Analysis of a Latent Risk of Ship Evacuation during a Tsunami using Ship Big Data

Hidenari MAKINO

Naval Architecture & Ocean Engineering, Osaka University

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Background

- This study aims to early restoration of the port of conservation and port functions when faced with huge natural disaster.

- When the tsunami and huge typhoon attack, extensive damage is expected to people living in the surrounding area, port facilities and the maritime industry.

- Needless to say, the ship to a place of the main activities in the sea would be fatal suffer.

- When such a huge natural disaster various factors linked in a complex manner, and they will cause a secondary or third disaster.

Background

- Under these circumstances, the ship is a huge structure that is itself floating on the sea surface, therefore, the ship easily can become perpetrators side.

- Large work object of port facilities, oil tanks of the petroleum complex and so on are also the same situation.

- If occur damage in port facilities, the port requires an enormous amount of time to recover lost functions.

- Even if there is no damage to the port itself, disaster becomes a factor that causes a variety of problems that directly to an economic activity caused by the stop or stagnation of the maritime logistics activities.

Background

- A secondary or third disaster caused by Ships during Tsunami

Several damages by ship

Grounding large vessel

Small vessel attacked house

Road interception by Fishing boat

Damage with drift containers

Some damages of large vessel

Crane that collapsed by large vessel

Torn off the bow by large vessel of the anchor chain

Expansion of damage by the ignited wreckage

Background

- In order to avoid such a risk, safety of collateral at sea is the most important measures as well as the evacuation activities on land.

- For ship safety evacuation, it is necessary to obtain accurate information immediately, and requires the accurate action of evacuation and a clear assumption until the complete of evacuation based on that information.

- Not only of their own ship safety, if evacuation is also considered of other ships or the surrounding safety, it is possible to reduce the secondary disaster.

Purpose of this study

To do the evacuation safety, there is a need for specific assumption of refuge status in advance

- It is necessary to grasp and analyze the details of the ship behavior that took the evacuation faced with actual huge disaster for the construction of basic data.
- The integrated utilizing the navigation status data of each ship that is sent from the ship Automatic Identification System (AIS) in real time.
- To understand the factors that have not been considered so far by analyzing the behavior of the ship during the huge disaster.
- Based on these results, the construction of a new evacuation method, and to create the corresponding measures of considering schedule plan with the stagnation prevention.

About this presentation

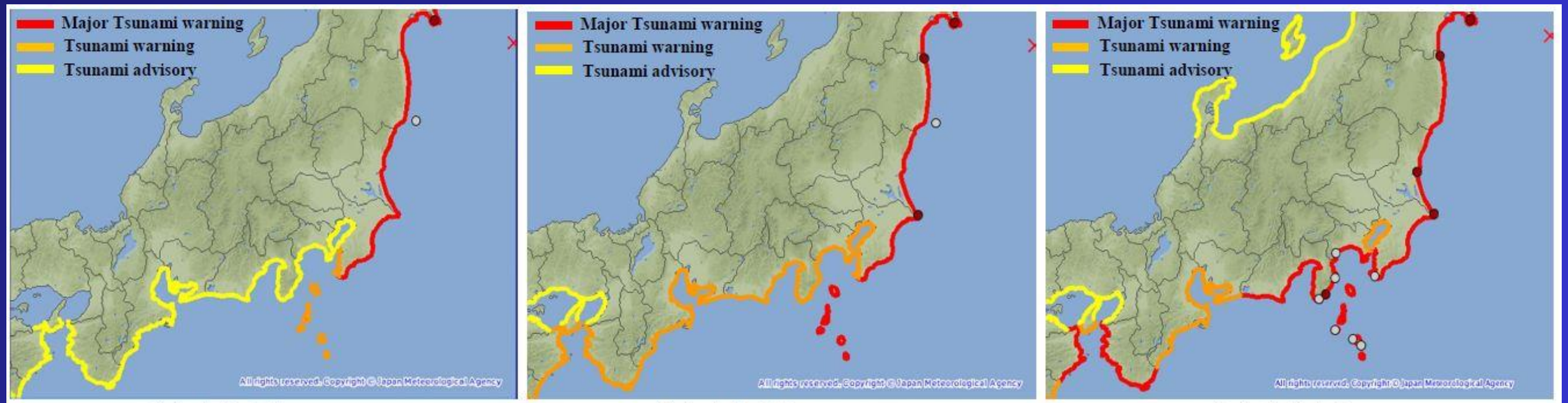
In this presentation, the results of an analysis of ship evacuation in the port during the huge tsunami following the 2011 earthquake off the Pacific coast of Tohoku on March 11, 2011 are presented in the following two aspects.

