# Post-tsunami oyster feeding environment in Miyagi prefecture


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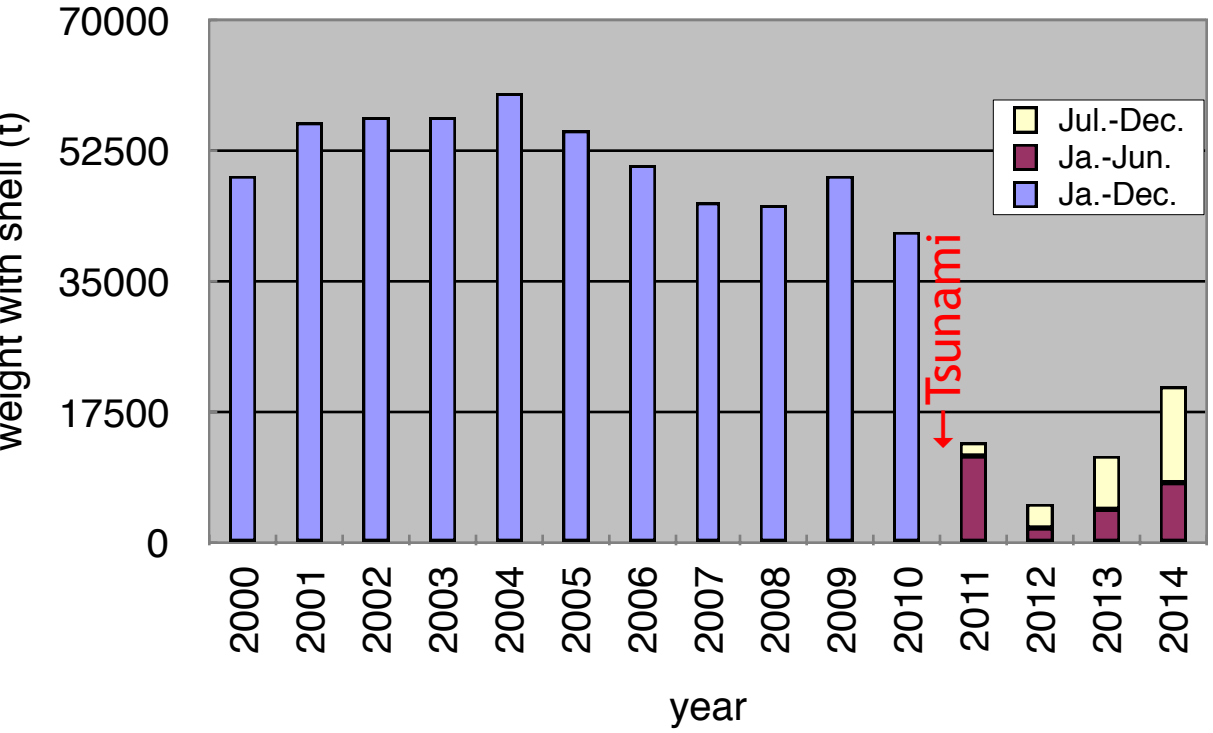
# Purpose

Temporal trend of oyster production in Miyagi Prefecture




Post-tsunami oyster harvest levels (about 20,000 tons/year with shell) are higher than just after-tsunami level (5,000 tons/year).

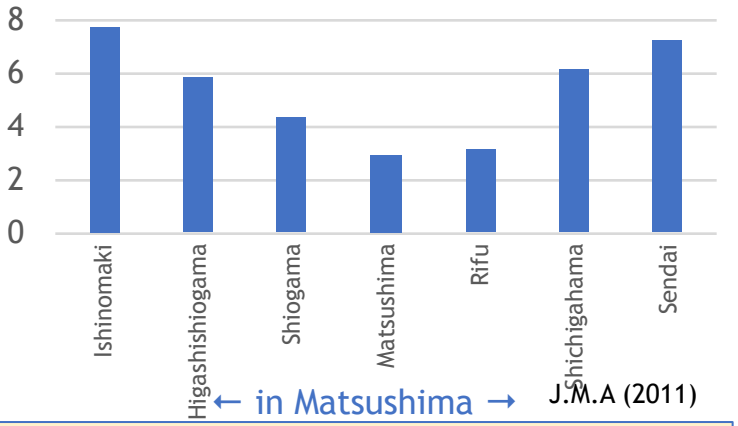
Although the levels are lower than pre-tsunami levels (40,000–60,000 t/year), oyster stocks within the Miyagi Prefecture have gradually recovered.

To aid recovery of oyster production, it was necessary to investigate the feeding environment and estimate a suitable stock density for the region.

# Tsunami in closed bay, Matsushima Bay (Backwash of second wave, about 1min)

This video was taken from the laboratory.


