

# Effects of the mega-earthquake and tsunami on rocky shore ecosystems on the Sanriku Coast, Japan

Hideki Takami, Tomohiko Kawamura, Daisuke Muraoka,  
Nam-Il Won, Hiroshi Nakaie

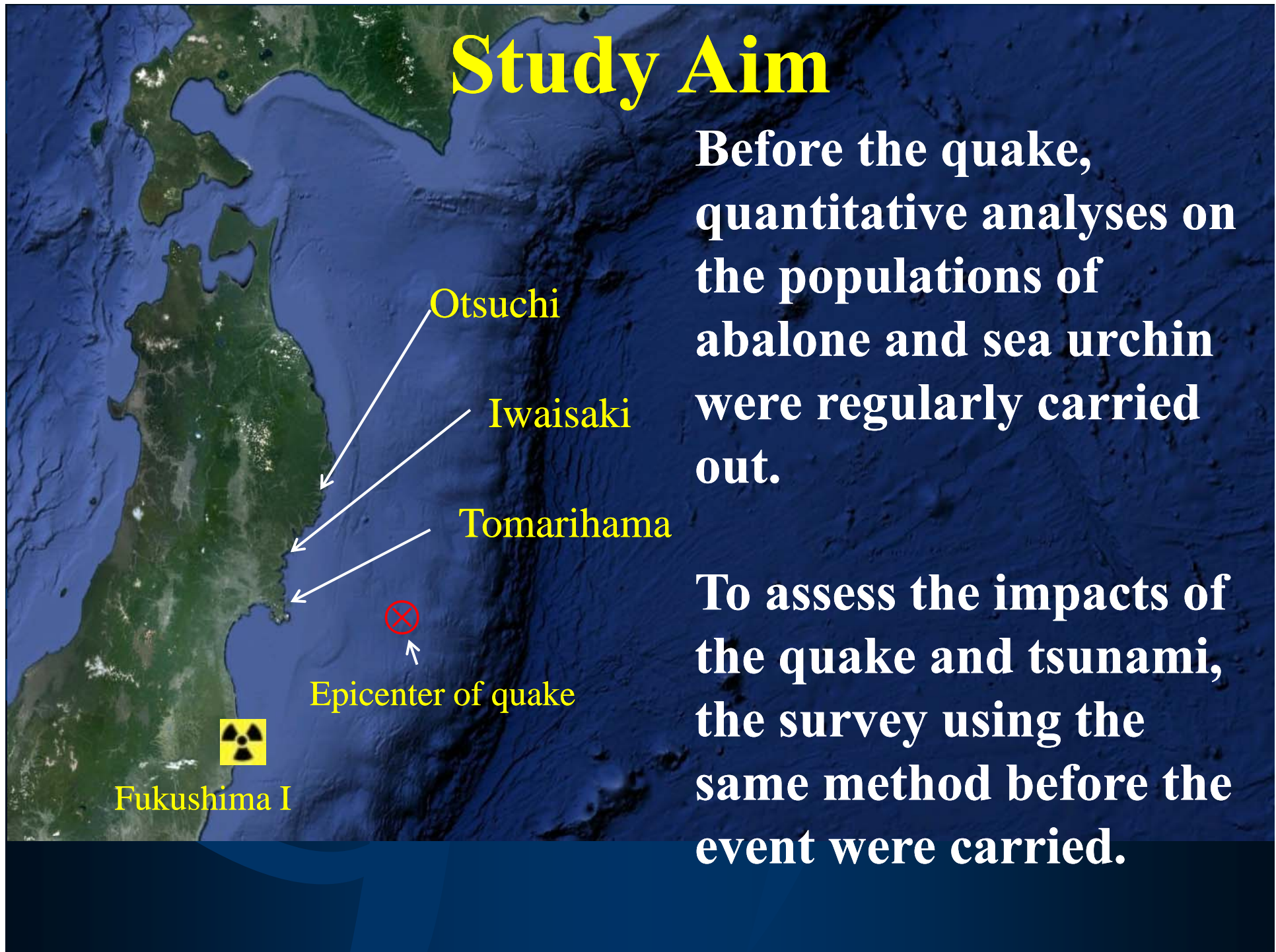
# Background

- **Massive tsunami** generated by a mega-earthquake hit a wide area of the **Pacific coast of northeast Japan**.
- **Fisheries are one of the important industries** in the coastal area impacted by the tsunami.
- **Rapid assessments are needed** to evaluate the effects of the tsunami on coastal ecosystems and populations of fishery organisms for **the future fishery and stock management**.
- The **abalone** *Haliotis discus hannai* and the **sea urchin** *Strongylocentrotus nudus* are **valuable fisheries resources** in this area, and also play important roles in the rocky shore ecosystem.

