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a comparative assessment between Japan and the USA

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Tsunami Awareness: A comparative assessment between Japan and the USA

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Awareness about the threats posed by different types of coastal disasters has increased throughout the world, as people are exposed to the nature of these hazards through media reports on events in distant countries. This has resulted in coastal residents being aware about the destructive power of tsunamis, despite no such events having taken place in their country in recent times. Regardless of this increased awareness, it has been hypothesized that there is still need for local governments to enact adequate policies to raise the awareness of local residents, for example, by holding regular evacuation drills. The present research presents a comparative assessment of tsunami awareness in two tourist destinations in Japan and the USA, which was derived through structured questionnaire surveys of beach users in the city of Kamakura and various coastal cities in Florida. The results show how despite relatively high level of awareness tsunamis still pose a considerable risk to each of the communities, for example, due to shortcoming in evacuation knowledge and infrastructure.

1. Introduction

The awareness of the risk associated with tsunamis throughout the world is increasing, due to the large number of events that have taken place since the Indian Ocean Tsunami in 2004 (see Shibayama, 2015, with recent events including the 2009 and 2010 tsunamis in Samoa, Mentawai and Chile (Aranguiz, 2015, Mikami and Shibayama, 2015) and the 2011 Tohoku Earthquake Tsunami, Mikami et al., 2012, Mori et al., 2012). The 2004 event can easily be considered one of the greatest disasters of recent times, with the media broadcasting its consequences and introducing the term “tsunami” to the vast majority of the planet’s population (though it is worth noting that some countries, such as Japan or Chile, had a long history of experience and awareness about such hazards, see Esteban et a., 2013).Subsequent events have led to the emergence of a heightened stage of tsunami awareness not only in the countries that suffered from them, but also in others where no tsunamis have taken place for a long time (Esteban et al., 2013, 2015). Actually, awareness about tsunamis has become so widespread that it appears to be higher than knowledge about other types of coastal flooding hazards, such as for instance storm surges. In the case of typhoon Haiyan in the Philippines in 2013, one of the strongest typhoons to have taken place in recent years (Mikami et al., 2015), it seemed that local residents had a low level of awareness about the nature of storm surges (Leelawat et al., 2014). The strong winds, together with the typhoon’s low central pressure (895hPa), generated a devastating storm surge which inundated several coastal towns and caused widespread damage (Takagi et al., 2015). Residents generally did not seem to adequately understand the concept of a storm surge, and many thought that it would have been better for authorities to describe it as a “tsunami” (Esteban et al., 2015, Leelawat et al., 2014).

The awareness that the inhabitants of coastal areas and tourists have about such natural hazards is clearly location specific, and depends on a variety of factors such as culture, education, and the policies of local and national governments (Esteban et al., 2013). The degree of awareness and preparedness can be reflected by various factors, depending on the protection countermeasures in place, the willingness to evacuate and various other measures taken by authorities or individuals (Esteban et al., 2013). However, literature on evacuation behaviour has typically focused on tropical cyclone evacuation, and an understanding of tsunami evacuation is still rather limited (Lindell and Prater, 2010). Although behaviour models based on tropical cyclone evacuation could be applicable to distant source tsunamis, near-shore events are significantly different given the short evacuation time available to local residents.

Fig. 1 shows how the degree of disaster awareness in a given country is thought to change throughout time, with recent events reinforcing awareness, but then this gradually fading with time unless significant efforts are made in education and training. This idea was conceptualized by Esteban et al., 2015, which shows how a given event (in a country or region that has not experienced them for several generations) can very quickly raise awareness. This awareness would then gradually decay as the following generations or immigrants that arrive to the area replace individuals that had experienced the event directly, though some degree of awareness might persist in the form of stories told from one generation to the next (Esteban et al., 2015, Gaillard et al., 2008, Viglione et al., 2014). Eventually, all memory of a given event would fade unless appropriate investments are made in tsunami memorials, education, and training, which can succeed in maintaining a high state of awareness, similar to that present the Tohoku areas in northern Japan in 2011 (Esteban et al, 2015c, Suppasri et al, 2015). However, even if the best efforts are made, a certain decay in awareness is probably inevitable, as even the best education system might not succeed in reaching every member of society and/or certain people might think that a certain type of hazard is unlikely to take place during their lifetime. There is also probably a limit to the maximum level of awareness that mass media can create by itself, and it is unlikely that a country can reach a “high” state unless disaster education and protection systems are installed, which should form part of a multi-layer safety system (Shibayama et al., 2013). Thus, an “education gap” exists (see Fig. 2), and even frequent and repetitive media exposure to distant tsunami events is unlikely to succeed in bridging it (Esteban et al., 2015).

Recently, several studies have been carried out regarding evacuation intent in a variety of countries, focusing on a variety of coastal hazards. For example, in the United States studies have been carried out to investigate the intended or hypothetical evacuation behaviour from wildfires (Mozumder et al., 2008) and hurricanes (Whitehead et al., 2000). Huang et al. (2016) went one step further and provide a comprehensive statistical analysis of the predictors of tsunami evacuation, and the actual behaviour of residents of coastal areas. Other studies have alto looked at the willingness to evacuate of specific groups (see Gray-Graves et al., 2010, regarding the evacuation of older adults). More recently a study in New Zealand addressed the intended evacuation behaviour of residents and visitors at Napier City in the event of a tsunami (Fraser et al., 2013). In Japan, Matsumaru and Kawaguchi (2015) studied the awareness regarding tsunami disasters of visitors to the tourist site of Enoshima, close to Kamakura. Other surveys on knowledge, attitude and practice (KAP) have been carried out in Trinidad and Tobago (Kanhai et al., 2016) or Vietnam (Esteban et al., 2014), or Japan after disasters already took place (Yun and Hamada, 2015, Esteban et al., 2013).

However, in order to test the utility of the conceptual framework given by Esteban et al. (2015), it is necessary to conduct a comparative analysis of differences in awareness between the populations of two countries. The present study thus attempts to shed some further light on whether there is some evidence for this conceptual framework by conducting a comparative analysis of awareness in two tsunami-prone famous tourist destinations, namely Kamakura in Japan (Fig. 3) and Florida in the United States (Fig. 4). Despite the differences in tsunami risk and history in these two areas, both have in common that these are major tourist destinations, and thus the type of disaster prevention measures that are possible are limited. This helps explain why no tsunami wall is present in Kamakura, as local inhabitants are against the alteration of the historical landscape of the town, which contrasts with the monolithic structures protecting much of the Tohoku coastline. It is important to note how visitors to these cities (either natives or foreigners) can be considered to be a high-risk group due the lack of awareness of the nature of local hazards (be it tsunamis or tropical cyclones). The importance of tourists as a vulnerable group and the difficulties they face during evacuation has been recognized by a number of authors (Drabek, 1995, Whitehead et al., 2000, Mahdavian et al. 2015, Cahyanto et al., 2014). Matyas et al. (2011) point out the importance of considering the tourist population in Florida, as it attracts a great number of visitors that do not necessarily have a great knowledge about hurricane risks, may be unfamiliar with their surroundings, and do not count with the support network of their local community. Other disaster management studies that focused on tourists include Sharpley (2005), who highlights the impact that the Indian Ocean Tsunami had on the world because of the large number of tourists that were victims, and Faulkner (2001) and Rittichainuwat (2013), who point out that despite tourist destinations being at risk not so much work had been done on disaster management. Drabek (1995) emphasizes the need to establish community partnerships between local emergency managers and those working in the tourist industry, and for more training activities to be conducted with those working in the tourist industry. In spite of this, Johnston et al. (2007) showed that training and preparedness for tsunami and other hazards in coastal Washington was generally low, especially amongst small operators.

The present work will thus attempt to shed further light on the degree of awareness of these groups, and identify potential general gaps in awareness and preparedness.