From Google Map




J.M.A (2011)

Although the height of the tsunami was lower inside the closed bay than outside of it, numerous recreational boats and bamboo pieces used in Porphyra culture were swept out. The tsunami's influence on the aquaculture industry within the bay quickly became a concern.

# Research papers on the influence of tsunami to phytoplankton, which is main diet of oyster

| Area | Methods | Target | After tsunami | Data before tsunami | References | |
|---|---|---|---|---|---|---|
| Kesennuma Bay | Microscopic observation | dinoflagellates | increase cysts | No | Nishitani et al. | (2013) |
| | Pigment profile | biomass | no change | Yes | Okumura et al. | (2015) |
| Ofunato Bay | Microscopic observation | dinoflagellates | increase cysts | Yes | Kaga et al. | (2012) |
| | Pigment profile | biomass | increase biomass | Yes | Okumura et al. | (2015) |
| | Dna sequence | all species | Diversity change | Yes | Okumura et | (2017) |
| Sendai Bay | Microscopic observation | dinoflagellate | cysts | Yes | al. | (2014) |

The present or absent of the tsunami effect on phytoplankton differ, in spite of the same area.

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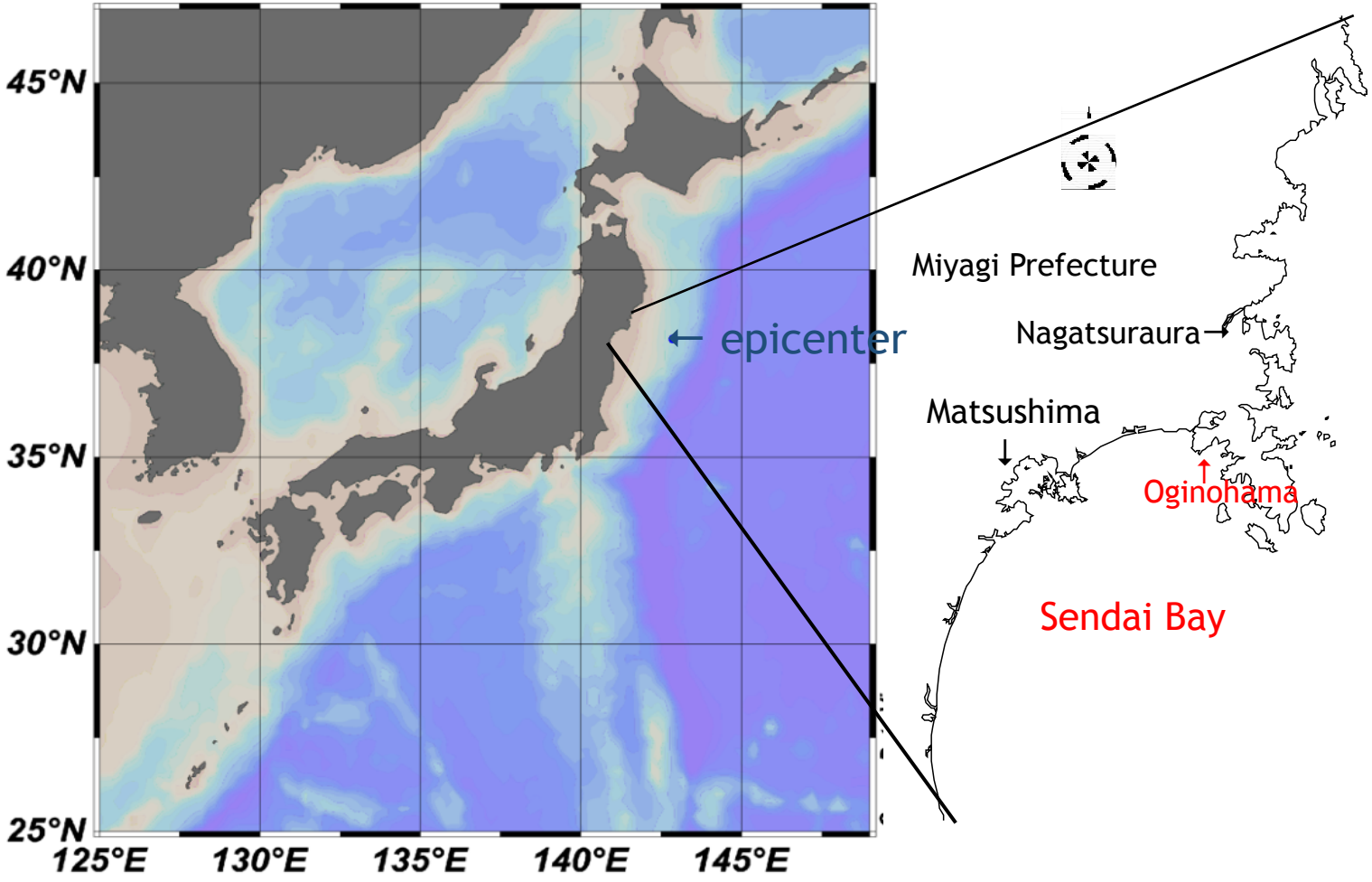
Many researcher have investigated specific phytoplankton and biomass. While, the research of phytoplankton assemblages is limited. We presumed the reason why present or absent of the tsunami effect on phytoplankton differs in the same area is the difference of target phytoplankton species.

