for further analysis together with the usage data described in the next section.

1.4 Use of the tidal flat before and after the disaster

We asked questions about the types of usage in the tidal flat in both surveys. For the questionnaire before the earthquake, we also asked respondents to answer the potential demand of each of the usage. For the questionnaire after the earthquake, we also asked questions about changes in usage. Respondents were asked to select their usage (or lack thereof) for the part of the Sanbanze wetland in front of Urayasu from the following choices: 1) walking or jogging, 2) observing nature on the tidal-flat, 3) bird-watching, 4) fishing, 5) clamming, 6) picnicking, 7) beach cleaning, 8) photography, 9) cycling, and 10) others. They could choose more than one option, but we also asked them to select their most frequent usage. Respondents who had never been to Sanbanze wetland were eliminated from the sample size for this question. To understand the relationships among the types of usages and the changes in usage after the earthquake, we calculated the co-occurrence of usage for each respondent. A co-occurrence network diagram was created using a matrix of presence–absence data. We also performed association analysis for data that had a high enough incidence of co-occurrence (R 2.15.1 and packages 'network' and 'arules'; Hahsler et al., 2005; R Core Team 2012). We also compared the diversity of usage and the number of usages that stopped after the earthquake. We calculated 95% confidence intervals to account for cases where users randomly stopped any usage, based on the average rate of stoppage. We also compared numerical values by categorizing users into core users (three or more types of use) or light users (less than two types of use, primarily walking or jogging, and clamming).

In order to determine the number of visitors at the time of spring low tide from May to July, we used an interval-timer camera from 29 April to 7 May and June 6 to July 7 in 2010 (Garden Watch Cam, Brinno Inc., Taipei) and for three consecutive days beginning 1 July 2011 (TimelapseCam 8.0 Wingscapes, Calera, AL, USA). In addition, the maximum number of visitors was observed visually on 6 May 2012 and the number of visitor was obtained from photographs of a limited area which covered over 70% of the interval–camera survey area on 1, 4 and 18 of May 2011 and result was offseted using this rate. Time series data from 2010 were used to produce a regression model of the population of visitors considering the tidal height and type of day (long holidays, normal week end and week day). Days with rain fall over 2.5 mm and tidal height higher than 40 cm were eliminated from the time series dataset.

In order to consider the general applicability and factors behind changes in usage that were observed in the Sambanze wetland, we compared the results with changes in the number of visitors for other similar types of tourism, such as clamming and sea bathing elsewhere in the prefecture. For this purpose, we compared the mean value for the numbers of visitors from 2008 to 2010 with the number of visitors for each year after the earthquake disaster. Data were obtained from the report on the Survey of the Number of Tourists, Chiba Prefecture as reported by the Tourism Planning Division, Commerce, Industry and Labor Department, Governor's Branch of Chiba Prefecture 2007–2014[2)].

2. RESULTS

2.1 Respondent profile

1) Basic profile

The response rate in percentage and number (written in the branket) were 25.5% (51) for the entire city (including Hinode) in 2010, 25% (25) for only the Hinode area in 2010, and 27% (27) for the Hinode area in 2013. In 2013 valid sample numbers were 26 except question about changes of the impression (section 2.1 3)) because one respondant left some answers blank. In the case of question about household damage (section 2.1 2)) it was 25 because another one left blank only for this question. We did not see a bias in the responses according to the order of the answer options listed in the questionnaire.

The respondents can be characterized as follows. This area was developed in the successive years after the construction of condominium apartments in the landfill area. Thus, similar types of respondants and the small variation in their answers were expected. No significant difference of the respondant generation was also observed in the different years (t test t=0.69 p=0.49 for age with offset of different years).。

Among respondents for the entire city in 2010, the median length of time living in the city was eight years and most of the respondents had moved in after construction of their apartments 20 years before. The average respondent was 50 ± 15 years old (mean ± SD), an office worker or a housewife, with children. The number of each sex of respondents was 25 and 25 (male and female).

For the subset of respondents in the Hinode area in 2010, the median time in the city was eight years, and most of the respondents had moved in after construction of their apartments 20 years before. The average age was 51 ± 13 years and likewise most worked as office workers or housewives, and had one child. The sex of the respondents was 13 and 12.

For the Hinode area in 2013, the median time living in the city was 12 years and most of the respondents had moved in after construction of their apartments 25 years before. The average age was 52 ± 12 years with a similar employment and family structure as shown by the survey in 2010. The sex of the respondents was 12 and 15.

