

Phytoplankton Community Structure in the HNLC Subarctic Pacific
Ocean is determined by *Neocalanus flemingeri* and *N. plumchrus*. **

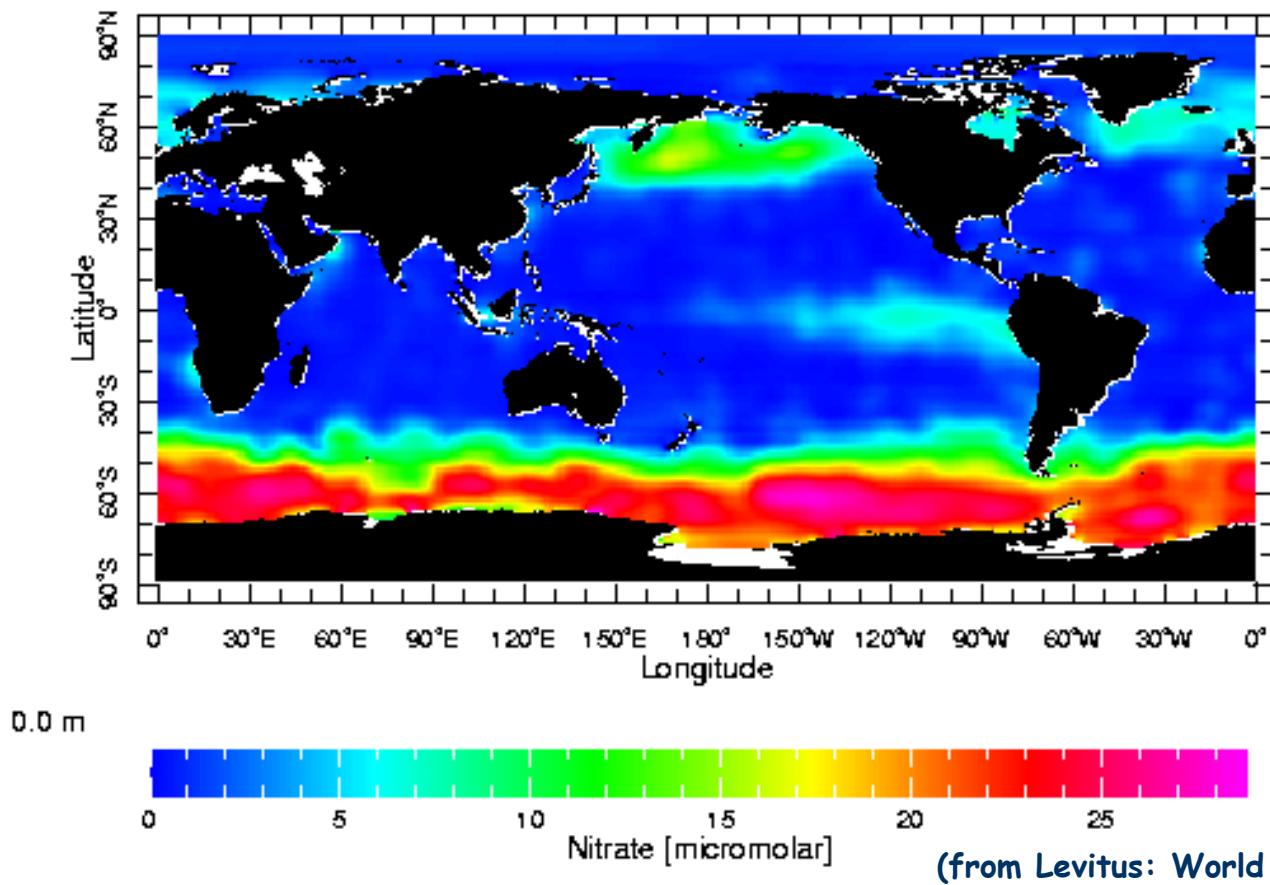
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- Low phytoplankton concentrations,
- iron-limited growth (especially large cells)
- Small phytoplankton - microzooplankton grazers
- Large grazers consume microzooplankton and large phytoplankton
- Most important large grazers are *Neocalanus* spp.

The mortality of large phytoplankton remains the least understood component of the lower trophic-level dynamics in the SPO

Here we re-evaluate the contribution of *N. flemingeri* and *N. plumchrus* to the control of phytoplankton biomass and community structure in the subarctic Pacific Ocean.

Surface

0 m

Mixed layer

N. plumchrus/flemingeri zone

Thermocline

35-45 m

N. cristatus and *E. bungii* zone

Permanent halocline

100-120 m

from Mackas, D.L., H. Sefton, C. B. Miller and A. Raich. 1993. Vertical habitat partitioning by large calanoid copepods in the oceanic subarctic Pacific during spring. Prog. Oceanogr. 32: 259-294.

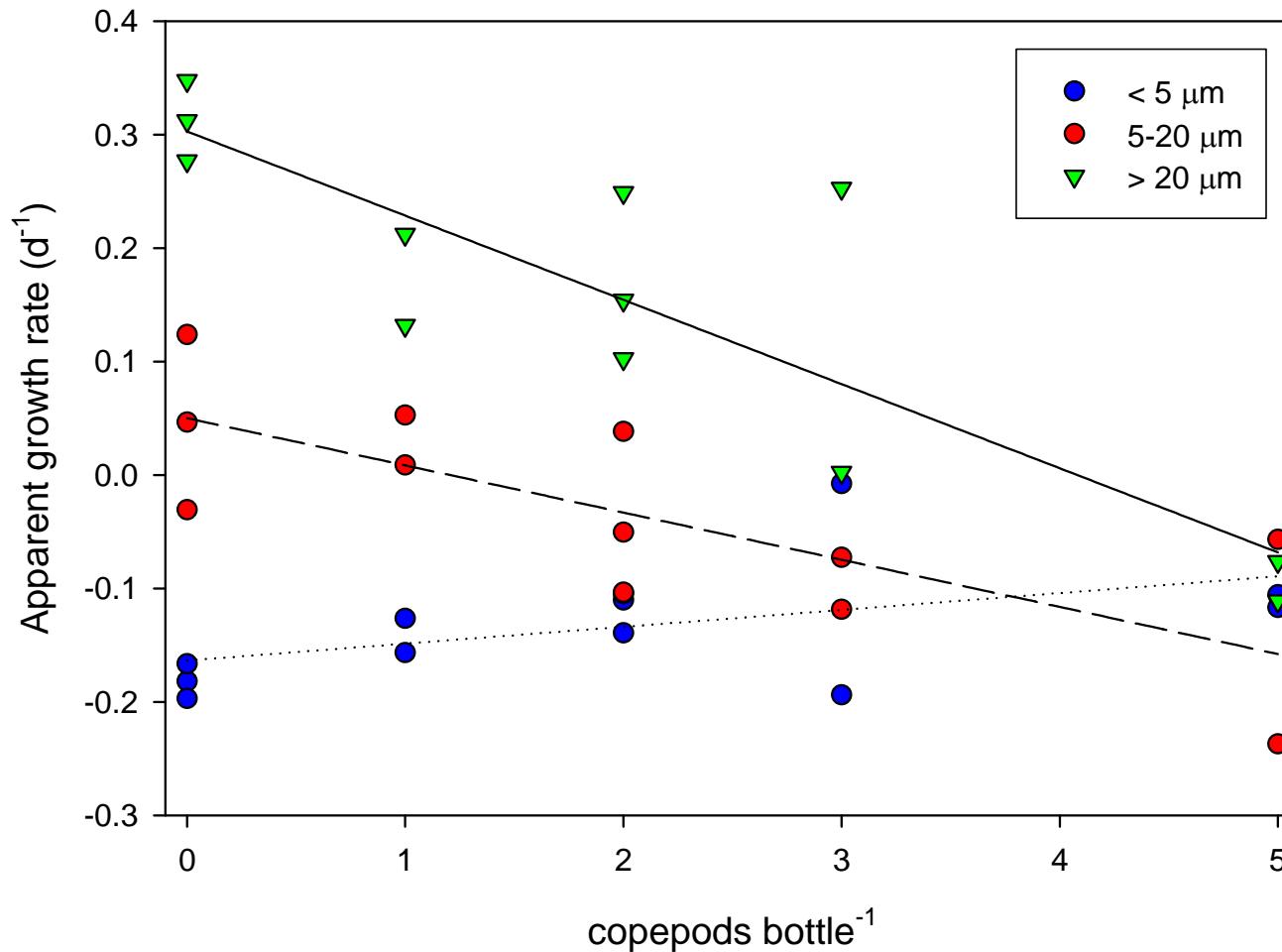
Chlorophyll concentration:

