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Importance of the bottom cold-water mass as an over-summering refuge for *Euphausia pacifica* in the Yellow Sea

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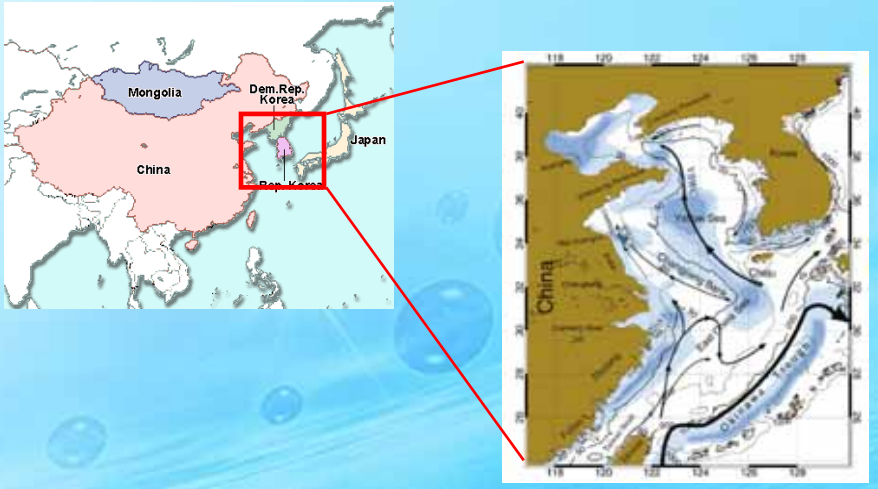
Contents

Backgrounds (1/2)

- Yellow Sea is one of highly productive Large Marine Ecosystems in the world ocean
  - total catch is 5% (3 million tons/yr) of global catches (FAO)



- Direct/indirect impact of human activities (land reclamation, pollution, overfishing, high activity of aquaculture, etc) from four countries (China, South Korea, North Korea, Japan).

- Become recognized the importance of YS on regional climate change/ fishery production/biodiversity
  - UNDP/GEF YSLME project
  - WWF YSEPP program

Backgrounds (2/2)

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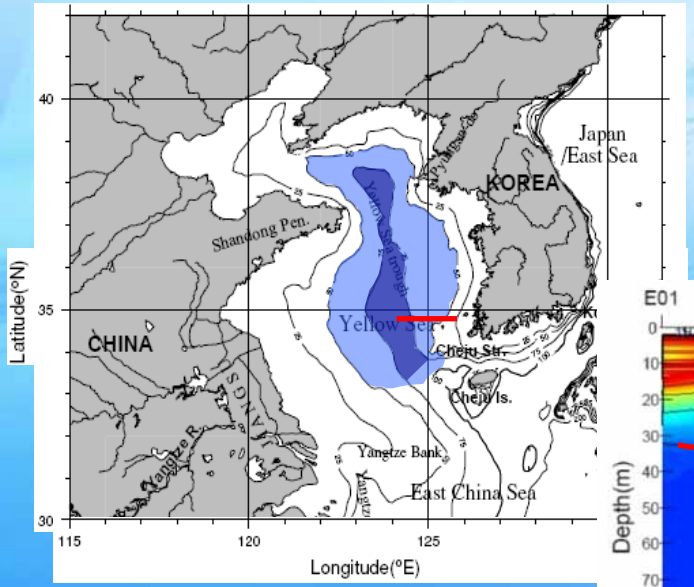
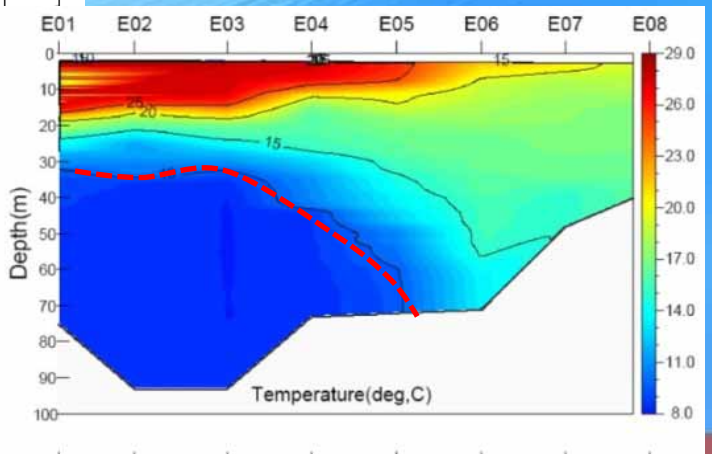
- Yellow Sea has a unique physical feature called YSBCW (≤10℃) which forms through winter cooling and mixing and it is persistently observed in the deep central region of YS during summer.

- It may provide a refuge (i.e. over-summering sites) for some organisms (i.e. *Euphausia pacifica*) to survive through the hot summer (>25℃ in surface water).



