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Tsunami Marine Hazards on Marine Environment

Mitsuru Hayashi (Kobe Univ.)

Menu

Relationship between Disaster and Environment

Marine environmental shift caused by a mega tsunami.
- Importance of the predictive study -

Climate Change

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is a typical event.
included in both.
caused by Human Activities.
causes Natural Disasters & Environmental Disasters.
e.g. Desertification, Transition of Ecosystem,
High Tide, Storm Surge & Flooding,
Mega Typhoon & Hurricane

Traditional Association between Disaster and Environment

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1. Natural disaster
is emergency to human activities
by a drastic or huge change of natural environments
e.g. Volcanic eruption, Earthquake, Tsunami

2. Environmental disaster
is hazard for the natural environment
by human activities
e.g. Oil spill, Explosion of plant, Air pollution, War

Additional Association between Disaster and Environment

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3. To End Poverty in all its forms everywhere
is Goal 1 of SDGs (Sustainable Development Goals)
(https://www.un.org/sustainabledevelopment/)

Q. Why are environment
and poverty & a disaster related?
> IUCN (https://www.iucn.org/)
(International Union for Conservation of Nature)
answered for the question in
"Environmental Guidance Note
for Disaster Risk Reduction".

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A. Climate change and disaster events are creating greater population vulnerability, especially among women and children. Vulnerable populations are more at risk to natural disasters – those are also heavily dependent on ecosystem services for their livelihoods and for physical protection.
Therefore, investing in ecosystems and mainstreaming disaster risk and ecosystem management in development planning is likely to make a major contribution to the goal of achieving sustainable livelihoods for the poor.

THE WORLD BANK

Human and economic costs of disasters underestimated by up to 60 percent

MARRAKESH, November 14, 2016– The impact of extreme natural disasters is equivalent to a global $520 billion loss in annual consumption, and forces some 26 million people into poverty each year, a new report from the World Bank and the Global Facility for Disaster Reduction and Recovery (GFDRR) reveals.

"Severe climate shocks threaten to roll back decades of progress against poverty," said **World Bank Group President Jim Yong Kim**. *"Storms, floods, and droughts have dire human and economic consequences, with poor people often paying the heaviest price. Building resilience to disasters not only makes economic sense, it is a moral imperative."*

The report, *Unbreakable: Building the Resilience of the Poor in the Face of Natural Disasters*, warns that the combined human and economic impacts of extreme weather on poverty are far more devastating than previously understood.

In all of the 117 countries studied, the effect on well-being, measured in terms of lost consumption, is found to be larger than asset losses. Because disaster losses disproportionately affect poor people, who have a limited ability to cope with them, the report estimates that impact on well-being in these countries is equivalent to consumption losses of about $520 billion a year. This outstrips all other estimates by as much as 60 per cent.

A.

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> the World Bank
answered for the question in
"Unbreakable : Building the Resilience of the Poor in the Face of Natural Disasters"
(https://openknowledge.worldbank.org/handle/10986/25335)
The outline is introduced in Press Releases in News (https://www.worldbank.org/en/news)

THE WORLD BANK

Who We Are / News

PRESS RELEASE

Natural Disasters Force 26 Million People into Poverty and Cost $520bn in Losses Every Year, New World Bank Analysis Finds

November 14, 2016

Additional Association between Disaster and Environment

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4. Eco-DRR
(Ecosystem-based Disaster Risk Reduction)
is the sustainable management, conservation and restoration of ecosystems to reduce disaster risk with the aim to achieve sustainable and resilient development.

" The Ecosystem-based Disaster Risk Reduction
- Case Study and Exercise Source Book – "
(https://www.preventionweb.net/publications/view/54582)

The World Conference on Disaster Risk Reduction

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is organized by UNDRR
(the UN Office for Disaster Risk Reduction)
(https://www.unisdr.org/)
to advance risk reduction policies of coming ten years.
All WCDRR were held in Japan.