In this study, we compared phytoplankton biomass and phytoplankton diversity before and after the tsunami in Sendai Bay.

# Sampling sites

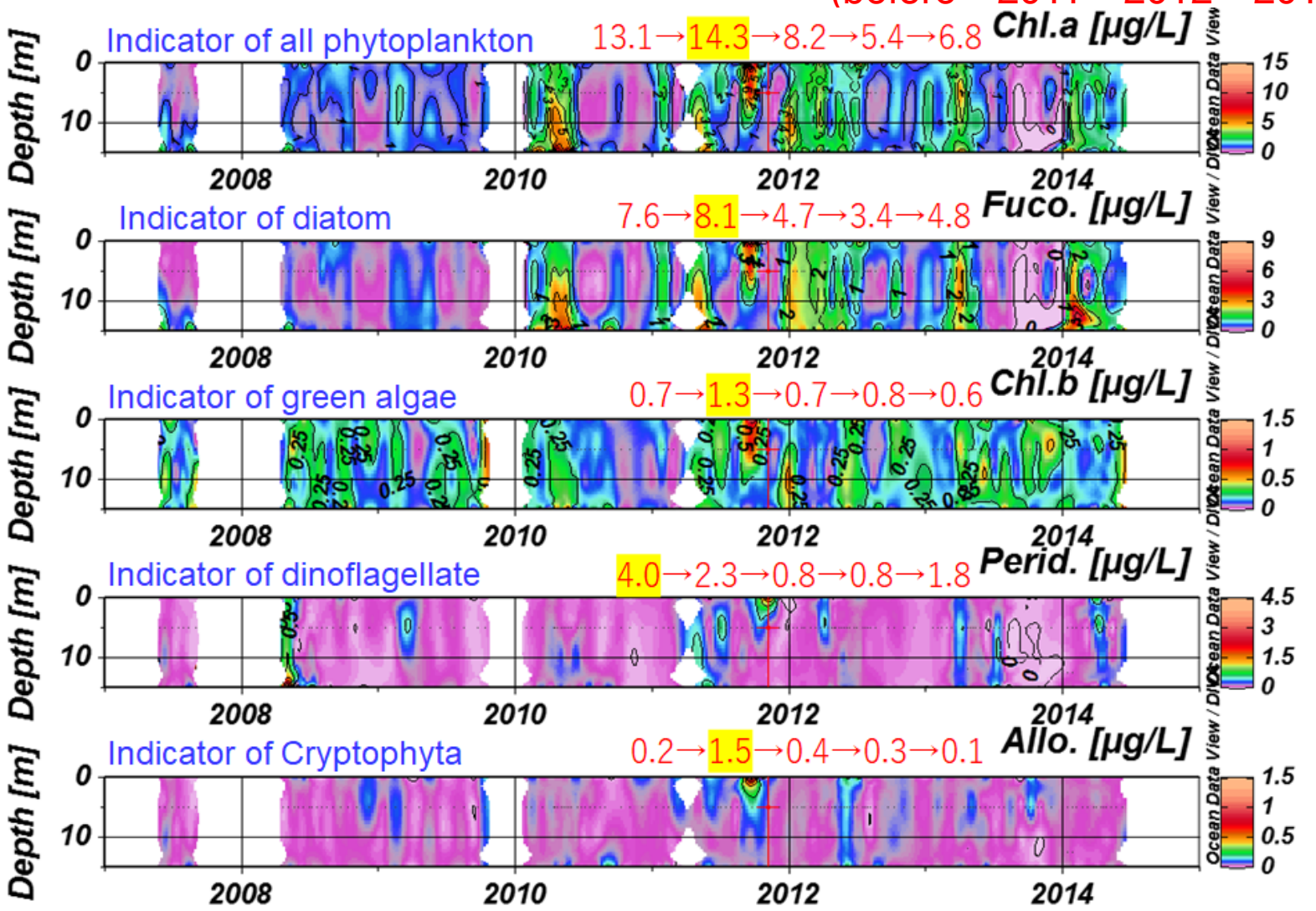



We investigate the dietary environment of oysters in Oginohama Bay (HPLC), and the phytoplankton diversity in Sendai Bay (microscopic observation).