$$< 5 \mu\text{m} = 0.577 \mu\text{g l}^{-1}$$

$$5-20 \mu\text{m} = 0.143 \mu\text{g l}^{-1}$$

$$> 20 \mu\text{m} = 0.051 \mu\text{g l}^{-1}$$

5/18/01



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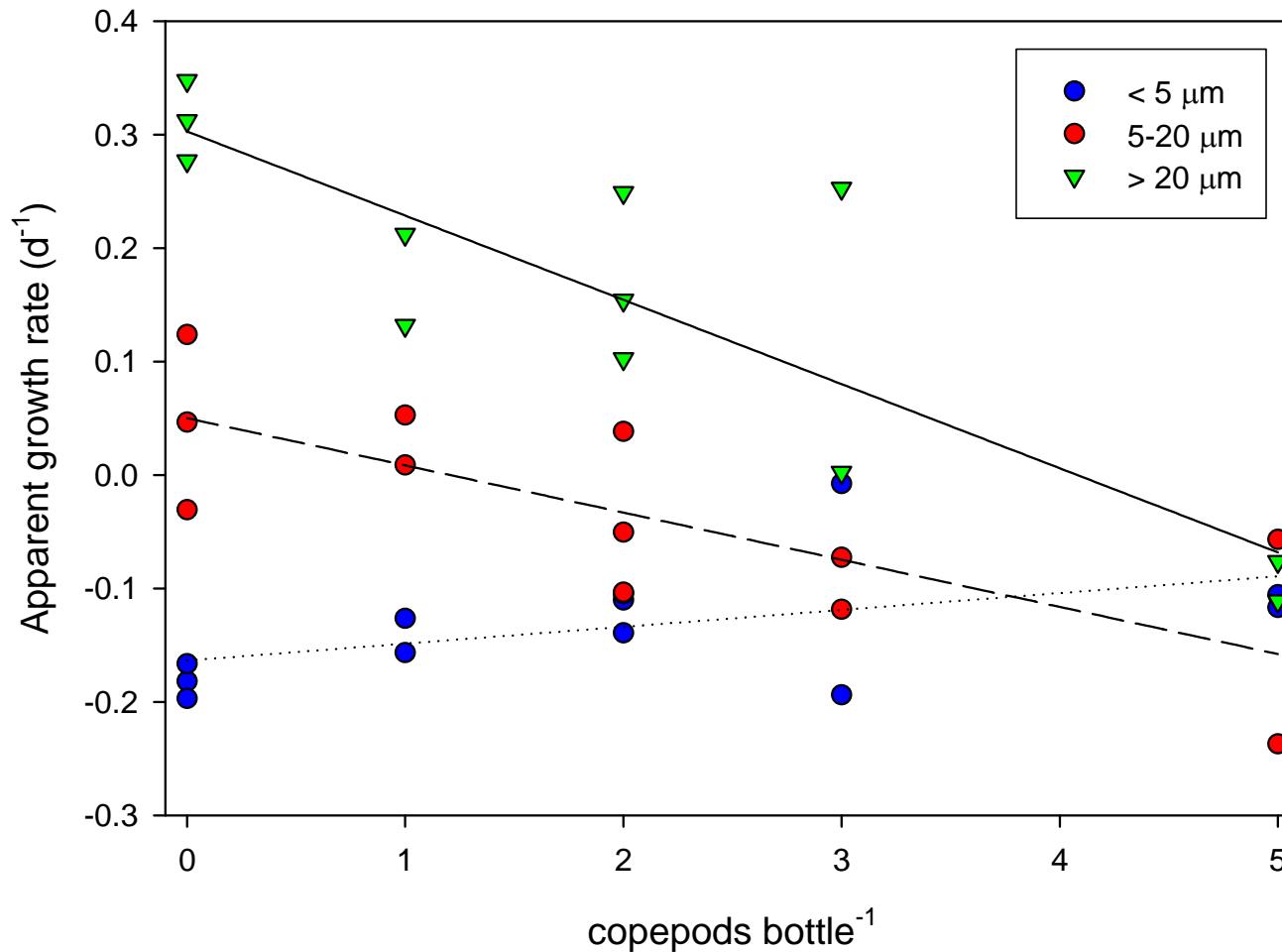
Clearance rate:

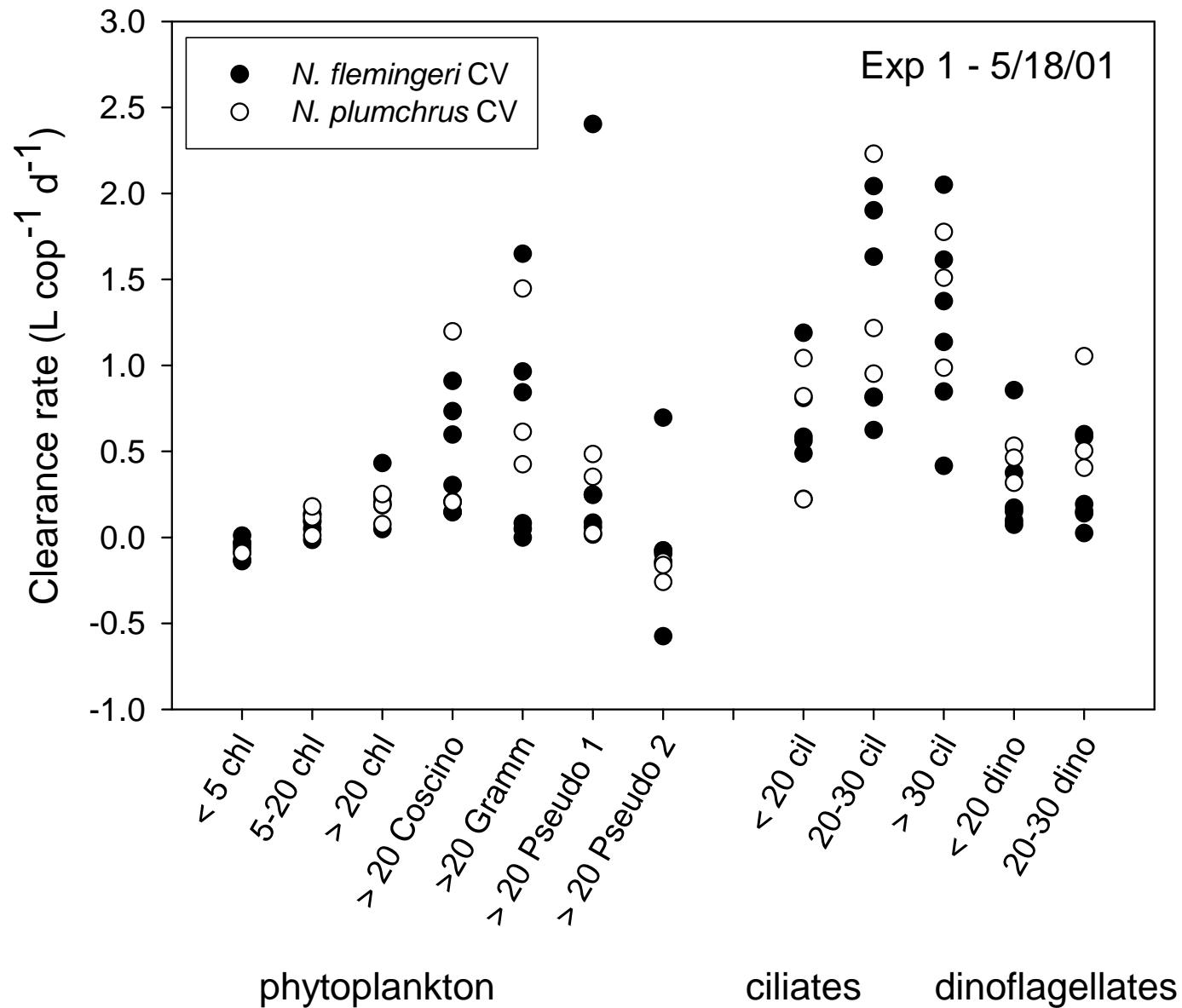
$$-0.068 \text{ L cop}^{-1} \text{ d}^{-1}$$

$$0.088 \text{ L cop}^{-1} \text{ d}^{-1}$$

$$0.208 \text{ L cop}^{-1} \text{ d}^{-1}$$

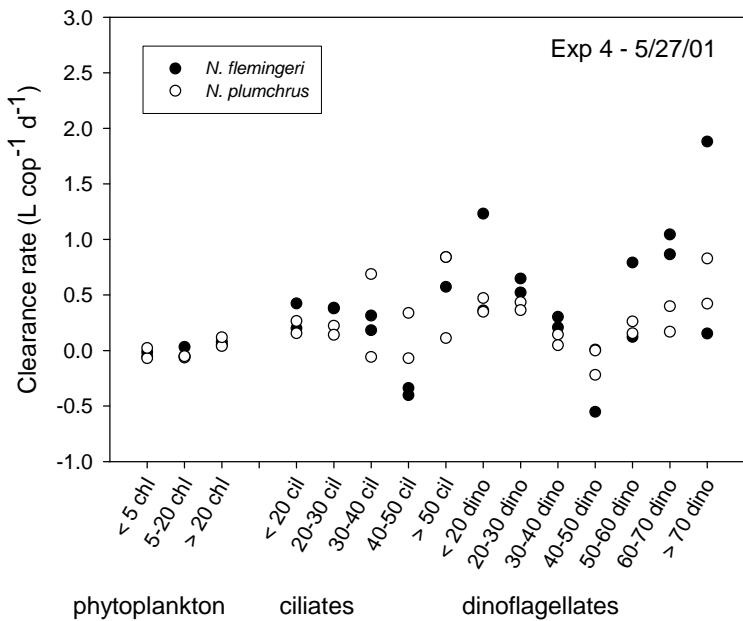
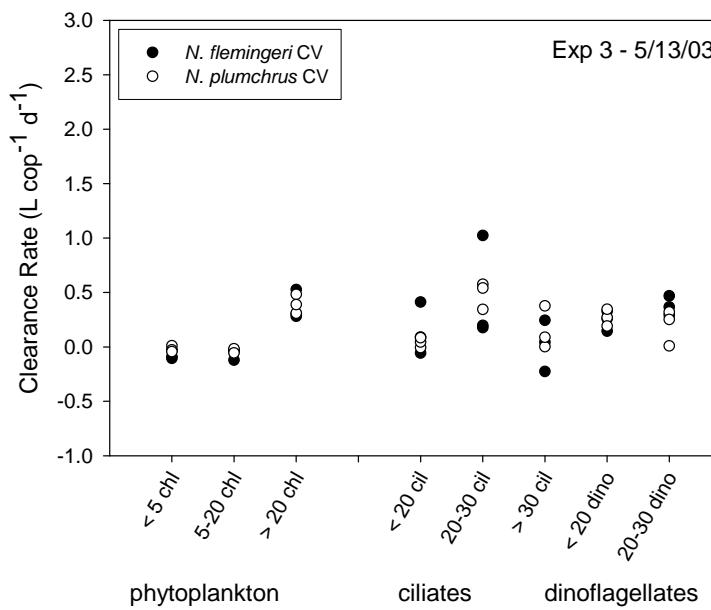
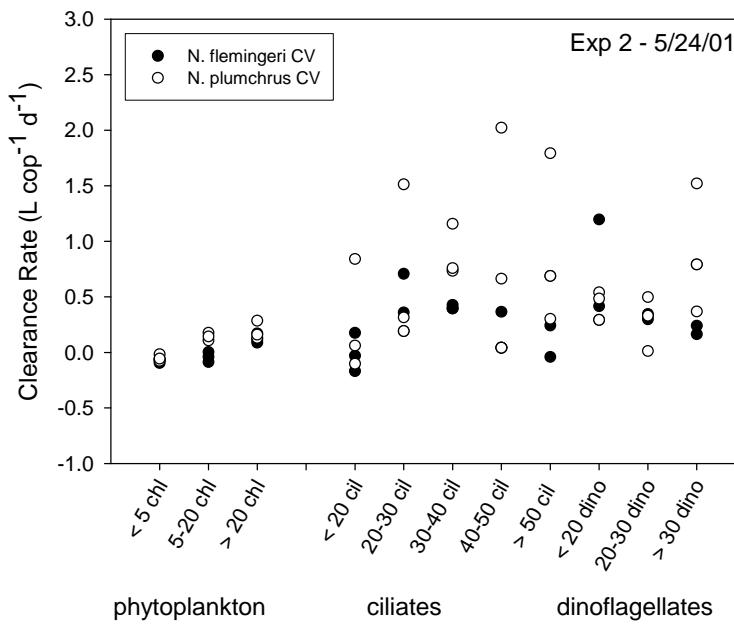
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Additional experiments with counts