The 1st @ Yokohama in 1994
"Yokohama Strategy & Plan of Action for a Safer World"
The 2nd @ Kobe in 2005
"The Hyogo Framework for Action (HFA)"
The 3rd @ Sendai in 2015
"Sendai Framework for Disaster Risk Reduction"
were adopted.

The Nankai Trough Earthquake

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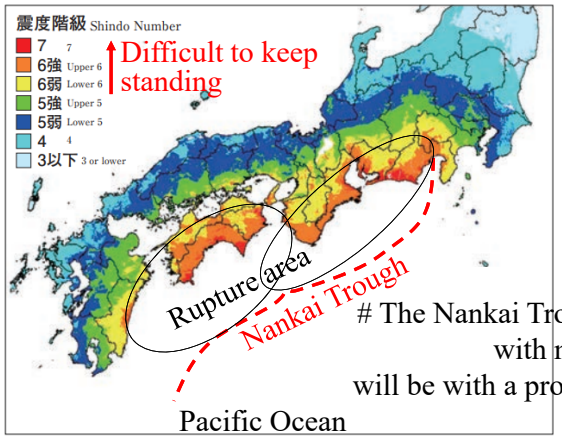
最大クラスの地震における震度の最大値の分布図
Distribution of Maximum Seismic Intensity (Shindo) in the event of maximum possible the Nankai Trough Earthquake



The Nankai Trough Earthquake with magnitude 8 or 9 will be with a probability of 70 % within 30 years.

Sendai Framework for Disaster Risk Reduction

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(https://www.unisdr.org/we/coordinate/sendai-framework)
" The Citizen's Guide to the Sendai Framework for Disaster Risk Reduction 2015-2030"(http://jcc-drr.net/en/)

Priorities for Action 3
Investing in DRR for Resilience

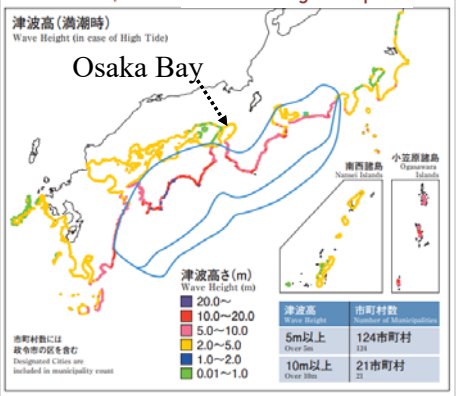
Urban Planning and Conservation of Ecosystems

When making decisions on urban planning and land usage it is important to take disaster risks into consideration. It is necessary to carry out risk assessments and mapping in order to identify safe areas, especially for farming communities in the mountains or near rivers, and communities in tsunami or flood zones. Through these processes, it is also possible to protect ecosystems which boost the resilience Column 7 of the community.

& harness = Eco-DDR
e.g. Green Infrastructure, Green/Bleu Carbon

Tsunami by The Nankai Trough Earthquake

最大クラスの地震における津波高分布
Distribution of Tsunami Wave Height in the event of maximum possible the Nankai Trough Earthquake



The huge tsunami will attack not only the shore line but also the inside bays.
Last one was in the end of WWII.
The next tsunami is our first one after the economic growth.
Different damage from the past may occur.
It is necessary to estimate it.

The tsunami caused by the Tohoku Region Pacific Coast Earthquake on 11 March 2011

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Huge tsunami (max. 40 m) attacked to the Tohoku Region.
Fishery is active in Tohoku region, and it is famous for the culture of oysters.

However, the culture bed and farm, seaweed and seagrass were swept away by the tsunami.