- Reproducible analysis of a ship's evacuation using the AIS data of a group of ships that executed evacuation procedures

- Visualization of the risk of danger in the port using a collision risk analysis and geographic information system based on the distance between ships during an emergency evacuation

Status of Tsunami warning

- The epicenter of the *9.0-magnitude* earthquake on March 11, 2011 at *2:46pm (14 :46)* was off the Sanriku Coast.
- The coastal regions along Tohoku areas received the major tsunami warning at 2:49pm(14:49), *3min* after the earthquake.
- All coastal areas along the Pacific Ocean received the major tsunami warning followed by the tsunami warning or advisory, *44min* after the earthquake.



About AIS data

- AIS is a type of automatic dependent surveillance-broadcast technology that provides useful information such as names of the ships and call signs for distinguishing ships as well as locations, velocity, and directions of the ships.

- The device automatically transmits information pertaining to destinations and loadings to the neighboring vessels.

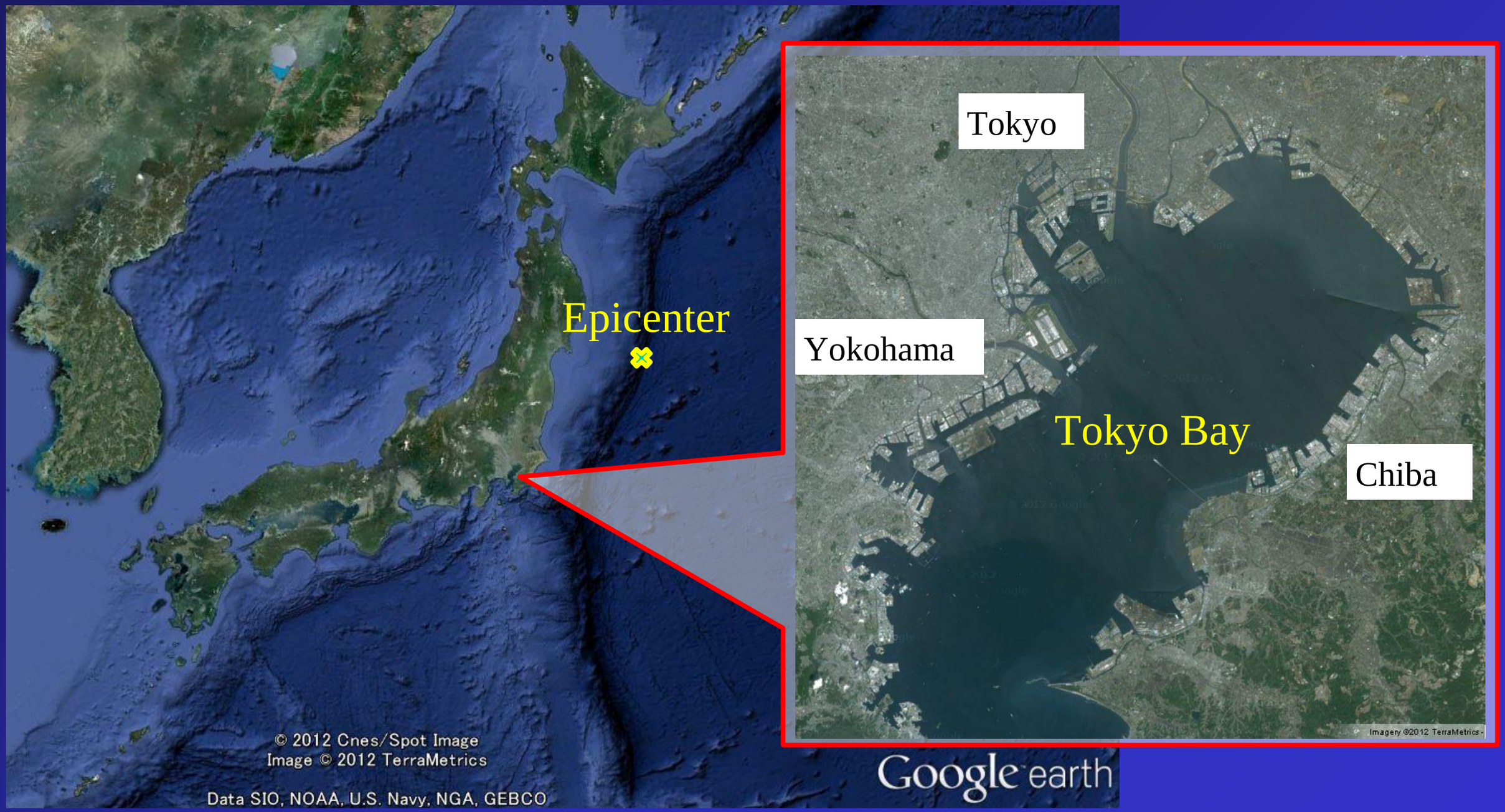
- IMO (International Maritime Organization) mandates sequential loadings for target vessels (passenger ships and ships with a total of more than 300 tons for international voyages and vessels with a total of more than 500 tons for non-international voyages).

- The data received by AIS is broadly classified into static data (such as her name & the call sign), dynamic data (such as her current position, speed, & course), and the voyage data (such as her draught and destination).