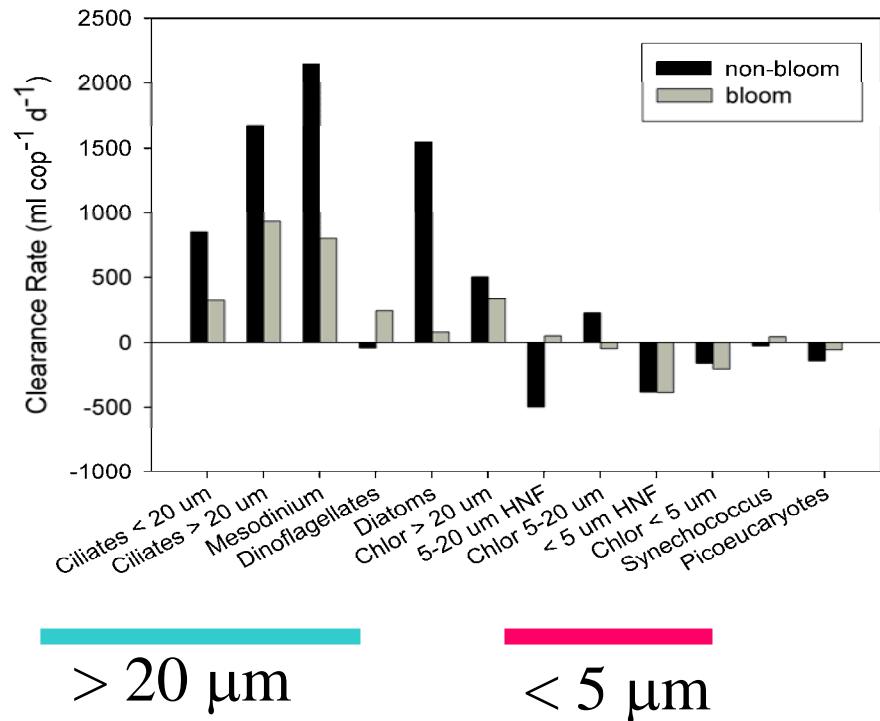
Chlorophyll concentration ($\mu\text{g l}^{-1}$)			
$< 5 \mu\text{m}$	$5-20 \mu\text{m}$	$>20 \mu\text{m}$	total
0.27	0.05	0.05	0.37
1.00	0.24	0.06	1.30
0.18	0.13	3.41	3.73



Exp 2 - 0.37 $\mu\text{g l}^{-1}$
 Exp 3 - 1.30 $\mu\text{g l}^{-1}$
 Exp 4 - 3.73 $\mu\text{g l}^{-1}$

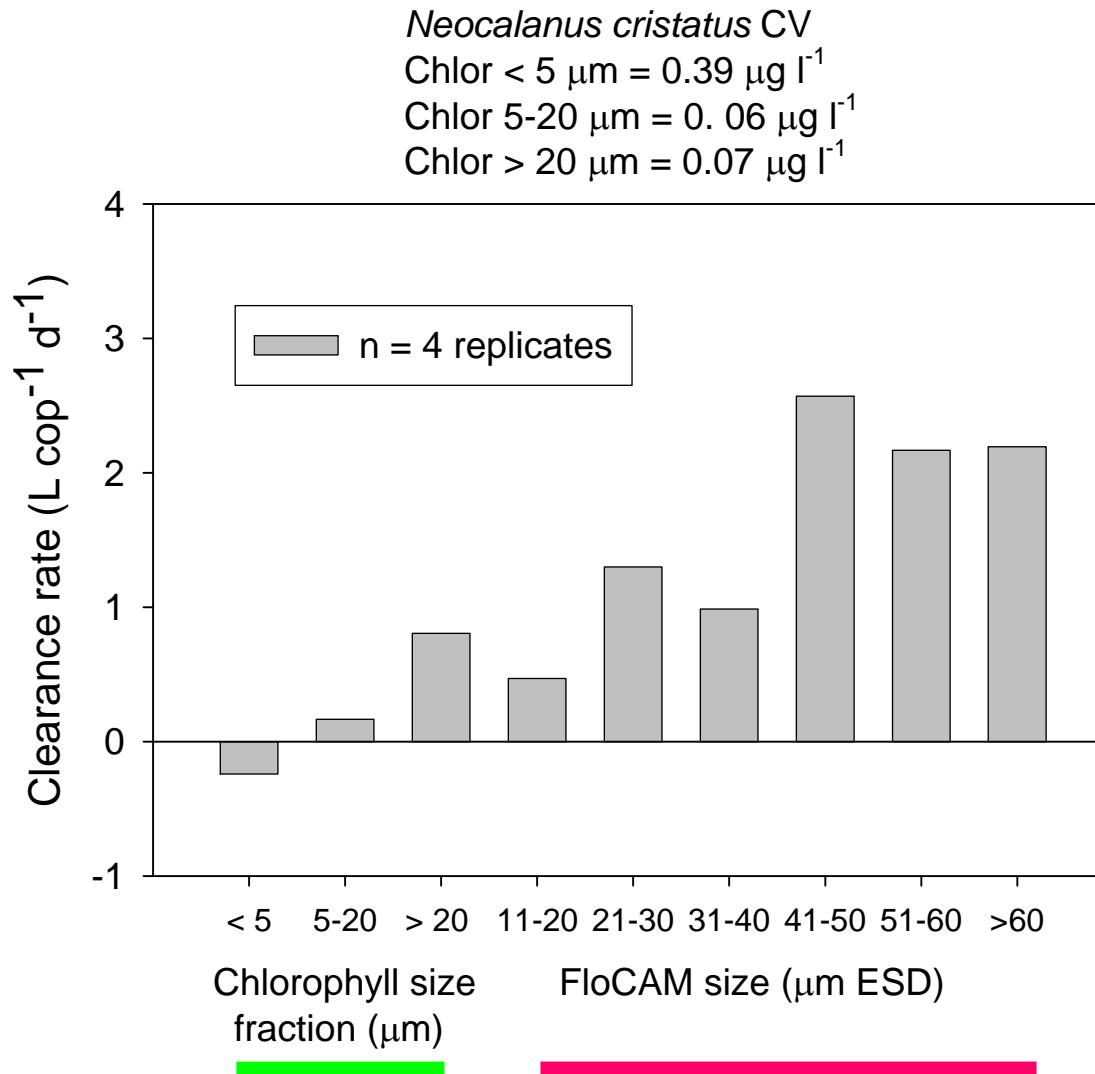
Clearance rate	Reference	Comments
0.12	Frost et al., 1983	high copepod concentrations
0.04	Landry and Lehner-Fournier, 1988	high copepod concentrations
0.112	Dagg, 1993	total chlorophyll removal
0.04 - 1.08	Dagg and Wyman, 1983	gut pigment converted to clearance
0.17 - 0.94	Gifford, 1993	cell counts
0.24 - 0.96	Tsuda et al., 2006	total ambient chlorophyll
0.12 - 0.60	Dagg and Walser, 1987	small cell (12 mm) and high concs
0.32 - 0.38	Landry and Lehner-Fournier, 1988	mesocosm - total chlorophyll
0.12	Landry et al., 1993a	mesocosm - total chlorophyll
0.42, 0.45, 0.17	Landry et al., 1993	mesocosm - <i>Nitzschia</i> , centrics, ciliates
0.00 - 2.40	this study	

