Estimations of development and mortality rates of ontogenetically migrating copepods in the SF_6 labeled water-mass during iron-enrichment experiments

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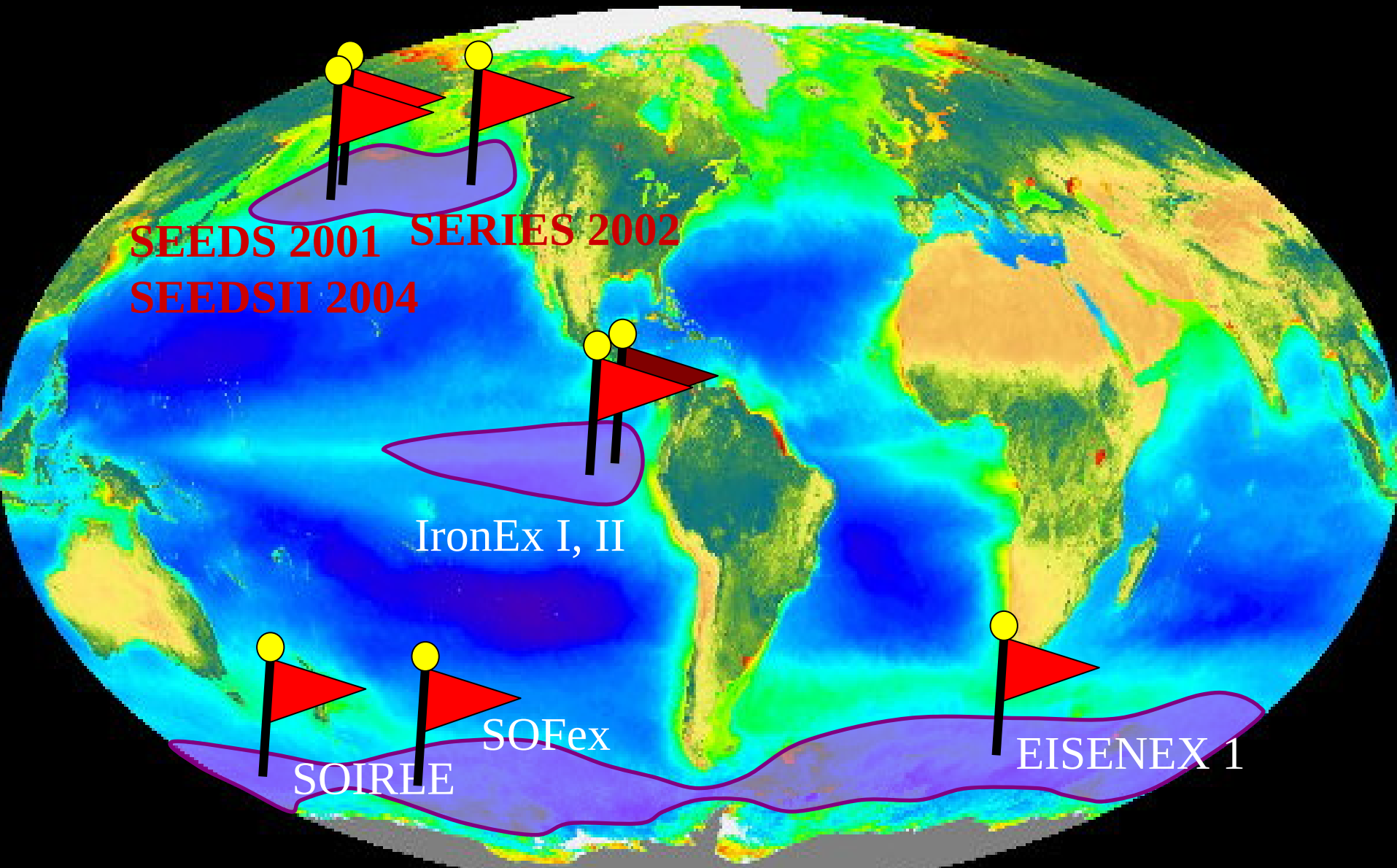
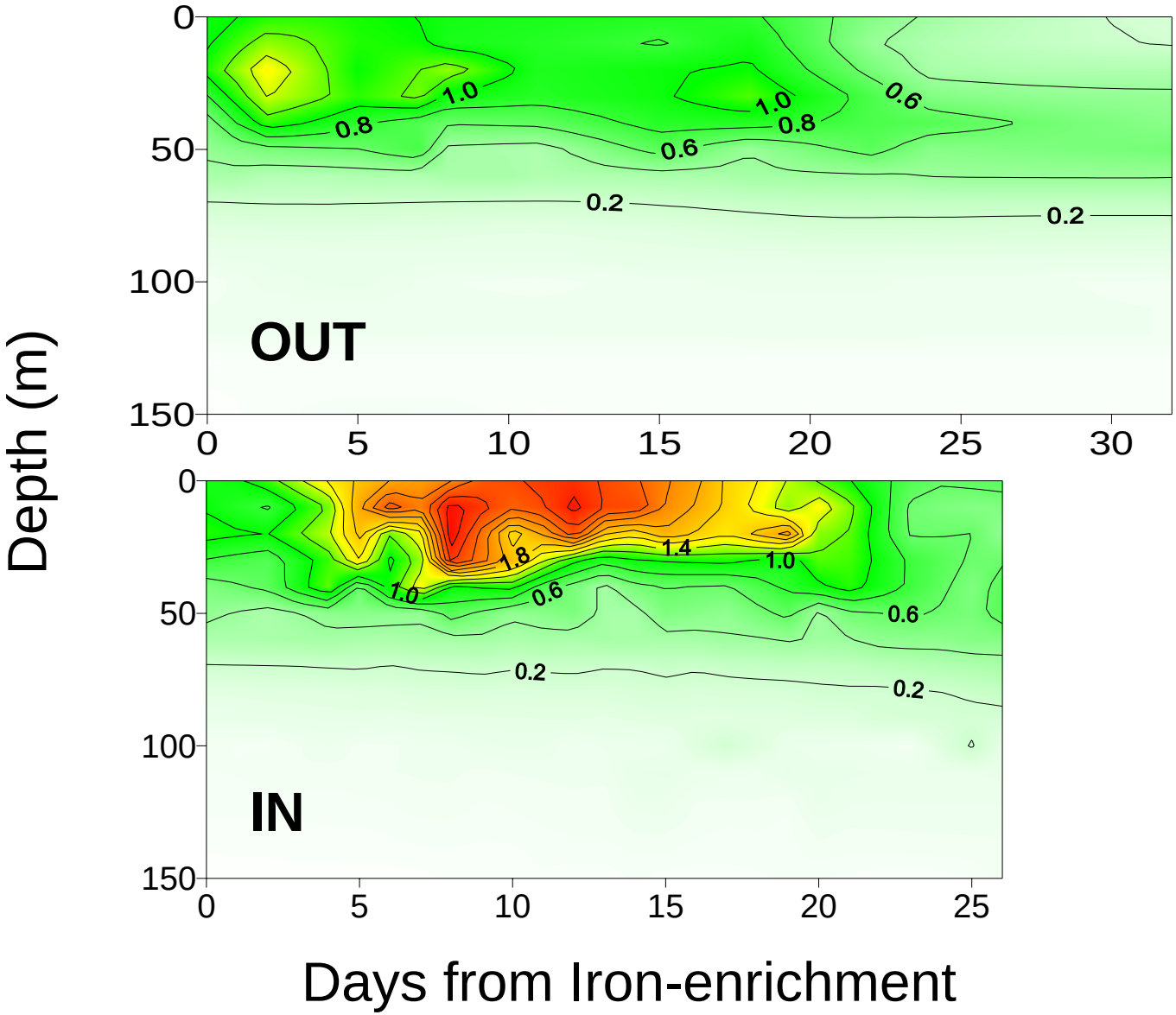
HNLC Oceans and locations of Iron Enrichment Experiment