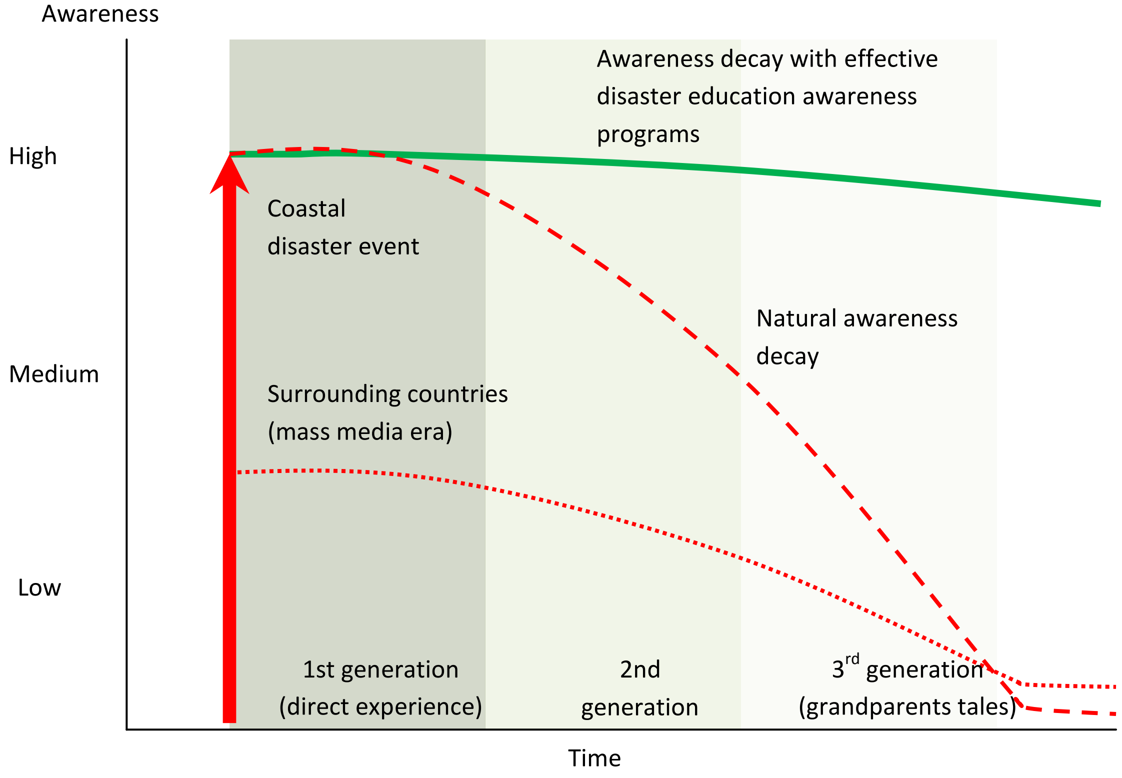

Fig. 1. Conceptualisation of disaster awareness and its decay with time in a country that directly experiences a given event (Esteban et al., 2015b)

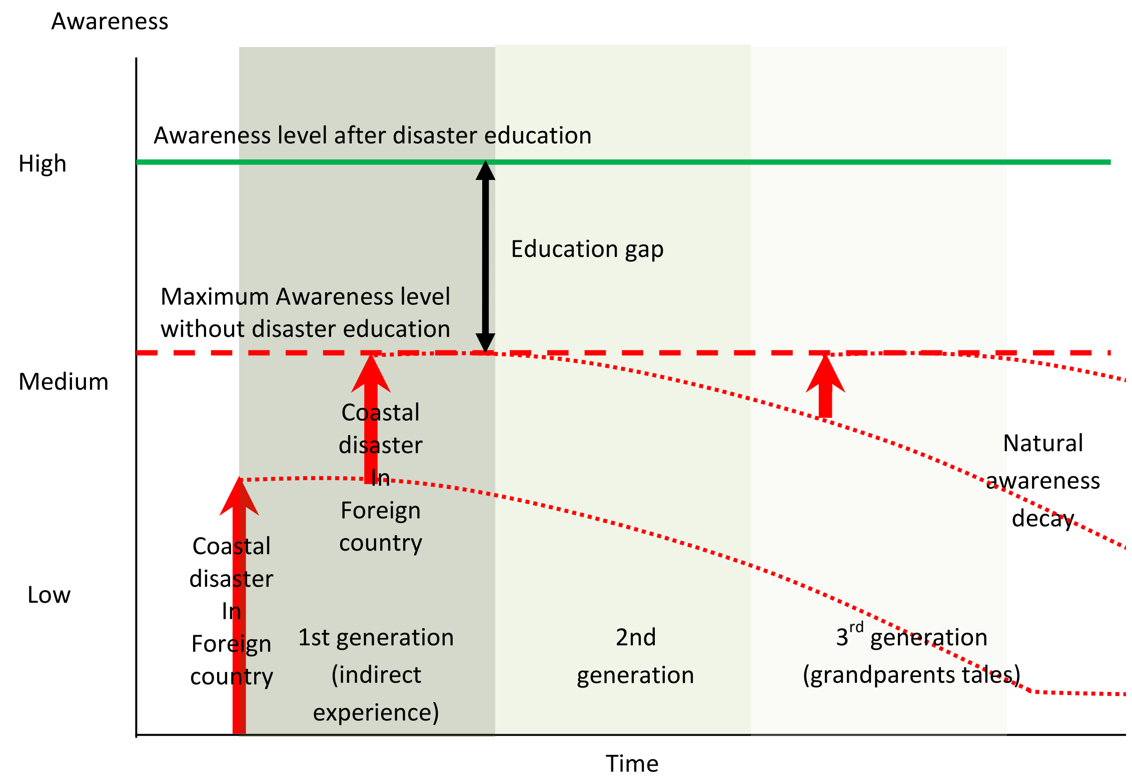

Fig.2. Conceptualisation of disaster awareness and its decay with time in a country that does not directly experience a given event, but learns about such events through mass media (Esteban et al., 2015b)[1]

2. Methodology

2.1. Study Areas

One particular tsunami-prone area in Japan (the city of Kamakura) was chosen for the case of a country that has experienced repeated frequent events (see Table 1). Florida was chosen because there are several potential seismic and volcanic sources in the Caribbean sea which have created tsunamis in the past (Pararas-Carayannis, 2004, Kanhai et al., 2016), together with potential distant sources such as the Canary Islands or the Azores-Gibraltar Fracture Zone according to the Atlantic and Gulf of Mexico Tsunami Hazard Assessment Group, 2008). The continental United States has not experienced any major tsunami events in recent years, and thus it represents a good case study of an area that will have only gained tsunami awareness due to media exposure to events in other countries. In fact, the Caribbean region has not experienced any tsunami since the Dominican Republic tsunami of 1946 (von Hillebrandt-Andrade, 2013), though between 1498 and present an estimated 85-106 tsunamis have been documented in the region (NOAA, 2016a, Lander et al., 2012). Thus, it is entirely possible that a relatively low level event could affect Florida in the future and inundate large

[1] One event might not fully raise awareness as it might be treated by the inhabitants of a nearby country as a "one-off" event, and only repeated events will fully raise awareness about the dangers of a given type of hazard. The green line indicates awareness if appropriate disaster education is provided, whereas the red line indicates awareness only from media exposure from disasters in nearby countries.

extents of the low-lying coastal zones in the states, despite the threat being considered to be low (Florida Department of Environmental Protection, 2016). Also it is worth noting that the tsunami warning system for the Gulf of Mexico and Atlantic coasts of the United States (NOAA, 2016b; NOAA, 2016c) is newer and less developed than that for the Pacific basin (NOAA, 2016d; JMA, 2016).

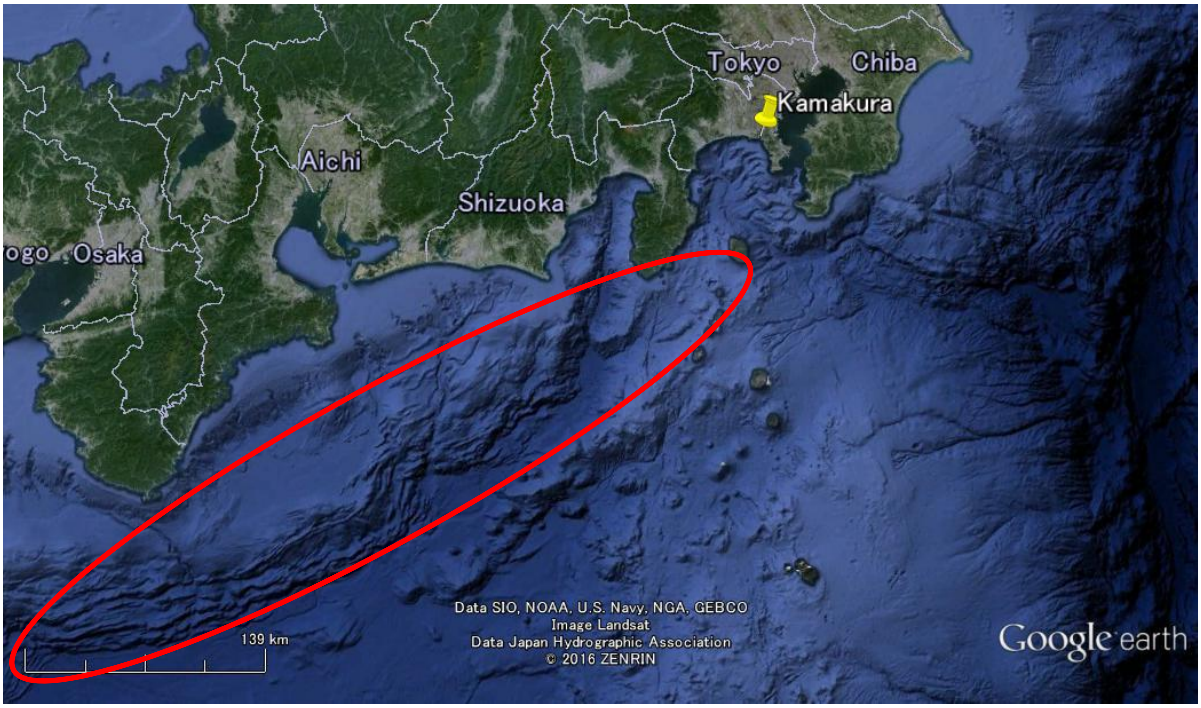

Fig. 3. Location of survey site in Japan: Kamakura (Kanagawa Prefecture). The red oval indicates the approximate source region of the Tonankai and Tokai tsunami sources (Forbes, 2012).

