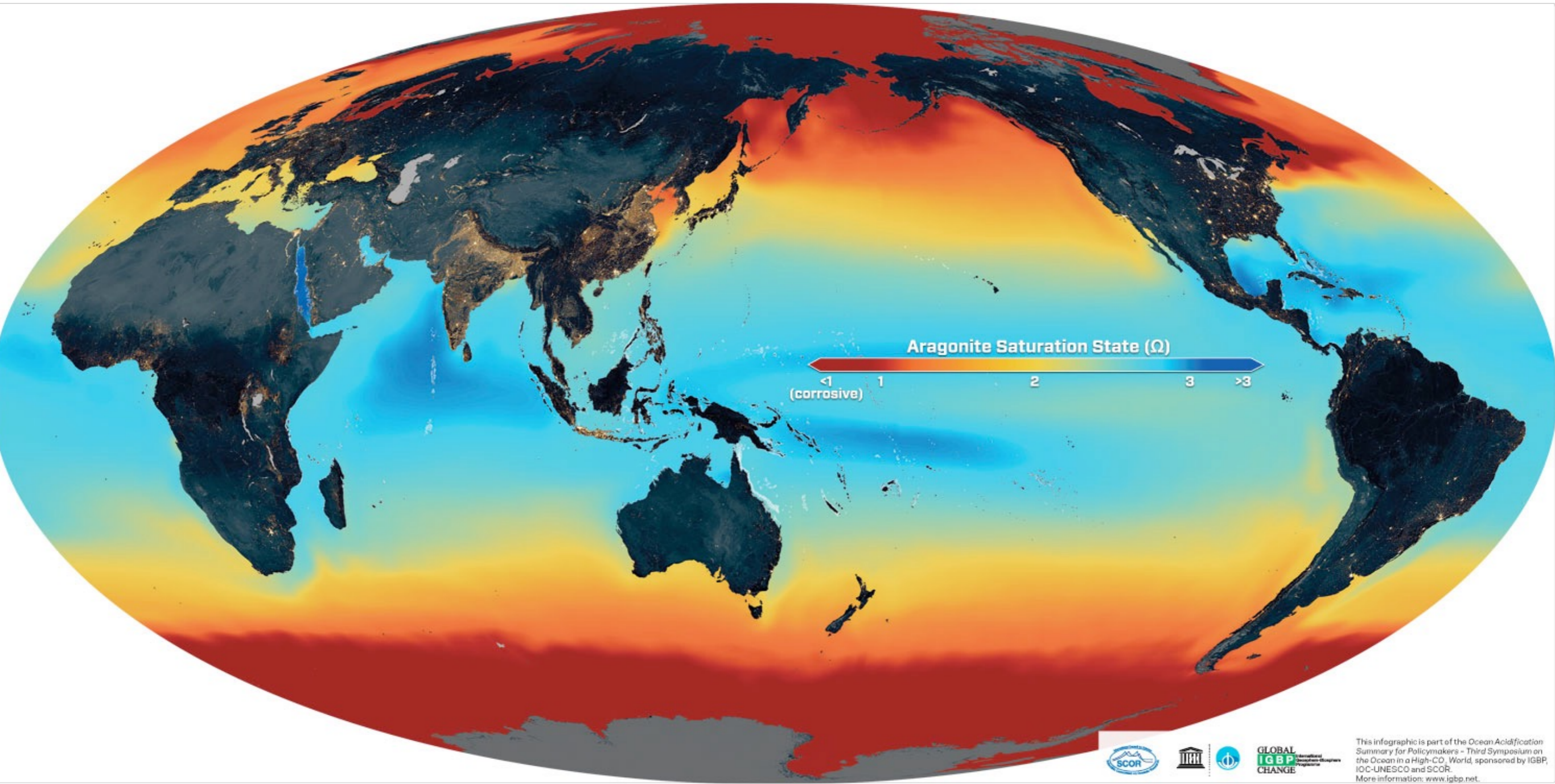




# **The biologic responses on the marine calcifiers to the Ocean acidification in the Arctic and North Pacific**

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JAMSTEC)**

# Aragonite saturation in 2100 ( $\Omega_{ara}$ )



polar & subarctic regions: low  $\text{CO}_3^{2-}$   $\rightarrow$  low  $\Omega$

saturation state ( $\Omega$ )  $\Omega = [\text{Ca}^{2+}] [\text{CO}_3^{2-}] / K'_{sp}$

$K'_{sp}$  : solubility product of calcite/aragonite

$\Omega > 1$ : precipitation(shell preserved)

$\Omega < 1$ : undersaturation (shell dissolved)

