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

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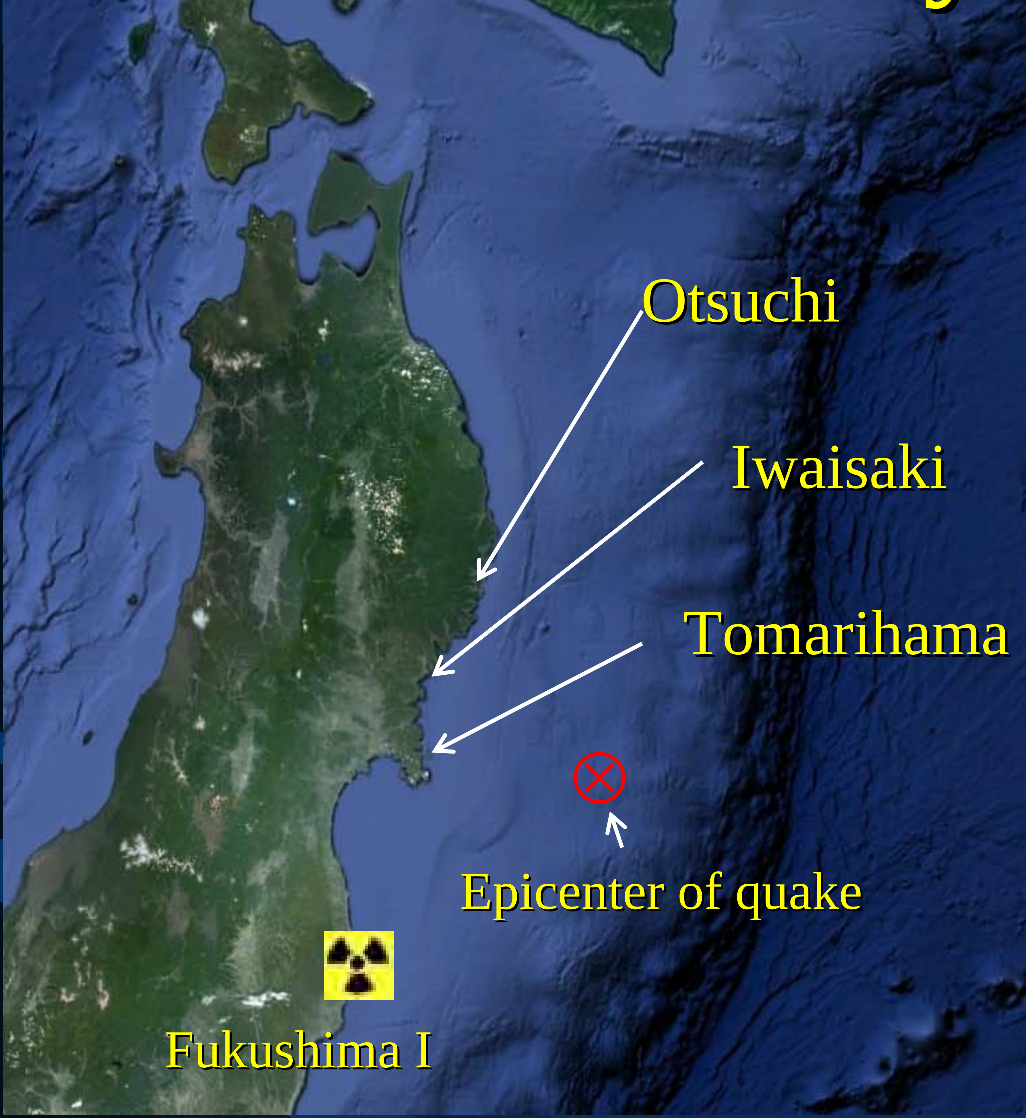
Background