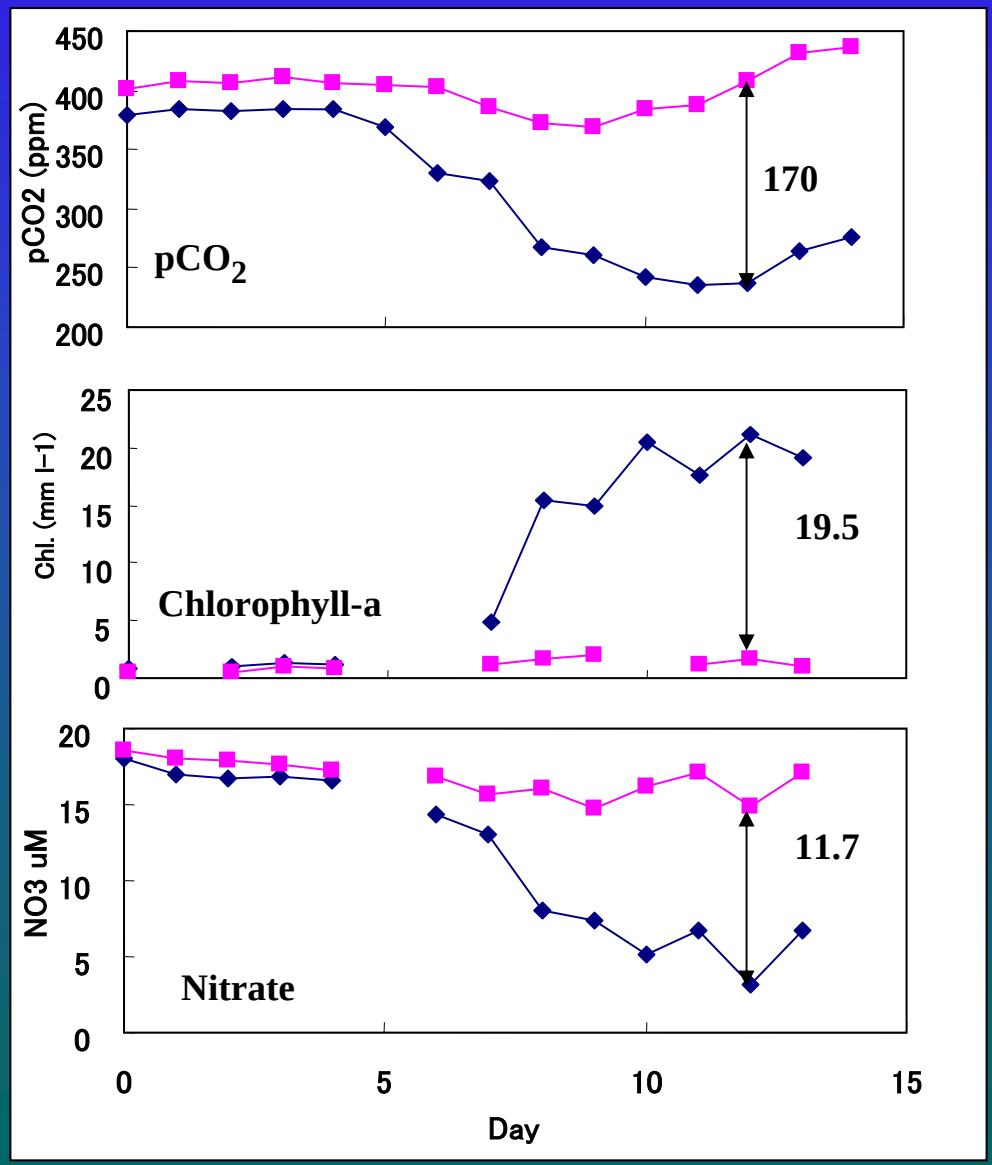


Chlorophyll-a concentration



SEEDS II

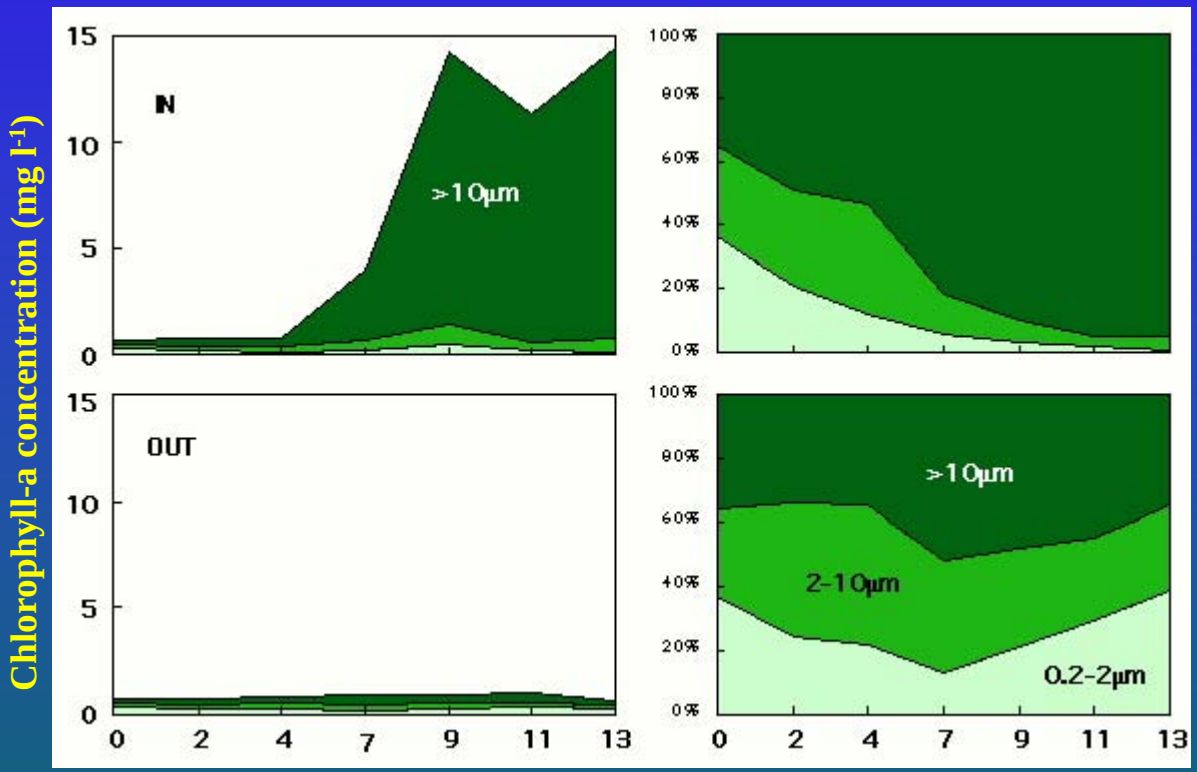
Change in pCO_2、Phytoplankton（Chl.a）、Nutrient (nitrate) concentrations in the patch



SEEDS

Tsuda et al (2003)

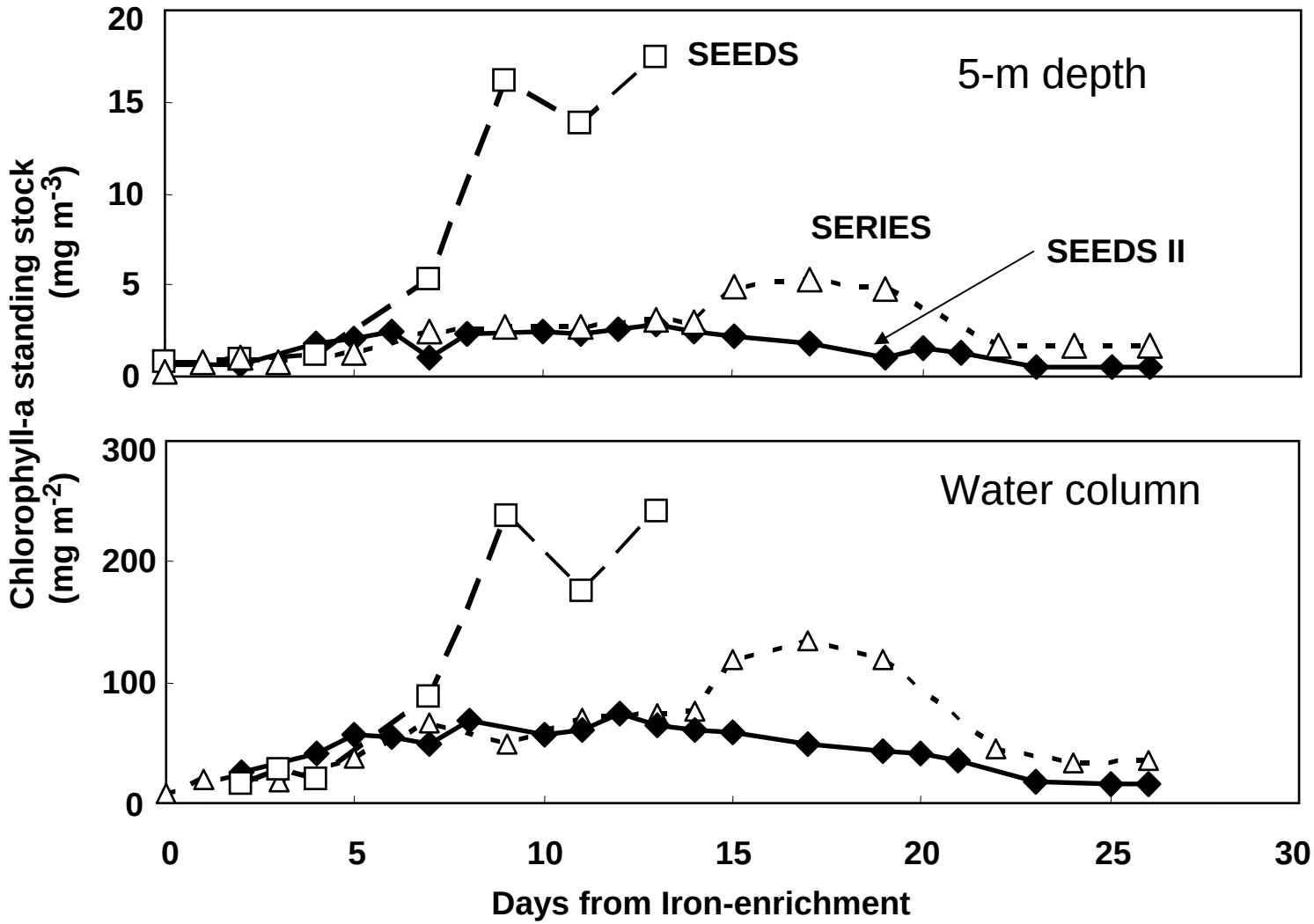
Temporal variations of size-fractionated chlorophyll-a



SEEDS

Tsuda et al (2003)

