2017 PICES annual meeting

Feeding impact of the copepod *Calanus sinicus* on phytoplankton in the northern East China Sea in late spring

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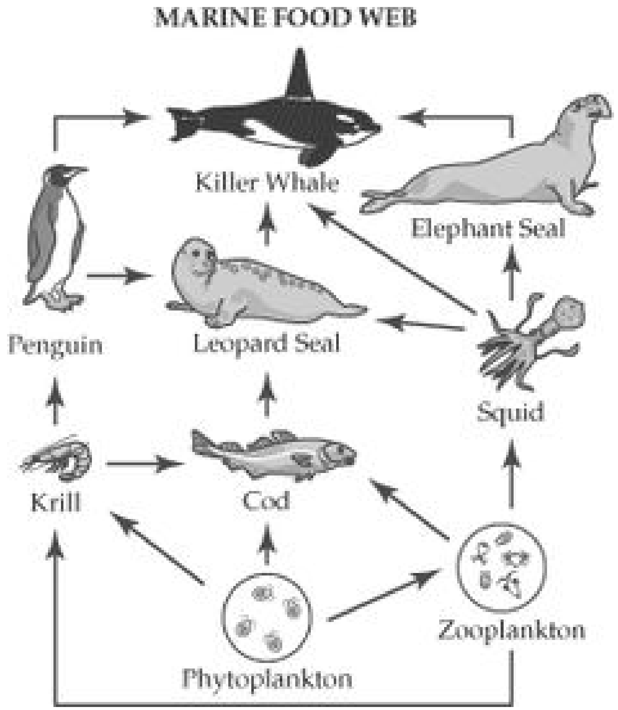
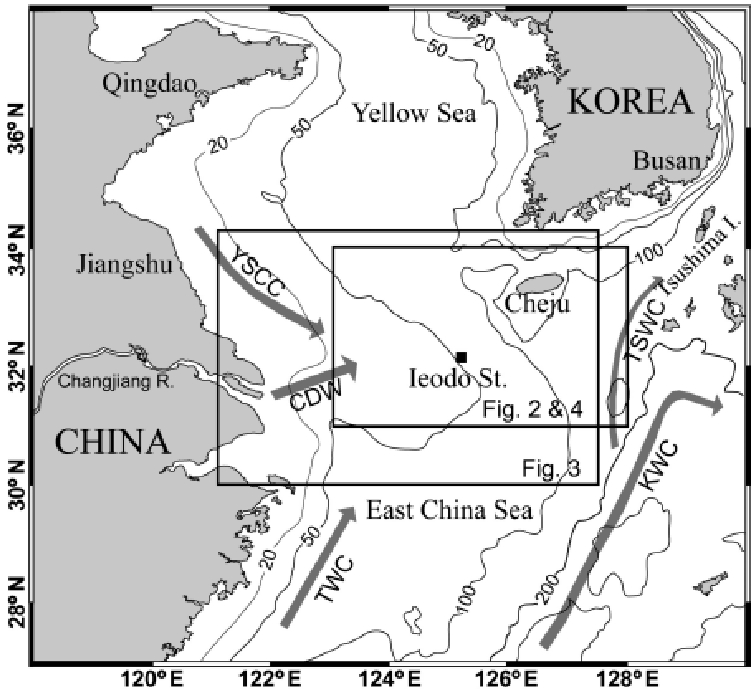
The role of zooplankton



- Zooplankton is a linkage between primary producers and predators

- Measuring zooplankton feeding are required to better understand marine food web

The northern East China Sea

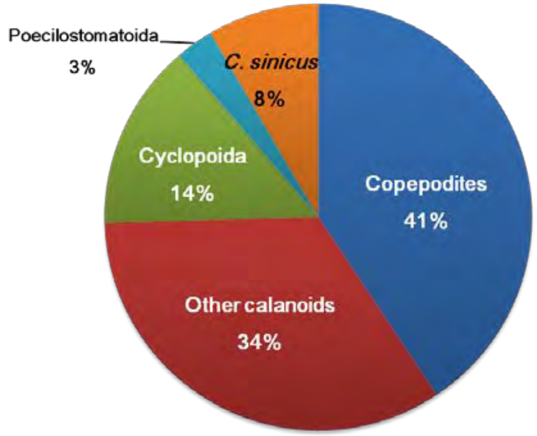


(Choi *et al*. 2010)

- Influences from Tsushima Warm Current, Taiwan Warm Current, Yellow Sea Coastal Current, and Changjiang diluted water

