Does ETS activity follow Kleiber's Law?

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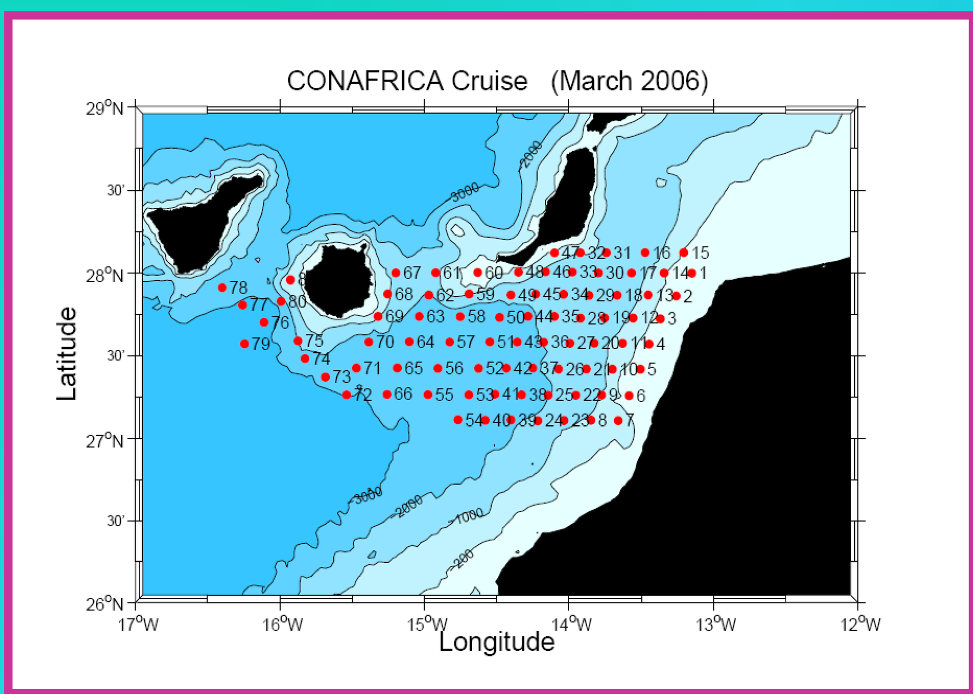
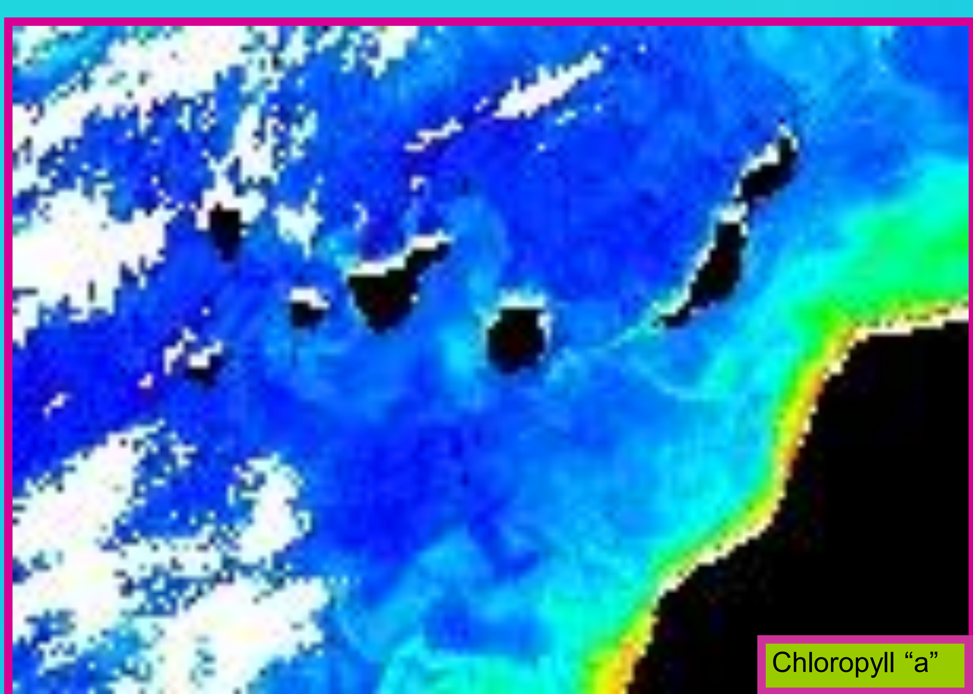
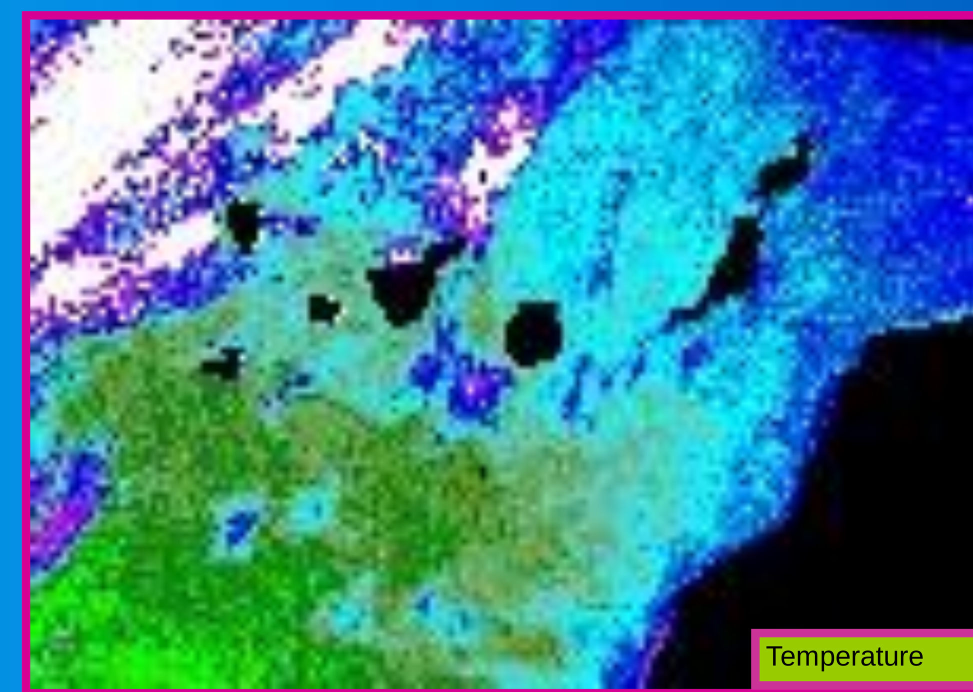