Same general pattern observed for *N. cristatus* CV

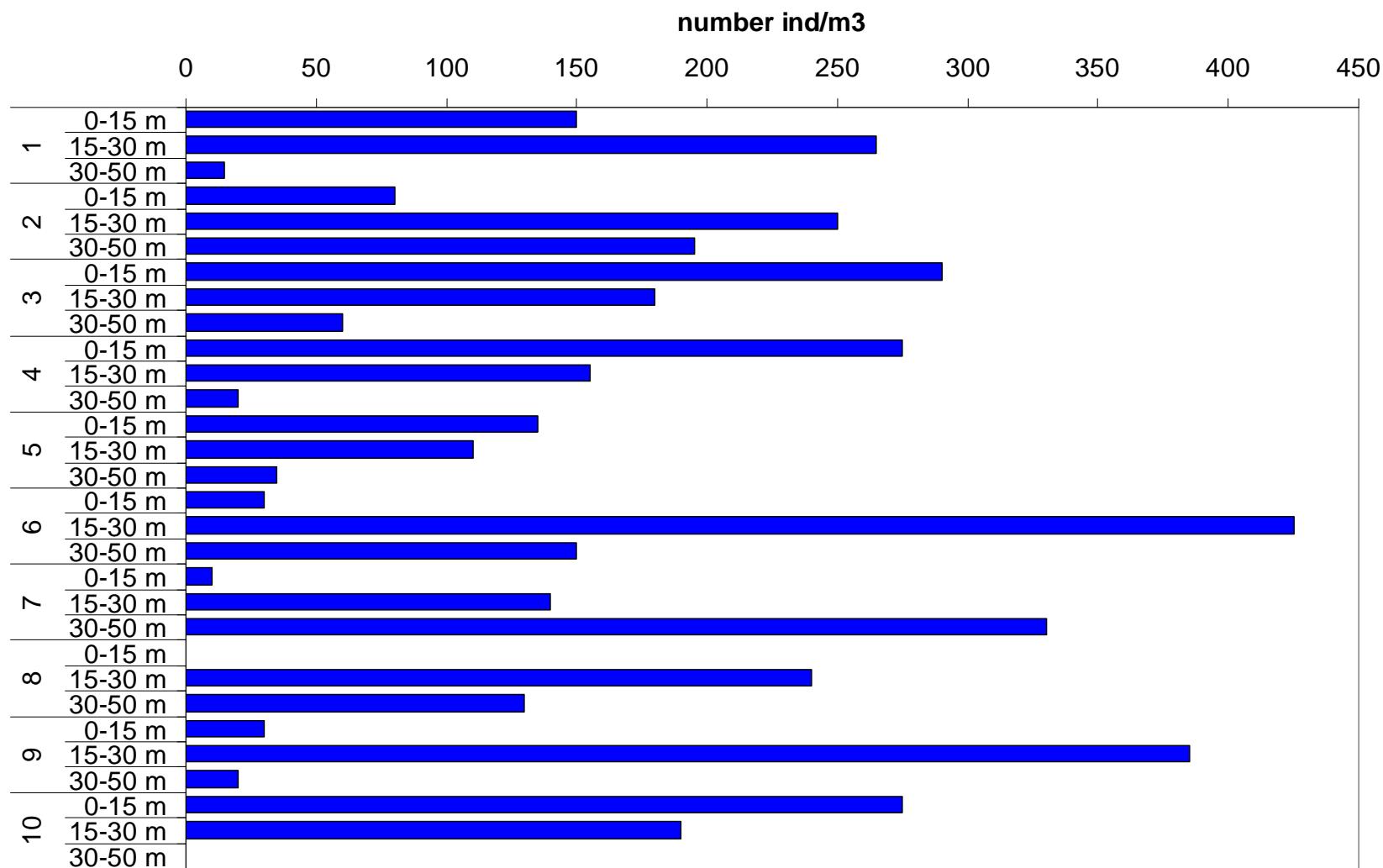


From Liu, Dagg and Strom. 2005. J. Plankton Res. 27: 647-662

FloCAM showed same general pattern

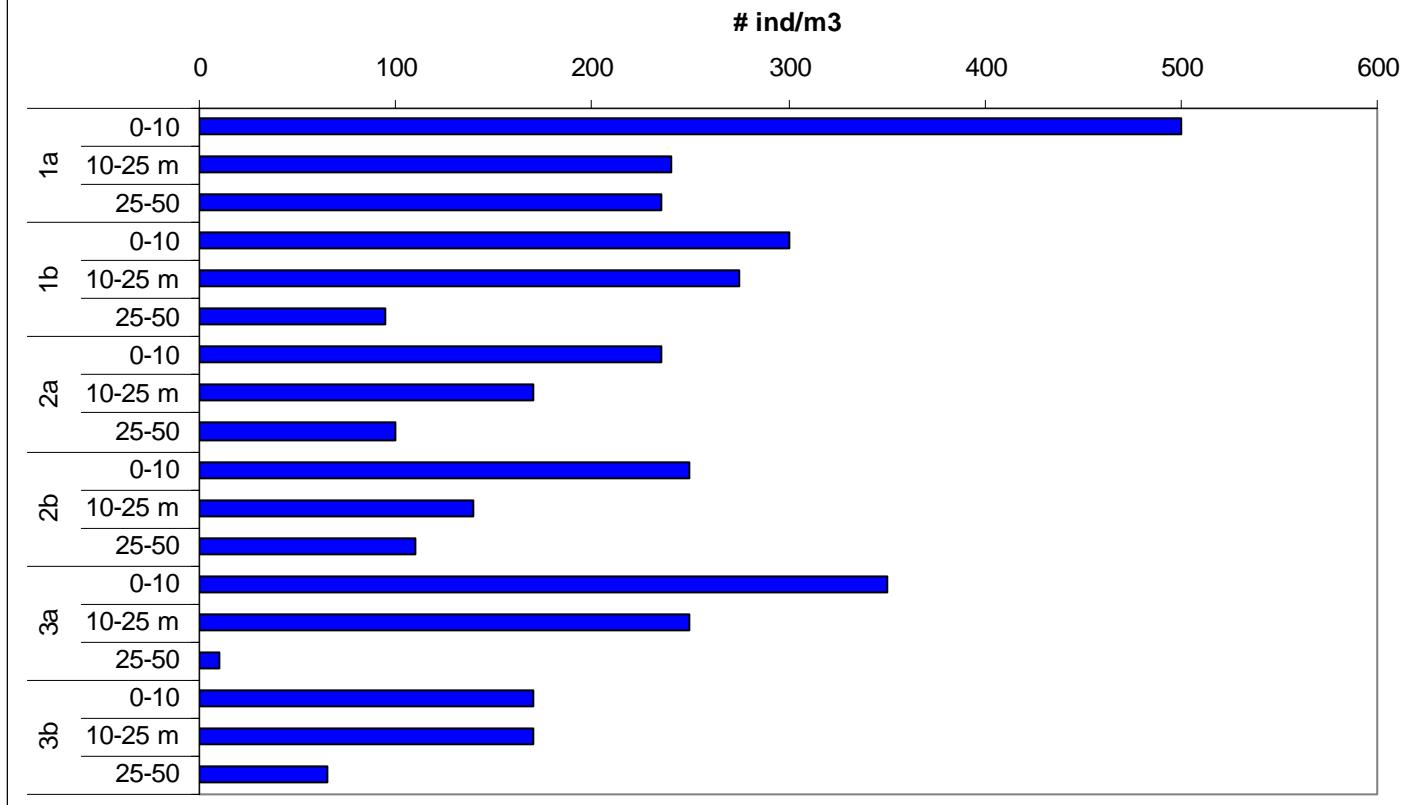