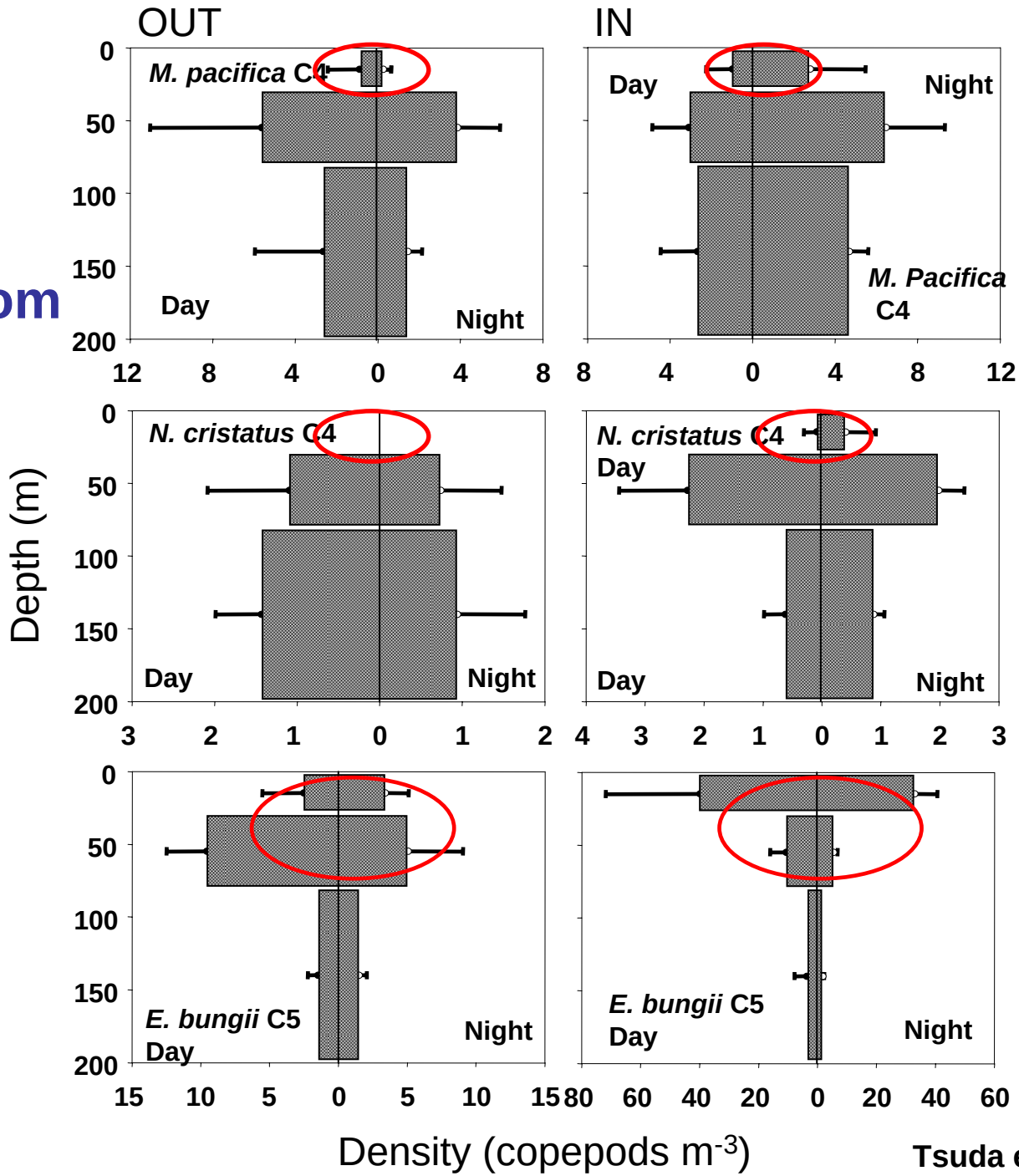
Chlorophyll concentration in SEEDS, SERIES and SEEDS II



Tsuda et al. (submitted)

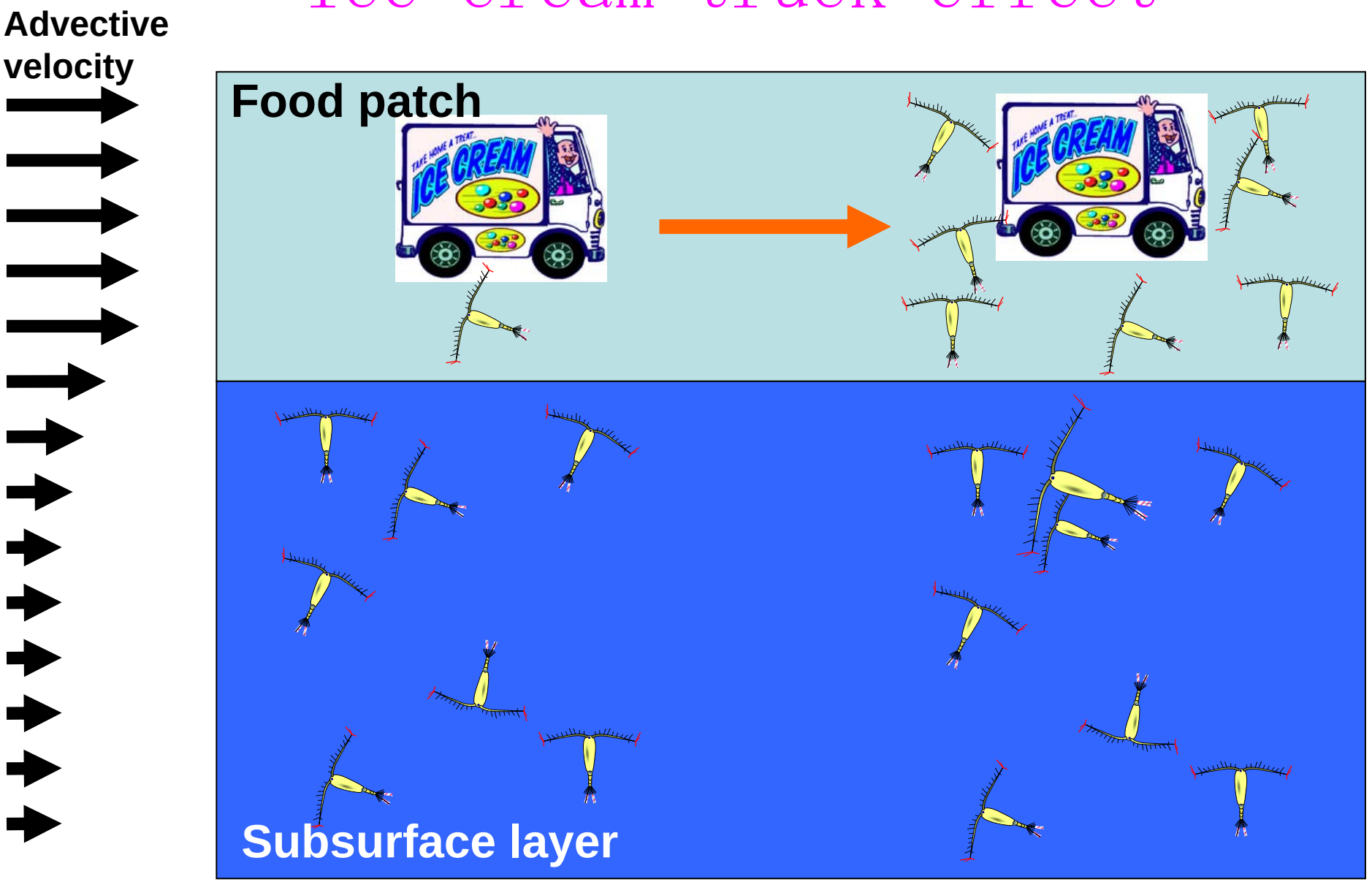
Averaged vertical distribution during diatom bloom

SERIES

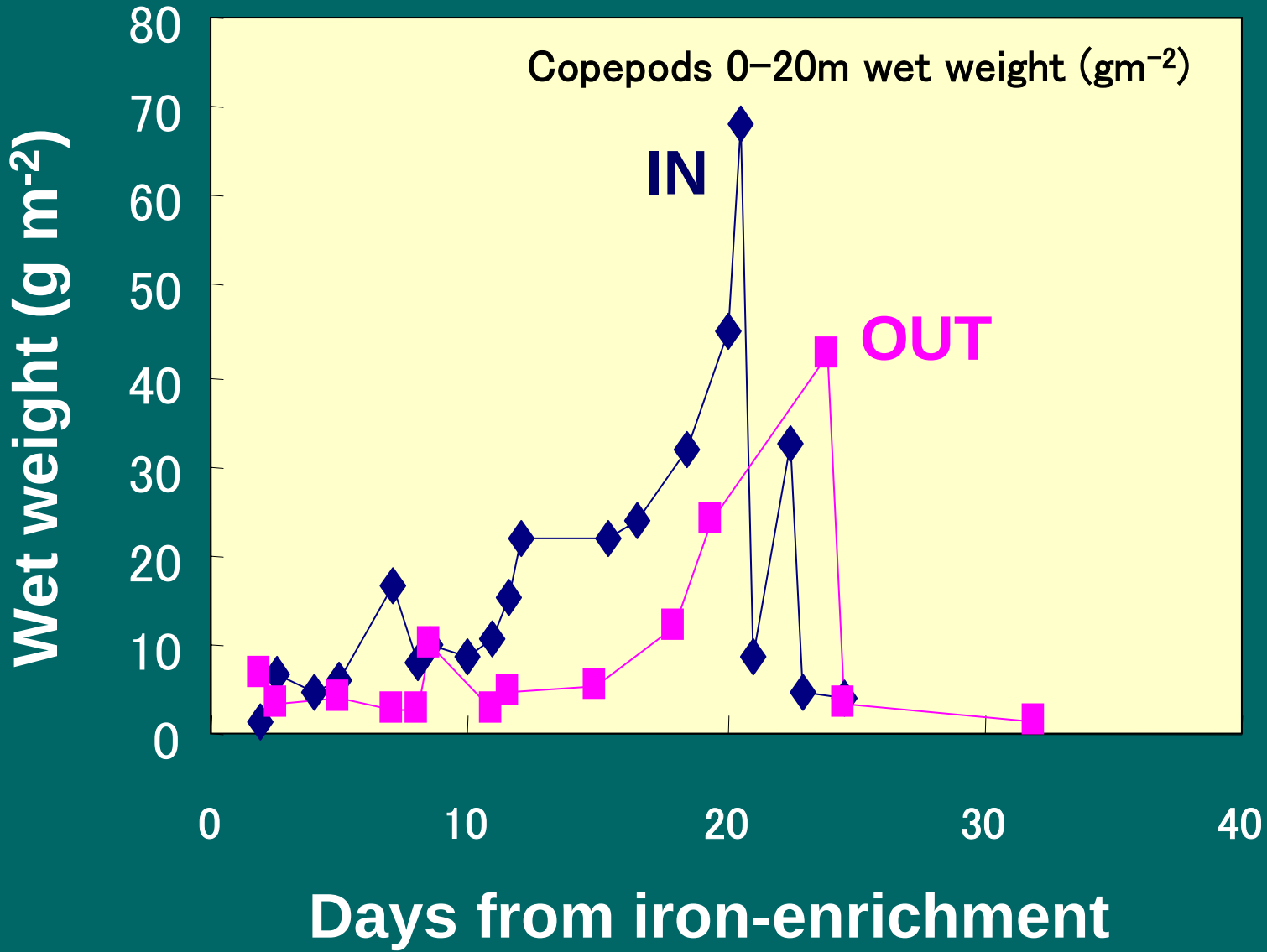


Tsuda et al. (2006)