- *Euphausia pacifica* is one of key species in YS because of the highest biomass among zooplankton and major prey for fishes (anchovy, sardine, etc.)



Questions

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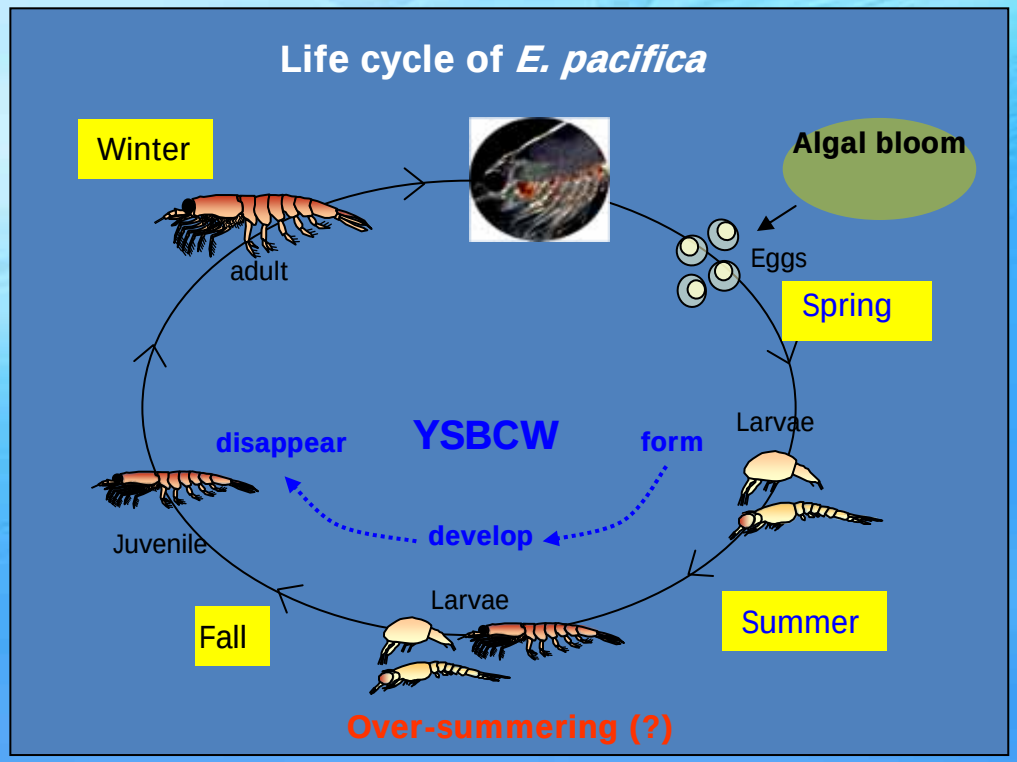
✓ How *Euphausia pacifica* survive through the high temp. and low Chl-*a* condition during the summer in Yellow Sea ?

- Does *E. pacifica* utilize YSBCM as an over-summering refuge ?
- If they do, how ? Lower metabolism, hibernate, ...



Sampling & Analysis (1/2)

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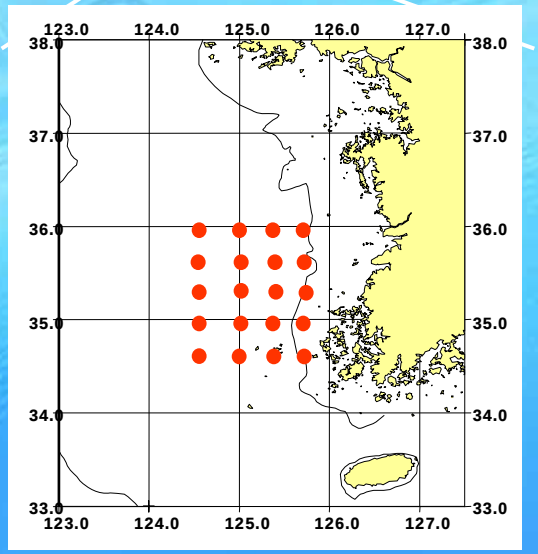
Field works – April & August ’10 & 11

- Net sampling : vertical tow from bottom (~5m) to surface/targeted depth (MBL) using 3 different types of net (Conical and Trawler; mesh 330, 417, 475 μm)

-Acoustic : 200 kHz split-beam transducer (BioSonics, USA)

- CTD: Temperature, salinity, and Chl- a



Net sampling

Acoustic transducer

R/V Eardo

Sampling & Analysis (2/2)

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Analysis in the lab.