# Target Areas

**St. NAP: 75N, 162W**

deployment: Oct. 2010 ~ ongoing

2 Sed.Traps (200m, 1300m)

Water depth: 1,950m

**St. K2: 47N, 160E**

deployment: 2008~ ongoing

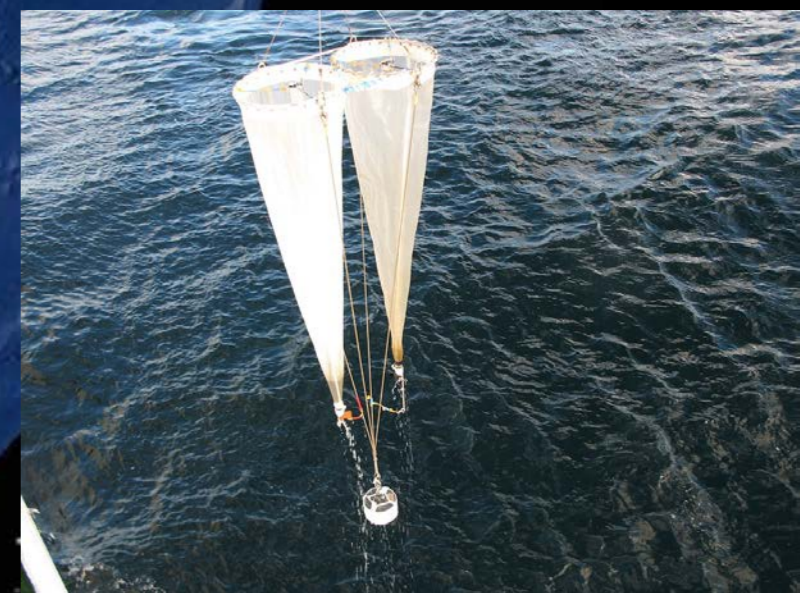
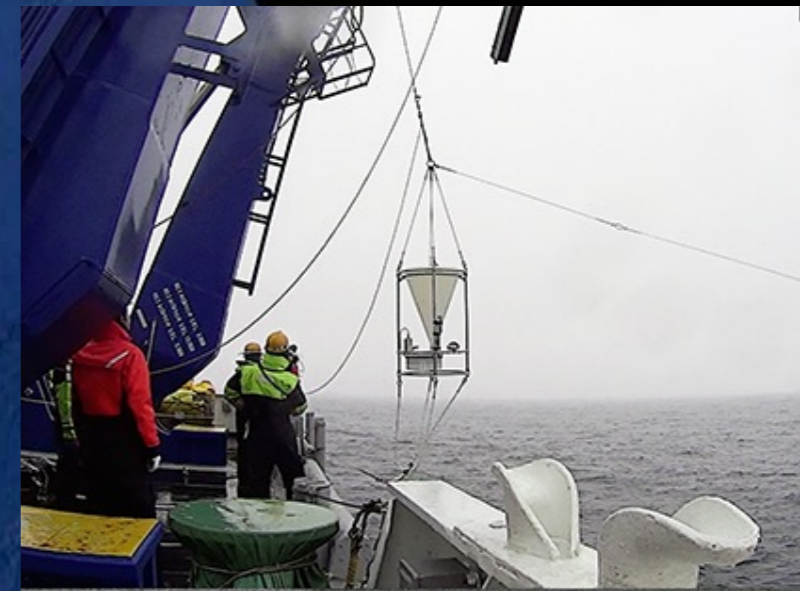
Multiple sed. traps (200m, 500m, 1000m, 4800m)

water depth 5,200m

Image IBCAO  
Image Landsat

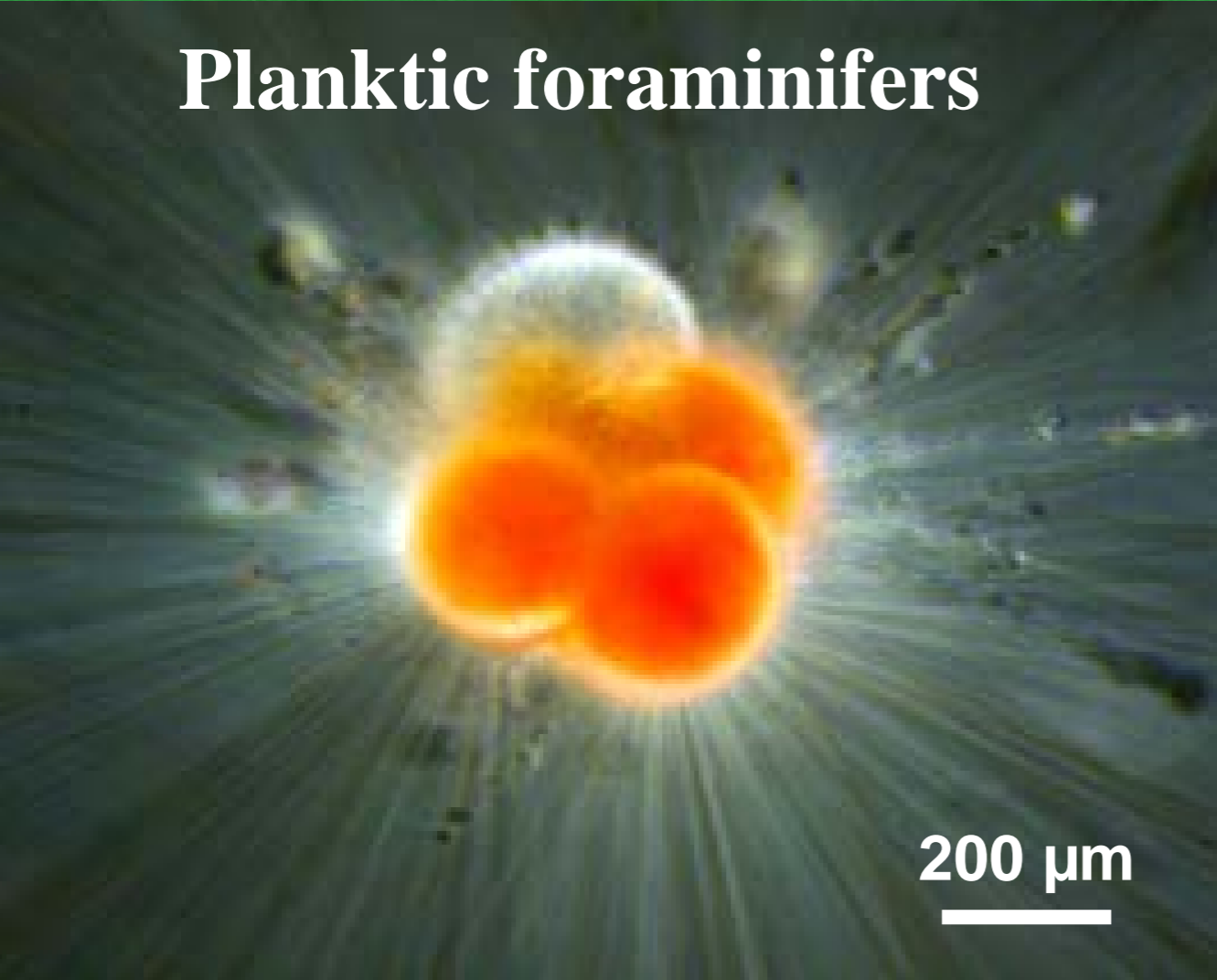
Data SIO, NOAA, U.S. Navy, NGA, GEBCO

画像取得日: 2013/4/10 55°26'41.87" N 144°57'57.99" E 標高 -205 m 高度 9195.16 km



# Marine calcifiers as the sentinel of OA

Planktic foraminifers



Thecosomata (Sea butterfly)