Fig. 4. Locations of survey sites in Florida, USA: Miami Beach, Fort Meyers Beach, and Clearwater Beach. The red oval indicates one of the potential tsunami source regions in the Caribbean (McCann, 2006).

Table 1. Historical tsunami events in Kanagawa Prefecture (NOAA, 2015)

Origin	Name	Year	Earthquake Magnitude	Tsunami Runup			Deaths
				Name	Distance from source (km)	Max Water Height (m)	#
JAPAN	Kamakura, Sagami Bay	1241	7.0	KAMAKURA	18		
				YUIGAHAMA	18		
JAPAN	Sagami Bay, Japan	1257	7.0	SAGAMI BAY	0		
JAPAN	Kamakura, Sagami Bay, Tokaido	1495	7.1	KAMAKURA	24	5.00	
				YUIGAHAMA	21		200
JAPAN	Sagami Bay	1633	7.1	SAGAMI BAY	27		
JAPAN	Off SW Boso Peninsula	1703	8.2	KAMAKURA	71		600
JAPAN	Nankaido	1854	8.4	FUKUURA	495		
				YOKOHAMA	501		9
JAPAN	Sagami Bay	1923	7.9	ENOSHIMA ISLAND	22	5.00	
				KAMAKURA	24	6.00	150
				KATASE	23	1.50	50
				YUIGAHAMA	21	6.00	100
				ZUSHI	20	5.00	
CHILE	Southern Chile	1960	9.5	KAWASAKI	17,068	0.62	
				YOKOSUKA	17,072	0.54	

2.2. Methodology

The authors conducted a series of structured questionnaire surveys with local residents and visitors in Kamakura, Japan and Florida, USA (Figs. 3 and 4), with the intention of measuring the level of awareness of beach users (either locals or visitors) to tsunamis. The interviews at Kamakura were conducted on the 23rd August 2014, which resulted in a collection of 110 valid respondents, whereas the surveys in Florida took placed between the 11th and 14th of February 2014 and resulted in 55 respondents, given considerable challenges in getting beach-goers to agree to complete the questionnaires. The level of awareness was also contrasted with the countermeasures present in the area, such as dykes, evacuation systems or elevated housing, in order to understand how prepared were the various communities against possible coastal flooding events. The structured questionnaire was originally drafted in English (used during the Florida surveys), and then a modified version was translated into Japanese and distributed to individuals encountered in the survey locations on an opportunistic basis, taking about 10 minutes per individual to complete.

In all areas, the enumerators (who were the authors themselves) actively sought respondents on the beach and areas close to it. Respondents were divided into three categories, namely “locals”, “non-local natives” (i.e. citizens of the country where the survey was being carried out, but who were not from that area, essentially domestic tourists) and “non-local foreigners” (i.e. foreign tourists). A fourth category, that of “local foreigners” (i.e. foreigners who lived in the area) was possible: out of the 172,279 residents in Kamakura, 1,252 were foreigners in 2017 (Kamakura City Office Data, 2017). However, in the present study none of the respondents belonged to this category, and thus it was excluded in the final presentation of the results. Table 2 shows how about half of those interviewed in Florida were non-local natives, compared to around 80% of those interviewed in Kamakura. Due to the opportunistic nature of the survey it was difficult to obtain balanced demographic distributions despite a moderate effort in attempting to do so. Hence, almost three quarters of respondents in Florida were male, though a balanced distribution was obtained in Kamakura.

Figure 5 and 6 show the occupation of respondents in Florida and Kamakura. As table 2 also indicates, respondents in Kamakura were young, with the age group “20-29” comprising 60% of respondents, and most people defining themselves as “office workers” (47%) or “students” (21%). Conversely, less than one-third of respondents in Florida were under the age of 50, and a large proportion being over the age of 65 (which correlated well with many of them being retired, as indicated by 23% of respondents). This can be considered typical of what could be expected of beach users in these regions, as Kamakura is a well-known destination for Japanese youth in the summer months, and Florida has become a tourist destination for other regions or a place to retire for the over 65s.

Table 2. Summary of demographic characteristics of respondents

Variable	**Florida (n=55)**	**Kamakura (n=110)**
Gender		
Female	22%	47%
Male	71%	50%
Unclear/No answer	7%	3%
Origin		

Local	26%	7%
Non-local native	45%	80%
Foreigners	29%	13%
Age		
18-29	7.3%	72.7%
30-49	23.6%	21.9%
50-70	47.3%	2.7%
70+	21.8%	0%
Unclear/No answer	0%	2.7%

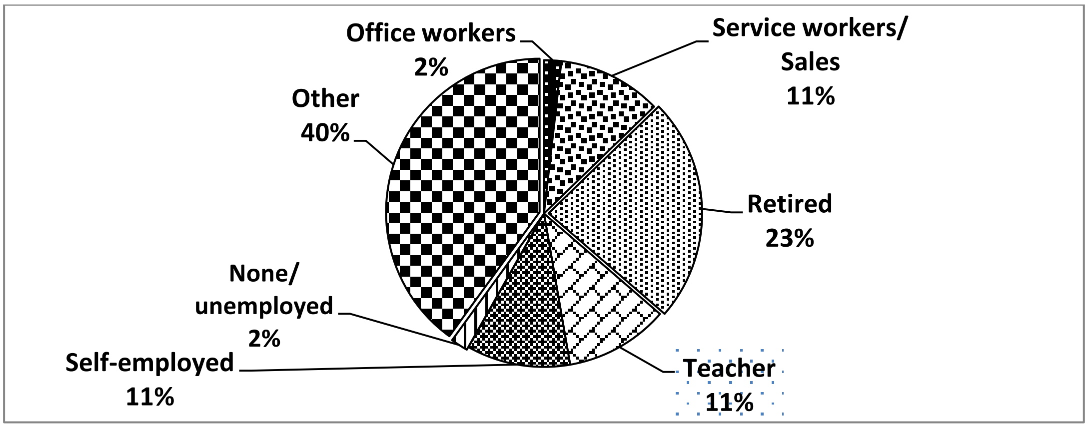

Fig.5. Occupation of respondents in Florida. The majority of the respondents in Florida had careers other than those listed in the questionnaire forms, with “retired” forming the second largest group of respondents (n=55)

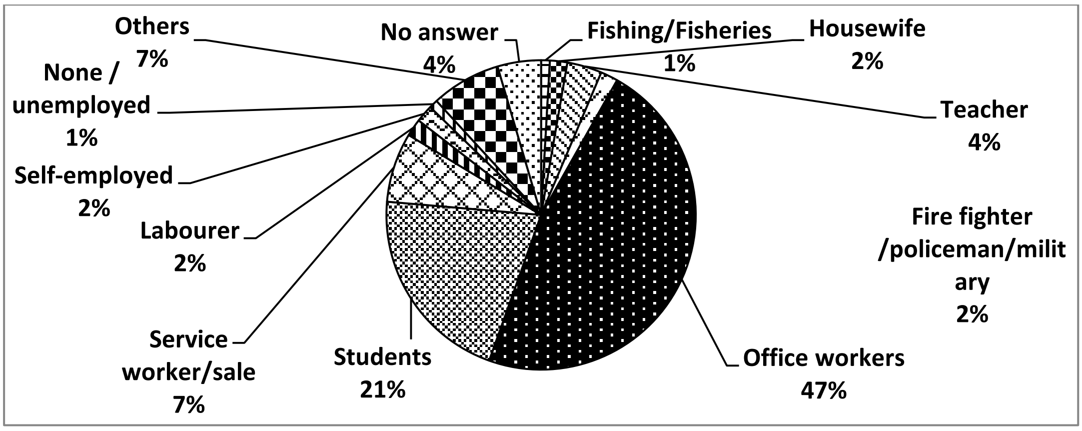

Fig.6. Occupation of respondents in Kamakura. The majority of respondents in Kamakura categorized themselves as office workers (n=110)

3. Results

3.1. Respondents'awareness of disaster risk and prior experience

In order to understand the degree of familiarity of respondents with possible flooding dangers, the questionnaire first asked whether the place where the respondent lived was at danger of flooding from the sea or rivers. Respondents were asked to quantify this on a Likert Scale of 1 ("no danger at all") to 5 ("very strong danger) (with a value of 1). Both in Florida and Kamakura, most respondents answered that their places were not in danger of flooding (1 "Not at all"), though the majority of this category were non-local foreigners (see Fig. 7 and 8). Local people were in general more likely to indicate that they lived in areas at danger of flooding (over 42% and 37% of respondents in Kamakura and Florida indicated a "moderate" or higher danger, respectively).