About AIS data

Kind	Contents
Static data	IMO number, call sign & name, length and beam, type of ship, location of antenna,
Dynamic data	Position, time in UTC(Universal Time, Coordinated), COG(course over ground), SOG(speed over ground), heading, navigation status(manual input), rate of turn(if available), angel of heel(optional, if available), pitch and roll(optional, if available)
Voyage related data	Draught, hazardous cargo type, destination and ETA, route plan(optional)

Ship evacuation of port in a bay



- Tokyo bay has the main harbors in Japan.
- Distance from the epicenter is about 400km

Tsunami observed in Tokyo Bay

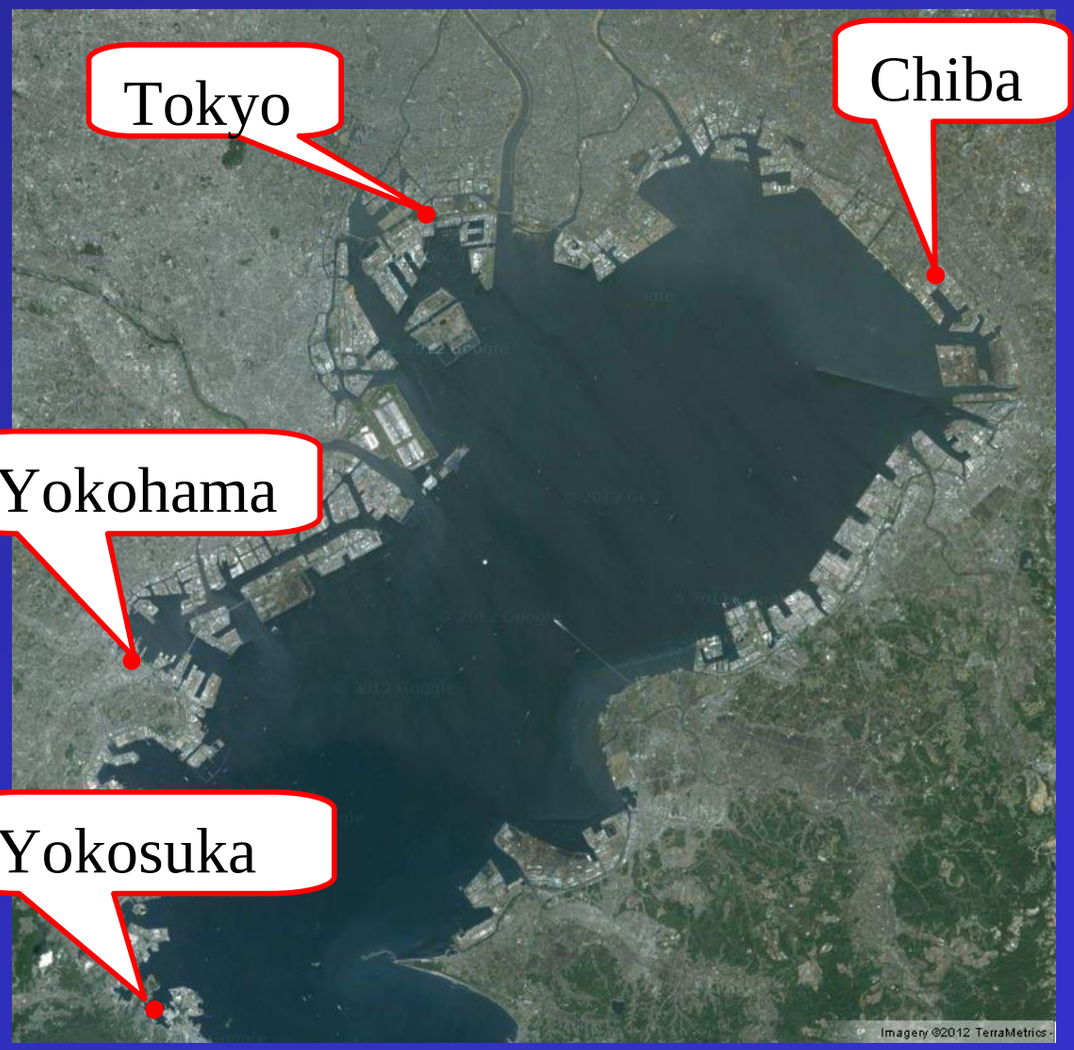
by Japan Meteorological Agency

The first wave was observed at

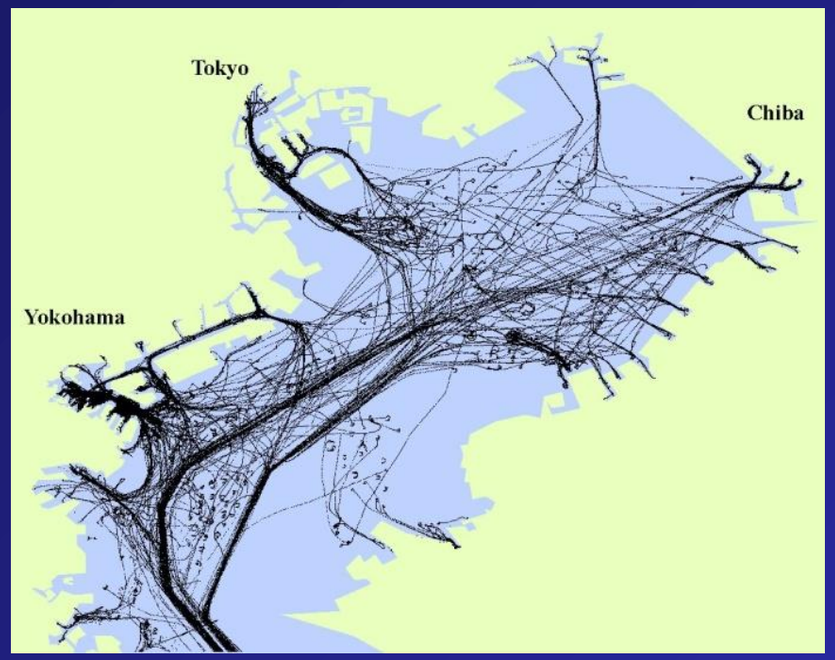
- Yokosuka at 15:52 (+0.9m)
- Yokohama at 16:09 (+0.8m)
- Tokyo at 16:37 (+0.8m)
- Chiba at 16:38 (+0.7m)

The maximum wave was observed at

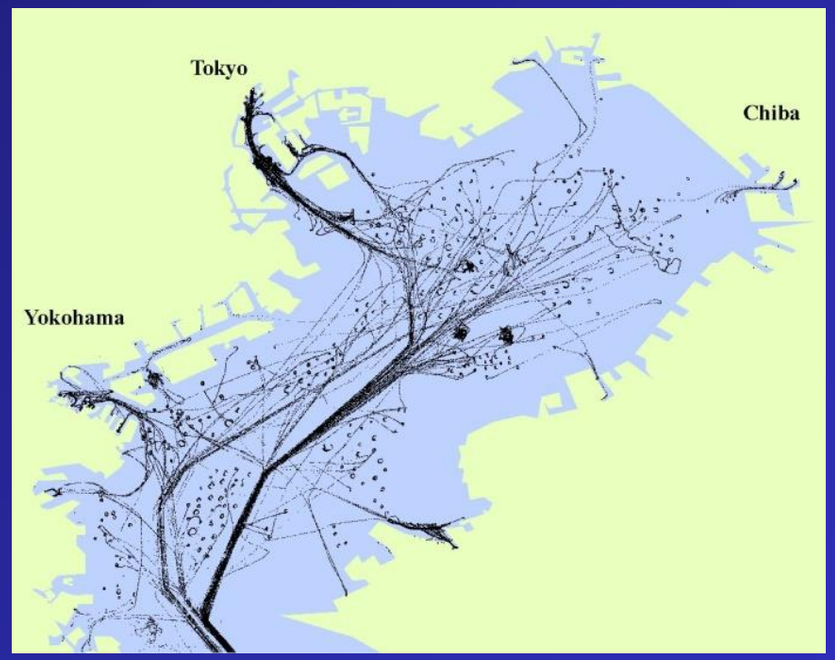
- Yokosuka at 17:16 (***+1.6m***)
- Yokohama at 17:37 (***+1.6m***)
- Tokyo Harumi at 19:15 (+1.3m)
- Chiba at 18:18 (+0.9m)



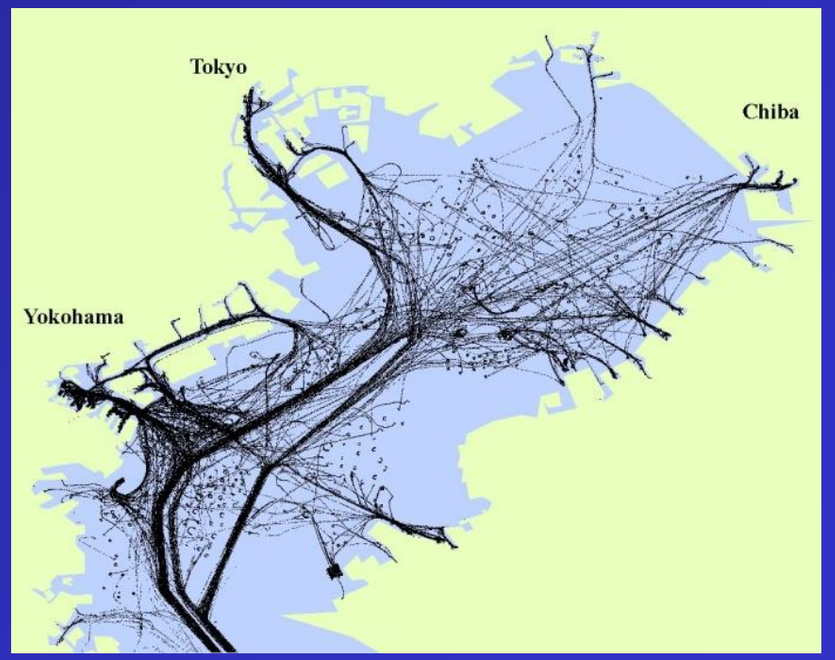
The comparison of ship traffic flows in Tokyo bay at 11, 12 and 13 March, 2011