Major calcium carbonate producer in the pelagic ocean (~80%)

Planktic foraminifers Unicellular marine protist living in the world oceans

Develop calcite shells and 1 month lifetime.  
Inhabiting surface water (~200 m)

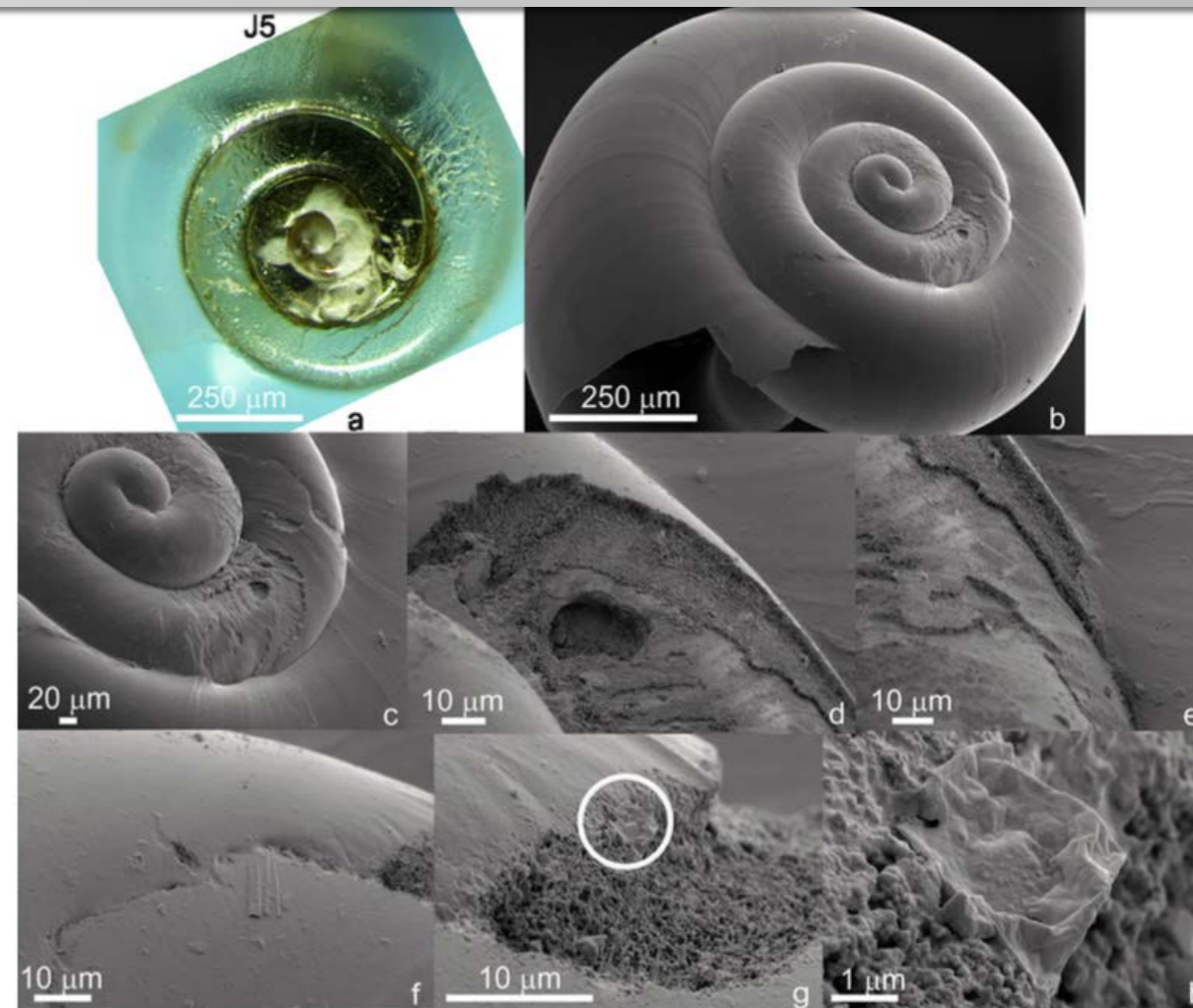
Thecosomata  
(Shelled pteropods)

Pelagic gastropod living in the world oceans  
Potential food source for fishes  
Develop aragonite shells and yearly lifetime.  
Inhabiting surface to deep water (~1000 m)

# Inhibition of calcification by OA

Reducing of carbonate ions by ocean acidification will accelerate inhibition of calcification of shelled plankton. So far, however, it does not well developed quantitative and comparable estimation method to evaluate biological impacts (damages) to the OA.

OA will make damages to the shell surface and thickness, probably affects shell density.



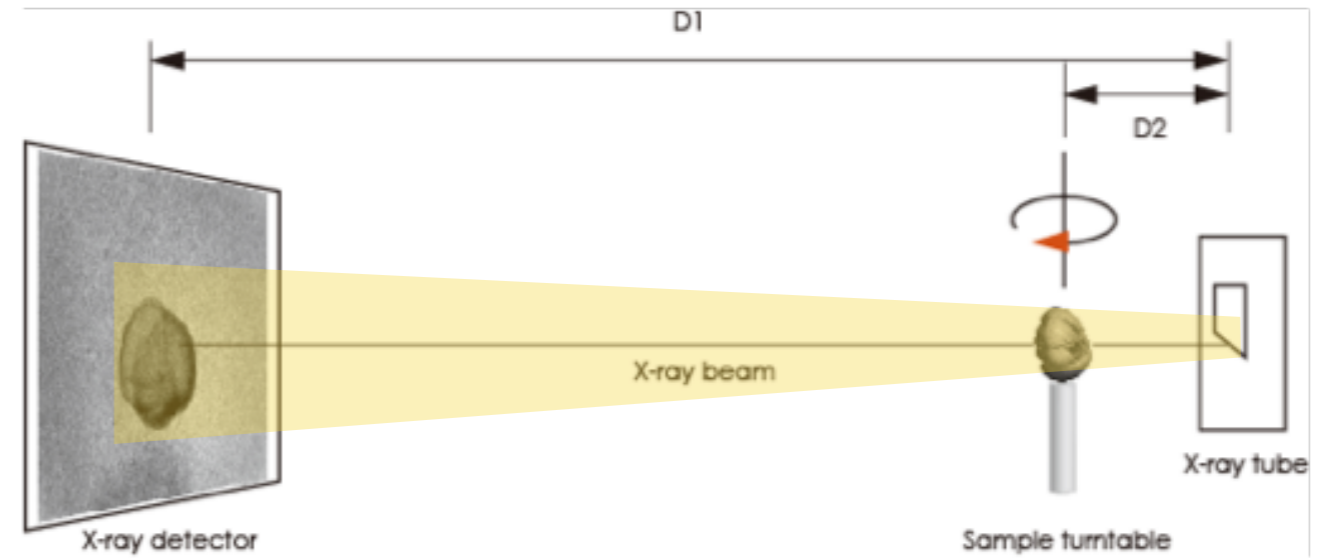
Peck et al. (2016)

