# Feeding rates of adult *Euphausia pacifica* on natural particle assemblages in the coastal upwelling zone off Oregon, USA

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# What is the study species?

*Euphausia pacifica* Hansen

Macrozooplankton

Temperate euphausiid crustacean

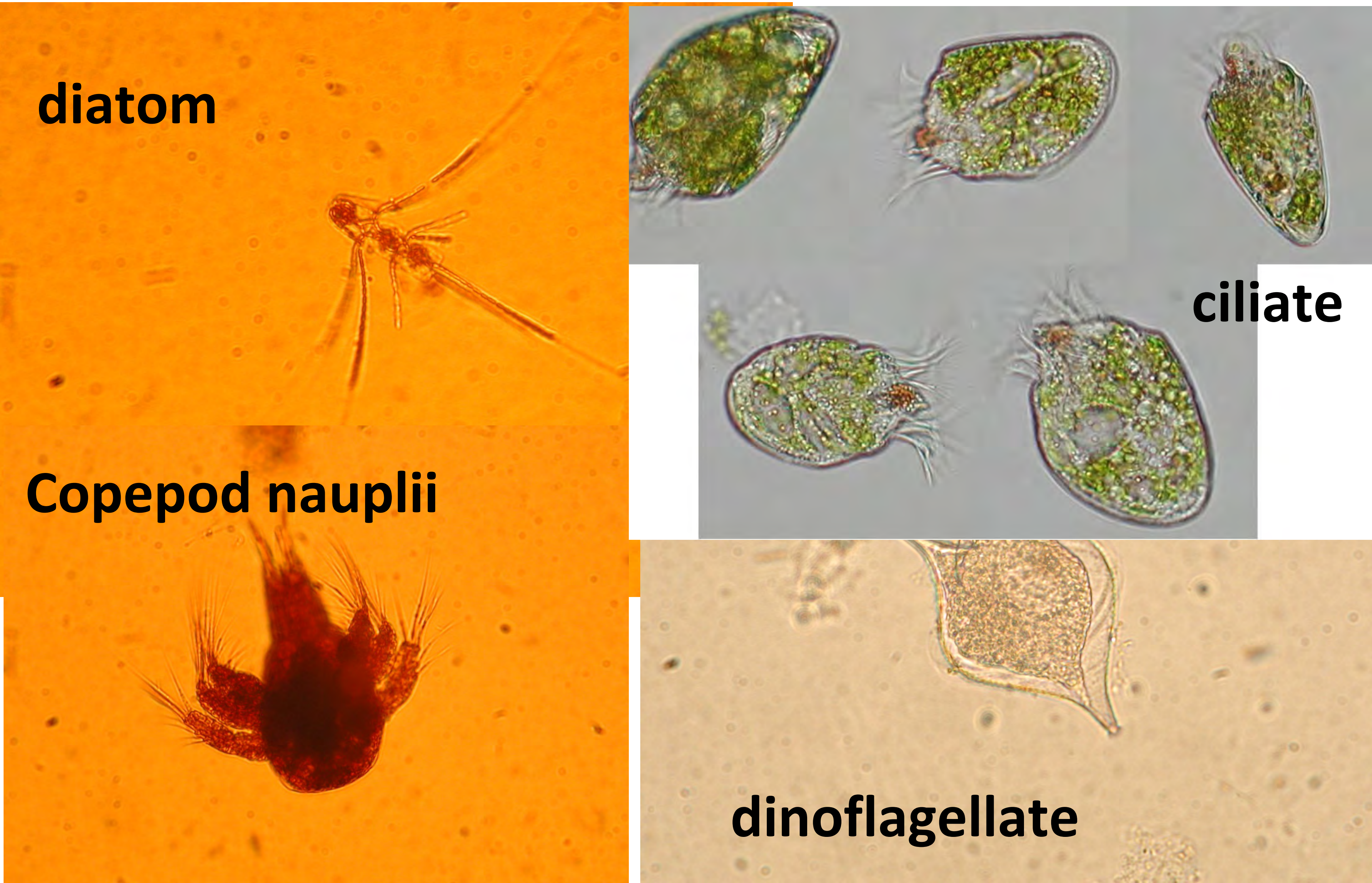
Important consumer

Eaten by many fish and seabirds (salmon, hake, rockfish, black cod; auklets, shearwaters)

# Why do we focus on *E. pacifica*?

- Widely distributed across the North Pacific
- Dominant euphausiid in California Current and in waters off Japan, Korea and China
- Key trophic link
- Peterson lab
- PICES WG 23