Impact of the tsunami for marine sediment

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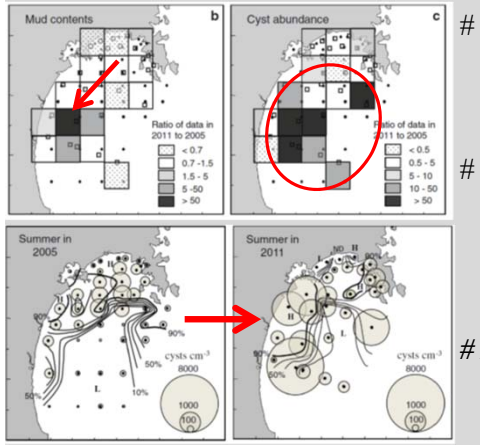


(Kamiyama *et al.*, 2014)

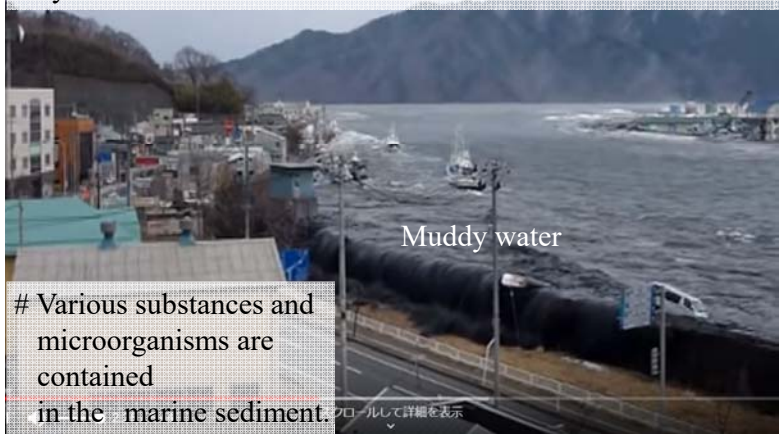
Marine sediment transferred to the offshore Sendai Bay.

Cyst abundance of *Alexandrium* in the sediment increased widely in the offshore.

Alexandrium spp. is a harmful phytoplankton that causes shellfish poisoning.

The tsunami with Muddy water

Marine sediments were disturbed, suspended and transported by a tsunami.



Various substances and microorganisms are contained in the marine sediment.

Impact of tsunami for a biological production

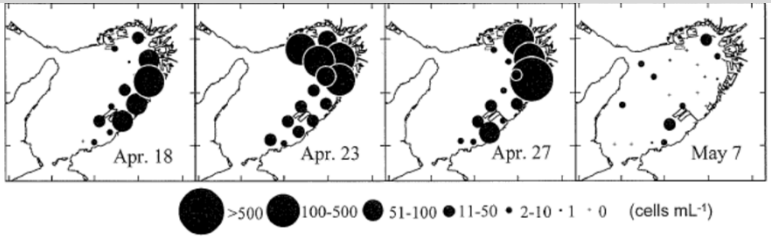
Depth (m)	Cell density (Cells/l)
0	20
2	100
4	24160
6	18440
8	100600
10	49600
12	36600
14	6800
16	4300
18	3520
20	1220
22	4080

Specimens	*A. tamarense* (天然細胞)	ムラサキイガイ中腸腺 平均±標準偏差(n=6)
調査日	6月5日	6月5日
	(mol%)	nmol/g (mol%)
C1,2	(9.9)[a]	2.8 ± 2.2 (6.1 ± 1.8)
GTX1,4	(56.5)[b]	27.0 ± 18.9 (56.7 ± 9.4)
GTX2,3	(33.6)[c]	12.4 ± 9.9 (25.5 ± 6.7)
dcGTX2,3	(−)	0.6 ± 0.4 (1.6 ± 0.7)
neoSTX	(−)	2.6 ± 1.0 (8.1 ± 5.4)
dcSTX	(−)	0.7 ± 0.5 (2.0 ± 0.9)
STX	(−)	− (−)
合計		46.1 ± 29.3

(Kaga *et al.*, 2012)

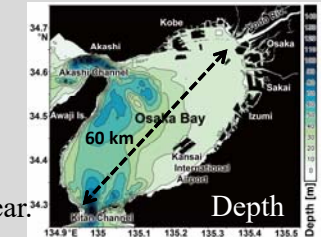
The *A.tamarense* in the water column increased.
Shellfish poisoning occurred in Ohfunato Bay
Density of the poisoning exceed the environmental standard.