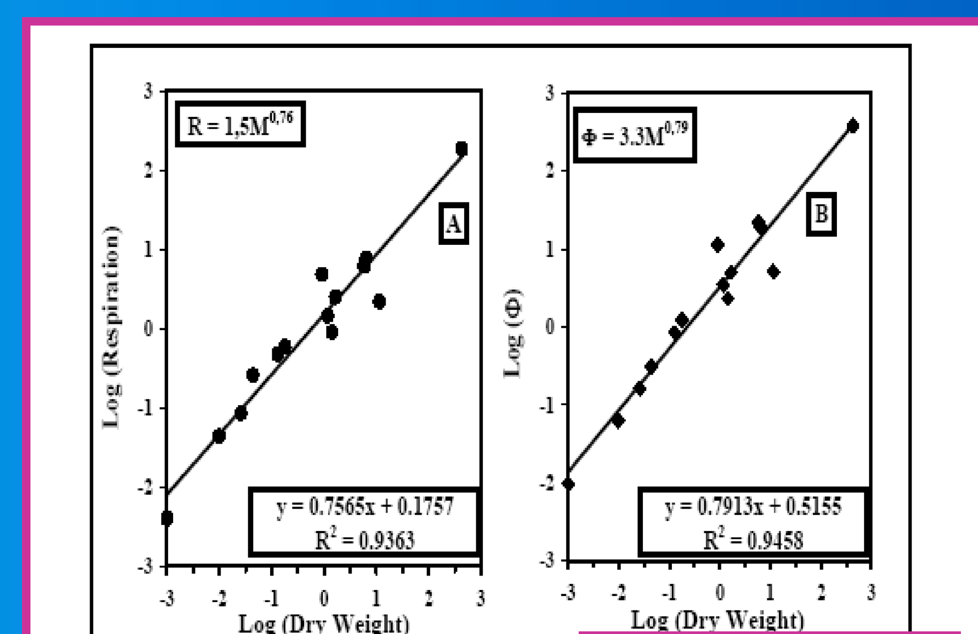
Chlorophyll "a"