# What do they eat?



# Previous work

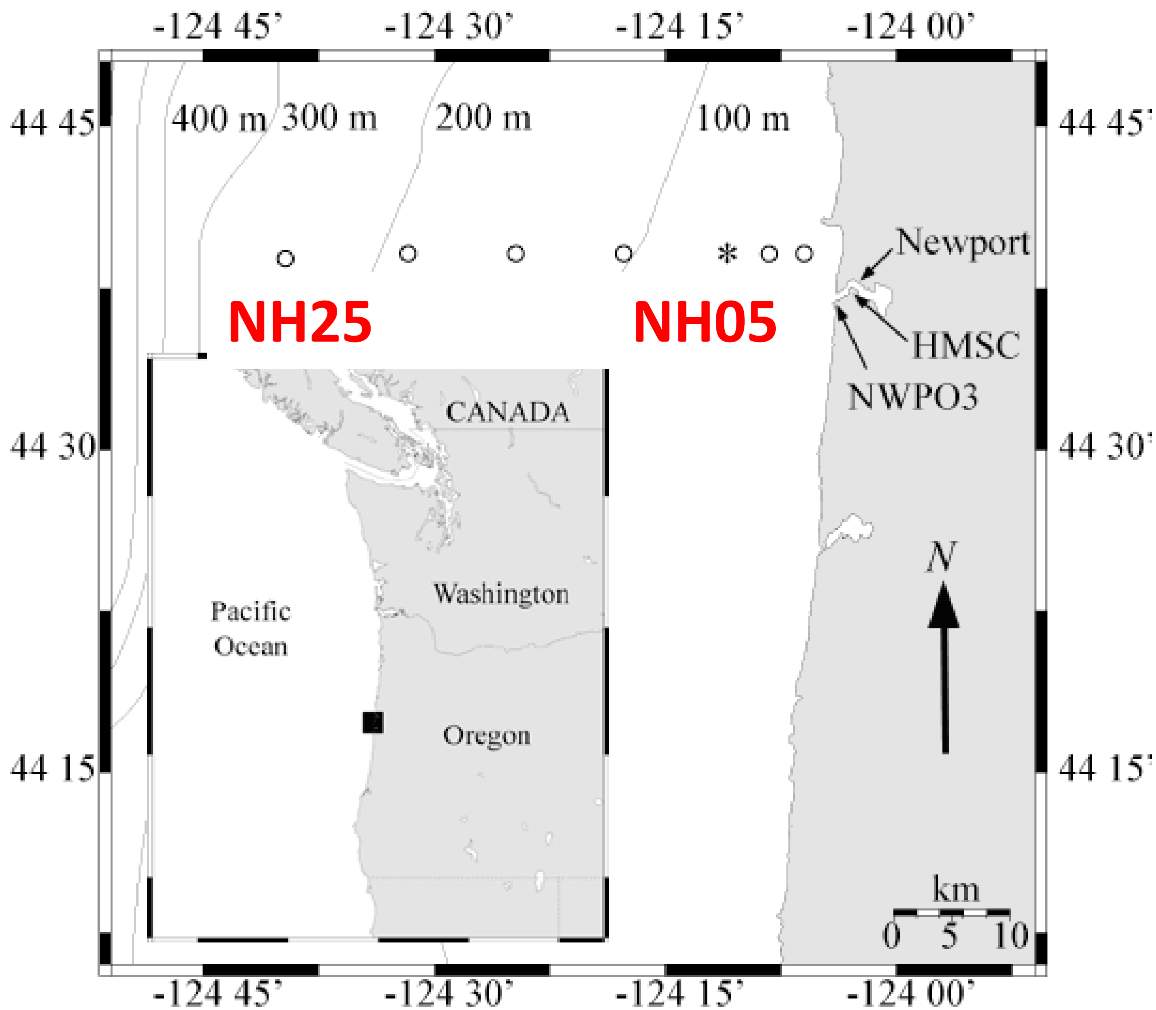
- A few studies in the laboratory using single species of cultured phytoplankton
- Some studies using stomach content and gut pigment analysis
- Need in situ feeding rates on natural assemblages

# Hypothesis from our project…

- *E. pacifica* feeds omnivorously on the natural plankton assemblages.

- Feeding intensity and selectivity are closely related to the seasonality of coastal upwelling.

# Study area and methods






**Disappearance of cells**

| Expt. No. | Date | krill source location | water source location | water source depth [m] |
|---|---|---|---|---|
| 1 | 23-Feb | NH25 | NH25 | 17 |
| 2 | 12-Apr | NH25 | NH25 | 17 |
| 3 | 5-Jun | Cascade Head | NH05 | 27 |
| 4 | 8-Jun | Cascade Head | Inshore waters (NH) | 10 |
| 5 | 19-Jun | NH25 | NH25 | 17 |
| 6 | 27-Jun | NH25 | NH25 | 10 |
| 7 | 21-Jul | NH25 | NH25 | 10 |

