Eastwood Richmonde Hotel, Quezon City, Manila, April 16, 2015

Japan–Philippine Urgent Collaborative Projects regarding “Typhoon Yolanda” within the J-RAPID Program

Detailed analysis on storm surge impacts due to Typhoon Yolanda and multidisciplinary research for disaster risk reduction

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J-Rapid Team

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Publication (as of April, 2015)

International Journal *(2 papers accepted and 5 journal papers still under review)*

H. Takagi, E. Miguel, T. Shibayama, T. Mikami, R. Matsumaru, L.D. Mario, Thao N.D., T. Oyama, R. Nakamura. Track Analysis, Simulation and Field Survey of the 2013 Typhoon Haiyan Storm Surge, Journal of Flood Risk Management, Wiley, 2015.

M. Esteban, Valenzuela V.P., Yun N Y., Mikami T., Shibayama T., Matsumaru R., Takagi H., Thao N.D., Mario De L., Oyama T., Nakamura R. Typhoon Haiyan 2013 Evacuation Preparations and Awareness, J-SustaiN, 2015.

Book Chapter

H. Takagi , L.D. Mario, E. Miguel, T. Mikami, R. Nakamura. Storm Surge due to 2013 Typhoon Yolanda in Leyte Gulf, the Philippines, IN: Esteban M., Takagi H., Shibayama T. *Handbook of Coastal Disaster Mitigation for Engineers and Planners*, 1st Edition, Elsevier (June, 2015 upcoming book) ISBN: 9780128010600

Japanese Domestic Journal

Nakamura R., Oyama T., Shibayama T., Matsumaru R., Takagi H., Esteban M., Takahito M. Comparison between simulation of storm surge invoked by typhoon "Yolanda" and field results, Journal of Japan Society of Civil Engineers, Ser. B2 (Coastal Engineering), Vol. 70, No. 2, pp. 236-240, 2014.

Esteban M, Mtsumaru R, Takagi H, Mikami T, Shibayama T, Mario d l, Valenzuela V.P., Thao N.D.. Study on disaster information dissemination and people's respose for evacuation - the case of the 2013 Typhoon Yolanda (Haiyan) -, Journal of Japan Society of Civil Engineers, Ser. B3 (Ocean Engineering), JSCE, Vol. 70, No. 2, 2014.

Shibayama T, Matsumaru R, Takagi H, Mario p. d, Esteban M, Mikami T., Oyama T, Nakamura R. Field survey and analysis of storm surge caused by the 2013 typhoon Yolanda (Haiyan), Journal of Japan Society of Civil Engineers, ser. B3 (ocean engineering), vol. 70, no. 2, 2014.

Takagi H, Mikami T, Shibayama T, Matsumaru R, Mario d l, Esteban M, Nguyen D. T., Nakamura R. analysis of the 2013 typhoon yolanda (haiyan) and subsequent storm surge, Journal of Japan Society of Civil Engineers, ser. B3 (ocean engineering), vol. 70, no. 2, 2014.

Seminar at De La Salle University, October 17, 2014

Japan Science and Technology Agency | Department of Science and Technology | De La Salle University | Tokyo Institute of Technology | Waseda University | Toyo University | The University of Tokyo | Japan Society of Civil Engineers | Ministry of Education, Culture, Sports, Science and Technology-Japan

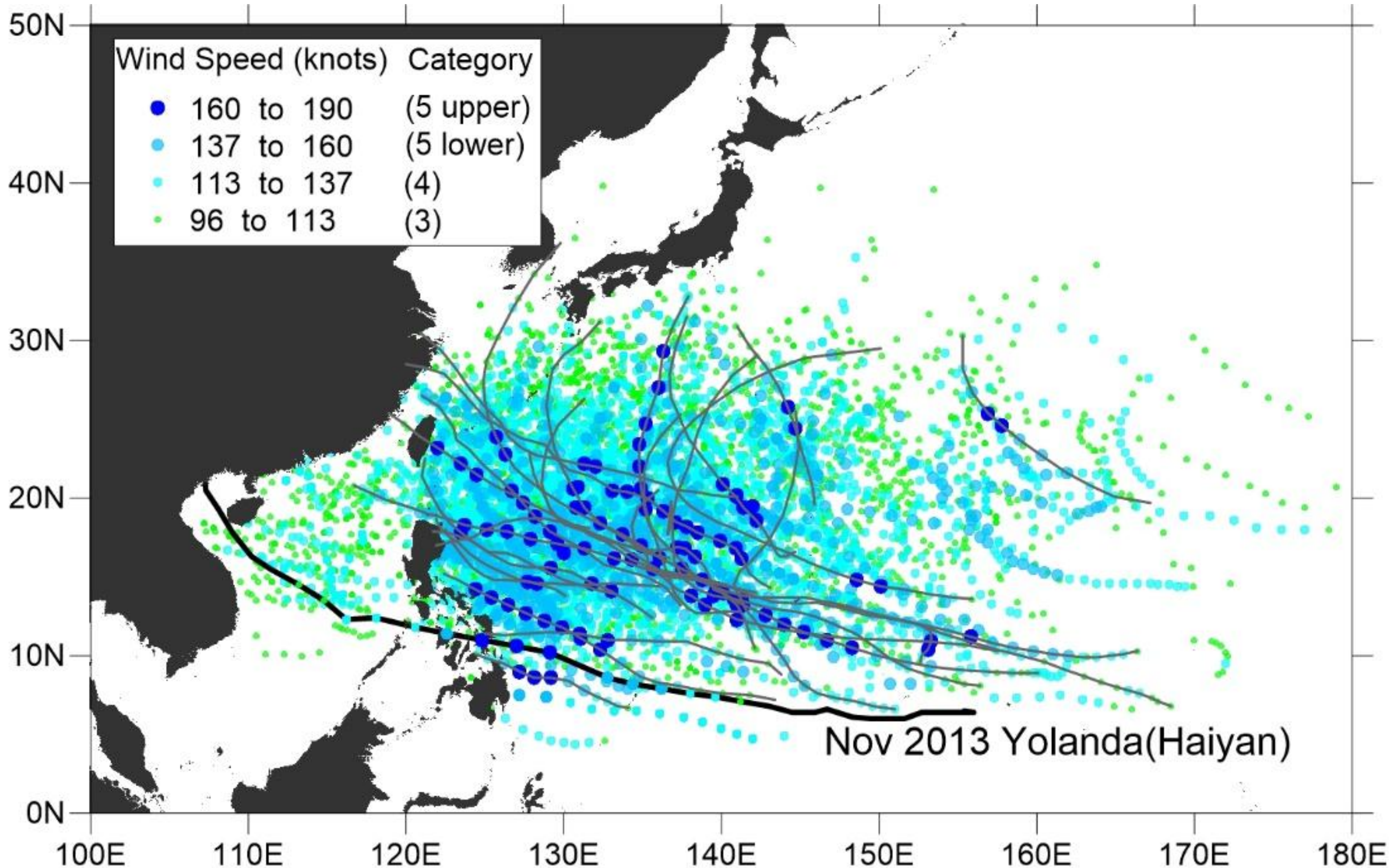
Topics

1. Characteristics of Typhoon Yolanda
2. Findings through the Field Surveys
3. Findings through Storm Surge Simulation
4. Intense Investigation in Tacloban
5. People's awareness of Storm Surge
6. Recovery Process

1. Characteristics of Typhoon Yolanda

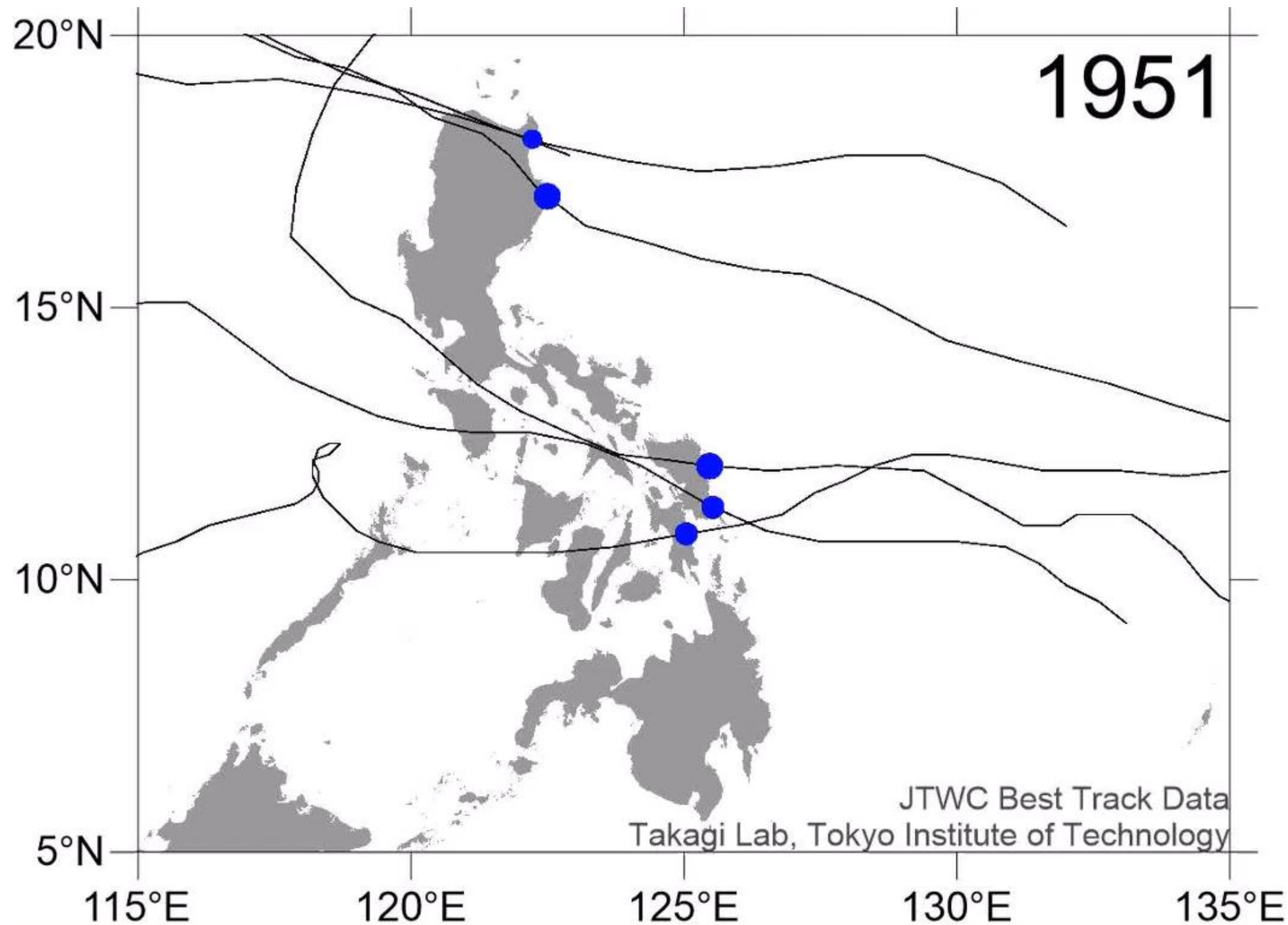
Typhoon Track Analysis

Yolanda was one of the largest typhoons in the North West Pacific, only 28 typhoons are comparable.

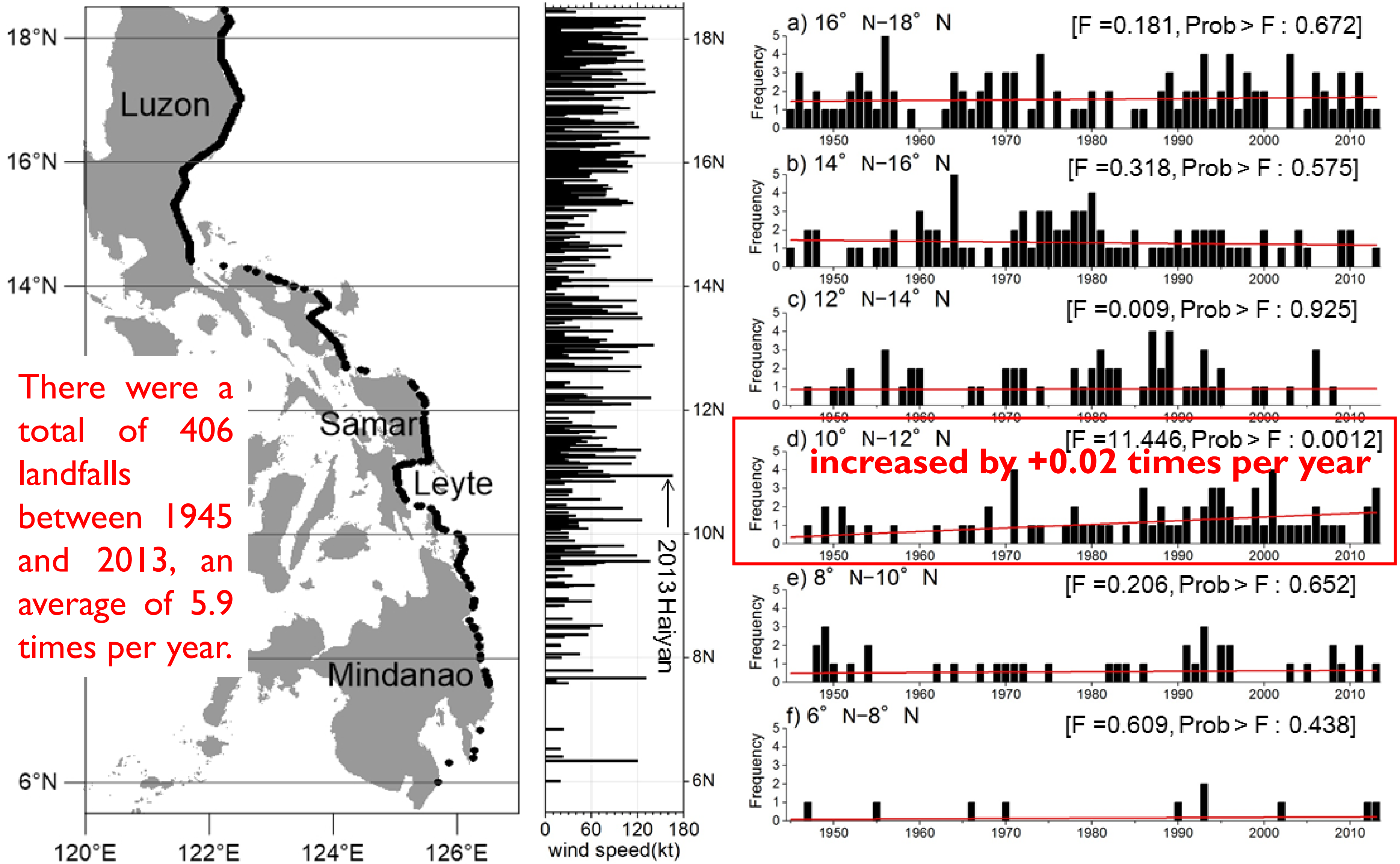


Track analysis using the JTWC Best track (1945-2013)

1. detect the landfall point at which a TC track intersects a coastline
2. estimate landfall time and wind speeds by interpolating the data before and after landfalls

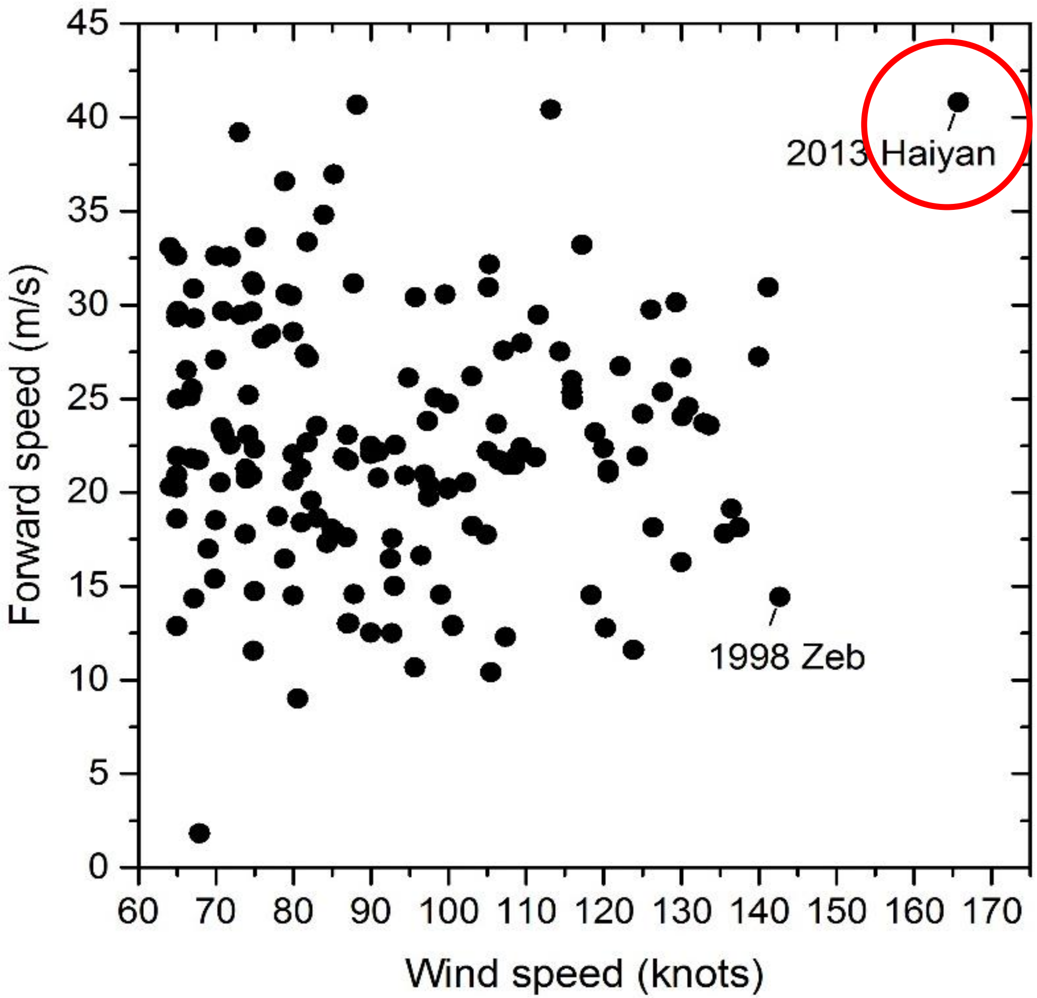


A statistical analysis indicated that the number of TC making landfall around Leyte and Samar Island has been steadily increasing over the past 7 decades, while other islands do not show any particular upward or downward trends.



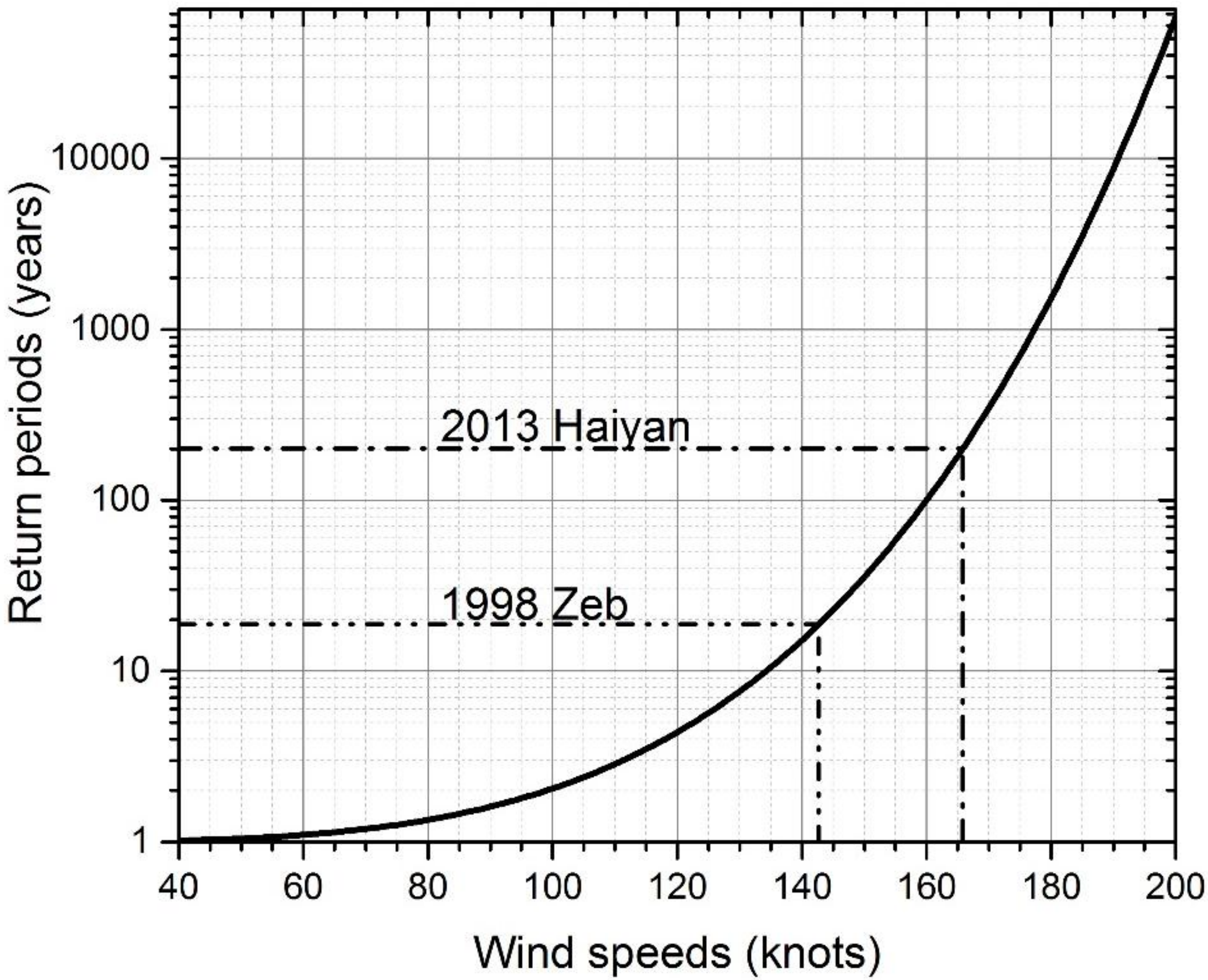
TC landfall points   Wind speeds   frequency of TC

Fig. Relationship between wind speeds and forward speeds for the strongest 67 among 406 TCs, which made landfall in the Philippines between 1945 and 2013



Haiyan (Yolanda) can be characterized as both the fastest moving and strongest typhoon measured in the Philippines.