- Abundant fishery resources

Importance of *C. sinicus* in ECS

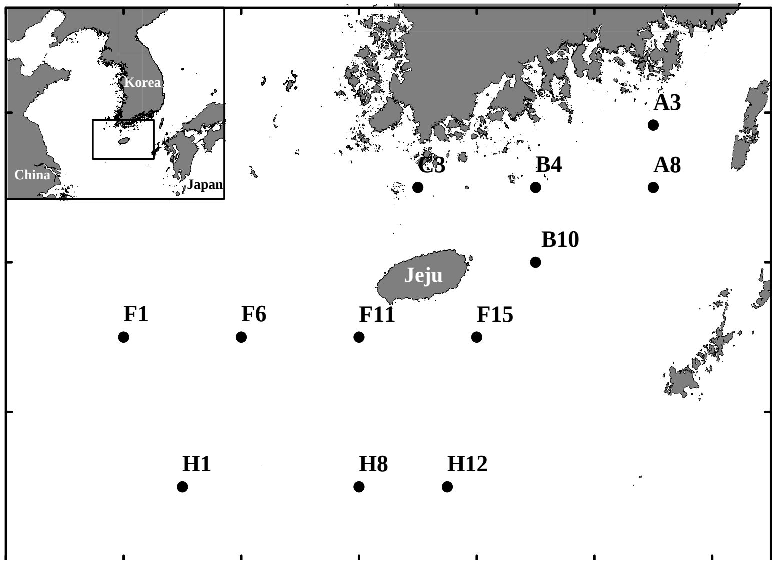


Copepod composition of the N ECS in early June 2015

- Research on the feeding of *Calanus sinicus* in the northern ECS is limited and only focused on the adult stage

➔ **Evaluate the feeding habits of *C. sinicus* with an emphasis on its developmental stages (CIV to adults)**

Field sampling



- 12 stations on June 1−8, 2015
- Bongo net oblique tow (60 cm, 200 μm), frozen in liquid nitrogen
- Temperature, salinity and chl-*a* were monitored

Gut pigment measurement

- *C. sinicus* were counted and sorted as copepodite 4 (CIV), copepodite 5 (CV), adult males, and adult females
- Gut pigment method

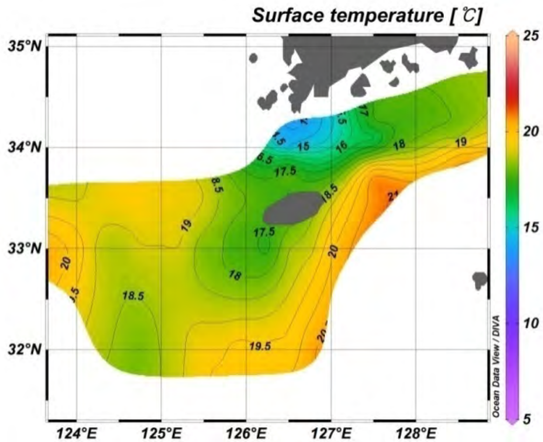
Gut pigment (Mackas and Bohrer 1976; Dagg and Wyman 1983)
Chl-*a* (ng ind⁻1) = $k\,(f_0 - f_a) / n$
Phaeopigment (ng chl a eq. ind⁻1) = $k\,(Rf_0 - f_a) / n$,

The ingestion rate (Uye and Yamamoto 1995)
$I = G \times E \times 60$

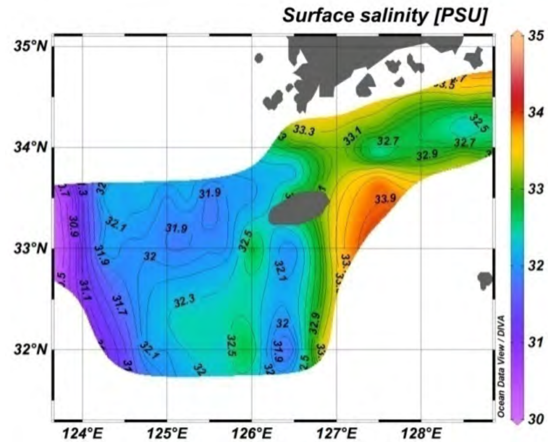
Daily ration, as the percentage of body carbon ingested per day (*DR,* Atkinson 1996)
$DR = GC \times E \times 1440$
$GC = 100 \times G \times (C{:}Chl\ a) / (0.45 \times BC)$
The prosome length were converted into body carbon using the equation (Uye 1988)