## Data:

- **Microscopic cell counts in terms of carbon**

**Size-fractionated chl a concentration**

***E. Pacifica* weight In terms of carbon**

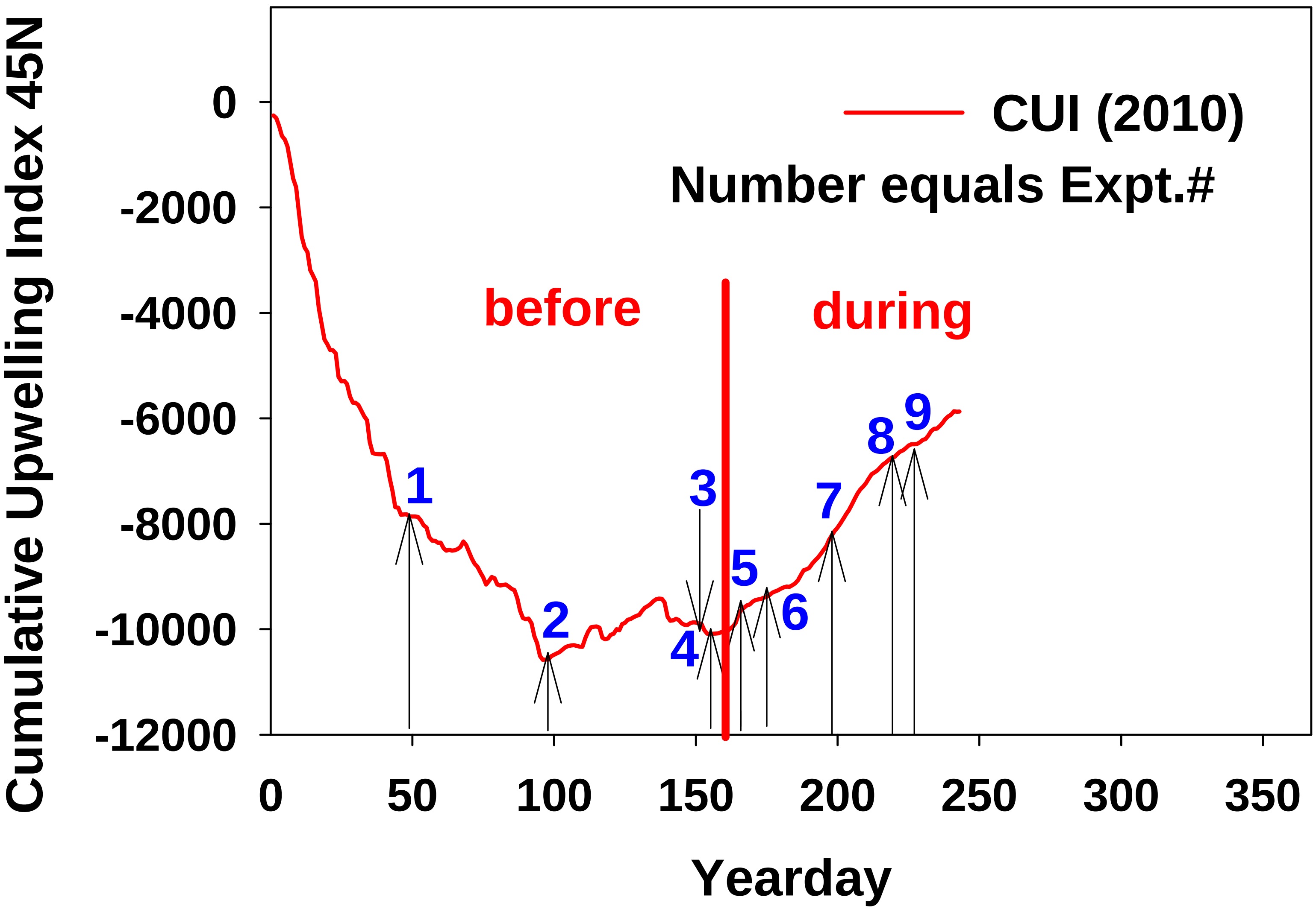
## Rates:

- **Filtration rate (F, ml euphausiid $^{-1}$ h$^{-1}$) and Ingestion rate (I, µg C euphausiid$^{-1}$ h$^{-1}$) were calculated from equations of Frost (1972). Daily Ration (DR, % body C d$^{-1}$) was calculated from ingestion rates (carbon units) and *E. pacifica* carbon weight.**

## Regression analysis:

- **Fit the Filtration and Ingestion rate data vs. food concentration with two different models, Ivlev ($Y = a*(1-\exp(-bX))$) and Holling Type-II ($Y = aX/(1+bX)$) and fit Daily Ration data with sigmoid model ($Y=a/(1+\exp(-(x-x_0)/b))$).**

# Results



Cumulative Upwelling Index 45N
0
-2000
-4000
-6000
-8000
-10000
-12000
0
50
100
150
200
250
300
350
Yearday
CUI (2010)
Number equals Expt.#
before
during
1
2
3
4
5
6
7
8
9