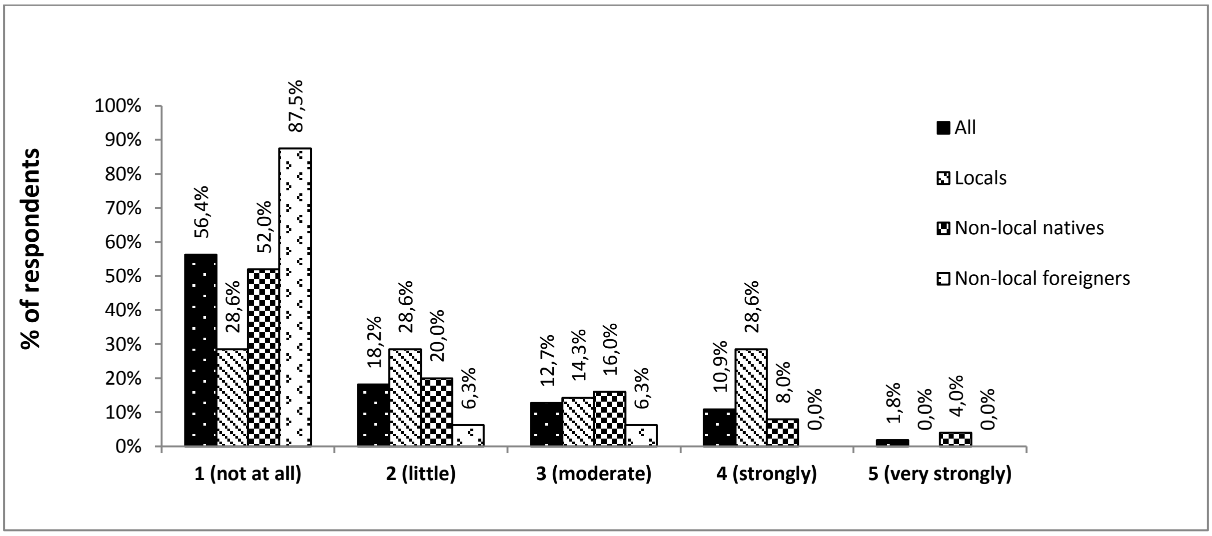

Fig.7. Florida responses regarding whether the place where they lived was at danger of flooding from the sea or rivers (n=55)

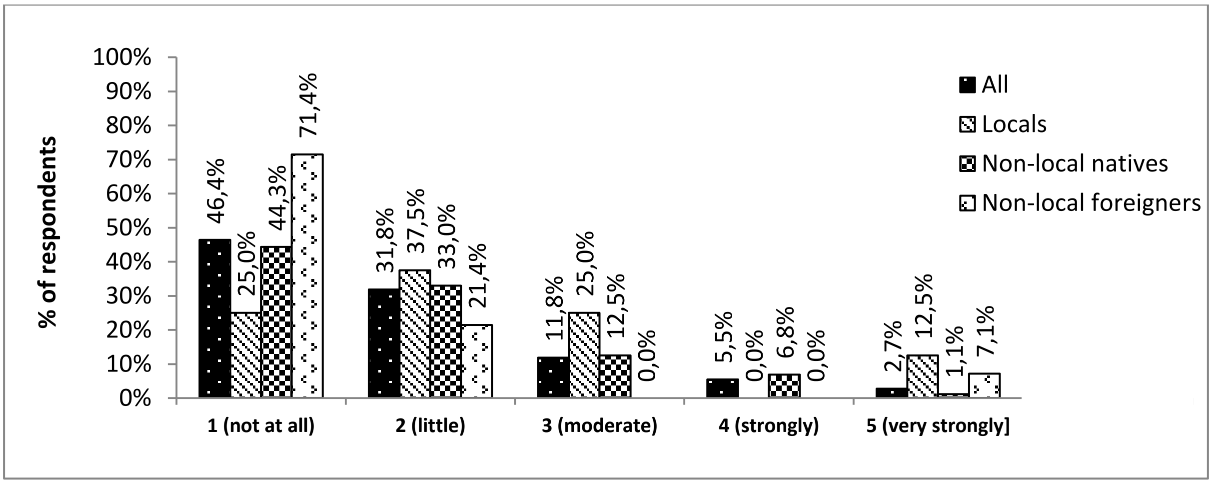

Fig.8. Kamakura responses regarding whether the place where they lived was at danger of flooding from the sea or rivers (n=110)[2]

[2] 1.8% of all respondents chose not to answer this question

Despite such answers, only 14.5% and 6.4% respondents in Florida and Kamakura had experienced some sort of flooding damage in the past, respectively(see Figs.9 and 10). This could be attributed to the fact that neither of the areas had experienced a major event within the last few decades.

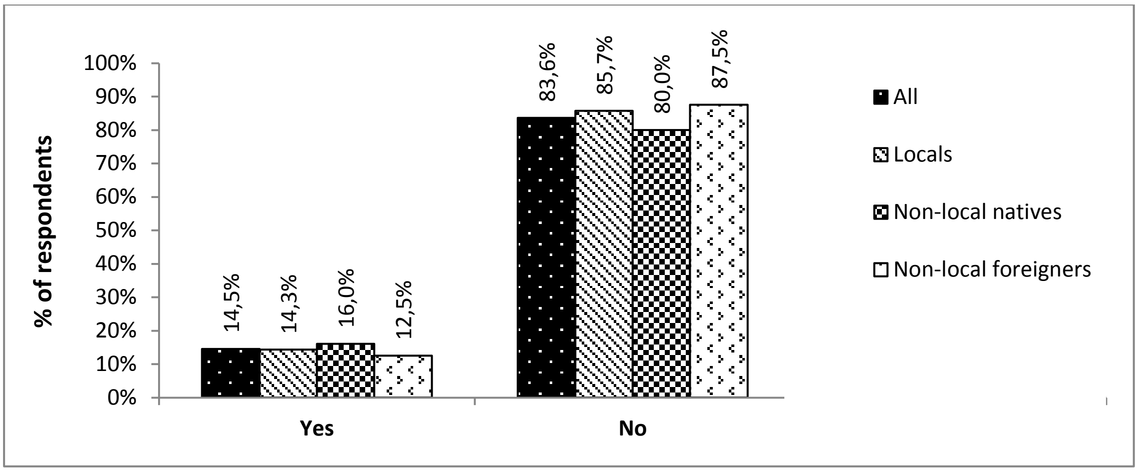

Fig.9. Distribution of respondents who had experienced some damage from previous flooding disasters in Florida (an answer of "yes" indicates that they suffered some damage, n=55)[3]

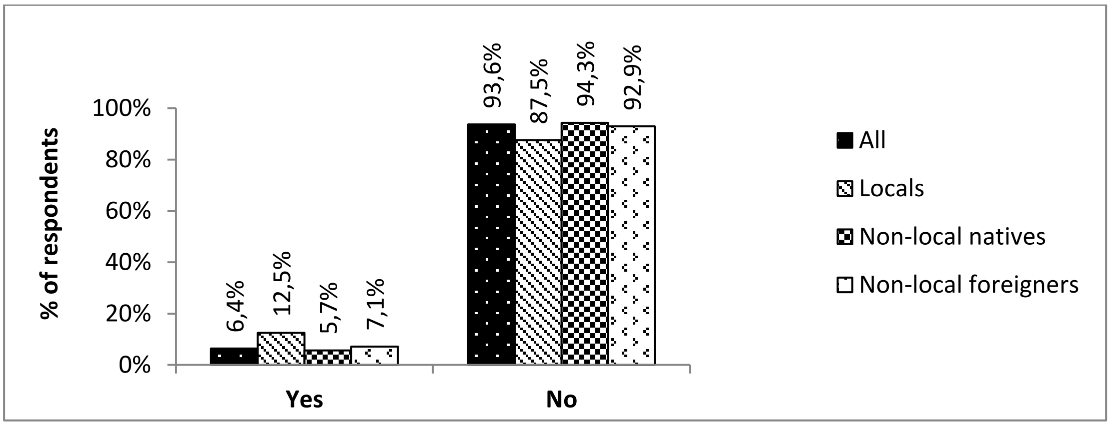

Fig.10. Distribution of respondents who had experienced some damage from previous flooding disasters in Kamakura (an answer of "yes" indicates that they suffered some damage, n=110)

3.2. Tsunami awareness

Despite the wide range of prior experiences and backgrounds, generally most respondents knew what a tsunami is, with 96.4% and 82.7% of individuals in Florida and Kamakura indicating they were

[3]1.8% of all respondents chose not to answer this question

aware of such phenomena, respectively (see Figs.11 and 12). Respondents were then asked to rate the level of danger that a tsunami posed to them using a 5 point Likert scale, with an answer of 1 indicating little danger and 5 a very strong danger. In Florida, 50% or more of all types of respondents replied that they did not feel they were in any danger (see Fig.13). However, in Kamakura, the most common reply for the local and all respondents category was either “strong” or “very strong” danger (representing over 58.2% of all respondents, and 62.5% of locals, as shown in Fig.14). This correlated well with the evaluation of the risk that a tsunami could take place in the area where the respondents were surveyed, with for example 71.4% of locals in Florida indicating that there was no risk or only a small risk of a tsunami (see Fig.15). In Kamakura, the “strong” and “very strong” risk were the most common answers (both over 30%), though it is worth noting that 25% of locals answered that there was only a small danger, as shown in Fig.16. The authors would like to note that in the Japanese case a “No answer” could be interpreted in a number of ways, including the possibility that they are aware of the overwhelming nature of the danger, and have a rather confused life attitude towards it. Focusing on the assessment of tsunami risk to respondents in Kamakura, 12.5% of locals provide no answer, yet none provide no anwer to the danger of tsunami risk to Kamakura (98.9% indicating moderate to very strong). Understanding more deeply the thought processes behind such issues is outside the scope of this work, as it would require in-depth interviews with local residents, and which will be the target of future research.