- 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

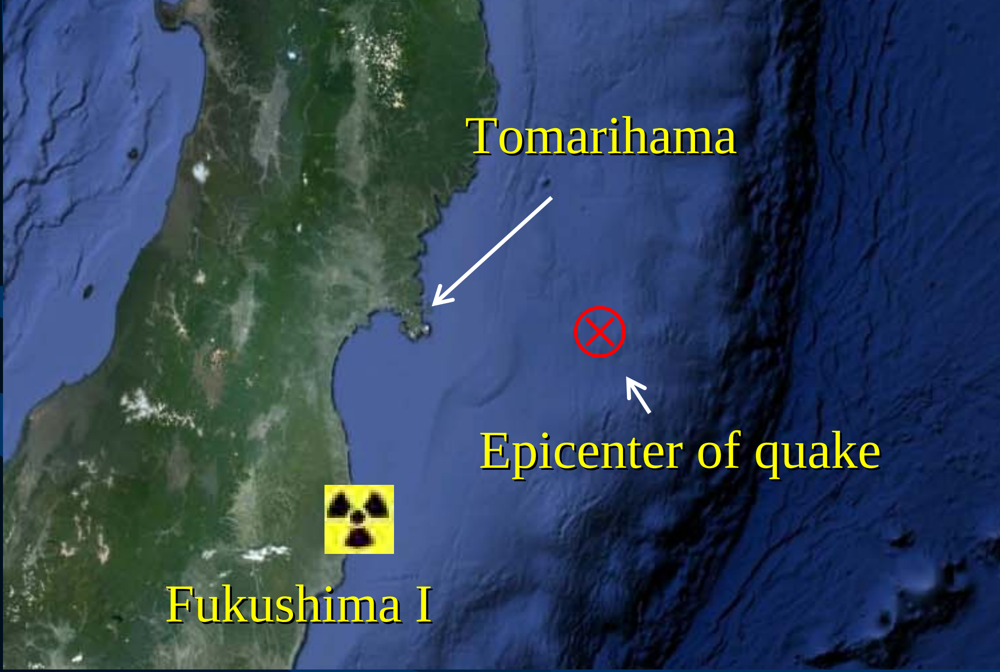


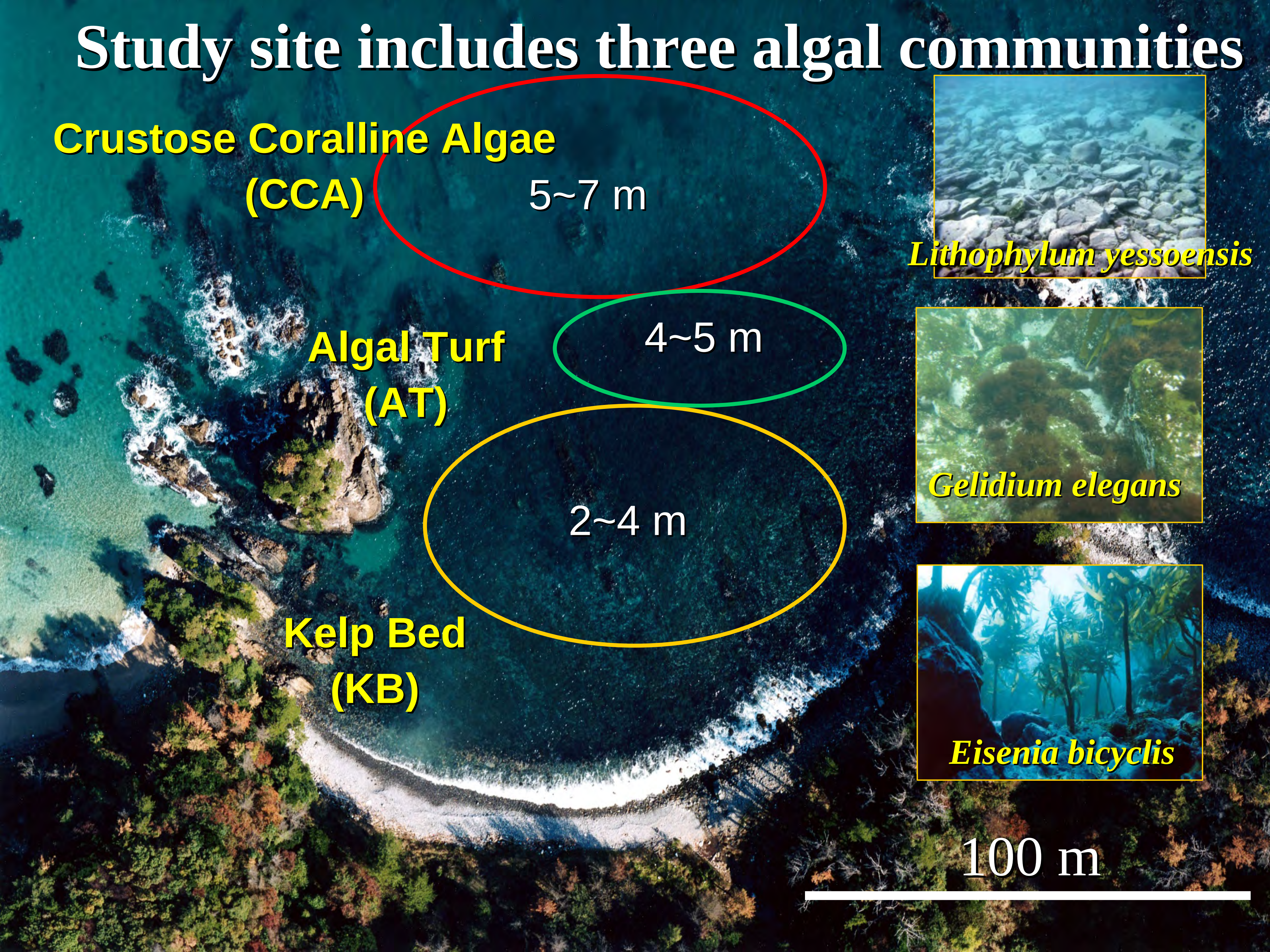
Before the quake, quantitative analyses on the populations of abalone and sea urchin were regularly carried out.

