PIANC MARCOM Seminar in Japan
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PIANC WG 53

Mitigation of Tsunami Disaster in Ports

Lessons learnt from the Great East Japan Earthquake

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Mitigation of Tsunami Disasters in Ports

Lessons learnt from the Great East Japan Earthquake

Contents

1. Introduction

2. PIANC WG53

3. 2011 Earthquake and Tsunami Disaster

4. Lessons Learnt from the disaster

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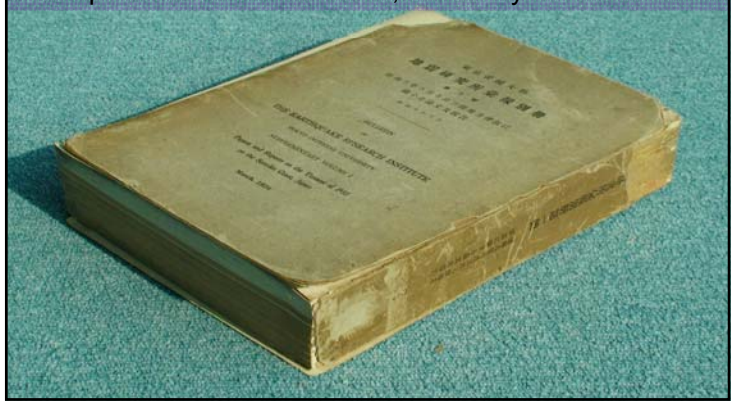
1. Introduction

Development of Tsunami Disaster Mitigation

Start of Modern Tsunami Research

Report on 1933 Showa Sanriku Tsunami

Earthquake Research Institute, U of Tokyo



Development of Tsunami Disaster Mitigation Technology

1960 Chilean Tsunami （M8.5 dead 139）
Start of Integrated Tsunami Disaster Prevention Research
Start of Construction of Tsunami defense facilities

1983 Nihonkai-Chubu Tsunami （M7.7 dead 100)

1993 Hokkaido-Nasei-oki Tsunami（M7.8 dead 200)

Significant Progress

of Tsunami Research and Preparedness

Indian Ocean Tsunami 2004 M9.1

Hambantota in Sri Lanka, Dead/Missing 220,000

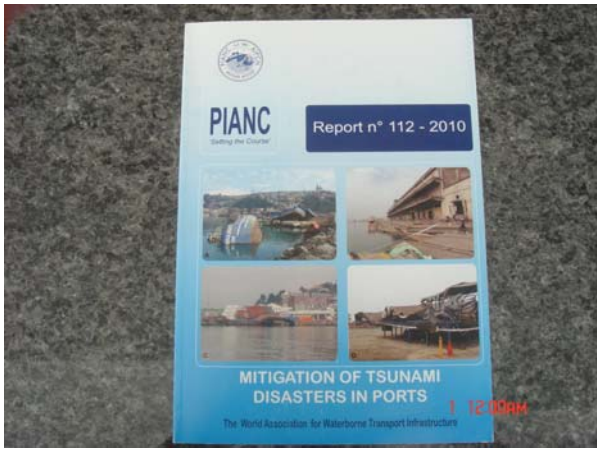
Studies on Tsunami Disaster Mitigation Experiment on Wooden House Destruction

Simulation of Tsunami intrusion into a port town Studies on Tsunami Disaster Mitigation

Disaster mitigation starts from people's understanding of the disaster.

International Workshop on Coastal Disaster Prevention


PIANC WG53 Report



2011 Earthquake and Tsunami Disaster

2011 Earthquake and Tsunami Disaster

Studies on Recovery from the Disaster and Mitigation of Future Disasters

PIANC WG53

Appendix

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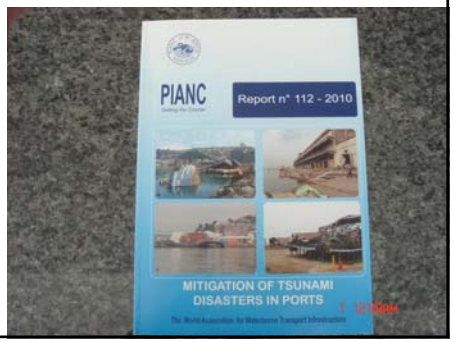
2. PIANC WG 53