2) Household damage incurred

As a first half of the result from the method 1.3 23 out of the 25 respondents had suffered from a suspension of the water supply. Planned power outages, ground subsidence, and sediment discharge affected on 14, 11 and 10 respondants sucsessively. Because most respondents lived in robust buildings, such as apartments, only 6 and 2 had experienced partial house destruction or stacking of furniture successively.

3) Changes in impressions of the ocean as related to the earthquake disaster.

As the rest half of the result from method 1.3 1) ocean, 2) landfilled areas, and 10) atomic power were selected by 16, 14 and 14 respondants successively as things for which their impression deteriorated. 8) the Self-Defense Forces (SD Forces) and 7) city government ware selected as things for which their impression improved (8 and 7 respondants serected). There were mixed positive and negative responses for 4) seawall protection and 5) Urayasu. Details are listed in the Figure 2.

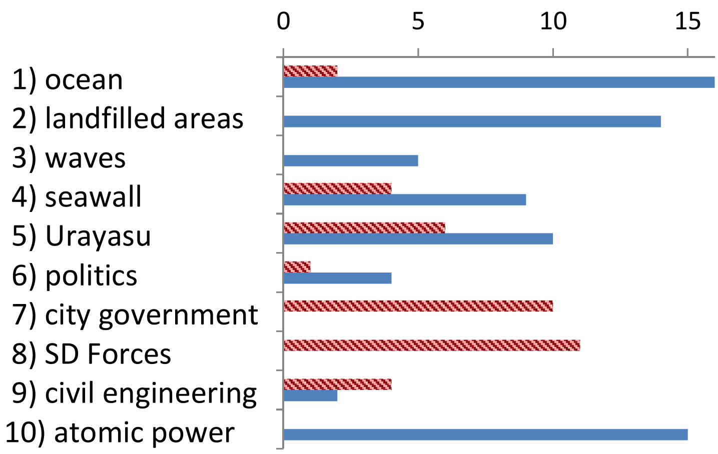

Figure 2. Changes in impressions of the ocean. Shaded red bar means positive. Filled blue bar means negative impression (*n*=26).

In addition, respondents were asked about changes in their impression of the ocean after the earthquake using the Likert scale of five levels from positive to negative. While 37% (10 respondants) of respondents answered that their impressions worsened, 52% (14) reported no change. Following the question about changing impressions of the ocean, we asked about the reason for the change using the following choices: tsunami, liquefaction, seawall protection, and nuclear radiation. From these multiple selections, 18 people selected the tsunami, 14 selected seawall protection and liquefaction, and 6 selected nuclear radiation.

2.2 Usage survey before and after the earthquake

1) Usage survey from the questionnaires

The usage results are summarized in Table 2 and Figure 3. In 2010 entire city data, 65% (17) of respondants used the wetlands area for walking or jogging. Clamming (50%; 13) was the second most common usage, followed by tidal-flat nature watching (35%; 9), fishing and bird watching (15%; 4), and cycling and photography (12%; 3). In the subset of data from the Hinode area, 80% (12) enjoyed walking or jogging, and 40% (7) preferred clamming, while 47% (7) tidal-flat nature watching.

In 2013, respondents were also asked about usages that had stopped after the earthquake. 64% (14) of the respondents who had enjoyed clamming before stopped clamming after, but the termination rates were generally lower than 34% for the each of the other activities (3 stopped among 9 who enjoied nature watching and 2 stopped among 6 who enjoied Cycling). Significant changes from past usage and continued usage were observed in claming and walking/jogging by pairwise comparison using McNemar's Chi-squared for 2013 data (astarisks on Figure 3; χ^2_m=5 and 9 p=0.03 and 0.003 for walking/jogging and clamming successively. Others are χ^2_m<2, p>0.15).

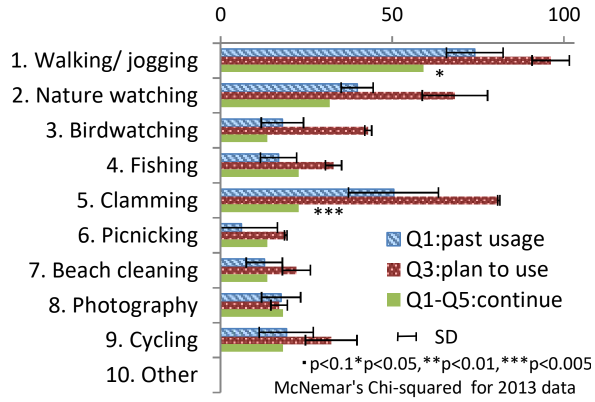

Figure 3. Comparison of the percentage ratio of wetland usage. Detail of the data is written in Table 1. Number of continued usage was calculated from the result of Q5 and Q1. SD is estimated from 2009 Hinode, 2009 entire city and 2013 Hinode area for Q1; 2009 Hinode and entire city for Q2.