**Quantitative estimation method of biological impacts should be needed**

# Microfocus X-ray CT (MXCT) technique



## Geometric layout



## CT Number

(proportional with density)

1000(highest density)  
= Limestone

Carbonate shell  
= 600~1000

Soft body  
< 600

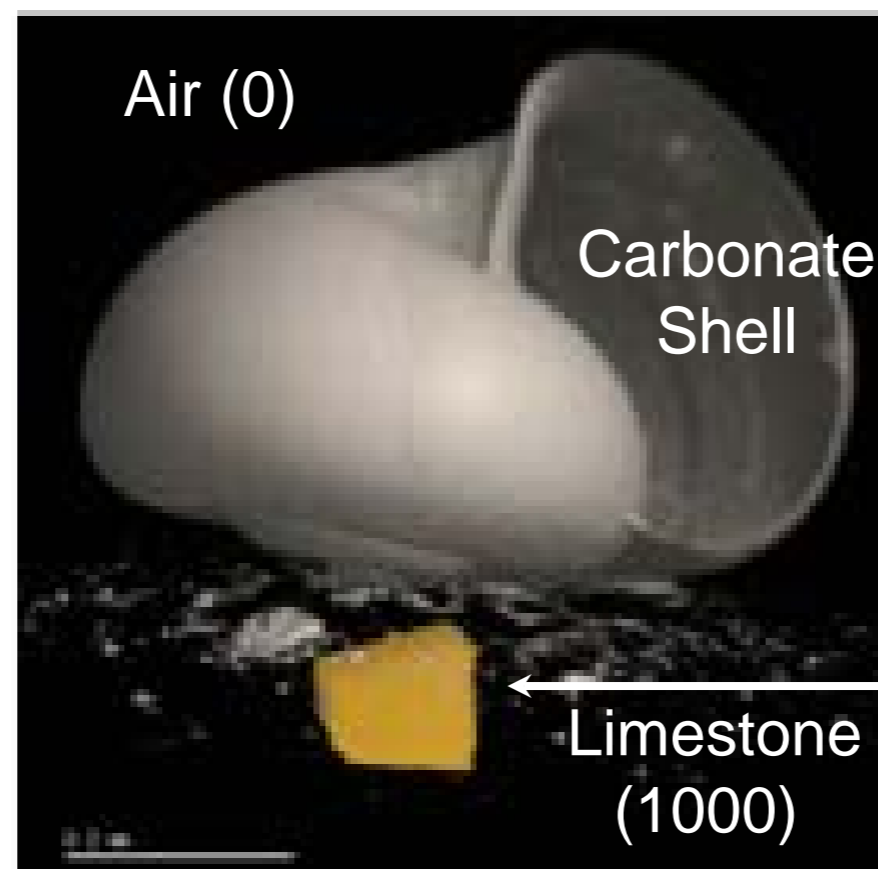
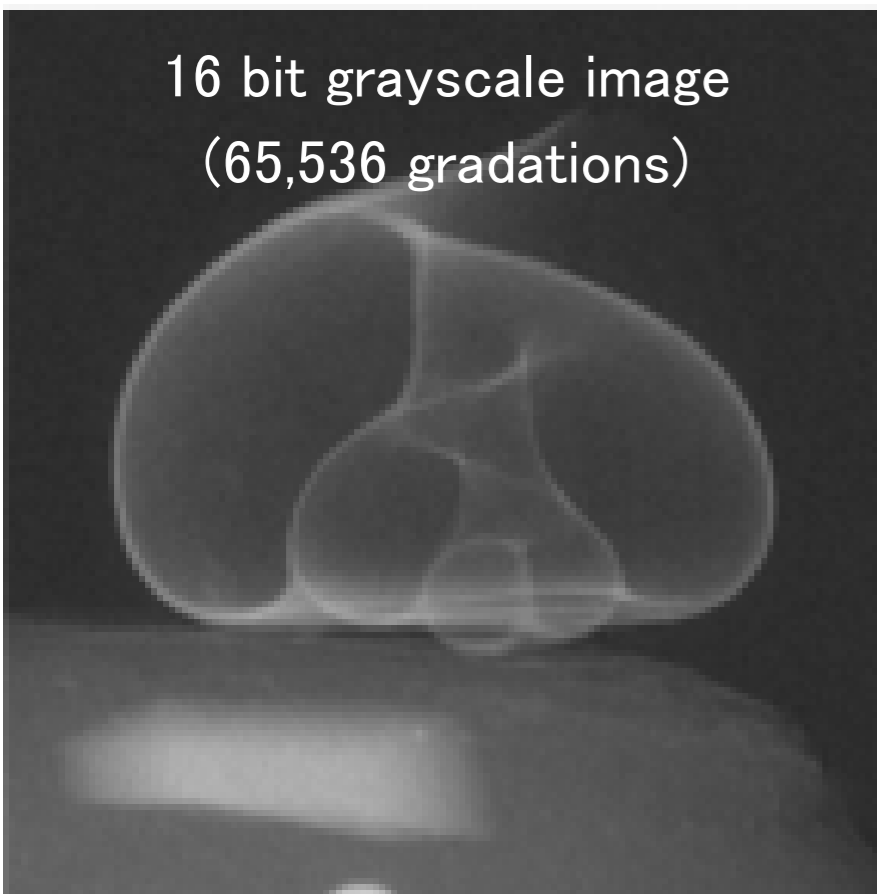
600(lower density)