WG53 Progress

December 14, 2005	Letter From MarCom Chair
January 20, 2006	Kick-Off Meeting at PARI
April 24, 2006	Set-up of WG53 Website
February 14, 2007	The Second Meeting in Sri Lanka
October 30, 2007	The Third Meeting at Yokohama
September 2008	PIANC MarCom Meeting at Palermo
2010	Published as Report No 112

Members of WG53

Dr. Shigeo Takahashi (Chairperson)
Dr. Wilfred Molenaar (Vice Chairperson)
Dr. Takashi Tomita, (Member and Secretary)
Dr. Hans F. Burcharth (Member)
Mr. John R. Headland (Member)
Dr. Constantine D. Memos (Member)
Dr. Subandono Diposaptono (Invited Expert)
Dr. S.S.L. Hettiarachchi (Invited Expert)
Dr. Panitan Lukkunaprasit (Invited Expert)
Dr. Ahmet Cevdet Yalciner (Invited Expert)
Dr. Solomon Yim (Invited Experts)
Ing. Jose Miguel Montoya Rodriguez (Invited Expert)
Dr. Taro Arikawa (Invited Junior Expert)
Dr. Saman Samarawickrama (Invited Junior Expert)
Mr. Peter S. Rasch (Invited Junior Expert)

Revised Contents

A: Examples of tsunami disasters

2. TSUNAMI DISASTERS AND DAMAGES IN PORTS

B: Tsunami from generation to damage

3. TSUNAMI GENERATION, PROPAGATION AND RUN-UP

4. TSUNAMI INTRUSION INTO PORTS AND INTERACTION BETWEEN TSUNAMI AND VESSELS

5. INTERACTIONS BETWEEN TSUNAMIS AND PORT FACILITIES

C: Tsunami disaster management

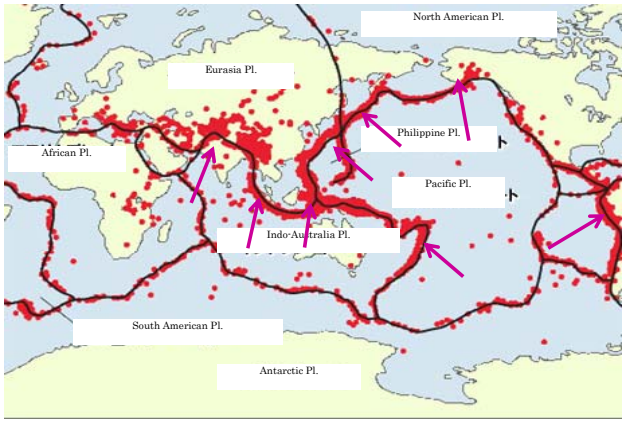
6. RECOMMENDATIONS REGARDING TSUNAMI DISASTER MANAGEMENT IN PORTS

7. RECOMMENDATIONS ON WARNING AND EVACUATION IN PORTS

8. RECOMMENDATIONS REGARDING STRUCTURAL COUNTERMEASURES IN PORTS

Epicenters of Large Earthquakes

Earth-Plates Boundaries and Subduction Zones



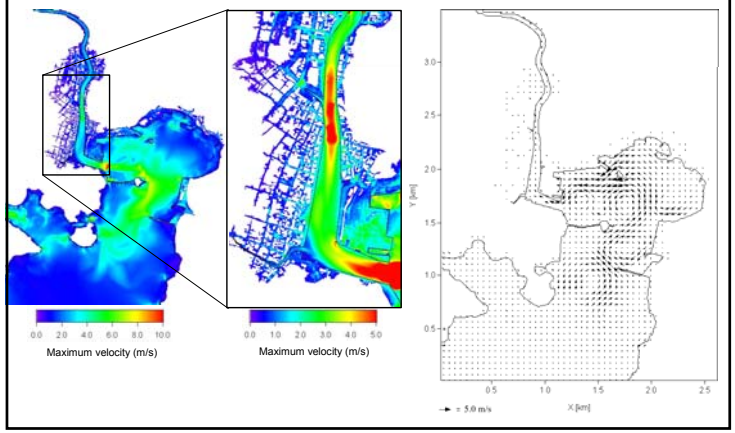
A: Examples of tsunami disasters

2. TSUNAMI DISASTERS AND DAMAGES IN PORTS

2.1 Introduction
2.2 Japan
2.3 U.S.
2.4 Mexico
2.5 Indonesia
2.6 Sri Lanka
2.7 Thailand
2.8 Turkey
2.9 Greek

The disasters caused by the tsunamis are very similar

Tsunami induced Flow



Non-structural Countermeasures

1.Effective Evacuation
@Tsunami Warning System
@ Hazard Map
@ Evacuation Facilities(Building, Tower etc)