✓Preserved samples

- Sorted and enumerated *E. pacifica* with development stages:
  egg, nauplii, calyptopis, furcilia, juvenile, and adult

- Gut content analysis using SEM

✓Frozen samples

- Lipid extracts
- Total lipid and lipid class analysis (TLC-FID)
- Fatty acid analysis (GC-FID & GC-MSD)

Physical properties

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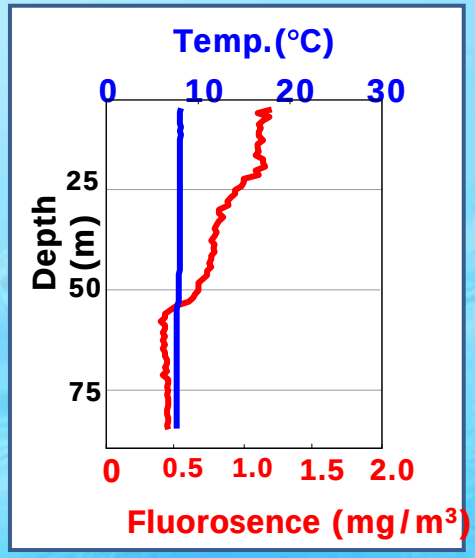
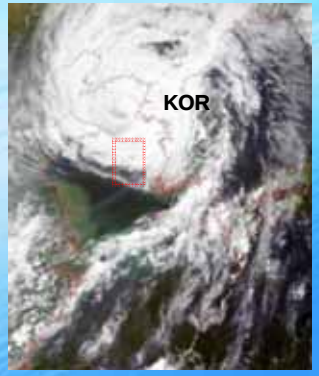
Spring

- Water masses were well mixed
- High Chl-a in the middle of YS
- Similar spatial distribution b/w years (2010 vs. 2011)



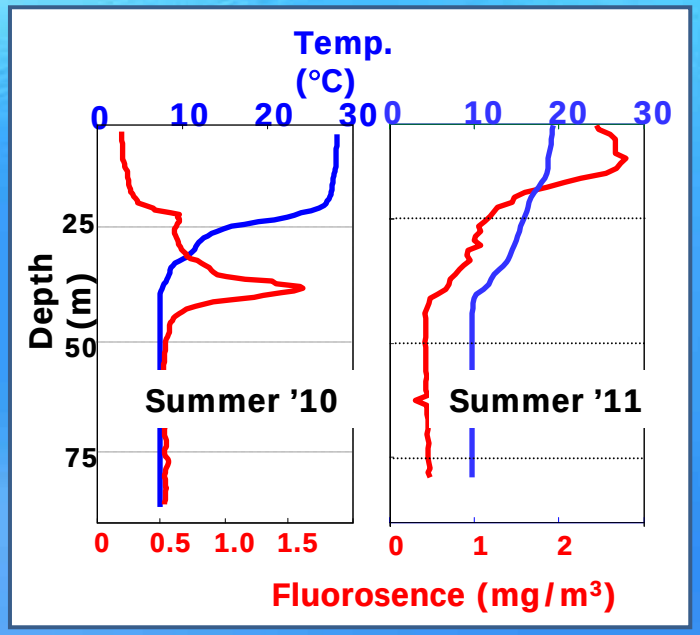
- Typhoon (Muifa)



Summer

- In 2010
  - Waters well stratified
  - YSCWM well developed
  - Chl-*a* Max found just below thermocline

- In 2011 (typhoon before the survey)
  - Surface water mixed with YSCWM
  - High Chl-a found in surface



