

# RELATIONSHIPS IN CELL ABUNDANCE BETWEEN MICROBIAL PRODUCER AND PREDATOR IN OCEAN'S INTERIOR

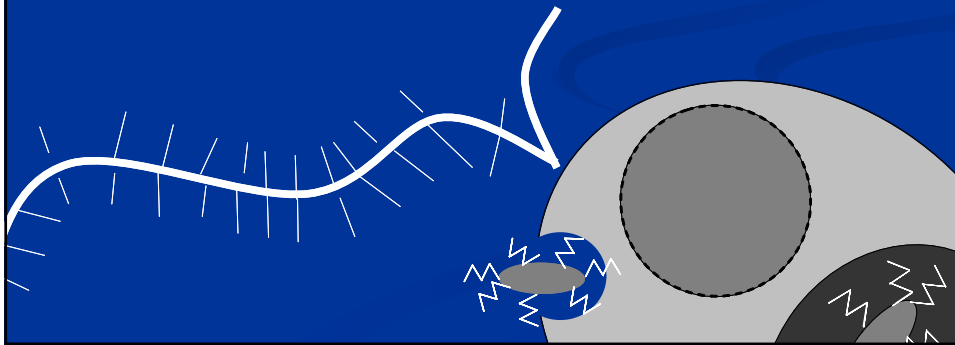
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Prediction of response of abundance of microbe to environmental changes by using simple food chain model.

### 2. Field observation

Full depth profiles of prokaryote production and abundances of prokaryote and heterotrophic nanoflagellate (HNF) in the subarctic Pacific.

### 3. Summary and Future plan

## How does abundance of Prokaryote (PA) vary along productivity gradient?

### Simple mathematical model (Billen et al. 1990)

#### Material flow:

Dissolved substrate → Prokaryote



At equilibrium

$$\frac{dS}{dt} = p - k_p \cdot S \cdot PA$$

$$\frac{dPA}{dt} = Y_p \cdot k_p \cdot S \cdot PA - d_p \cdot PA$$

$$S^* = \frac{d_p}{Y_p \cdot k_p}$$

$$PA^* = \frac{Y_p}{d_p} p$$

$p$ : productivity [ $\text{mol ml}^{-1} \text{s}^{-1}$ ]  
 $S$ : substrate concentration [ $\text{mol ml}^{-1}$ ]  
 $PA$ : prokaryote abundance [ $\text{cells ml}^{-1}$ ]  
 $k_p$ : encounter rate [ $\text{ml cell}^{-1} \text{s}^{-1}$ ]  
 $Y_p$ : growth yield [ $\text{mol cell}^{-1}$ ]  
 $d_p$ : mortality rate [ $\text{s}^{-1}$ ]