## Initial food conditions.
## Chl a concentration (µg $L^{-1}$); cell counts (µg C $L^{-1}$)

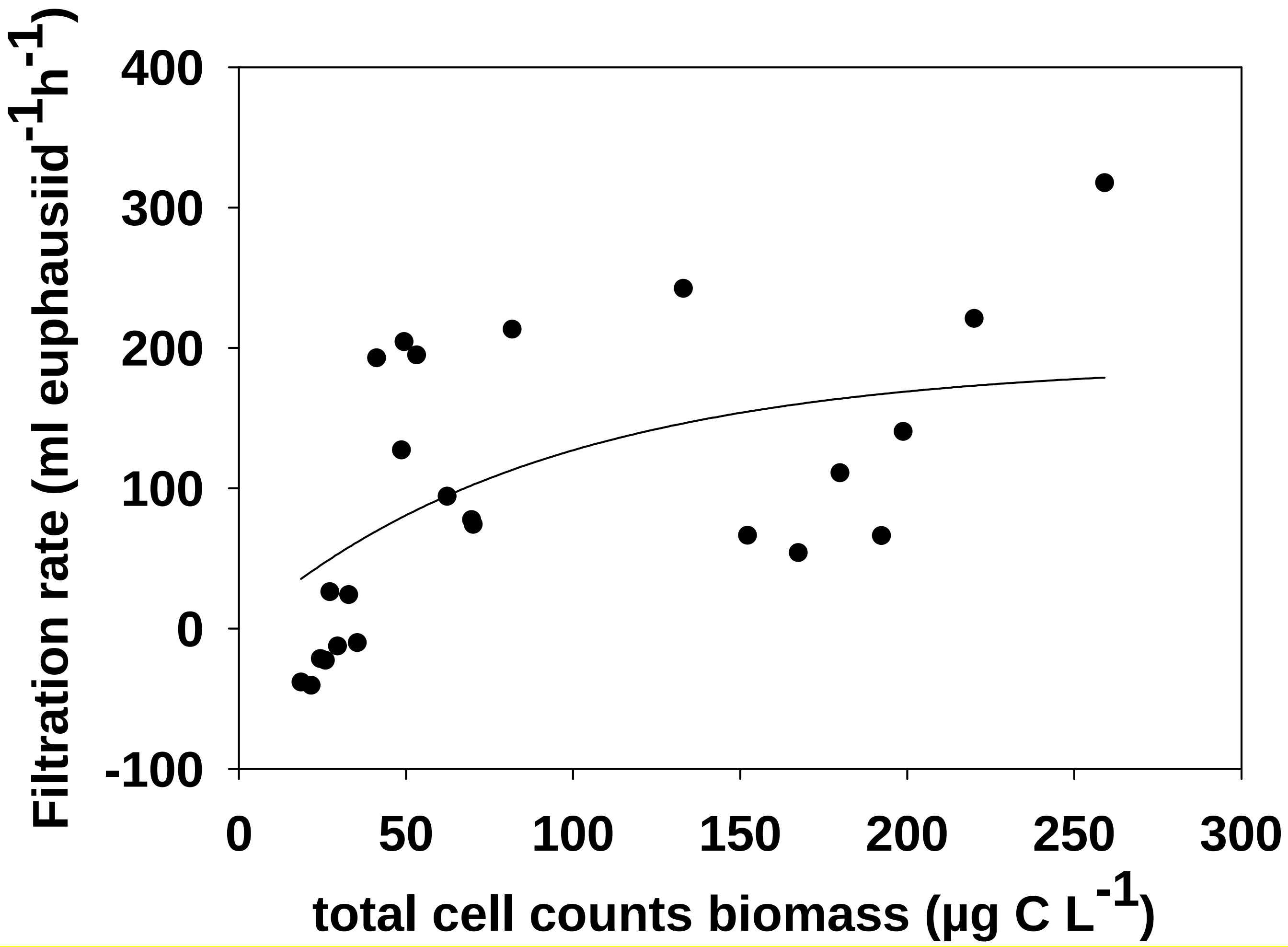
| Expt. No. | Chl a concentration < 5µm | 5-20 µm | >20 µm | Total | autotrophic Diatom | Other | heterotrophic H.dino | Ciliate |
|---|---|---|---|---|---|---|---|---|
| 1 | na | na | na | 4.92 | 114.8 | 13.3 | - | 8.3 |
| 2 | 0.52 | 0.09 | 0.23 | 0.84 | 6.3 | 11.4 | 0.5 | 7.2 |
| 3 | 0.24 | 0.12 | 0.06 | 0.42 | 0.4 | 9.9 | 0.3 | 5.5 |
| 4 | 0.27 | 0.17 | 0.04 | 0.48 | 6.2 | 7.4 | 1.6 | 34.5 |
| 5 | 0.25 | 0.20 | 0.43 | 0.89 | 68.3 | 103.6* | 2.1 | 24.0 |
| 6 | 0.41 | 0.16 | 0.23 | 0.80 | 7.4 | 22.1 | 8.1 | 31.8 |
| 7 | 0.60 | 0.66 | 4.90 | 6.16 | 149.5 | 6.7 | 3.4 | 10.6 |

"Other" mainly comprised of autotrophic dinoflagellates and other flagellates; "*" High biomass came from dinoflagellates bloom