2.Dissemination of Tsunami Knowledge

3. Land Usage Planning

Tsunami Disaster Management

Disaster Management Team

1. Disaster Assessment at present

2. Disaster Mitigation Planning

3. Implementation of Plan

Table 6.1: Tsunami Levels and Damage and Protection Levels

Tsunami level	Definition	Damage and protection level
Level 1	Frequent Tsunami	Possible damage to fishery activities and ships
Level 2	Preventable Tsunami	No significant damage to on-land facilities with coastal defenses
Level 3	Worst-Case Class Tsunami	Severe damage and need for measures to mitigate disaster

Appendix to Report No. 112-2010

Mitigation of Tsunami Disasters in Ports

Tsunami Disasters in Ports
due to the Great East Japan Earthquake

The appendix covers the tsunami itself and its induced disasters in addition to lessens learned from the disasters.

Contents of APNDX

1. Introduction
2. Preparedness against estimated tsunamis in the Sanriku coast
3. Earthquake and strong ground motion
4. Tsunami generation, propagation and inundation
5. Human responses against tsunami
6. Outline of tsunami damage
7. Tsunami damage in ports
8. Damage and effectiveness of defense facilities
9. Restoration and reconstruction of ports
10. Advanced tsunami countermeasures
11. Concluding remarks

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3. 2011 Great East Japan Earthquake and Tsunami Disaster

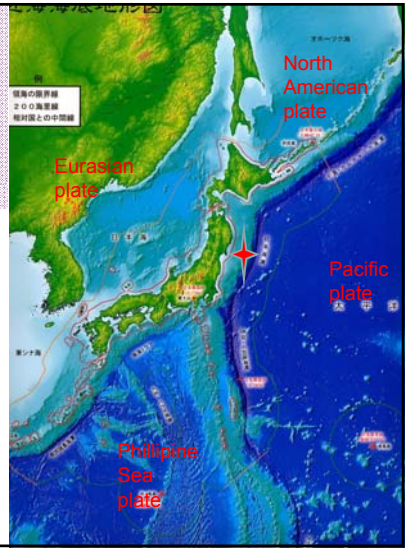
Map of seas surrounding Japan

(Deep Trenches : Subduction Zones)

Epicenter
130km from Sendai

Sanriku Coasts

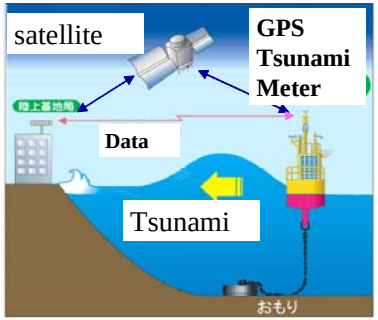
Tohoku Region
Iwate Prefecture
Miyagi Prefecture
Fukushima Prefecture



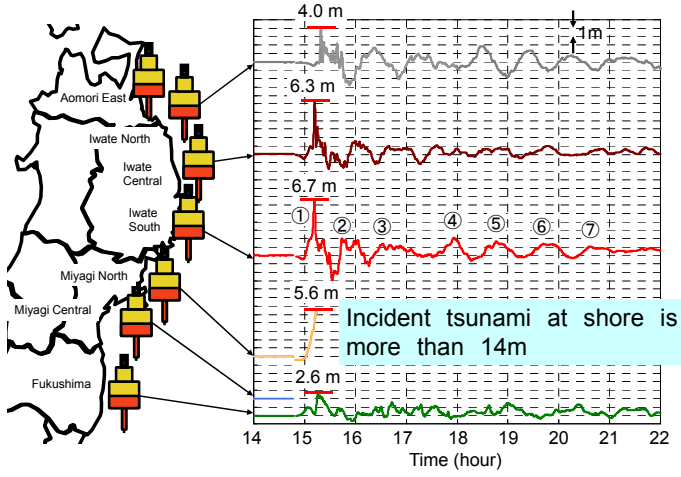
Tsunami Warning With Offshore Tsunami Observation