Spatial distribution of *E. pacifica*

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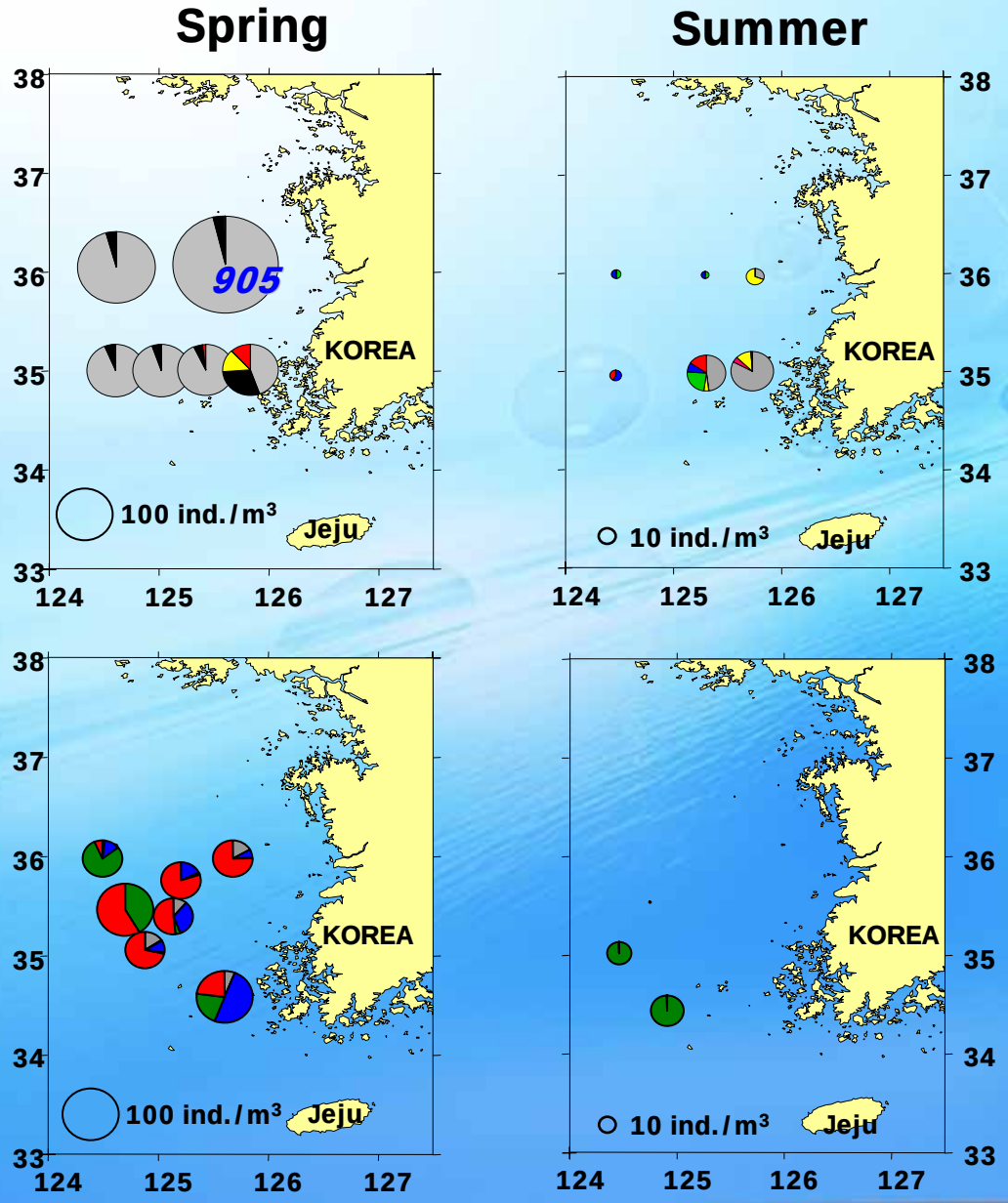
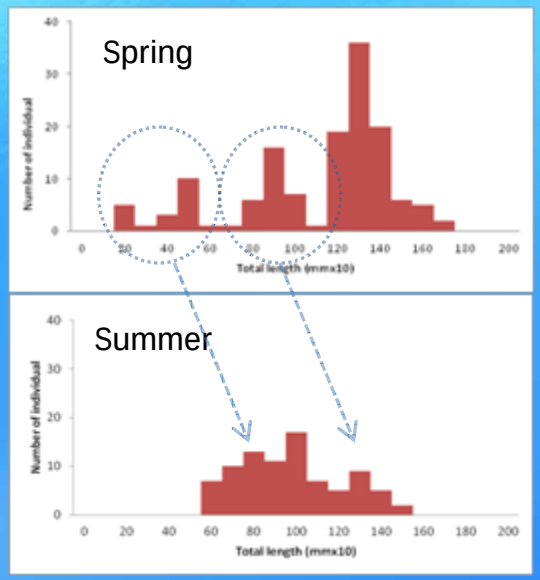
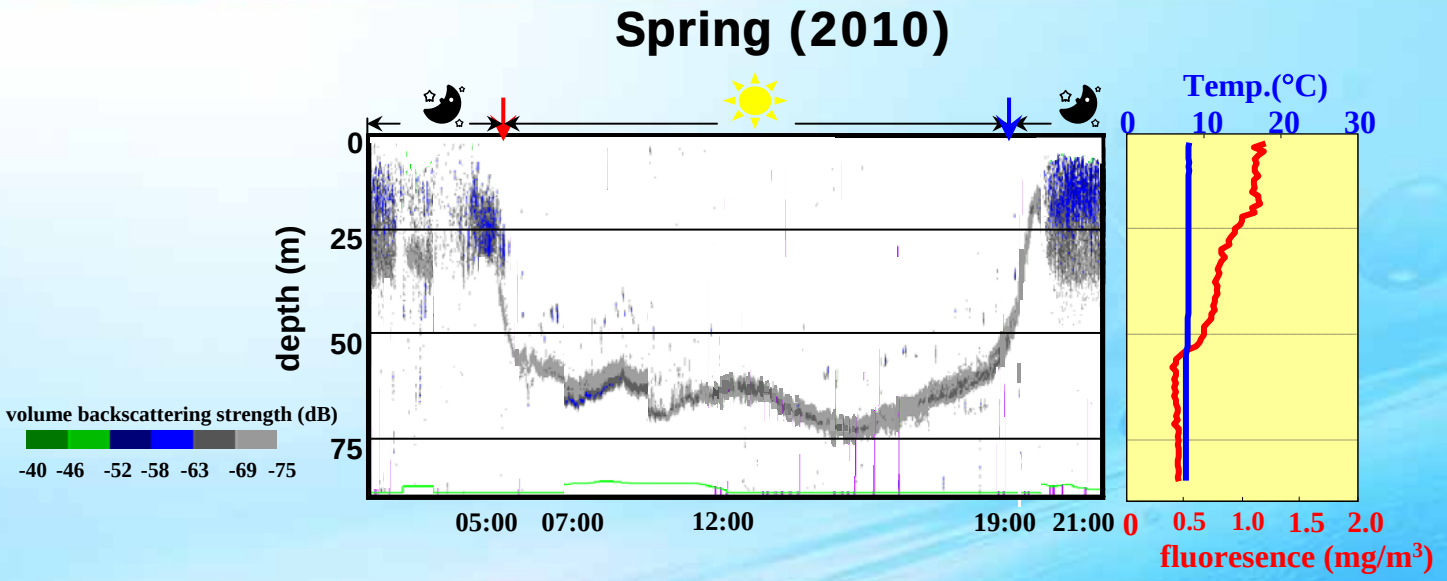