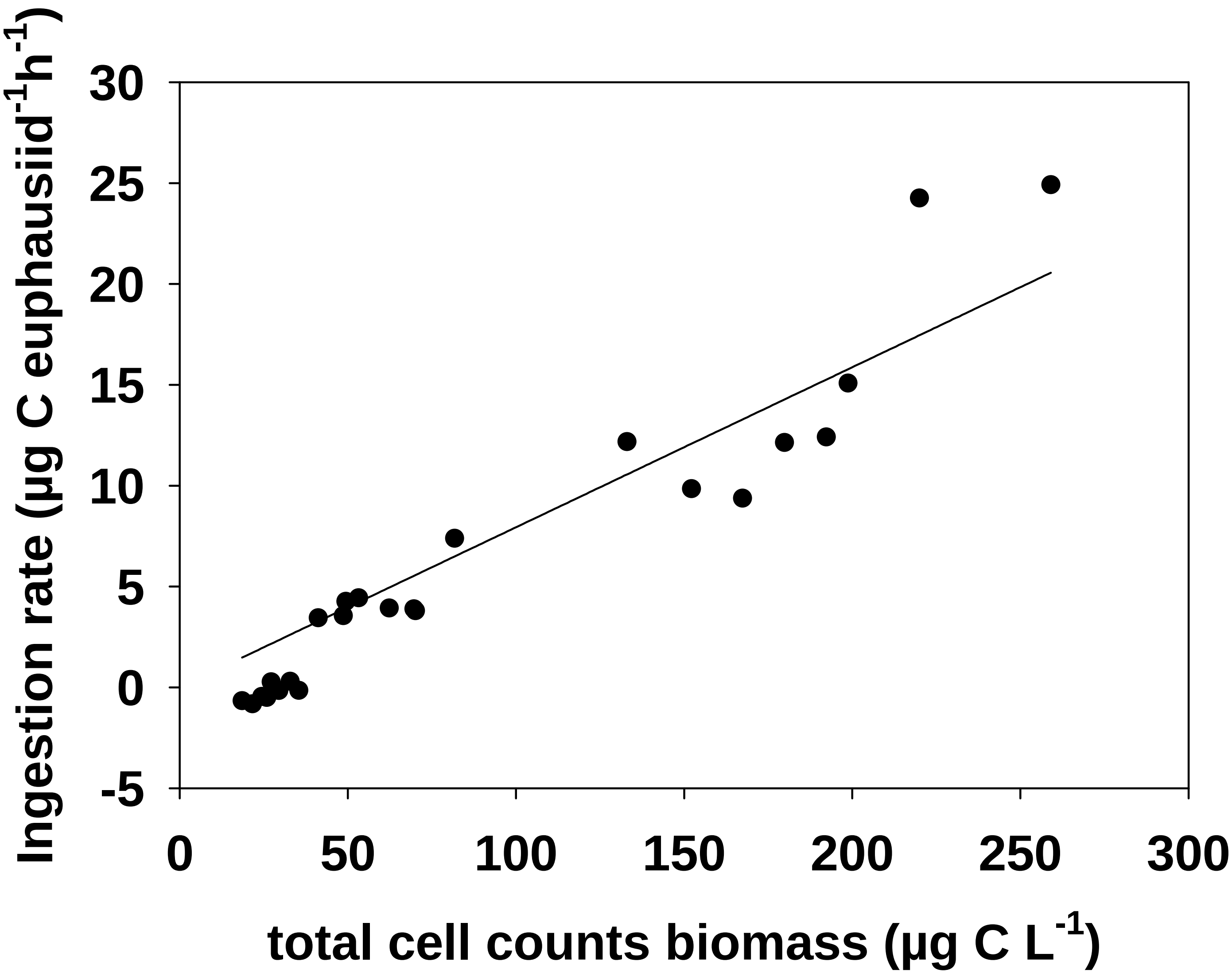
# Filtration rates (F), Ingestion rates (I) and Daily Ration (DR)

| Expt. | F (ml euphausiid $^{-1}$ h$^{-1}$) | | I (µg C euphausiid$^{-1}$ h$^{-1}$) | | DR (% body C d$^{-1}$) |
|---|---|---|---|---|---|
| No. | cell counts | Chl a | cell counts | Chl a | cell counts |
| 1 | 19.8 | 19.1 | na | na | 5.3 |
| 2 | -30.7 | 8.0 | -0.6 | 0.01 | -0.5 |
| 3 | 6.93 | 30.4 | 0.06 | 0.01 | 0.04 |
| 4 | 195.0 | 97.9 | 3.4 | 0.03 | 1.8 |
| 5 | 202.8 | 129.7 | 16.1 | 0.07 | 7.6 |
| 6 | 114.8 | 57.8 | 4.8 | 0.04 | 2.9 |
| 7 | 101.9 | 105.4 | 14.0 | 0.54 | 5.6 |

