Zooplankton productivity, trophic dynamics and size spectra in the Oregon shelf areas

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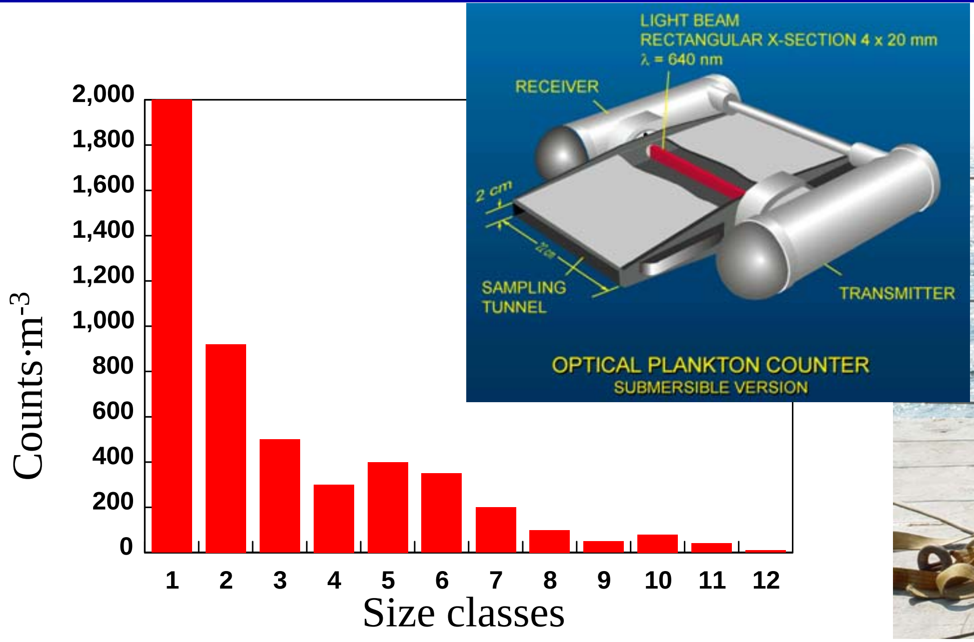
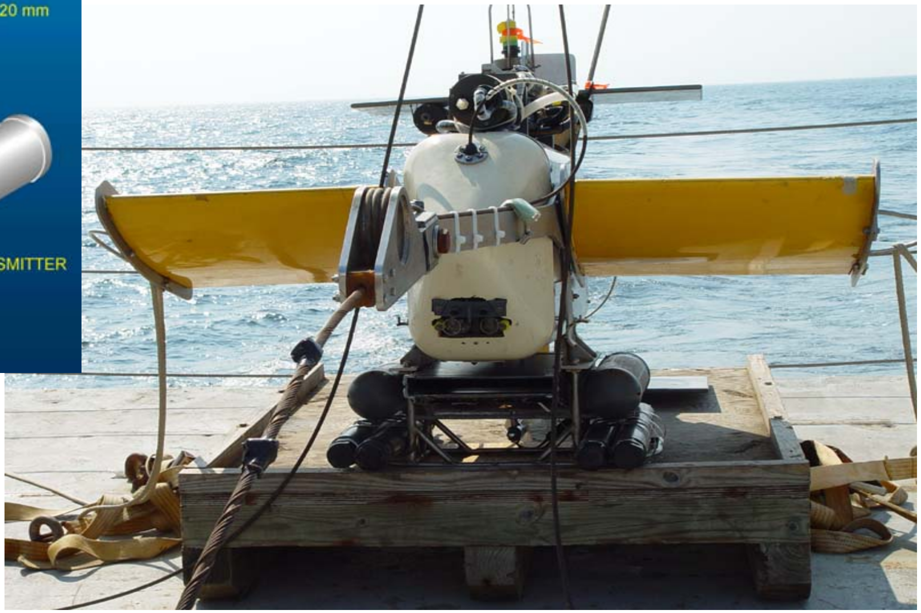
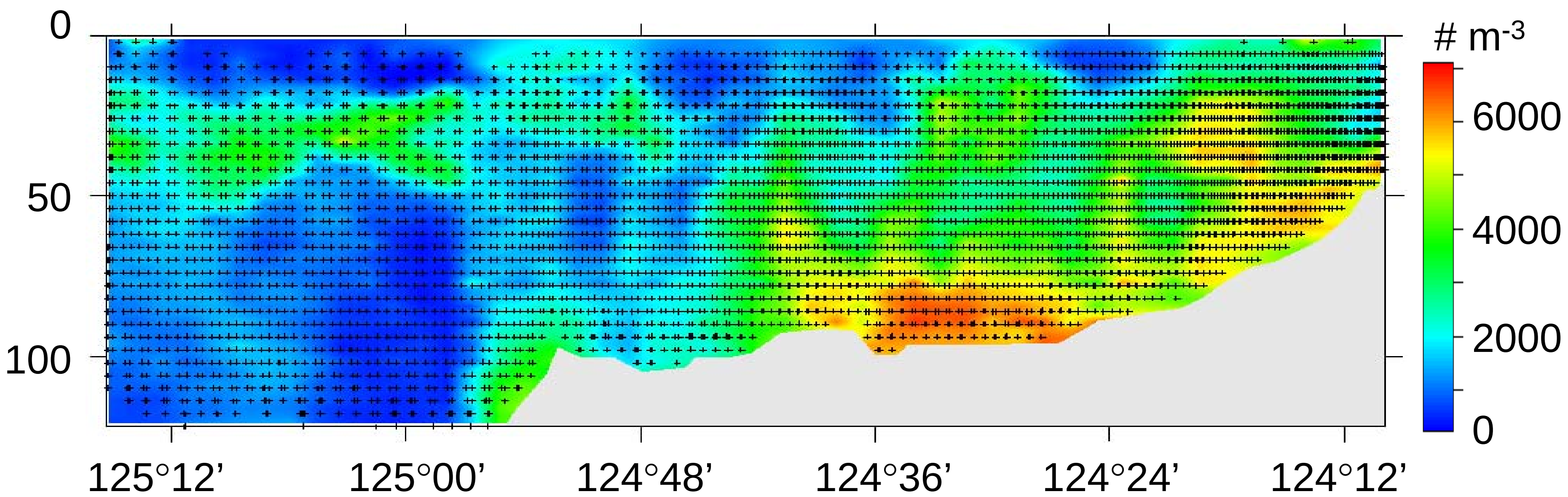
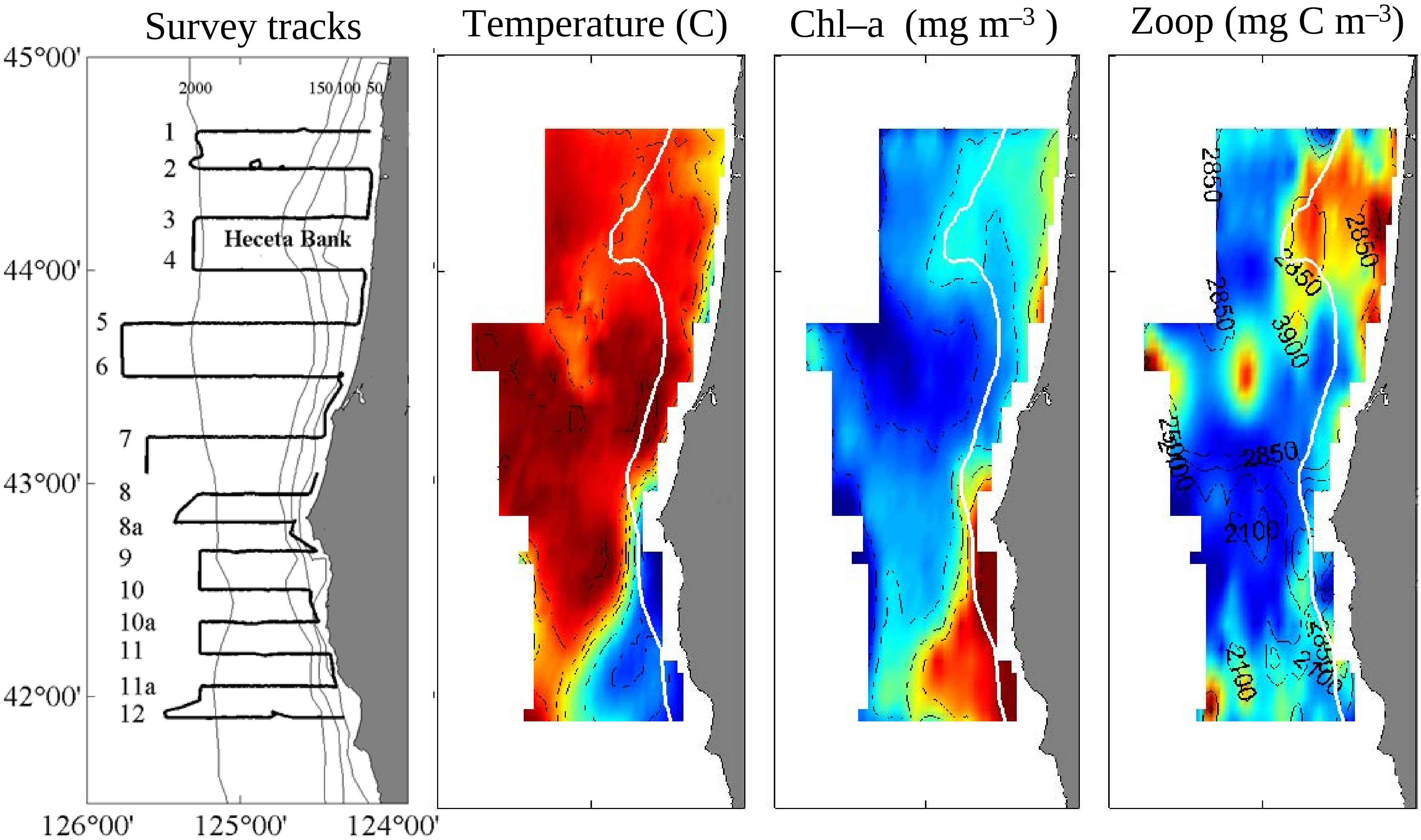
Achievement: Integrated SeaSoar-CTD-AC9-OPC