Ice-cream truck effect



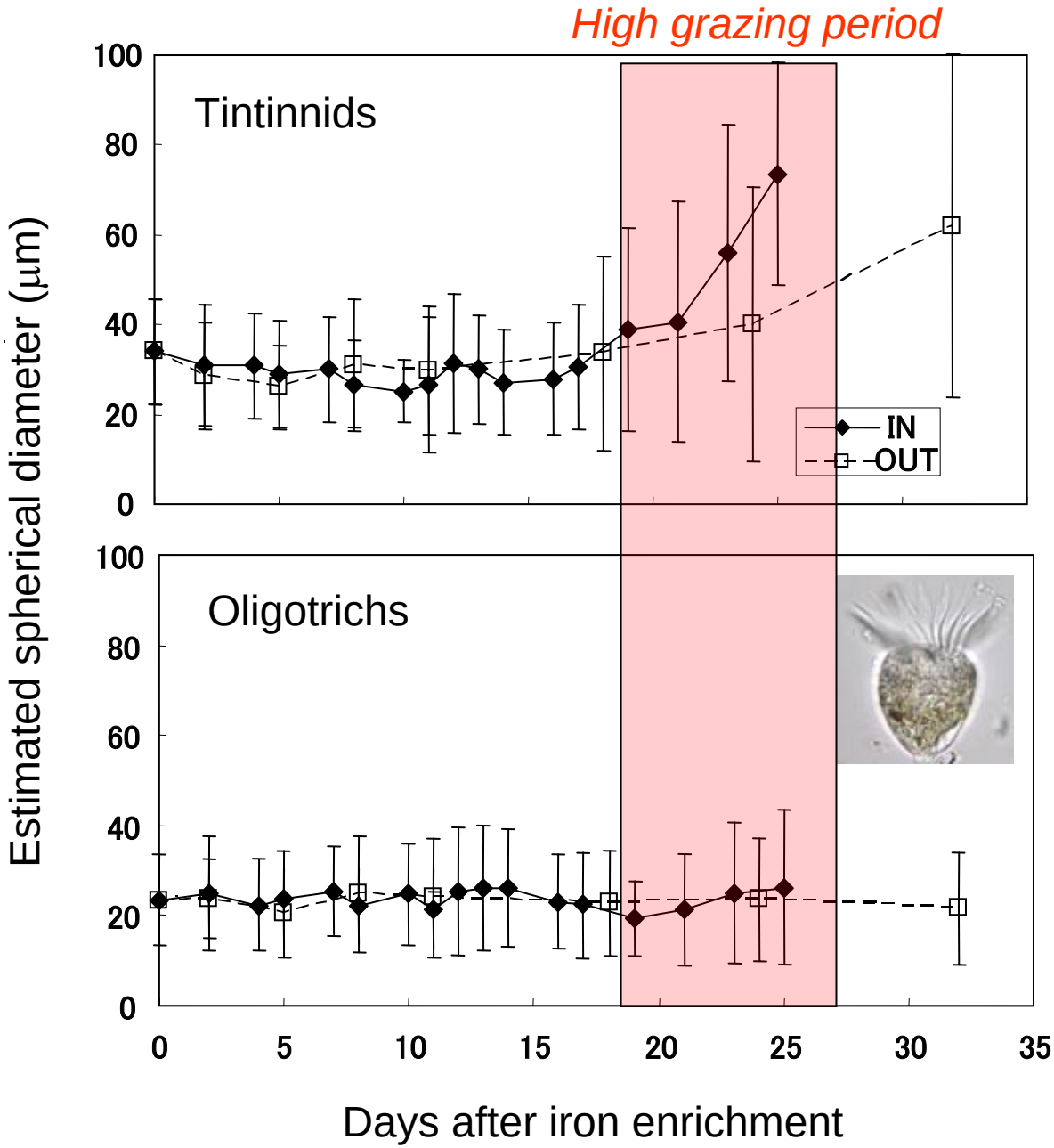
Copepod biomass



Tsuda et al. (submitted)

Average cell size of ciliates

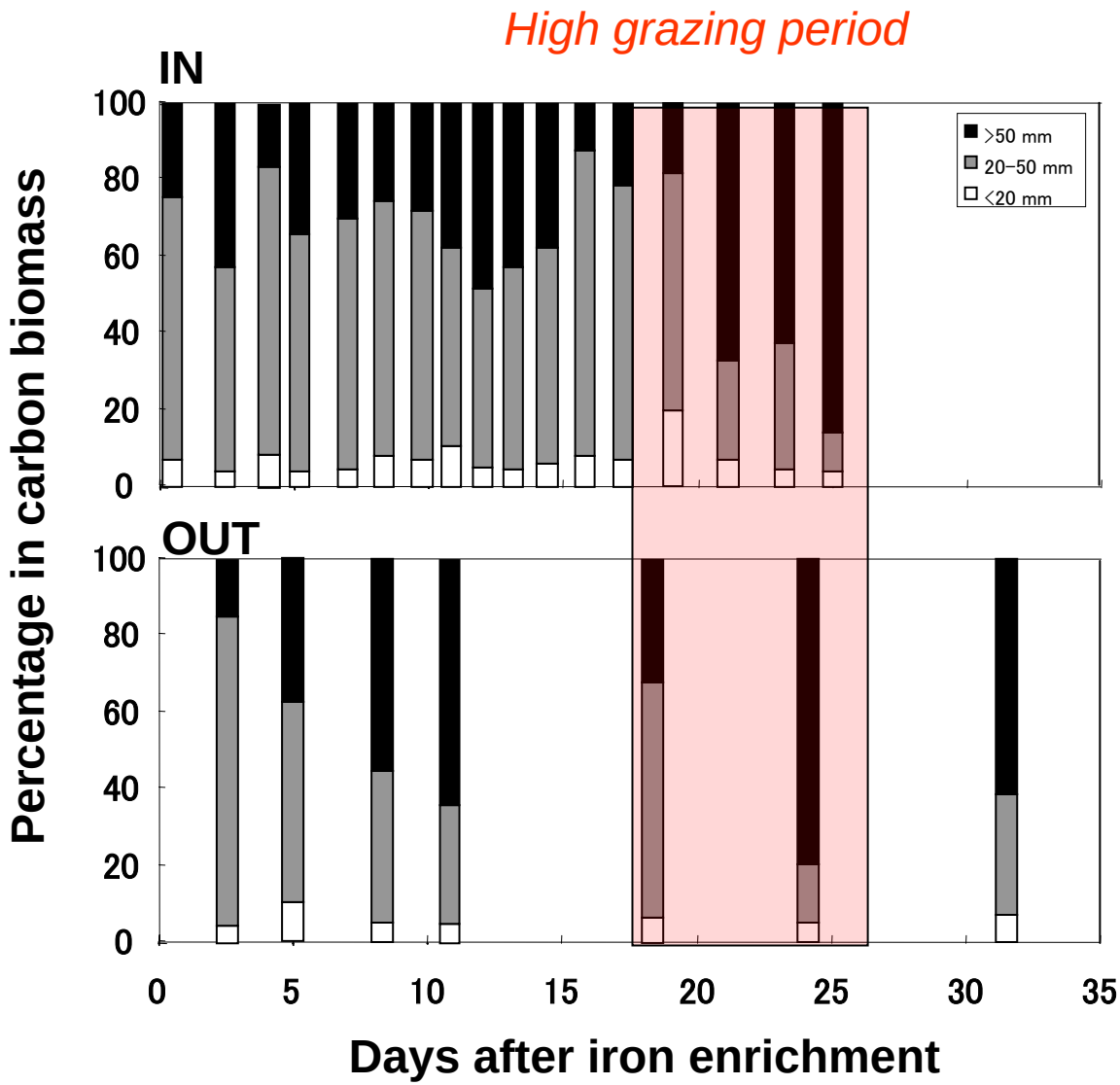
SEEDS II



Tsuda et al. (in prep)

Cell size Composition of Oligotrich ciliates

SEEDS II



Tsuda et al. (in prep)