A.tamarense & Shellfish poisoning in Osaka Bay

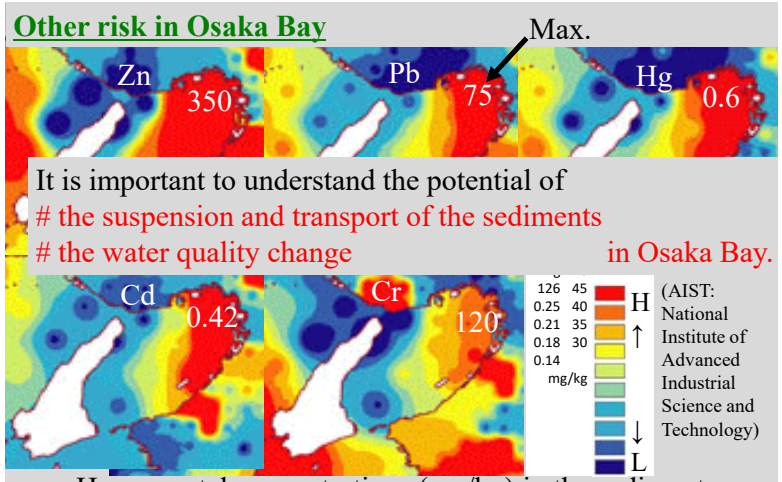


Cell density of *A.tamarense* in the marine sediment (Yamamoto *et al.*, 2009)

Osaka Bay is adjacent to the big cities,
Mach nutrients are supplied from rivers.
Red tide of *A. tamarense* and shellfish poisoning occur almost year.



Other risk in Osaka Bay



It is important to understand the potential of
the suspension and transport of the sediments
the water quality change
in Osaka Bay.

(AIST: National Institute of Advanced Industrial Science and Technology)

Heavy metal concentrations (mg/kg) in the sediment with 3cm thickness in 2010 by AIST.

Heavy metals are contained in the inner part of Osaka Bay.

Impact of tsunami for a microbial environment

Depth, h & Moisture content, ω

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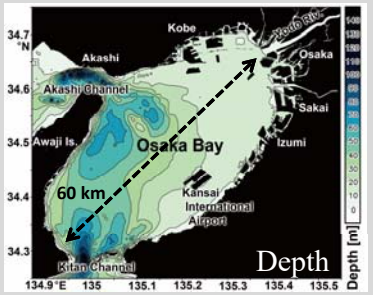

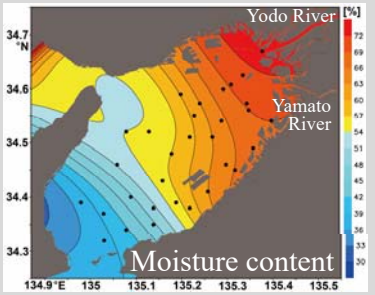

East
Shallow (almost < 30 m)
High ω (max 75 %)
West
Deep (almost > 30 m)
Low ω (< 40 %)

Surveyed in 2013 by the Res. Inst. of Env., Agri. & Fish., Osaka Prefecture.
50 m mesh data was created by the inner-extrapolation, which assumed the Gauss function.

Tsunami Simulation Model

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Fault Model (Var. of Topography)

Tide data (Ver. of Tidal level)

2D Tsunami Model (Tohoku Univ.) + Tide

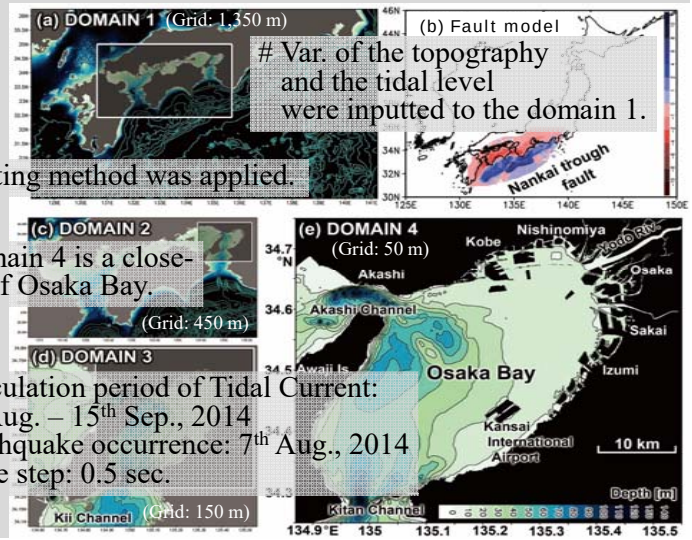
Flow velocity (U) & Elevation (η) of the Tsunami