# Study Aim

Before the quake, quantitative analyses on the populations of abalone and sea urchin were regularly carried out.

To assess the impacts of the quake and tsunami, the survey using the same method before the event were carried.



# Main study site: Tomarihama on Oshika Peninsula, Miyagi

- This study site is 130 km away from the epicenter.
- Run up height of 15 m waves hit around the study site.

Tomarihama



Epicenter of quake



Fukushima I



# Study site includes three algal communities

**Crustose Coralline Algae  
(CCA)**

5~7 m



*Lithophylum yessoensis*

**Algal Turf  
(AT)**

4~5 m



*Gelidium elegans*

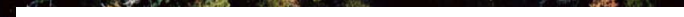
**Kelp Bed  
(KB)**

2~4 m

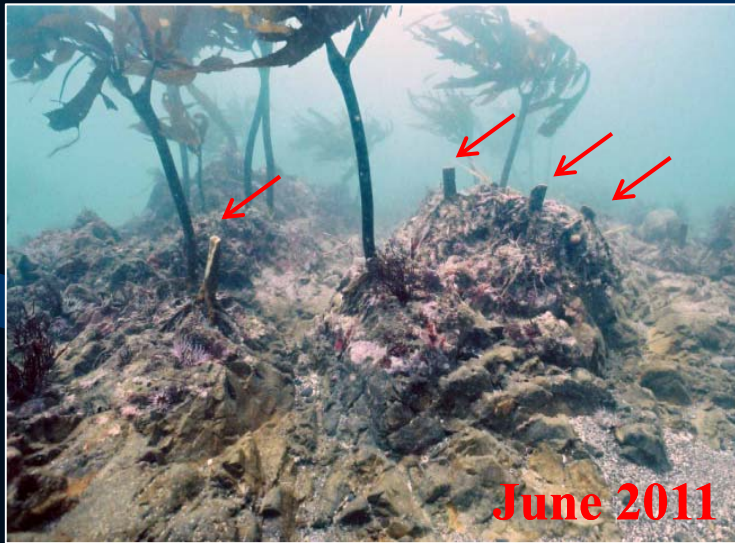


*Eisenia bicyclis*

100 m



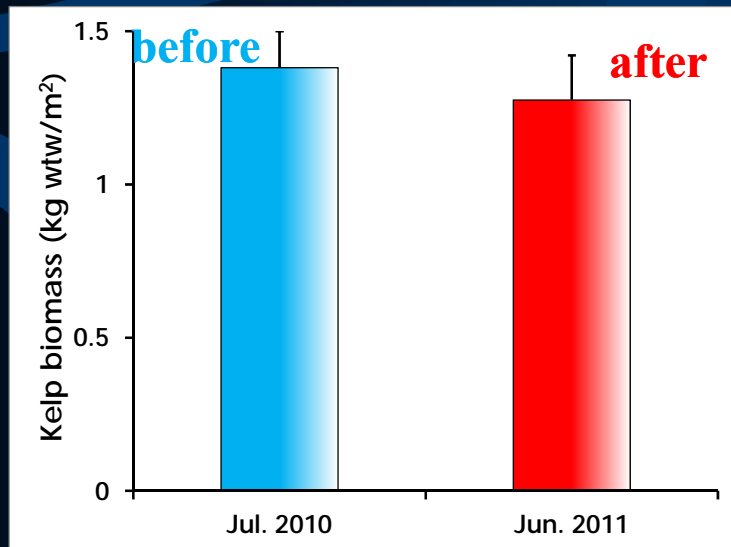
# Changes in algal communities between before and after the tsunami



## Kelp Beds (KB)

Remaining holdfasts of brown algae that lost their fronds were observed (not many).

The biomass of brown algae was not significantly different.