# Temporal trend of pigments

Maximum of pigment contents

(before→2011→2012→2013→2014)

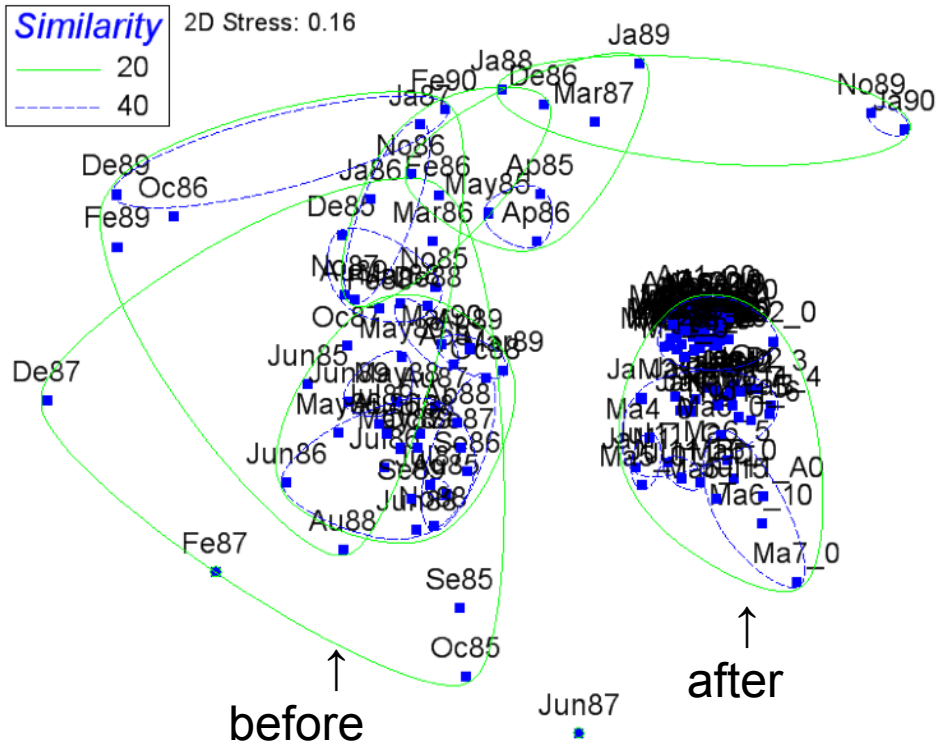



In Oginohama, spring bloom was observed. Chl a and many pigment concentrations were high after the tsunami. The contour figure of Fuco was similar to Chla. Diatom was predominant taxa.