U & η were calculated by the tsunami simulation

We used the tsunami model of Tohoku Univ. that JG is using for a tsunami prediction, and gave the tidal effect.

Variation of the topography and the tidal level were inputted to the model.

Tsunami Simulation in Osaka Bay (Nakada *et al.*, 2016).



Var. of the topography and the tidal level were inputted to the domain 1.

Nesting method was applied.

Domain 4 is a close-up of Osaka Bay.

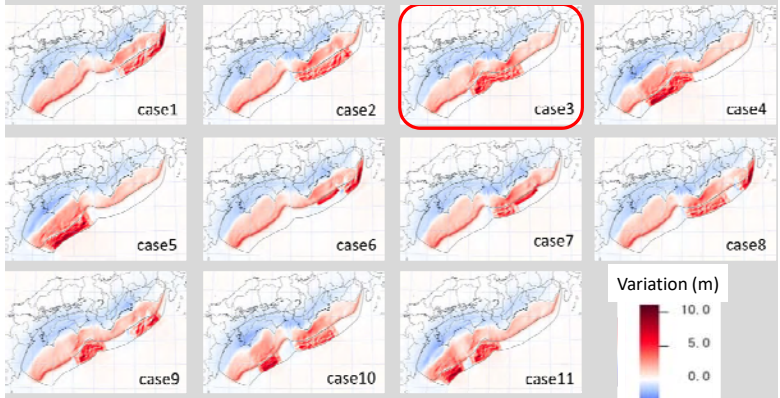
Calculation period of Tidal Current: 1st Aug. – 15th Sep., 2014

Earthquake occurrence: 7th Aug., 2014

Time step: 0.5 sec.

Fault model of the Nankai Trough Earthquake

(Central Disaster Prevention Council of JG, 2014)



JG assume the 11 rupture cases of the fault.

Case 3, which give most severely affect to the Osaka Bay, was used.

Result of tsunami simulation (for 10 hr.)

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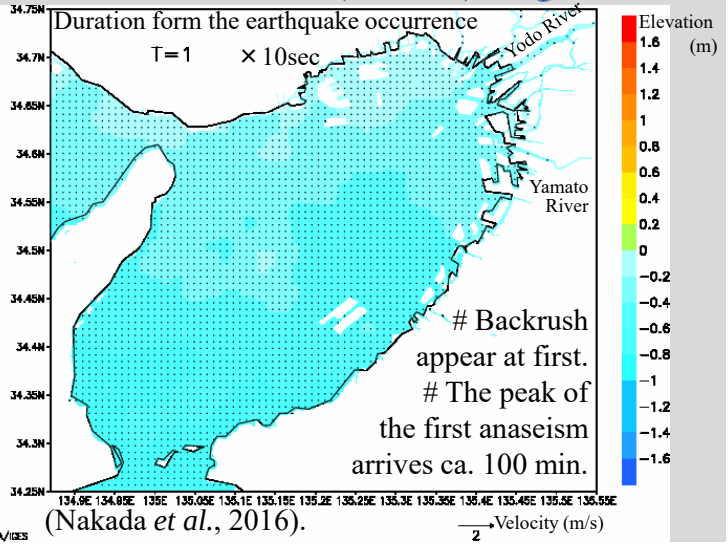

Backrush appear at first.

The peak of the first anaseism arrives ca. 100 min.

(Nakada *et al.*, 2016).