Kleiber's Law, relating an organism's biomass (M) with its metabolic rate (R), has been shown to follow the allometric equation, R=aM.0.75. This law has been found to hold over 20 orders of magnitude for respiration and productivity, and over smaller ranges of magnitude for many other physiological processes. This law has gained increasing importance in recent years, because it serves as the basis for the Metabolic Theory of Ecology. (Brown et al, 2004).

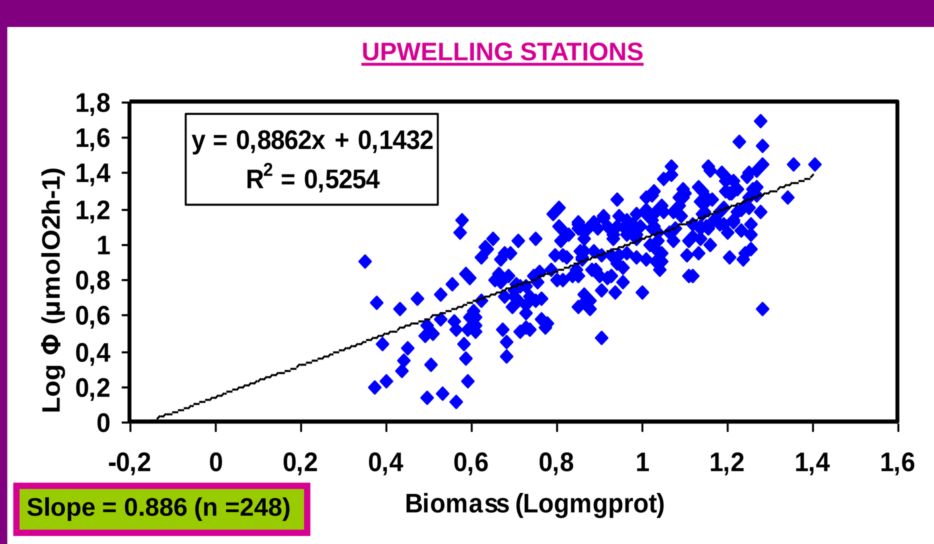
We have previously shown that at the physiological level, Kleiber's law holds for zooplankton (King and Packard, 1975), but we do not know if it holds at the ecological level. To investigate this question, zooplankton samples of ETS activity and protein, from the northwest African upwelling system were taken in March of 2006 (CONAFRICA 0603 Cruise). These samples included both offshore oceanic, nearshore upwelling, and zooplankton from ten different depths until 200 meters. These samples were analysed in total and by depth, for the different regions, for agreement with Kleiber's Law