The feeding impact (Morales and Harris 1990)
$T = (A \times I) / C$

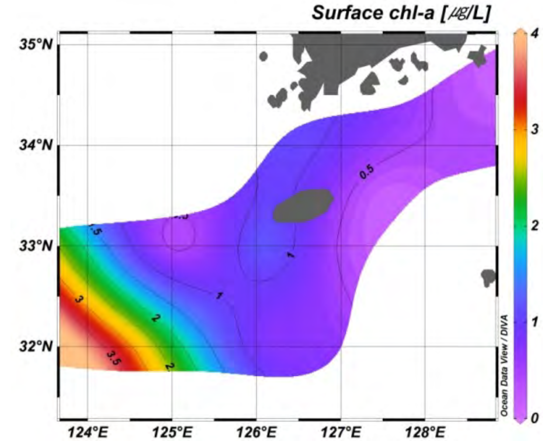
Hydrographic conditions



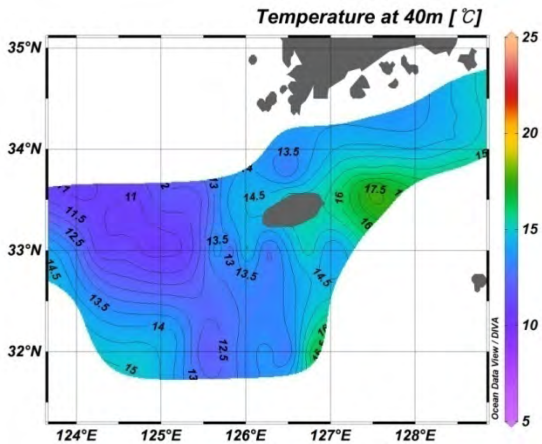
Mean18.8°C (14.2–20.6°C)



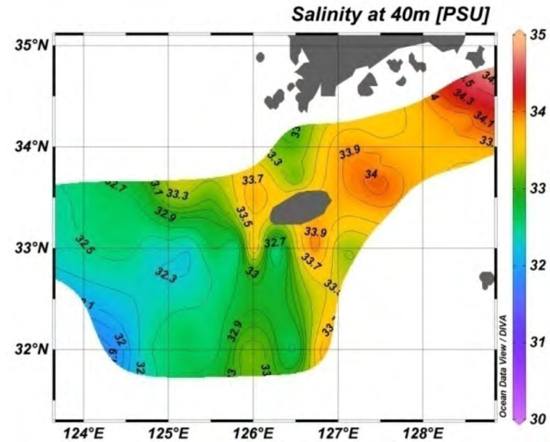
Mean 32.7 psu (31.1–33.8 psu)



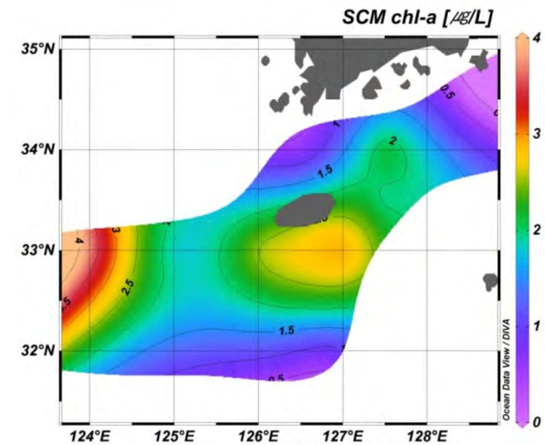
Mean 0.9 μg L^{-1} (0.2–3.1 μg L^{-1})



Mean 14.4°C (10.9–17.5°C)



Mean 33.3 psu (32.0–34.3 psu)