Maximum Elevation (η)

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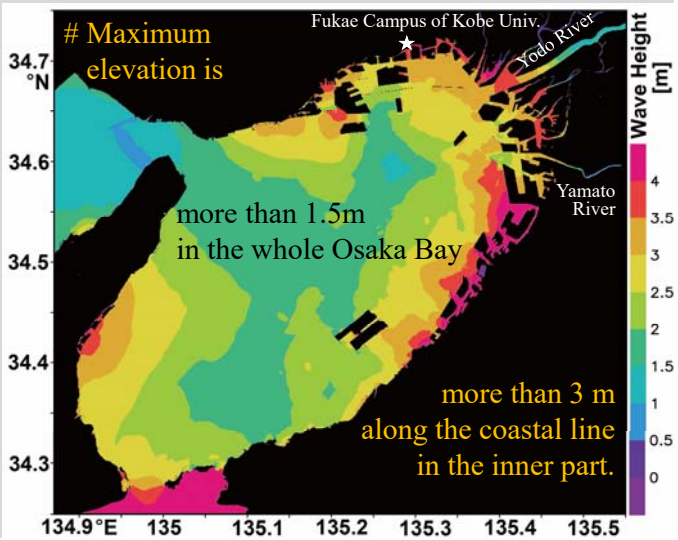

Non-dimensional bed shear stress (Rτ)

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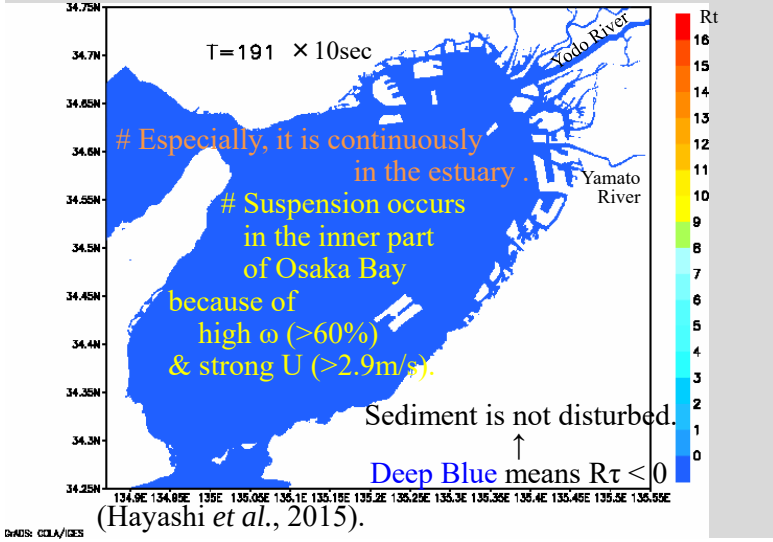

(Hayashi *et al.*, 2015).

Flow velocity (U)

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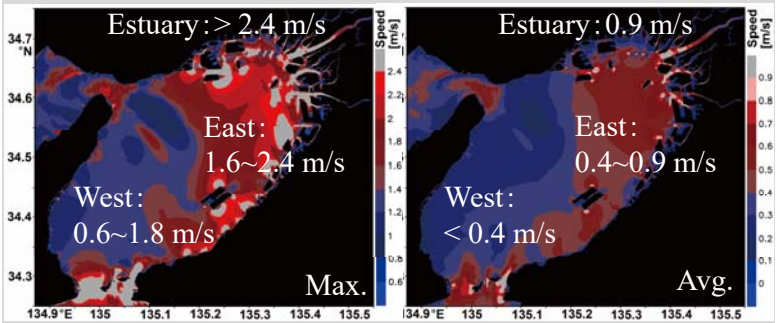

These are related to

whether suspension occurs even if only once.

whether suspension occurs easily and continually.

U is very large compared with ordinary tidal currents.

U in the estuaries is continually large.