Relationship between return periods and wind speeds derived from extreme value analysis using a Weibull distribution. The return period of Haiyan (Yolanda) is estimated to be 200 years, while that of typhoon Zeb in 1998 is 19 years.



Key Points for Disaster Management (1)

The wind speed at the time of landfall (165.8 knots) was found to be the strongest among 406 TCs in the last seven decades, 16% faster than the second strongest typhoon (142.7 knots during Typhoon Zeb in 1998). The return period for a Haiyan-class typhoon to make landfall was estimated to be 200 years.

A significant increase in TC landfall frequency (+0.02 times per year) in recent decades was found in the latitude zone between 10° N and 12° N, which encompasses Leyte Island.

One of the most unusual characteristics of Haiyan is that it was found to be the fastest typhoon in addition to the strongest typhoon in the past 7 decades.

The fast moving typhoon caused:

→ amplification of storm surge at some locations

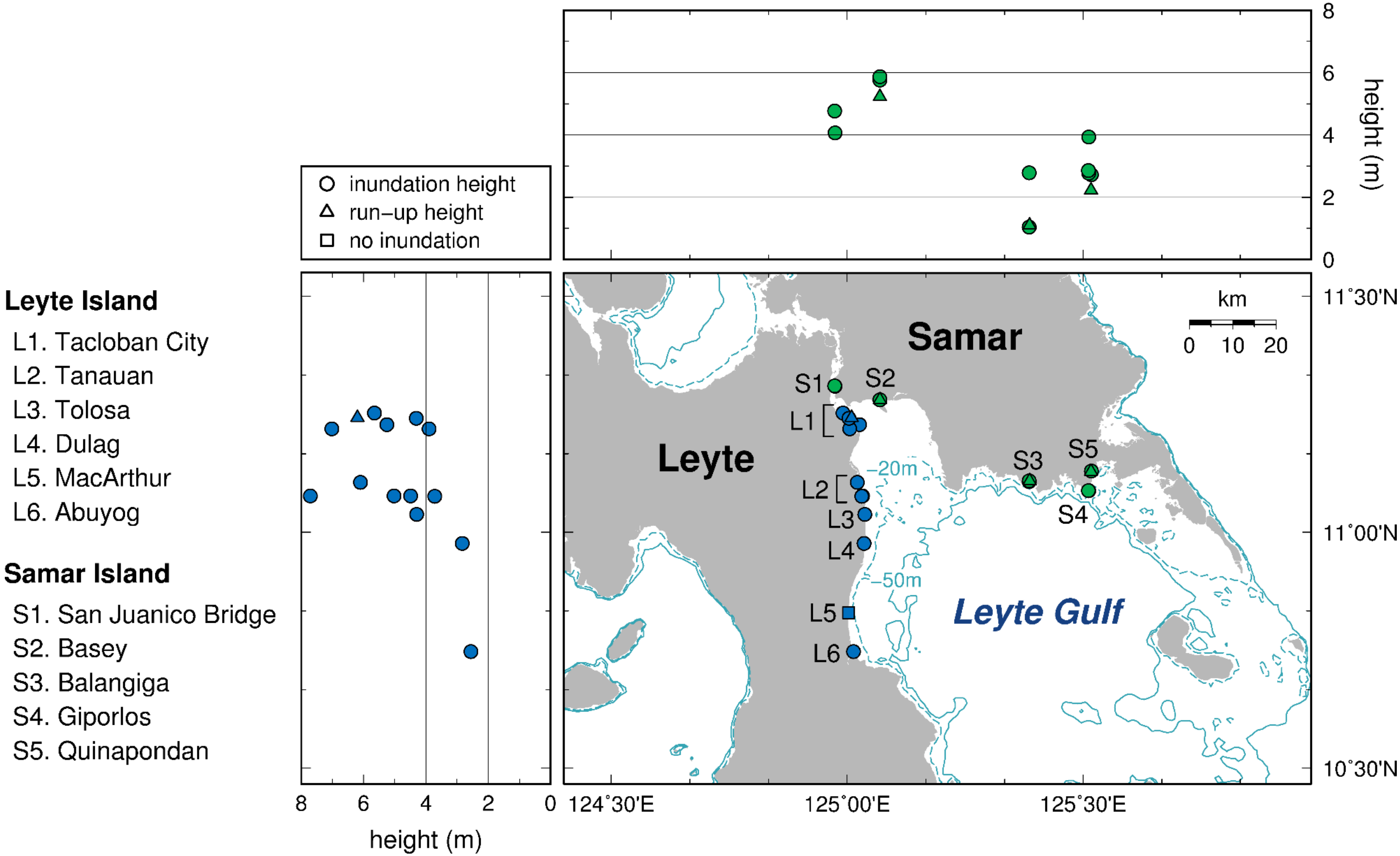
→ insufficient time for local people to prepare and evacuate

2. Findings through the Field Surveys

Post-disaster Survey in the Philippines after Yolanda

Storm Surge Height Measurements

Storm Surge Height Distribution



Storm Surge Height Distribution

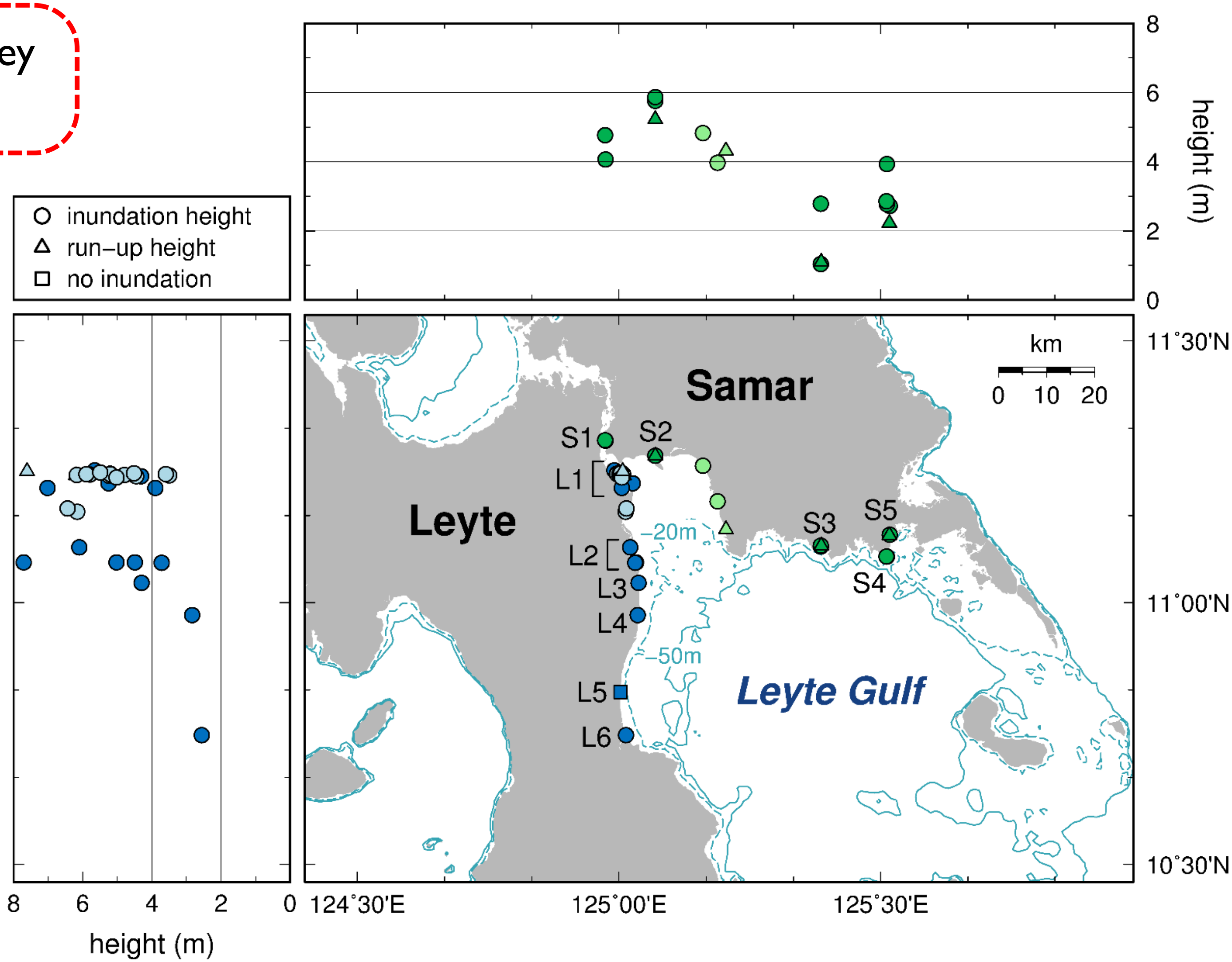
Results of survey
in May 2014

Leyte Island

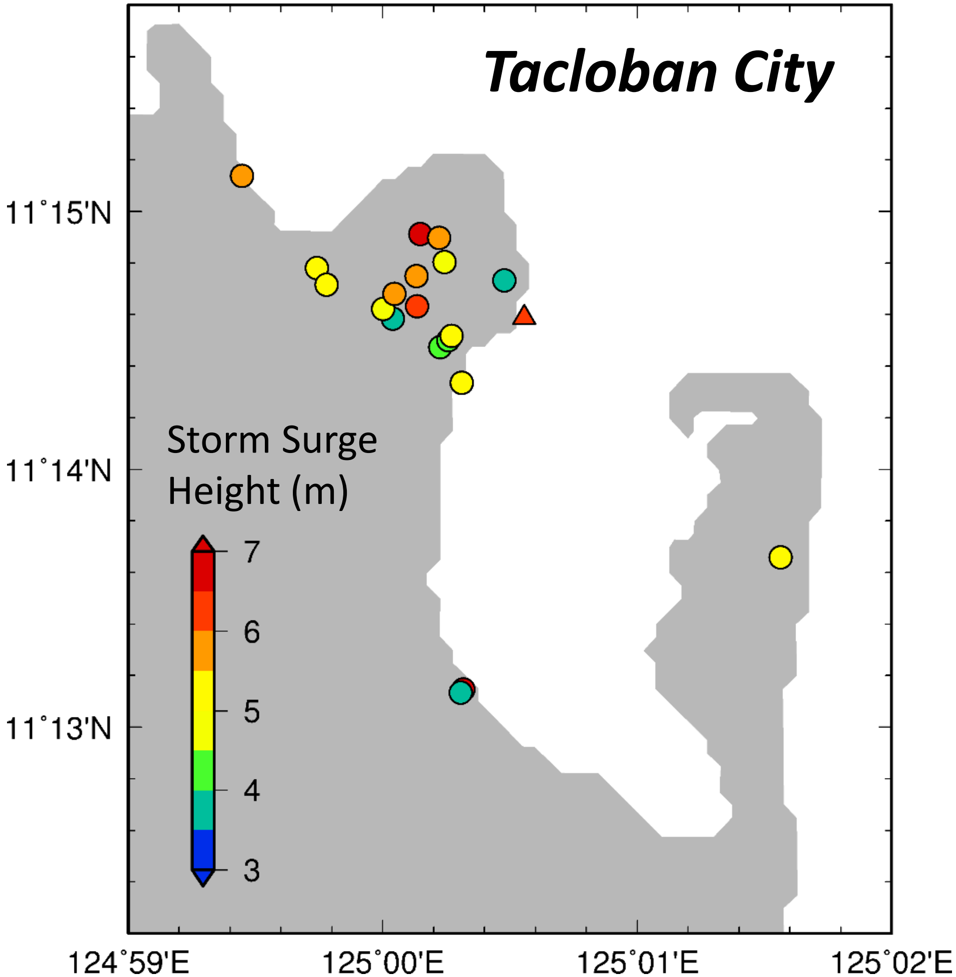
L1. Tacloban City
L2. Tanauan
L3. Tolosa
L4. Dulag
L5. MacArthur
L6. Abuyog

Samar Island

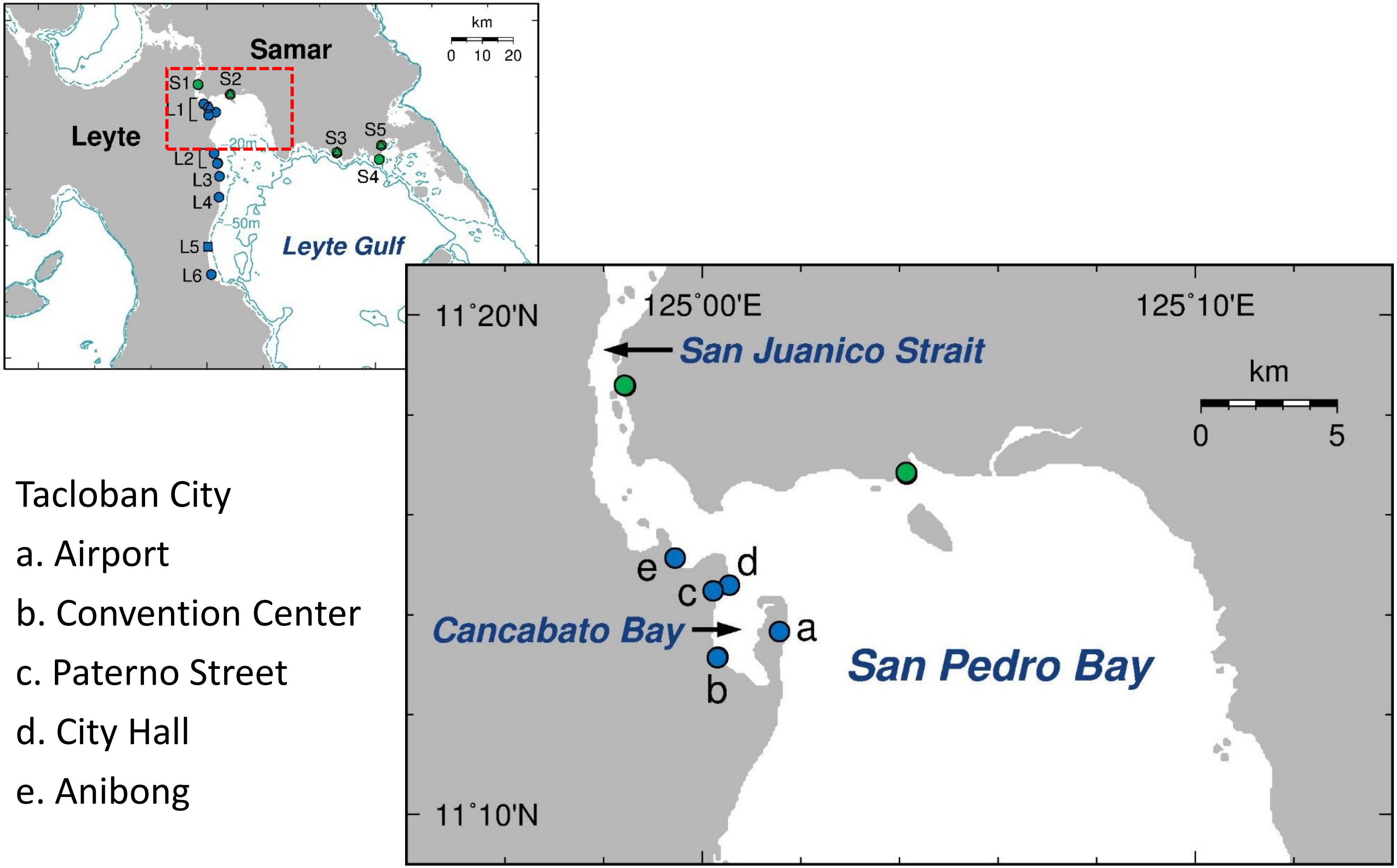
S1. San Juanico Bridge
S2. Basey
S3. Balangiga
S4. Giporlos
S5. Quinapondan



Storm Surge Height Distribution



Surveyed Points (San Pedro Bay)



Tacloban City

a. Airport

b. Convention Center

c. Paterno Street

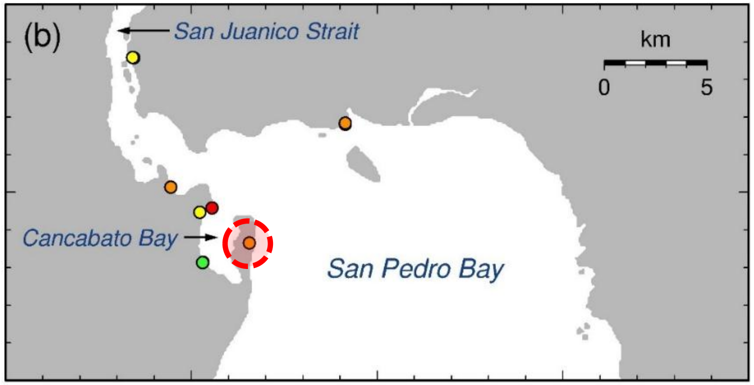
d. City Hall

e. Anibong

Survey Results – Airport, Tacloban City

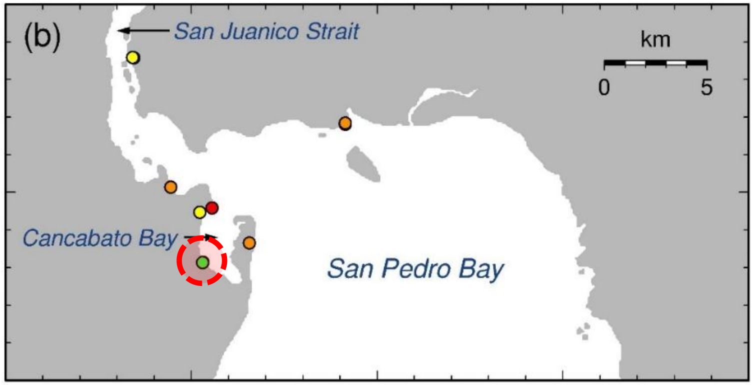
- Located in a narrow low-lying peninsula
- Airport worker (remained at the airport during the event) "the water level came to the outer air conditioning machine"

  ⇒ Height: 5.25m (Depth: 3.45m)



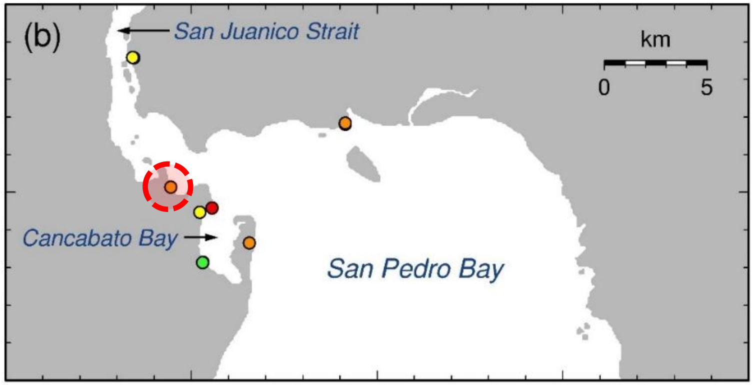
Survey Results — Tacloban City

- Height: more than 3.90m (at Hotel)
- Height: 7.02m (2nd floor of a house)
- It was difficult to estimate the maximum storm surge height around this area.



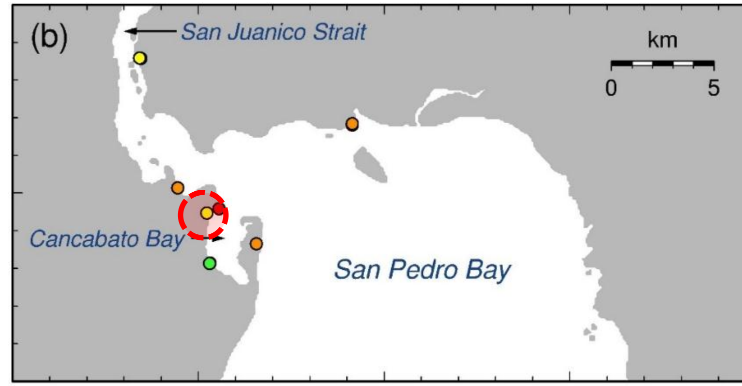
Survey Results – Anibong, Tacloban City

- Height at a house: 5.65m (residents evacuated to a hill behind the house).
- Storm surge attacked densely populated area.
- Ships were washed inland (this area is next to a port area).



Survey Results — Alejandro Hotel, Tacloban City

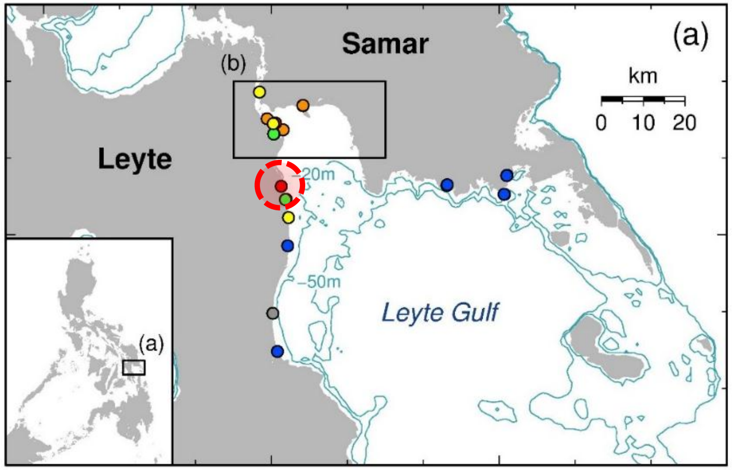
- Height: 4.31m (350m from the coast)
- Video footage during storm surge
- "The inundation started at 7:30AM and family decided to evacuate after the sea water reached a waist level."