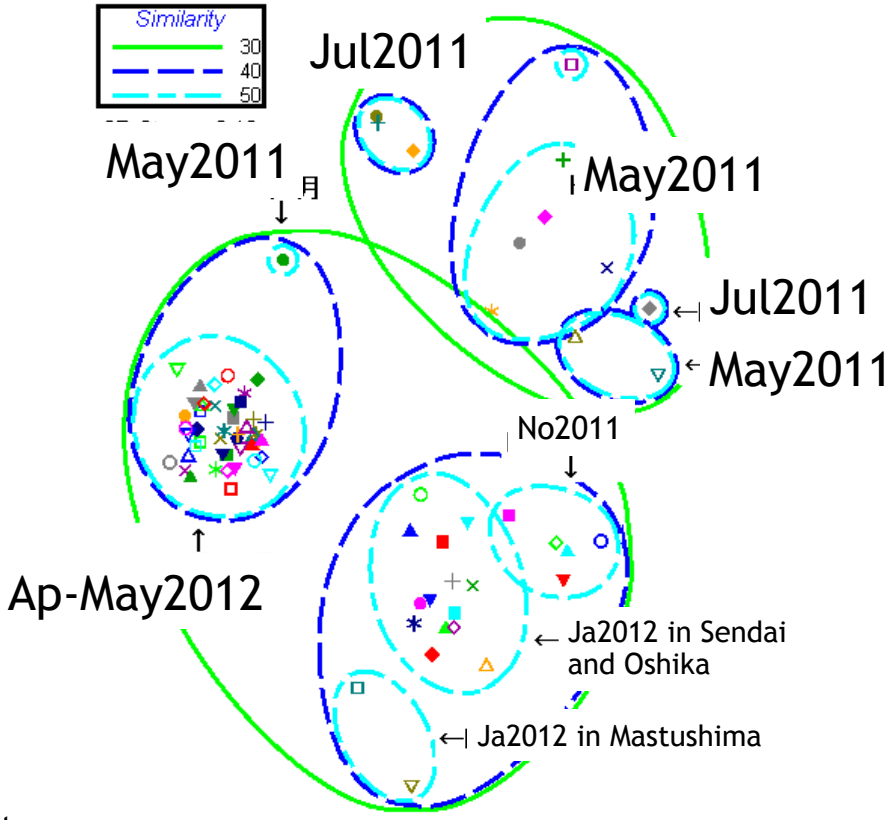
# Phytoplankton diversity in Sendai Bay

## Similarity of phytoplankton data by microscopic observation using nMDS

The comparison of before (1985-1990) and after the tsunami




Only after the tsunami



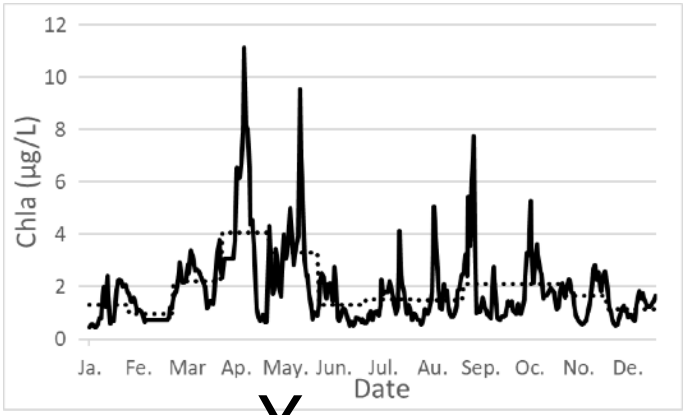

Data from 1985 to 1990 were published by Sendai city.

Phytoplankton diversity was different before and after the tsunami.
After the tsunami, phytoplankton diversity varied with the periods.

# Calculation method of the suitable culture density of oyster

We defined the suitable oyster culture quantity as phytoplankton quantity in the aquaculture areas minus the total filtration, and that value is more than zero.

Phytoplankton biomass

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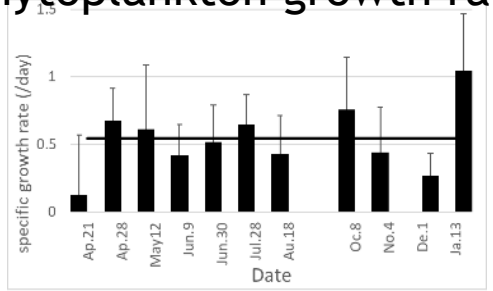
Phytoplankton growth rate




Phytoplankton growth in the culture area was calculated by multiplying Chl *a* concentration by average growth rate.

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Total filtration was calculated by multiplying total biomass by filtration rate.

Equations of filtration rates by oyster and the periphyton

| species | calculations (F) | D.W./ W.W. | conditions | references |
|---|---|---|---|---|
| Crassostrea gigas | $0.26e^{(0.1584xT)} \times WW$ | | T<11.8 | Okumura personal communication |
| | (0.70 x T - 6.6) x WW | | 11.8 < T<18.5 | Akashige et al. (2005) |
| | 4.9 x WW | | 18.5 < T | Akashige et al. (2005) |
| Mytilus galloprovincialis | $6.773 \times DW^{0.678}$ | | | Riisgard et al. (2014) |
| | | 5(%) | | Miura et al. (2013) |
| Ascidiella aspersa | $54.4 \times DW^{1.05}/1000 \times 60$ | 5(%) | conversion from ml/min | Randlov and Riisgard (1979) |
| Ciona intestinalis | $46.4 \times DW^{0.84}/1000 \times 60$ | 5(%) | conversion from ml/min | |
| Styela clava Herdman | $\exp(0.119T-4.54) \times DW^{0.6745}$ | 8.5(%) | T<29 | Kim Y.S. and Moon T.S. (1998) |
| Halocynthia roretzi | $(0.1956+0.0182T) \times DW^{0.7978\exp(-0.0273T)}$ | | 5<T<25 | Jeong W.G. and Cho S.M. (2013) |
| | | 12.2(%) | | Yamamoto and Handa (2001) |
| Halocynthia aurantium | We substituted the calculation of H. roretzi. | | | |

F: filteration (l/ind./h), DW: dry weight (g), T: temperature, WW: wet w

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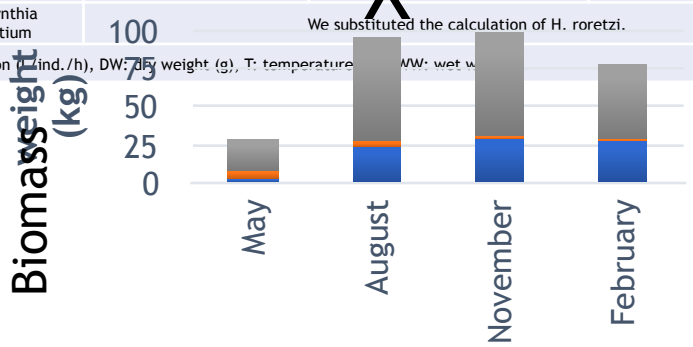