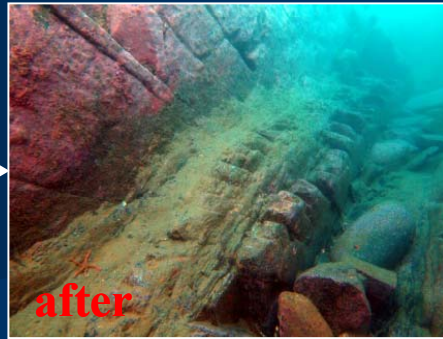


# Changes in algal communities between **before** and **after** the tsunami

November 2010



June 2011

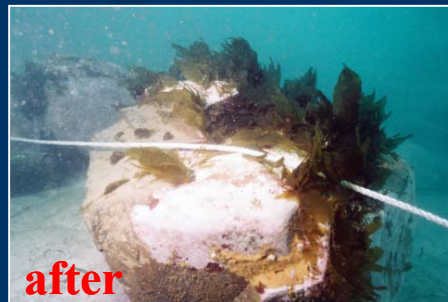


**Algal Turf (AT) and Crustose Coralline Algae (CCA)**

Heavy sedimentation of mud and silt covered the bed rocks



Many of the large rocks were cracked and turned over on the sea floor. Urchin density extremely reduced.



Young recruits of large brown algae were observed.

# Densities of urchin and abalone



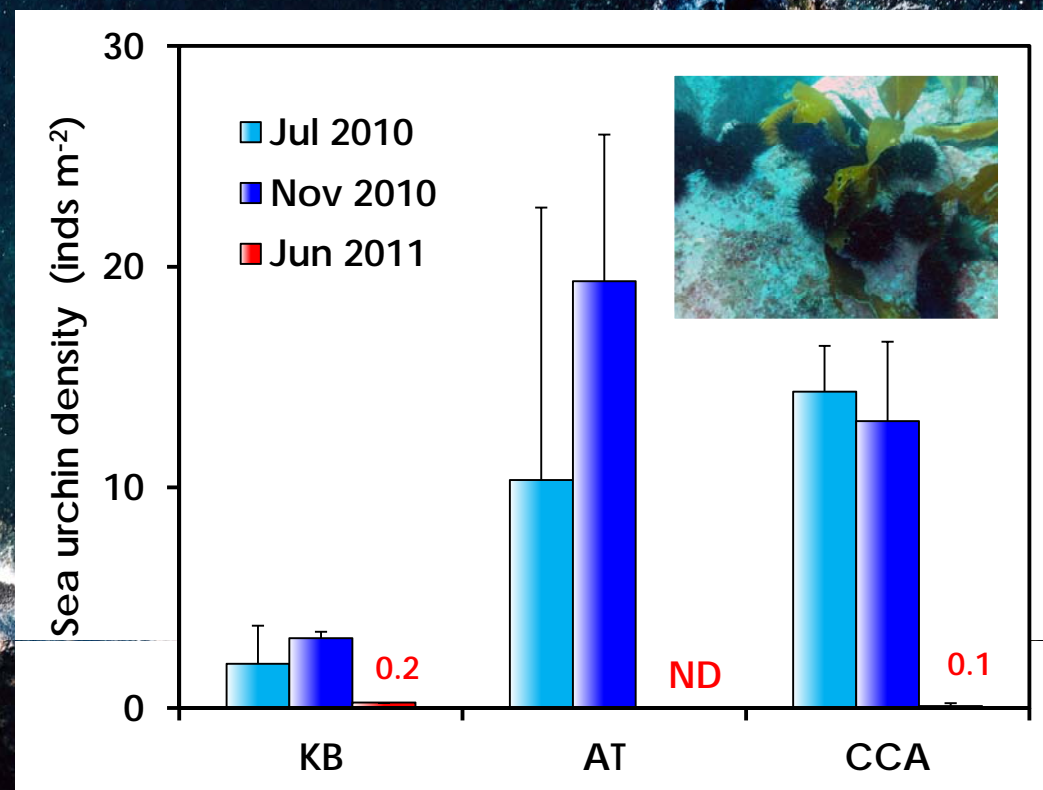
## Methods



- Urchins and abalone were sampled using quantitative quadrats (2 m × 2 m).
- In each algal community (KB, AT, and CCA), 3 replicate quadrats were haphazardly located.
- All animals in the quadrats were collected by hand.
- Densities were compared between before (Jul 2010-Feb 2011) and after (Jun 2011).