Source: YouTube, http://www.youtube.com/watch?v=4wrgrJwYdy8

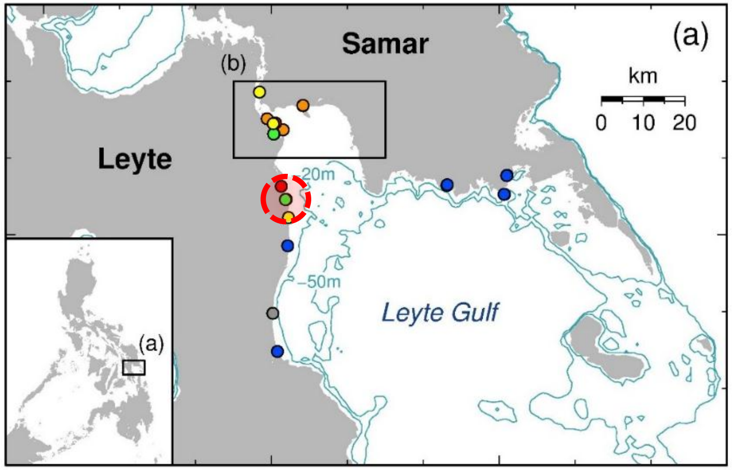
Survey Results – Edible Oil Mfg., Tanauan

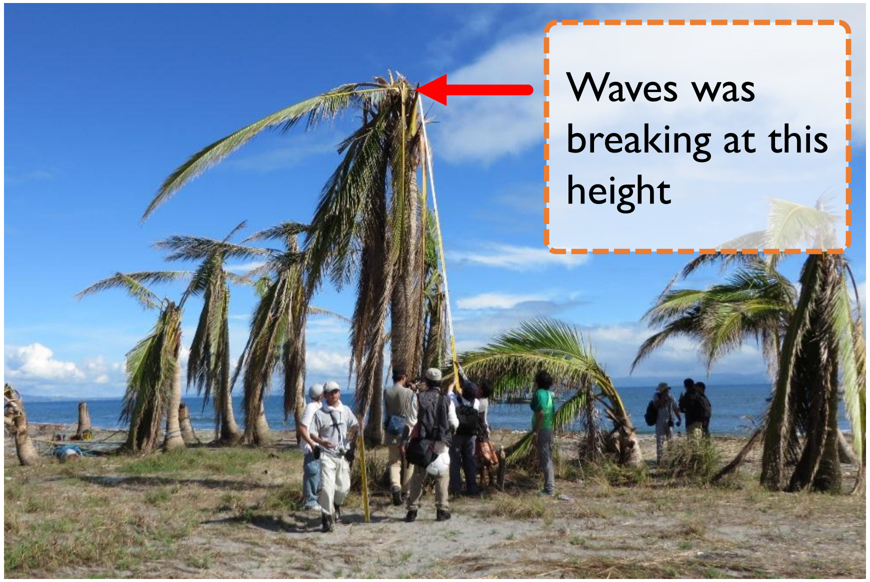
- Height: 6.10m (100m from the coast)
- Oil tanks were displaced by the storm surge and the high waves.



Survey Results – Bislig, Tanauan

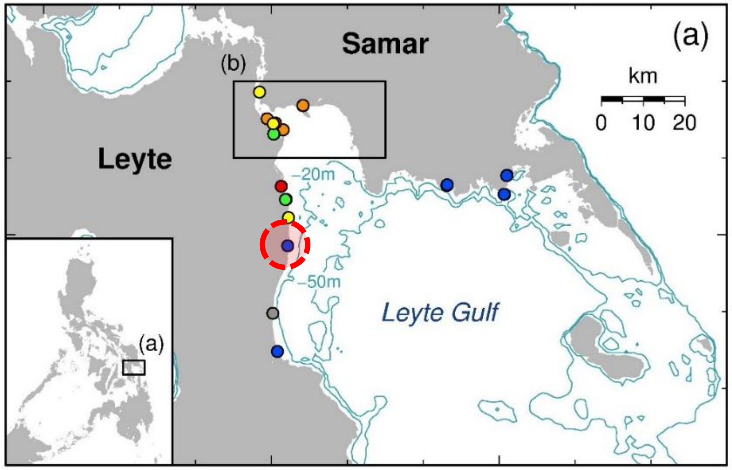
- Height: 7.71m (near the coast)
- Height: 3.72m (290m from the coast)
- The water carried a great deal of garbage with it (flow was like "washing machine").





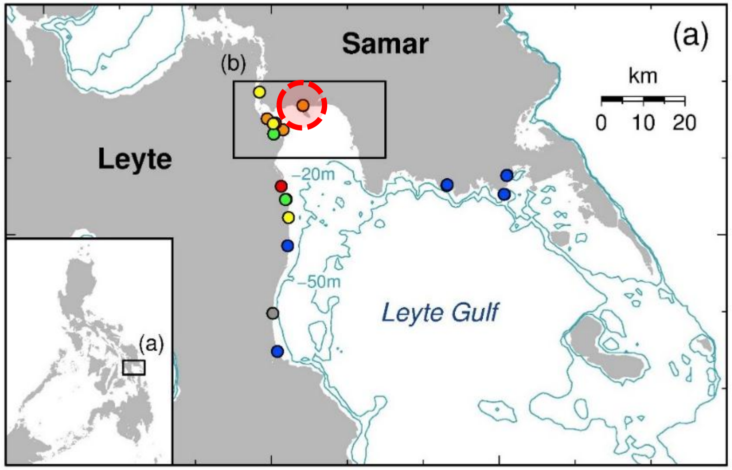
Survey Results – Luan, Dulag

- Height: 2.84m (300m from the coast)
- When the typhoon came, residents evacuated to an elementary school (designated evacuation site).
- Storm surge reached this school (depth was 80cm).



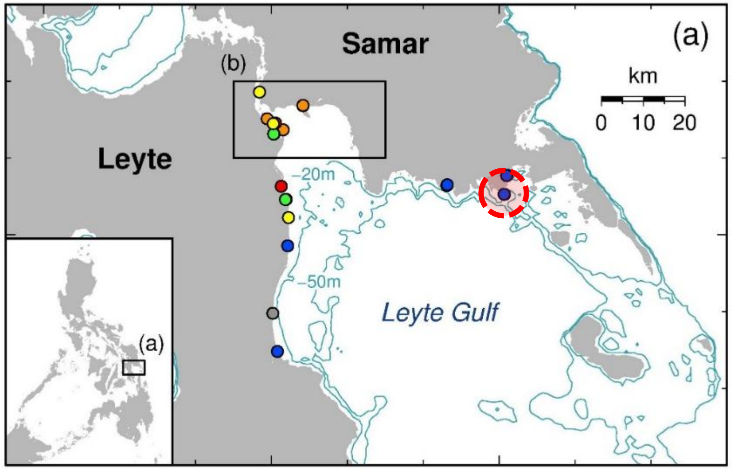
Survey Results — Basey

- Height: 5.87m (City Hall)
- Height: 5.22m (behind the City Hall)
- 1st floor was flooded
- Strong winds started around 5AM
  → the water started to recede 6AM
  → the storm surge started 7AM



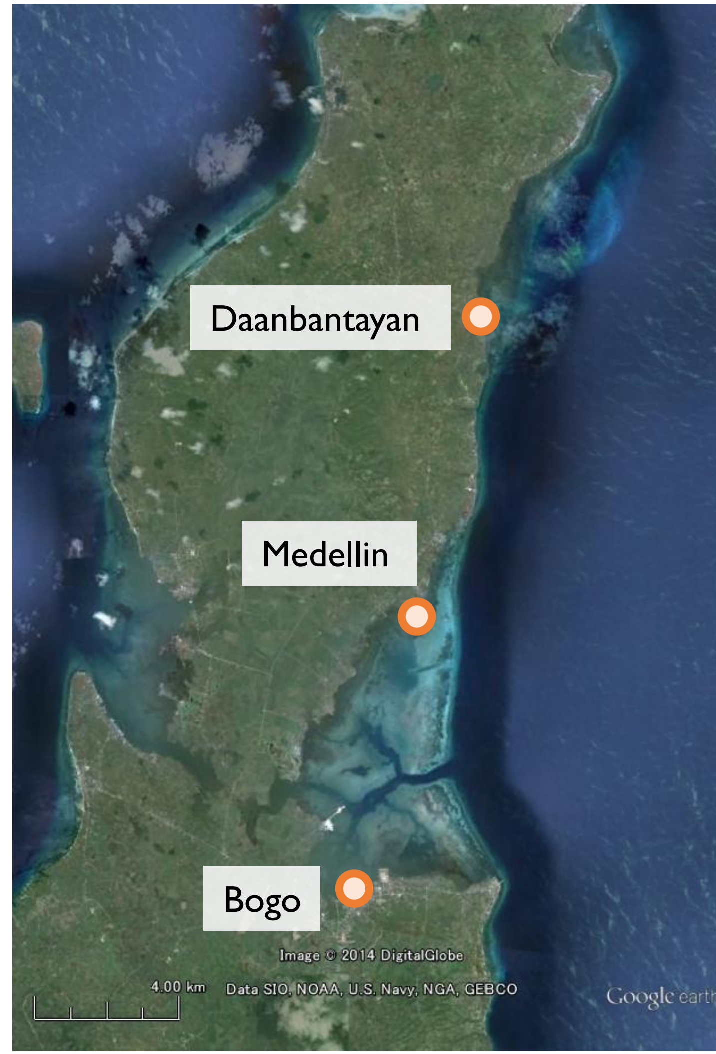
Survey Results – Gigoso, Giporlos

- The mayor brought us to the most affected barangay.
- Height: 3.93m (near the coast)
- 1st floor was flooded and the water came to the 2nd floor (wind waves?).



Survey Results — Northern Cebu

- Some evidence of storm surges was found (but not as great as that observed in Leyte and Samar).
- Low tide during the typhoon.
- Coral reef and mangrove forests.



Key Points for Disaster Management (2)

Storm Surge Field Survey after the 2013 Typhoon Yolanda

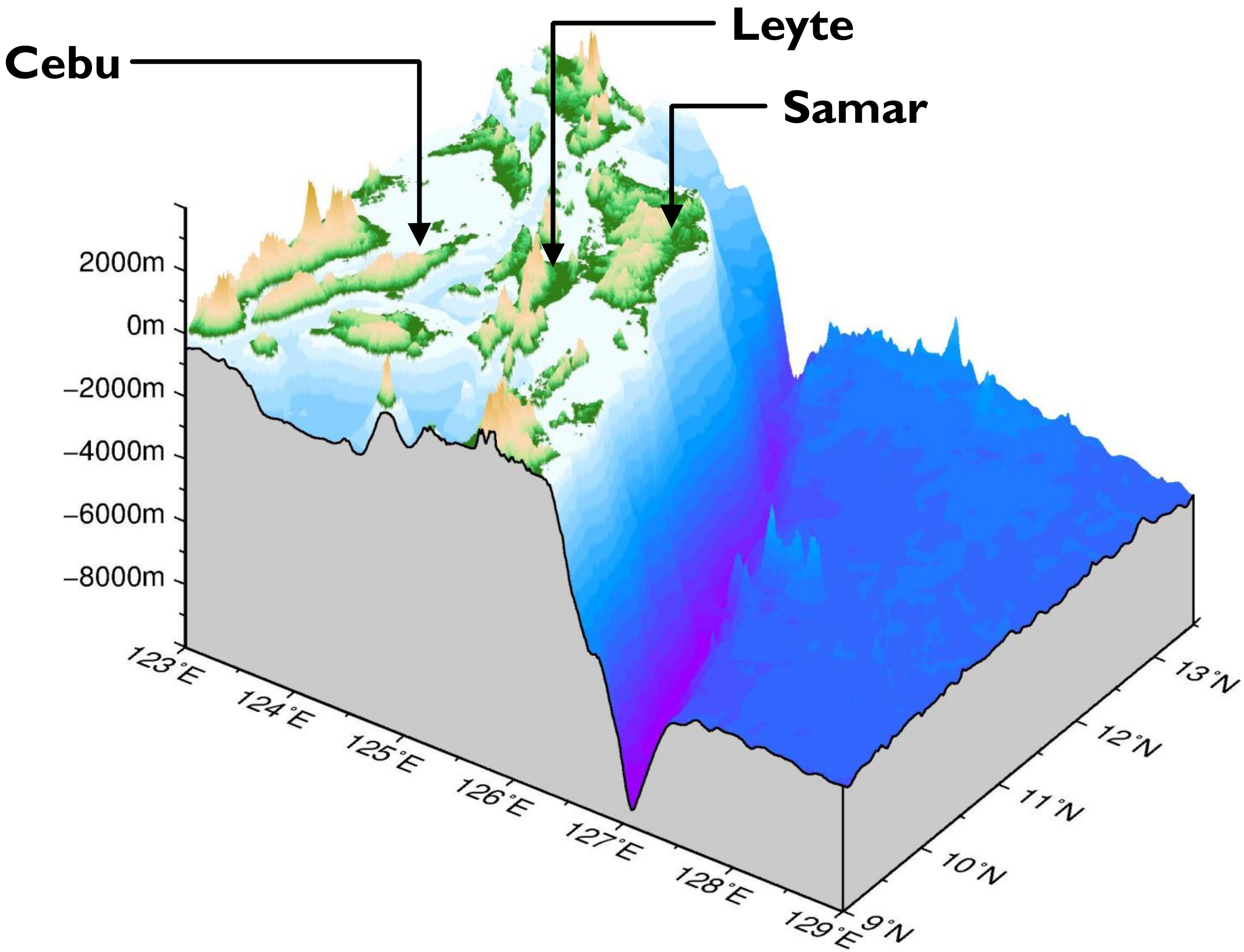
- Field surveys revealed that:
  - Storm surge heights were over 5m inside Leyte Gulf
  - Storm surge above 3m started to cause damage to housing, especially to the wooden settlements
  - Devastating storm surge was induced by rapid change of wind direction over Leyte Gulf
- In the Philippines, the characteristics of storm surges can be different depending on typhoon path, shape of a bay, near shore bathymetry, etc.
- In order to prepare for future typhoons, it is important to analyze past storm surge events as well as recent events and accumulate knowledge and lessons.

3. Characteristics of Storm Surge revealed through Numerical Simulation

Storm Surge Model

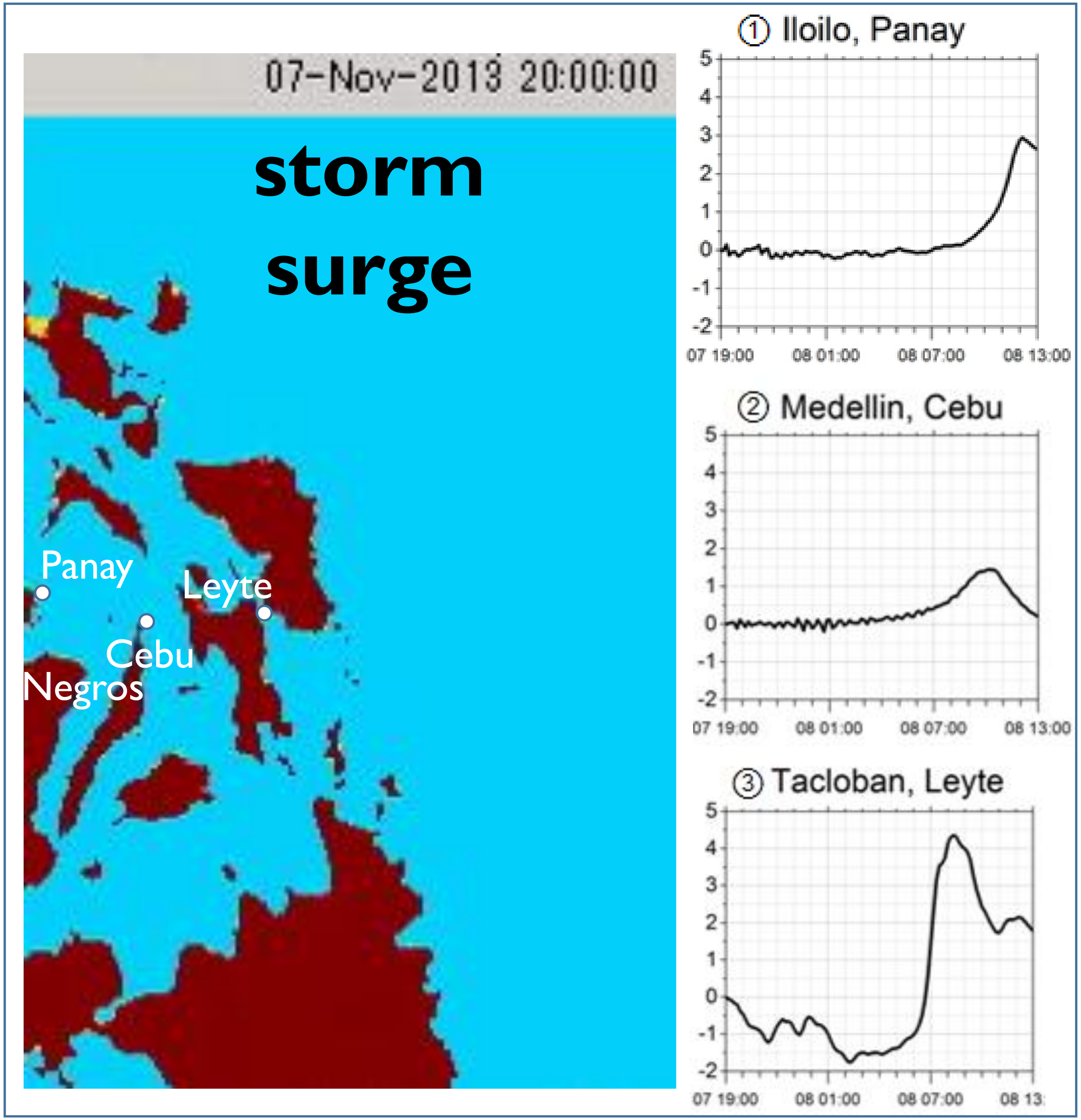
Typhoon Path	**JMA Typhoon Best Track**
Typhoon Model	**Pressure: Myers Formula, Wind: Gradient winds considering Super-gradient wind effect**
Fluid Dynamics Model	**Nonlinear shallow water equation**
Computational Domain	**Cartesian (UTM51N), grid @3000m (Philippines), @100m (San Pedro Bay)**
Bathymetry	**GEBCO_08 Grid (Philippines) Chart by NAMRIA (San Pedro Bay)**
Terrain Data	**ASTER GDEM (Satellite Data) Tacloban, measured by the team**
Manning's *n* value	**Ocean: 0.025, Land: 0.060**

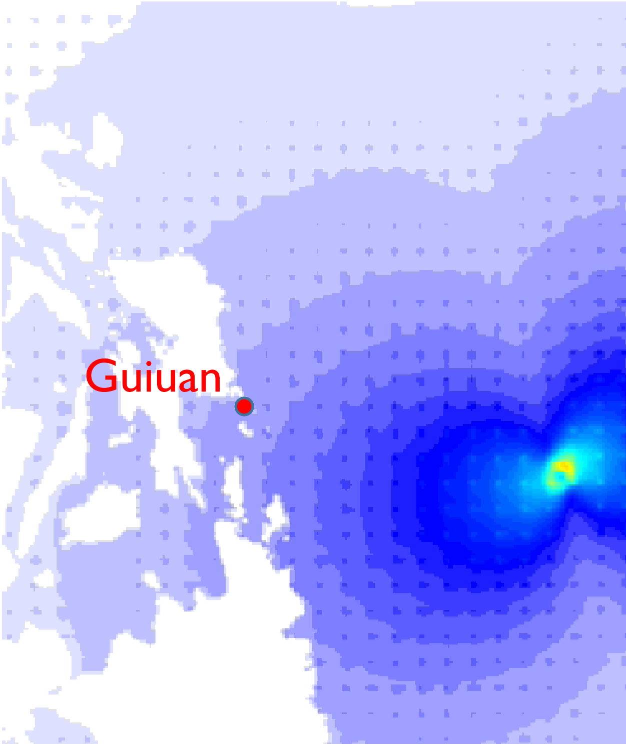
Bathymetry around Leyte and Samar



Data: GEBCO_08 Grid, GEBCO (General Bathymetric Chart of the Oceans)