N. plumchrus + N. flemingeri CV



May 1984 - 10 stations: mean abundance = 152 CVs m³
(from Mackas et al. 1993)

N. plumchrus + N. flemingeri CV



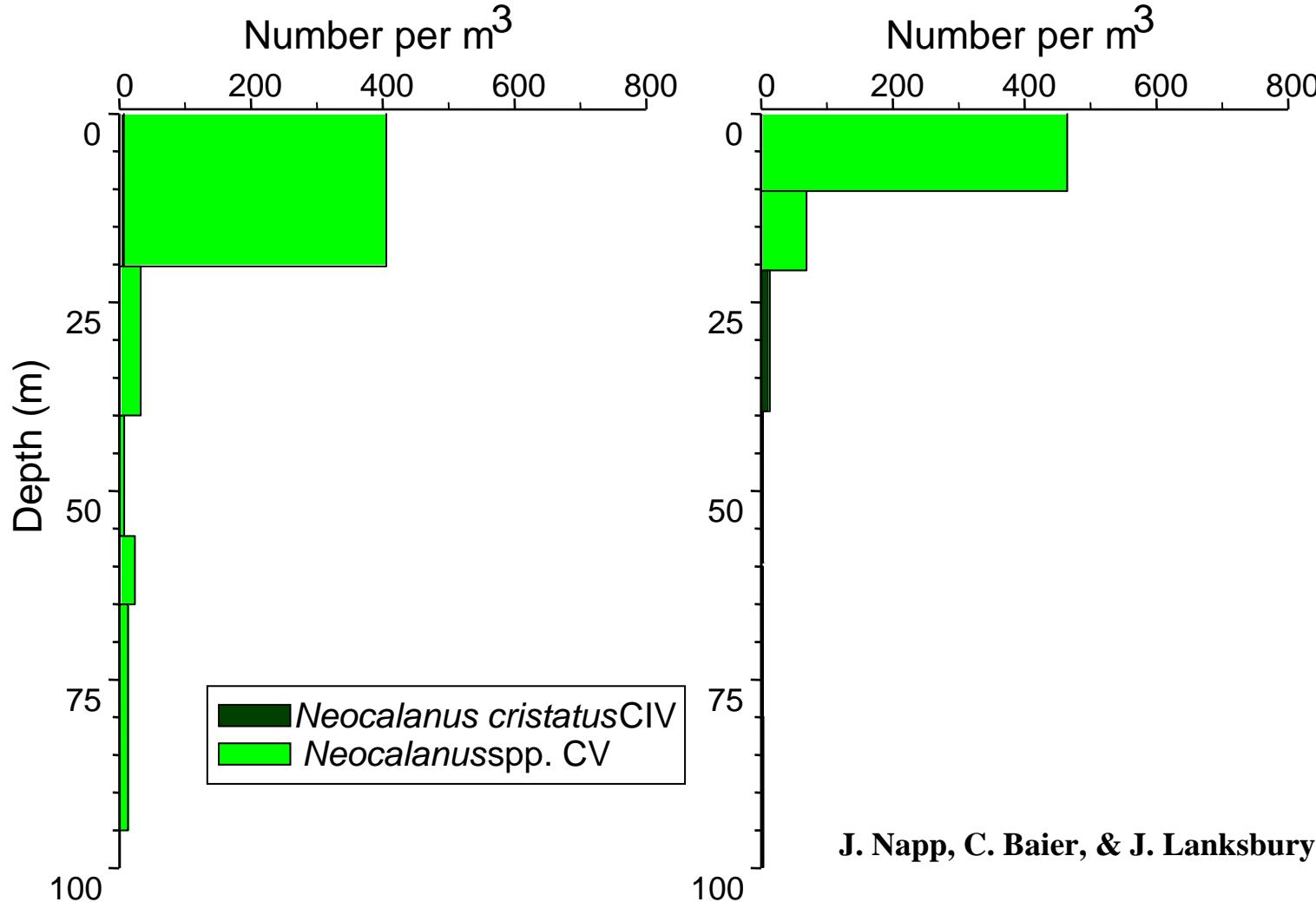
June 1987 - mean abundance = 204 ind m³
(from Mackas et al. 1993)