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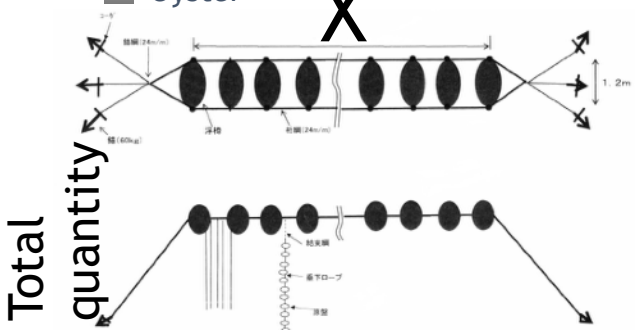
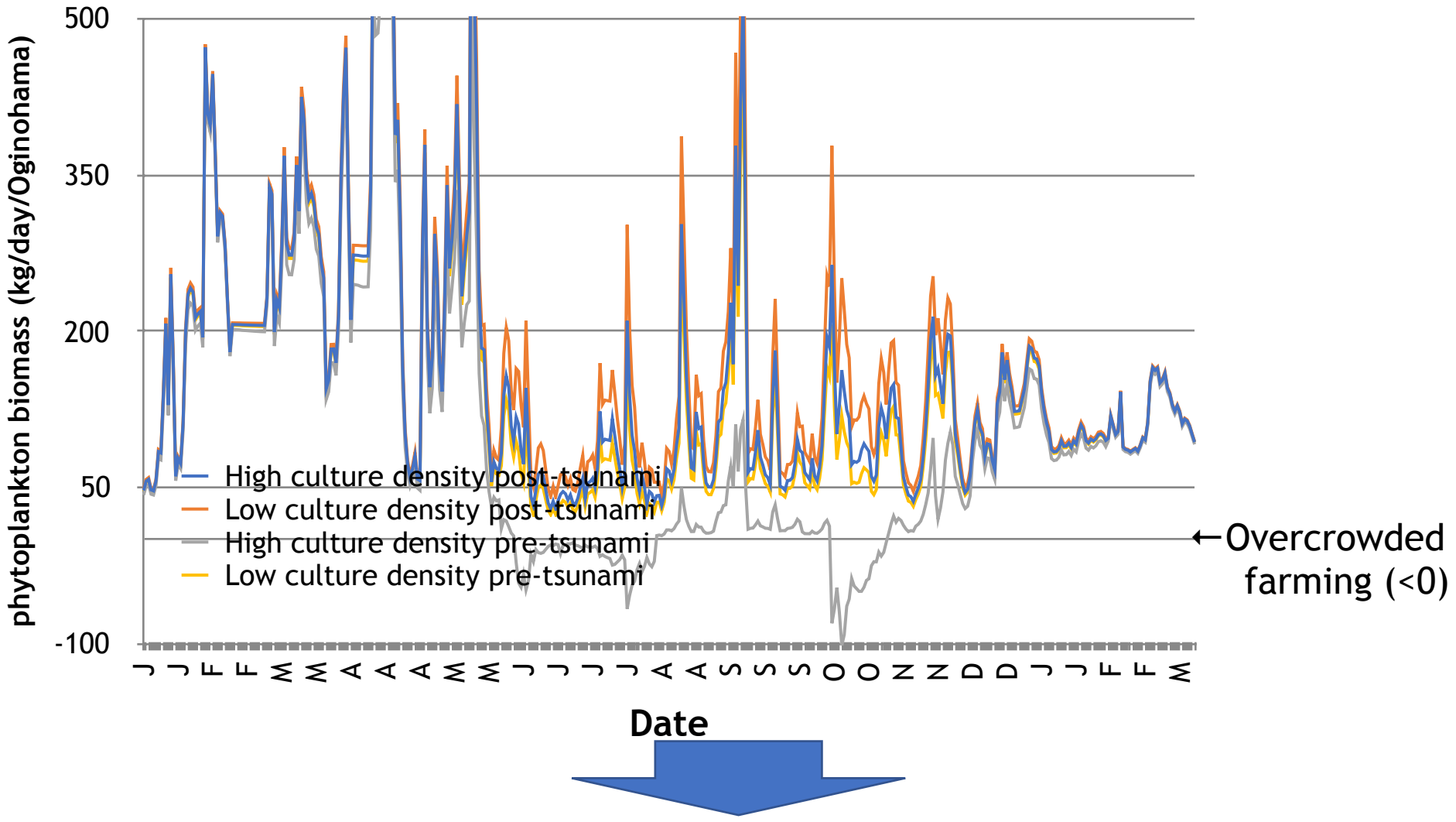
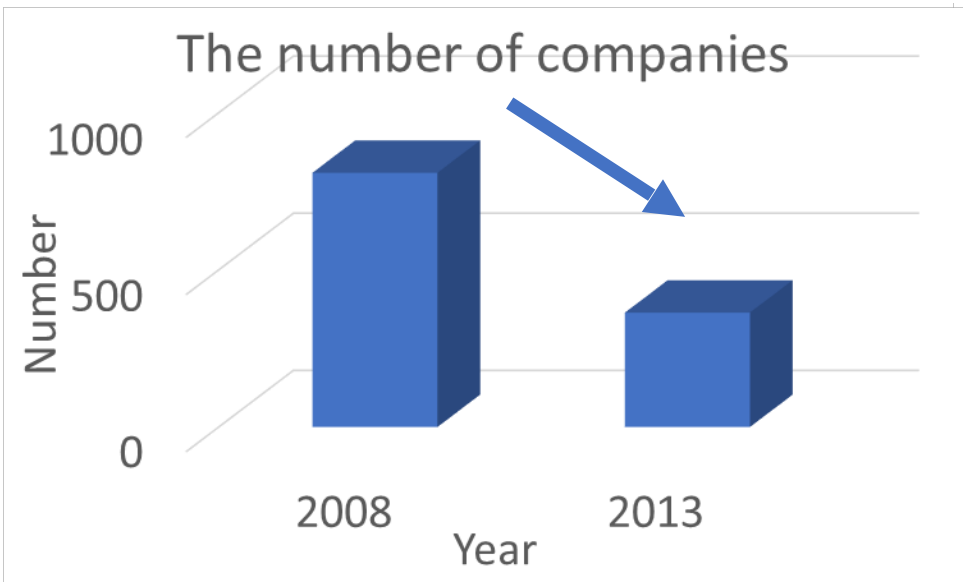