Simulation for a wide area of the Philippines



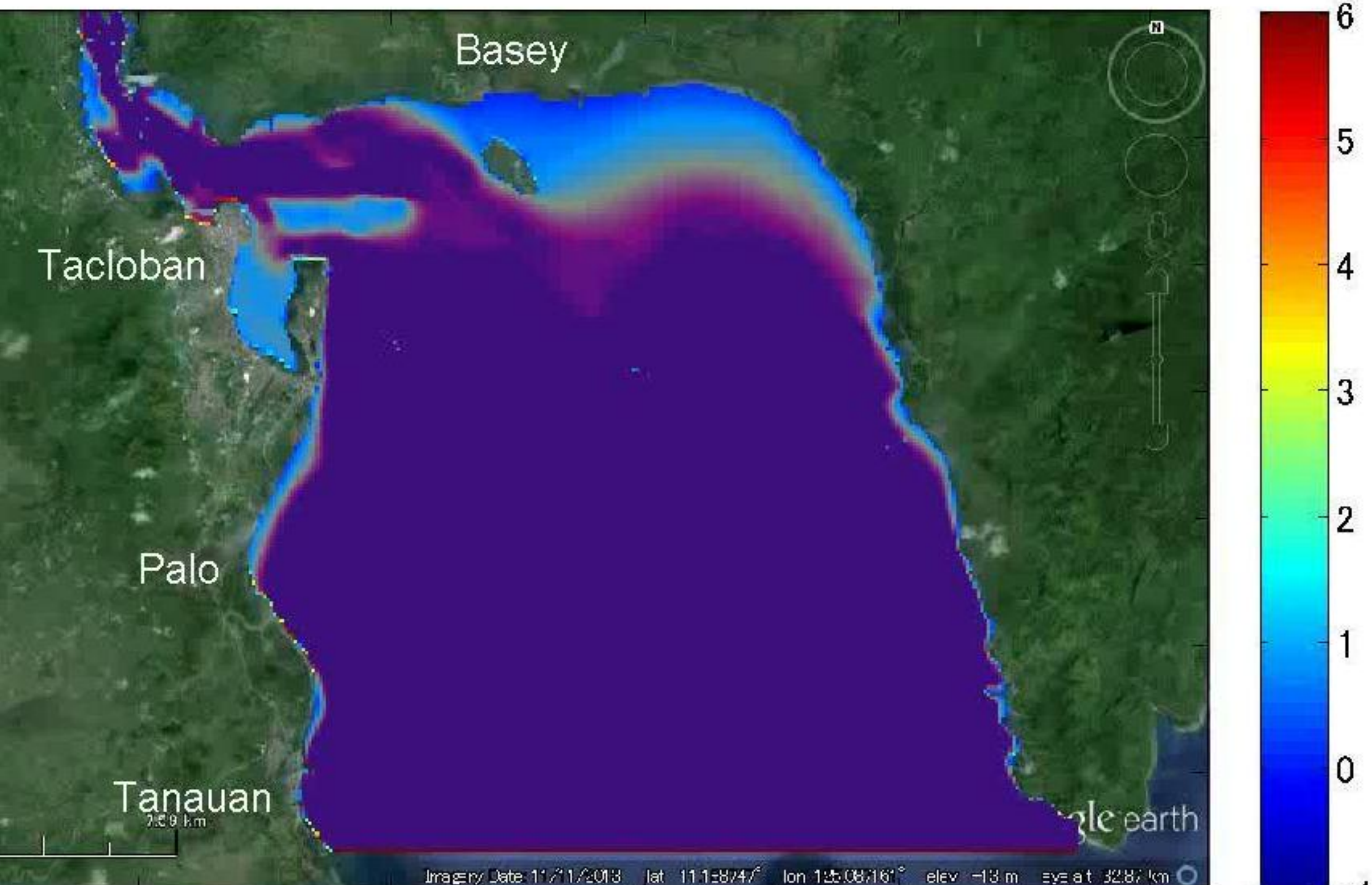


Wave

movie embedded

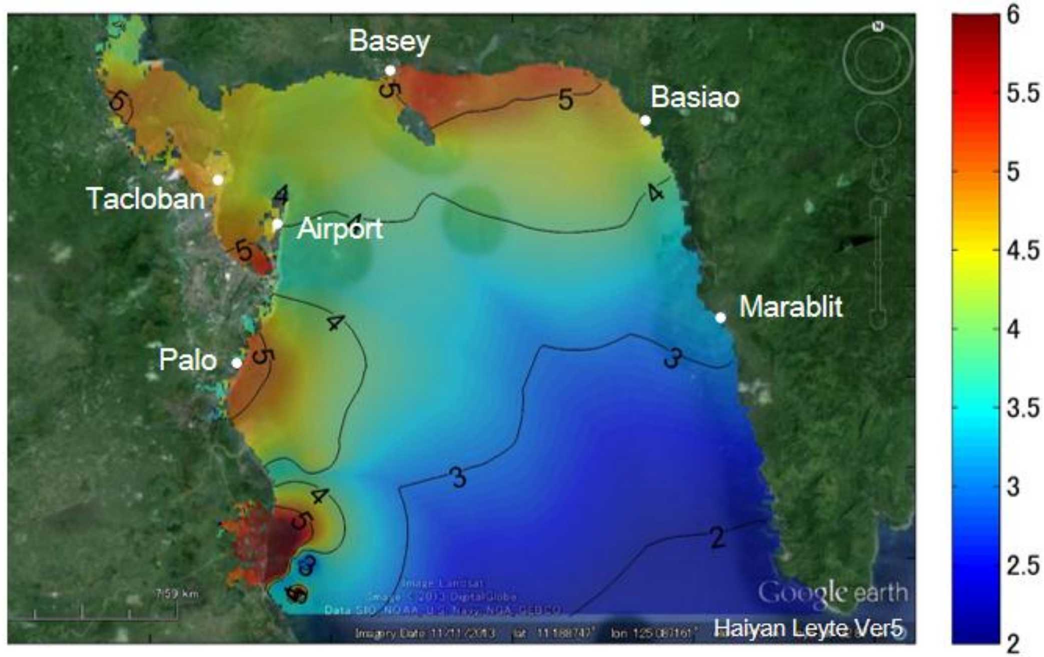
Detailed simulation focusing on Leyte Gulf

08.11.2013 06:00

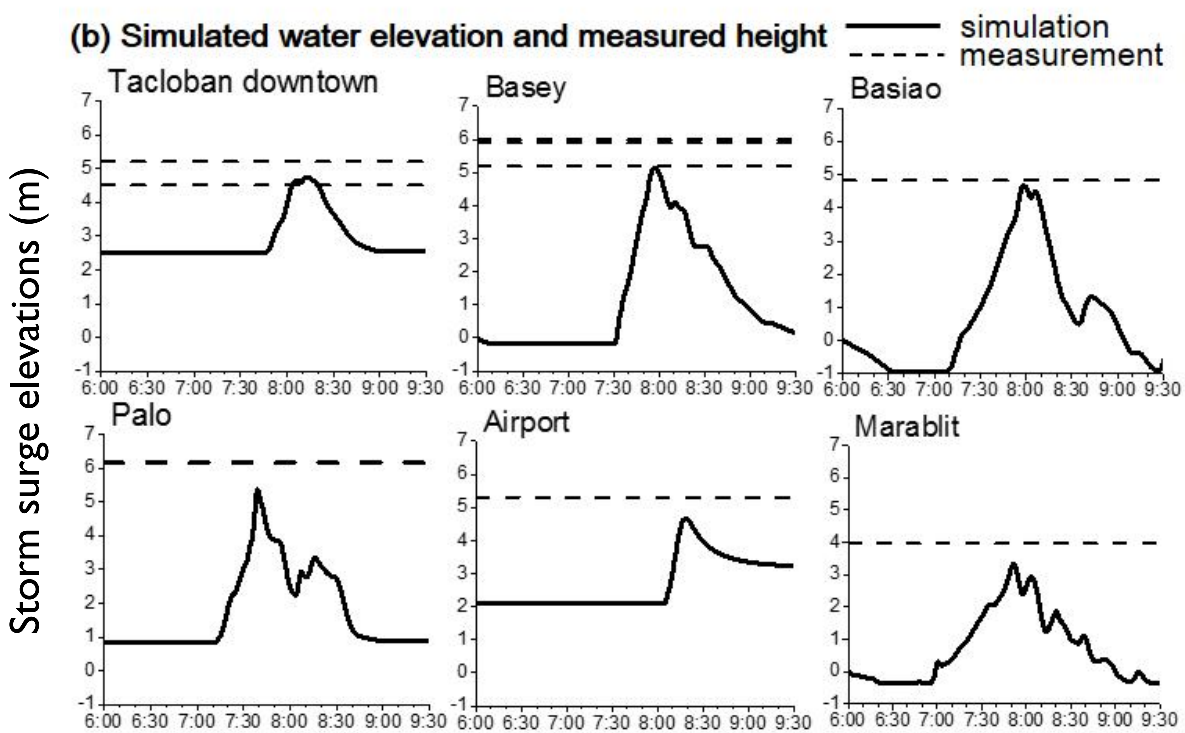


Leyte Ver.5, Tokyo Institute of Technology, Takagi Lab.

movie embedded

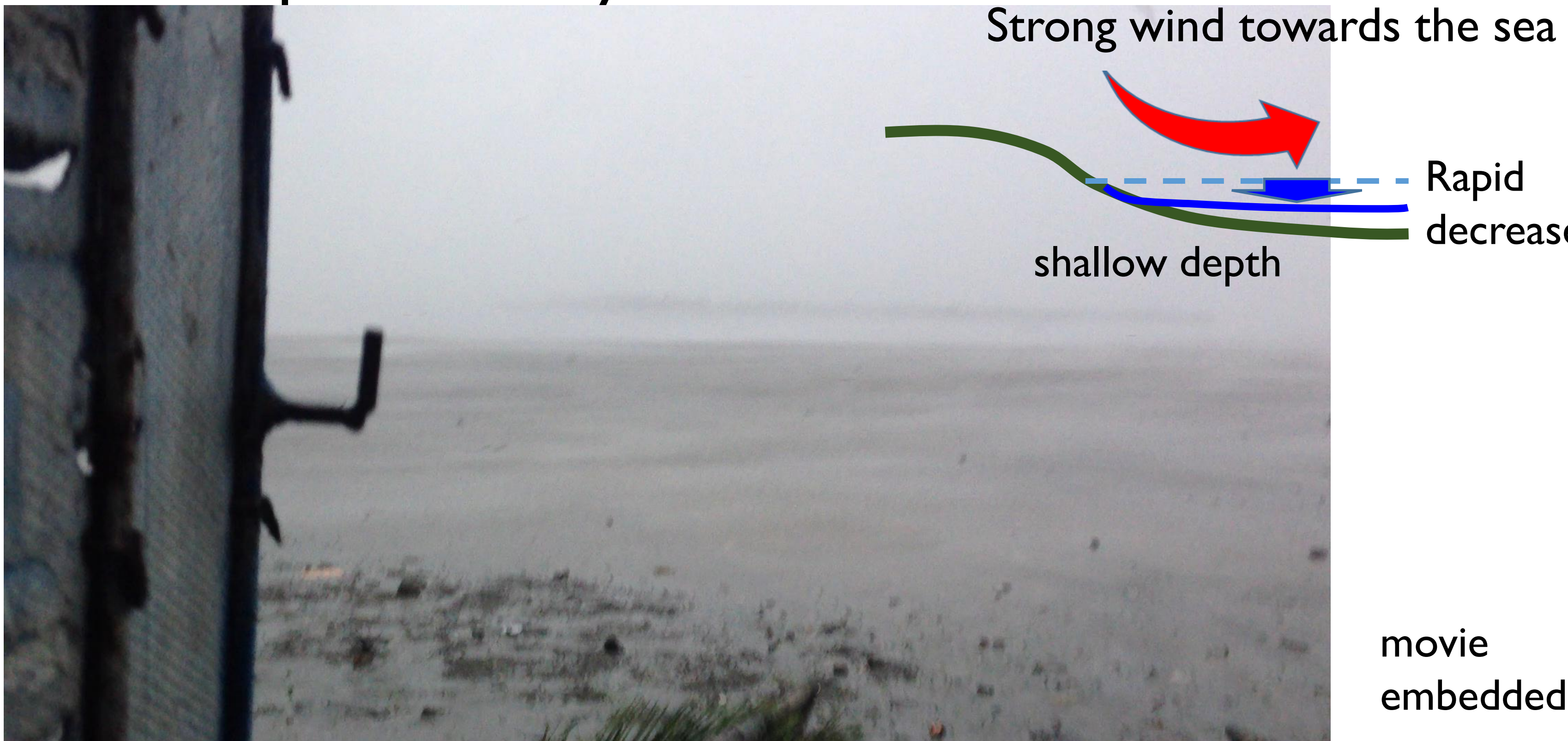


Basey
Basiao
Tacloban
Airport
Marablit
Palo
Google earth
Haiyan Leyte Ver5
6
5.5
5
4.5
4
3.5
3
2.5
2



(b) Simulated water elevation and measured height
simulation
measurement
Storm surge elevations (m)
Tacloban downtown
Basey
Basiao
Palo
Airport
Marablit
6:00 6:30 7:00 7:30 8:00 8:30 9:00 9:30

Receding of water observed in Basey, which was reproduced by the simulation as well.



movie
embedded

water was receded by strong wind towards the sea

Damage of houses due to runup flow

Key Points for Disaster Management (3)

- The winds brought by Yolanda was one of the strongest in the history of the Philippines between 1945 and 2013.
- The return period of Yolanda-class typhoon was estimated to be 200 years.
- The forward speed of Yolanda was unusually fast, reaching speeds of 41km/h, which potentially increased the extent of damage.
- Water levels begun with receding at some places, which might have intrigued people living nearby the coasts.
- The result of numerical simulation is sufficiently reliable, which shows a good agreement with the inundations observed in the survey along the coast of Leyte Island.

4. Intense Investigation in Tacloban

Detail simulation focusing on the downtown Tacloban

Intense field survey

(a) Inundation height

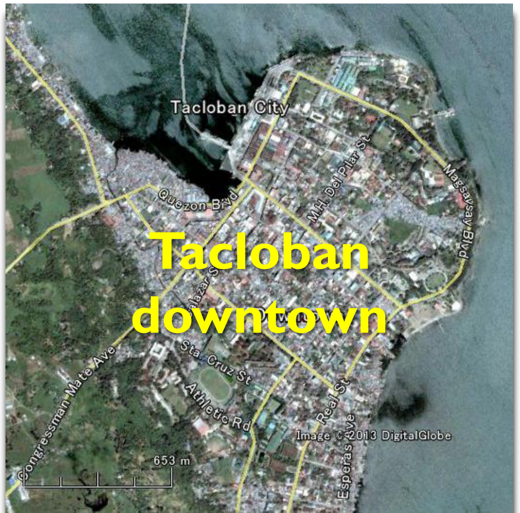
(b) Inundation height

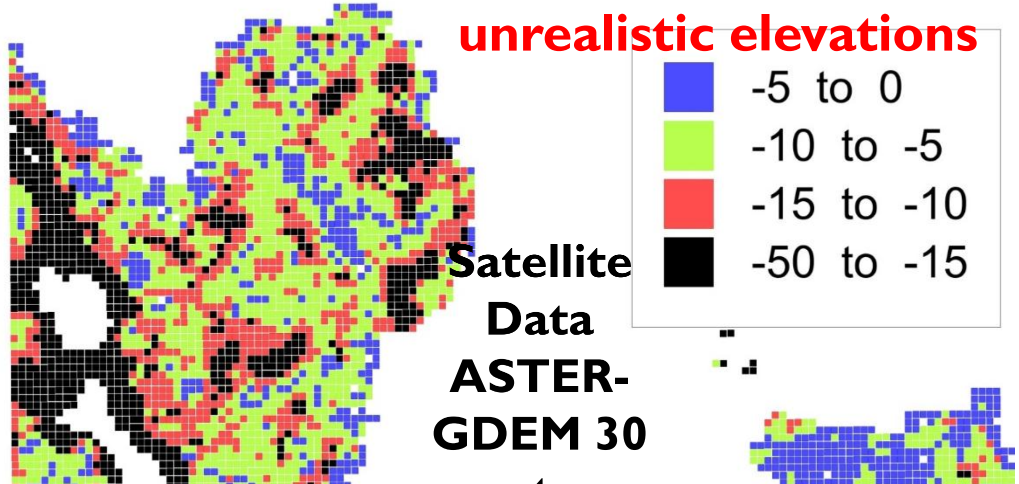
(c) Inundation height

(d) Topographical survey

Topographical survey in the downtown Tacloban

The precise ground elevation is a key to a reliable simulation



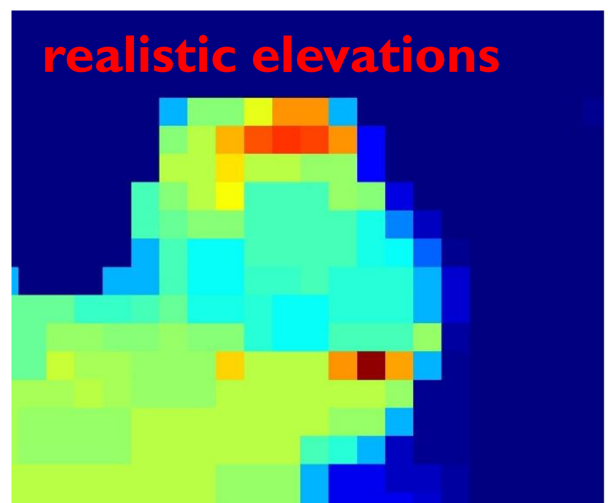


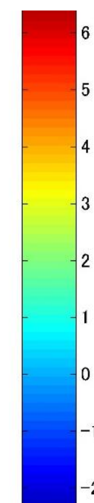
Satellite Data ASTER-GDEM 30 meters

modified

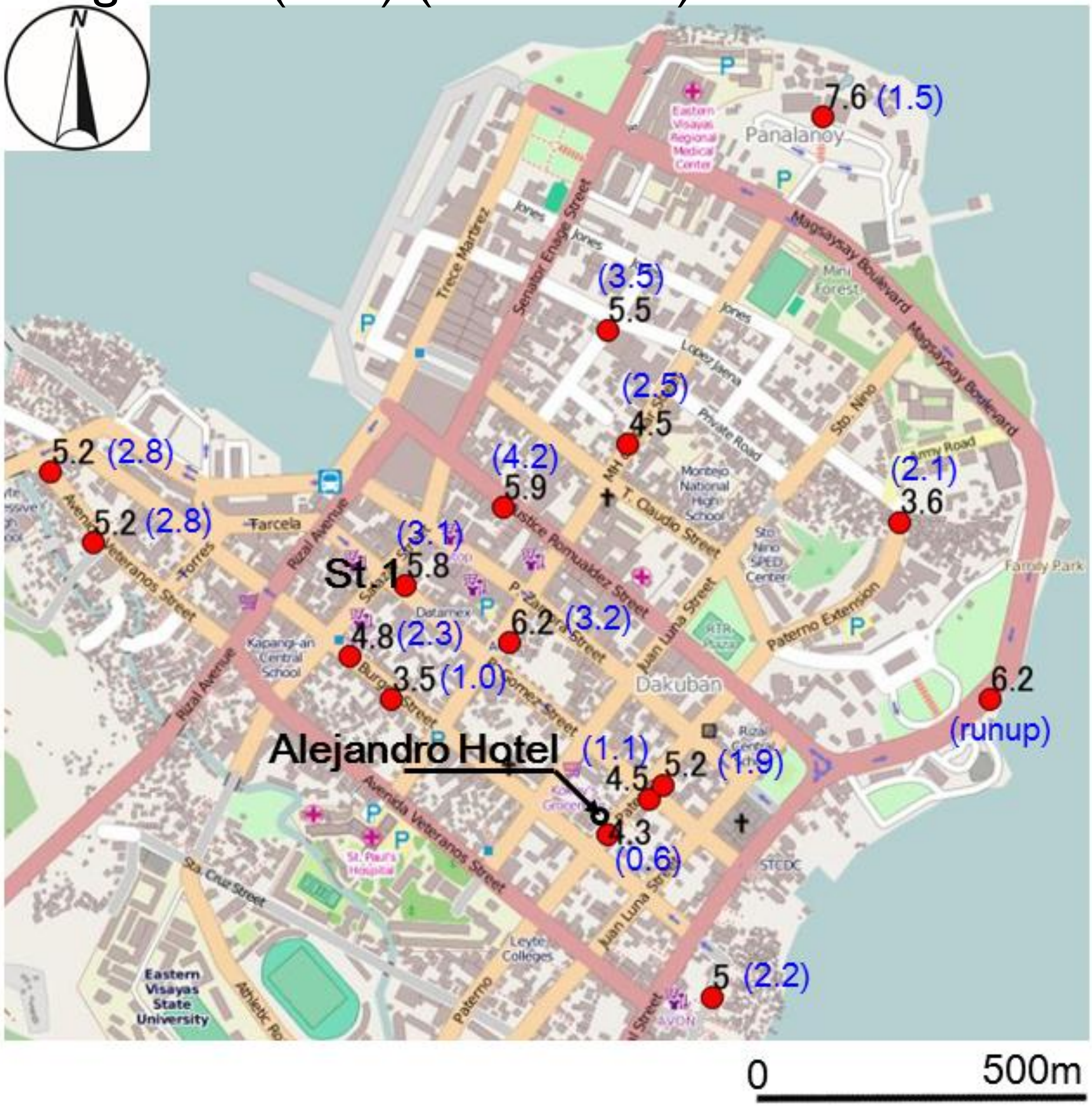
Refined elevation data of Tacloban City

topographical survey





Storm surge heights from the sea surface (black) and inundation depths from the ground (blue) (unit: meter)