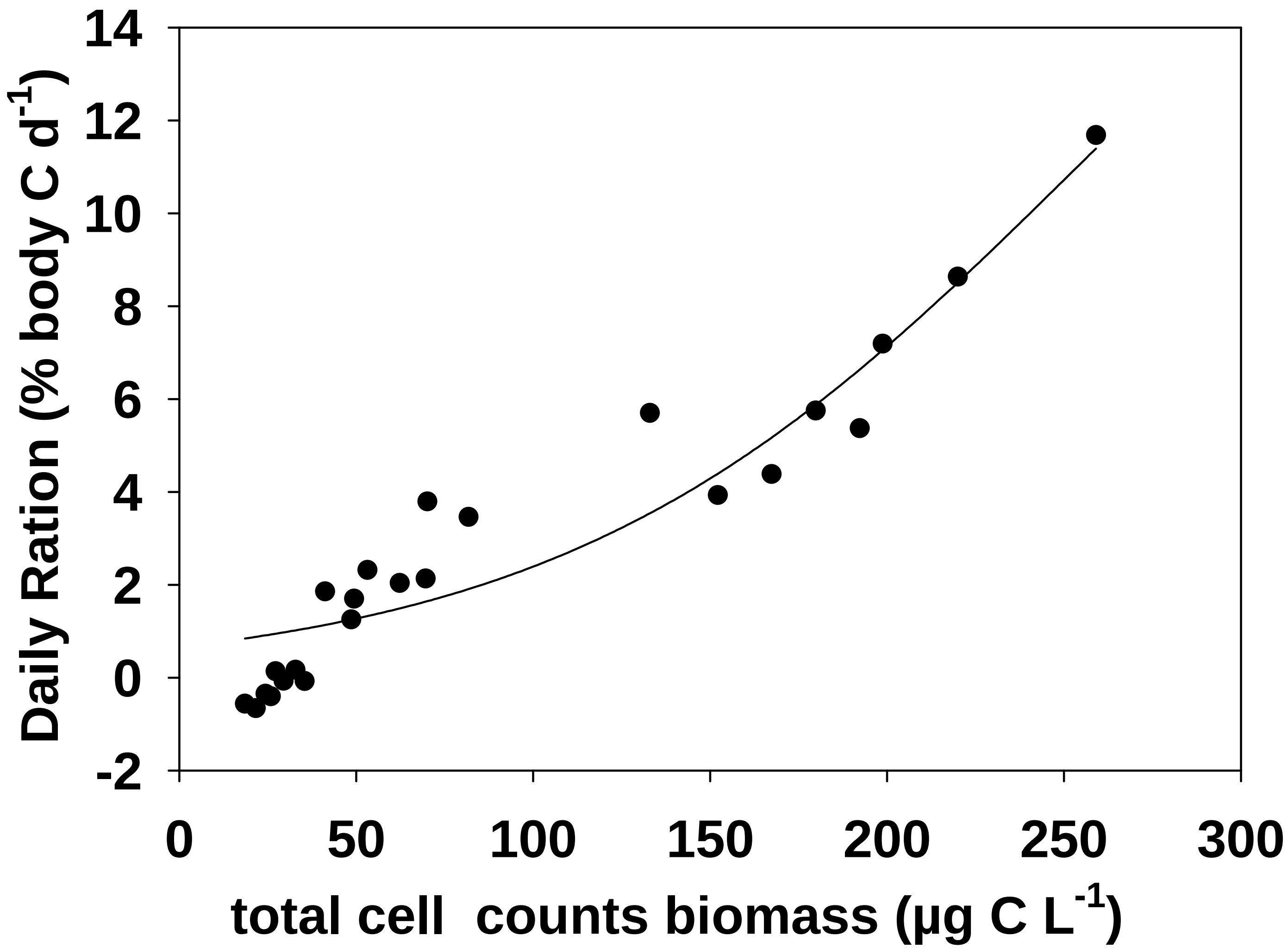
# Feeding behavior



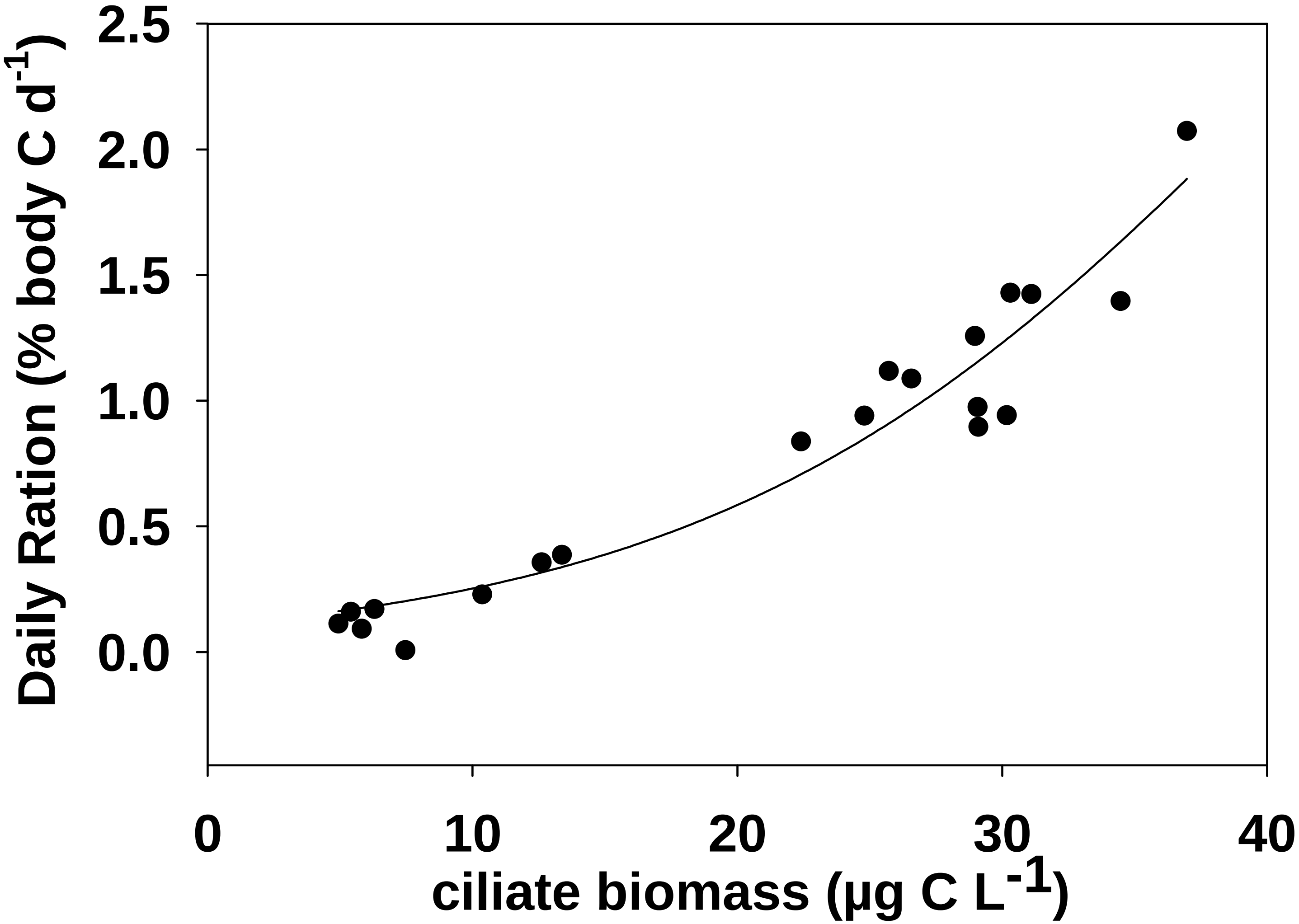

**The relationship was significant (F=11.04, P=0.003, $R^2$=0.33) with estimated maximum value is 189.6 ml.**




**Ingestion rates increased significantly as total food biomass increased ($F=157.06$, $P<0.0001$, $R^2=0.88$).**

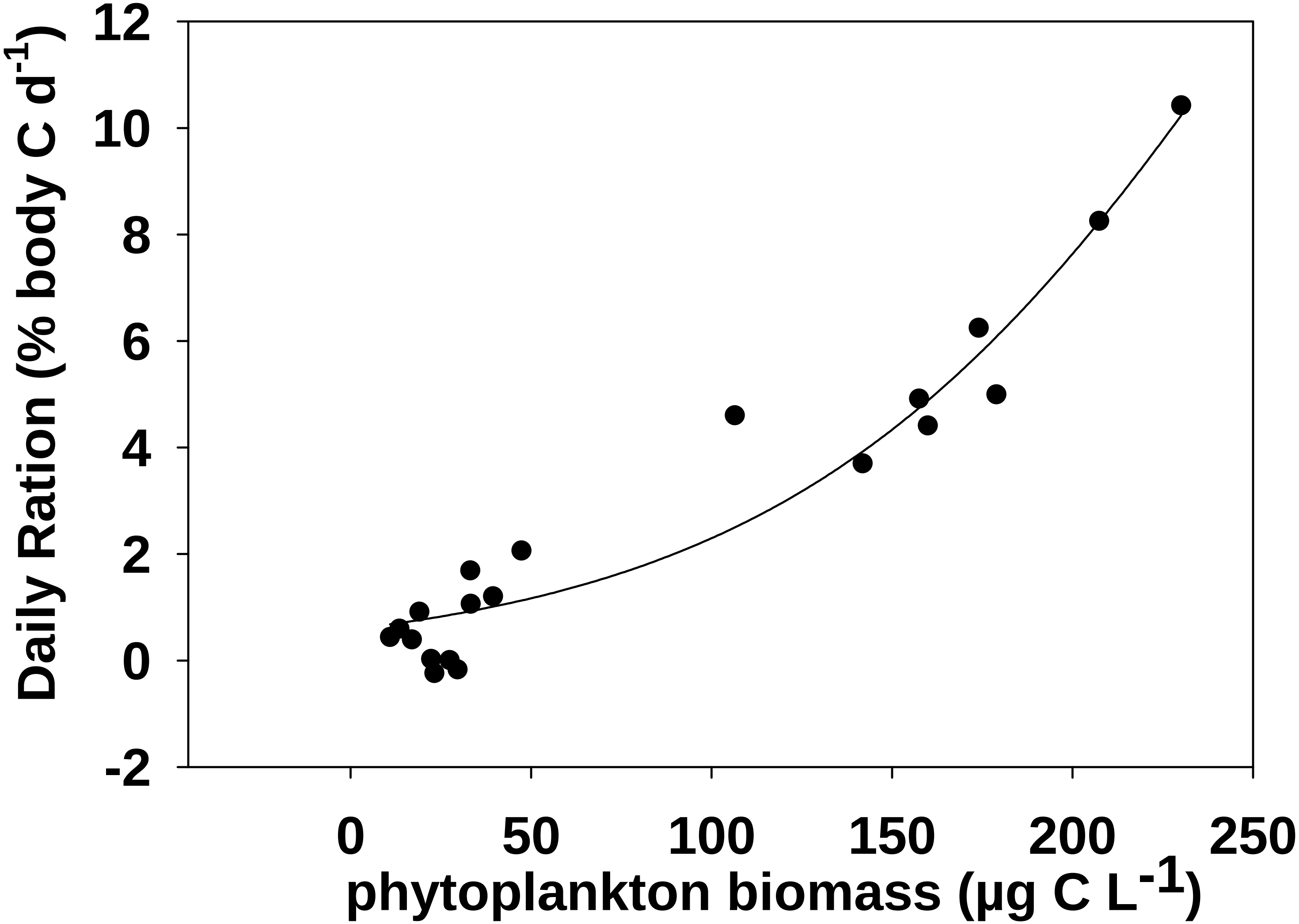



**Daily Ration significantly increased against total cell counts biomass (P<0.0001, $R^2$=0.83).**

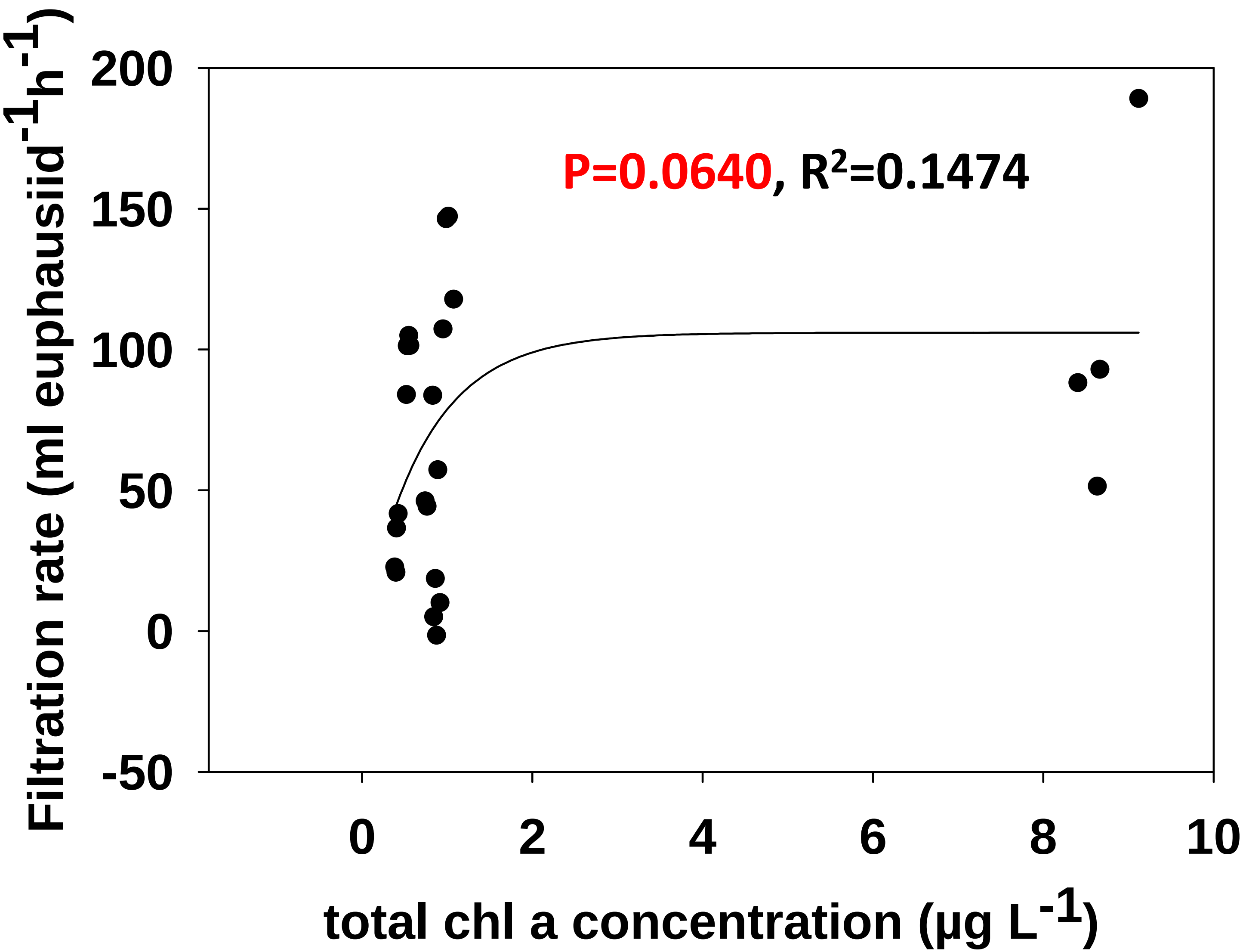



**Observed Daily Ration values: range = 0.03% ~ 1.4%**

**Significant relationship between Daily Ration and ciliates biomass($P<0.0001$, $R^2=0.93$).