Achievement: Distributions at 5 m
(US GLOBEC 2002 spring cruise)

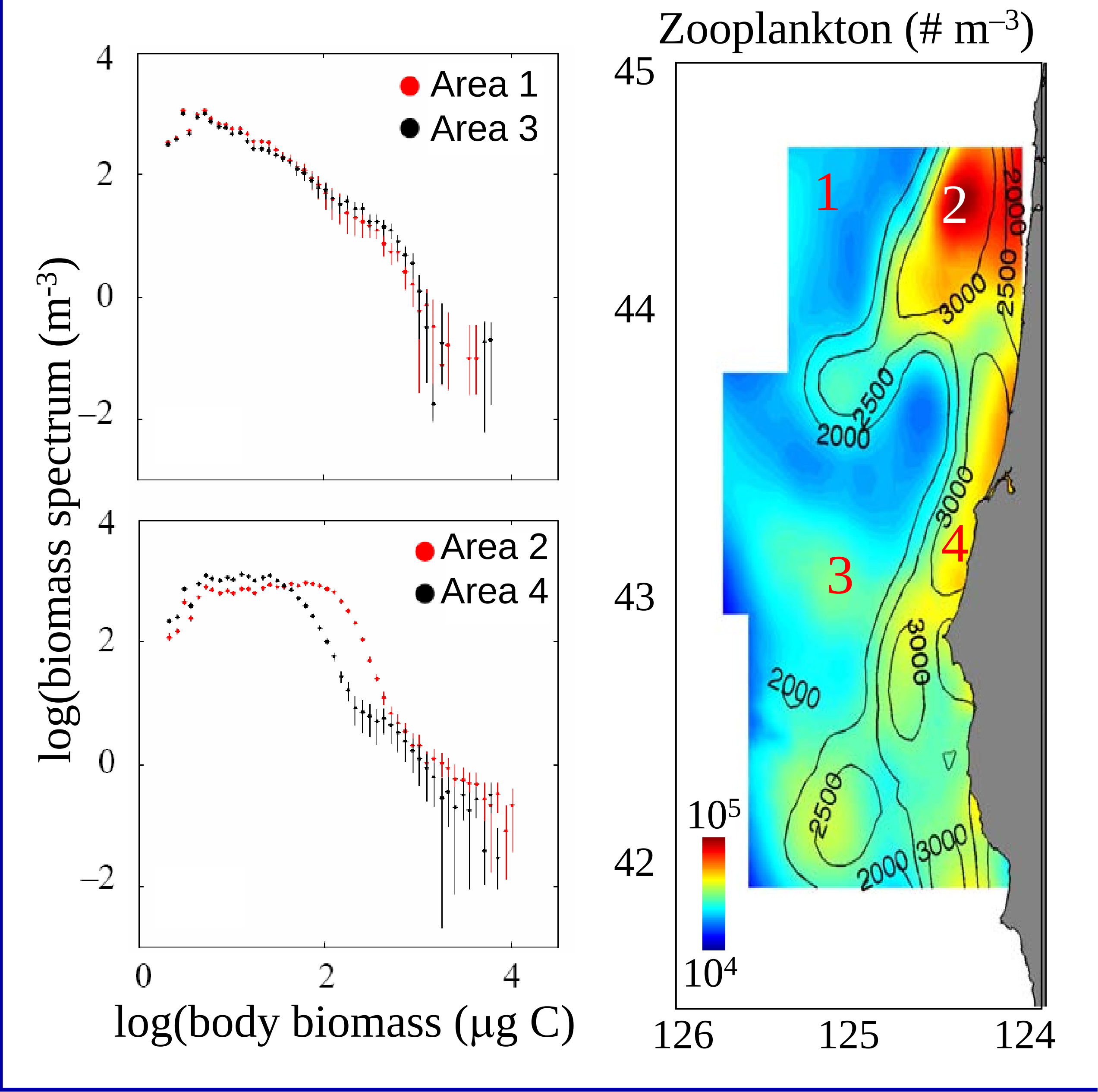


Achievement: Size structure (depth averaged in 0–153 m)

Remaining questions:

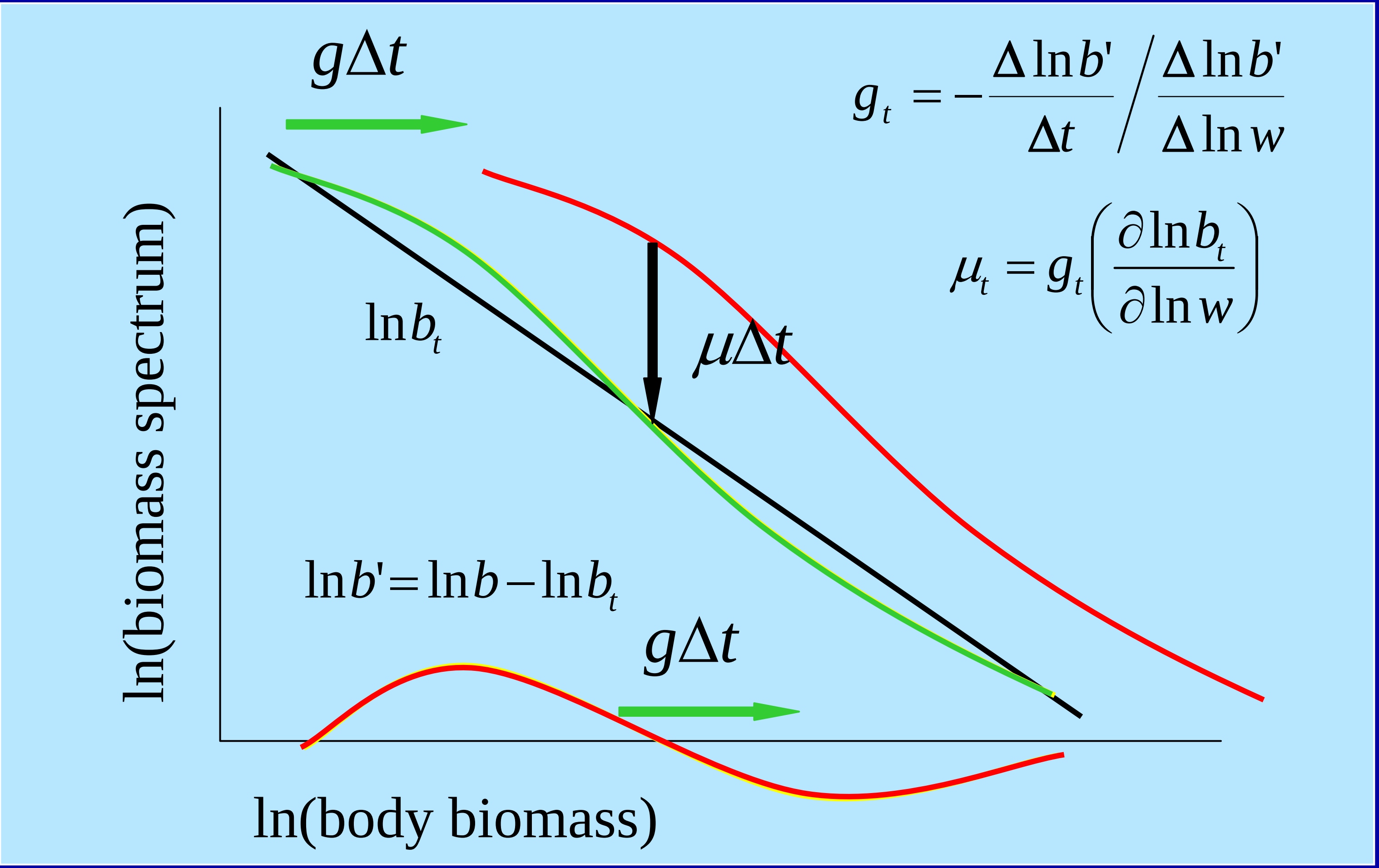
What causes the difference between the biomass spectra?