GPS Wave (Tsunami) buoy

12 buoys 20km off the coasts at a depth of about 200m



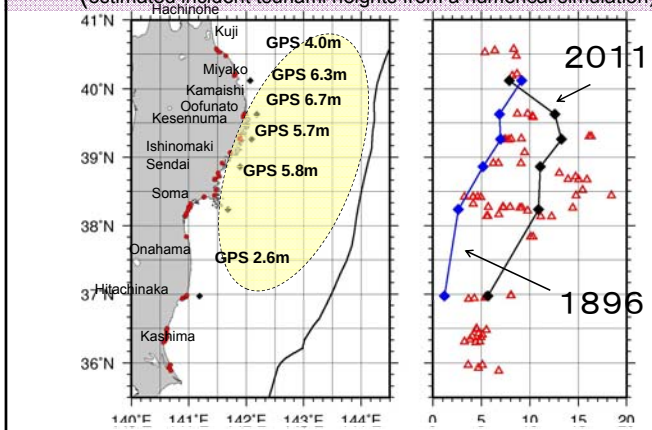
GPS wave buoys measured the tsunami.



Incident tsunami at shore is more than 14m

Comparison with Meiji-Sanriku Tsunami

(estimated incident tsunami heights from a numerical simulation)



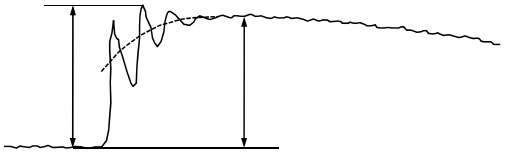
◆ : Equivalent incident tsunami height at shoreline (2011 off the Pacific coast of Tohoku Earthquake)
◆ : Equivalent incident tsunami height at shoreline (1896 Meiji Sanriku Earthquake)
△ : Inundation height

Tsunami front with Soliton Fission at a water depth 30m

NHK Special “The Great Eastern Japan Earthquake”
by NHK (Japan Broadcasting Corporation) on May 7, 2011.

Special feature of tsunami front in coasts.

Soliton Fission (Split) and Breaking of Tsunami Front



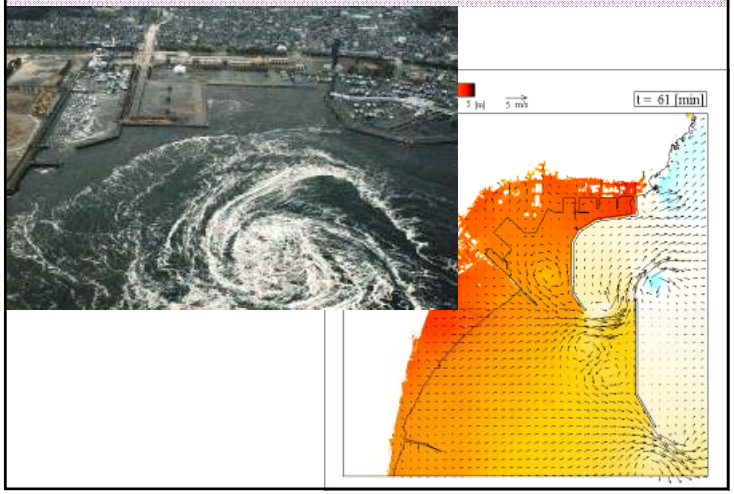
The behavior of tsunami front near the coasts is very important especially to understand the mechanism of failures of coastal defenses.

Tsunami at Kuji (Breaking of soliton waves)

Tsunami at Kuji (Breaking wave front)

NHK Special “The Great Eastern Japan Earthquake”
by NHK (Japan Broadcasting Corporation) on May 7, 2011.

Large vortex at Oharai Port



10m Tsunami Caused all types of the tsunami damages.