Suspended region

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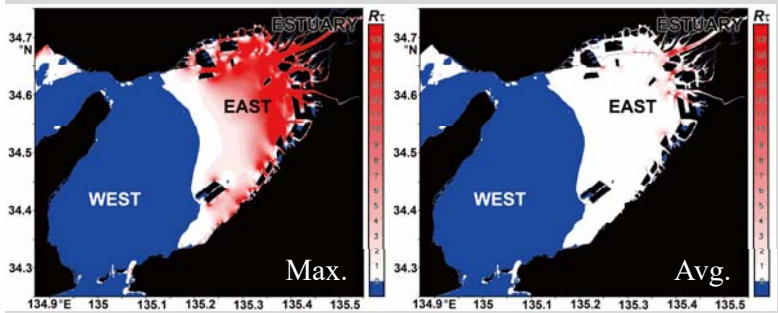


West (h≥30 m) : Does not occur. Hayashi *et. al.* (2015)

Deep & Low ω (≤57%).

East (h<30m) : Occur.

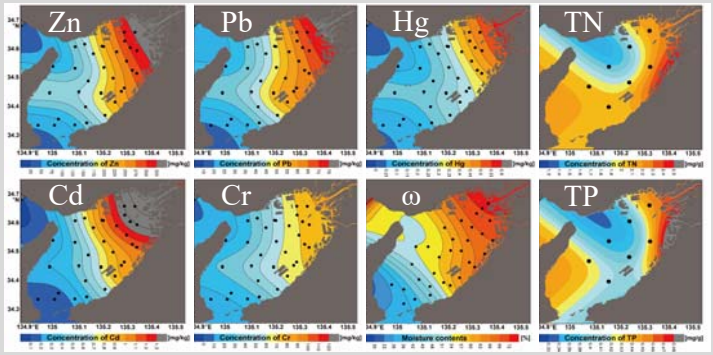
Sallow, High ω (>60%) & strong U (>2.9m/s).

Estuary (h<10m) : Hot Spot (Dominates and Continuously)

Extremely large ω & Strong U.

Material concentrations, *Cs* (mg/kg) in the sediment

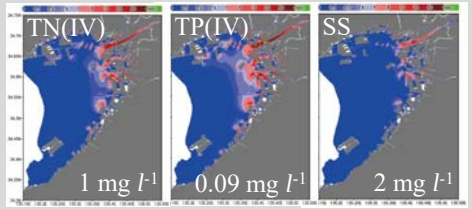
Heavy metals & Nutrients are focused in this study.



Heavy metals were surveyed by Nagaoka et al. (2004) with 3 cm thickness & AIST.
TN & TP were surveyed MLIT of JG with 10 cm thickness.

All materials are contained much more in the inner part.

Standardized concentrations of TN, TP and SS



The concentrations are high in the type IV region, especially in the south side.

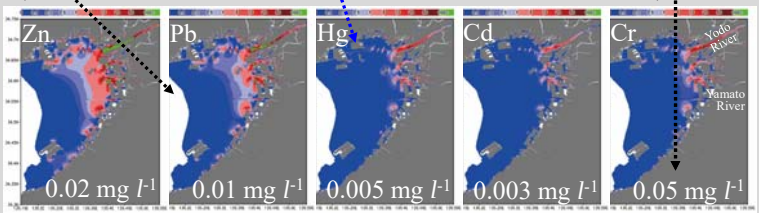
However, it may exceed the standards in wide area, and may fall into the hyper-eutrophic condition in the IV region.

Because TN and TP concentrations in Osaka Bay is high basically, and exceed the standards sometimes.

It is necessary to estimate the influence on the primary production considering both the nutrient and SS concentrations.