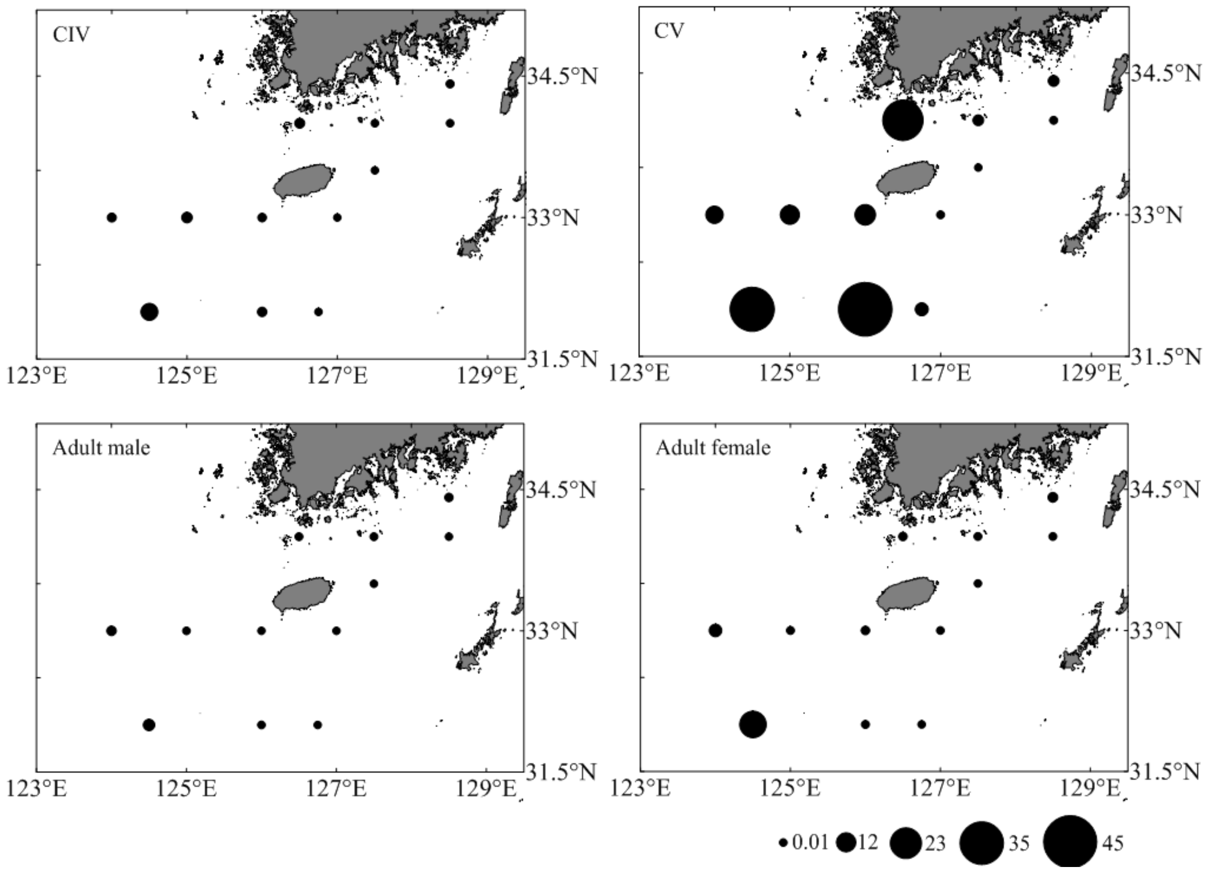


Mean 1.7 μg L^{-1} (0.3–3.8 μg L^{-1})

- Relatively high temp and salinity at the eastern side and high chl-*a* at the western side