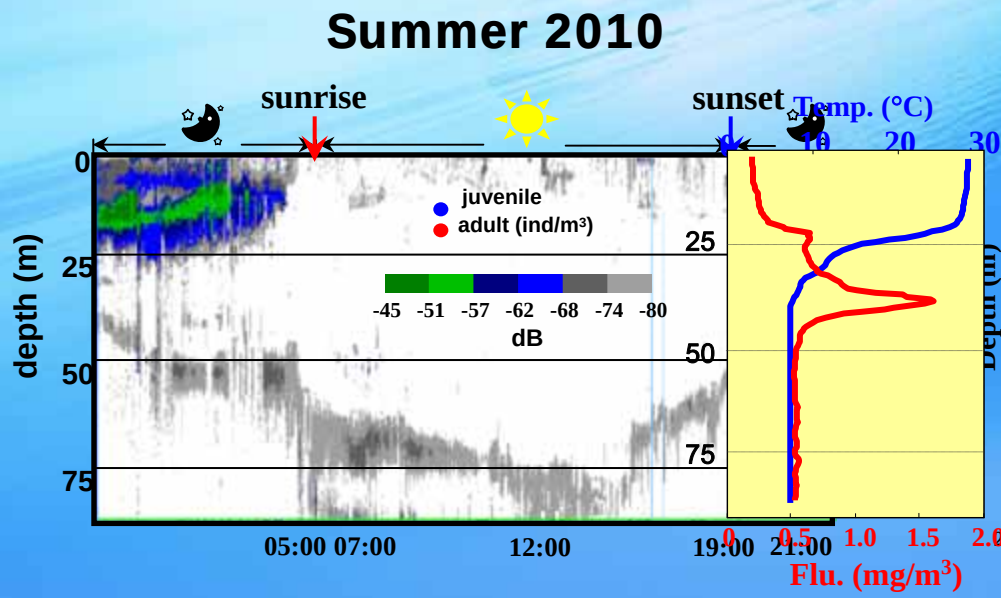
Eggs
Nauplii
Calyptopis
Furcilia
Juvenile
Adult