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

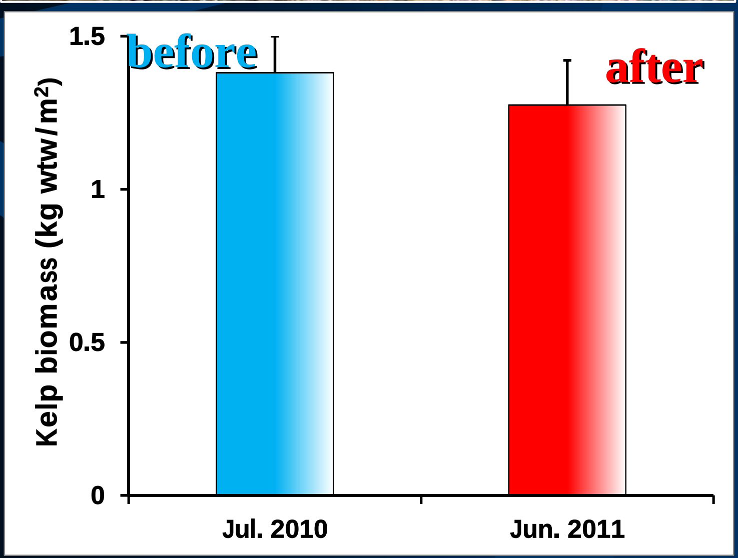
Main study site: Tomarihama on Oshika Peninsula, Miyagi

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




Study site includes three algal communities
Crustose Coralline Algae
(CCA)
5~7 m
Algal Turf
(AT)
4~5 m
Kelp Bed
(KB)
2~4 m
Lithophylum yessoensis
Gelidium elegans
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