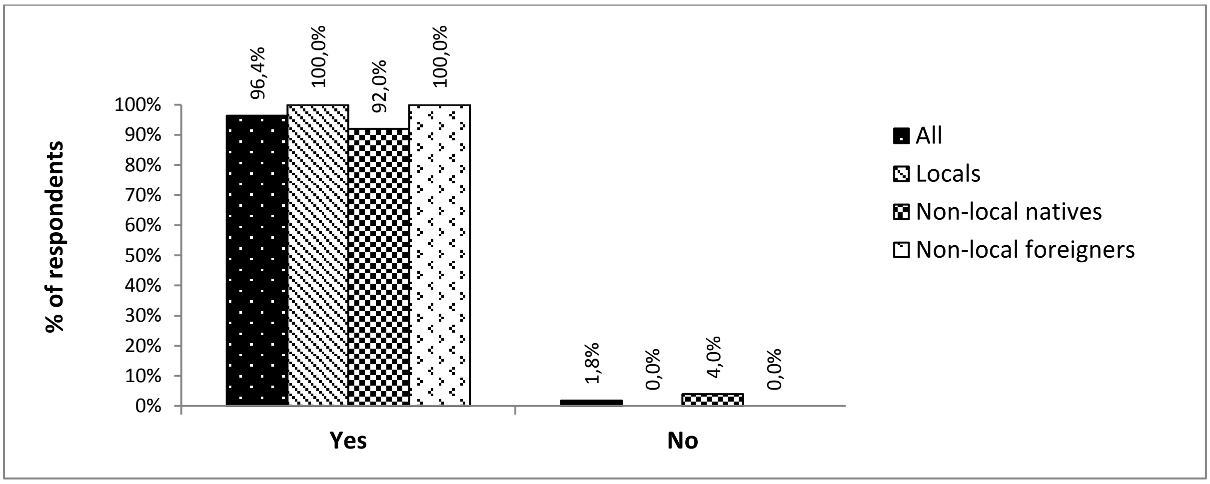

Fig.11. Proportion of Florida respondents who indicated that they knew what a tsunami is (n=55)[4]

[4]1.8% of all respondents did not answer this question

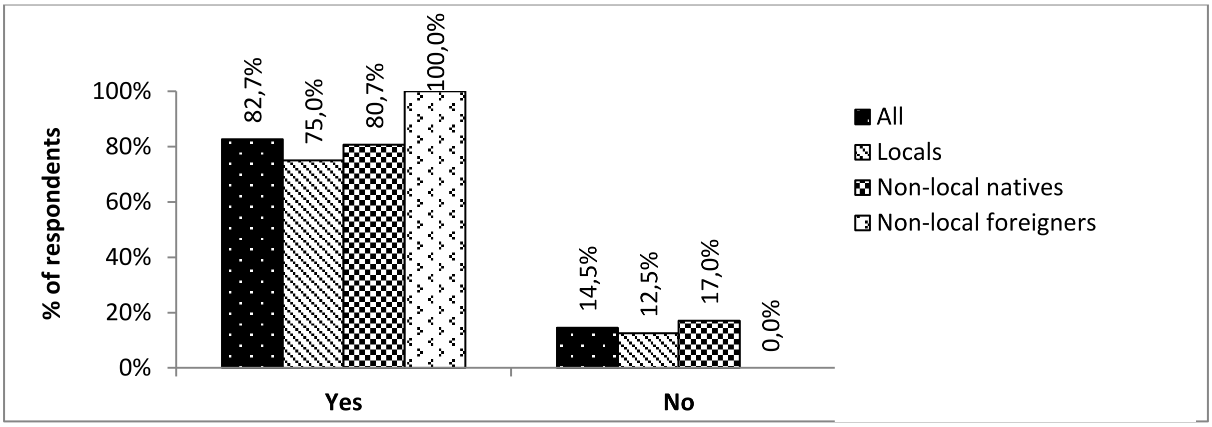

Fig.12. Proportion of Kamakura respondents who indicated that they knew what a tsunami is (n=110)[5]

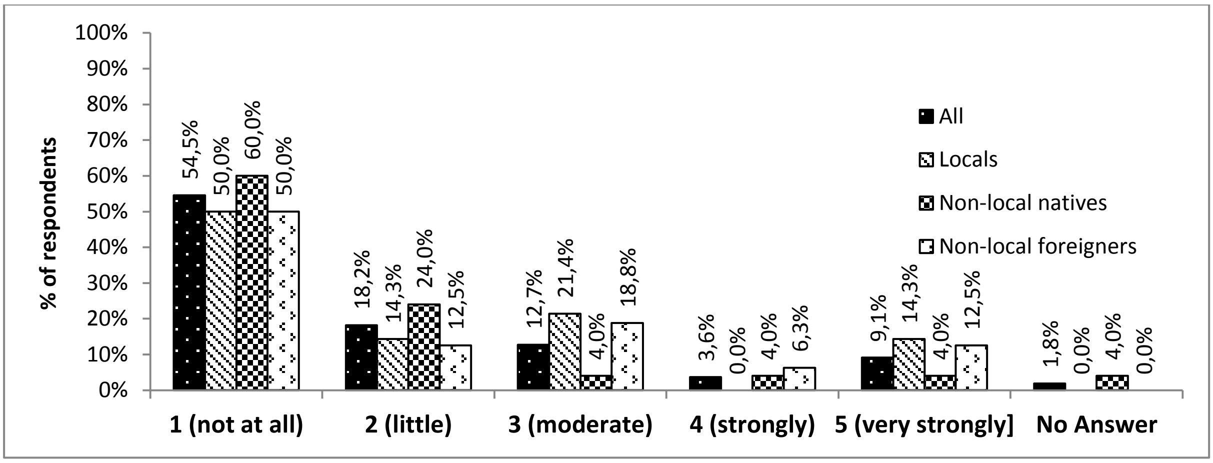

Fig.13. Assessment of tsunami risk by respondents in Florida. Respondents were ask to rate the level of danger that a tsunami posed to them.

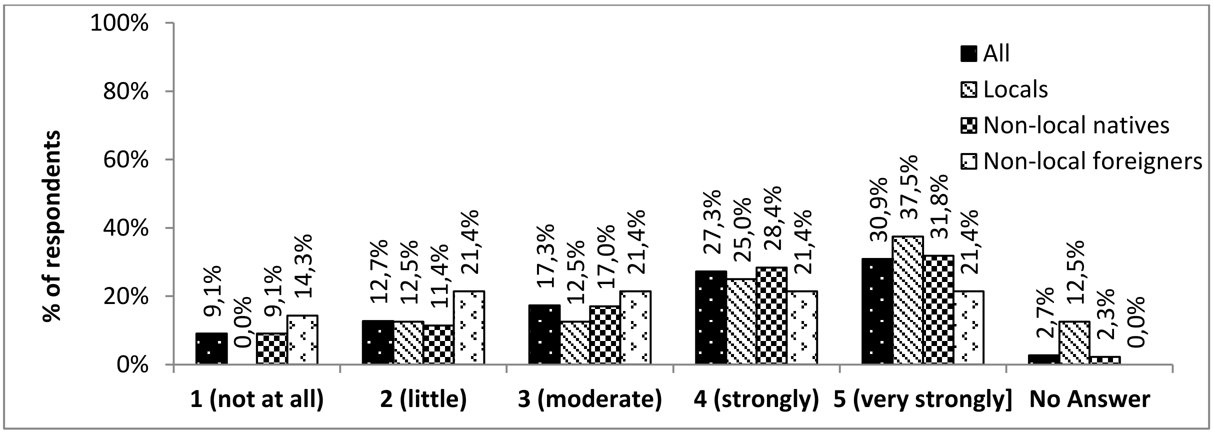

Fig.14. Assessment of tsunami risk by respondents in Kamakura. Respondents were ask to rate the level of danger that a tsunami posed to them.

[5] 2.7% of all respondents chose not to answer this question

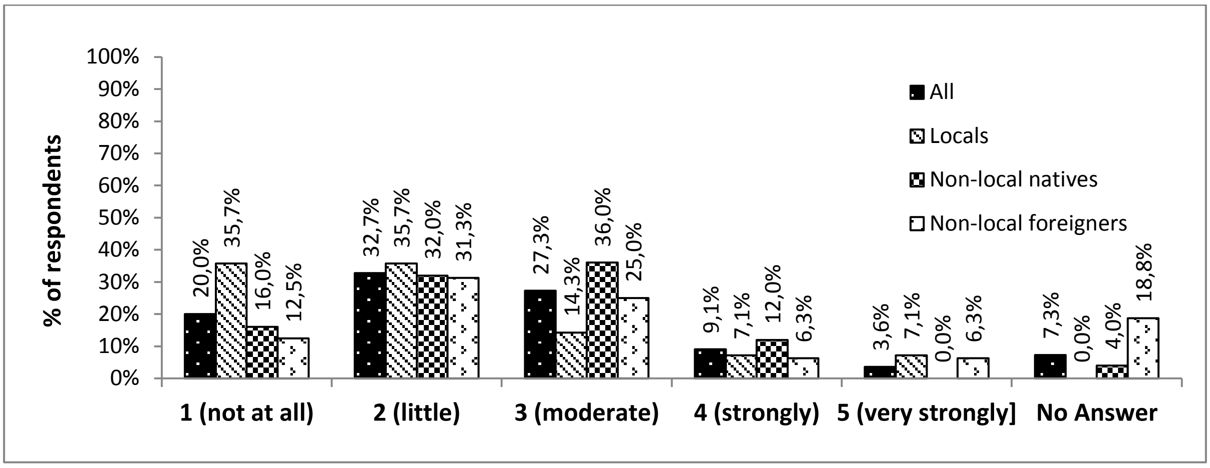

Fig.15. Evaluation of tsunami risk in surveyed areas in Florida (n=55)