# Changes in **urchin** density between **before** and **after** the tsunami

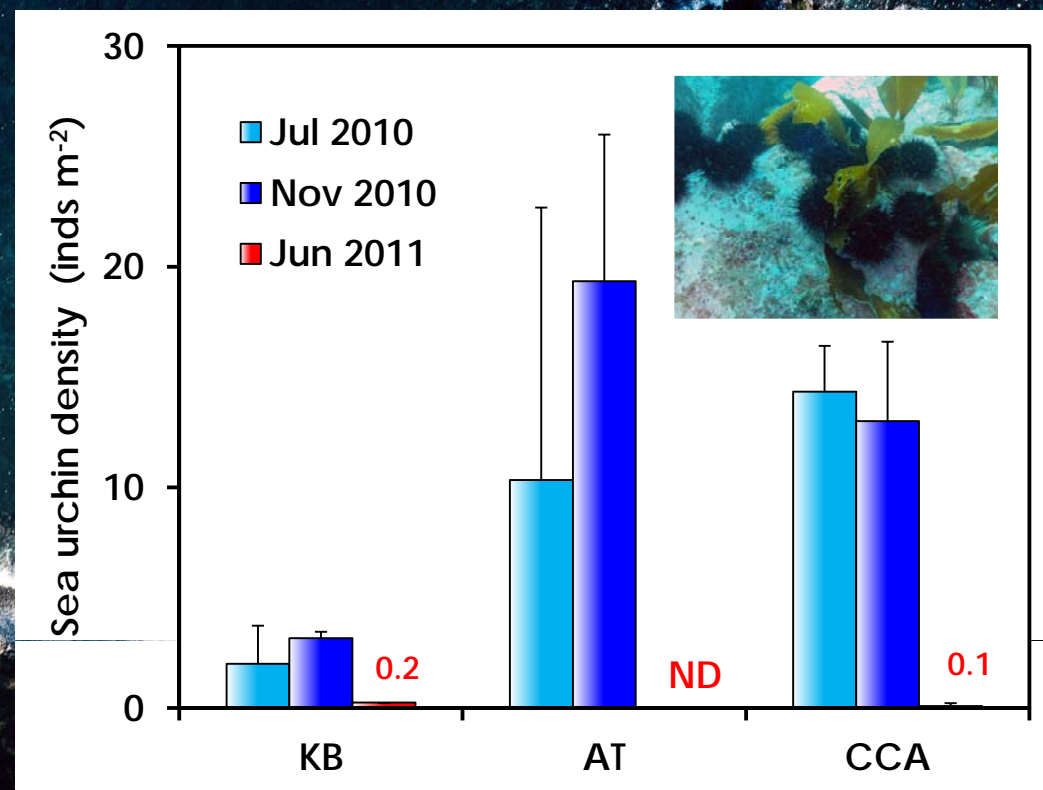


# Changes in **urchin** density between **before** and **after** the tsunami

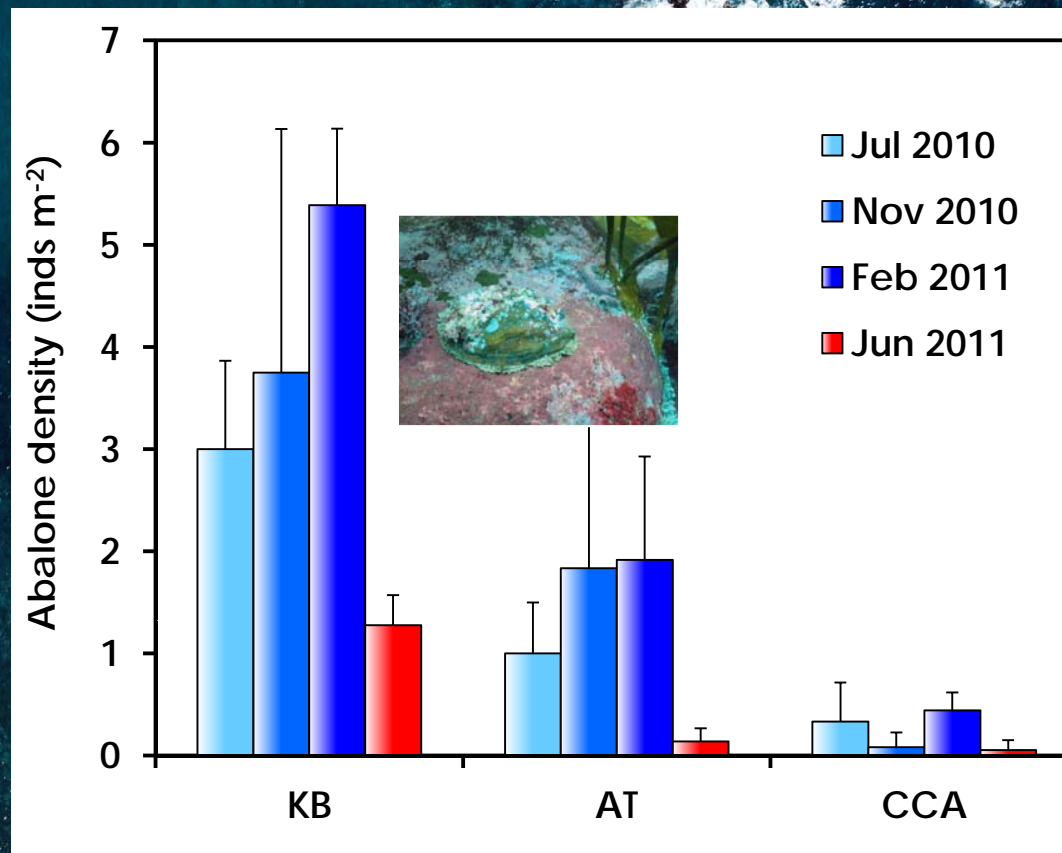


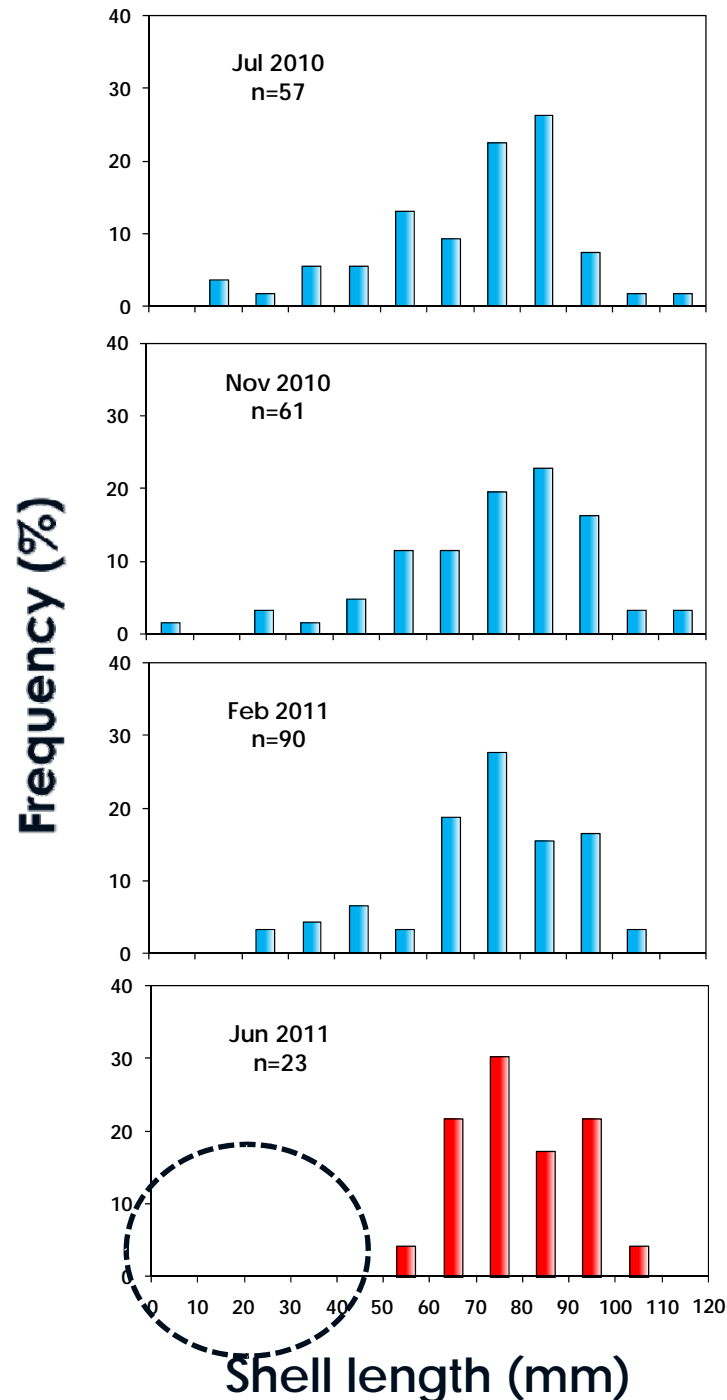
**CCA: grazer resistant, dominating under high grazing pressure of urchins.**