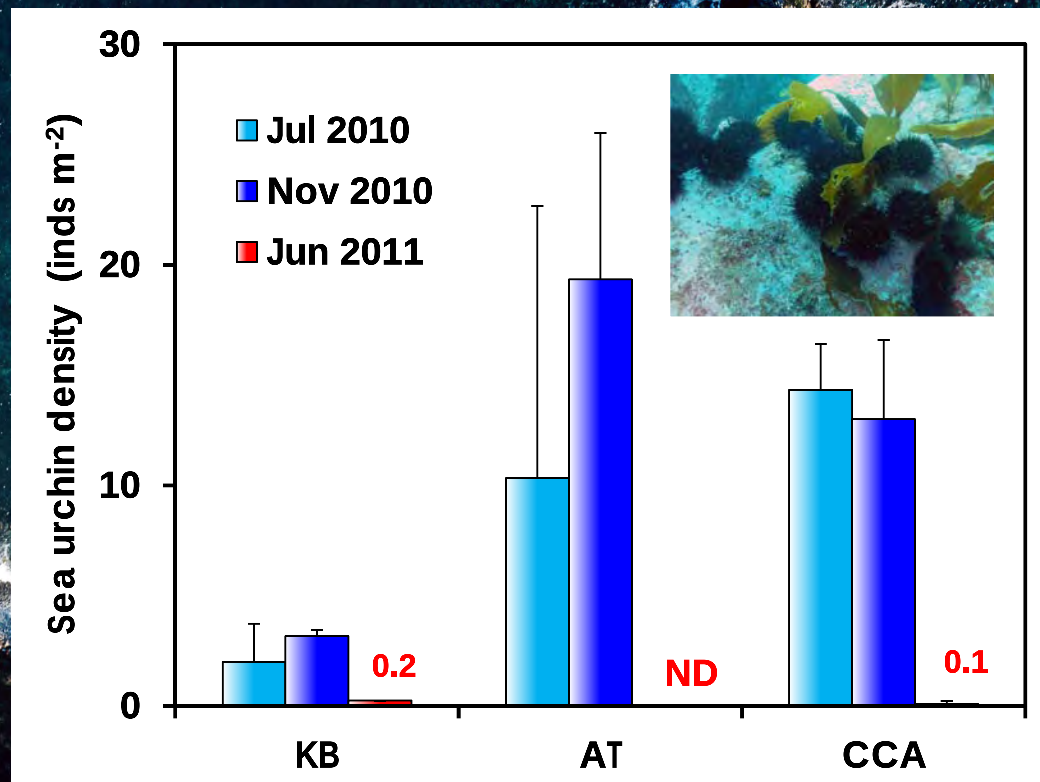
Methods

- 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).

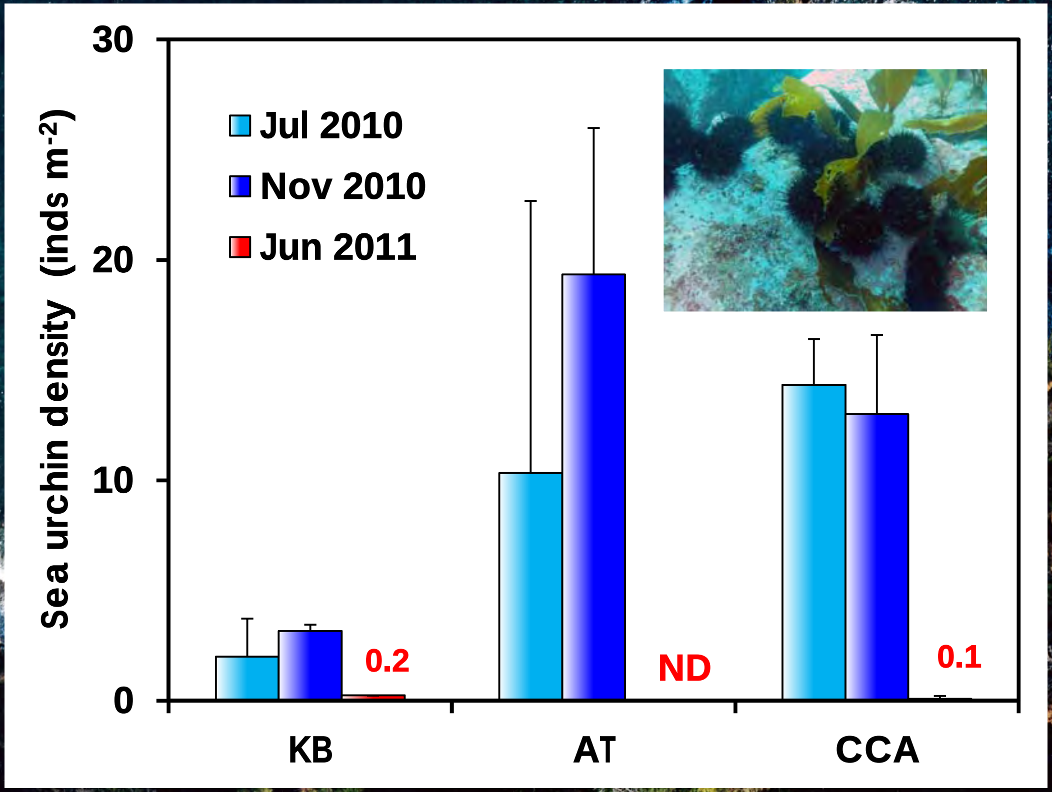
Changes in urchin density between before and after the tsunami