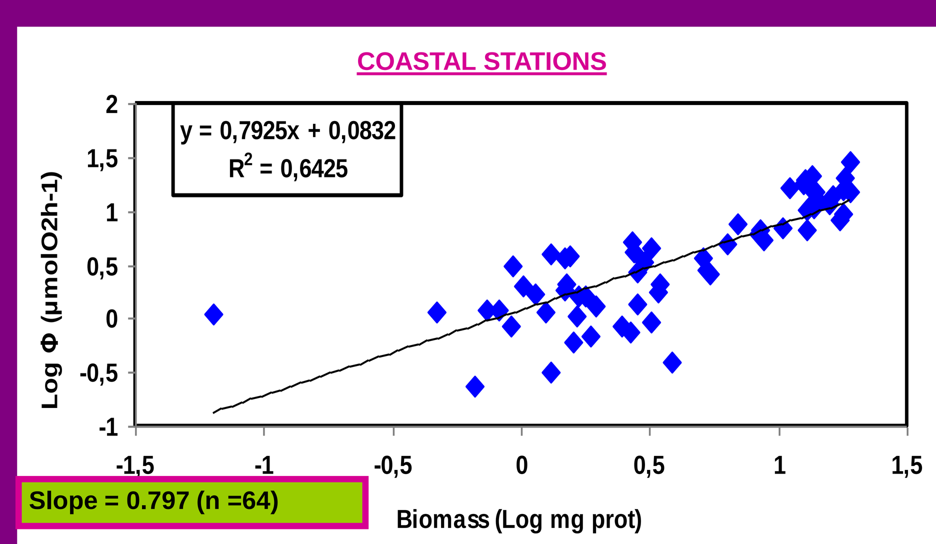


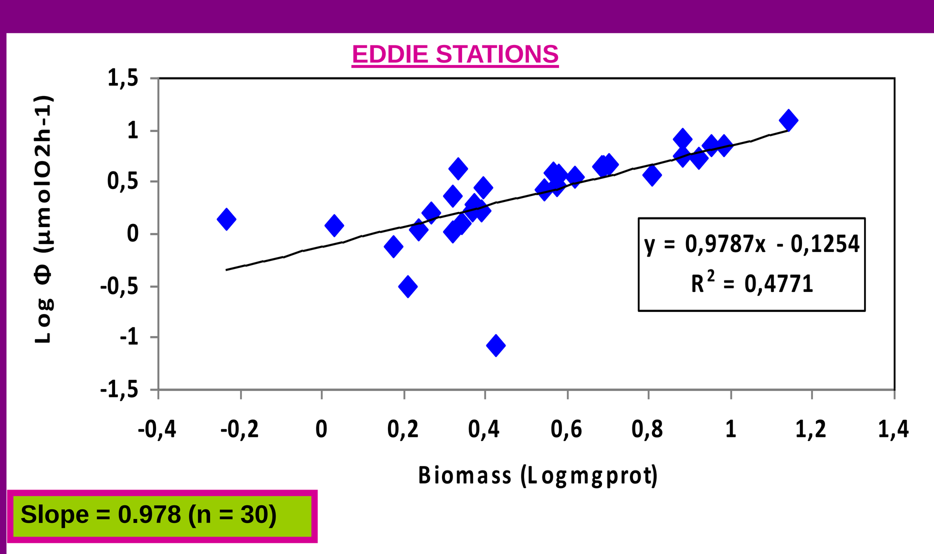
Temperature

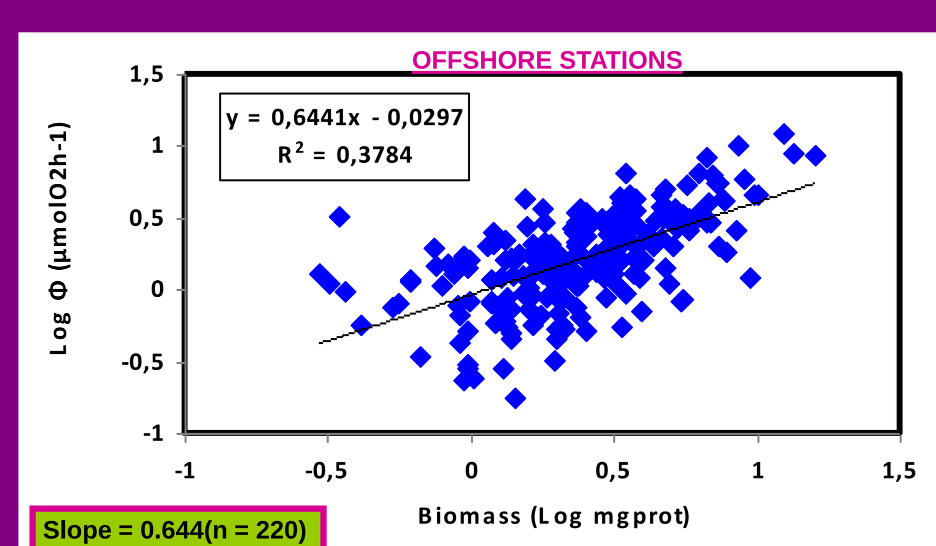


Packard and Gómez (2008)