2) Co-occurrence of the answers

Based on the combined results of the 2010 and 2013 surveys (48 pooled samples), we generated a co-occurrence network diagram (Fig. 4a). There

Table 2. Results from questionnaires about wetland usage. The number represents the voted numbers. Those who never used this area were eliminated.

Survey questions:
Q1. How have you used the Sanbanze wetland at Urayasu?
Q2. Please choose the most frequent usage from your response to Q1 above.
Q3. (2009 only) How do you plan on using Sanbanze wetland at Urayasu in the future?
Q4. (2009 only) Please choose the most frequent usage from your response to Q3 above.
Q5. (2013 only) After the earthquake, which usage did you quit?

	2009 the entire city including Hinode area (n = 26)				2009 Hinode area only (n = 16)				2013 Hinode area only (n = 22)		
Wetland use	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q5
1. Walking/ jogging	17	12	24	18	12	6	16	9	18	15	5
2. Nature watching	9	2	16	2	7	1	12	1	9	2	3
3. Birdwatching	4	1	11	0	4	1	7	0	3	0	0
4. Fishing	4	1	9	3	2	0	5	2	5	1	0
5. Clamming	13	6	21	7	6	3	13	5	14	3	9
6. Picnicking	0	0	5	1	0	0	3	0	4	0	3
7. Beach cleaning	2	1	5	1	2	1	4	1	4	0	1
8. Photography	3	0	4	0	3	0	3	0	5	0	1
9. Cycling	3	0	7	0	3	0	6	0	6	1	2
10. Other	0	0	0	0	0	0	0	0	0	0	0

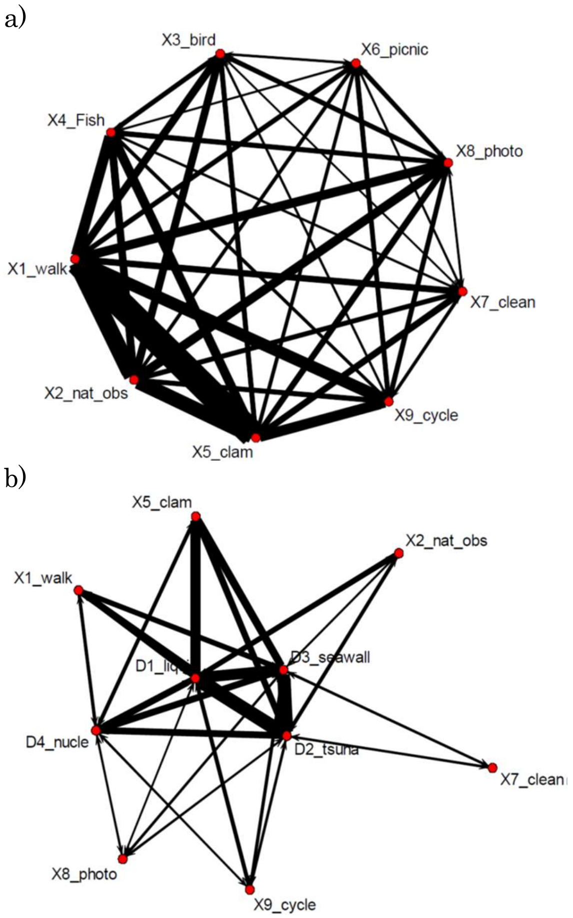

Figure 4. Co-occurrence network diagram of the use and changed attitude*,. a) Co-occurrence of the types of tidal-flat usage. b) Co-occurrence the terminated usage after the earthquake and elements associated with changes in attitudes toward the ocean.**

* The thickness of the line reflects the relative number of co-occurrences (from 1 to 4 for a) and from1 to 9 for b)).

** The abbreviated variable names are as follows: X1, walking or jogging; X2, nature watching; X3, bird watching; X4, fishing; X5, clamming; X6, picnicking; X7, beach cleaning; X8, photography; X9, cycling; D1, land liquefaction'; D2, tsunami; D3, seawall protection; D4, nuclear radiation.

was no significant difference in the percentage of each usage for multiple selection and single selection questions (pair wise t test t = -1.54 p =0.15 mean difference = 3.89). Of the respondents, 55% who enjoyed walking or jogging did both clamming and walking or jogging (support = 0.55, confidence = 0.86, lift = 1.05) whereas 10% participated in neither activity. Walking co-occurred not only with clamming but also with fishing, cycling, beach cleaning, and nature-watching (support >= 0.12 confidence >= 0.80, lift >= 0.94). We also generated a co-occurrence network diagram of the usages that stopped after the earthquake. The number of samples was very limited in this case, because half of the people who stopped clamming did not have a co-occurrence with another activity. The co-occurrence diagram of the usages after the earthquake also showed a dominance of walking or jogging because of the lack of clamming.