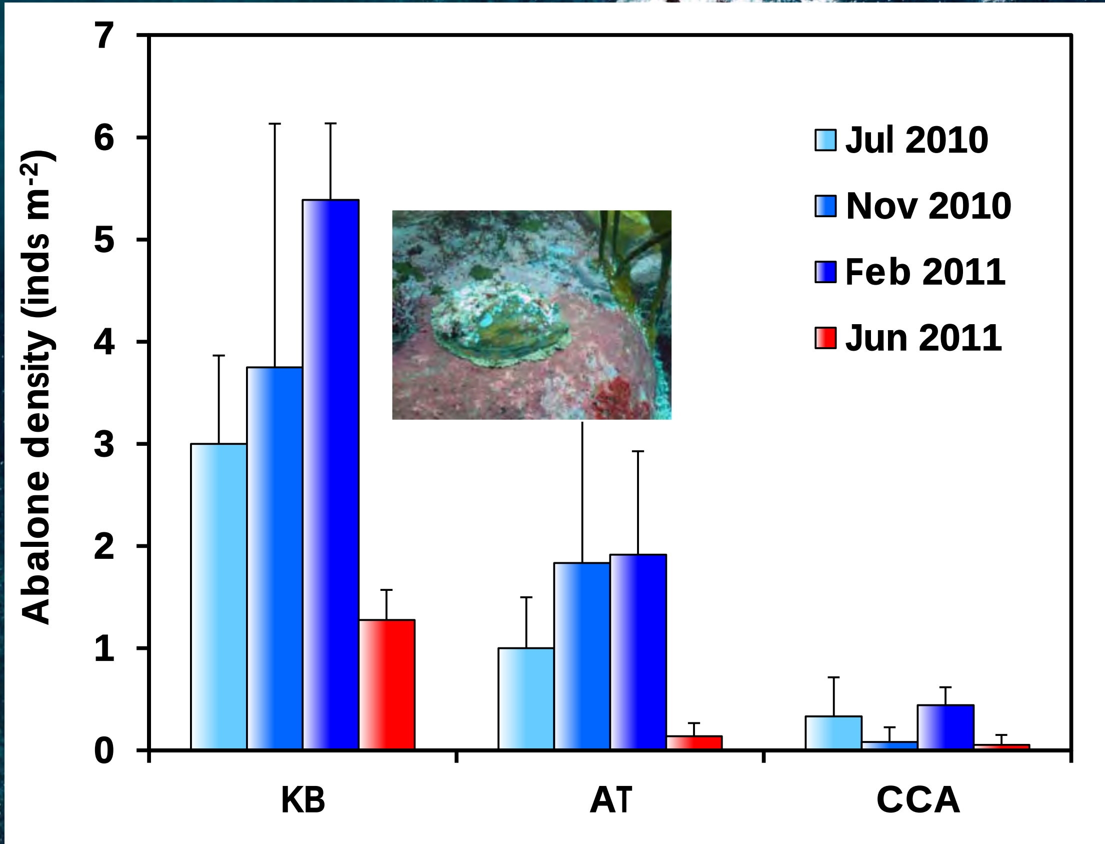
Changes in urchin density between before and after the tsunami