Results

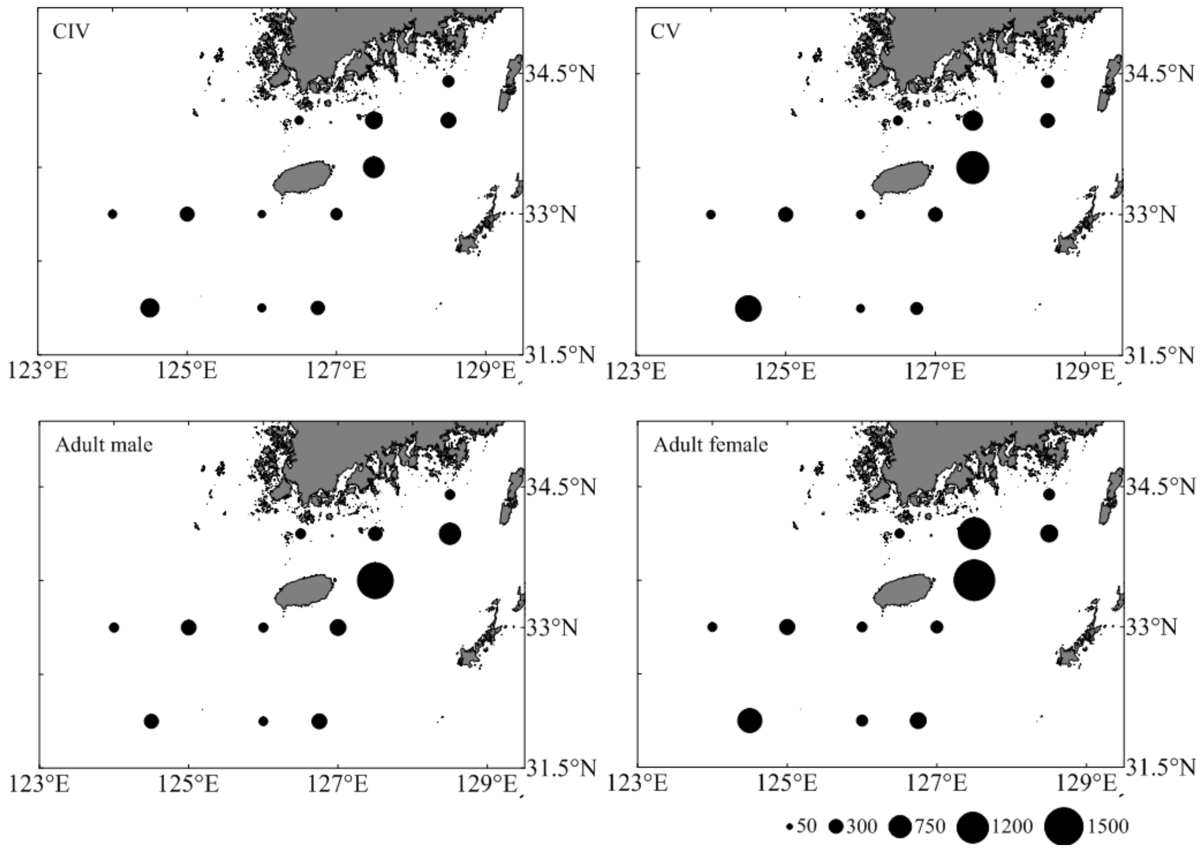
Population biomass



- The largest biomass for CVs, with a mean of 13.5 mg C m^{-3}
- Relatively high total at the SW of Jeju Island, and low at the NE side

Results

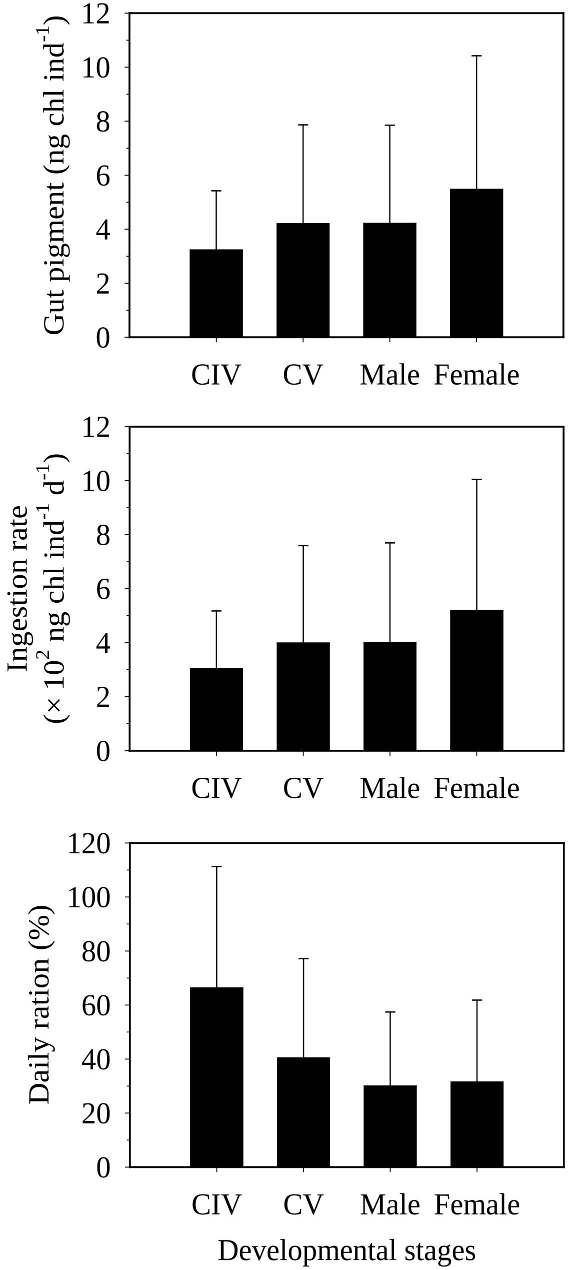
Ingestion rate



- The mean ingestion rate was 406 ng chl ind^{-1} d^{-1} (111–1,253 ng chl ind^{-1} d^{-1} by stations)
- Relatively high at the NE of Jeju Island and low at the SW side