**




**Observed Daily Ration values: range = 0.6% ~ 6.6%**
**Significant relationship between Daily Ration and phytoplankton biomass ($P<0.0001$, $R^2=0.94$).**




**Filtration rates (F) weakly correlated with total chl a concentration; no significant relationships between F and chl a size fractions: >20µm, 5~20µm and <5µm.**

# Summary

- *E.pacifica* feeding rates strongly depend on in situ food biomass. Higher ingestion rates were observed during upwelling season (Expts 5&7).

- Under low plankton biomass situation, low biomass of both diatom and ciliate, *E.pacifica* showed weak grazing activity and they might switch to smaller phytoplankton (Expts 2&3).

- *E.pacifica* always showed grazing pressure on ciliates no matter if phytoplankton were abundant or not. When ciliates were the main biomass contributor, they could significantly enhance grazing intensity (Expts 4).

- ❖Daily ingested carbon generally corresponded with the relative contributions of the main prey items, phytoplankton and ciliates.

- ❖Larger phytoplankton (mainly diatoms) and ciliates both could be the important food sources at the same time or alternatively (Expts 4&7).

- ❖We couldn't track feeding rates on dinoflagellates very well since they usually have a low abundance.


Thank you for your Attention!
Any Questions?
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# Acknowledgements

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