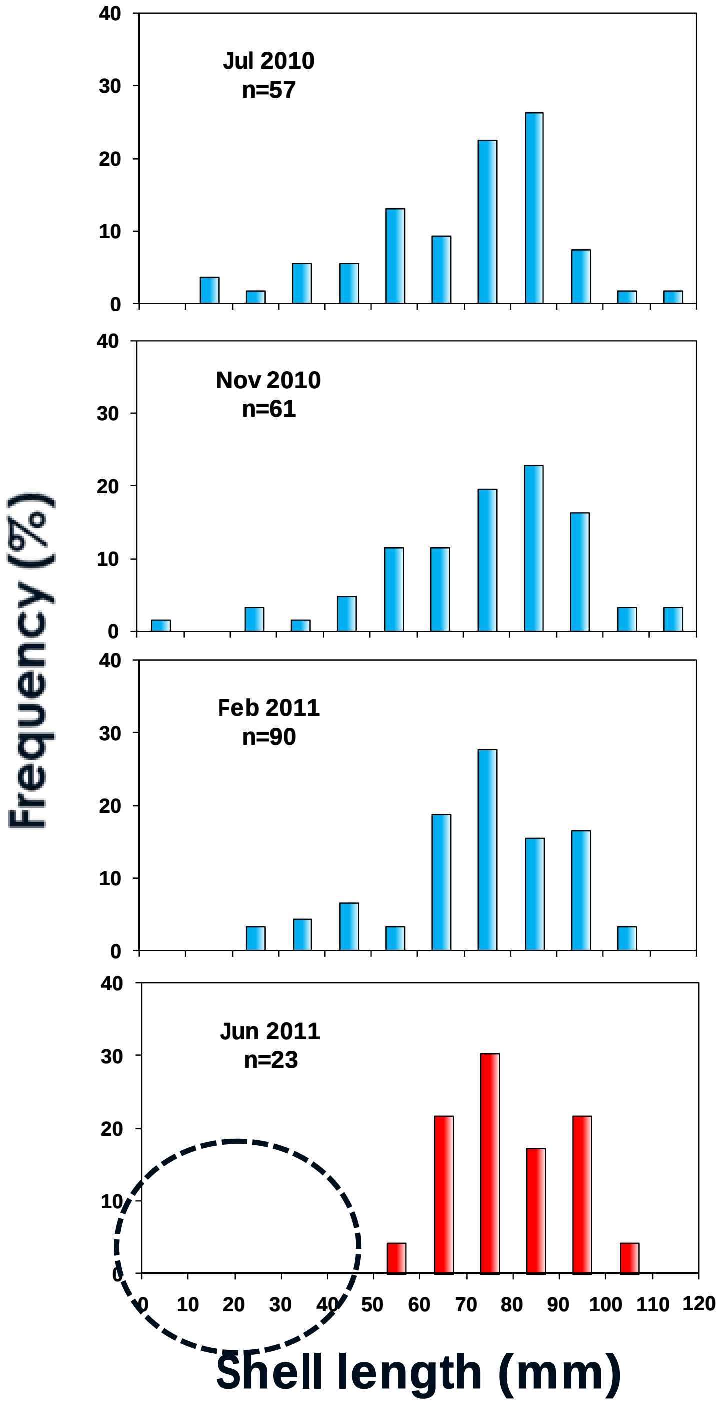
CCA: grazer resistant, dominating under high grazing pressure of urchins.