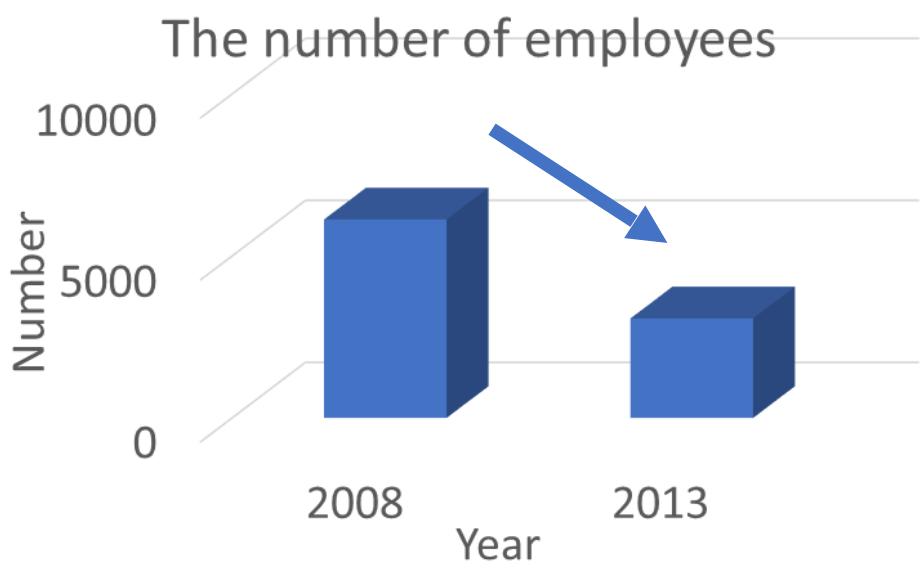
# Estimation of suitable culture density




By current estimations, we believe that a hanging-culture quantity at present condition would not constitute overcrowding. While, we believe that a hanging-culture quantity of “high culture density pre-tsunami“ condition would overcrowding.

# Various statistics on oyster culture in Miyagi prefecture

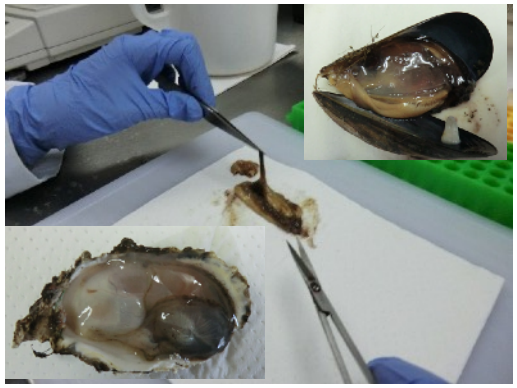



The number of companies producing oysters in 2008 and 2013 was 809 and 364, respectively. With the post-tsunami retirement of many employees, and reduction in number of companies, the total quantity of oysters in the aquaculture grounds has decreased. The aquaculture grounds are currently not overcrowded.