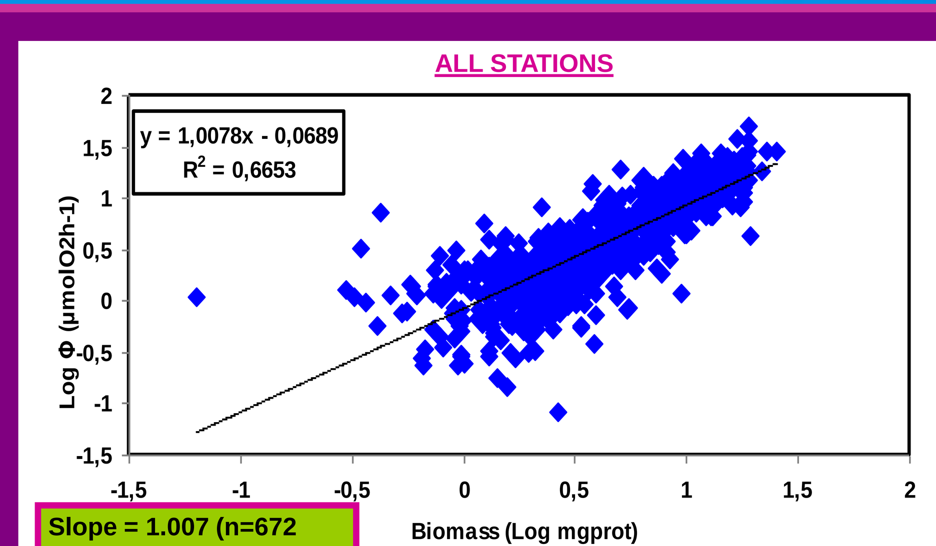
Our results show that in stations with high values of chlorophyll "a" (upwelling area and stations related with the cyclonic eddy) zooplankton are growing with high metabolic rates. In this area ETS activity is well correlated with biomass. In coastal stations this relationship diminishes somewhat and is closer to Kleiber's Law. In offshore stations we note that the ratio, ETS/Biomass, decreases to very low values. In general, regardless of the depth, the samples in the upwelling zone have higher ratios than the samples offshore or inshore.

In the coastal stations, there were no significant differences in the ETS-protein ratio between day and night. On the other hand, in the offshore stations, the slope is higher in the night, probably due to the vertical migration of the mesozooplankton community.

The depth of the sample seems to have very little impact on the ETS-protein ratio in the upwelling area. However, offshore the ETS-protein ratio between 100-200 m is much lower than it is in the surface layer. This can be seen in two typical offshore transect (G and H)

When we analyse the total number of samples (672), we find a slope of 1, so it confirms that the ETS is a very good biomass proxy. King and Packard (1975) found the same for zooplankton at the physiological level, Packard, et al 1983 and Berdalet et al (1995), found the same results in bacteria cultures, and Martínez et al, 2007, in Artemia salina cultures.

DAY		NIGHT	
Coastal St.	Offshore St.	Coastal St.	Offshore St.
y = 0.755x + 0.064 (R² = 0.578) N = 44	y = 0.544x – 0.006 (R² = 0.281) N = 143	y = 0.754x – 0.229 (R² = 0.667) N = 20	y = 0.823x – 0.094 (R² = 0.553) N = 77