16 bit grayscale image  
(65,536 gradations)

Air (0)

Carbonate  
Shell

Limestone  
(1000)



# MXCT: High resolution 3D morphometry

Hi-Res

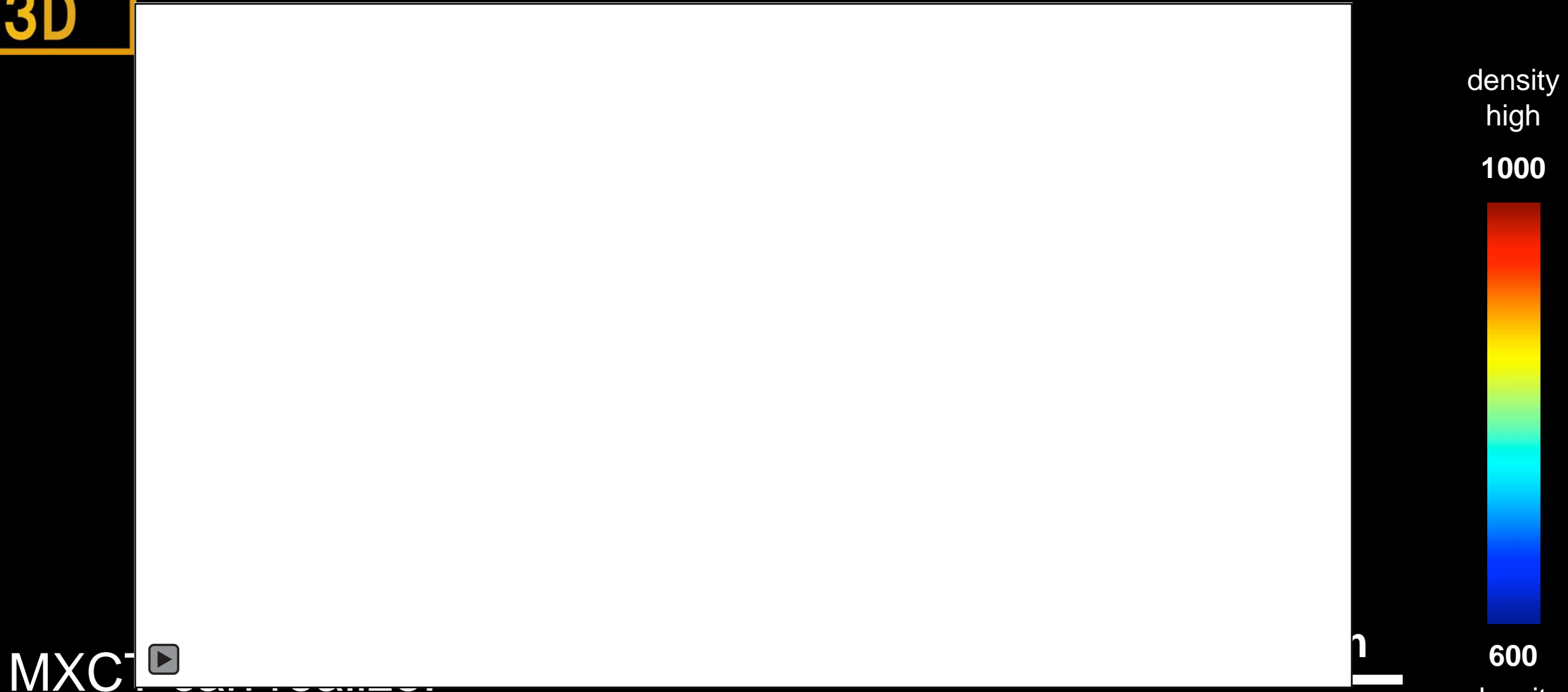
**Thecosomata (Shelled Pteropod): *Limacina helicina***  
(spatial resolution : 0.8  $\mu\text{m}$ , Cross sectional image with density)



# MXCT: High resolution 3D morphometry

Hi-Res  
3D

Planktic foraminifer: *Globigerina bulloides*  
(spatial resolution : 0.8  $\mu\text{m}$ , Cross sectional image with density)