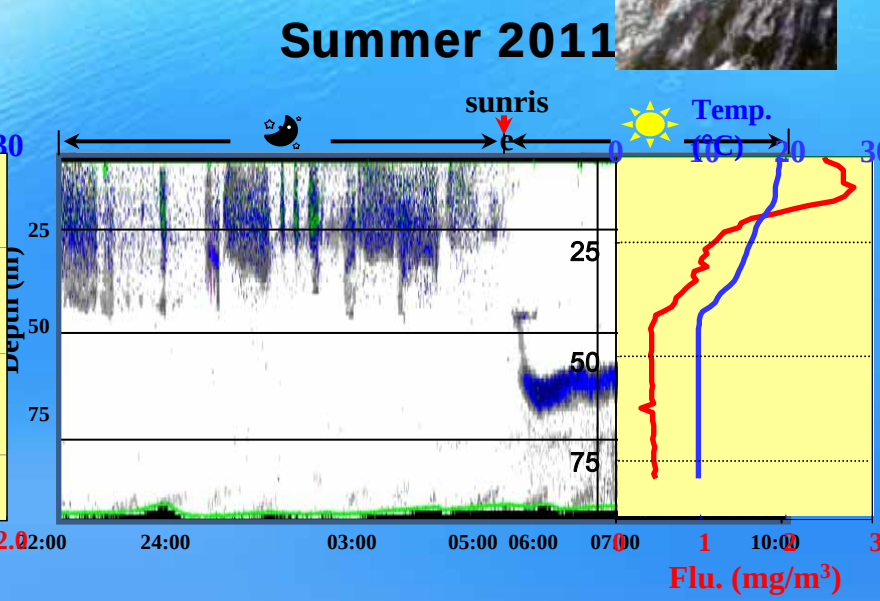
Size-frequency histograms



Behavior - diel vertical migration



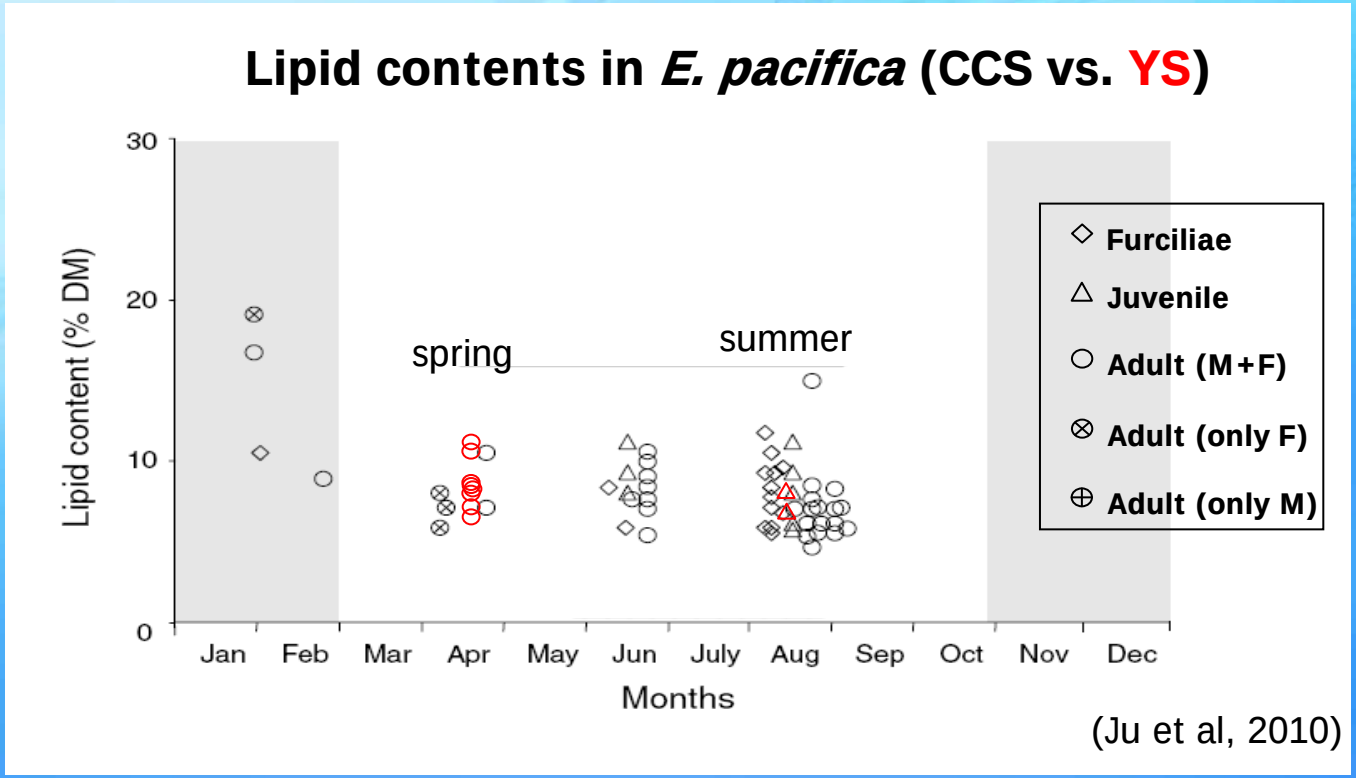




Energy store - lipid content

– Lipid contents (5 ~ 11 % DW) and class compositions (dominated by phospholipids & triacylglycerols) of *E. pacifica* were not significantly different between seasons (No energy stored !).

- Lipid contents of *E. pacifica* from YS were similar level as those from California Current System.