It destroyed all the town including tsunami defenses

General	Destruction and washed-away of houses
	Drift and crash of cars
	Fires
	Destruction of tanks and oil spill
	Destruction of Railways, roads and bridges
	subsidance of ground
	Inundation of rice paddles
Ports and Coasts	Drifting and collision of ships
	Destruction and inundation of port faciliteis
	Drifting and collision of timbers and containers
	Debris deposit in ports
	Scouring and deposit in ports
	Scouring of sandy beaches and destruction of green belts
	Destruction of acuaculture facilities
Coastal Defenses	Scouring and sliding of Breakwaters and quaywalls
	Destruction of jetties and detached breakwaters
	Destruction (scouring) of Dykes and Seawalls
	Destruction of water gates

Tsunami Damages on People and Houses

Total Inundated area 535km^2

Population in the Inundated area (600,000)

Dead and missing people 20,000

Total Damaged Houses (completely) 120,000
(partially) 100,000

Rikuzen-Takada

Rikuzen-Takada(Video by Iwate Prefectural Police）

Kamaishi port

Tsunami at Kamaishi (a video by MLITT)

Fires at Kesen-numa

Stranded Fishery Boat (Kesen-numa)

More than 20,000 fishery ships

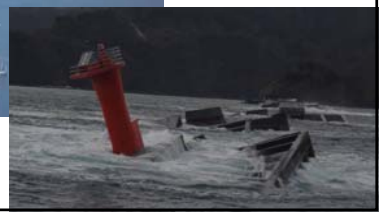
Stranded Cargo Vessel (Kamaishi)

More than 30 vessels damaged
(stranded or sunk: more than 11 vessels)

Drifted Containers (Sendai Port)

Failures of Coastal Structures

Damaged Breakwater at Kamaishi

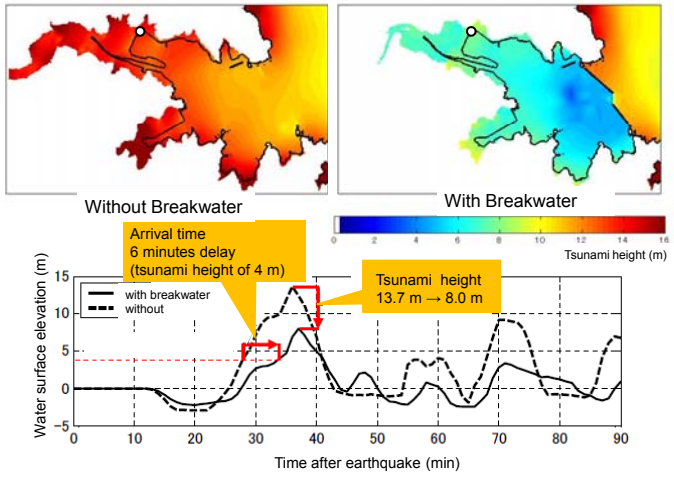


Narrow Multibeam Echogram (Kamaishi Breakwater)

Scouring of Rubble Mound
And Settlement and Sliding of Caissons

The difference of Water levels =8m
Sliding Safety Factor
Shallow area SF=0.95; Deep area SF＝1.15

Effect of breakwater(Numerical Simulation)

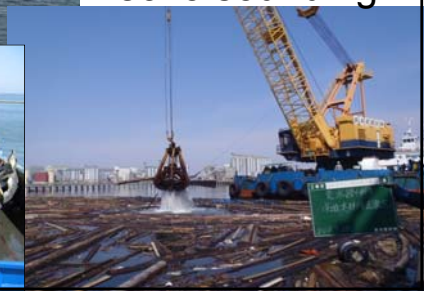


Seawall Failures

Ryouishi -Kamaishi

Rescue operation and Emergency Restoration

Removal of tsunami debris with echo sounding



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4. Lessons Learnt from the Disaster

We are now discussing the Improvement of Tsunami Preparedness

Improvement of Tsunami Preparedness

@Worst Case Scenario

@Resilient Coastal Towns

@Vertical Evacuation

@Early Warning with Offshore Tsunami Observation

Huge tsunami exceeding our design level

We had to and have to consider the worst case to mitigate the disaster.

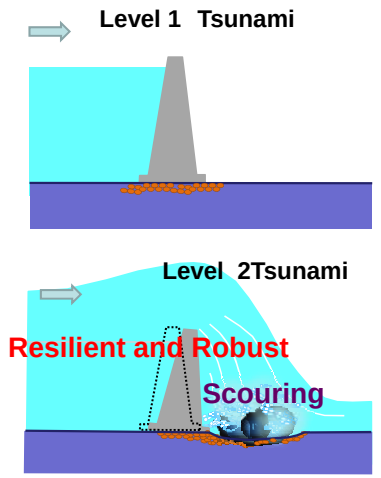
We need the worst case scenario.