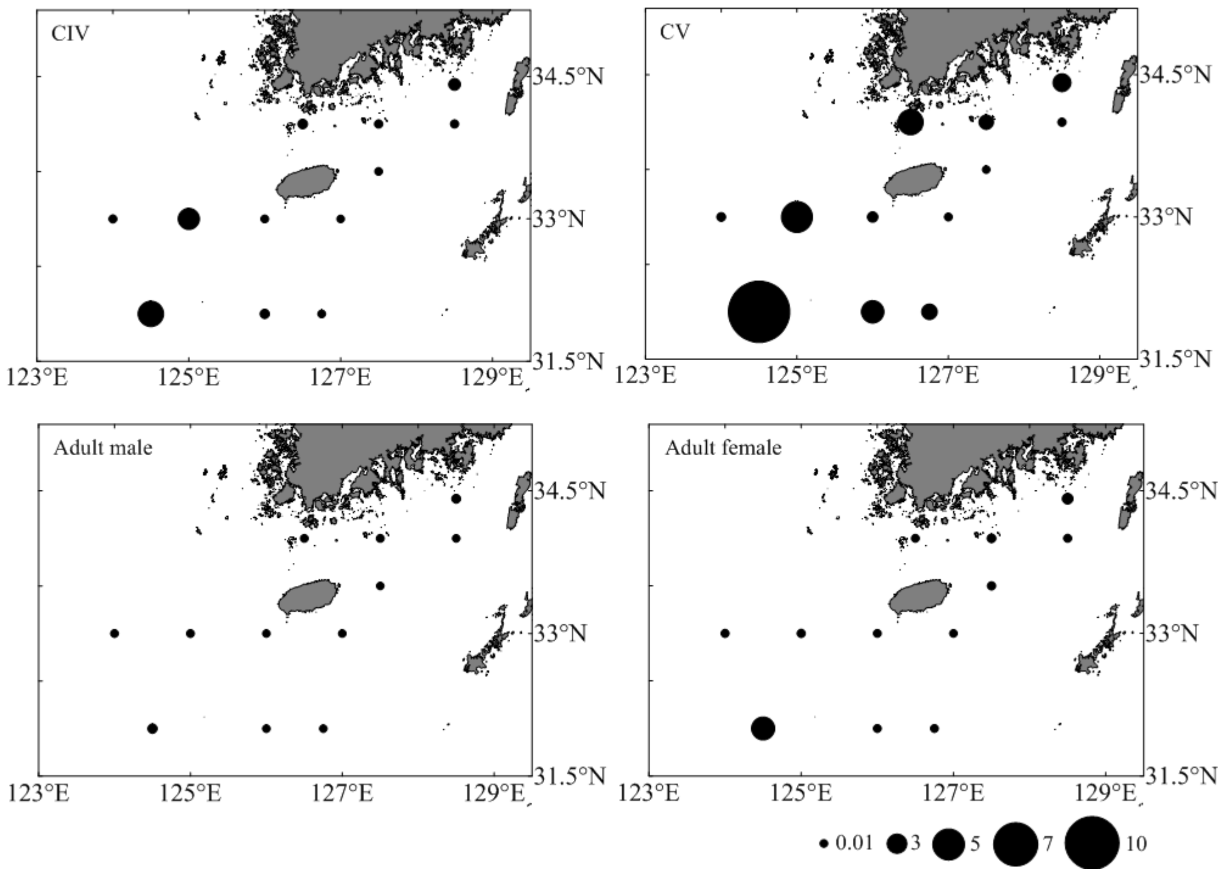
Results

stage averaged GP, IR and DR



- Gut pigment of females was the highest at 5.48 ng chl ind^{-1}
- Ingestion rate of females was the highest at 519 ng chl ind^{-1} d^{-1}
- Daily ration of CIVs was the highest at 66.4%
- The differences among the developmental stages were not statistically significant (Kruskal–Wallis test, $P > 0.05$)