Standardized concentrations of heavy metals in the water

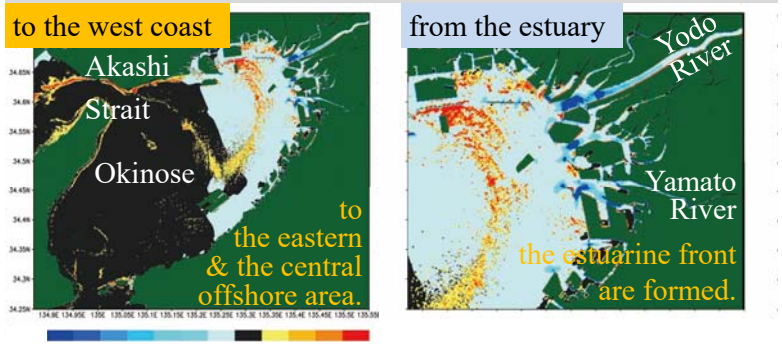
The concentrations after 10 hours from the earthquake were estimated, and were divided by the environmental standard by Ministry of the Environment, JG to understand the water quality after the tsunami.
(White : Not disturbed Blue : Less than the standard)



Hayashi *et al.* (2019)

The concentration in the inner part exceeds the environmental standard for "health protection of people"
Especially, 10 times or more are seen in the estuary.

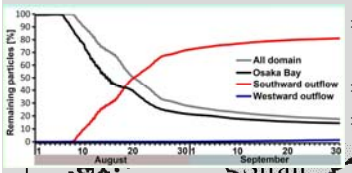
Reposition of SS after 1 month from the earthquake

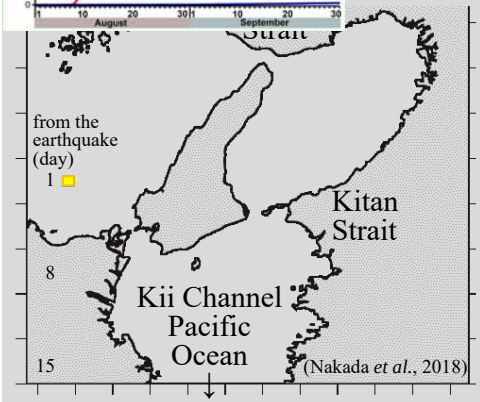


(Nakada *et al.*, 2016)

Okinose, the shallow water is formulated by the tide-induced residual current.
The locations of the offshore two lines accord with the place where the tidal front of Akashi Strail and

Transport of the dissolved maters and the fine grain





It becomes the steady state 2 months later.
80 % are transported to outside.
20 % are remained in the Bay.

They are
transported in the surface layer to southward along the east coast.
spread vertically in the Kitan and Akashi strait
are filled into the bay and Kii Channel widely.

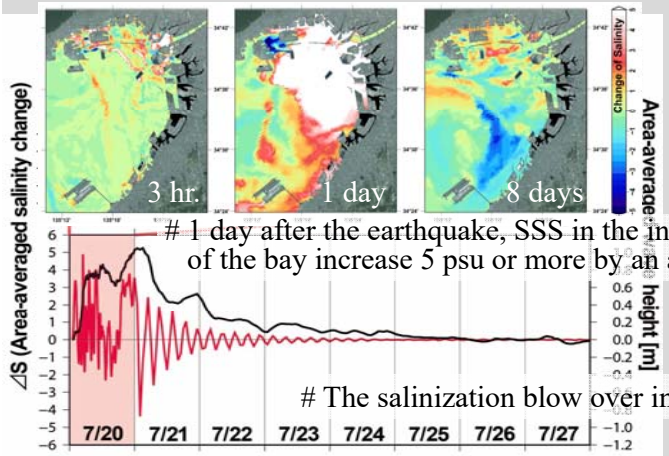
Conclusion -the Possible Scenario-

The huge tsunami with the Nankai Trough Earthquake attacks to Osaka Bay.
The marine sediments & materials in the inner part of the bay are disturbed.
The concentrations of materials in the water exceed the environmental standard.
The coastal water was significantly salinized.
The salinization blow over in a week.
2 months later, 20 % of materials are remained in the bay.

We have to consider carefully
not only the short-term but also the long-term change
of the primary production and the microbe environment.

The variation of Sea surface salinity

The variation of SSS by a tsunami is able to simulate by using FVCOM. (Nakada *et al.*, 2016)



1 day after the earthquake, SSS in the inner part of the bay increase 5 psu or more by an average.

The salinization blow over in a week.