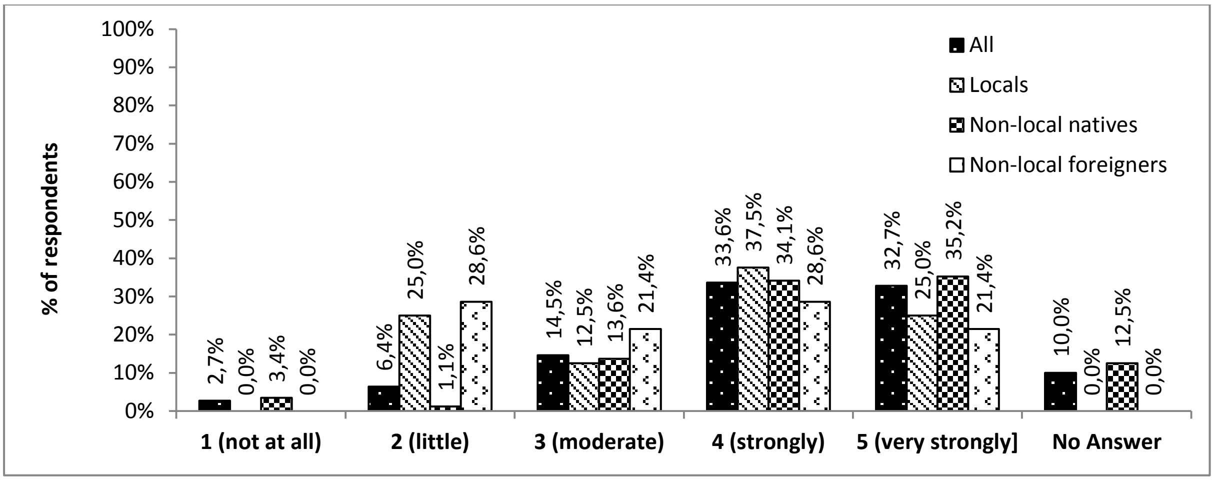

Fig.16. Evaluation of tsunami risk in surveyed areas in Kamakura (n=110).

3.3. Knowledge of evacuation

Three quarters of all respondents in Florida answered that they had no idea regarding the existence of any evacuation and alarm systems in the area, though half of the local inhabitants of Kamakura knew that there is indeed a warning system in the city (see Figs.17 and 18). The questionnaire also asked respondents whether they had taken part in evacuation drills in the last 5 years, with only a minority of respondents in Florida (less than 10% of all respondents, and only 14.2% of residents) having taken place, through a further 18.2% responded that despite not having taken part they knew the evacuation route, as shown in Fig. 19. The picture in Kamakura was completely different, with half of respondents (and 87.5% of locals) indicating they had taken part in evacuation drills, and only around 10% of individuals responding they had neither taken part nor knew the evacuation route, as shown in

Fig.20. A chi-square test was performed between the sites, indicating that there are significant differences between the sites ($p < .001$). The most interesting answers from the questionnaire concerned the knowledge of how to evacuate, as 65% of Florida respondents said they knew how to escape a tsunami, whereas 75% of locals in Kamakura (and 53% of all respondents in this area) did not (see Figs.21 and 22).

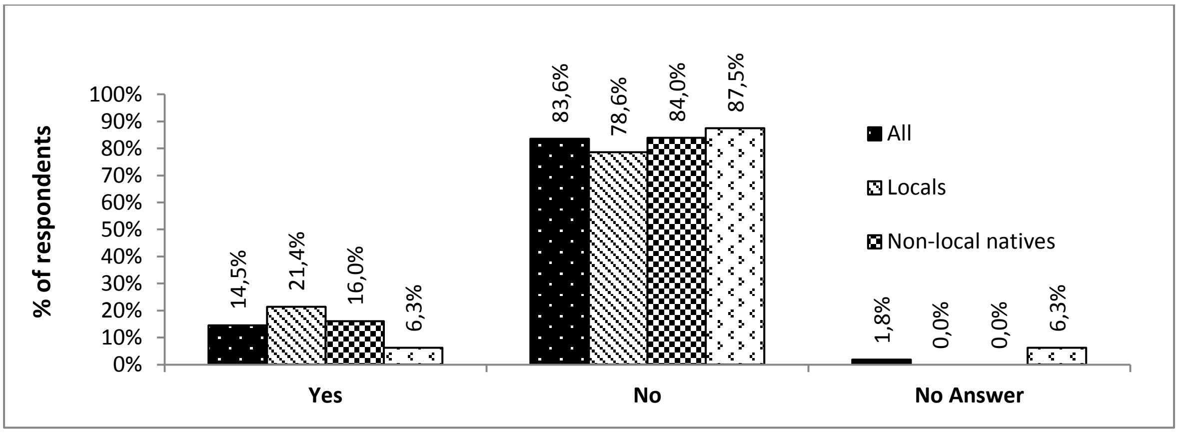

Fig.17. Knowledge of Florida respondents about whether a tsunami warning system existed in the area (an answer of "yes" indicated whether they knew if a warning system existed, n=55)

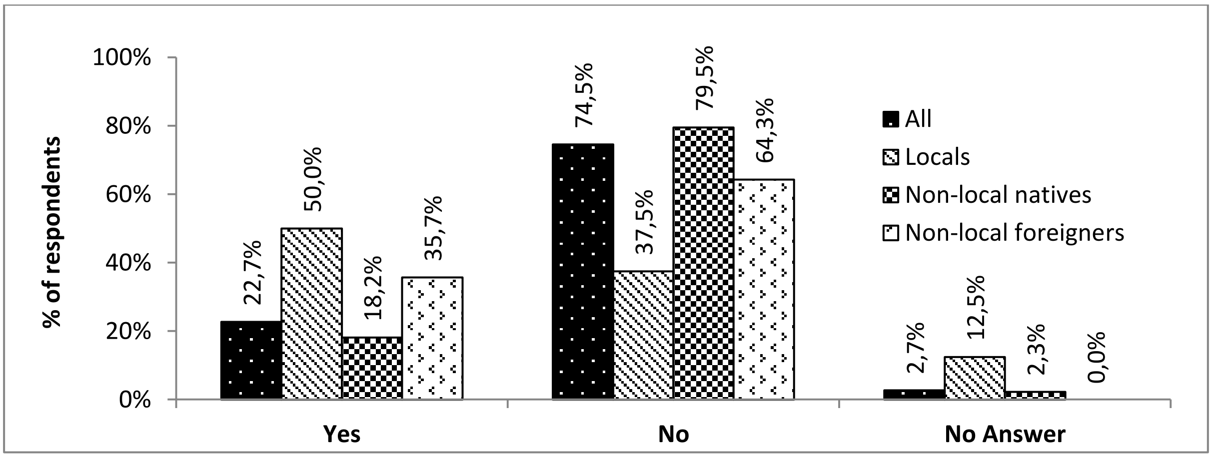

Fig.18. Knowledge of Kamakura respondents about whether a tsunami warning system existed in the area (an answer of "yes" indicated whether they knew if a warning system existed, n=110)

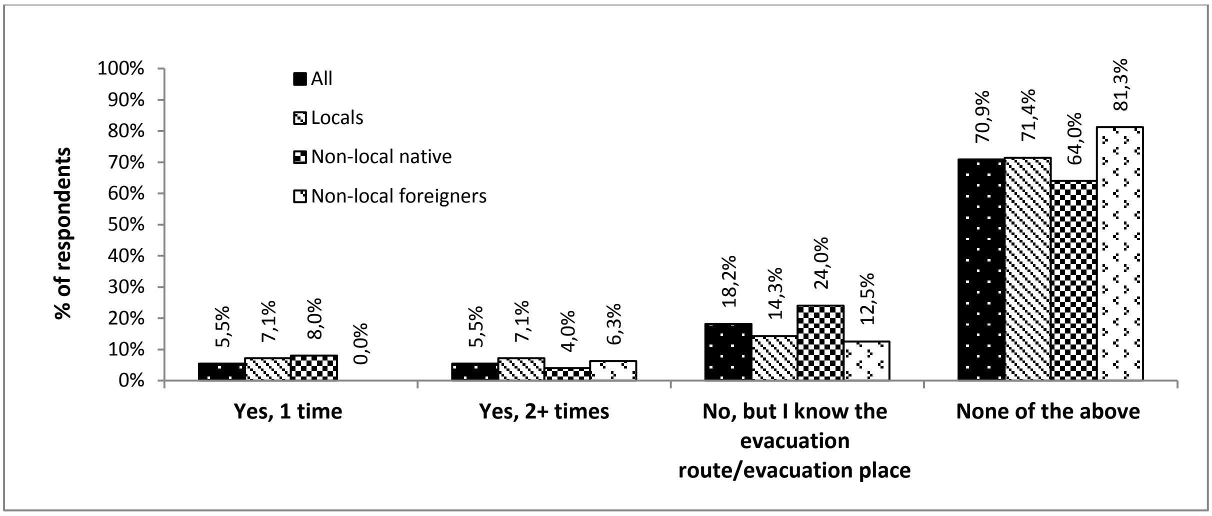

Fig.19. Proportion of respondents who had taken part in evacuation drills in the last 5 years in Florida (n=55).