Can we interpret the shape of a biomass spectrum in terms of physical and biological processes?



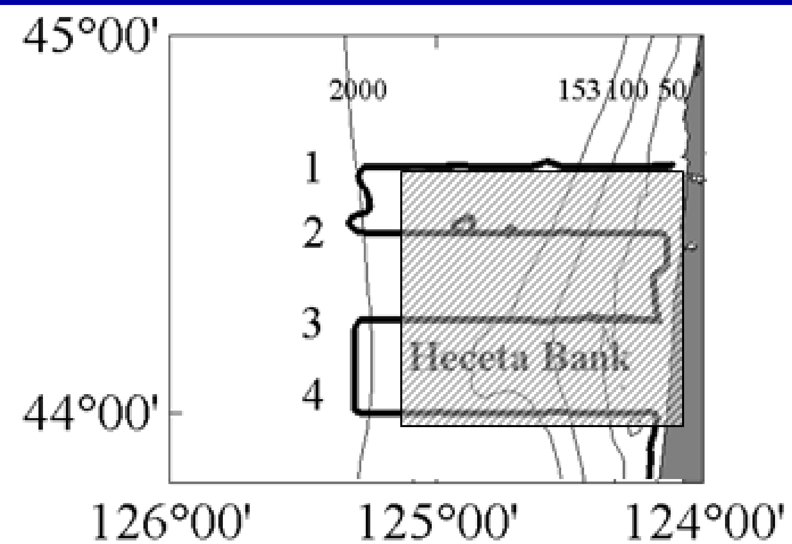
Theory 1: Growth & mortality rates

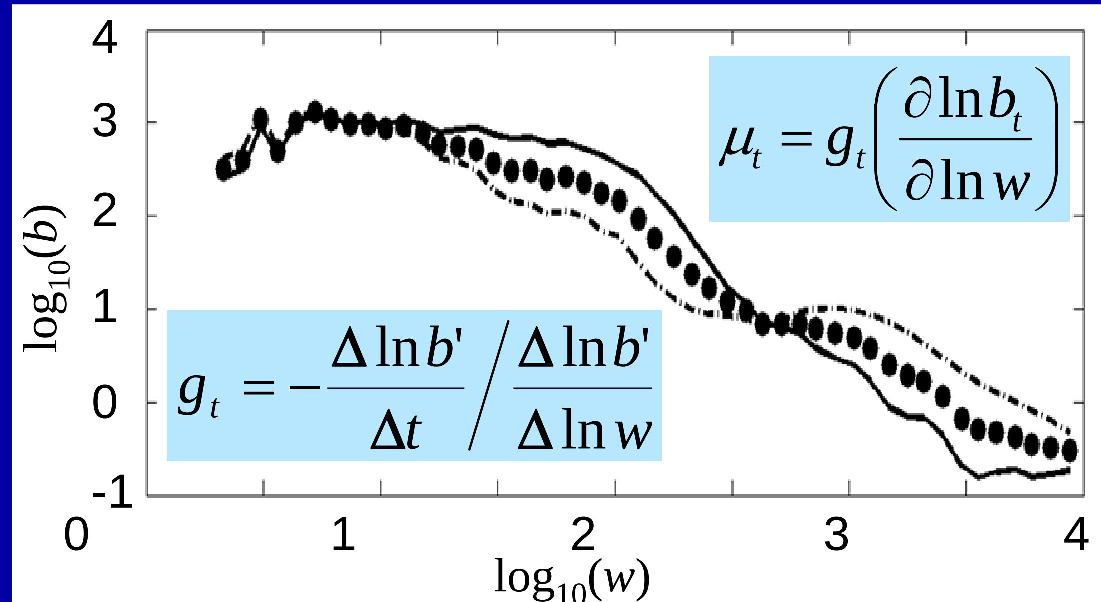
(Zhou & Huntley 1997; Edvardsen et al. 2002; Zhou 2006)

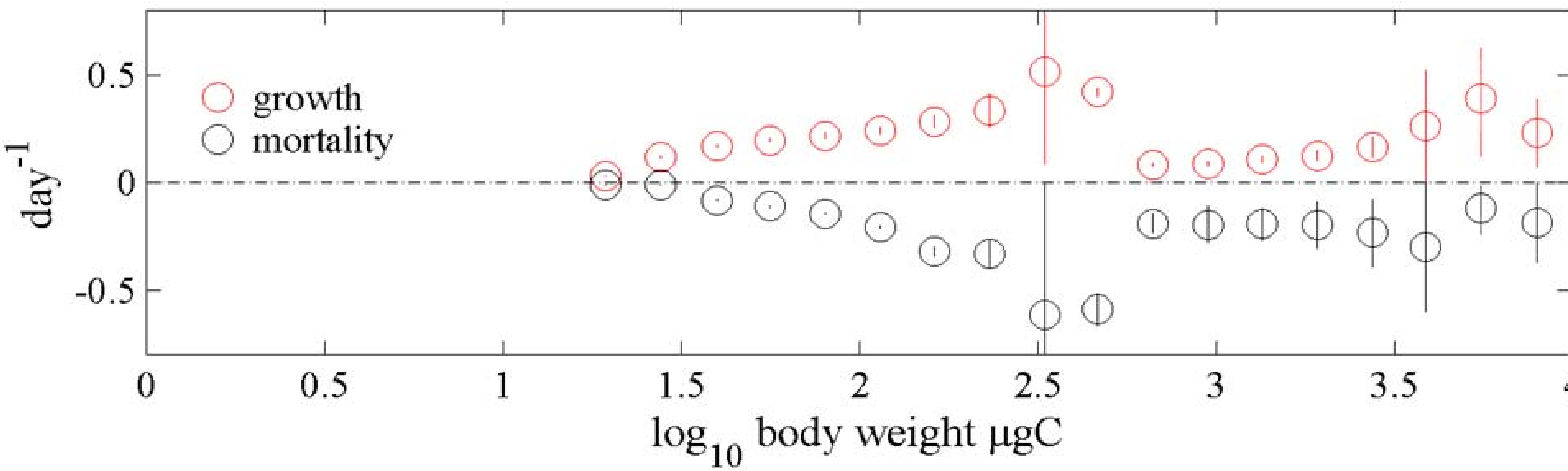


$$\frac{\partial \ln b}{\partial t} + g \frac{\partial \ln b}{\partial \ln w} = \mu - \frac{\partial g}{\partial \ln w}$$