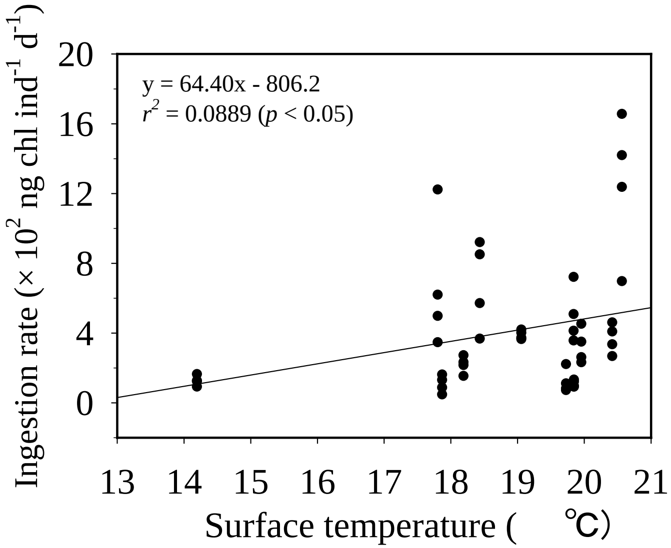
Feeding impact

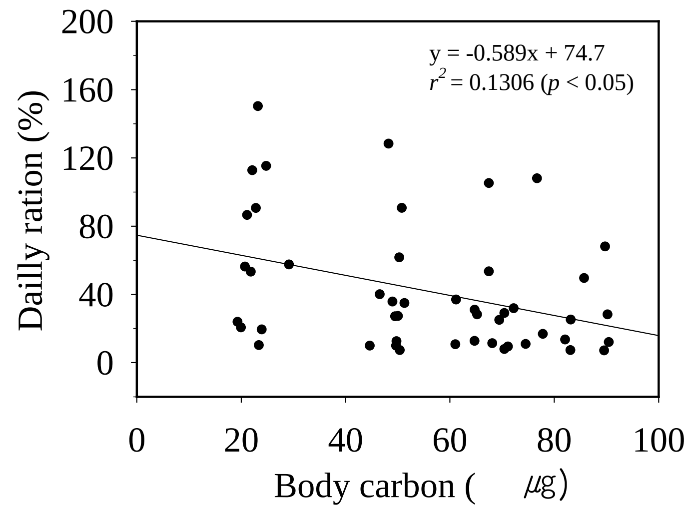


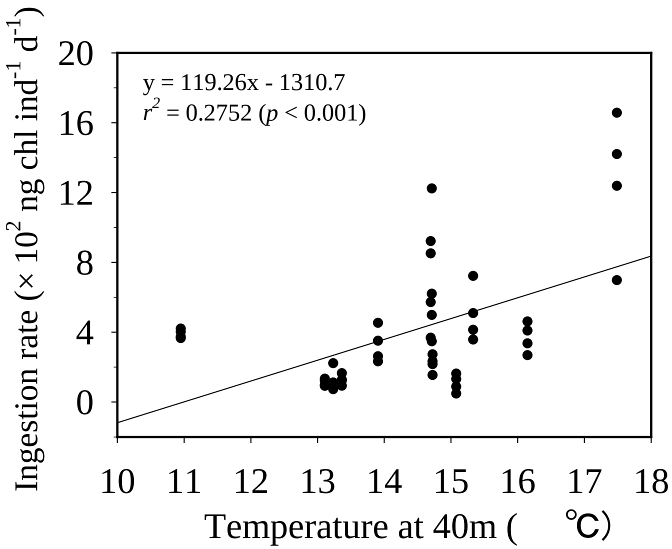
- The total mean feeding impact of the *C. sinicus* population was 3.9%
- The highest in the CVs with 2.6% and the lowest in males at 0.1%
- Relatively high total at the SW of Jeju Island

Results

Correlations



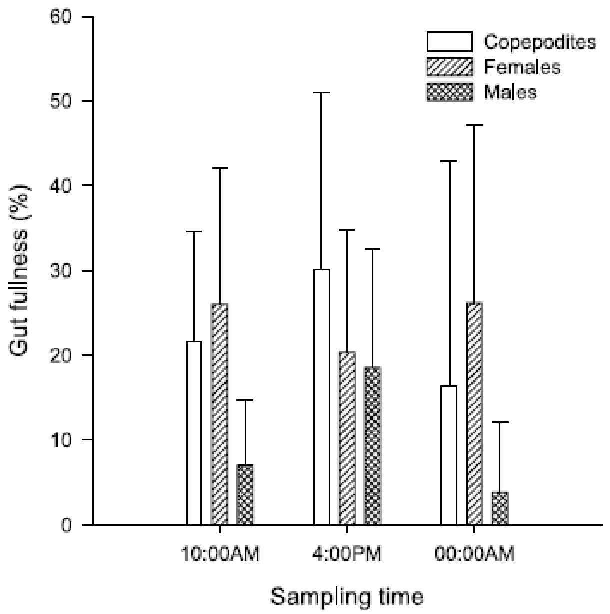




- The ingestion rate tended to increase with temperature
- The daily ration decreased when size and weight increased
- No relationship with salinity or chl-*a*