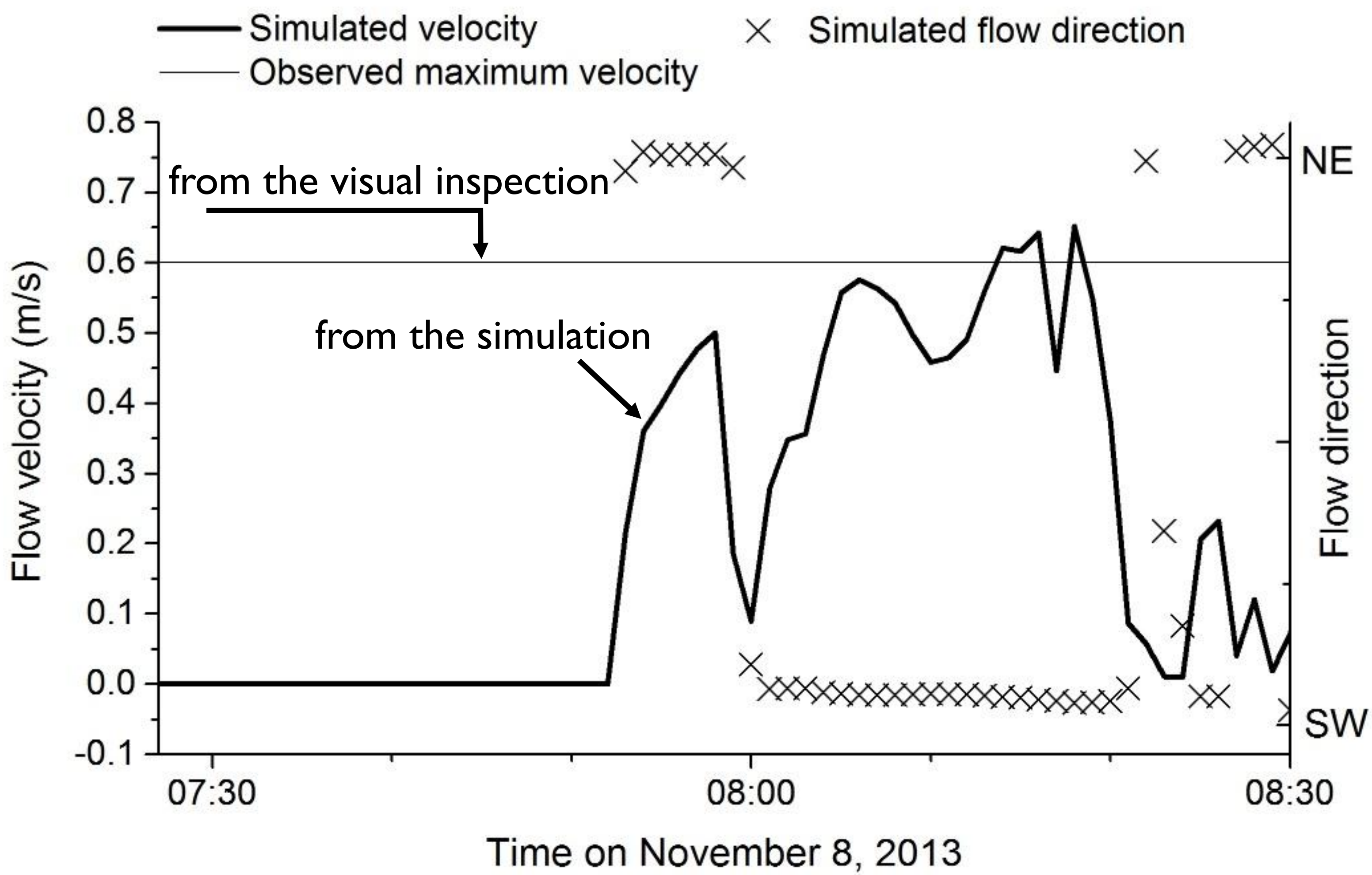


Visual inspection using a movie taken from Alejandro Hotel

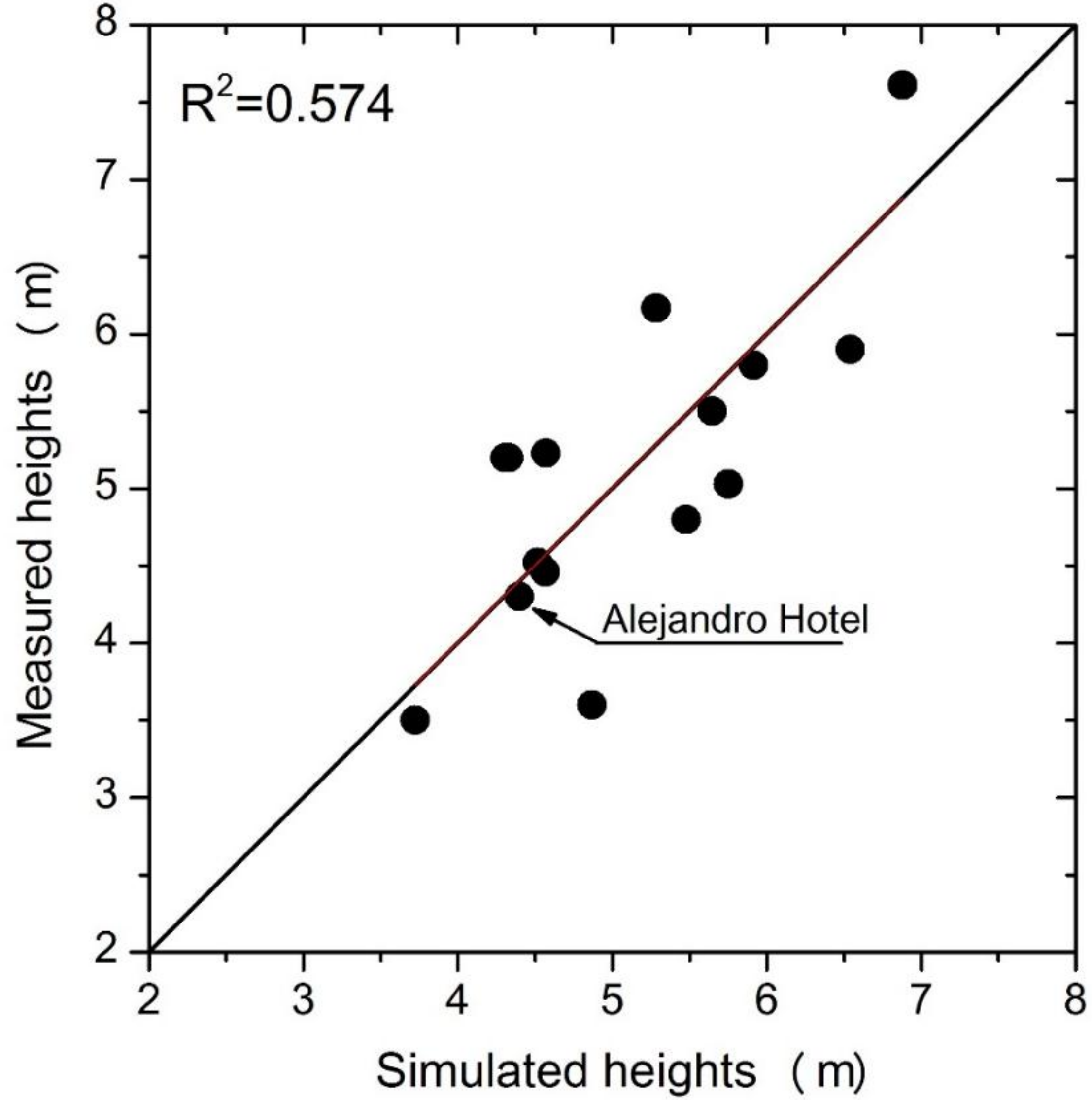
movie embedded

Comparison of flow speed between the movie and simulation

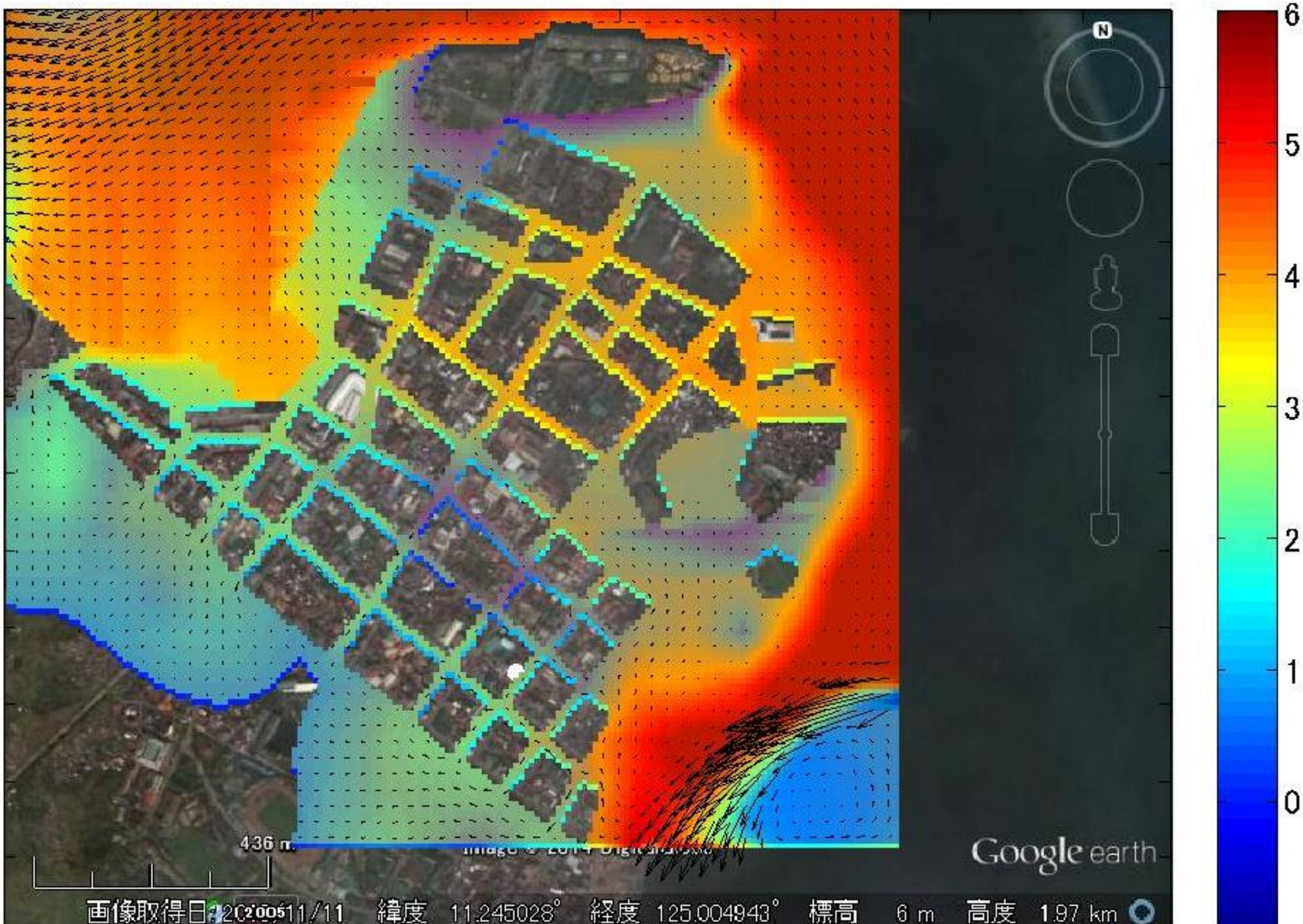
The flow speed was about 60cm/s in front of Alejandro Hotel



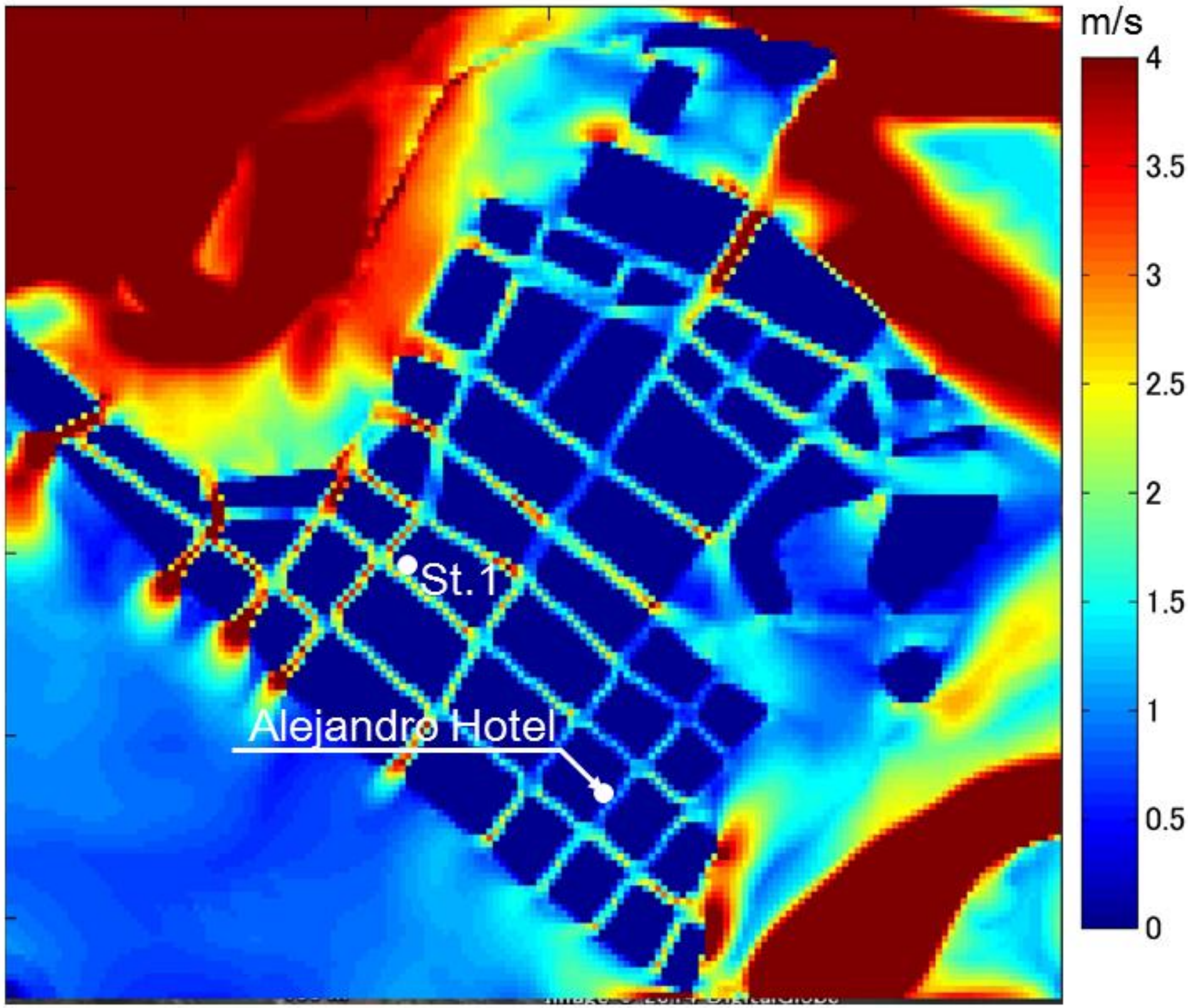
Comparison of storm surge between measured and simulated heights at 15 locations in Tacloban downtown



08.11.2013 08:04



Flow velocity was significantly fast along some streets, which reached more than 4m/s.



Key Points for Disaster Management (4)

- Flow velocities along the streets reached more than 4m/s, intensified by flow contraction due to the high-density residential district, and water significantly rose just in 10 minutes.
- Pedestrian evacuation during the peak of typhoons could be more hazardous than staying in houses some places.
- Early evacuation before the arrival of typhoon is definitely important for safe evacuation. Evacuation is needed to finish sufficiently before typhoon arrives.

5. People's awareness of Storm Surge

Survey Period: Dec. 2013

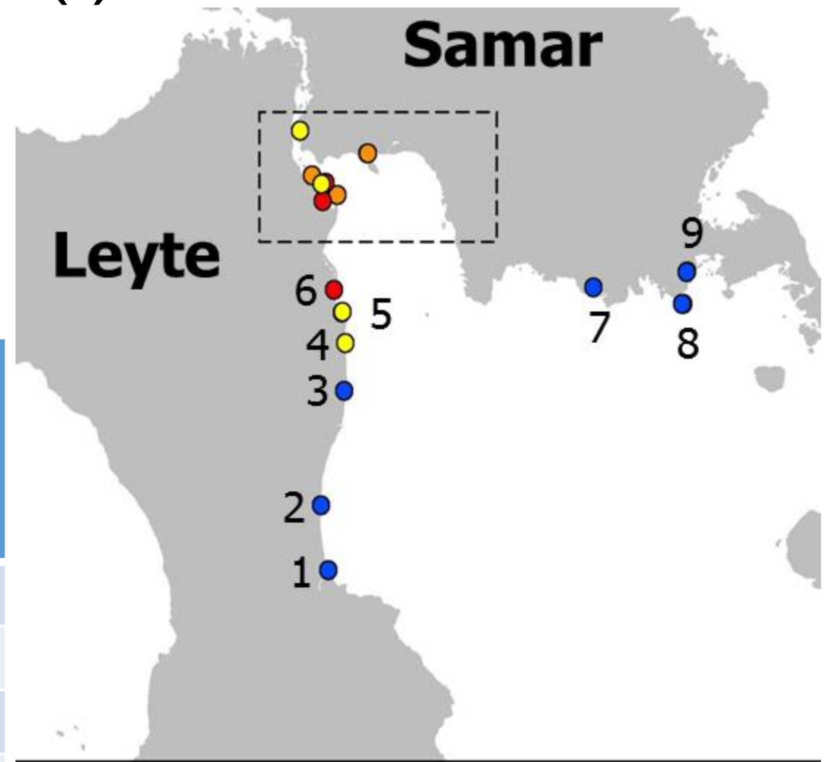
Types of Questionnaires Conducted

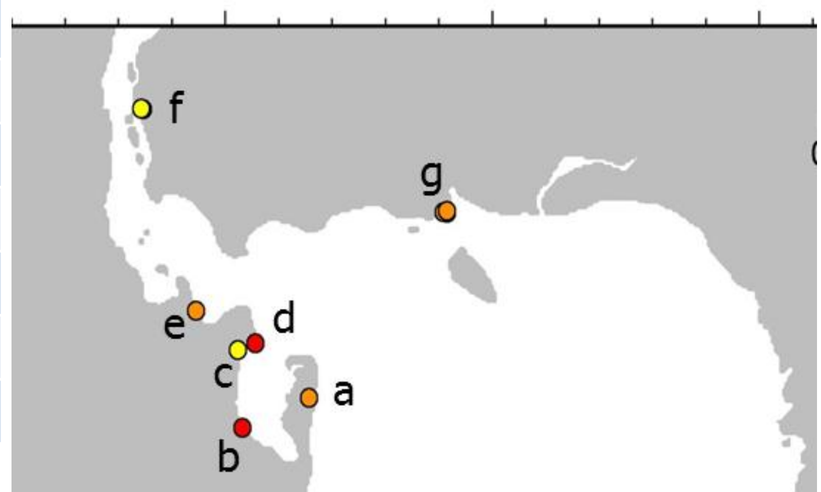
	Methods	Number of Participants (areas)
Structured	Questionnaire Survey	172 (survey locations, see next slide)
Semi-structured	Group Interview (5-8 participants)	20 from Tacloban City, Tanauan, Leyte and Giporlos, Eastern Samar,
Non-structured	Interview (1:1)	Government officials in towns of Tanauan, Palo, Tacloban, and Basey and DRRM officer of the province of Leyte

Structured Questionnaires (I): Distribution

- Same place as storm surge survey.
- 172(valid response)
  /198(distribution)

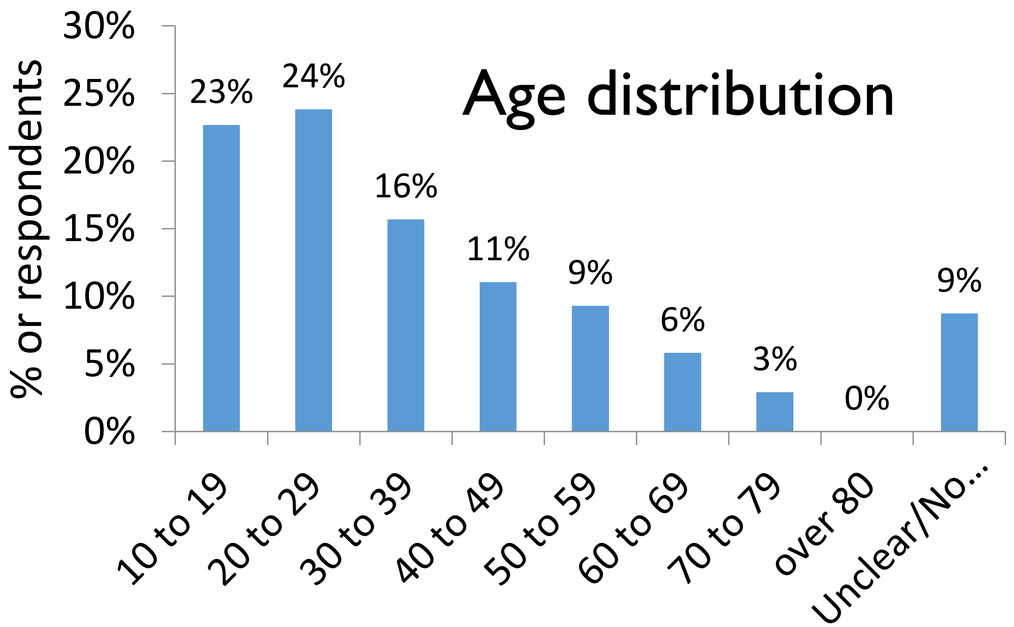
	Place	No. of response	Storm Surge Height (m)
a	Tacloban Airport	13	5.25
d	Tacloban City Hall	7	6.20
b	Convention Center	44	7.02
g	Basey	13	5.87
9	Sto Nino	15	2.72
8	Gigoso	16	3.93
7	Balangiga	22	2.78
1	Bislig, Tanauan	15	7.71
e	Barangay 68, Tacloban	5	5.65
c	Hotel Alejandro, Tacloban	8	4.31
	Palo	14	-