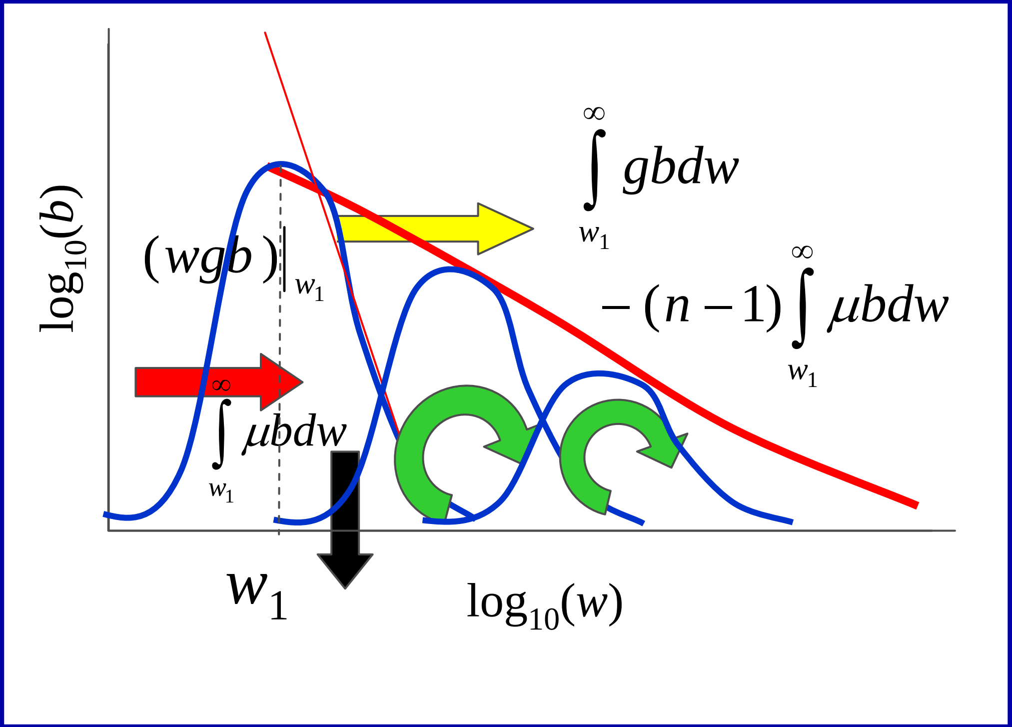
Example: Zooplankton growth and mortality rates estimated from repeated samplings







Theory 2: Slope, assimilation & trophic levels



$$n = -\frac{1+\eta_n}{\eta_n \times slope}$$

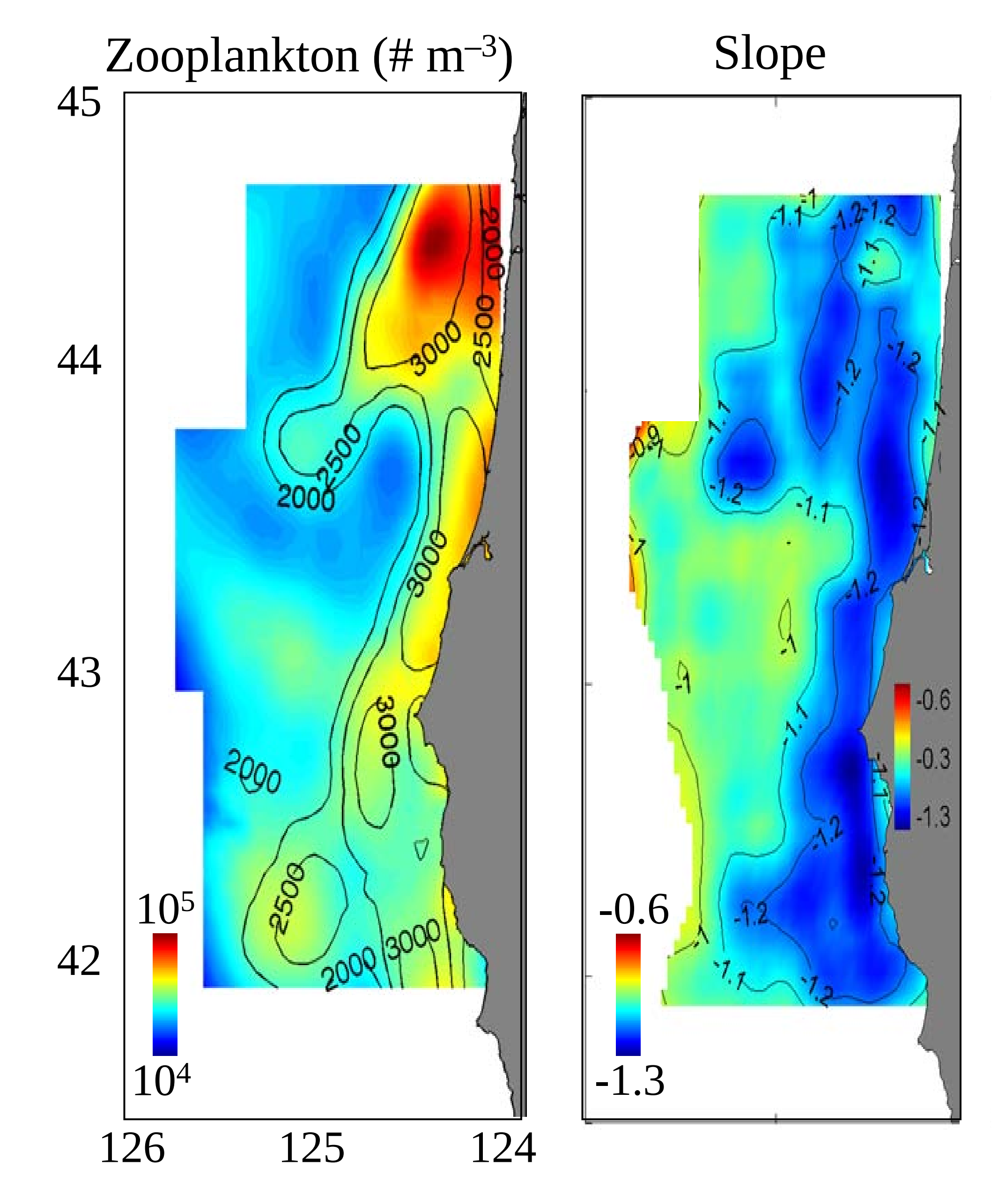
n: an index for the # of trophic levels

Net biomass change: $\int_{w_1}^{\infty} gbdw$

Total biomass used: $(wgb)_{w_1} - (n-1)\int_{w_1}^{\infty} \mu bdw$

Community assimilation efficiency: $\eta_n = \int_{w_1}^{\infty} gbdw \Big/ \left[(wgb)_{w_1} - (n-1)\int_{w_1}^{\infty} \mu bdw \right]$