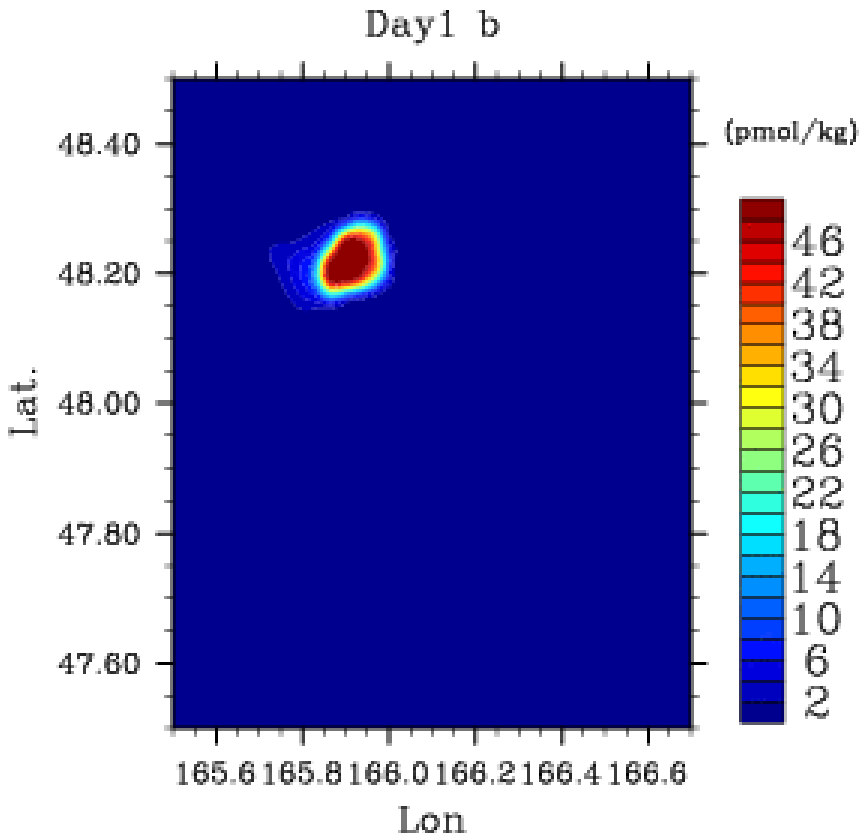
Mortality-related topics

1. Estimation of mortality and development rates in the iron-enrichment experiments

2. Young copepodites increase in the diatom-dominated blooms

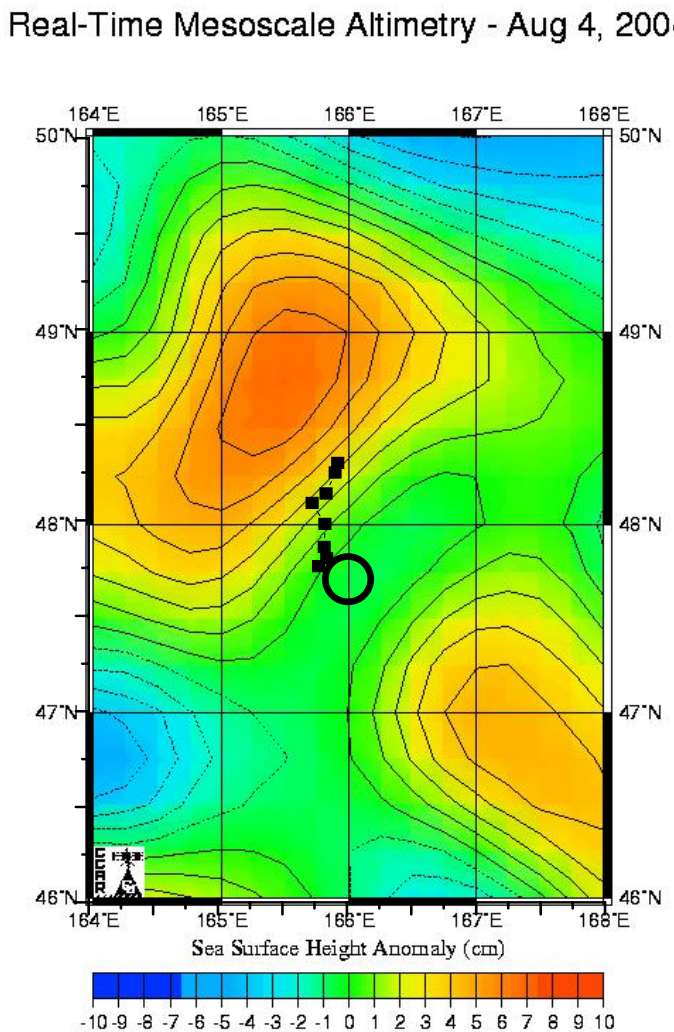
Iron-enrichment experiment

- Ideal (?) experiment to estimate zooplankton mortality and growth rates
  - Water-mass tracing by SF_6
  - Intensive sampling frequency
  - Suitable time scale of the observation (1 months)


Day1 b
(pmol/kg)
46
42
38
34
30
26
22
18
14
10
6
2
48.40
48.20
48.00
47.80
47.60
Lat.
165.6
165.8
166.0
166.2
166.4
166.6
Lon

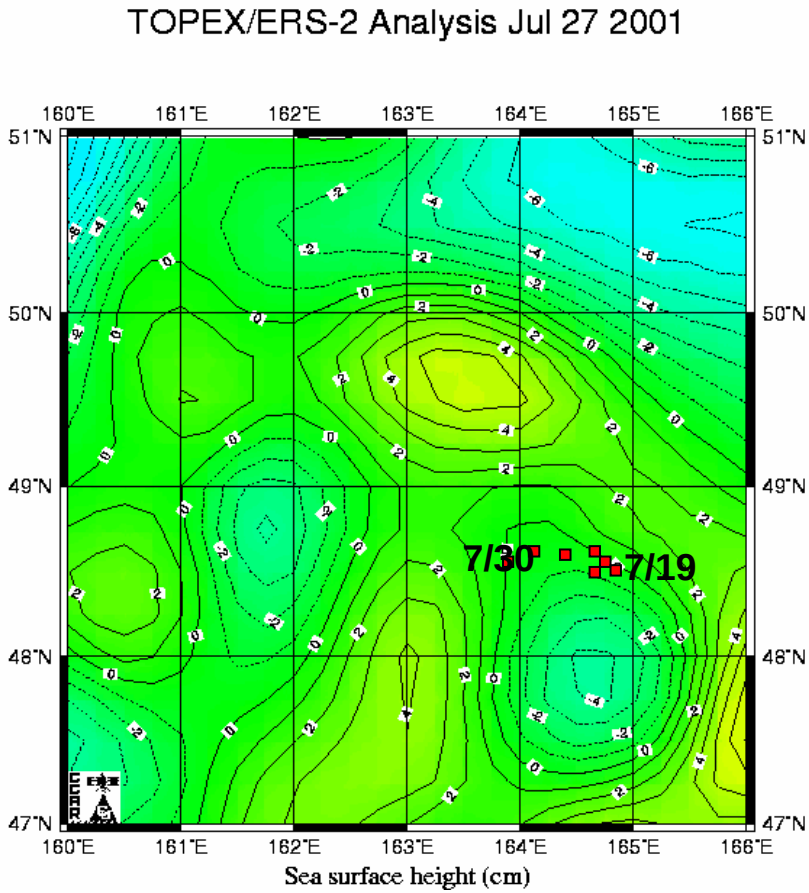
Patch movement on the SSH map

SEEDS II



CCRR, CU

SEEDS

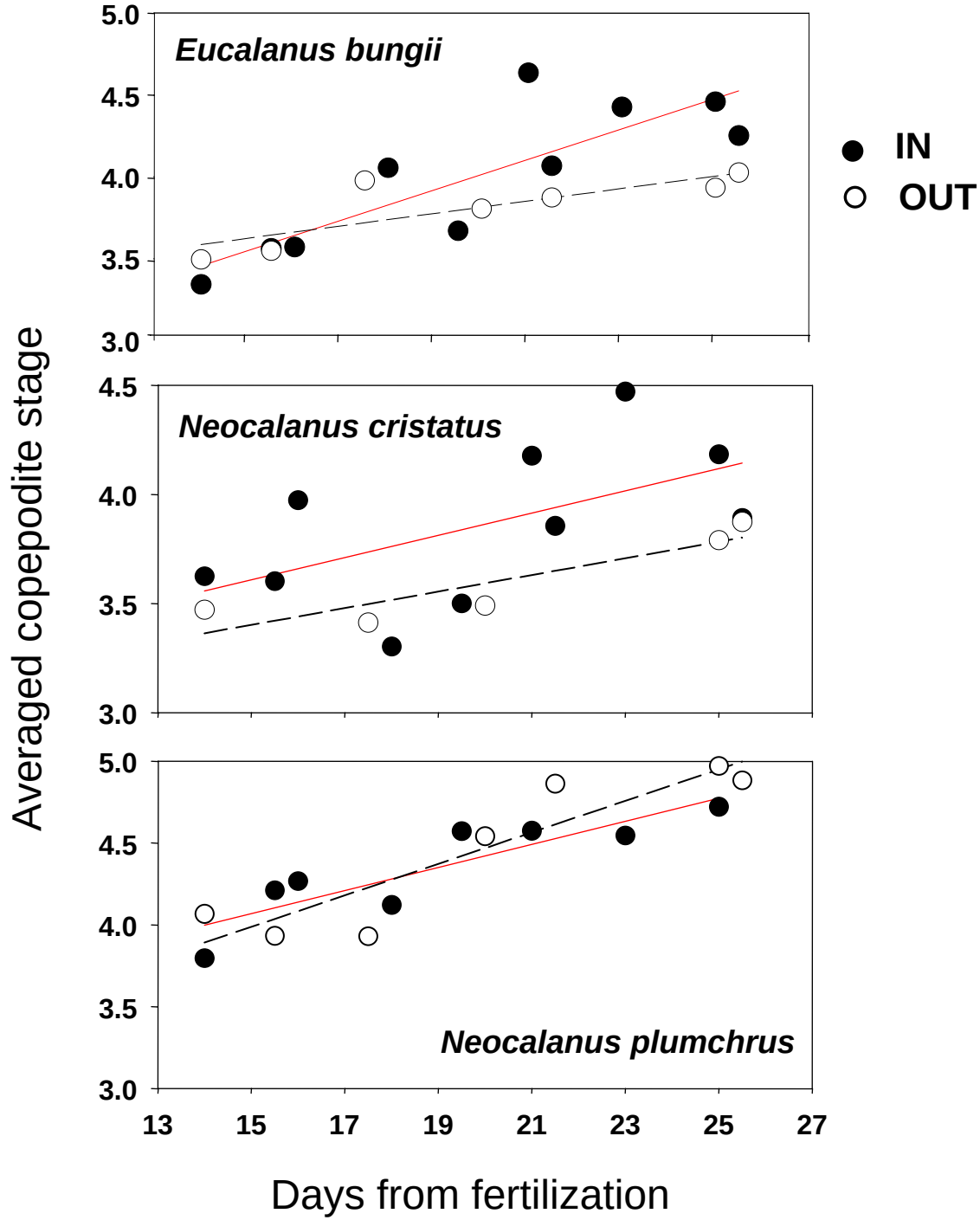


CCRR, CU

Tsumune et al. (in prep)