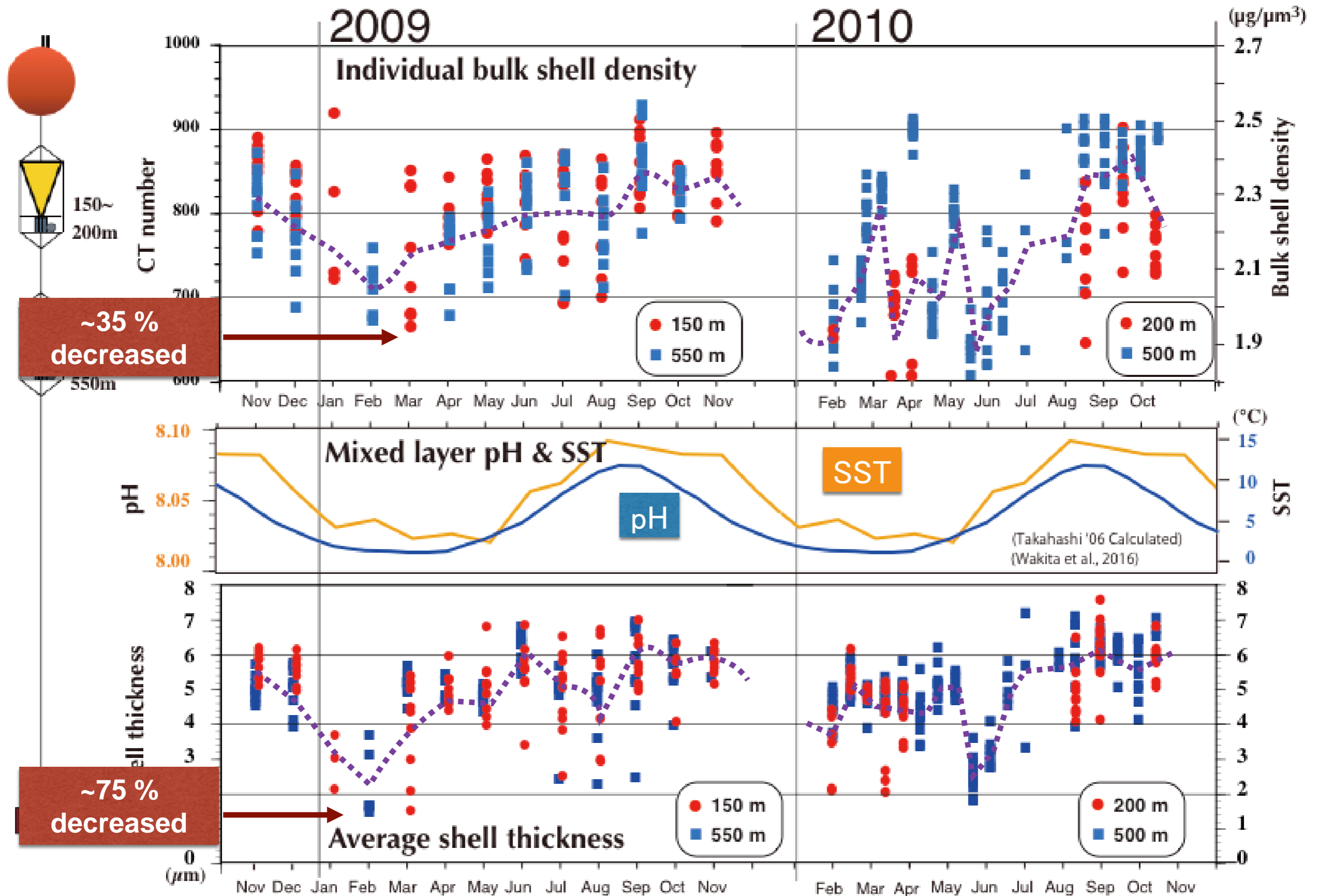
volume, surface area, thickness, density, and others  
for individual specimen

Nondestructive

Quantitative



# Shell density changes of planktic forams in NW Pacific @St. K2



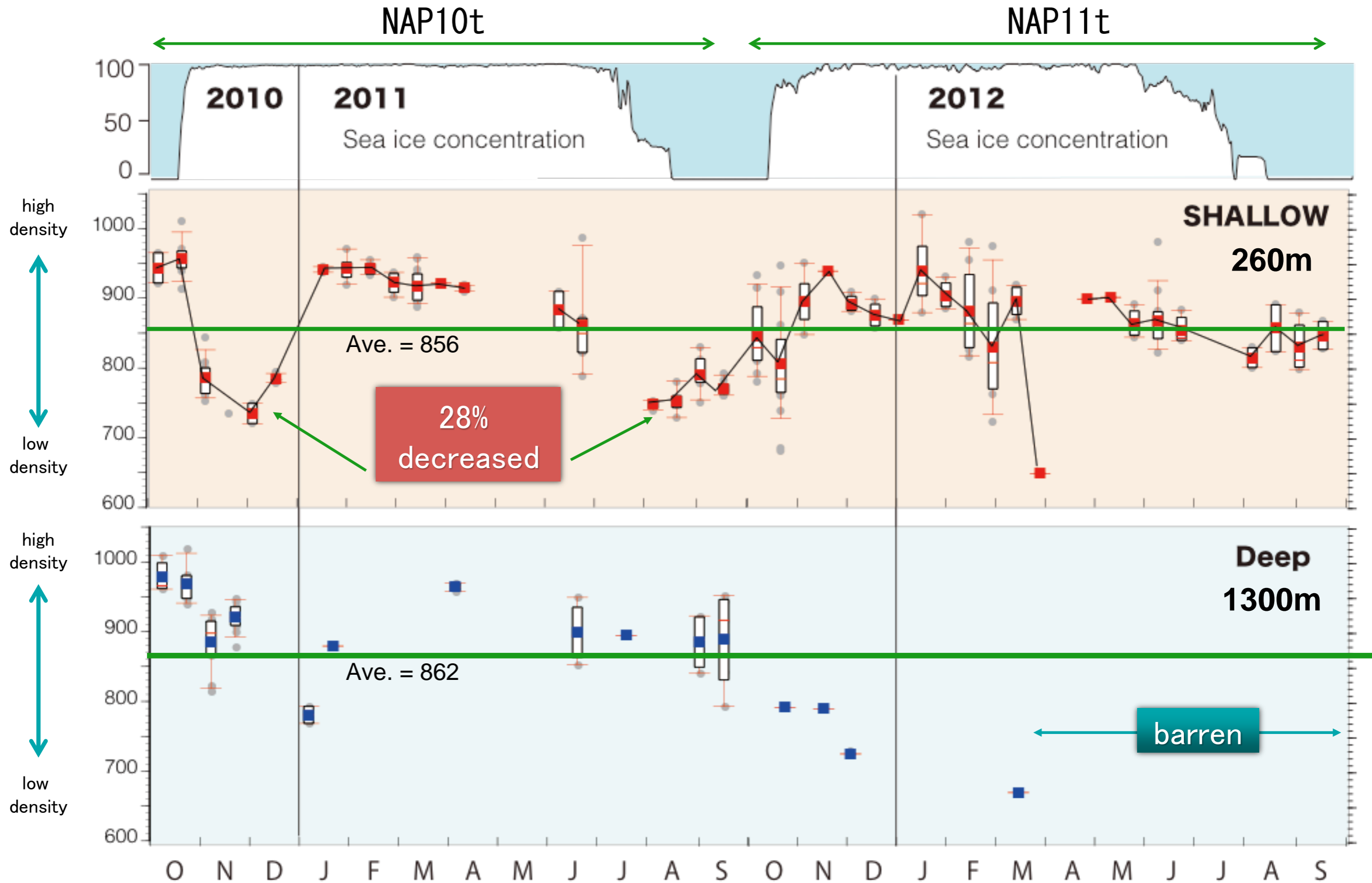
# Time-series Mooring System in the Arctic Ocean