Example: Trophic level differences

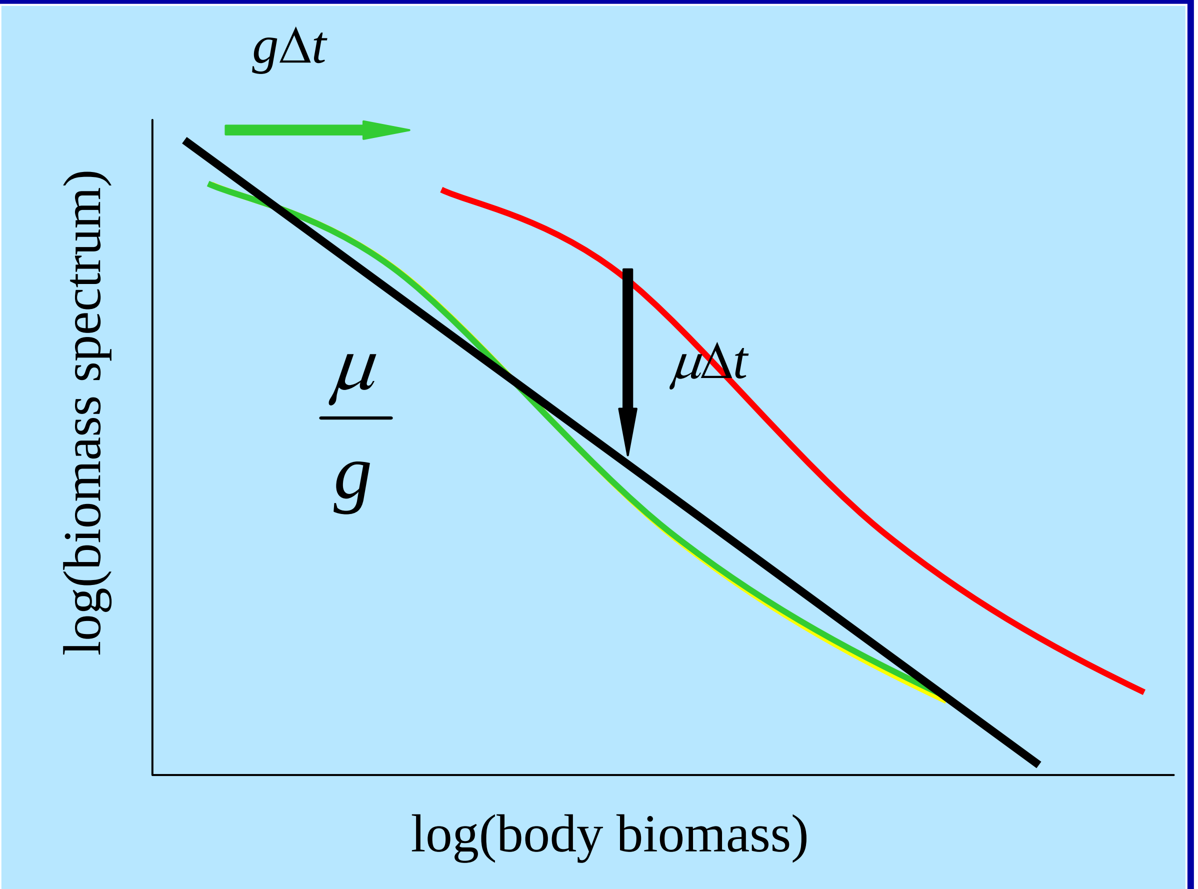


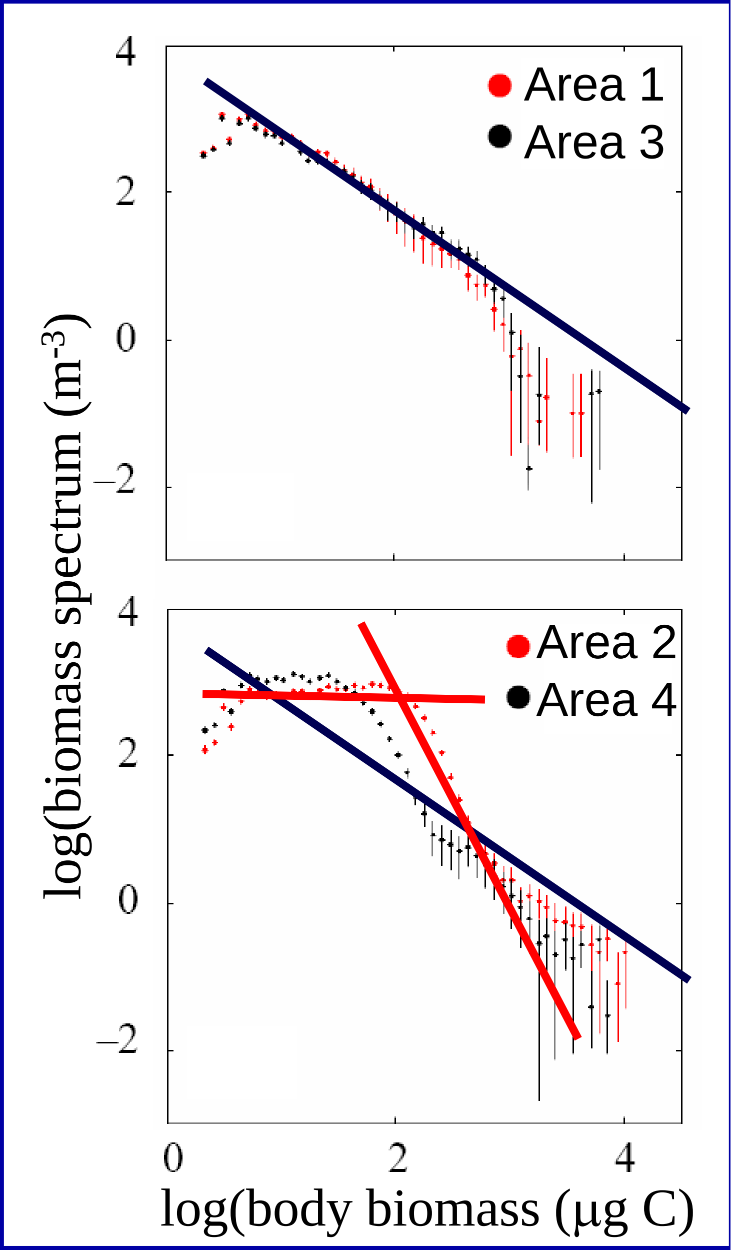
$$n = -\frac{1+\eta_n}{\eta_n \times slope}$$

	# of levels	Recycles
Nearshore:	2.0	1
Offshore:	2.4	1.4

Considering to use the slope as an **indicator** for the food-web.