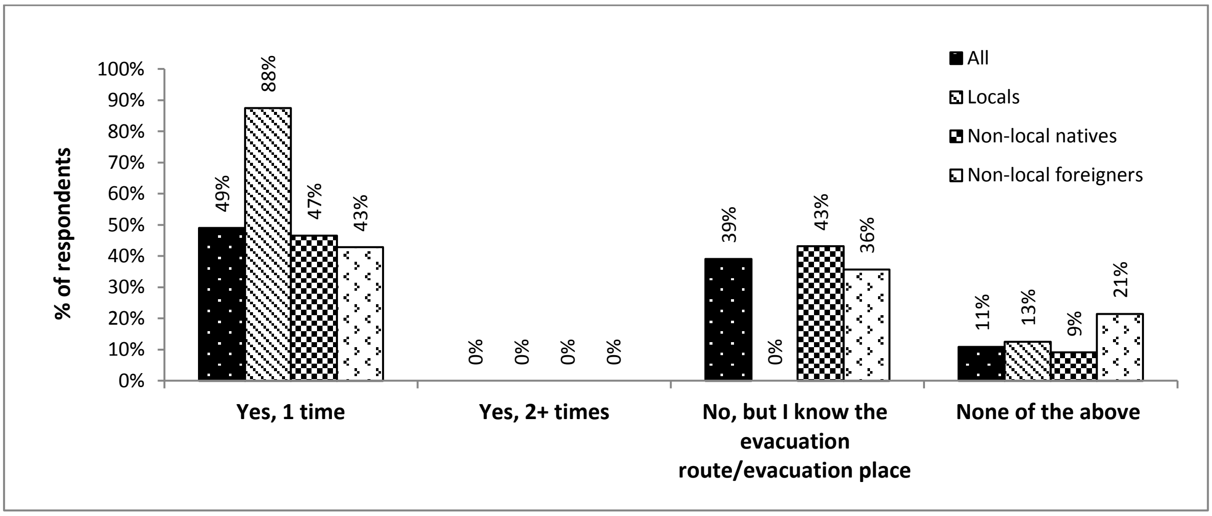

Fig.20.Proportion of respondents who had taken part in evacuation drills in the last 5 years Kamakura (n=110). Note that a small percentage of respondents (0.9%, in total, provided no answers to this question)

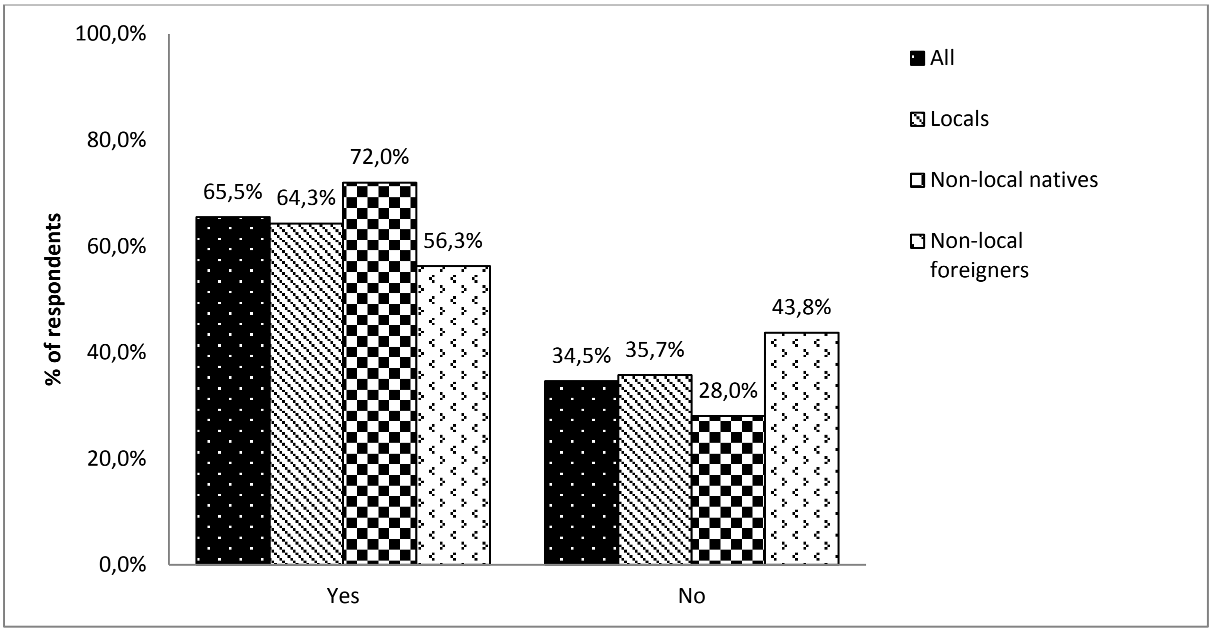

Fig.21. Proportion of Florida respondents who said they knew how to evacuate in the event of a tsunami (an answer of "yes" indicates that they knew how to evacuate, n=55)

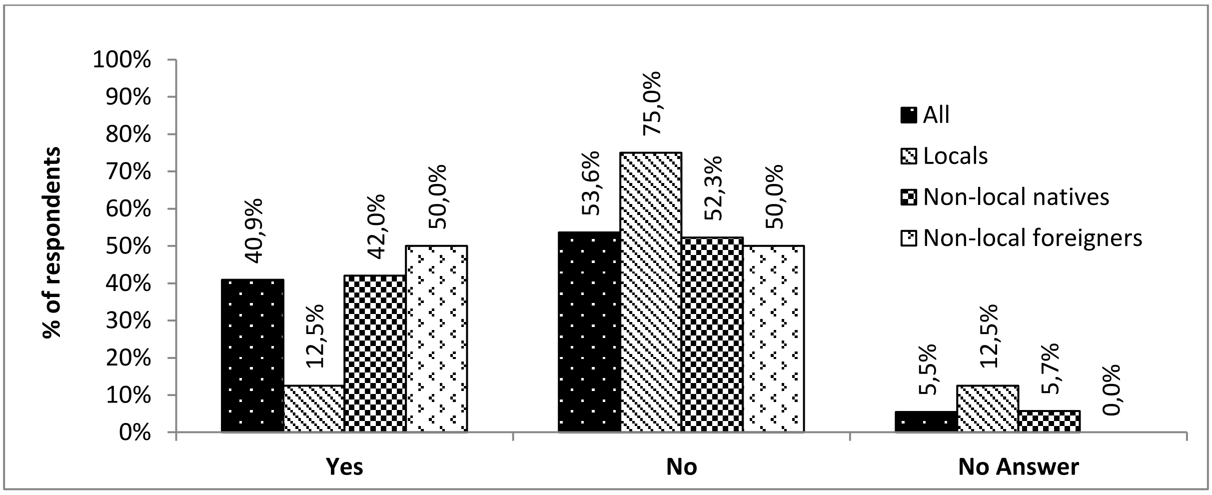

Fig.22. Proportion of Kamakura respondents who said they knew how to evacuate in the event of a tsunami (an answer of "yes" indicates that they knew how to evacuate, n=110)

4. Discussion

Every major tsunami strongly imprints the memories of those who experienced it, though the extreme devastation brought about by higher order (often referred to as "level 2" events, such as the 2004 Indian Ocean Tsunami or the 2011 Tohoku Earthquake Tsunami) can raise awareness even in countries that did not directly experience them, such as through TV footage or other media. This has been hypothesized and described previously by Esteban et al (2015), and the present paper attempts to ascertain whether this actually takes place. The results clearly show that awareness in Florida in particular, and the United States in general, is surprisingly high, despite the country not having experienced a tsunami for a long time, and Florida being at low risk (see Fig.11, where the practical totality of respondents indicated that they knew what a tsunami is). In fact, other research also reported that the awareness was much higher than a similar study conducted along the central coast of Vietnam, where only around 80% of those surveyed indicated that they knew what a tsunami was (Esteban et al., 2014).

The findings of this paper are thus significant, despite the relatively modest (n=55) number of respondents in Florida. The profile of respondents in both locations (Table 2, Figs. 5-6) were typical of the type of beach user that could be expected at each location. Typically, a young Japanese population, mainly made up of office workers and students for the case of Kamakura, and an older (often past retirement age) demographic group, mostly composed of individuals from other States within the USA, for the case of Florida. Due to both areas being well connected (by public transport for the case of Kamakura, and highways for the case of Florida) many respondents did not actually live close to the sea, and thus there was a widespread range of answers regarding whether the place where respondents lived was at danger of flooding (Figs 7-8). This, together with the fact that neither area has experienced any major disaster recently, explains why few respondents answered that they have experienced some damage from natural disasters (see Figs 9-10, note also that for the case of Florida it is also likely that many respondents have previously lived –or continue to live, for the case of visitors- in other, often landlocked, States).