Vertical Distribution

Inner Shelf Station
29-May-01, 23:53

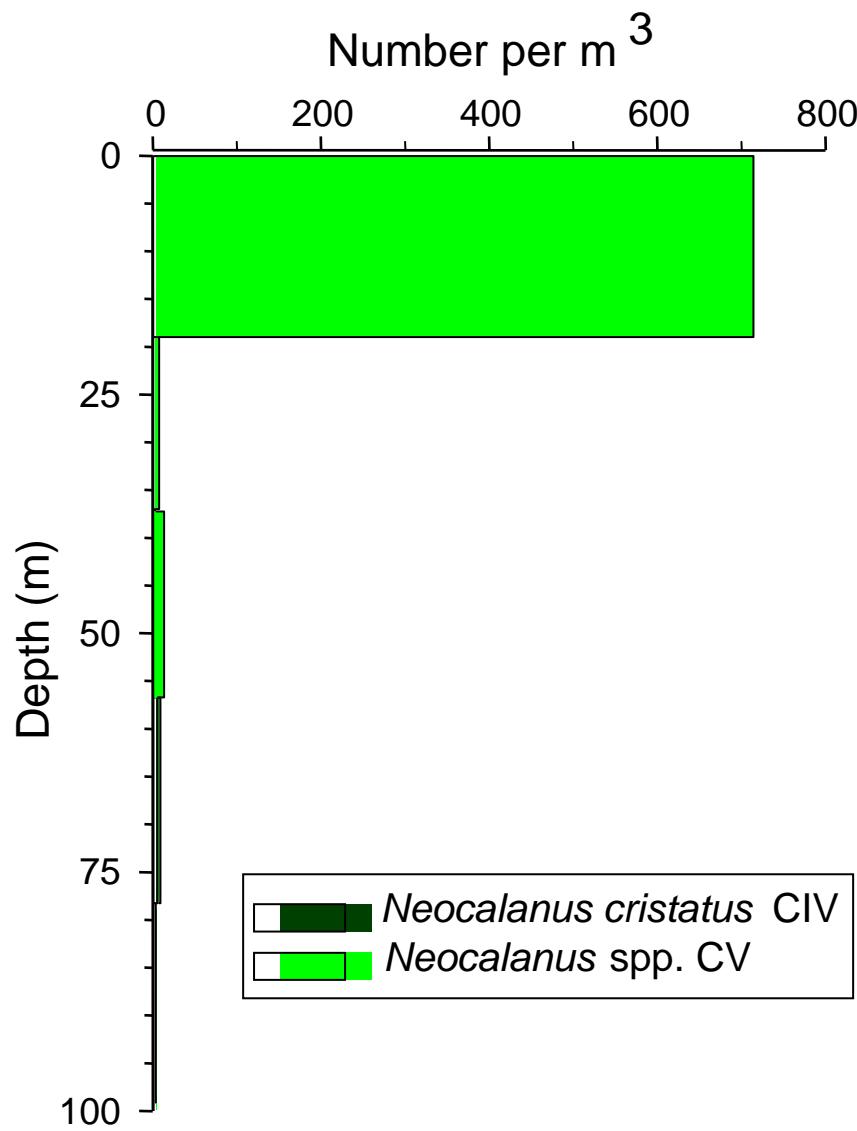
Outer Shelf Station
19-May-01, 00:10



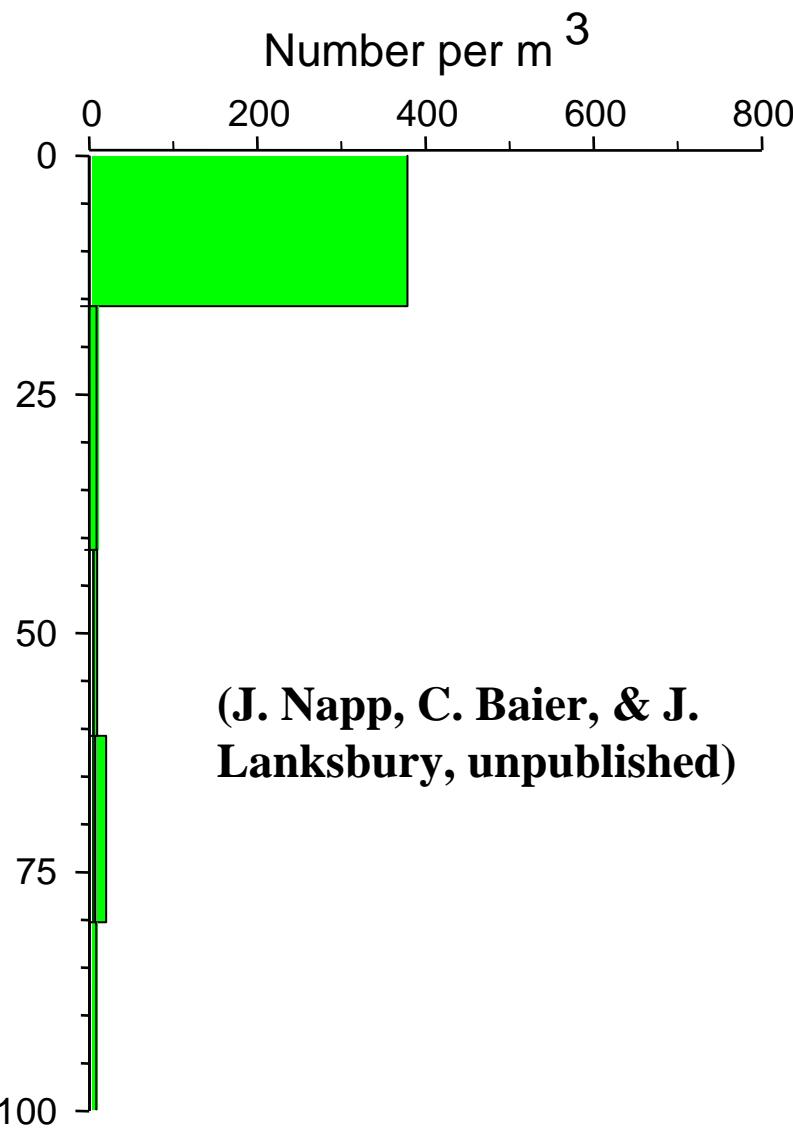
J. Napp, C. Baier, & J. Lanksbury, unpublished



Middle Shelf Blue Water (GAK4)
26-May-01, 23:54



Middle Shelf Bloom (4IW)
25-May-01, 23:52



Other abundance data

Miller, 1993; Goldblatt et al., 1999; Kobari et al., 2003 report average abundances to depths somewhat greater than the seasonal thermocline but compressing these populations into the upper 50 or 25 m results in CV concentrations similar to those observed by Mackas et al. (1993): 60 to 260 m^{-3} (Miller, 1993); 200 to 400 m^{-3} (Goldblatt et al., 1999) and 180 to 510 m^{-3} (Kobari et al., 2003).