Variation in Averaged Copepodite stage

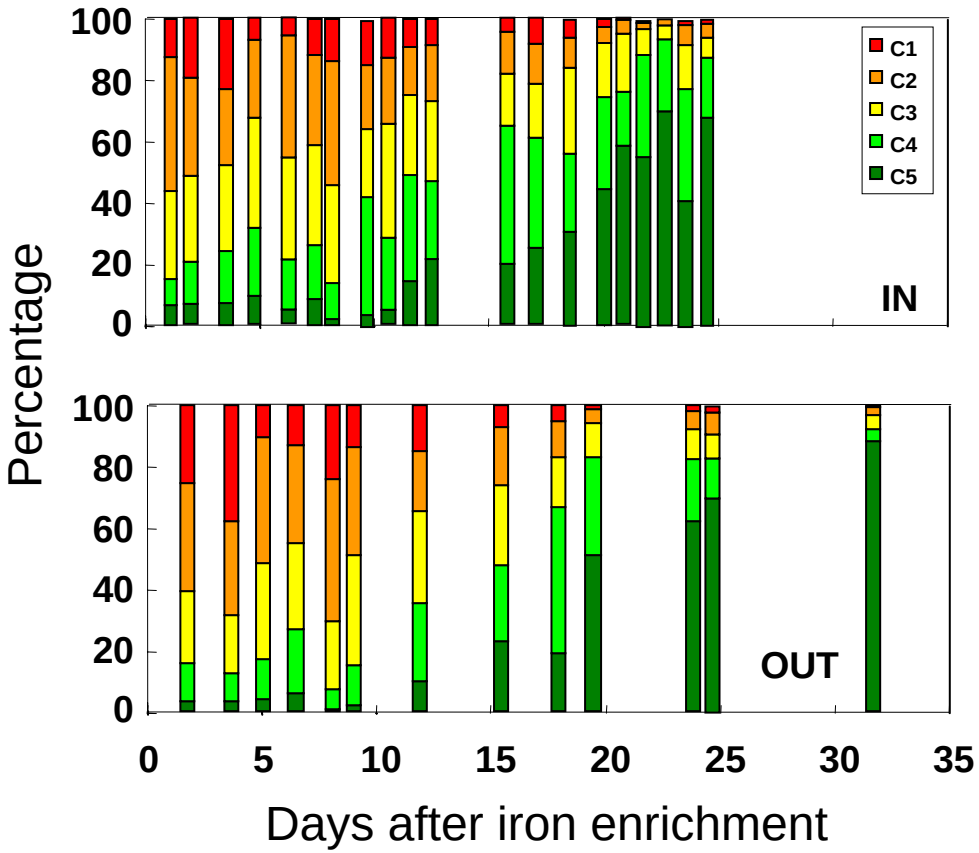
SERIES



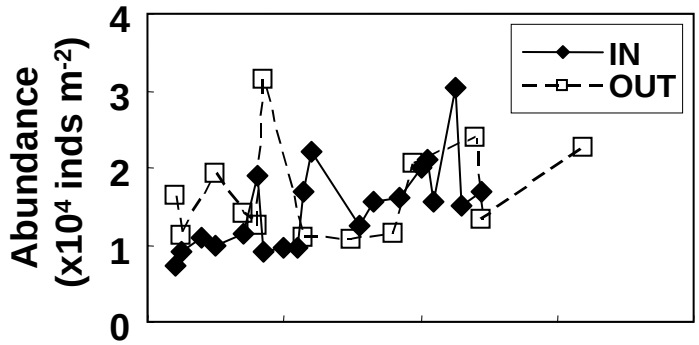
Tsuda et al. (2006)

Neocalanus plumchrus in SEEDS II

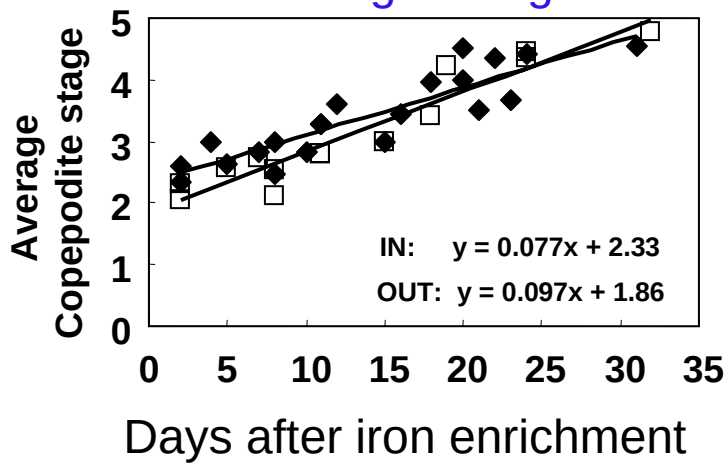
Copepodite stage composition



Abundance



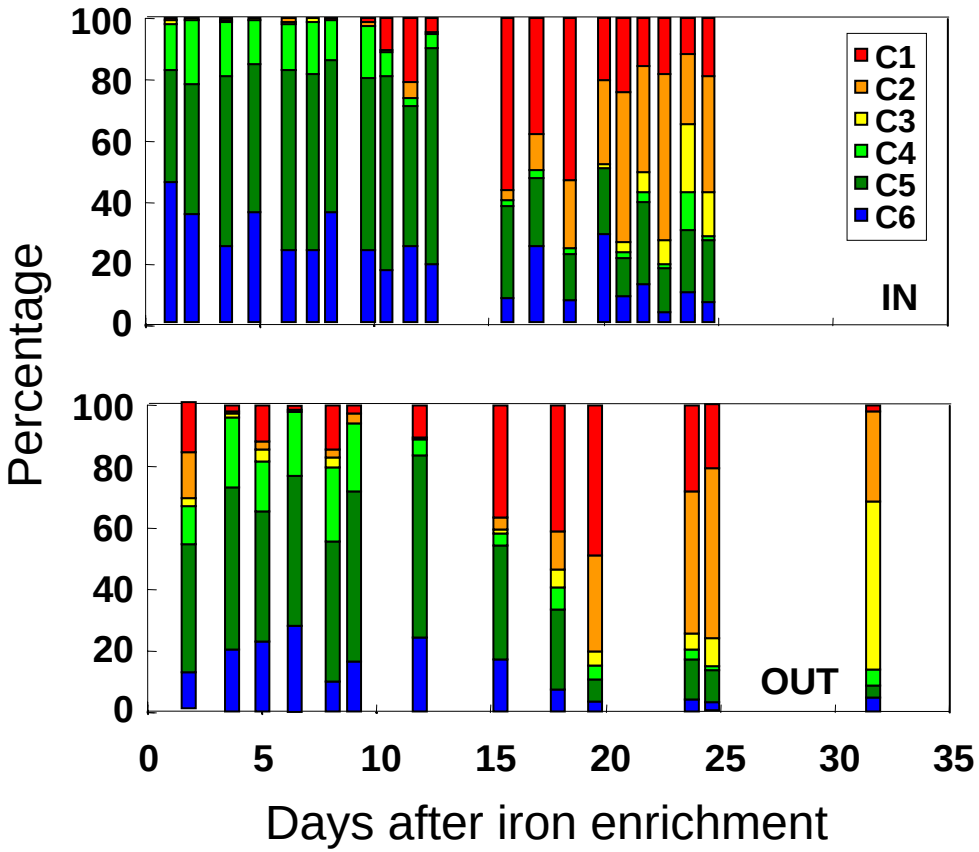
Averaged stage



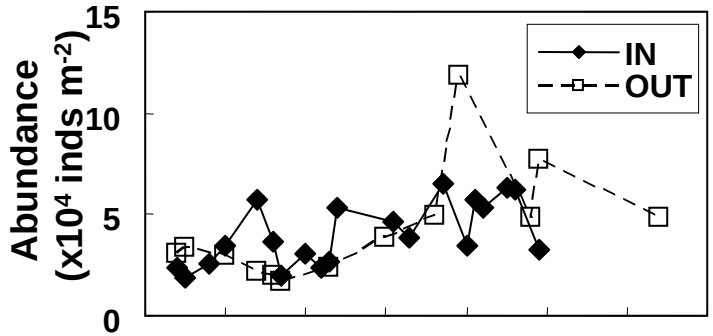
Tsuda et al. (in prep)

Eucalanus bungii in SEEDS II

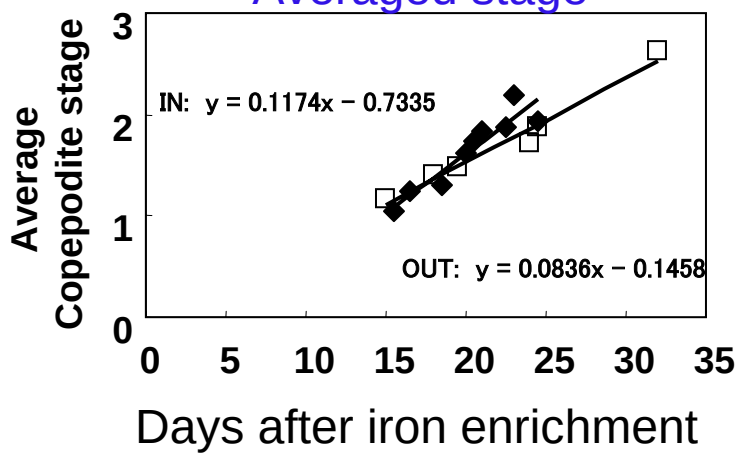
Copepodite stage composition



Abundance



Averaged stage



Tsuda et al. (in prep)

Estimation of Growth and Mortality Rates using a stage-structured model (SSM)

- Estimated Parameters
  - G: Growth rate
  - M: Mortality rate
- Objective function $\sum_{s,t}\left(\ln D_{s,t} - \ln \hat{D}_{s,t}\right)^2$
- where

$D_{s,t}$: observed density at stage s and time t

$\hat{D}_{s,t}$: predicted density

$$\hat{D}_{s,t} = \hat{D}_{s,t-1}(1-M)(1-G) + \hat{D}_{s-1,t-1}(1-M)G$$

Growth and mortality rates inside and outside the iron-patch by a simple method and the stage structured model