**After the tsunami, previously unrecorded recruitment of juvenile macroalgae were observed on CCA due to large-scale removal of urchins**



# Changes in **abalone** density between **before** and **after** the tsunami





## Changes in size distribution of abalone between **before** and **after** the tsunami

- Abalone collected by the quadrat sampling from CCA, AT, KB were pooled for size distribution data.
- The juvenile abalone <50 mm SL were not collected **after** the tsunami.
- The juveniles are more vulnerable to the impact of the tsunami than adults.

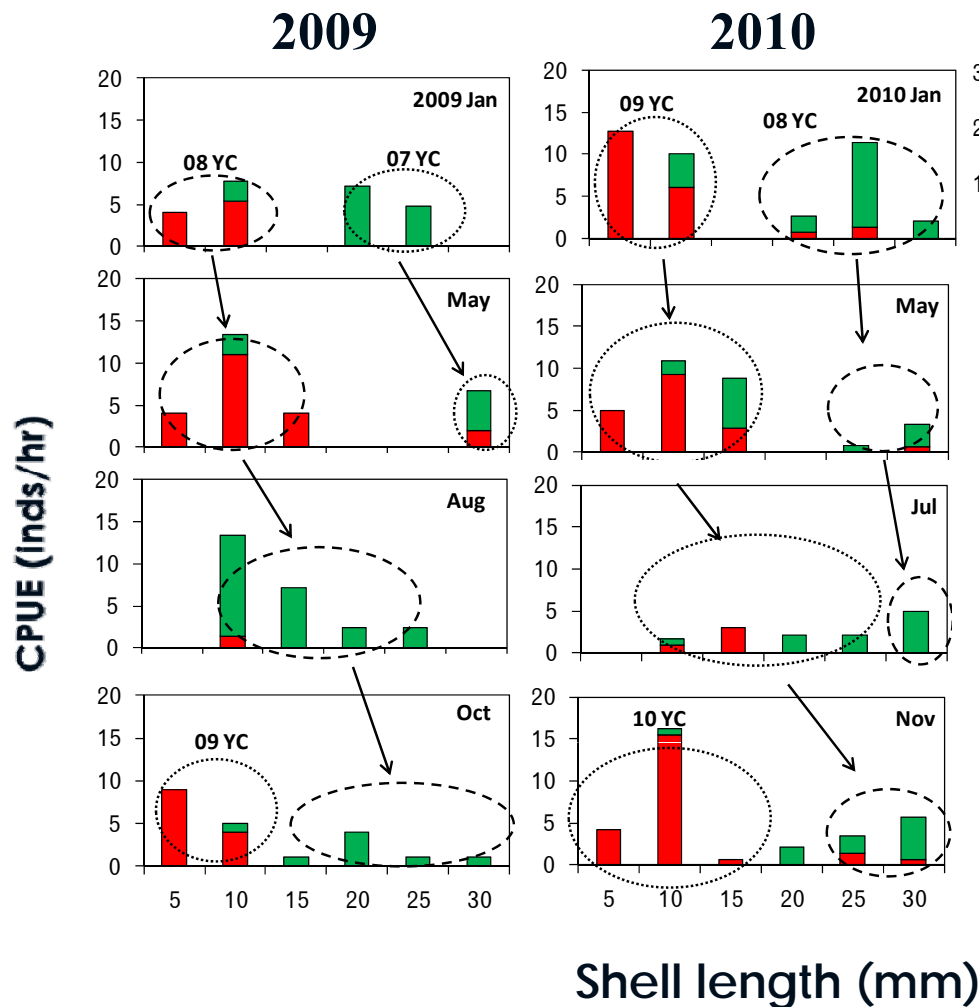
# Impact of tsunami on survival of 0-1 year-old juveniles -Methods-