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





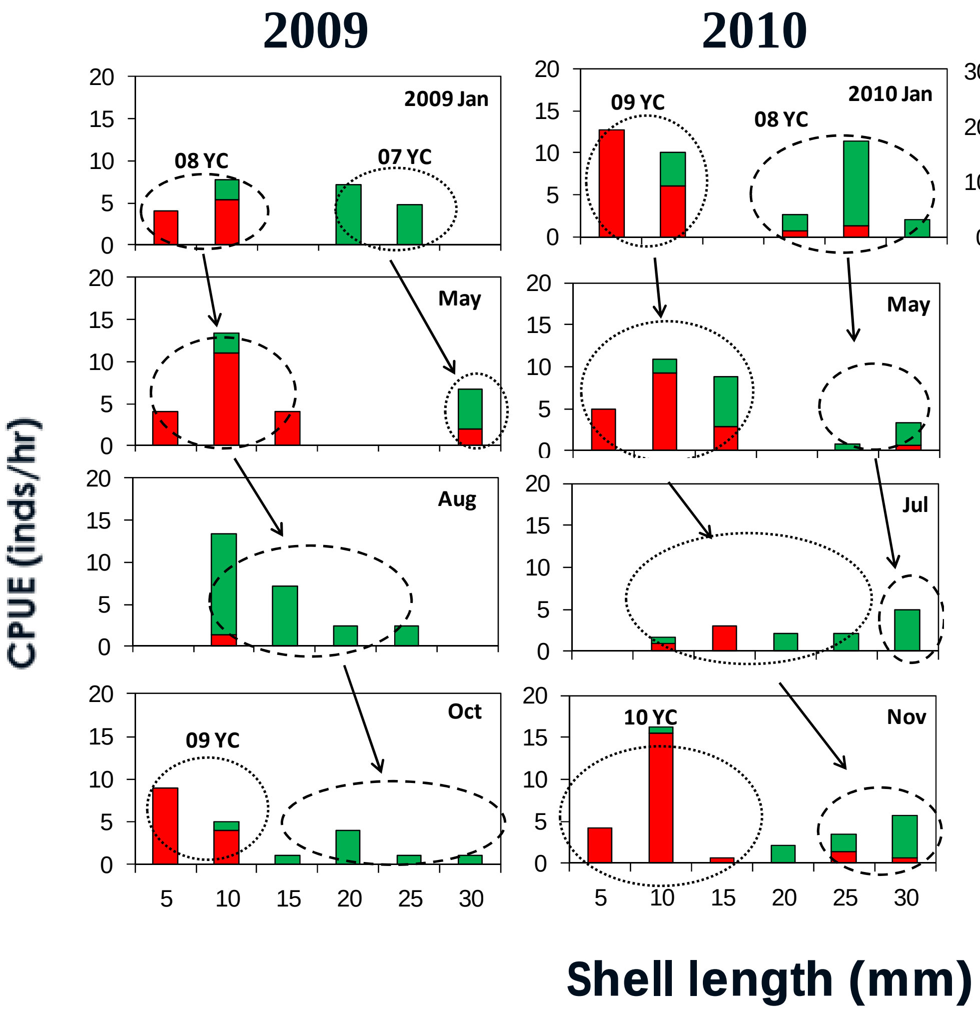
Changes in size distribution of abalone between before and after the tsunami