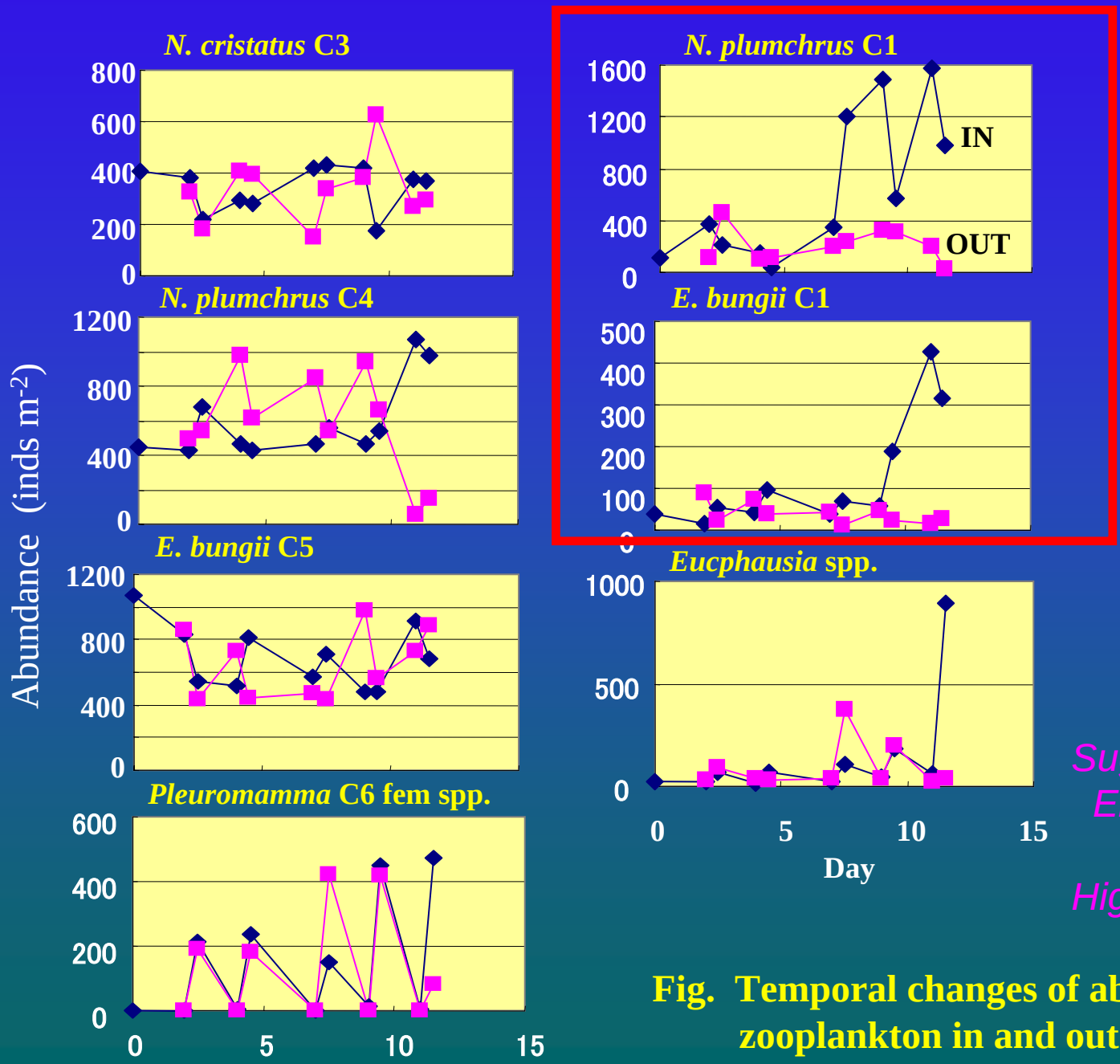
	Stage duration (day)		Mortality (d^{-1})
	Simple	SSM	SSM
N. plumchrus			
In	12.99	6.74	0.000
Out	10.30	6.65	0.044
***E. bungii* C1-C3**			
In	8.52	-	-
Out	11.96	-	-

Mortality-related topics

1. Estimation of mortality and growth rates in the iron-enrichment experiments

2. Young copepodites increase in the diatom-dominated blooms

Copepod abundance in SEEDS



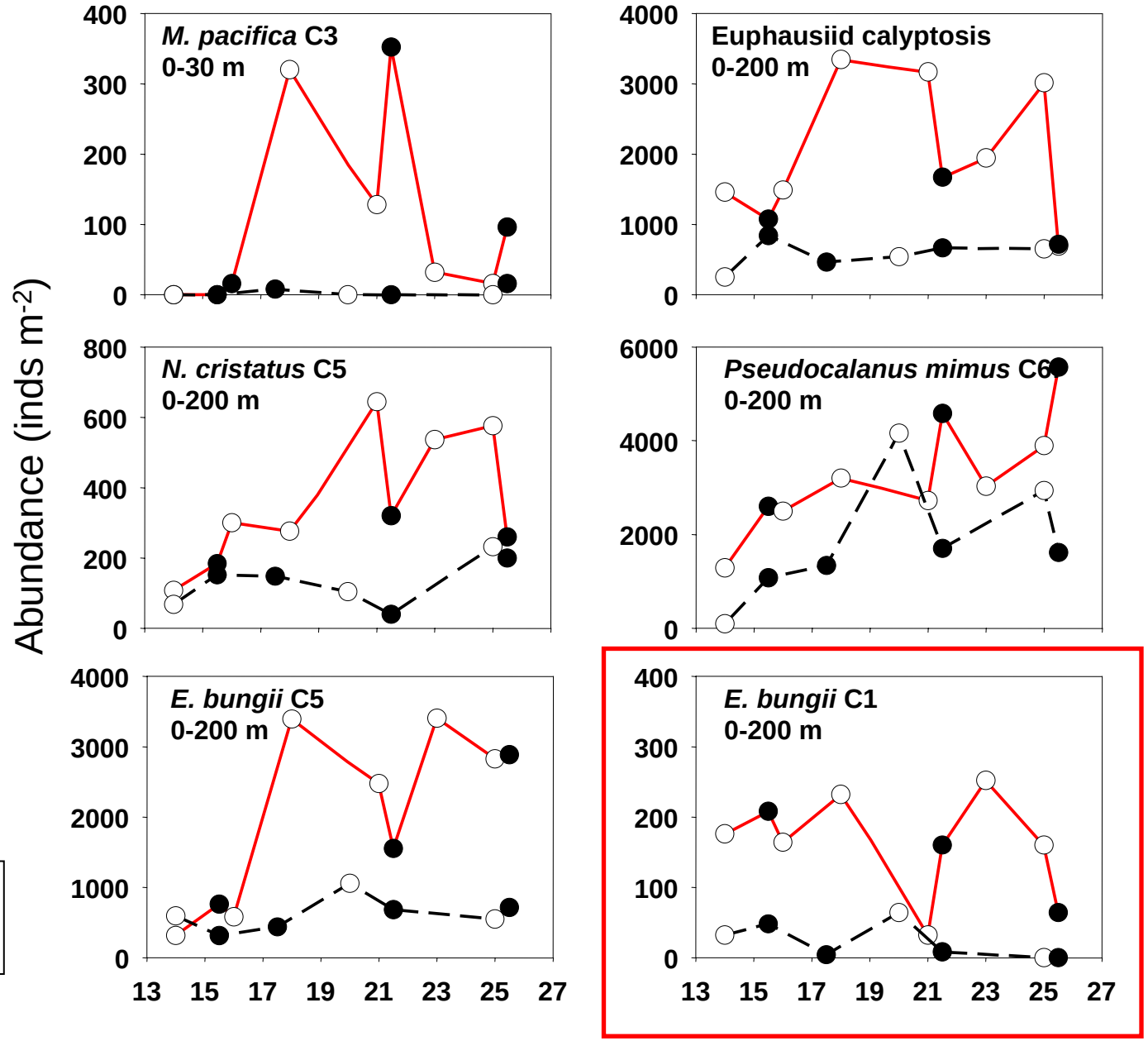
Suggesting
Enhanced reproduction
or
High survival rate

Fig. Temporal changes of abundance of major zooplankton in and out the iron patch

Tsuda et al. (2005)