# Phytoplankton in several samples using Next Generation Sequencing (NGS)

## To investigate the food of the oysters



DNA extraction and purification from seawater, stomach and gut contents of Oyster and Blue mussel



PCR of Psb*A* gene, encoding the D1 protein of photosystem II

Mixing PCR products and NGS analys

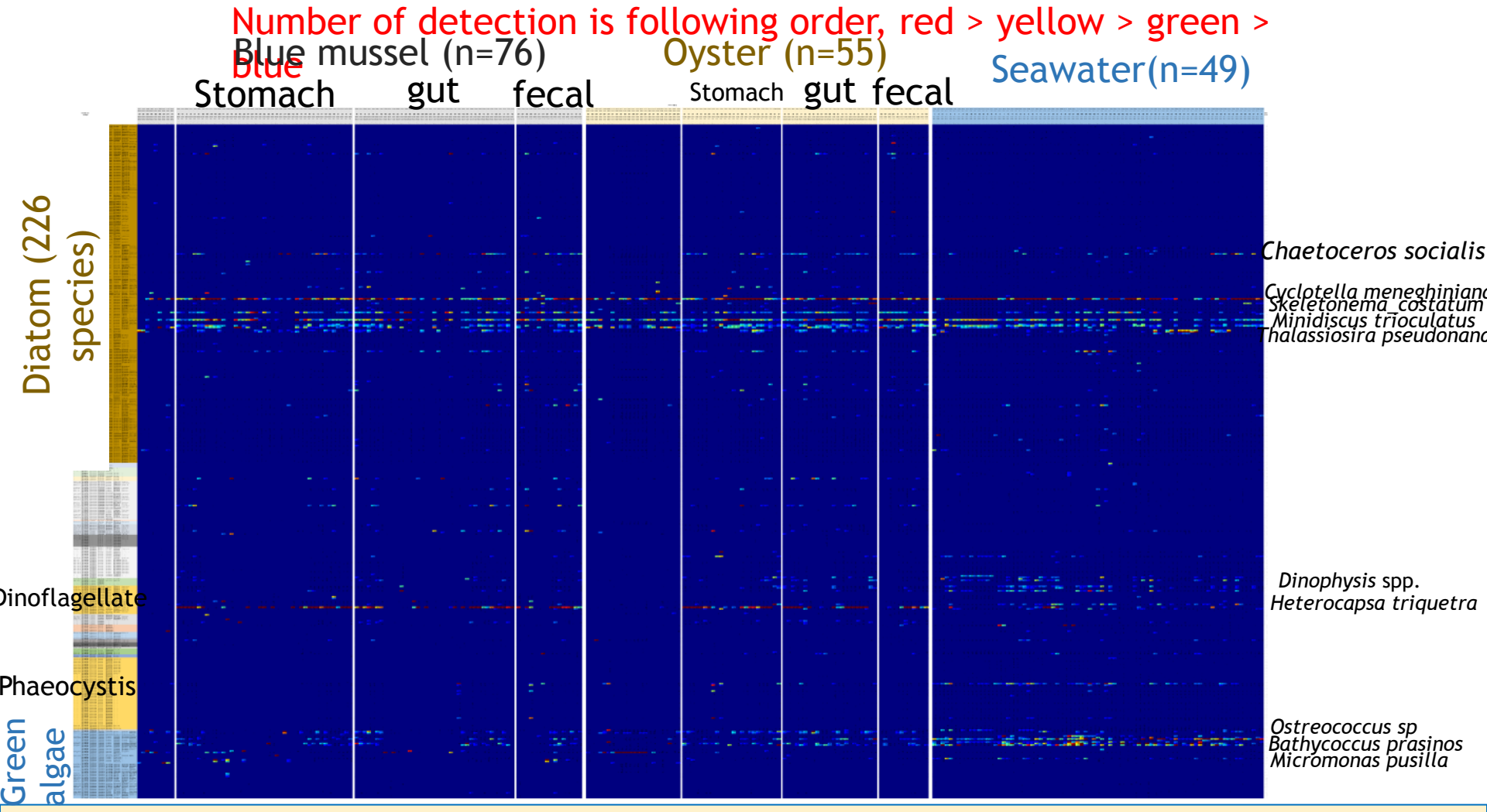
NCBI

Quantitative Insights Into Microbial Ecology

qiime

Creation of PsbA gene database from NCBI site and analysis by QIIME bio-pipeline

# Heatmap of phytoplankton detected from seawater and shellfishes




About 450 species were detected. Diatom was predominant taxa. Predominant diatoms were detected from both seawater and shellfishes. Dinoflagellate; *Heterocapsa triquetra* was mainly detected from shellfishes. Pico-prasinophytes were mainly detected from seawater.

# Summary

- In Oginohama, Chl *a* and many pigment concentrations were high after the tsunami. In Sendai Bay, phytoplankton diversity was different before and after the tsunami.
- By current estimations, we believe that a hanging-culture quantity at present condition would not constitute overcrowding.
- With the post-tsunami retirement of many employees, and reduction in number of companies, the total quantity of oysters in the aquaculture grounds have decreased.
- We could successfully determine phytoplankton species in seawater and shellfishes using NGS. Predominant diatoms were detected from both seawater and shellfishes. Dinoflagellate; *Heterocapsa triquetra* was mainly detected from oyster and blue mussel. We thought that the shell of *H. triquetra* was hard, and could not be digested by shellfishes. Pico-prasinophytes were mainly detected from seawater. We thought that the size of pico-prasinophytes were small (3μm), and could not be captured by shellfishes.