Anomalies on biomass spectra

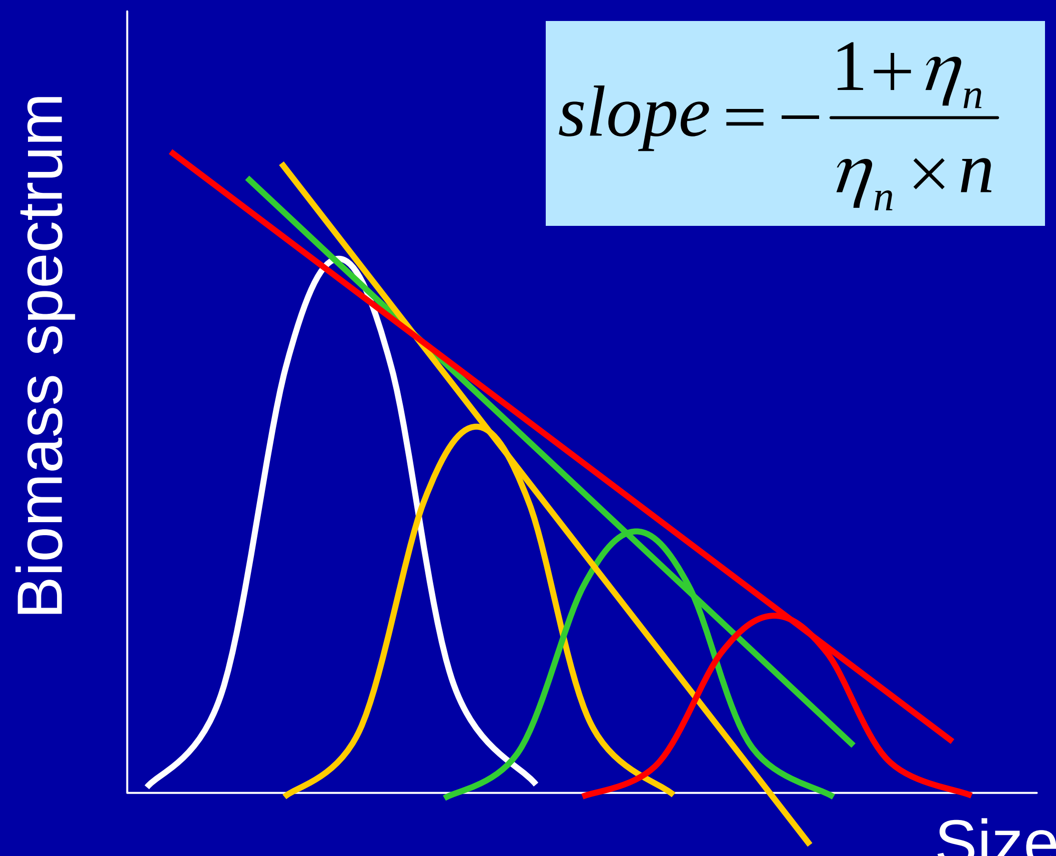




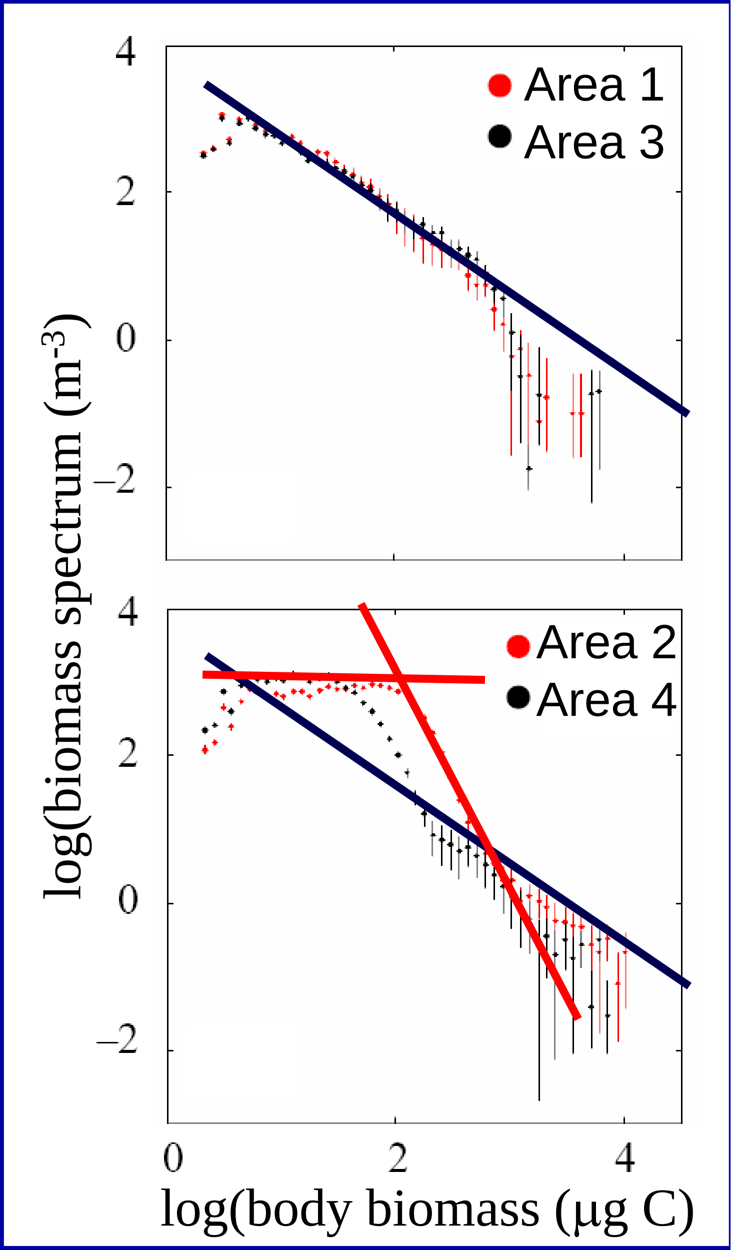
$$\frac{\partial \ln b}{\partial t} + g\,\frac{\partial \ln b}{\partial \ln\, w} = \mu - \frac{\partial g}{\partial \ln\, w}$$

Can the mortality be zero?

Anomalies on biomass spectra



$$slope = -\frac{1+\eta_n}{\eta_n \times n}$$



n: # of trophic levels

η_n: Community assimilation efficiency

Can the biomass be recycled infinitely?

The general size spectrum theory

Biomass spectrum equation
(Silvert & Platt 1978; Zhou & Huntley 1997)

$$\frac{\partial b}{\partial t} + \frac{\partial (u_x b)}{\partial x} + \frac{\partial (u_y b)}{\partial y} + \frac{\partial (wgb)}{\partial w} = gb + \mu b$$

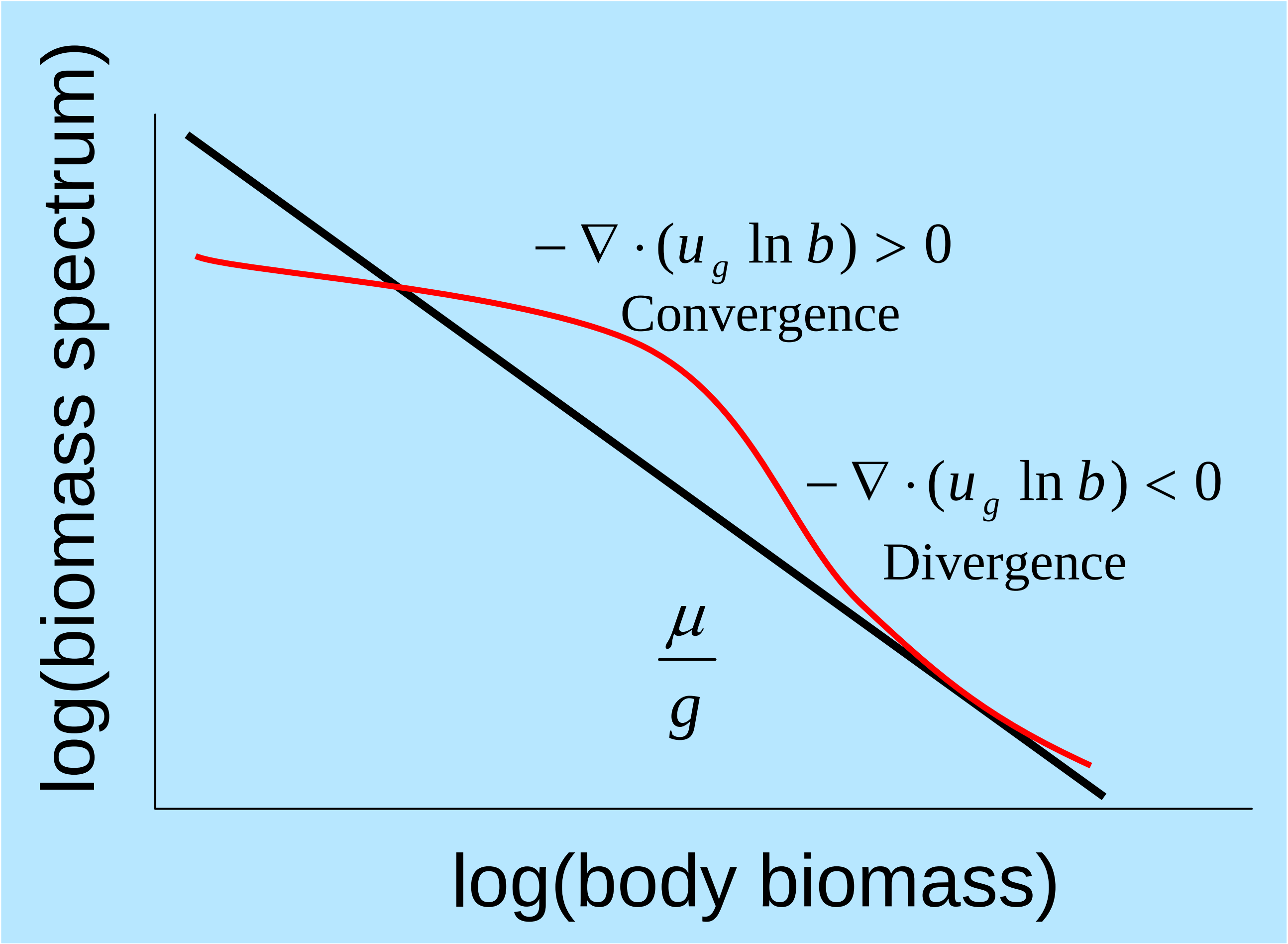
advection

Biomass
flow in sizes

u_x,u_y: geostrophic current
b: biomass spectrum
g: specific rate of individual body growth
μ: specific rate of abundance (concentration) change

$$\frac{\partial \ln b}{\partial t} + \frac{\partial (u_x \ln b)}{\partial x} + \frac{\partial (u_y \ln b)}{\partial y} + g\frac{\partial \ln b}{\partial \ln w} = \mu - \frac{\partial g}{\partial \ln w}$$