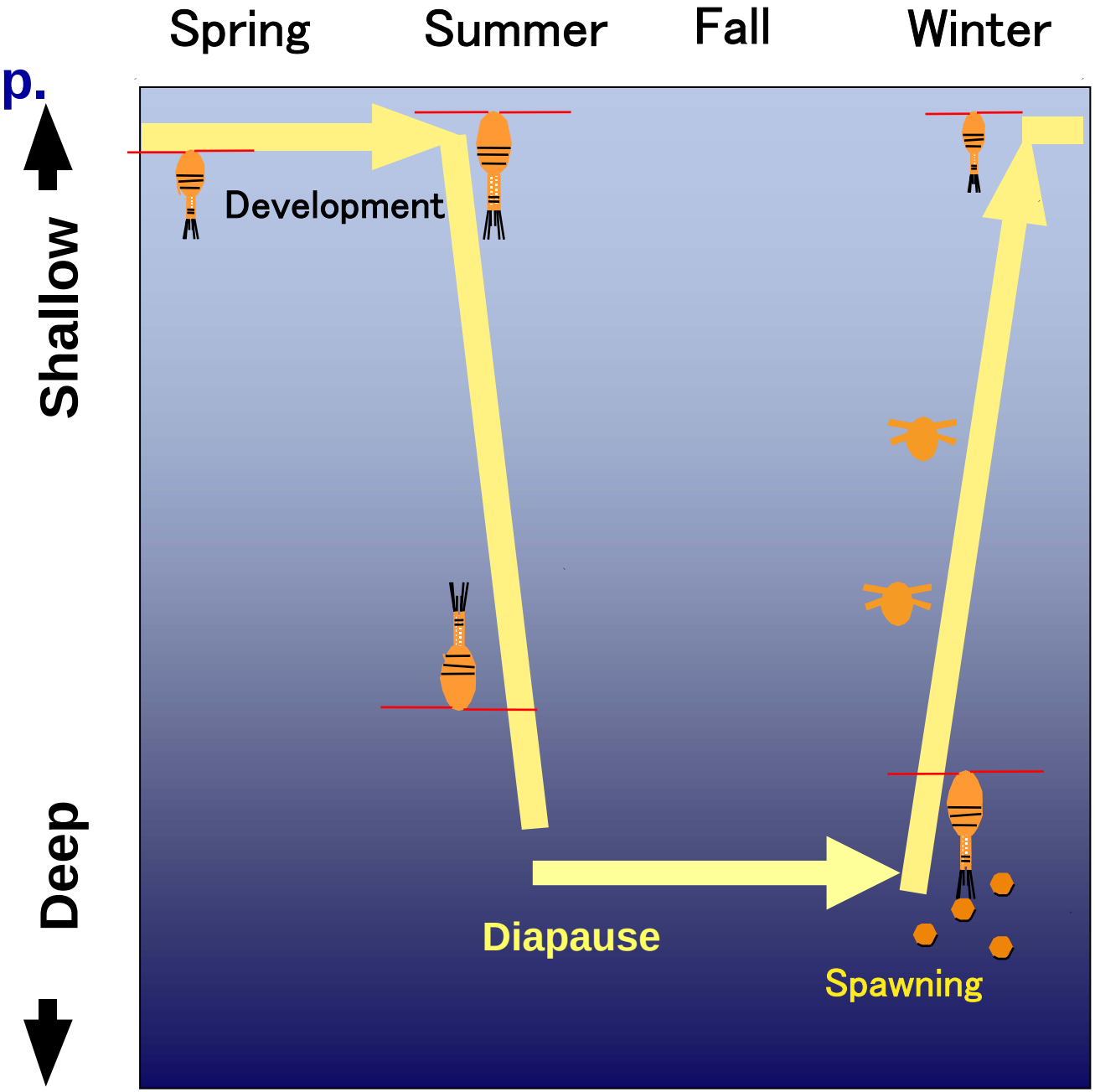
Variation in Abundances of copepods

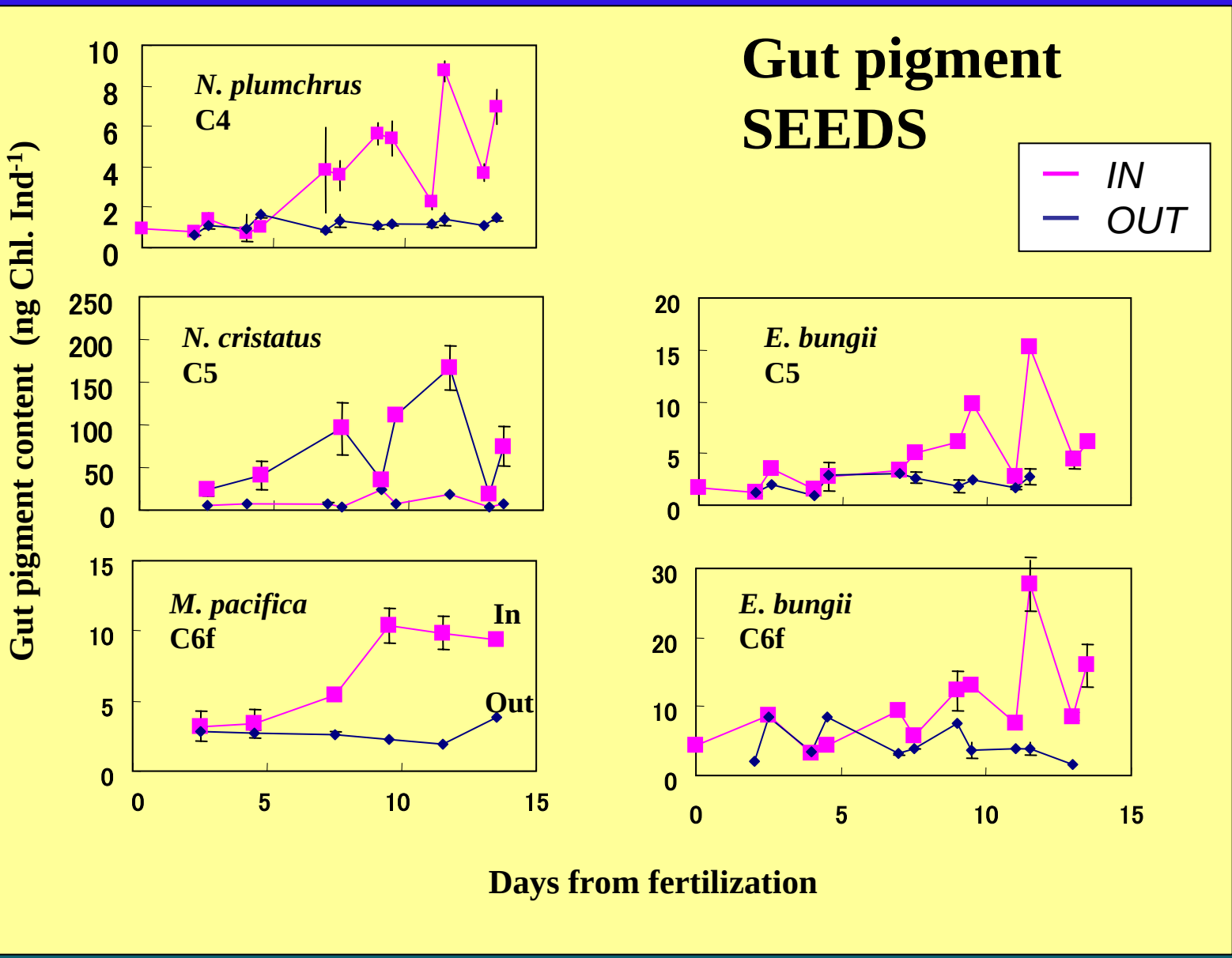
SERIES



Tsuda et al. (2006)

Life cycle of *Neocalanus* spp.



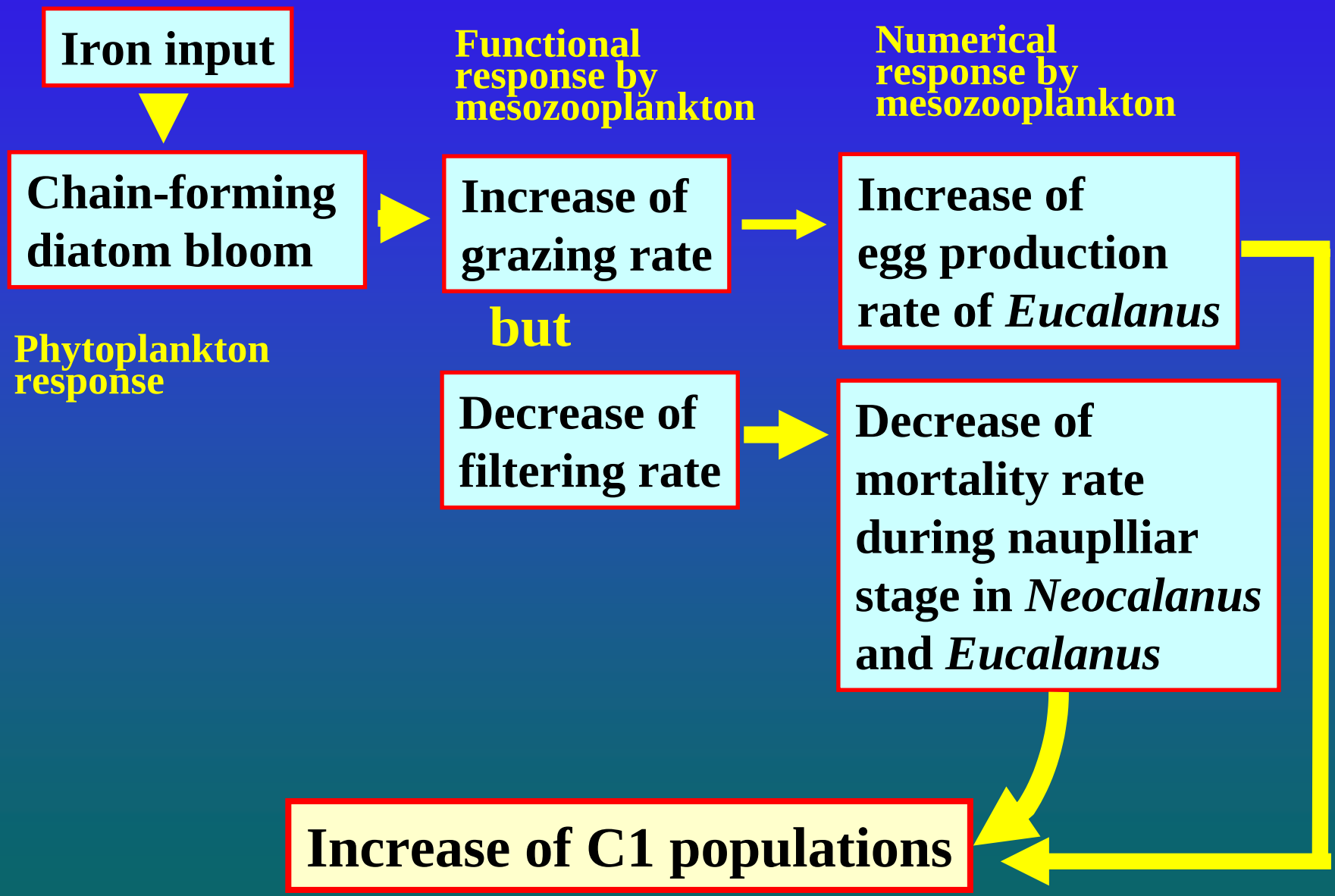


Temporal variations of gut pigment contents of dominant copepods

Comparison of filtering rates of major copepods during the blooming period (D7-D13) between inside and outside of the patch

	Outside Average (S.D.)	Inside Average (S.D.)	factor
	($ml\ h^{-1}.\ Ind^{-1}$)		
N. plumchrus C4	3.2 (1.1)	1.8 (0.6)	0.55
N. cristatus C5	22.1 (15.4)	37.5 (20.9)	1.69
E. bungii C5	7.9 (4.7)	2.8 (1.4)	0.35
C6f	7.5 (1.7)	4.5 (2.5)	0.60
M. pacifica C6f	7.4 (4.5)	2.8 (0.7)	0.38

Mechanism of C1 increase in the patch



Conclusions

- SF_6 labeling experiment is a good way to examine the growth and mortality rates of zooplankton.
- Development rates estimated in the experiments were relatively high than the reported values, and the mortality rates were very low in the patch.
- Diatom bloom most likely make the mortality rates of egg and nauplius stages low.

Thank you