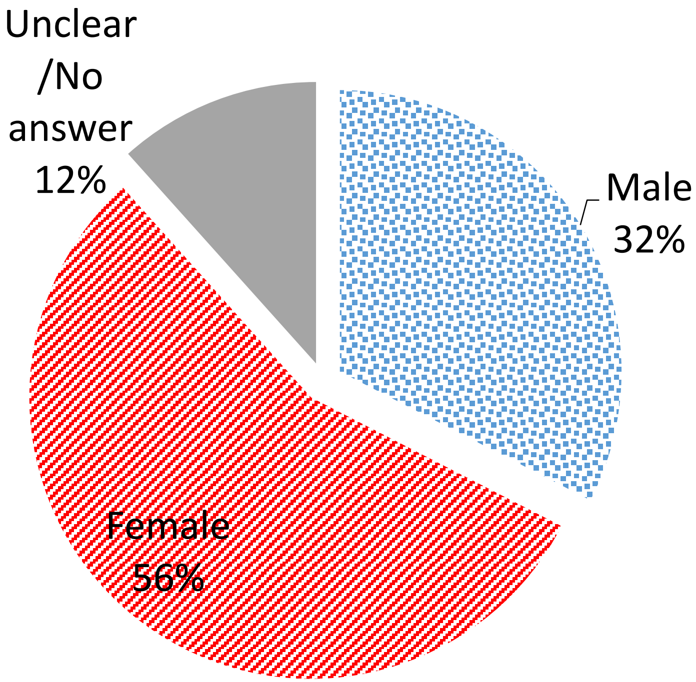




Structured Questionnaires (II): Demographics

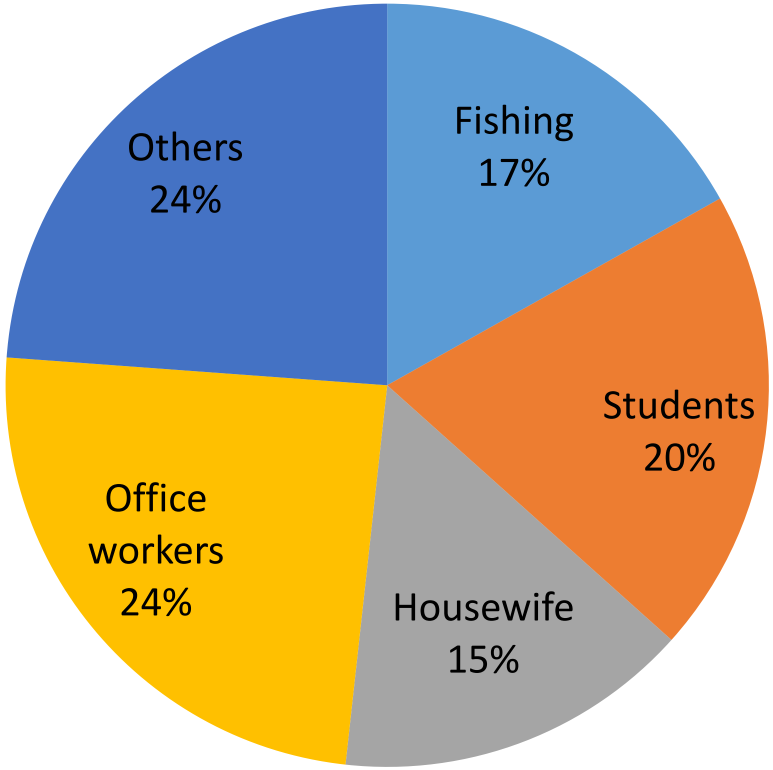
- Structured questionnaires of local residents and emergency officials (n=172)





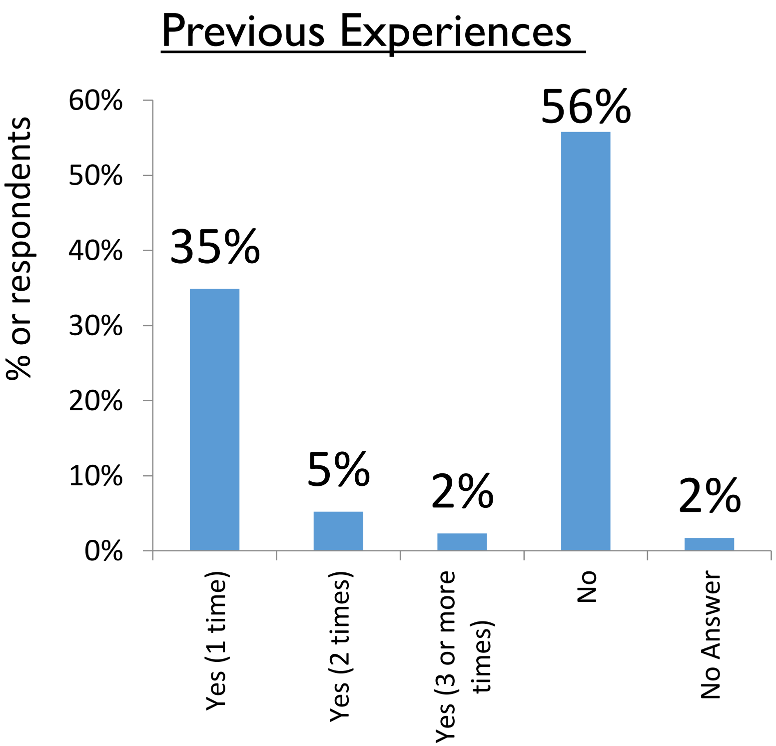
Structured Questionnaires (III): Occupation

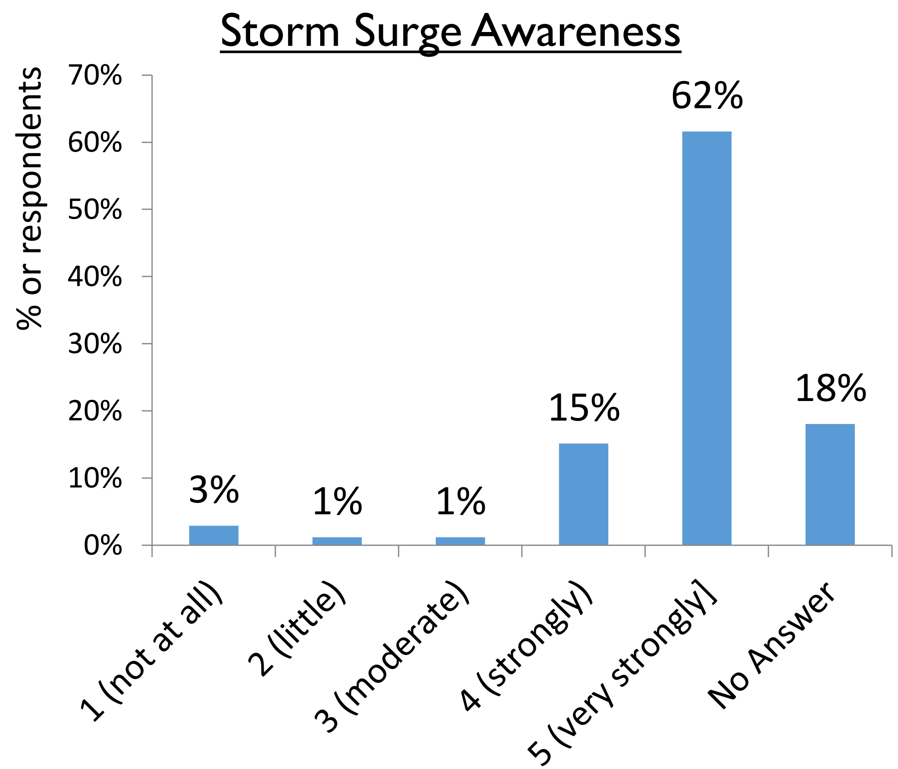
- Majority were young people, many students and people in fishing industry
- Also many office workers (emergency officials, etc)



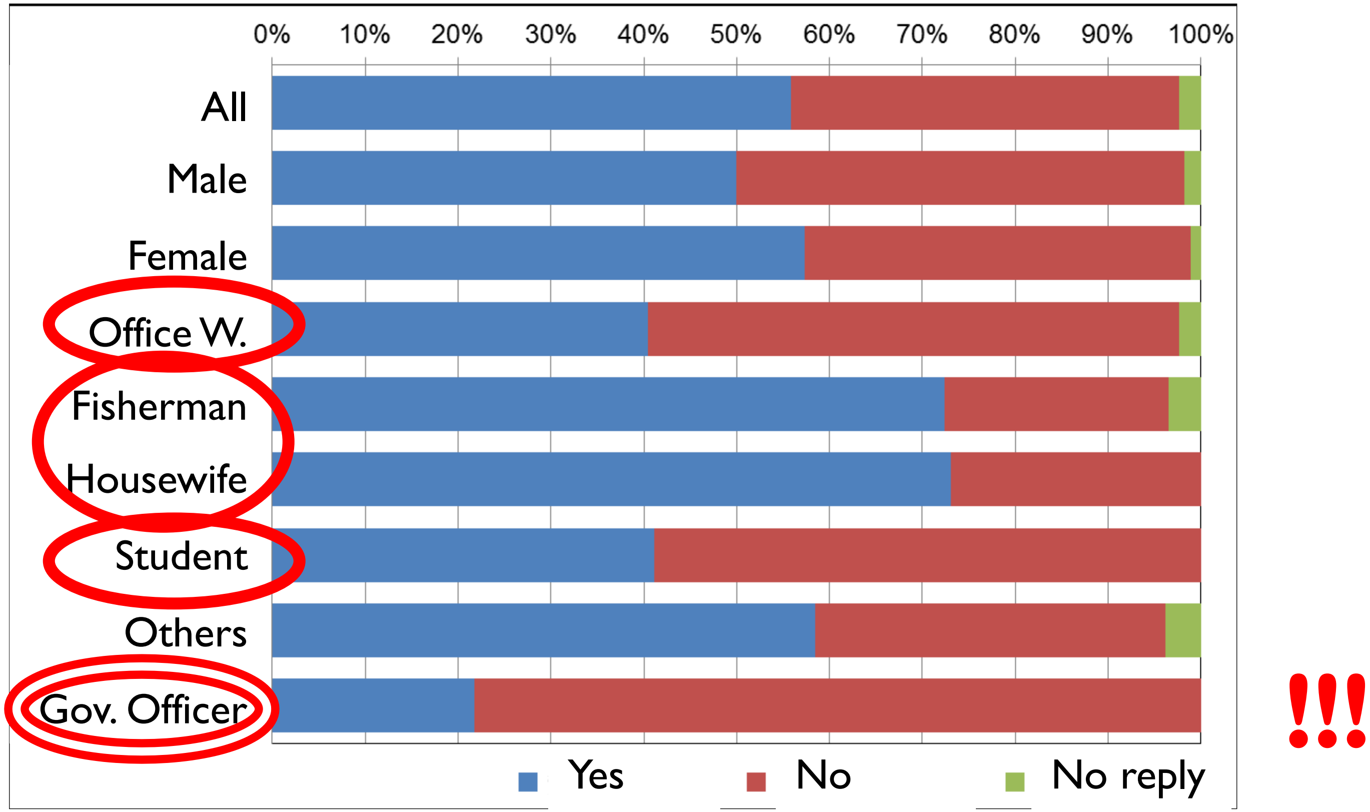
Storm Surge Awareness

- Despite no recent storm surge events 77% of all respondents felt that storm surges represented a strong or very strong danger for them. Thus, relatively high awareness about the potential danger





Understanding of Storm Surges

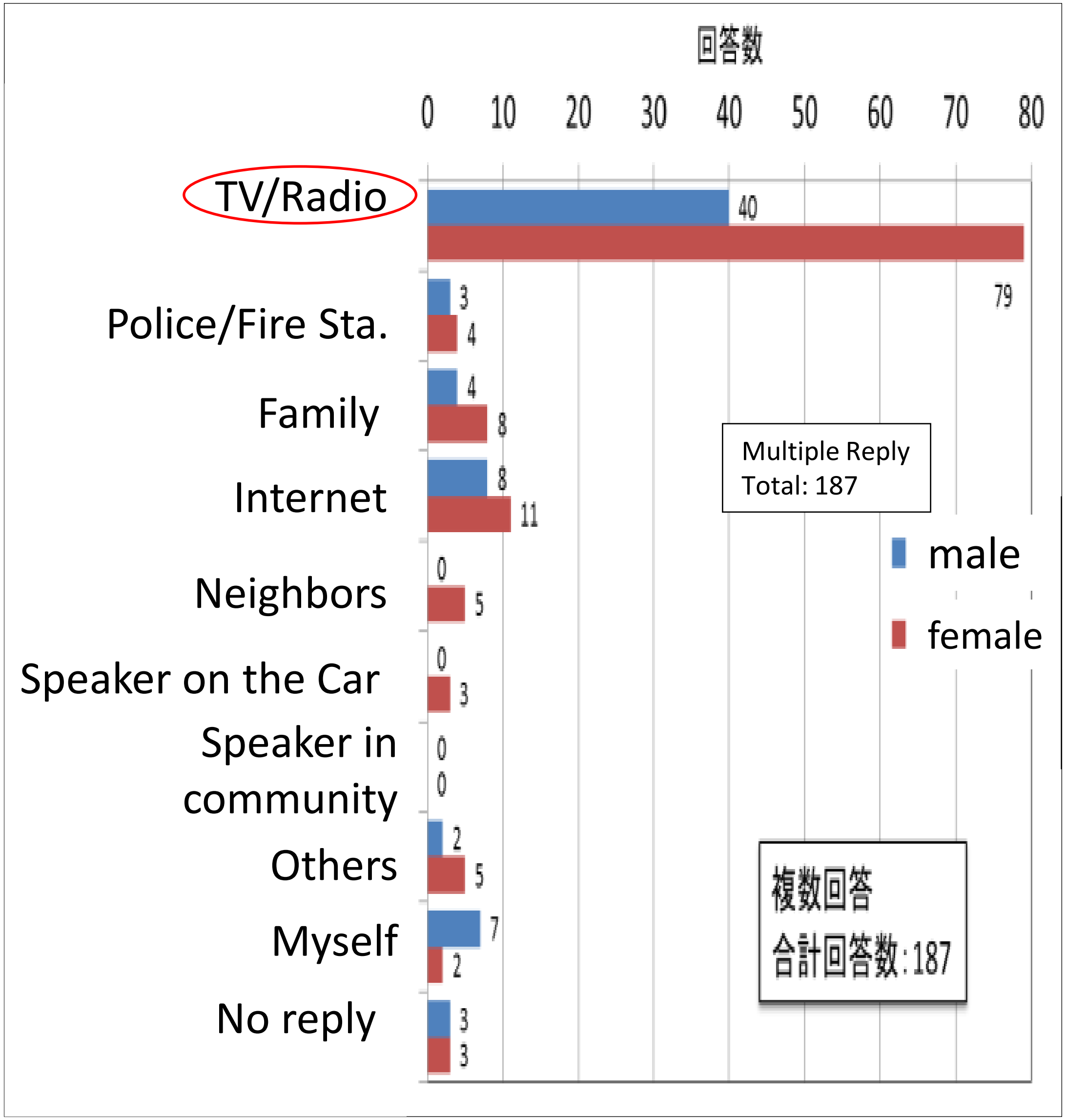


Semi-structured interview showed that only a few respondent correctly answered the phenomena of storm surge. Therefore, it can be judged that actual knowledge of the people was lower than that of the questionnaire survey result.

Understanding of Storm Surges

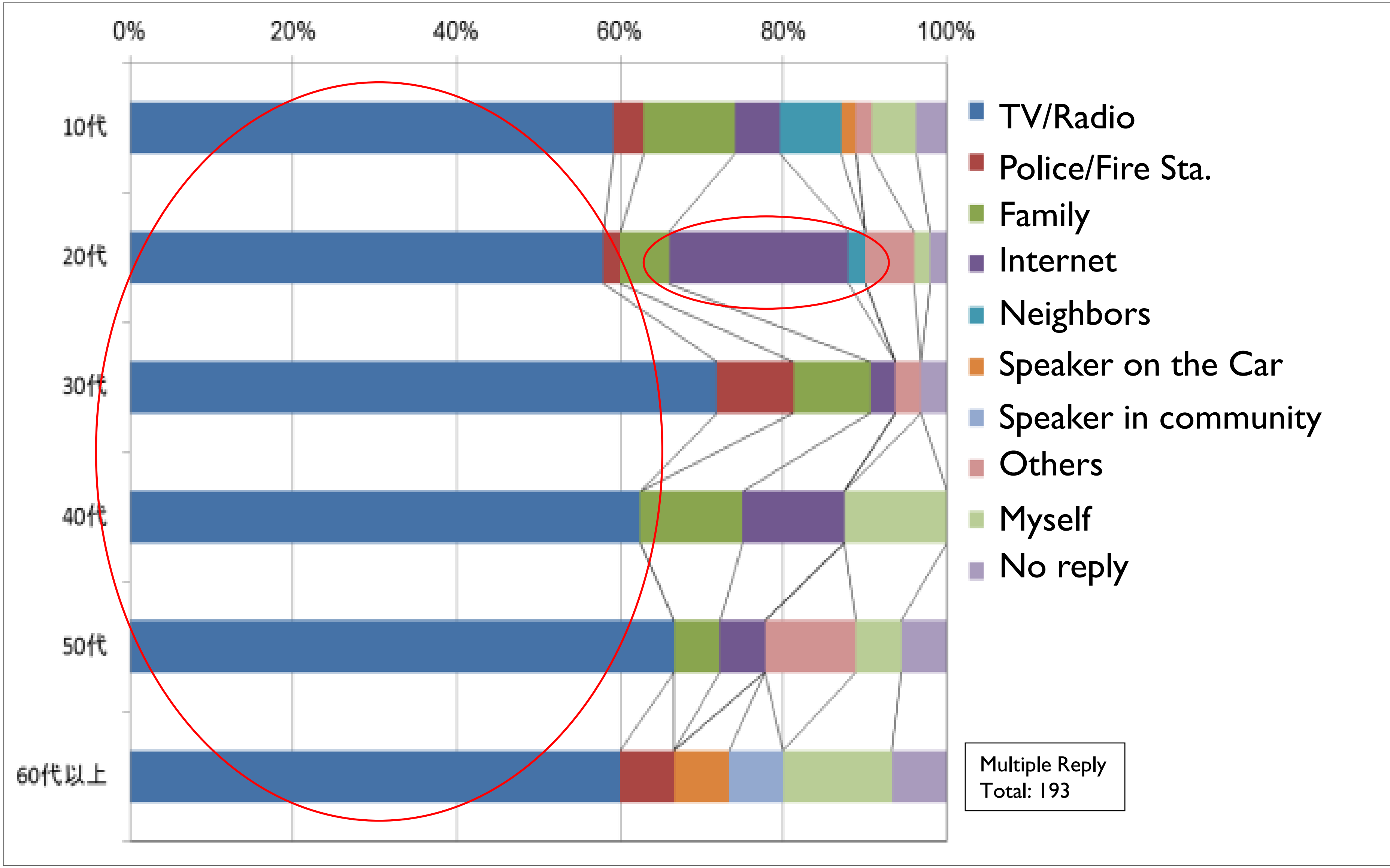
- It is not entirely clear that respondents understood the phenomenon of the disaster before it struck.
- Only 47% of respondents ***said*** that they understood what a storm surge was ***and*** that the typhoon could bring with it a storm surge.
- It is not even clear that this 47% of people accurately understood the threat of the storm surge.

Sources of information (by gender)



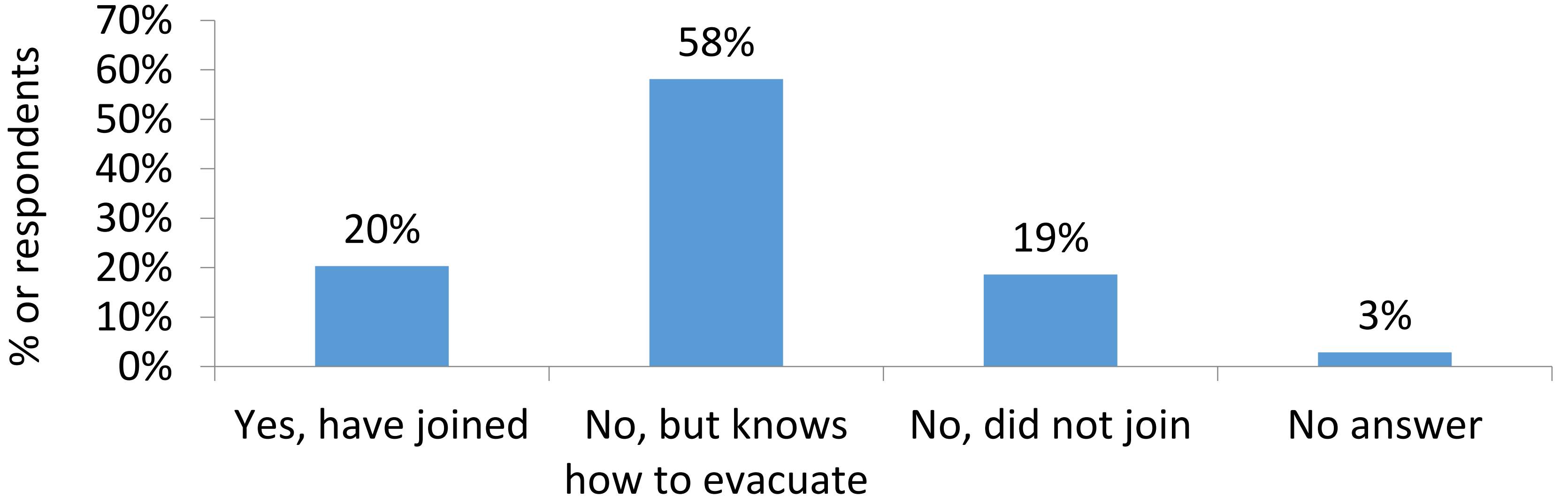
- People rely on media.
- Information from the Internet was emerging.
  - ✓ Diffusion of smart phone?
- Government-based information sources were not widely used.
  - ✓ Might be issue considering gov. responsibility.