Performance design for tsunami disaster mitigation

	Design tsunami	Required performance
Level 1 Tsunami	Largest tsunami in modern times (return period: around **100** years)	**Disaster Prevention** • To protect human lives • To protect properties • To protect economic activities
Level 2 Tsunami	One of the largest tsunamis in history (return period: around **1000** years)	**Disaster Mitigation** • To protect human lives • To reduce economic loss, especially by preventing the occurrence of severe secondary disasters and by enabling prompt

Level 2 tsunami is the worst case.
We are now making the worst case scenarios.

Tsunami Defense Structures for Level1 and Level 2



We have to prevent Level 1 tsunami by tsunami defenses.

For level 2 tsunami, tsunami defense should reduce the tsunami.

At least, in the event of 'Level 2 tsunami', the deformation of these facilities have to be not so large to maintain the performance to reduce tsunami.

Resilience for the worst case

Early Recovery

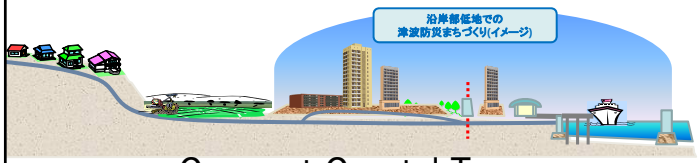
→ Reduction of Damages

→ Redundancy & Robustness

→Resilience of Tsunami Defense Structures

Resilient Coastal Towns

Disaster reduction (mitigation) to ensure early recovery



Compact Coastal Towns
by House Relocation into high lands
and High Buildings near Coasts

Improvement of Evacuation

Not Horizontal but Vertical Evacuation

5 Minutes Evacuation by Emergency Refuge using High Buildings

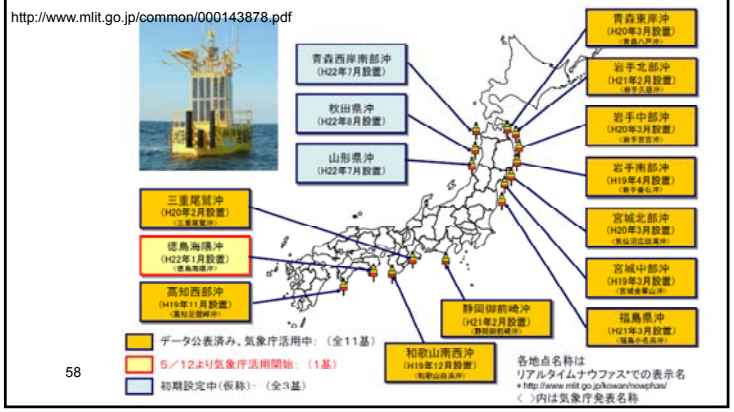
Modern concrete buildings were inundated but remained.

Offshore Tsunami Observation

More accurate tsunami warning

More Offshore Tsunami Observation Stations

http://www.mlit.go.jp/common/000143878.pdf



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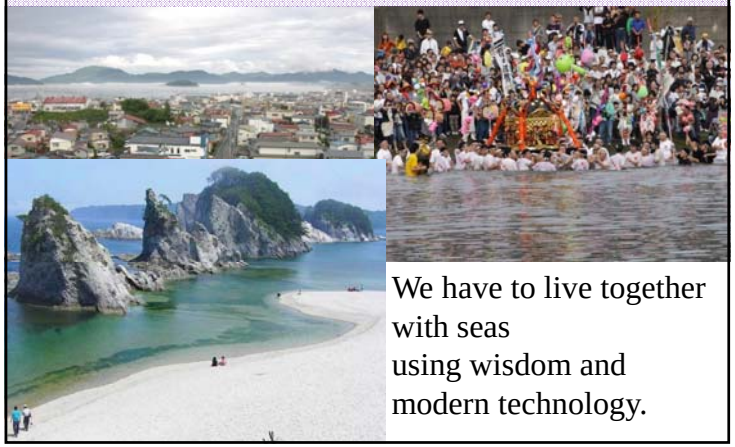
We learned harsh nature of seas this time

But we all know richness of seas.



We have to live together with seas
using wisdom and modern technology.

Thank you for your kind attention.