By comparing the diversity of usage types and the number of terminated usage types, we found that 42% of those involved in only two usages stopped both activities after the earthquake (n = 7). In the cases of those with more than two types of uses for the wetland, the number of stopped usages varied. Compared to the null hypothesis of randomness with the occurrence of stoppage, only two cases were significantly differed from the null hypothesis. Thus, it was difficult to reach any conclusions with such a small sample size. We also categorized those involved in more than three types of any uses as core users. Six out of 13 core users continued their usages after the earthquake. Another three core users continued all of their activities except for clamming.

Finally, we generated a co-occurrence network diagram for the usage types that stopped after the earthquake together with the elements affecting changes in attitude towards the ocean after the disaster (Fig. 4b). Seven out of nine respondents who stopped clamming pointed to liquefaction as the reason, four indicated the seawall, three selected the tsunami and two identified nuclear radiation.

2. 3 Camera survey of visitor numbers

The survey of visitor numbers using an interval camera showed that the number of visitors entering the tidal flat increased in conjunction with the lowest tide of the day. Although the trend of the increase differed among the long holiday season, normal weekend and weekday, the number of visitors were highly correlated with the lowest tidal hight using linear model with or without log transformation (y=4.15x-181.6,

R^2=0.98, t=12.7, F=160.7, p=0.001 for long holiday; log(y)=7.73*log(x)-32.14, R^2=0.98, t=11.4, F=129.9 p=0.001 for normal weekend; log(y)=0.045x-1.37, R^2=0.60, t=3.45, F=11.8, p=0.009 for weekday).

During the 2010 spring holiday season (from 29 April to 7 May), the maximum number of visitors to the tidal flat was 210 during a 15-minute survey interval. From 1 May to 4 May in 2011, there were fewer number of visitors as compared to before the earthquake (27% in average; Table 3). For this calculation the number after the earthquake was compared with the predicted values by the above linear model considering tidal range. For 6 May, 2012, it was 25%. During thease seasons there were no rain in the daytime. A strong windy day observed only in 1 May 2011. In the case of a normal week day and week end such as three consecutive days beginning 1 July and 18 May, 2011 it was from 89% for weekday and 87 % for weekend compared to the value predicted by tidal hight using the linear model in 2010. In addition, it should be mentioned that the number of family visitors with children, which were mainly observed during the spring holiday season, decreased after the earthquake.

Table 3. Number of daily visitors observed in Hinode area before the earthquake, and the percentage after the earthquake compared with the predicted number based on tidal height.

	2010 max (mean)	2011	2012
Holiday season	210 (136)	27%	25%
Weekend	64 (45)	89%	-
Weekday	17* (7)	86%	-

*97 visitors observed on 11 June 2011 was considered as outliner and eliminated when produce this table.

Table 4. Average number of annual visitors (thousands) before the earthquake, and the percentage of the number after the earthquake [2)]

Location (activity)	mean 2008 –2010	2011	2012	2013
Funabashi (sports and recreation)	20	closed		
Funabashi (clamming)	14	closed	42%	63%
Kisarazu (clamming)	32	41%	51%	69%
Futtsu (clamming)	17	35%	52%	58%
Sum of sea bathers	2374	48%	68%	76%
Sum of visitors swimming pool	1226	80%	101%	103%
Sum of visitors in prefecture	152366	88%	102%	109%

2.4 Comparison with other tidal flat and marine activities.

In 2011, the number of visitors to three clamming ground areas was only 38% of the mean from 2008 to 2010 (mean of two areas; one area was closed in 2011; Table 4). Even in the years following, the percentage of visitors entering the clamming grounds as compared to earlier years was 48% in 2012 and 63% in 2013 (mean of three areas), compared to the mean from 2008 to 2010.

In contrast to similar trends observed for sea bathing following the earthquake in 2011, both the number of visitors to swimming pools and the total number of visitors for all sightseeing in Chiba prefecture were 80% of the mean from 2008 to 2010. The visitorship fully recovered to 2010 levels by 2012 (Table 4). There were differences in recovery rates between marine leisure use and other leisure.