- Continuous monitoring of juvenile densities have been carried out since 2009.
- Density of juveniles was difficult to estimate by quadrat (patchy and cryptic). The abundance was monitored by intensive visual searching.
- The relative abundance was expressed as catch per unit effort (CPUE) accounting for the number of collected juveniles per searching time in hours.



# Seasonal changes in CPUE of 0-1 year-old abalone



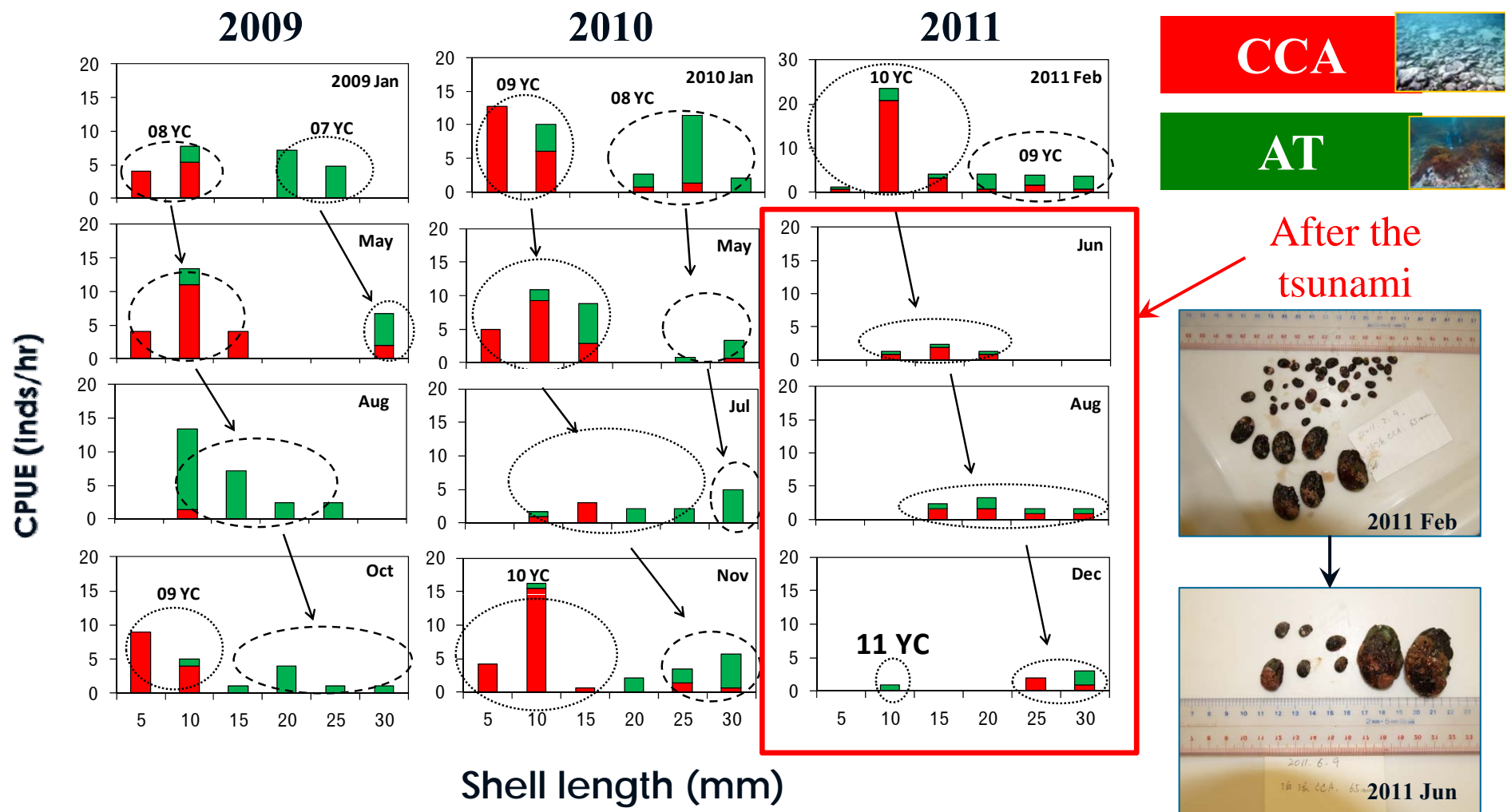
Adults inhabited in **KB**, but juveniles <30 mm SL were not observed in **KB**.