(Ju et al, 2010)

Feeding – gut & dietary FA markers

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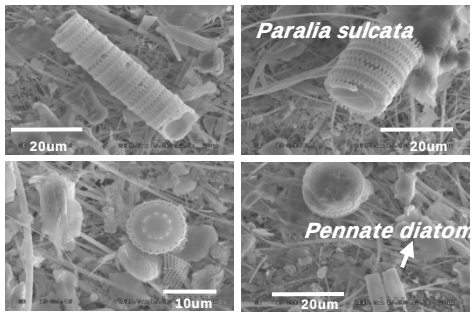
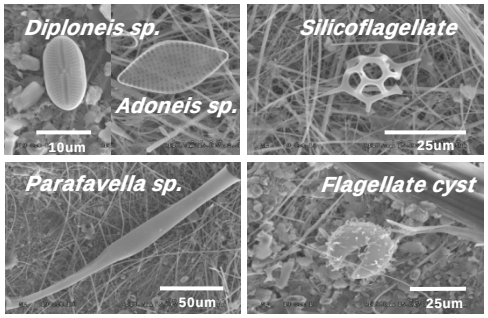
Spring

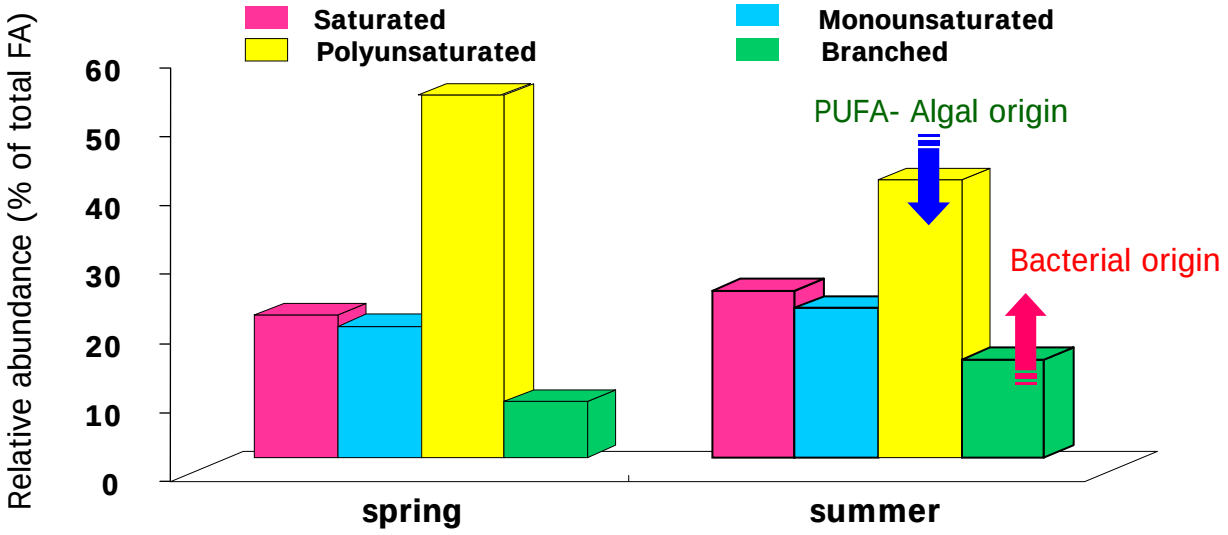
Almost diatoms



Summer

Some diatoms, dinoflagellates, protozoa, and detritus





Summary

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✓ Major spawning occurs in spring.
(even it was weak, still some spawning activity occurred in summer)

✓ *E. pacifica* showed strong DVM but, during the summer, their DVM pattern (depth) was changed to avoid the high temp water – krill utilize YSBCW as over-summering refuge !

✓ Episodic events (i.e. typhoon) could temporally affect krill behavior (DVM pattern).

✓ Krill mainly feed on diatom in spring but in summer, they feed on any particles sized from 10 to 200um (protozoa, detritus, dinoflagellate, diatom, etc) – these feeding behavior make them live in a wide range of environments !

Answers

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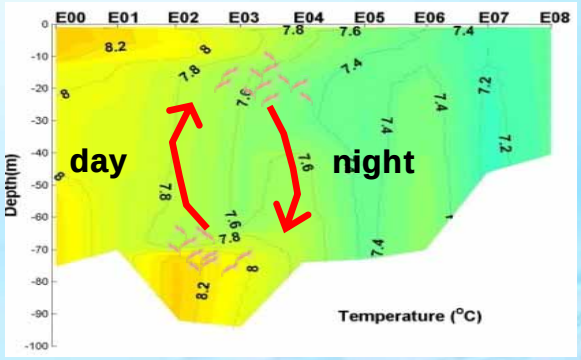
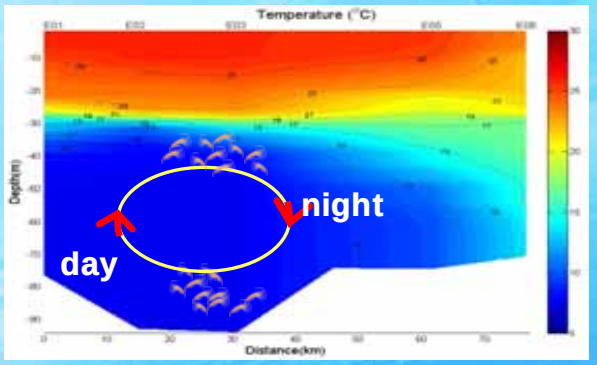
- **Does *E. pacifica* utilize YSBCM as an over-summering refuge ?**
  - **Yes, they still actively do DVM within YSBCM during the summer (staying their optimal water temperature range).**