3. DISCUSSION

Although number of the response in the questionaries was limited, the result was considerable at least majority of usage because of latter reasons. There are significance in the changes of the usage in 2013 survey. Robustness of the result was corresponded to similar trend of the answer in different year. Similar profile of the respondandts also expect small variance in the answer. However minor types of the usage were still limited number of the sampling, thus we mainly focus on the trends in majority of the usage.

Our findings show that clamming and walking or jogging are common uses of the Hinode area in the

Sanbanze wetland. Among the major types of uses, clamming is one of a few that can be pursued by many people at once. Clamming is also unique as it is a type of use that involves getting directly into the water (Gotoh *et al.,* 2008). Thus, clamming among the major usages can be considered an important activity for promoting ecosystem services.

A comparison of the visitors to the tidal flat before and after the earthquake showed a decrease of 73% during the holiday season (Table 3.). Similar decrease observed in clamming estimated from the questionnaire results (64%; Table 2) and tourism statistics[2)] (62%; Table 4).

Corresponding to the spatial aspect of our subject, research was conducted in the area away from the epicenter of the devastation to evaluate the influence of the disaster. For example, macro-scale studies such as the impact on travel and supply chains were conducted and showed recovery within several months (Murakami *et al.,* 2012; Todo *et al.,* 2013). There were also some studies focusing on the human dimension at the local scale, including surveys of behavioral changes and perceptions of the disaster. For example, a survey into the causes of stress in an area not affected by the tsunami but affected by heavy shaking showed that psychological stress was influenced both by the presence of damaged houses, and by concerns over contamination with radioactive materials (Niitsu *et al.,* 2014). A survey on the happiness of people in major cities in Honshu, the main island of Japan, reported a reduction in the sense of well-being after the earthquake across all cities. Thereafter, recovery was observed in western Japan with the advent of the cherry-blossom season. However, there was a delayed recovery in eastern Japan, especially in the city of Sendai, one of the areas along the coast most severely damaged by the tsunami (Ohtake, and Yamada, 2013).

Our comparison of the different locations and types of leasure in Table 4, also observed termination of leasure itself which are not exclusive to the coastal area. Thus at least the decrease rate in tourism itself will be affected by universal drivers. Because such decrease happened in everyware these drivers were not affected by physical damage to the infrastructure, which varied from place to place. Basic fears that caused widespread anxiety can be the single driver to explain the results (Masten 2010).

From the aspect of usage types the observed negative impact was higher and stayed in coastal area especially clamming than swimming pool or total visitors in tourism statistics (Table 4). Similar trend also observed by field survay as compared with walking/jogging and clamming. In addition the negative impact was higher especially during the holiday season which majority of the pople will use than a normal weekend. This fact can be considerd that people who gathered to do popular leisure activities into the waters were (i.e. clamming as marine leisure) more sensitive to the situation.

In local scale near our study site, the seawall and roads, damaged by liquefaction were in the process of being repaired. Anxiety was high for both the seawall and liquefaction. Part of the tidal flat settled, more than just from ground subsidence. Thus, this physical damage on land might have contributed or trigger to the majority of people's anxiety in addition to the universal impact in the study site area.

CONCLUSION

In conclusion, we found the earthquake decreased clamming, the most important cultural ecosystem services, even in the Tokyo Bay area which is located far from the epicenter of the earthquake. Recently, the importance of human–nature relationships have been examined from the viewpoint of human well-being, mainstreaming biodiversity, and pro-environmental behavior (Soga, and Gaston, 2016; Yamakita, 2017). With an effort to foster this current momentum, it is important to recognize that the earthquake and tsunami destroyed not only aspects of the material world, but also the social infrastructure underlining this momentum (Takeuchi *et al.,* 2014). The opportunity to evangelize the masses to consider cultural ecosystem services by participating in clamming activities, was lost at least for the successive years after the disaster.

On the other hand, those pursuing other uses continued their activities in general. We suggest two courses of action to increase users of the tidal flat. 1) Increase the number of people clamming, by approaching users who already enjoy walking and jogging (highly correlated before the earthquake) to see if they may be interested in adopting clamming as well as walking/jogging. 2) Enhance uses that involve a very low number of users (but high potential demand before the earthquake; such as nature watching) but are robust, and continued after the disaster.

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NOTES

[1] Nature Conservation Bureau, Ministry of the Environment (23/5/2014 updated) Economic valuation of ecosystem services of wetlands. <http://www.env.go.jp/press/press.php?serial=18162>, 5/2/2016 referred.

[2] Industry and Labor Department, Chiba prefecture Government (8/10/2016/updated) Website of the Tourist trends <https://www.pref.chiba.lg.jp/kankou/toukeidata/kankoukyaku/index.html>, 31/7/2015 referred

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