Biomass spectrum theory

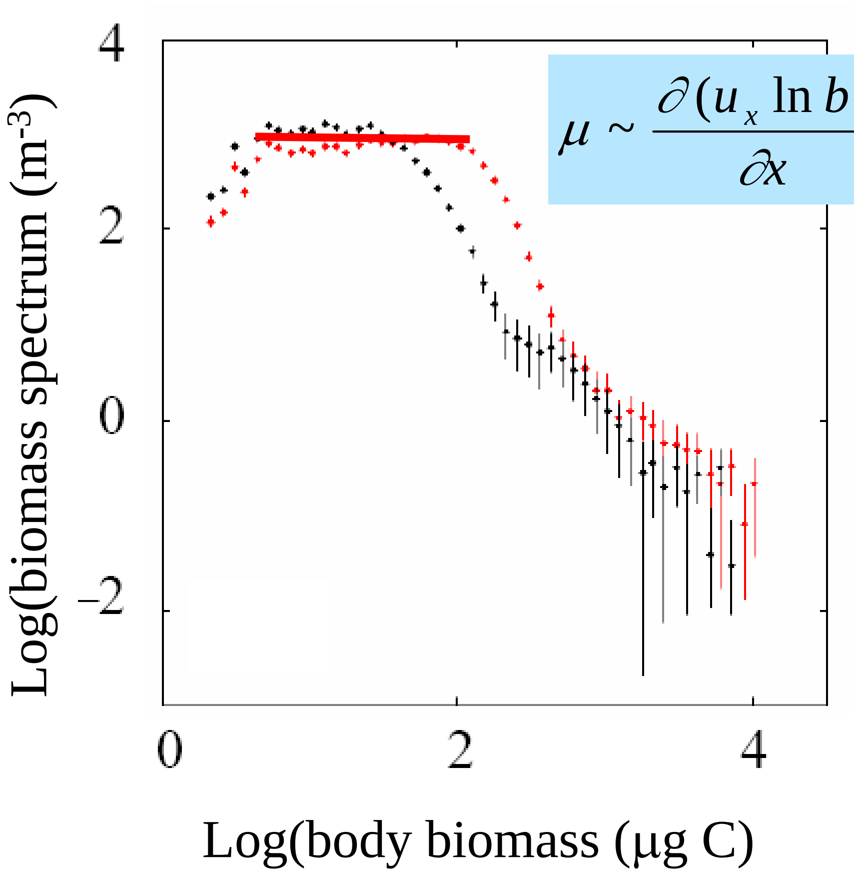


$$\frac{\partial \ln b}{\partial \ln w} = \frac{\mu}{g} - \frac{1}{g}\left\{\frac{\partial (u_x \ln b)}{\partial x} + \frac{\partial (u_y \ln b)}{\partial y}\right\}$$

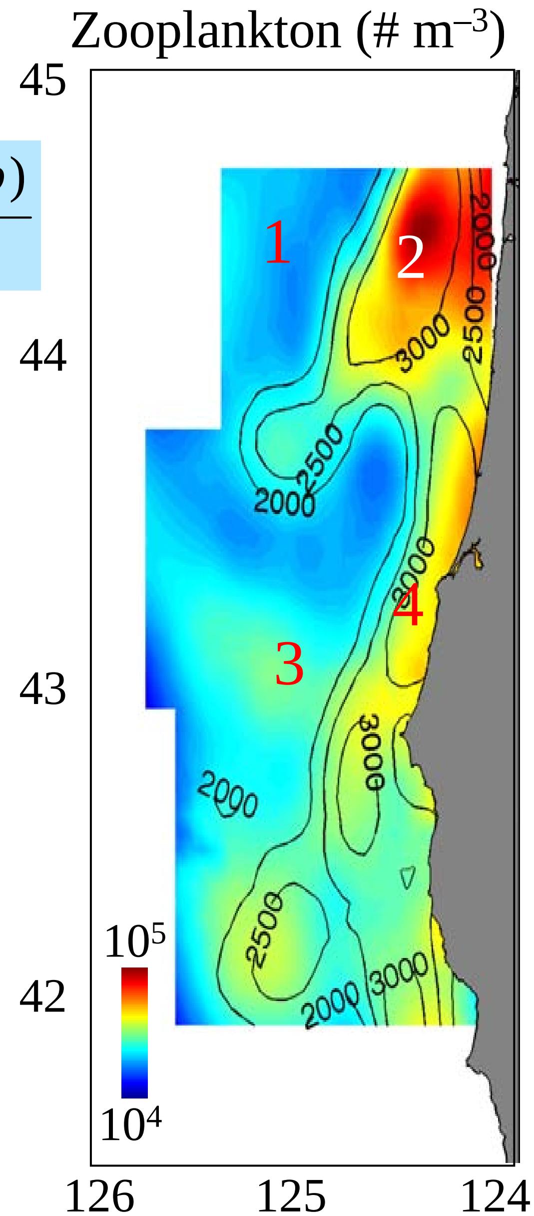
$$\frac{[u_x]}{\Delta x} = \frac{0.1 \sim 0.2\,\mathrm{m\ s^{-1}}}{50\ \mathrm{km}} = 0.2 \sim 0.3\ \mathrm{day}^{-1}$$

g: 0.1-0.3 day^{-1}

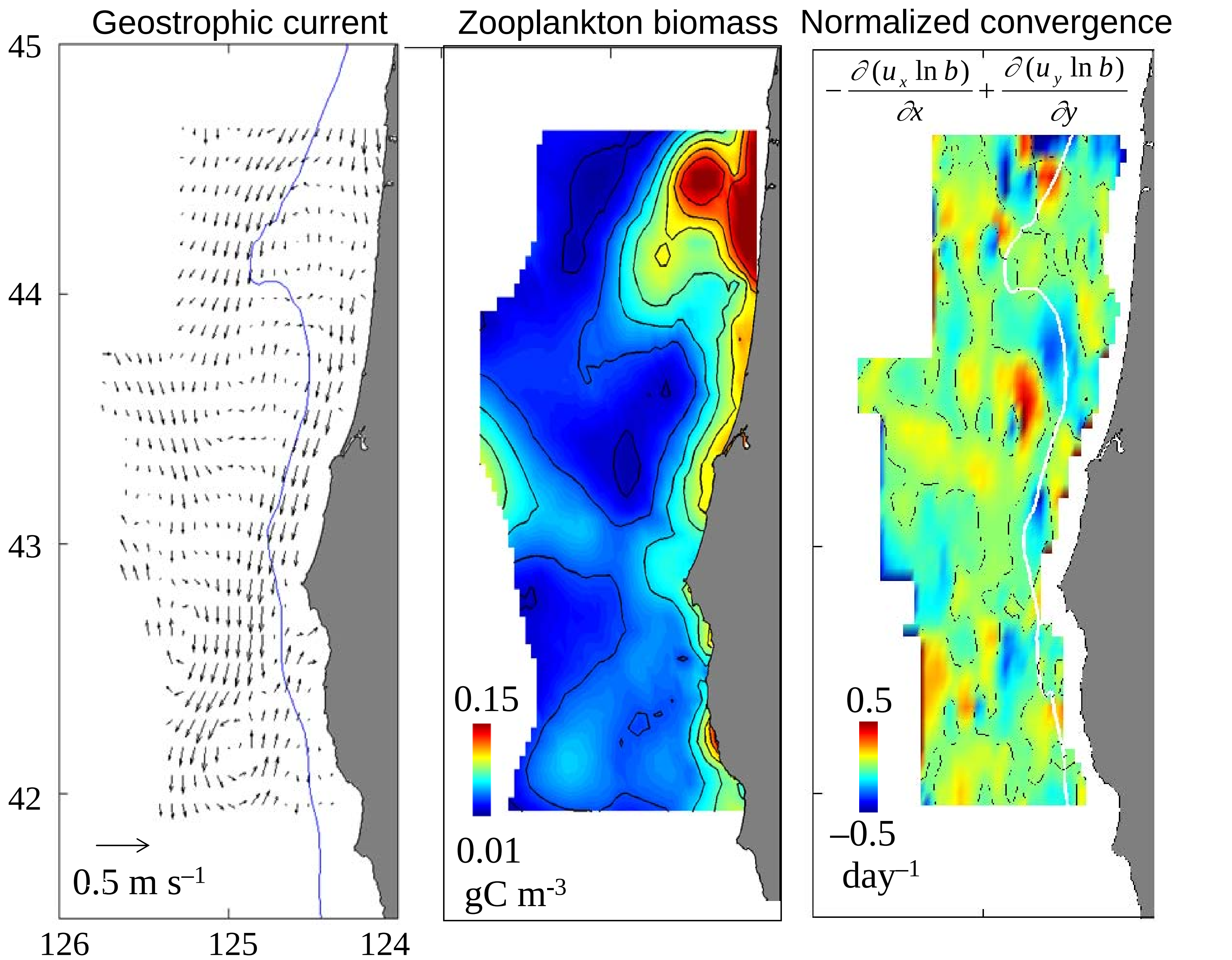
Depth averaged zooplankton distributions (0–153 m)



$$\mu \sim \frac{\partial (u_x \ln b)}{\partial x} + \frac{\partial (u_y \ln b)}{\partial y}$$