However, Figs 19 and 20 show a clear difference in the level of preparedness of the authorities, which would clearly influence the actual level of awareness of the population. Most of the inhabitants in Florida (even over 70% of locals) had not taken part in evacuation drills in the last 5 years, compared to almost 50% of those in Kamakura (which raises to 87.5% of locals).

The most surprising results from the survey would appear to, a priori, be suggested by Figs 14 and 22, which indicate that despite having shown comparatively high awareness and preparedness against tsunamis, most respondents in Kamakura then indicate that they do not know how to evacuate in the event of a tsunami (only 40.9% of total respondents, and less than 12.5% of locals indicated that they knew how to evacuate). This contrasts markedly with the results of Fig. 21, where despite probably not having had much information about tsunamis, over half of respondents in Florida (66.5% of all) indicated that they knew how to evacuate. However, for the case of Kamakura, a high level of preparedness with respect to tsunamis appears to have only made residents aware of the complicated nature of evacuation in the area, as some of the possible tsunami scenarios indicate waves that could be of the order of 10m high and arrive within 30 minutes (Yamao et al., 2015). Against such scenarios, and given the nature of the propagation of the tsunami (Sittichai, 2007) in the town (with multiple rivers that can cut evacuation routes) higher awareness only appears to lead to a realization that there is no effective way to evacuate, explaining the answers in Fig.22. Essentially, surveys by the city of Kamakura put the number of residents in the area at risk of inundation at around 44,000, though the peak number of visitors to Kamakura is around 150,000 per day (as indicated by the City Government through committees in which one of the authors sits). Residents are typically well informed and have their own plan and training systems which are organized by neighborhood associations (Cho-nai-kai). However, through the 2011 Tohoku disaster, residents are also aware that neither the capacity nor the height of the evacuation buildings is sufficient to save them against the worst case scenarios, and that they should try to evacuate to hill areas immediately after a seismic shock, though reaching such areas in time would be challenging (Yun and Hamada, 2015). Therefore, Also, how to manage the risk to tourists and those practicing marine sports is not clear, though evaluating the risks to this group is outside the scope of this paper and should be dealt with in future research.

Residents in Florida are much less well-informed. The closest seismic tsunami source is the Caribbean (Fig. 4), which would allow 3 hours of warning time (NOAA, 2018), and the inundation heights would be limited. People would have more time to evacuate and access information on how to do so than in Kamakura. However, the warning and evacuation system in Florida is built to reduce casualties from hurricane storm surges, for which a much longer warning time is available. With a warning system based on meteorological and storm surge simulations, such evacuations are typically issued at least 2 days in advance (Miami Herald, 2017; Miami-Dade County, 2017). Evacuation primarily relies on personal vehicular transportation, and roads and freeways are signed to indicate hurricane evacuation routes. For residents who do not have access to personal vehicles or who are not able to evacuate in time, local governments designate evacuation centers (Miami-Dade County uses public schools for this purpose, while New Orleans famously used the Superdome during Hurricane Katrina) and organize buses for transport to these centers. The 3 hour lead time of a Caribbean tsunami would not allow this evacuation system to be implemented. Even evacuation orders would be difficult to issue, as these are broadcast via television, radio, and other media, and not via sirens or cellphones as they are in Japan. Even in the case of a far-field event that allows time to issue evacuation orders, evacuation may not be effective because local roads and freeways are not designed to handle the volume of cars that would be expected (for example, nearly 7 million people were ordered to evacuate south Florida before Hurricane Irma in 2017); the problem of traffic jams during evacuation has been shown to be a disincentive for residents to evacuate during future hurricanes as well (Naples Daily News, 2017). Furthermore, attempting to evacuate too late using vehicles has been shown to be the major cause of death in floods (Jonkman and Kelman, 2005), indicating that issuing an evacuation warning with too short a lead time could cost more lives than would be saved. However, local evacuation structures (schools) and hotels might be able to function as tsunami evacuation centers, as these buildings are all built to the Florida Building Code, which for South Florida was updated after Hurricane Andrew to require structural integrity in the face of extreme wind loading (Structure Magazine, 2017). Though flood and wind loading are different, they both exert lateral forces on buildings, and other low-lying, tsunami-prone, tourist-heavy areas such as Waikiki (in Honolulu) also rely on similar buildings for vertical evacuation against tsunamis (Chock and Butler, 2014; FEMA, 2012).

The results of the present survey thus highlight the need to mainstream measures to improve disaster resilience in the population of disaster-prone areas. Resilience is generally considered to have 3 components: agents (the people and organisations involved, including local authorities), institutions (referring to the sets of rules that guide human behaviour) and systems infrastructure. Improving the awareness of coastal residents is clearly necessary to minimise the loss of life during natural disasters (Esteban et al., 2015). Thus, improving the role that institutions in rising awareness amongst agents is of paramount importance. One of the most efficient ways to do this is through education, particulary amongst the younger generations, and many examples of the role this played in the 2011 Tohoku Earthquake Tsunami are documented in literature (Esteban et al., 2015).

However, it is also important for coastal residents not to overly rely on flood protection structures (Viglione et al. 2014). Thus, modern disaster prevention systems should generally have multiple safety layers, ensuring that there are a variety of protection measures in place to protect both residents and property (National Water Plan of the Netherlands, 2012, Tsimopoulou et al., 2013). Both Florida and Kamakura lack any significant layer 1 “hard measures” (essentially offshore breakwaters or tsunami walls that can protect coastal settlements from an incoming tsunami), though spatial planning (layer 2) and evacuation systems (layer 3) do not necessarily require large investments and can prove to be highly effective against coastal disasters (Esteban et al., 2013). If adequately designed and constructed, certain government buildings and other robust structures can survive tsunamis of considerable height, and the building of such Evacuation Buildings should take place in all areas that are at risk of suffering from coastal hazards (Shibayama et al., 2013). Furthermore, in New Zealand people seemed receptive to the alternative of vertical evacuation (Fraser et al., 2013), although some of the concerns expressed related to the integrity of the structures and appropriate height. However, evacuation buildings (layer 3 measures, see Figs.23-24) that are high enough to shelter people against level 2 tsunamis are still not available throughout Kamakura. Essentially, as Kamakura is a historical and traditional residential area, residents have mutual agreements with neighborhood associations to limit the height of buildings to maintain a good living environment. The maximum height is thus restricted is 8-12 m, depending on the area. For the case of Florida, National Flood Insurance Program (NFIP) regulations require residents of FEMA A (flood) and V (wave hazard) zones to raise all new and substantially rebuilt (50%) structures above the Base Flood Elevation via piles, piers, landfill, or appropriately designed non-residential first stories (FEMA, 2016), in order to protect against storm surges (these would arguably be layer 2 measures). Construction not in compliance with NFIP regulations cannot qualify for a mortgage. This is likely to also offer some protection against low level tsunamis, though it could provide residents with a false sense of confidence, which in other tsunami events has been responsible for the deaths of local residents (see Yun and Hamada, 2014, describing the 2011 Tohoku Earthquake tsunami).

It is thus clearly important for local authorities to put in place effective layer 2 measures in order for the population of coastal areas remembers past events and the construction of housing in areas that are at high risk is prevented (Esteban et al., 2015). This can be established through adequate regulations and zoning control, as well as financial incentives and education, all of which should prevent development in potentially hazardous areas, while building practices can reduce the fragility of vulnerability development (Lindell et al., 2006). Nevertheless, an early warning system is well-developed for the case of Kamakura, with flood drills being conducted in the area and hazard maps visible throughout the town. Also, Japan has a very efficient tsunami warning dissemination system, which can communicate to the population the likelihood of a tsunami within 3 minutes (Yun and Hamada, 2015, 2014). Efforts at developing tsunami warning systems, as well as establishing zoning and building regulations are occurring in the US also (Chock, 2016), but only on the west coast, and in Alaska and Hawaii(Tang et al., 2008; Ge and Lindell, in press).

Fig.23. Evacuation building in Kamakura

Fig.24. Houses on piles in Florida

5. Conclusions

The high number of tsunami events in recent years has raised awareness about the destructive potential of these phenomena throughout the world. It is clear that while in the past a given event would have only raised awareness around the coastal regions that suffered from it, which might have to some extent been passed on to latter generation through tsunami memorials or oral accounts, modern communication technology allows even those in distant countries to also gain an understanding. The results outlined in the present paper do indeed show how virtually the totality of beach users in Florida, either locals or foreigners, stated that they knew what a tsunami is, certainly from watching or reading about such events in foreign countries, given that no tsunami has affected the continental USA in recent times (and Florida for a longer time).

However, watching news footage about an event on a distant shoreline does not mean that populations at risk can fully understand how to evacuate. In this sense the present study showed how even in a place like Kamakura, which has spent much time and effort preparing and educating the local population, it is not immediately obvious what is the best way to evacuate against a tsunami. Thus, it is imperative that more efforts are made to develop long-term strategies to improve the resilience of coastal areas against tsunamis. This should involve further spatial planning measures that attempt to locate the most vulnerable people away from danger, improved evacuation buildings that can guarantee the safety of evacuees against level 2 tsunamis, and probably innovative defence strategies that can hinder the progress of the tsunami wave, while not visually affecting the natural beauty of places like Kamakura and Florida (both major tourist destination areas).

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