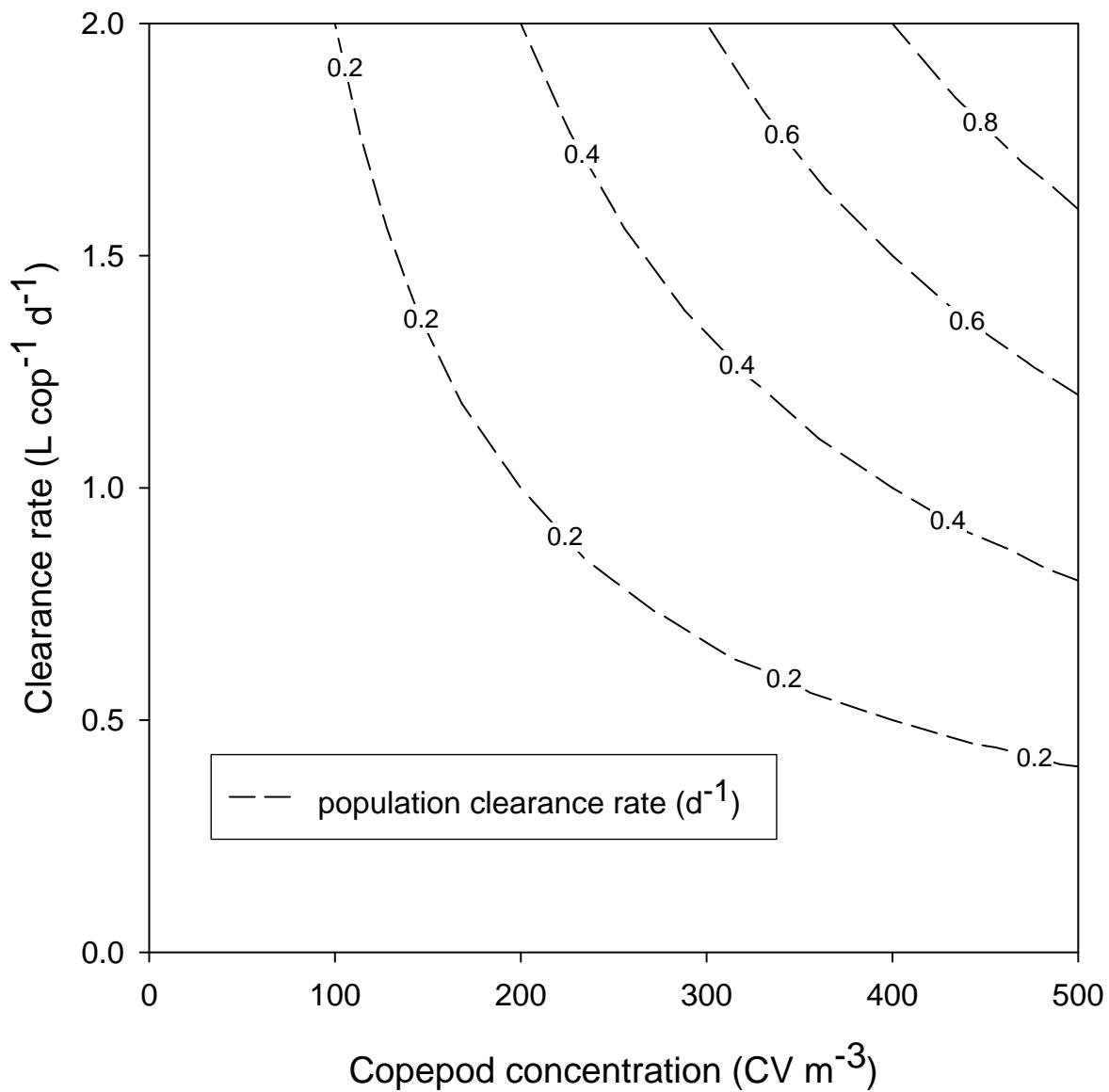
Underway pumping of surface water by Kawamura (1990) commonly showed surface concentrations between 200-600 CVs m^{-3} , and $> 800 \text{ m}^{-3}$ on several occasions

N. flemingeri and *N. plumchrus* concentrations in surface waters are typically several hundred m^{-3} , and population distributions are highly patchy, both horizontally and vertically.

Growth rates of phytoplankton

<u>Growth rate (d⁻¹)</u>	<u>reference</u>	<u>comments</u>
0.54, 0.98, 1.33	Noiri et al., 2005	Grow-out experiments at 5, 8 and 13°C
0.1, 0.4	Noiri et al., 2005	Fe conc < 0.5 nM, 8 and 13°C
0.0 - 0.5	Tsuda et al., 2005	SEEDS enrichment experiment-early
0.5 - 0.9	Tsuda et al., 2005	SEEDS enrichment experiment-max growth
0.2 - 0.5	Tsuda et al., 2005	SEEDS enrichment experiment-post bloom
0.3 - 0.5	Saito et al., 2005	SEEDS - outside Fe enriched patch
0.2 - 0.9	Boyd/Harrison, 1999	eastern SPO - spring
0.3 - 0.8	Boyd/Harrison, 1999	eastern SPO - summer
0.3 - 1.0	Booth et al., 1993	eastern SPO
0.1 - 0.7	Landry et al., 1993b	eastern SPO
0.2 - 0.6	Rivkin et al., 1999	eastern SPO
0.0 - 0.8	Strom/Welschmeyer, 1991	eastern SPO
0.24	Boyd et al., 1999	eastern SPO

Population clearance rate



Other considerations: top down effect by *N. flemingeri/plumchrus*

- growth rates of large diatoms in this Fe limited system are $0.2 - 0.4 \text{ d}^{-1}$
- growth rates of large ciliates and dinoflagellates??
- other copepodid stages must contribute also

Post-ontogenetic descent

Annual phytoplankton max (Yoo et al., 2008; Clemons and Miller, 1984; Boyd and Harrison, 1999; Parsons and Lalli, 1988)

a higher fraction of phytoplankton growth is consumed by microzooplankton (Strom and Welschmeyer, 1991)

N. cristatus moves up into the surface layer after the descent of *N. flemingeri* and *N. plumchrus* so its contribution to surface layer grazing will increase at this time (Mackas et al., 1993; Goldblatt et al., 1999)

Other mesozooplankton, especially *Oithona* spp. and *Pseudocalanus* spp., increase in surface water at this time, although their grazing capacity is small (Liu et al., 2008).

Phytoplankton growth may be further reduced by onset of low light (fall/winter) season

Conclusions

Neocalanus spp. exert a strong structuring effect on the nano-and pico- food webs of the N. Pacific Ocean, tending to drive the food web towards a small-cell dominated system by

- a) selective removal of large cells
- b) cascade effect

These effects are strongest:

- at low food concentrations when copepod clearance rates are highest, and
- under nutrient or food limiting conditions when growth rates of prey are lowest

The END