(a) 11 March, 2011

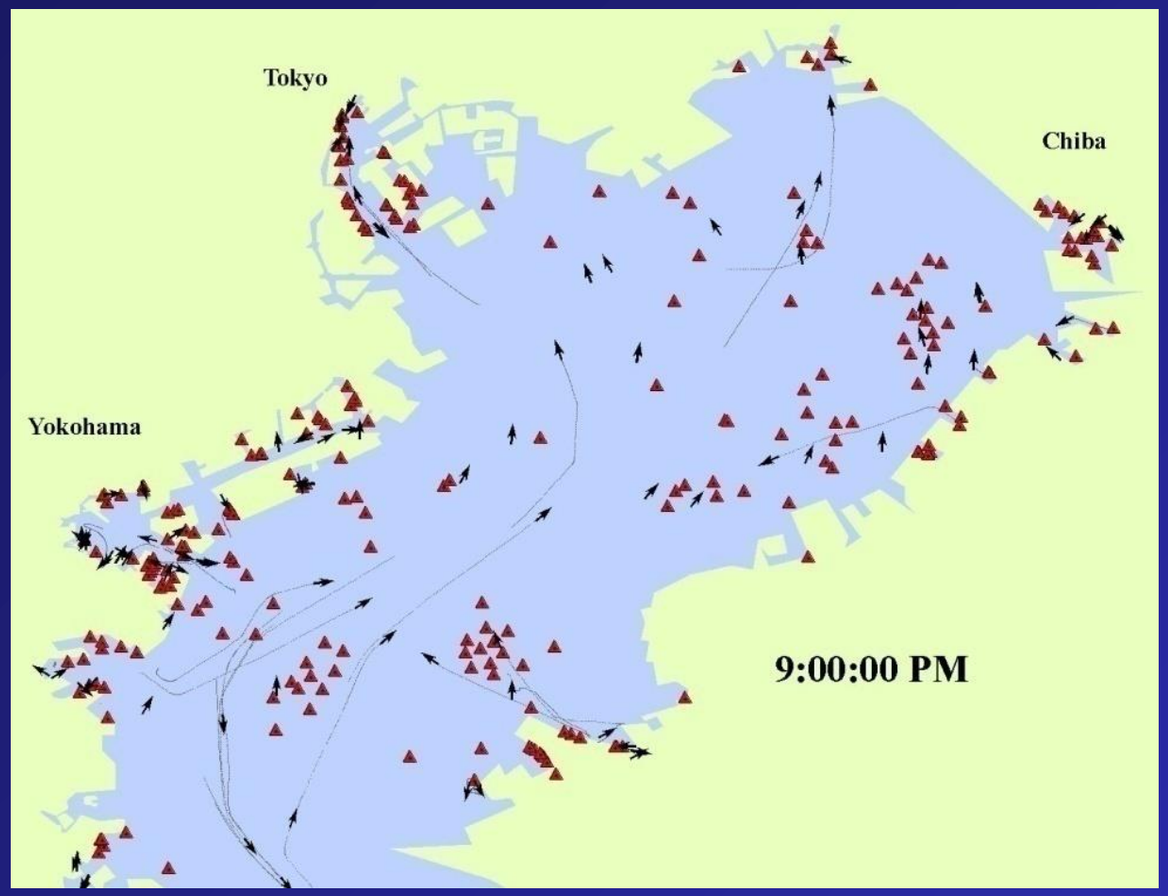


(b) 12 March, 2011

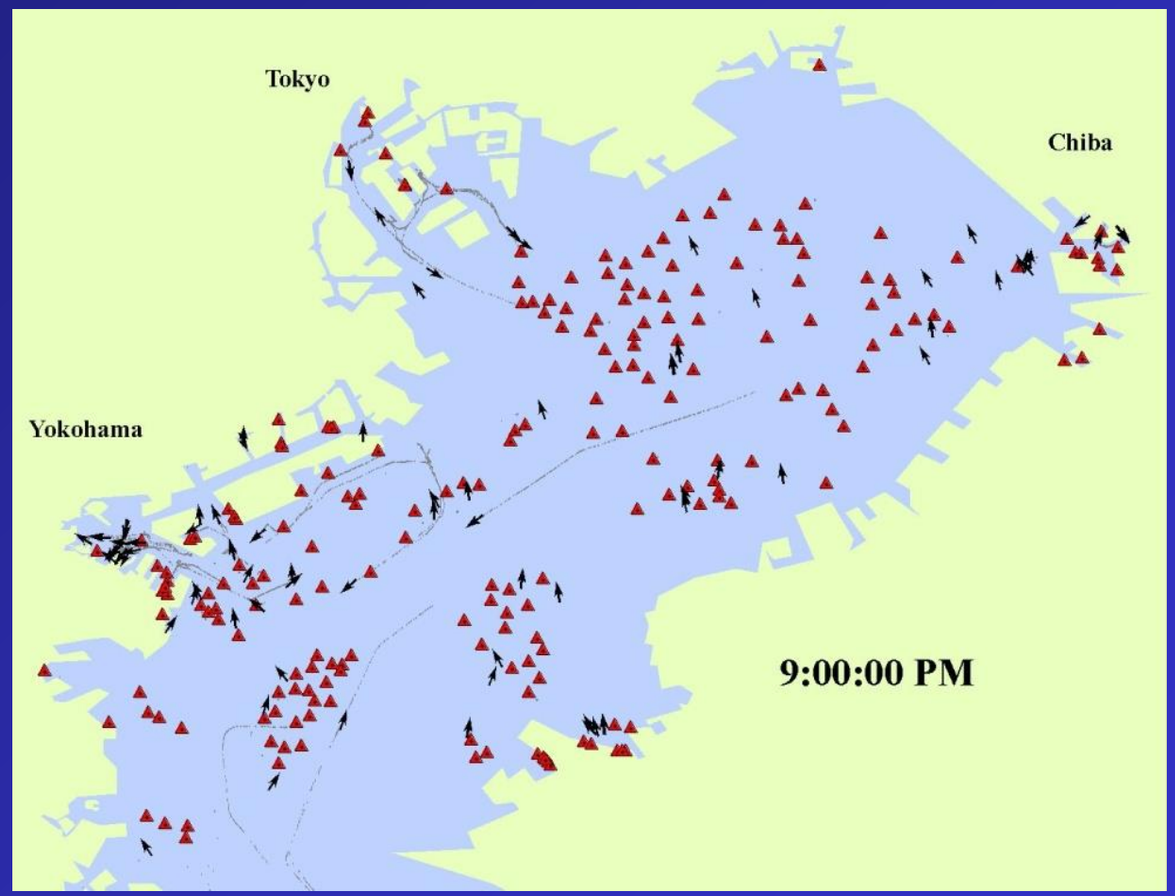


(c) 13 March, 2011

The comparison of ship situation in Tokyo bay



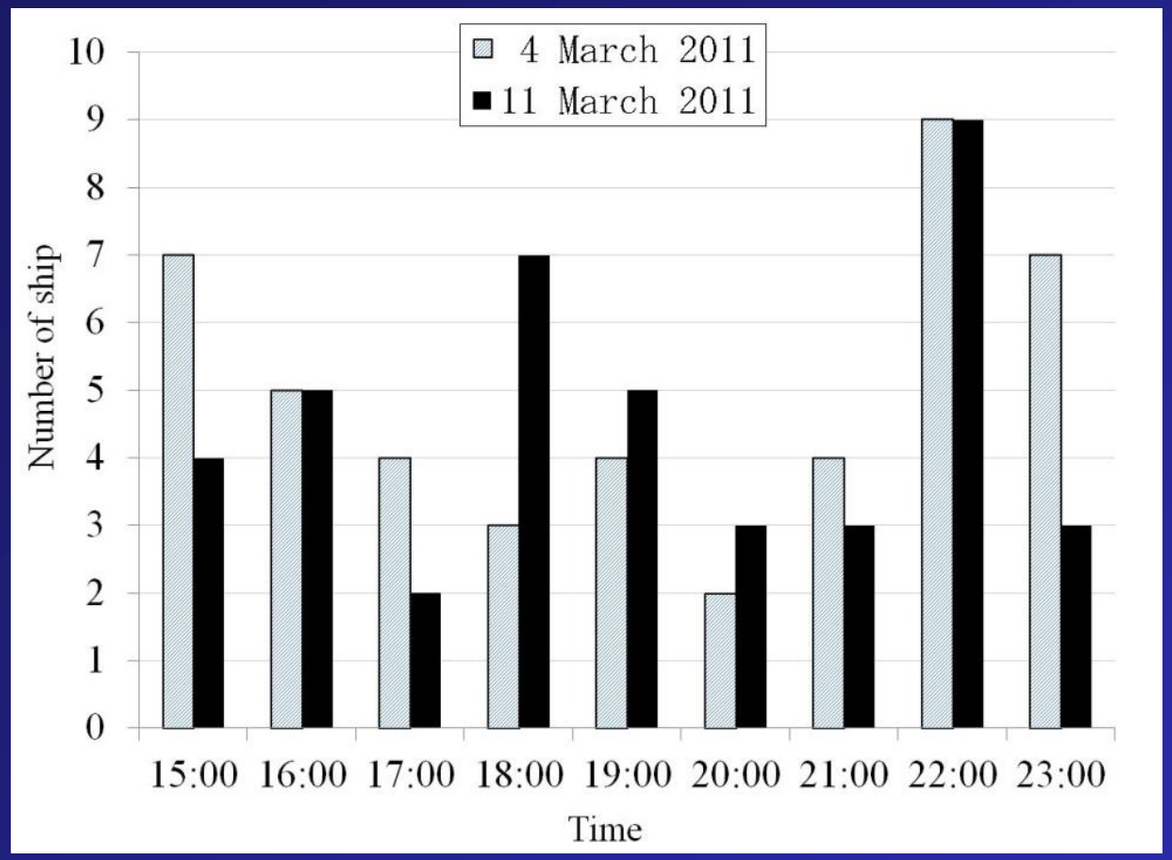
(a) 4 March, 2011