Correlations

- The influence of chl-*a* on *C. sinicus* feeding was not significant
- Due to variation in feeding ecology among individuals by:
  - intermittent food intake
  - omnivorous feeding
  - different feeding patterns among developmental stages



Gut fullness *C. sinicus* in northern coastal waters of Taiwan (Chen *et al*. 2010)

Discussion

Comparison to previous studies

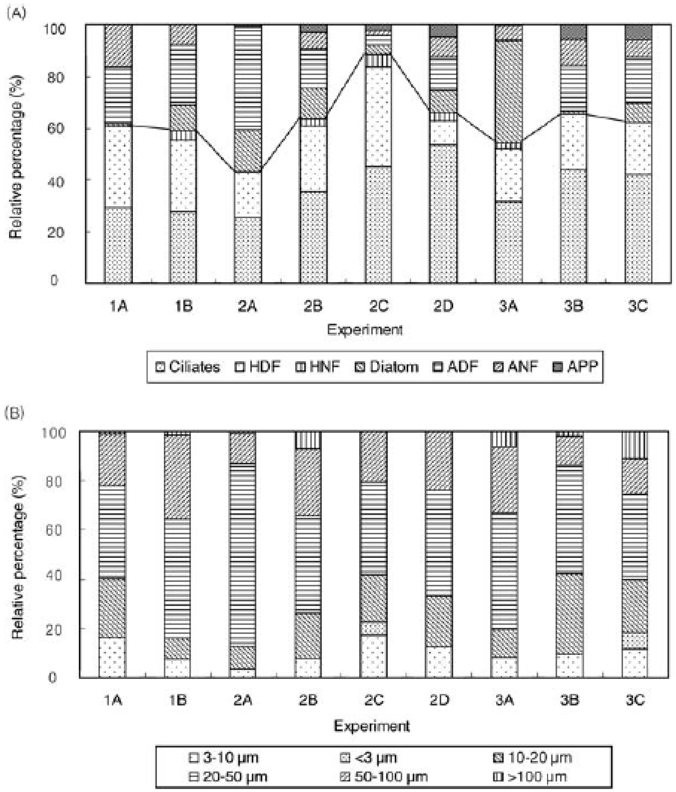
Species	Ambient chl-*a* (μg L^{-1})	Ingestion rate (ng chl ind^{-1} d^{-1})	Daily ration (% BC d^{-1})	Feeding impact (%)	Region	Reference
C. sinicus	0.5–1.1	209–842	-	13–85	Inland Sea of Japan	Uye and Yamamoto 1995
C. sinicus (CV–adults)	< 0.5	32.5–182.5	2.7–9.1	-	Yellow Sea	Li *et al*. 2004
C. sinicus	0.6–6.2	~48.2*	-	0.1–1.6	Taean, Yellow Sea	Song *et al*. 2010
C. sinicus	?	2.9–394.6*	0.2–18.4	1.2	Asan Bay, Yellow Sea	Lee *et al*. 2012
C. sinicus (CIV–adults)	0.3–3.8	305–519	30.1–66.4	0.1–2.6	Northern East China Sea	This study

- Possible factors for differences among studies:
  - Phytoplankton biomass
  - Phytoplankton cell size
  - Composition of prey items

Discussion

Possible factors for differences among studies

- The feeding of *C. sinicus* may be influenced by:
  - The amount of phytoplankton of the preferred size class
  - Feeding on protozoans



Relative protozoan compositions and size class to the total diets of copepods in August at East Sea/Japan Sea (Yang *et al.* 2009)

Summary

• The feeding habits of *C. sinicus* in the northern East China Sea in late spring were estimated with an emphasis on its developmental stages (CIV to adults)

• The ingestion rate of *C. sinicus* individuals tended to increase with development, and the daily ration was opposite

• The grazing impact of CVs was the highest despite their mediocre ingestion rate and daily ration, due to their high biomass

➔ **This study suggests the importance of the copepodite stages in estimating feeding rates for better understanding the feeding habits of copepods in marine food webs**