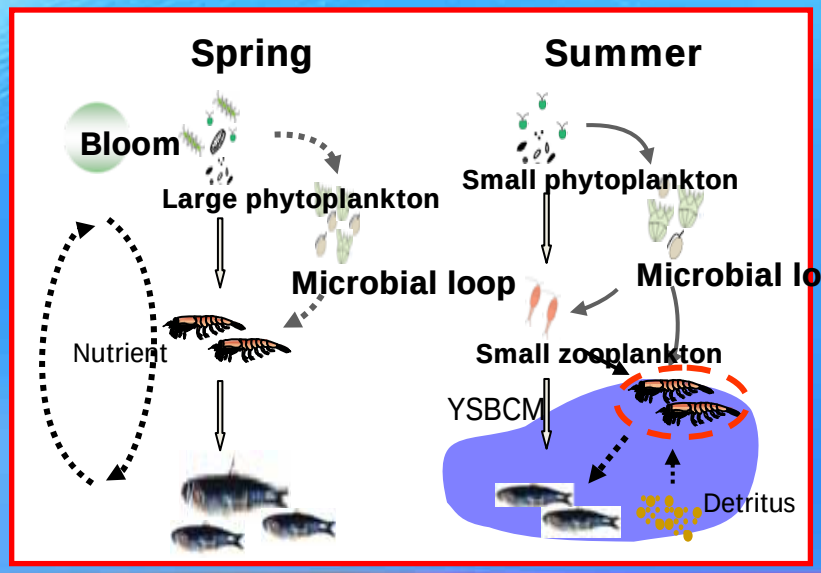
Spring



Summer



- **If they do, how ?**
  - **Lower metabolism (x), hibernate (x), ...**
  - **Business as usual : actively feed on any available particles**



Still unresolved issue !

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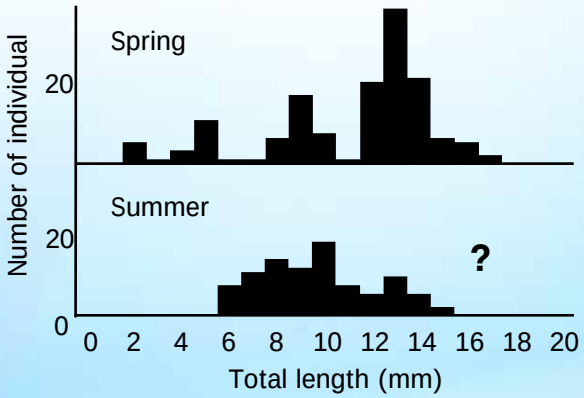
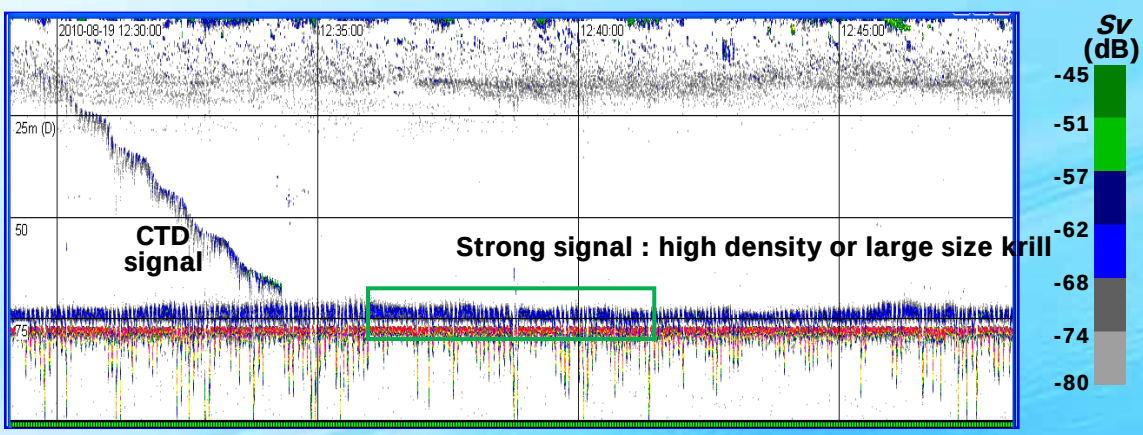
Where are most of adult *E. Pacifica* during summer ?





- Based on acoustic signals, they were condensed near the bottom (2-3m above the bottom)
- In order to confirm this, we have been tried but we need different sampling devices (trawling also did not quite work !)