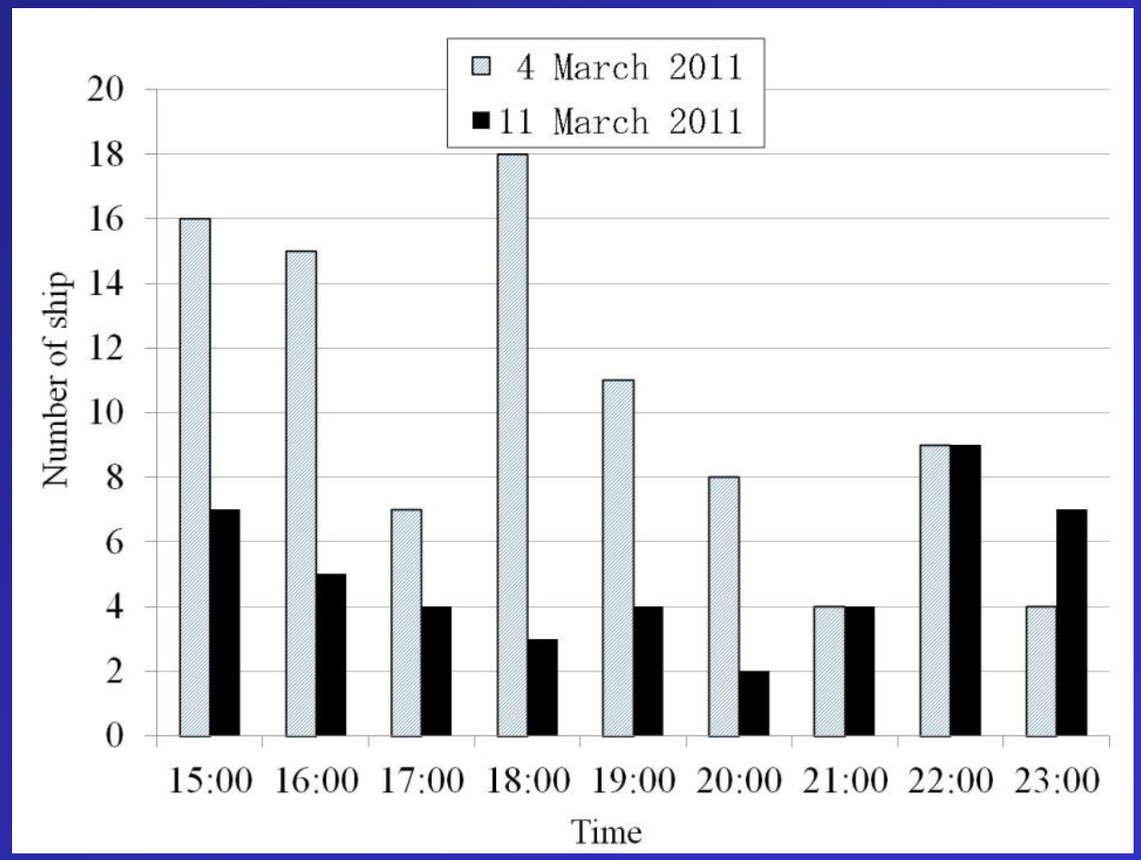
(b) 11 March, 2011

- Fig (a) shows that anchoring ships are the anchor stay **aiming at entry into the port** near harbor boundary of each harbor.
- On the other hand, ships are the anchor stay aiming at the evacuation as Fig (b).
- **289 ships** were checked from AIS data about the number of vessels in Tokyo Bay at 9:00 pm on March 4.
- Meanwhile, **no less than 331 ships** were checked at 9:00 pm on March 11 at the time of emergency situation.