#### Material flow:

Dissolved substrate → Prokaryote



$$\frac{dS}{dt} = p - k_p \cdot S \cdot PA$$

$$\frac{dPA}{dt} = Y_p \cdot k_p \cdot S \cdot PA - k_F \cdot PA \cdot FA$$

$$\frac{dFA}{dt} = Y_Y \cdot k_F \cdot PA \cdot FA - d_F \cdot FA$$

$$S^* = \frac{Y_F \cdot k_F}{k_p \cdot d_Y} p$$

$$PA^* = \frac{d_F}{Y_Y \cdot k_F}$$

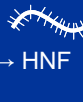
$$FA^* = \frac{Y_p \cdot Y_F}{d_Y} p$$

$$PA \propto p^{0 \text{ or } 1} ?$$

## Which exponent is relevant for complicated food web?

#### Material flow:

Dissolved substrate → Prokaryote



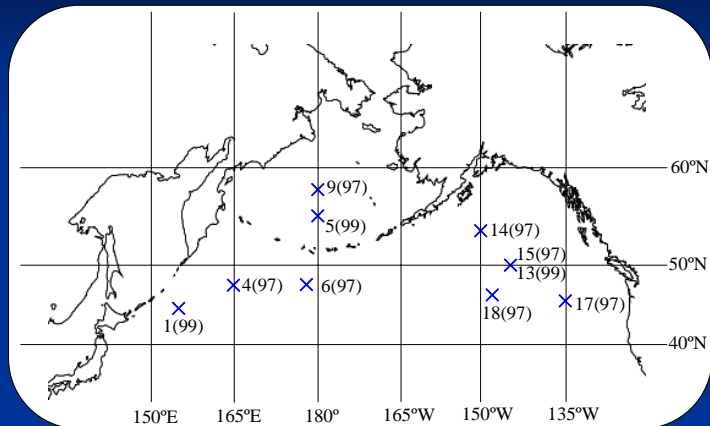
Viruses

Ciliate

$$PA \propto p^{0 \text{ or } 1} ?$$

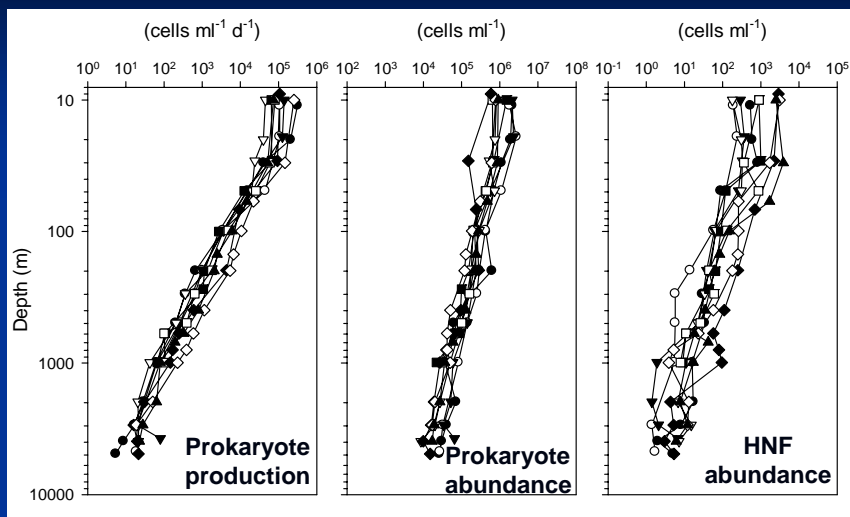
## 2. Field observations

R/V Hakuho-Mar cruises (9 July – 8 September 1997 and 25 June – 22 July 1999)



- Abundance of prokaryote (*PA*) and that of HNF (*FA*)  
Direct counting by using the epifluorescent microscopy
- Prokaryote production (*PP*) was  
Estimated from the incorporation rate of  $^3\text{H}$ -leucine

### Depth profiles in subarctic Pacific and Bering Sea (KH97-2 & KH99-3)



The slopes

$-1.23 \pm 0.42$ ,  $n = 9$

$-0.78 \pm 0.12$ ,  $n = 10$

$-1.00 \pm 0.26$ ,  $n = 10$

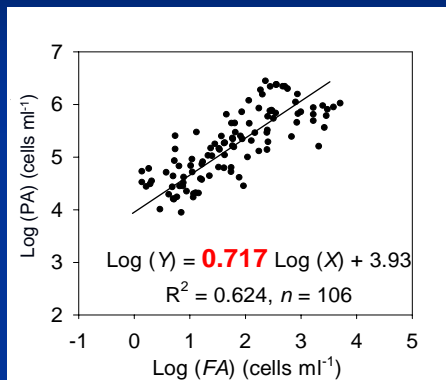
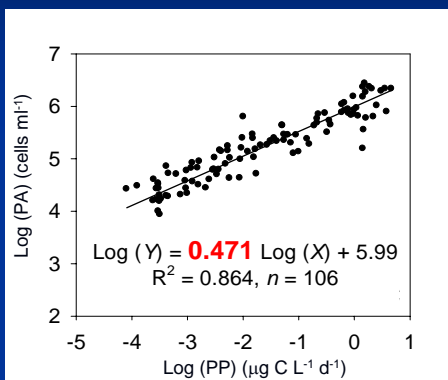
Table. Prokaryote turnover time (PA/PP, d) in surface (0-100 m), mesopelagic (100-1000 m) and bathypelagic (1000 m bottom) layers.

	Mean (+/-SD)*, **
Surface layer	17(6.2) days
Mesopelagic layer	97(53) days
Bathypelagic layer	1100(320) days

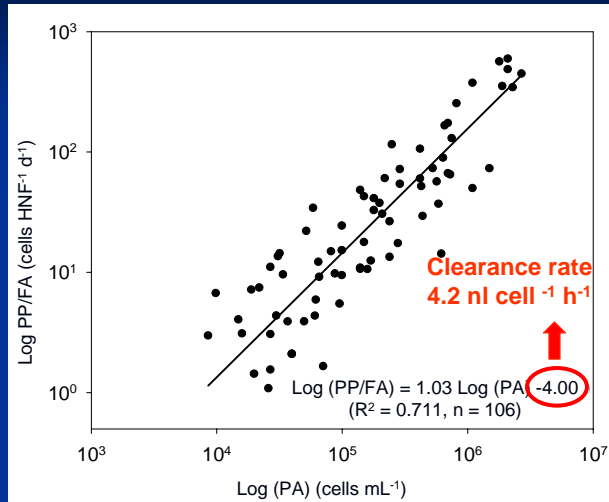
\*: Depth integrated values were used. \*\*: n = 7.