- 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



CCA 

AT 

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

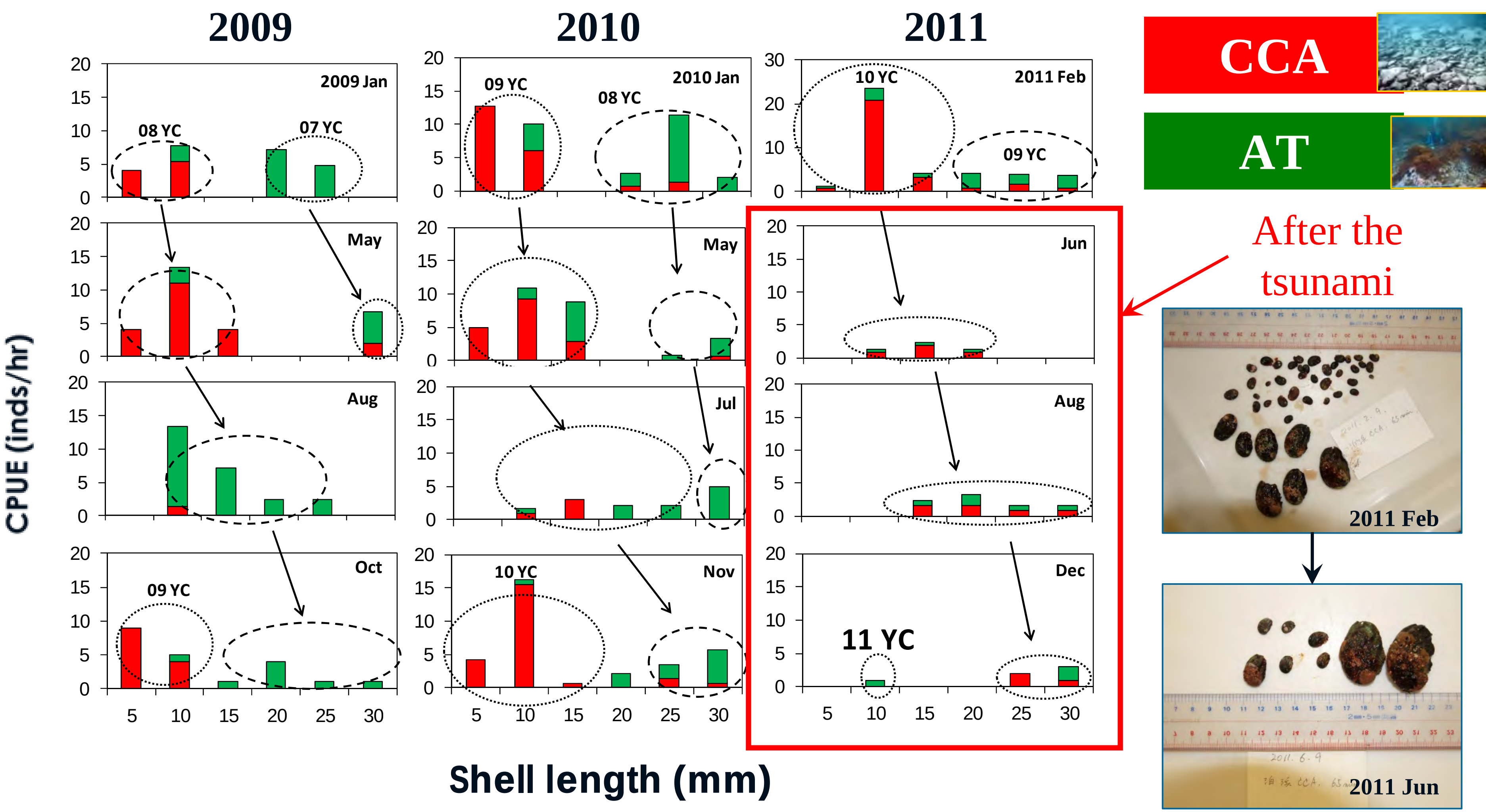
From winter to spring, 0-year-old CPUEs were high in CCA.

↓

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

Site	Kelp biomass	Density of adult abalone	CPUE of juvenile abalone	Density of sea urchin
Otsuchi	Not significant →	Not significant →	Significant ↘	Significant ↘
Iwaisaki	Not significant →	Not significant →	Significant ↘	Significant ↘
Tomarihama	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

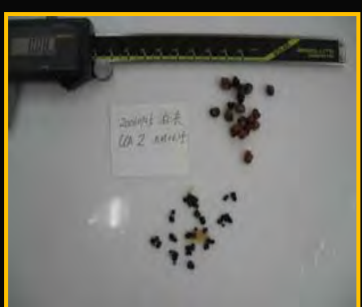
Kelp biomass not changed

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.



Thank you for your attention.

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

ARIGATOU!!

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Coastal Ecosystem Complex