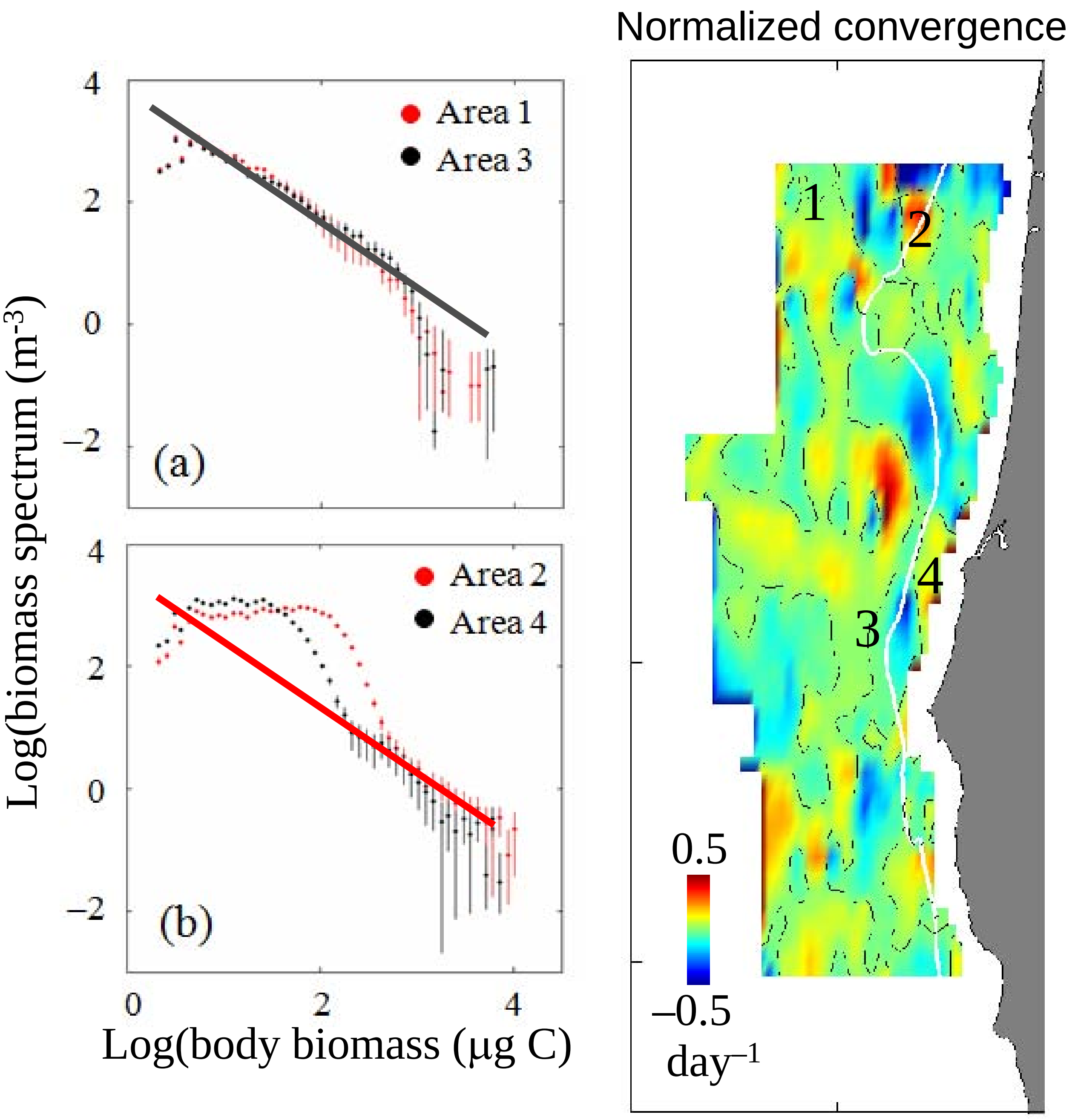
Is the mortality of small ones balanced by advection of small ones?



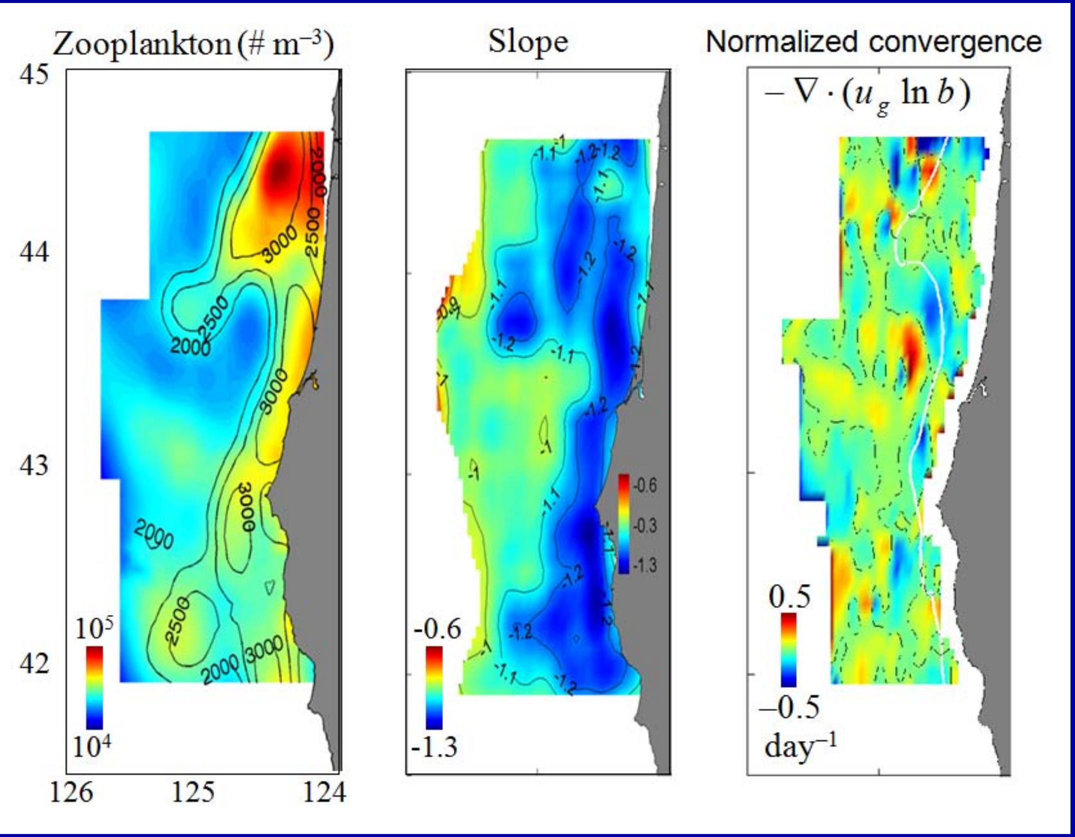
Geostrophic current
Zooplankton biomass
Normalized convergence
$-\frac{\partial(u_x \ln b)}{\partial x}+\frac{\partial(u_y \ln b)}{\partial y}$
45
44
43
42
126
125
124
0.5 m s–1
0.15
0.01
gC m-3
0.5
–0.5
day–1

Physical processes can significantly affect the size structure of a zooplankton community

The same rule should be applied to species based structure, that is, the advection affects the community structure.



Summary



- Size spectrum measurements and theories have provided quantitative methods to access zooplankton distributions, growth, mortality and trophic interaction.
- Physical processes have significant effects on the zooplankton community structure which may bias the interpretation of their population dynamics and trophic interaction.