Why does divvy of each prokaryote cell decrease?

### Relationships between PA and PP and between PA and FA

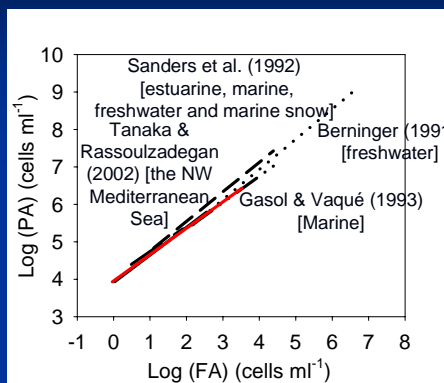
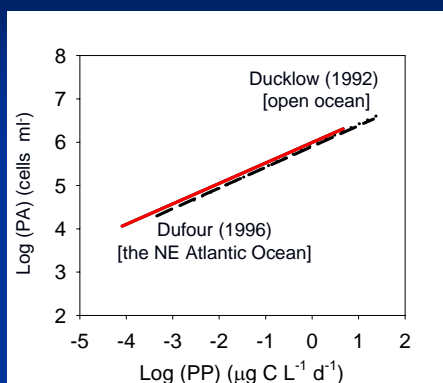


Relationship between prokaryote production per HNF cell (PP/FA) and prokaryote abundance (PA)



$$\frac{PP}{FA} \propto PA ? \quad PP = k \times PA \times FA$$

In other aquatic environments...



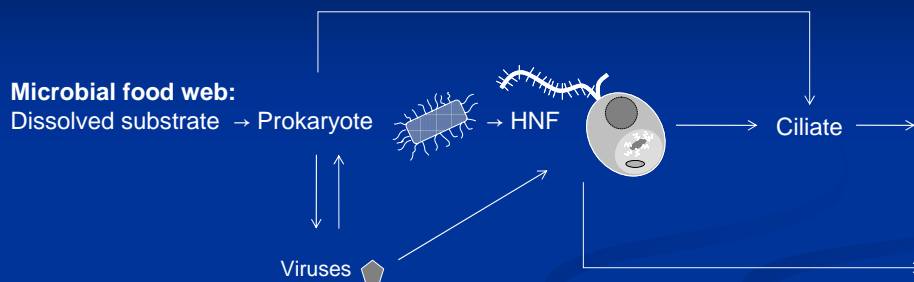
Universal relationship?

## Summary

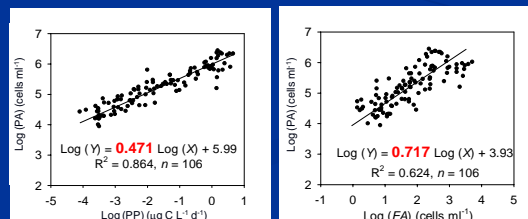
1. Bathypelagic zone is thin and unproductive environment. Mean turnover rate of prokaryote in bathypelagic zone was lower than those in surface mesopelagic layers.
2. Relationships between prokaryote production (PP) and prokaryote abundance (PA) and between prokaryote abundance (PA) and HNF abundance (FA) could be extended to bathypelagic layer. But they are not proportional!

## Unsolved problems....

### 1. Is diversity of microbial food web not so high?



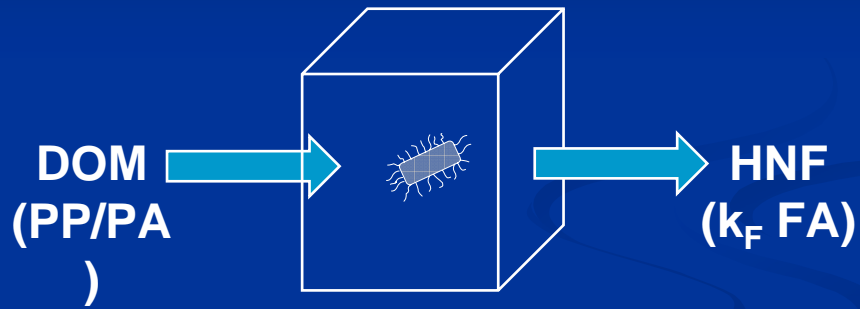
### 2. Why are the exponents these values?



$$FA \propto PA^\alpha (\alpha > 1)$$

$$BP = k \times BA \times FA$$

$$\leftrightarrow \frac{PP}{PA} \propto FA$$



$$PA : [cells \cdot ml^{-1}]$$

$$PA^{-1} : [ml \cdot cell^{-1}]$$