From winter to spring, 0-year-old CPUEs were high in **CCA**.

↓  
From spring to summer, CPUEs in **CCA** were decreased, while increased in **AT**

In autumn and winter, the next year class occurred in **CCA**

# Impact of the tsunami on 0-1 year-old abalone



- Dramatic reduction of 2010 YC after the tsunami was caused by catastrophic wave action.
- New recruit after the tsunami (2011 YC) was negatively affected by the sedimentation covering their nursery ground, CCA.

# Impacts of the tsunami on rocky shore ecosystem at three sites on Sanriku coast



**Otsuchi**

Dec. 2010 vs  
Jul 2011

**Iwaisaki**

Feb 2011 vs  
Jun 2011

**Tomarihama**

Feb 2011 vs Jun 2011

Kelp biomass	Density of adult abalone	CPUE of juvenile abalone	Density of sea urchin
Not significant →	Not significant →	Significant ↘	Significant ↘
Not significant →	Not significant →	Significant ↘	Significant ↘
Not significant →	Significant ↘	Significant ↘	Significant ↘



# Conclusion 1

- The impact of tsunami was more profound in AT and CCA than in KB. In KB, the turbulent flow induced by the tsunami might have been attenuated by the presence of the algal canopy.

Deeper ←

→ Shallower



Large reduction of juvenile abalone and sea urchin



Adult abalone survived

Kelp biomass did not change

# Conclusion 2

- Juvenile abalone and sea urchins largely decreased after the tsunami. Most of these animals inhabited AT and CCA.



Large reduction of juvenile abalone and sea urchin



Adult abalone survived

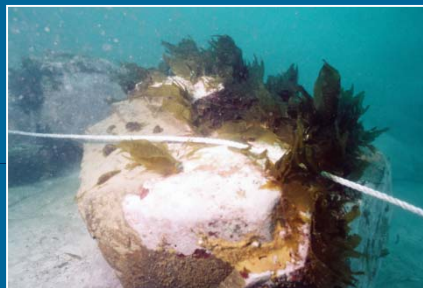
Kelp biomass did not change

# Conclusion 3

- Juvenile macroalgae were observed in CCA after the tsunami. Decreased grazing pressure by large-scale removal of sea urchins. Tsunami affects the succession of algal species indirectly through the changes in the grazing pressure of herbivores.



Large reduction of urchin and  
dense recruit of macroalgae



Adult abalone  
survived

Kelp biomass  
did not change

# Conclusion 4

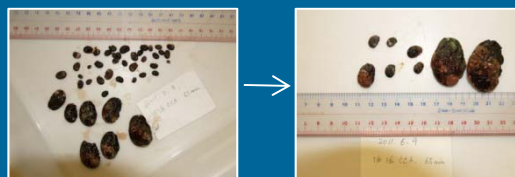
- The youngest year class of abalone was seriously damaged by the tsunami. Since the age at first capture of abalone is 4 to 5 year olds, the future commercial catch may decrease at least after 3 to 4 years from the tsunami.



## Recruitment failure of juveniles

Disturbance by catastrophic wave action

Sedimentation covering nursery ground, CCA



Adult abalone survived

Kelp biomass not changed

# Further studies

to dig into deeper to understand the impacts of the huge disaster



- Conducting the continuous monitoring to understand the recovering process of abalone and urchin populations.



- Analyzing the data of before/ after comparisons of other benthic organisms to fully understand the effects on rocky shore ecosystems.



**TO BE  
CONTINUED...** →

Thank you for your attention.

We also thank **PICES members** for your praying and support after the Japanese mega-earthquake and tsunami.

ARIGATOU!!



This study was partly supported by the **Coastal Ecosystem Complex** of Ministry of Education, Culture, Sports, Science and Technology Japan.