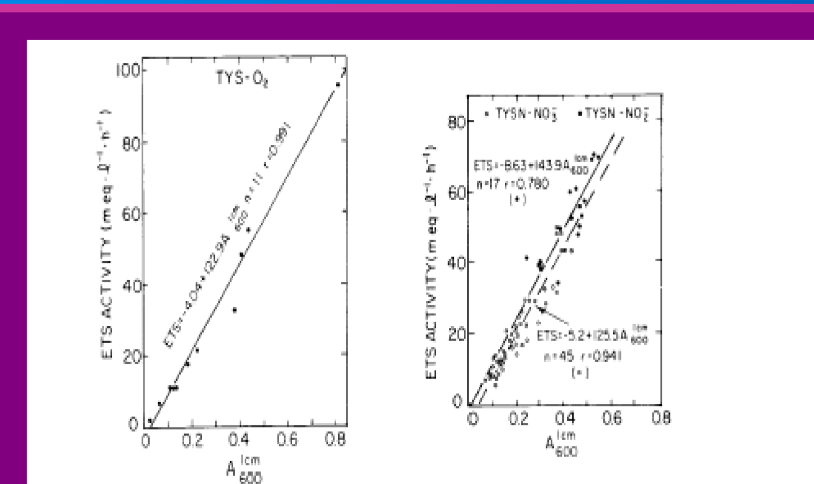
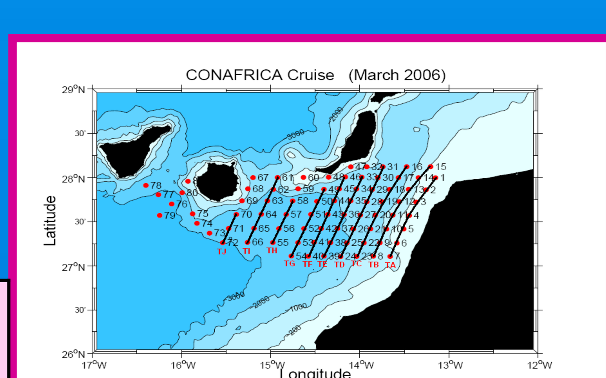


Fig. 8. ETS activity vs bacterial biomass in aerobic (left) and anaerobic (right) cultures of P. perfectomarinus.

Packard et al. (1983)



TRANSECT	DEPTH (M)	
TB	0-100	y = 1.153x – 0.115 (R^2=0.68, N= 30)
	100-200	y = 1.201x – 0.232 (R^2=0.823, N= 40)
TC	0-100	y = 0.728x + 0.390 (R^2=0.503, N=39)
	100-200	y = 0.687x + 0.114 (R^2=0.601, N= 41)
TD	0-100	y = 1.052x + 0.150 (R^2=0.573, N= 39)
	100-200	y = 1.112x – 0.102 (R^2=0.565, N= 40)
TE	0-100	y = 1.036x + 0.003 (R^2=0.224, N= 29)
	100-200	y = 1.173x – 0.328 (R^2=0.731, N= 33)
TF	0-100	y = 0.751x + 0.010 (R^2=0.469, N=33)
	100-200	y = 0.588x + 0.055 (R^2=0.5, N=31)
TG	0-100	Y = 0.631x +0.075 (R^2=0.6, N=29)
	100-200	y = 0.231x + 0.107 (R^2=0.034, N=29)
TH	0-100	y = 0.55x + 0.161 (R^2=0.453, N=22)
	100-200	y = 0.184x + 0.135 (R^2=0.128, N=18)
TI	0-100	y = 0.101x + 0.088 (R^2=0.016, N= 28)
	100-200	y = 0.253x – 0.305 (R^2=0.05, N=28)
TJ	0-100	y = 0.856x + 0.023 (R^2=0.726, N=13)
	100-200	y = 0.795x – 0.041 (R^2=0.583, N=17)

From our results and the literature we can conclude that:

1.- When organisms are well nourished (Upwelling and cyclonic eddy area) the ETS-biomass ratio is high, near to 1. This is in accordance with the result observed in cultures (Packard et al, 1983).

2.- In natural conditions, i.e.,in coastal stations and in fresh zooplankton samples (Packard and Gómez, 2007), the ratio is lower and closer to Kleiber's law.

3.- In low food conditions, as in the offshore stations, the ratio is lower than Kleiber's Law.

4.- In general, considering all the data, the exponent in the ETS/Biomass relationship is closer to 1 than it is in Kleiber's Law (0,75). This means that the ETS and biomass are directly linearly related and do not follow the allometric equation and consequently do not require a logarithmic transformation.

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