The number of ships which passed the Nakanose route



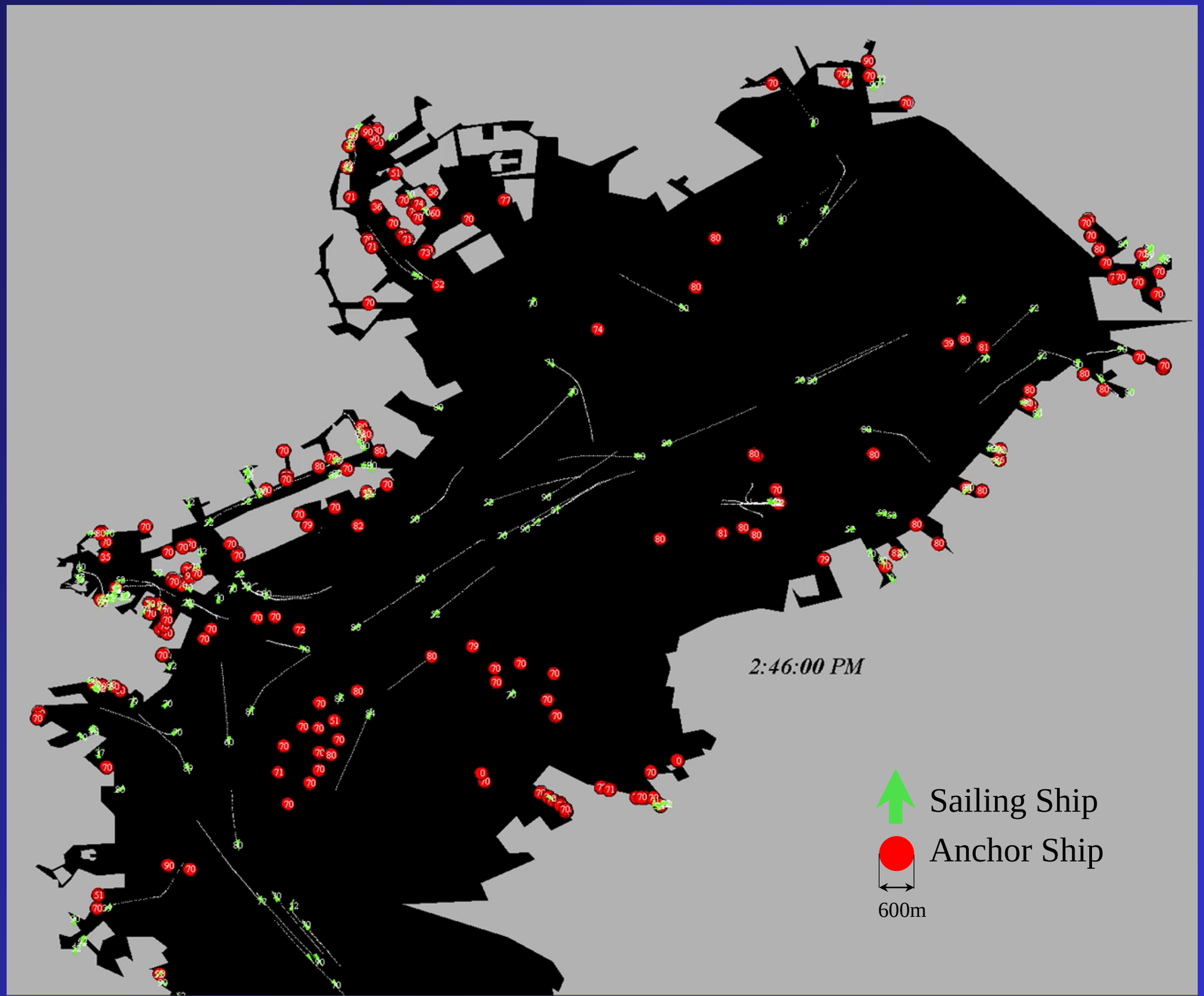
(a) Number of entered ship to Tokyo bay



(b) Number of left ship from Tokyo bay

- Fig. (b) shows that March 4 was 92 ships and March 11 was only 39 ships left from Tokyo bay.
- It is considered that most of ship had stayed and taken evacuation in the inside of the bay.

Situation of ship refuge in Tokyo bay



Conclusions

Conclusions

- Using the data obtained from AIS, this study investigated the evacuation behaviors of the vessels equipped with AIS around the Tokyo bay during the tsunami warning announcement.

- The result shows that most vessels started evacuating approximately 30 min after the major tsunami warning announcement and completed evacuation 120 min after the announcement.

- Moreover, it also checked that the vessel traffic in Tokyo Bay had stopped mostly from about 21:00 on March 11, 2011.

- There was no report of the vessel which suffered the damage of tsunami directly, or the vessel which resulted in marine accidents, such as a collision, under the influence.

Conclusions

- It is surmised that each vessel performed suitable evacuation activity based on tsunami information.
- This contributed in understanding the actual status of the vessel evacuation.
- Based on the results obtained in this study, our future study will conduct further analysis for preparing a manual that provides appropriate evacuation instructions during a tsunami.
- The analysis will provide more comprehensive perspectives including evacuation behaviors of all vessels.

Conclusions

- To understand of the latent risk area, a kernel density presumption analysis was conducted based on the distance between ships during evacuation with anchoring situation, and some risky areas where the distances between ships were too close were identified.

- Based on the results obtained in this study, our future study will conduct further analysis for preparing a manual that provides appropriate evacuation instructions during a tsunami.

- The analysis will provide more comprehensive perspectives including evacuation procedures for all vessel types.

Thank you for your kind attention.