Sources of information (by age group)

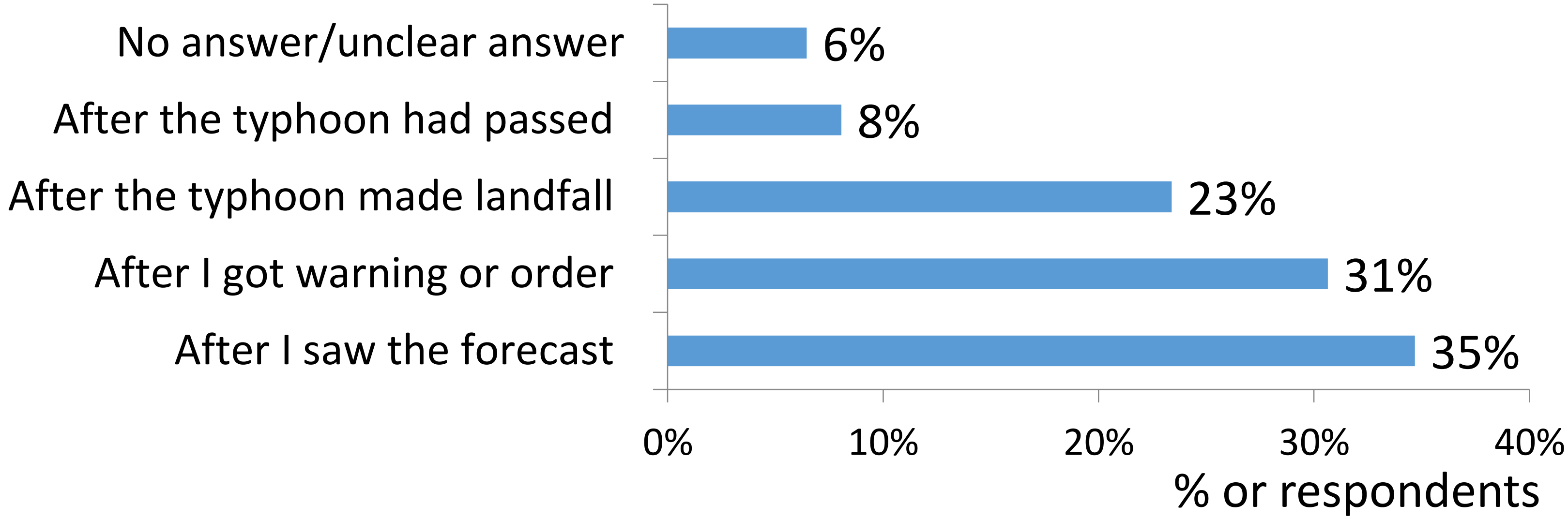


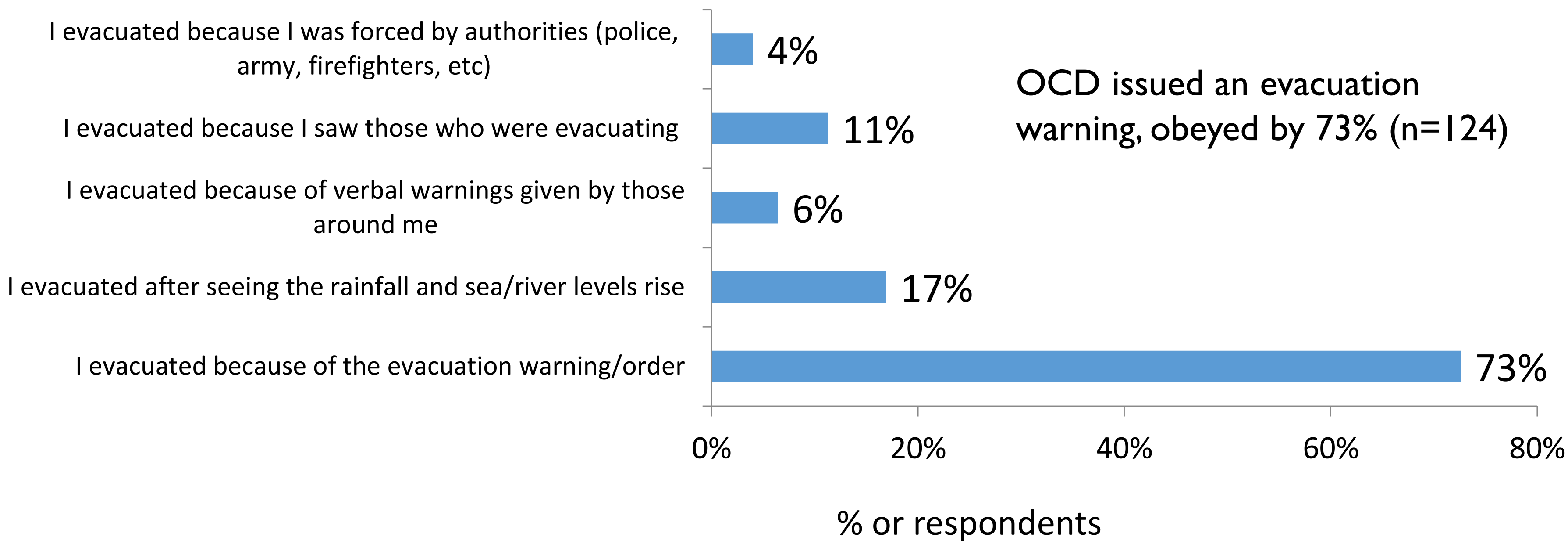
Knowledge about evacuation

- Only 20% or respondents confirmed that they had taken part in evacuation drills at some point in their lives (13% in one evacuation drill, and 7% in 2 or more)
- 58% said they knew how to evacuate
- Indication of efforts by train the population, generally understood by a sizeable majority of the population.

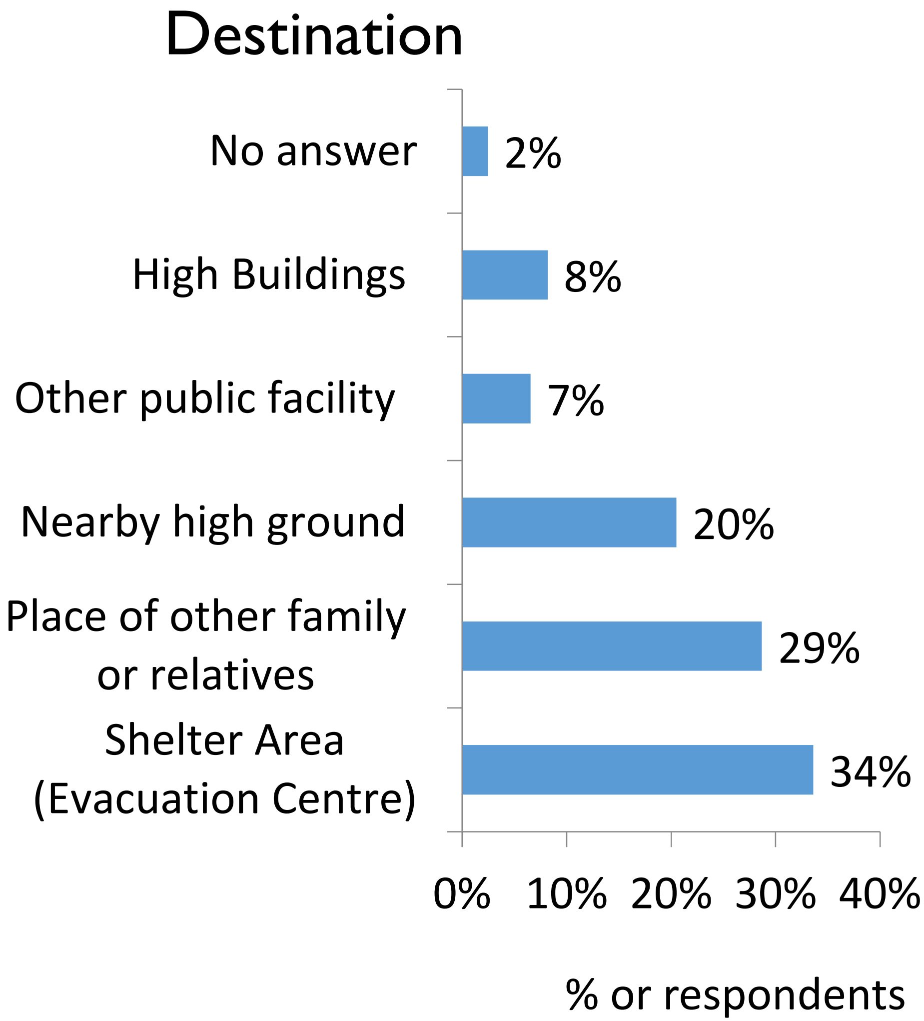


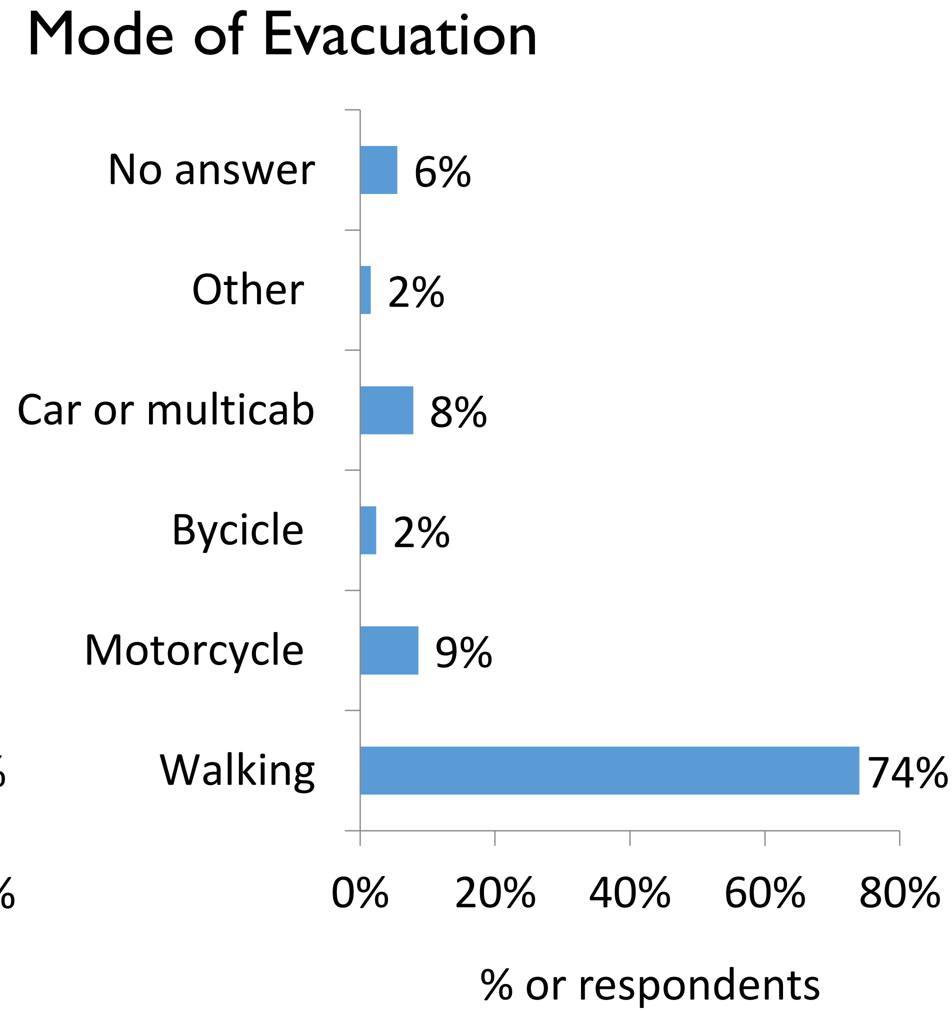
Actual Evacuation Behavior





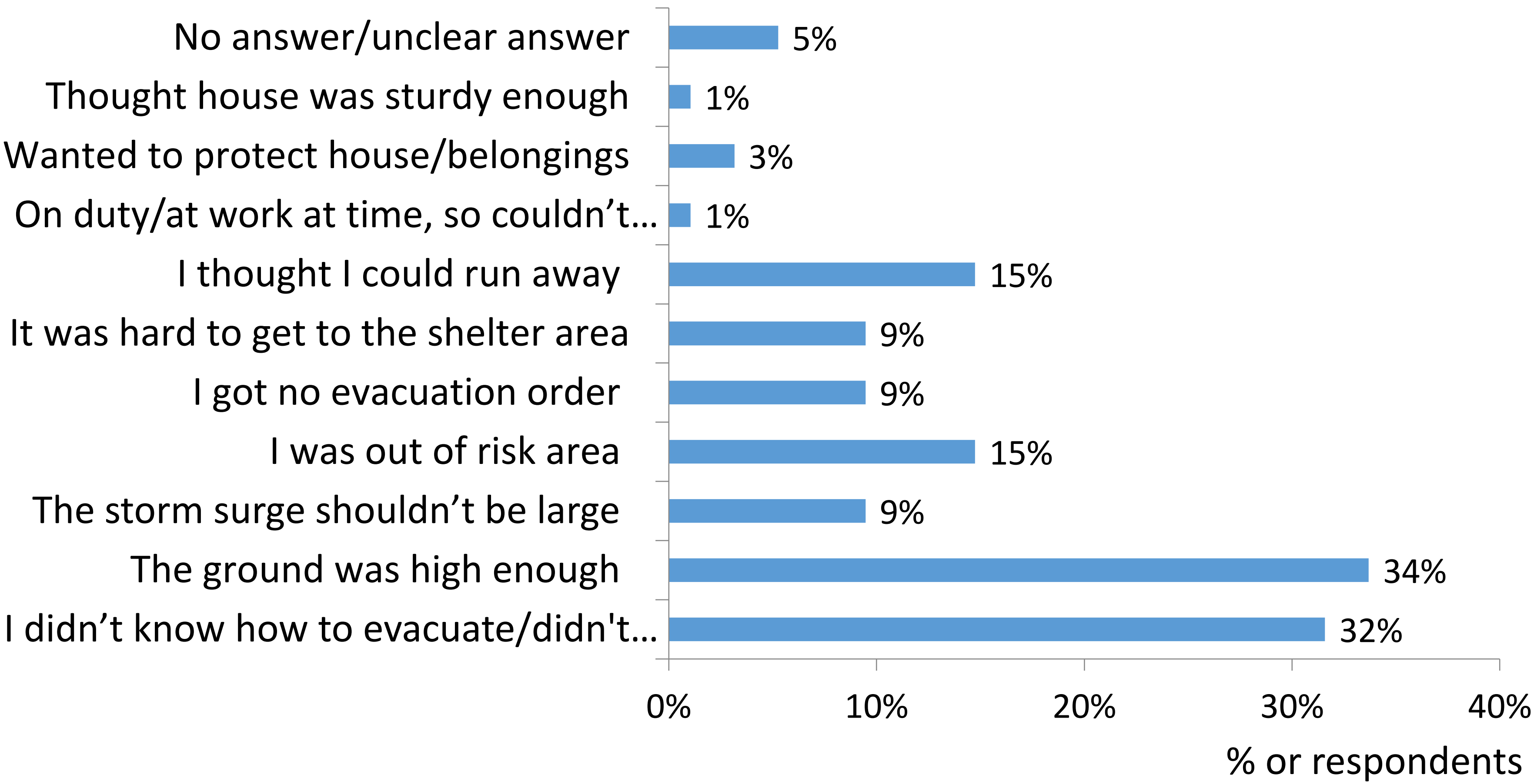
Evacuation mode and destination





Reasons for not evacuating

- Nevertheless, 94% of respondents agreed that if they faced a similar situation once again, they would indeed evacuate.



Key Informant Interview

- Leyte & Samar
  - Regional Director, OCD Region VIII
  - DRRMO Officer
    - Leyte Province
    - Cities of Tacloban, Tanauan, Palo and Basey
- Manila
  - Advisor to OCD Administrator
  - Officer in charge of PAGASA

Key Informant Interview
at OCD Regional Office

Key Points for Disaster Management (5)

- Give an accurate picture of the event
  - Many respondents said that they **did not possess an accurate picture of the event**.
  - Key informants emphasized that **people had been warned of the flooding**, though they just **did not seem to conceptualize the phenomenon** itself correctly.
  - Many people expressed the view that it would have been **better for authorities and media to describe it as a "tsunami or tidal wave",** which would have given people a better feeling of the danger
- Give an easy warning
  - **Information given by PAGASA being too technical**. Storm surges were explained as *"dagko nga balod"* ("very big waves"). Some people thought that their houses could withstand strong waves, and did not evacuate
- Education
  - Many of respondent did not evacuate because of the lack of knowledge on evacuation.

6. Recovery Process

Survey Period: May 2014

6. Recovery Process

(1) Change of Living Place

Living place – Four different case

1. Own House (Original Place)
2. Evacuation Center
3. Bunkhouse

4. Tent

Change of living place - Own house

- Before the disaster
  - Own house or emergency shelter
- At the time of disaster
  - Own house or emergency shelter
- Soon after the disaster

  Stayed short period in emergency shelter then

  1. Went back to own house
  2. Left Leyte for relatives or friends place (sometimes stayed in several place) then came back to own house
- May 2014
  - Own house

Why they left?

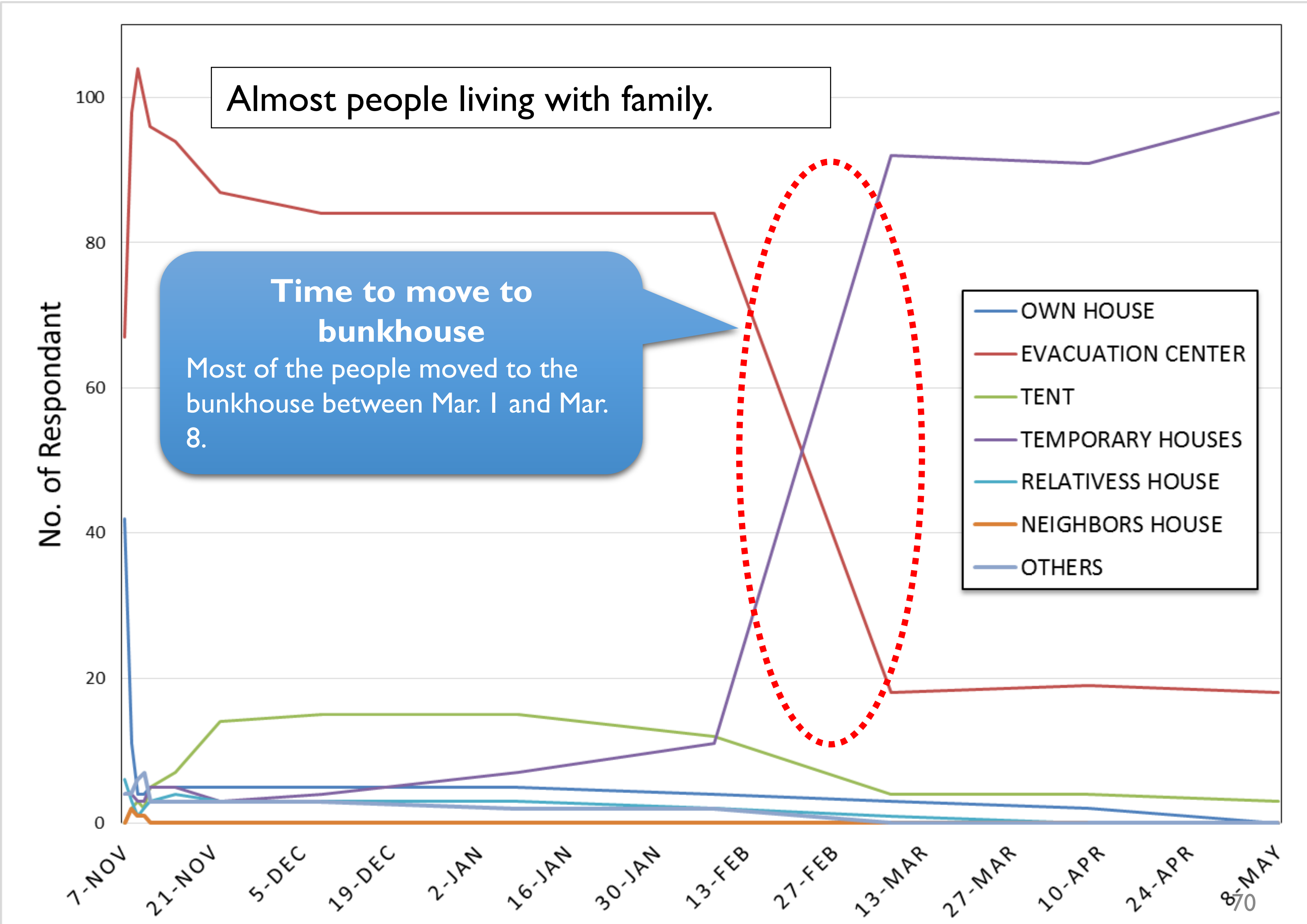
- Difficult to reach emergency supplies.
- No water and electricity

→ Reason for they left Tacloban City

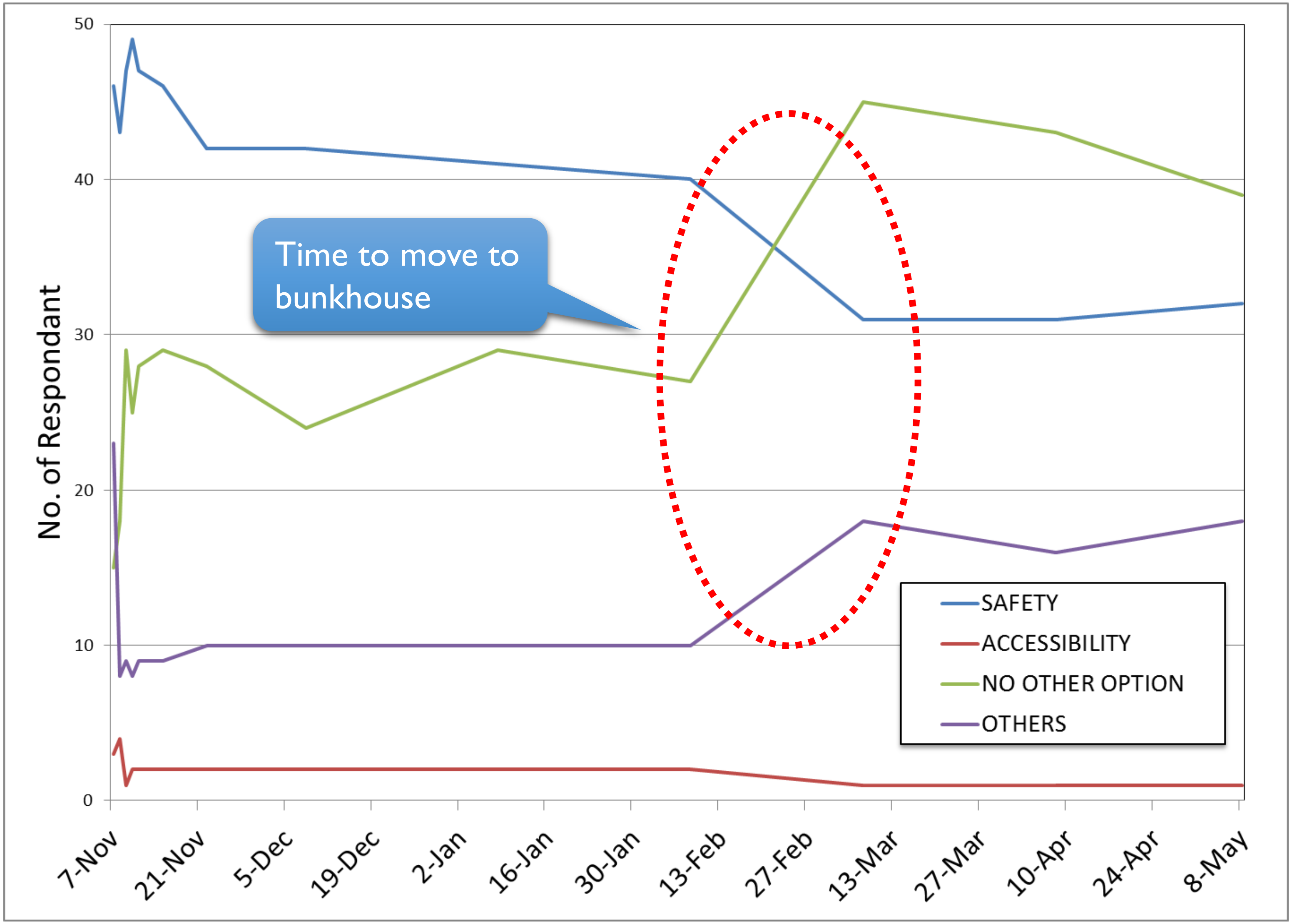
Threfore,

- After establishment a system to supply relief goods to the disaster affected people who were staying outside the evacuation centers, they came back to Tacloban.
- Relief goods supply ended at the end of March, 2014.