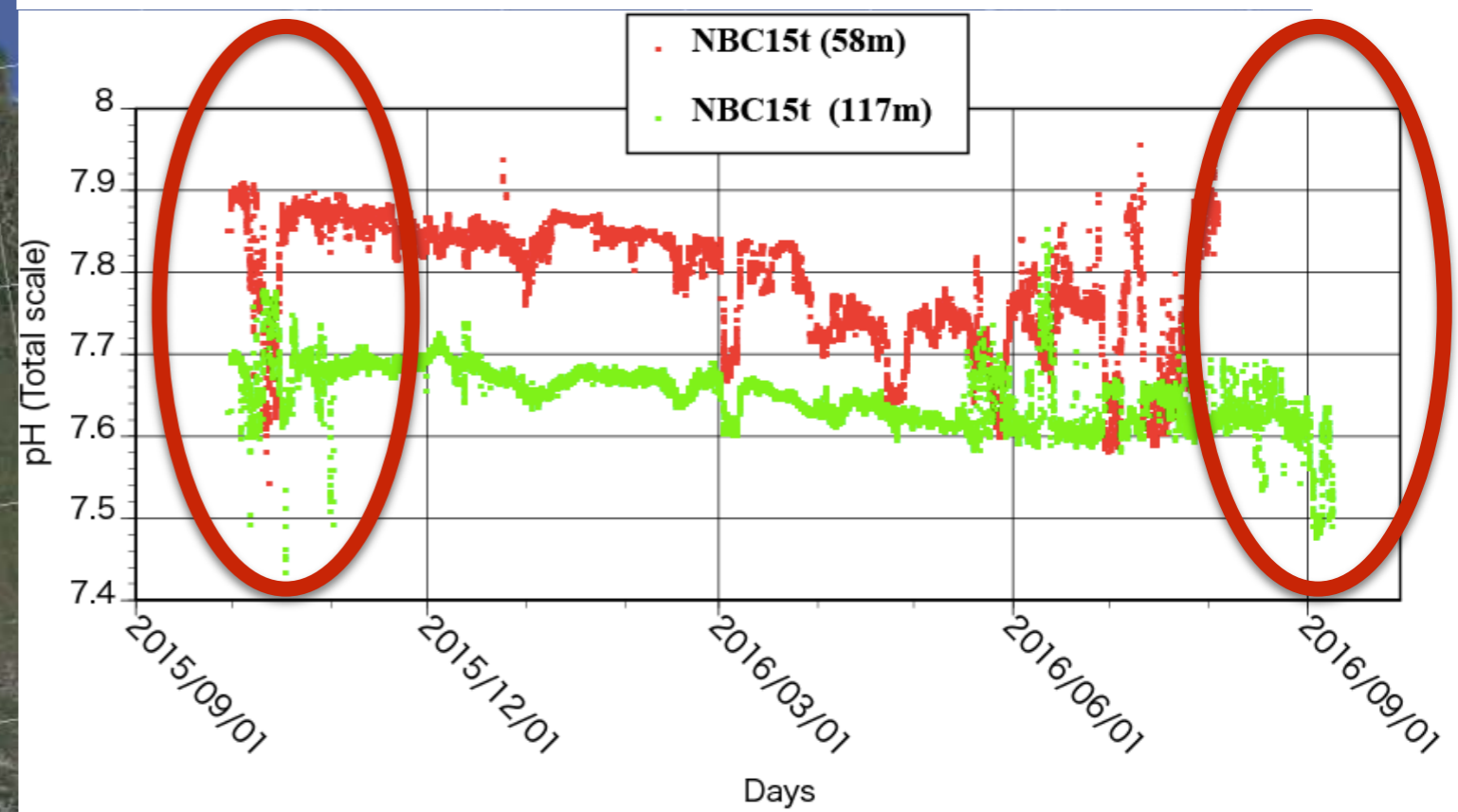
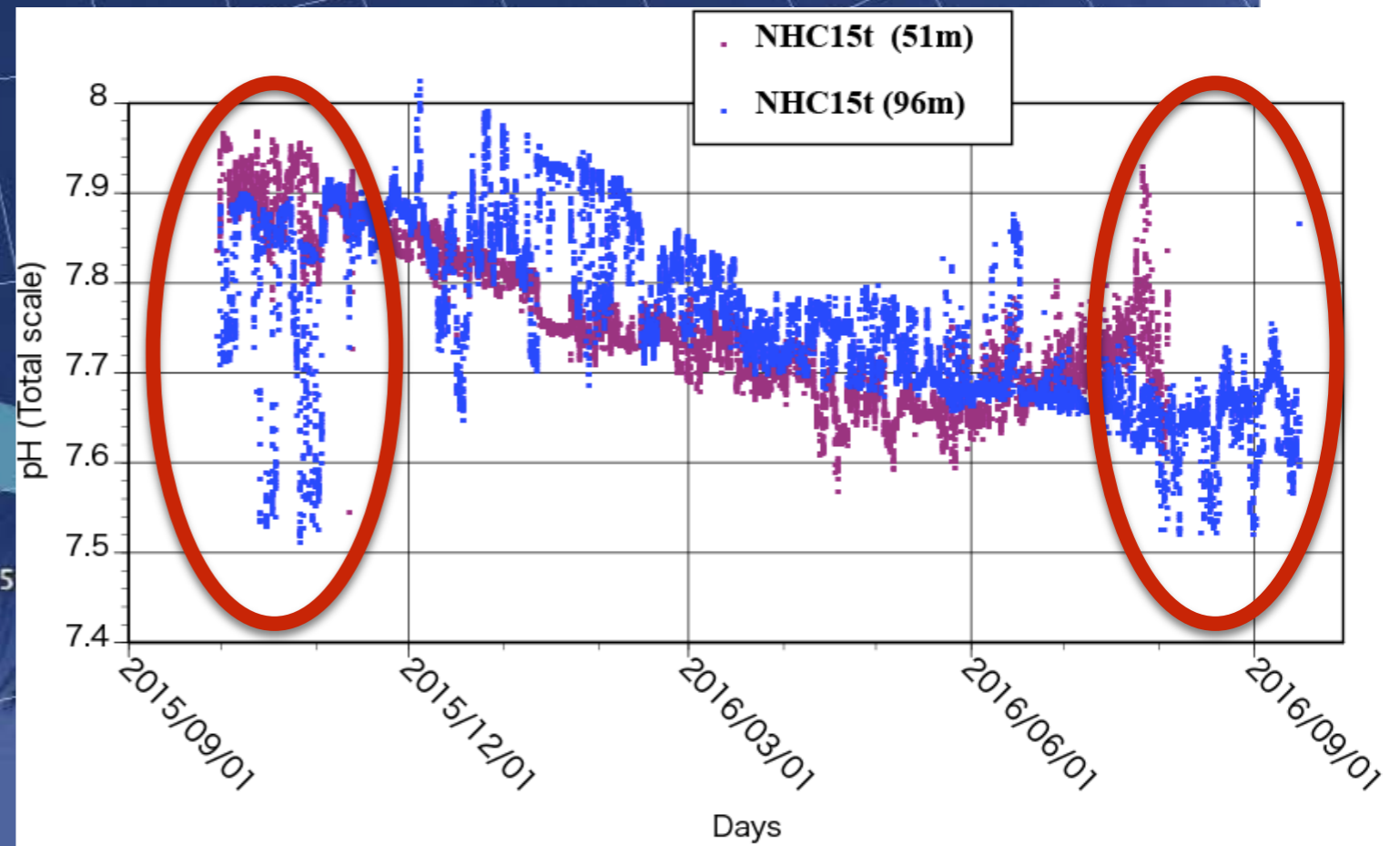
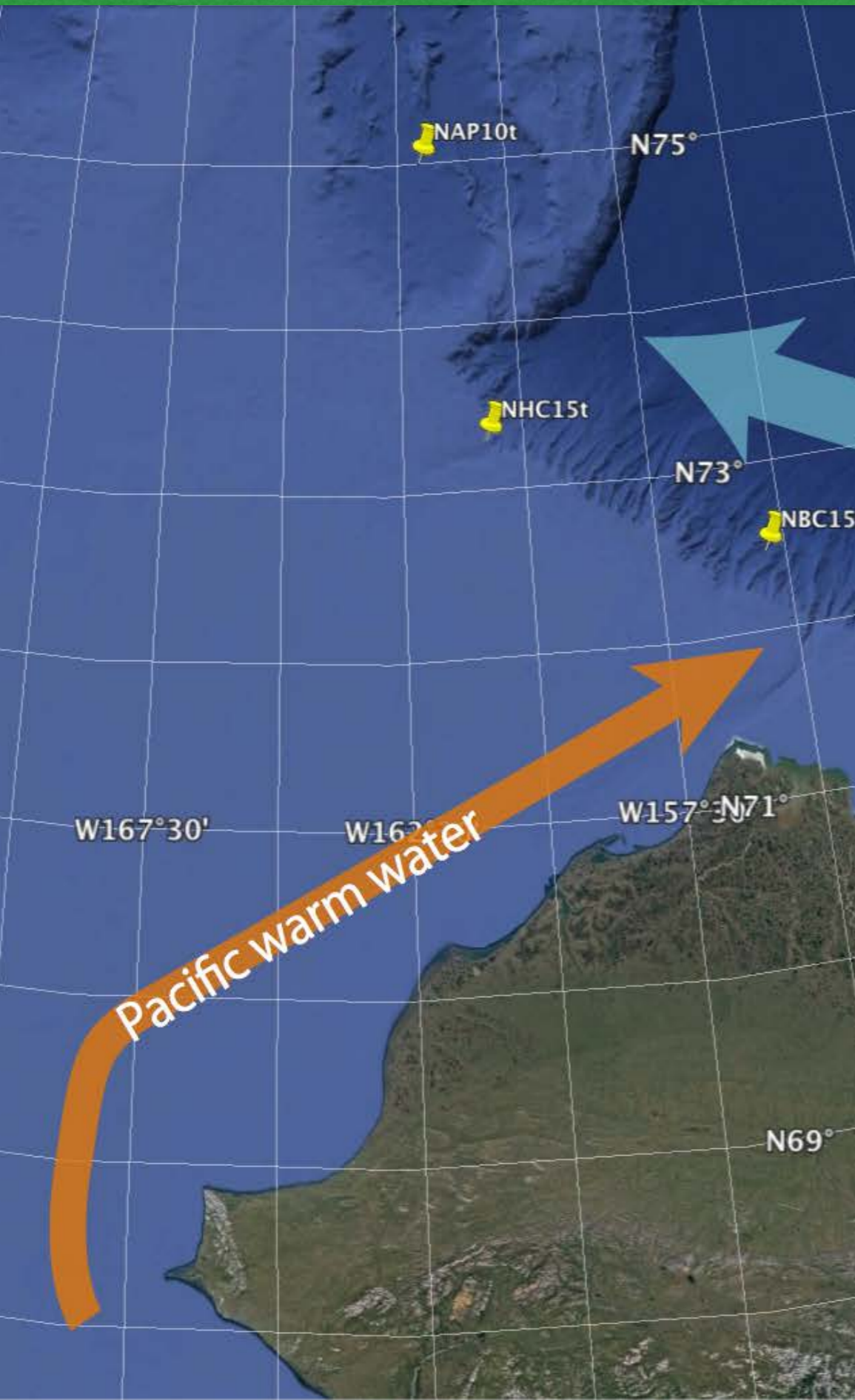
Recovered sediment trap at NAP10t  
(photo by Dr. Nishino, S.)

# Shell density changes of Pteropods in the Arctic

(the result of more than 250 individuals)



# Large changes of oceanic pH



# Concluding remarks

Microfocus X-ray CT (MXCT) technique can be applied successfully to evaluate the impact of OA for marine calcifies quantitatively.

- Carbonate density of marine calcifies changes seasonally and ~35 % reduction were observed in specific seasons in the subarctic NP (winter) and Arctic Ocean (summer and early winter)
- MXCT has a potential to be common standard method to evaluate the shelled plankton responses on OA.-----more higher trophic level plankton (e.g., Copepoda---chitinous substance)
- To make carbonate density popular between OA communities, JAMSTEC can provide the technique how to analyze carbonate density by MXCT and is also preparing to receive measurement request from the world.