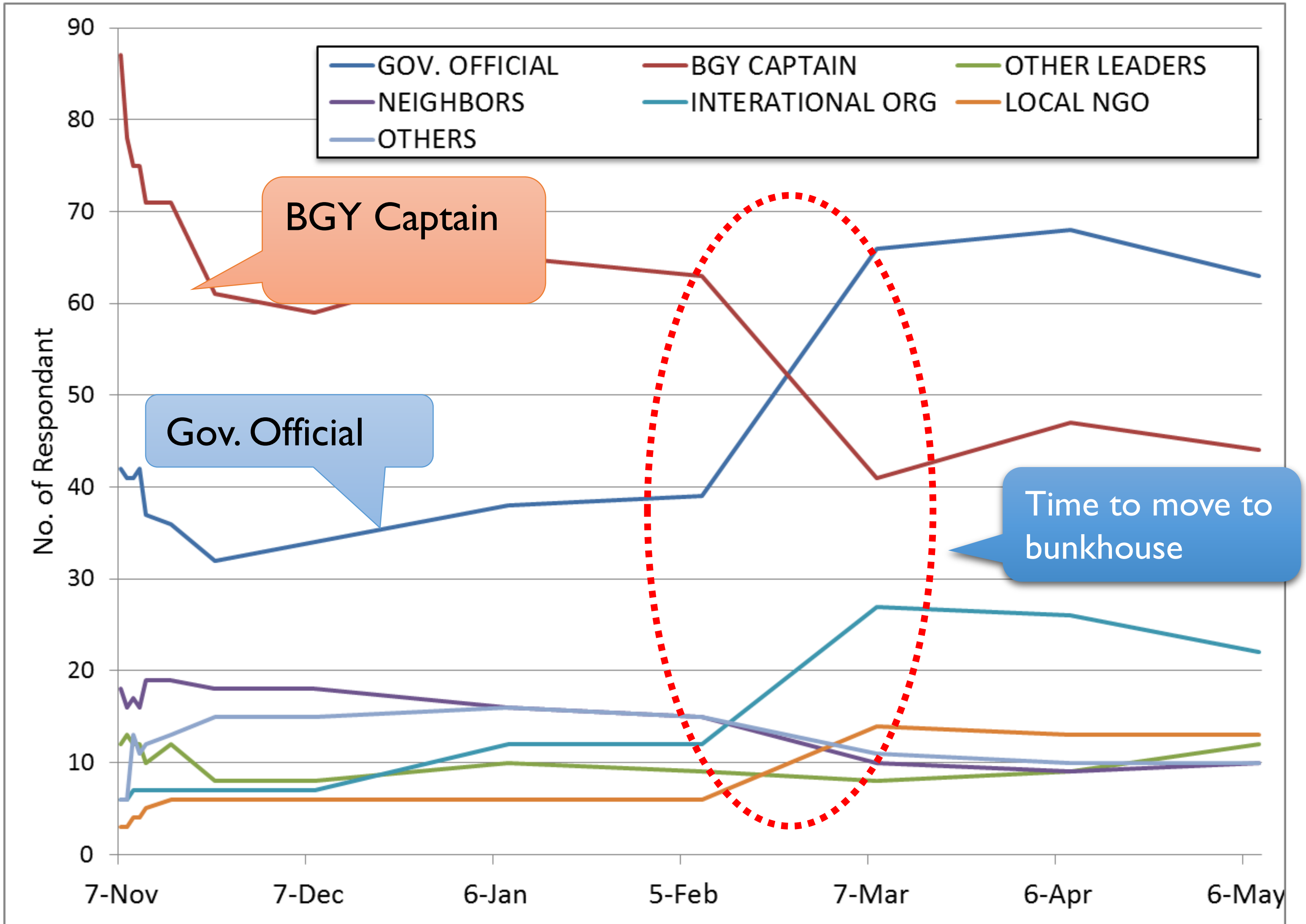
Change of living place - Bunkhouse



Q: Why did you choose the place?



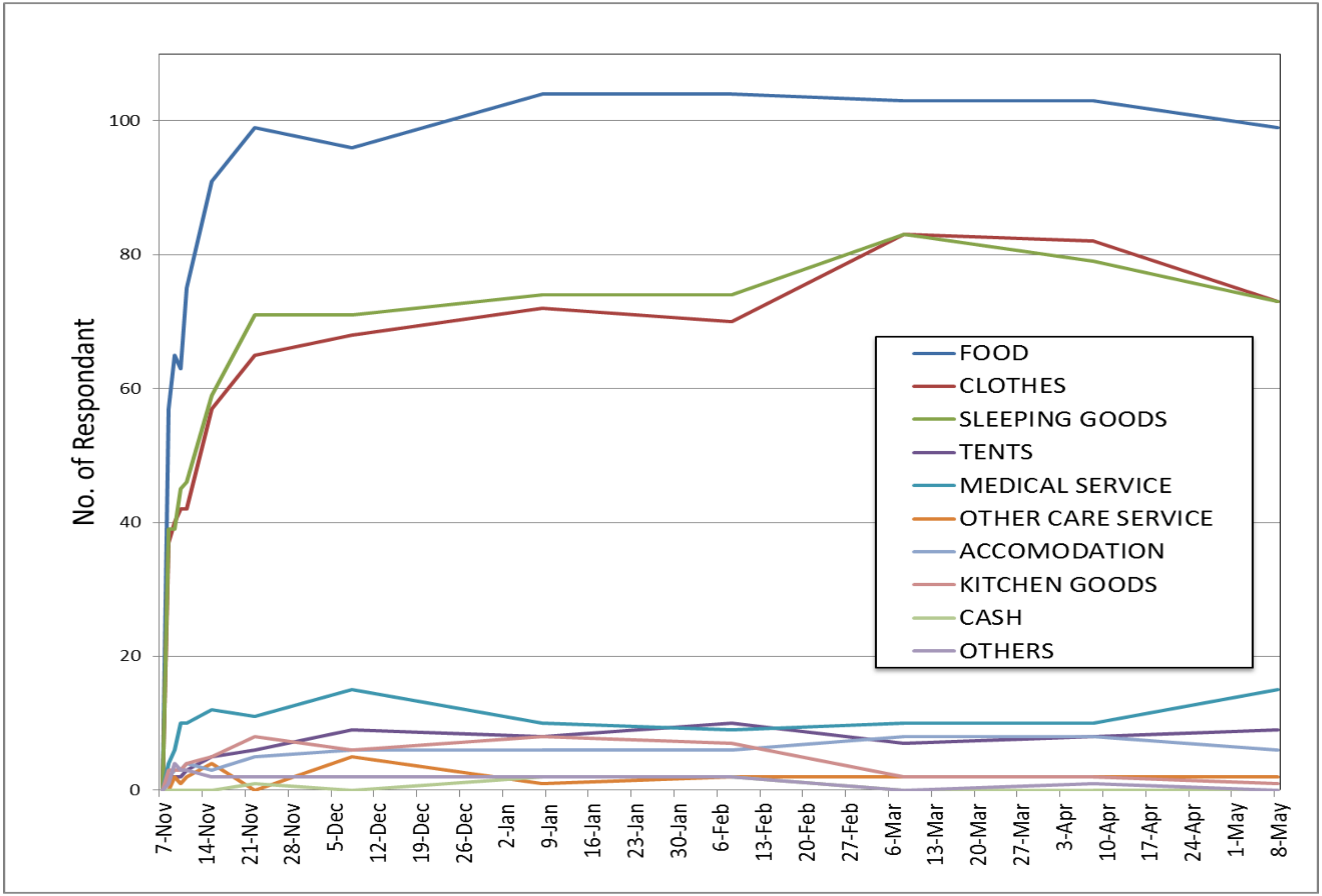
Q:Who instructed you to go to the place?



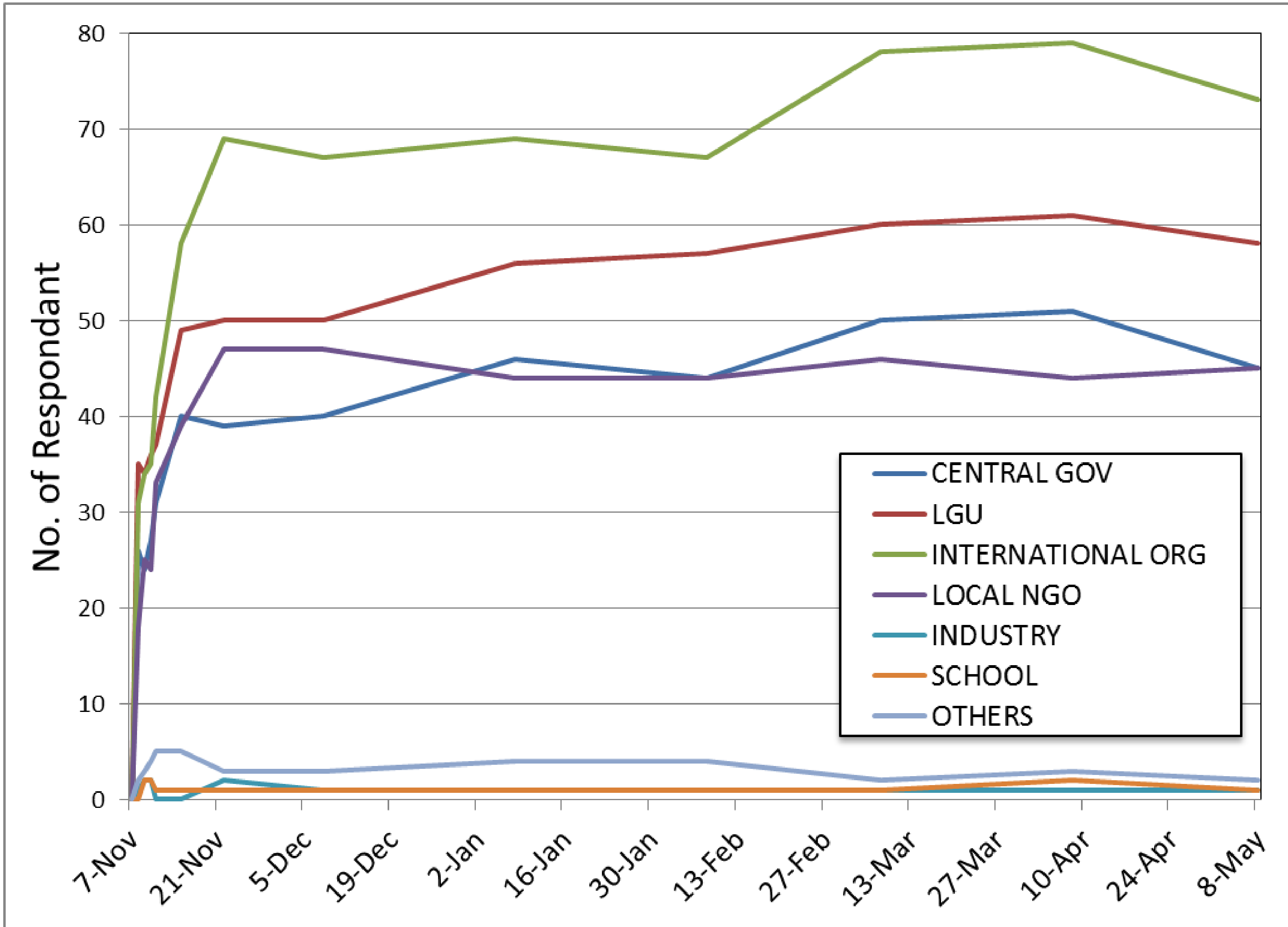
6. Recovery Process

(2) Gaps between Assistance and Needs

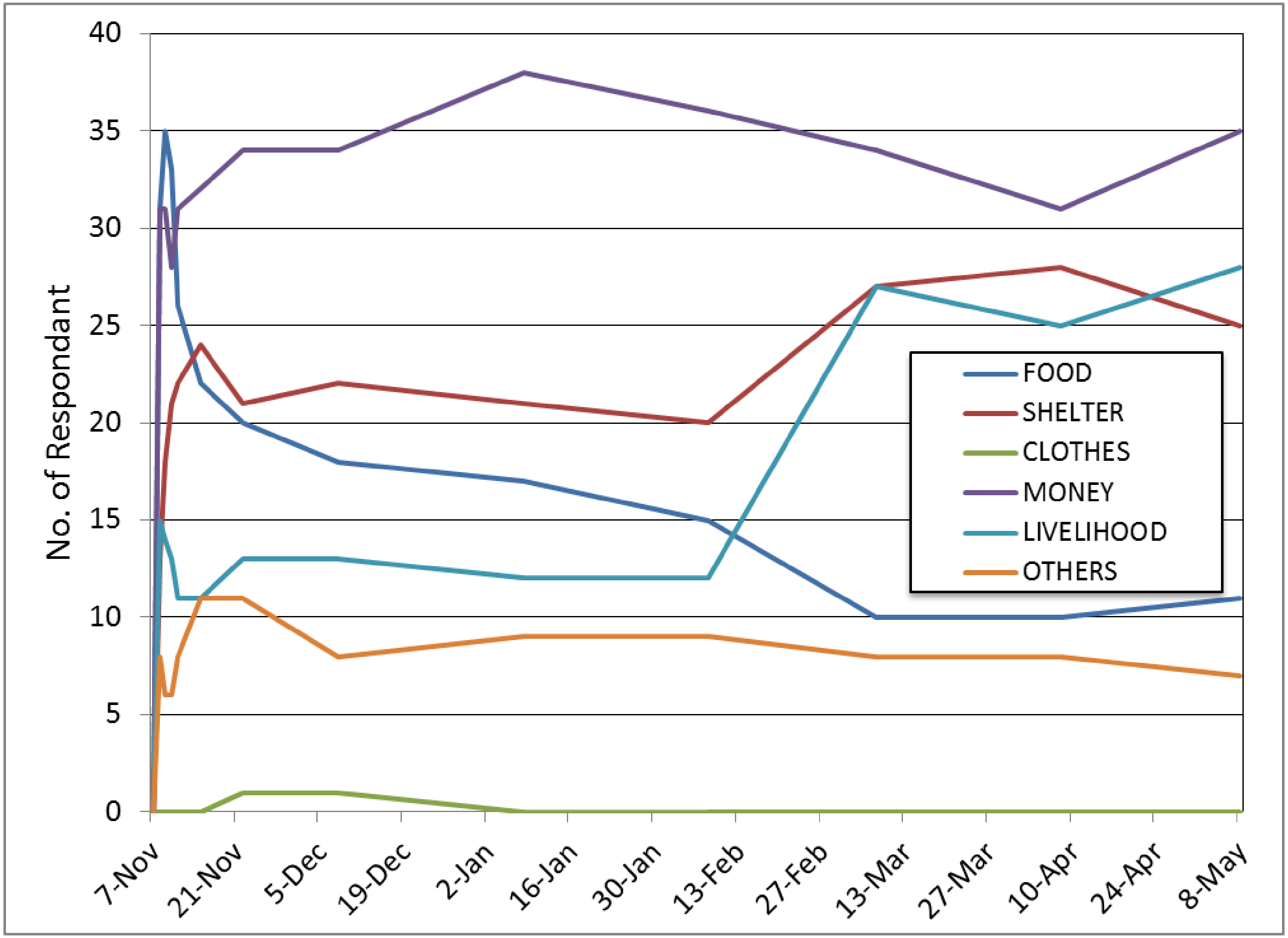
Q: What kind of assistance did you receive?

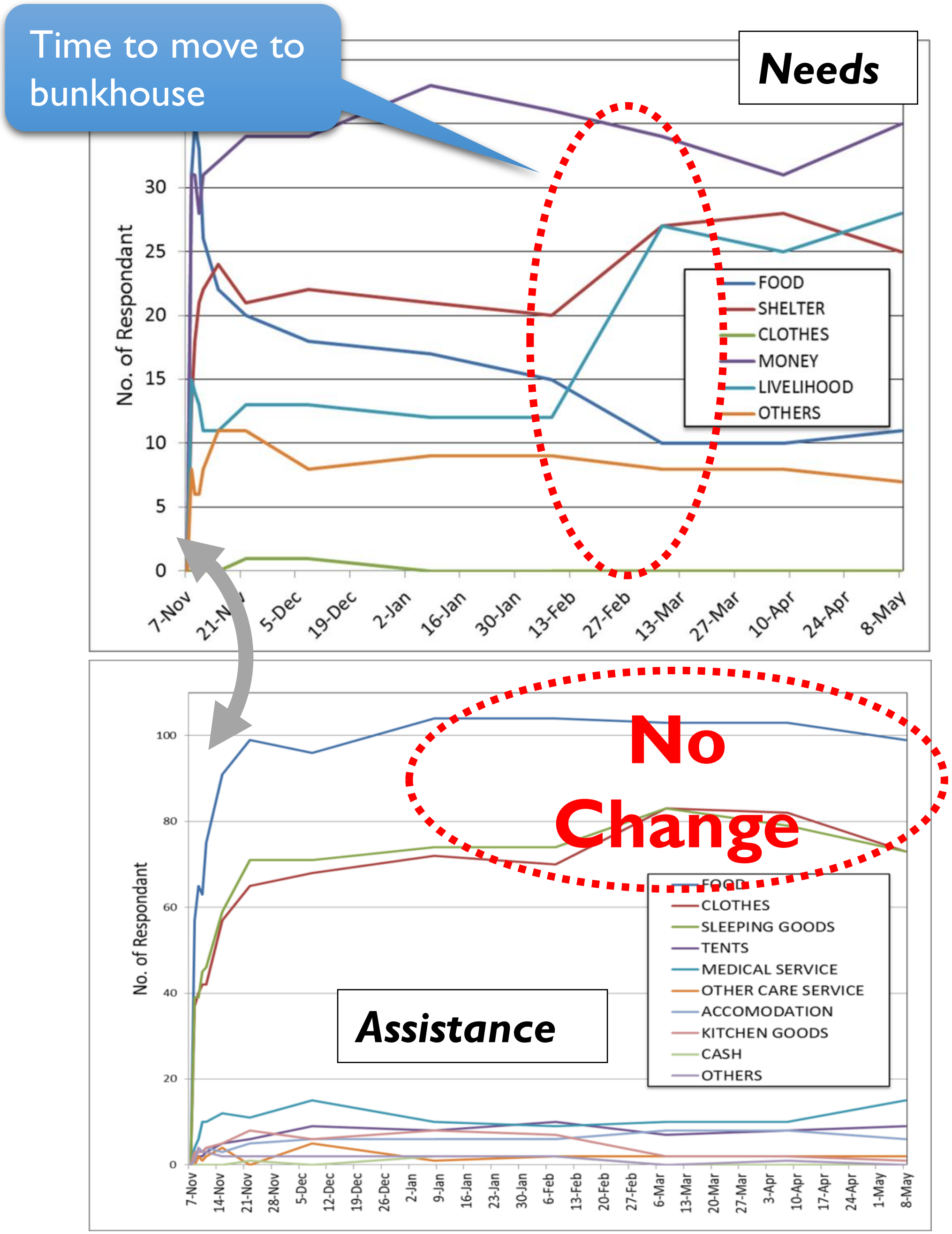


Q: Who gave you the assistance?



Q: What kind of assistance did you need?





- Affected people were expecting financial support and to have safe place (shelter) throughout of the period.
- **Assistance for Livelihood recovery was important** for affected people after passing relief period.
- Needs of affected people **changed when they moved to the bunkhouse**. However, provided assistances were not changed.

Key Points for Disaster Management (6)

- Establishment of an appropriate system for distributing assistances to the people who were staying outside the evacuation centers
  - Victims who returned to home from the evacuation center left Tacloban because of the difficulty of access to the assistance
  - Establishment of the appropriate system will also contribute to minimize the people in evacuation centers, and it will lead the improvement of living environment of the evacuation centers
- Mindsets Change of assistance providers
  - Gap between provided assistance and needs

    Victim's needs: changed form goods to livelihood recovery

    Provided assistances: no change

Thank you for your attention