ETS activity is a good zooplankton biomass proxy

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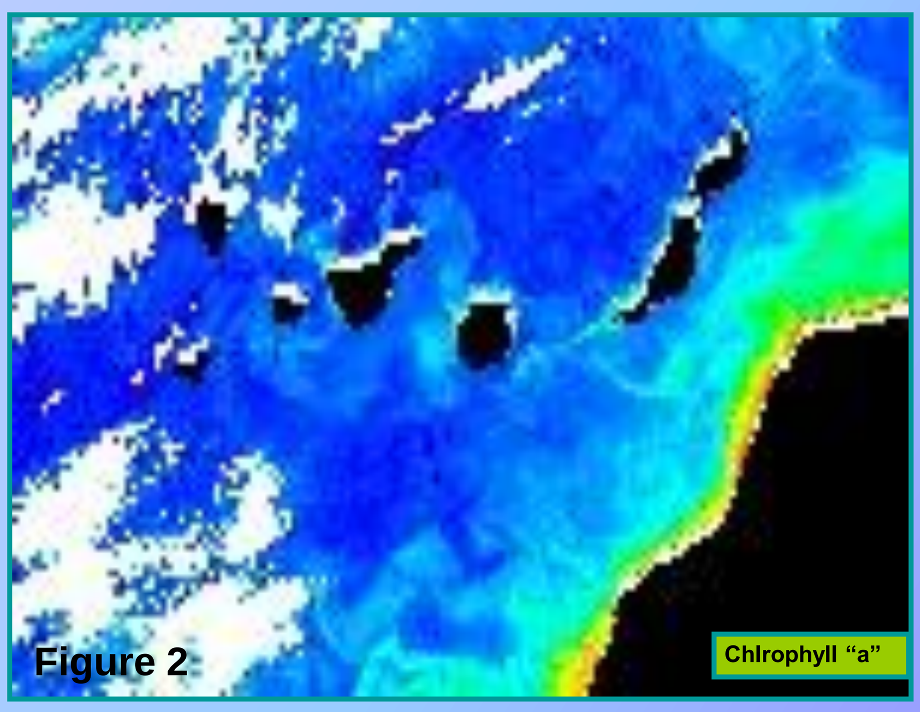


Figure 2

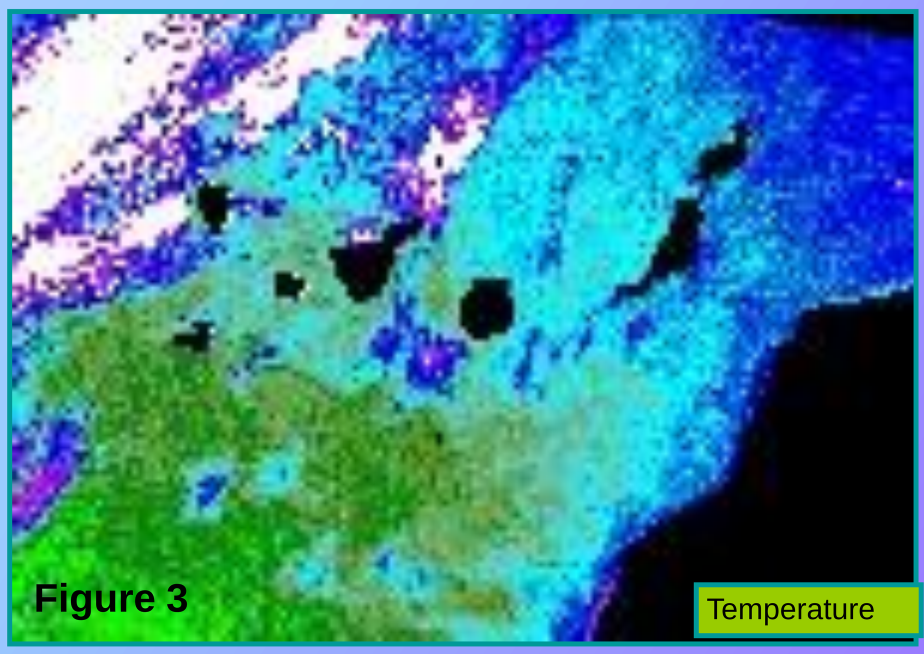


Figure 3

Kleiber's Law, relating an organism's biomass (M) with its metabolic rate (R), follows the allometric equation, R=aM.0.75. It holds over 20 orders of magnitude for respiration and 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 Figure 1). These samples included both offshore oceanic, nearshore upwelling, and zooplankton from ten different depths until 200 meters. These samples were analysed in total, by size, by depth, and by different regions, for agreement with Kleiber's Law.

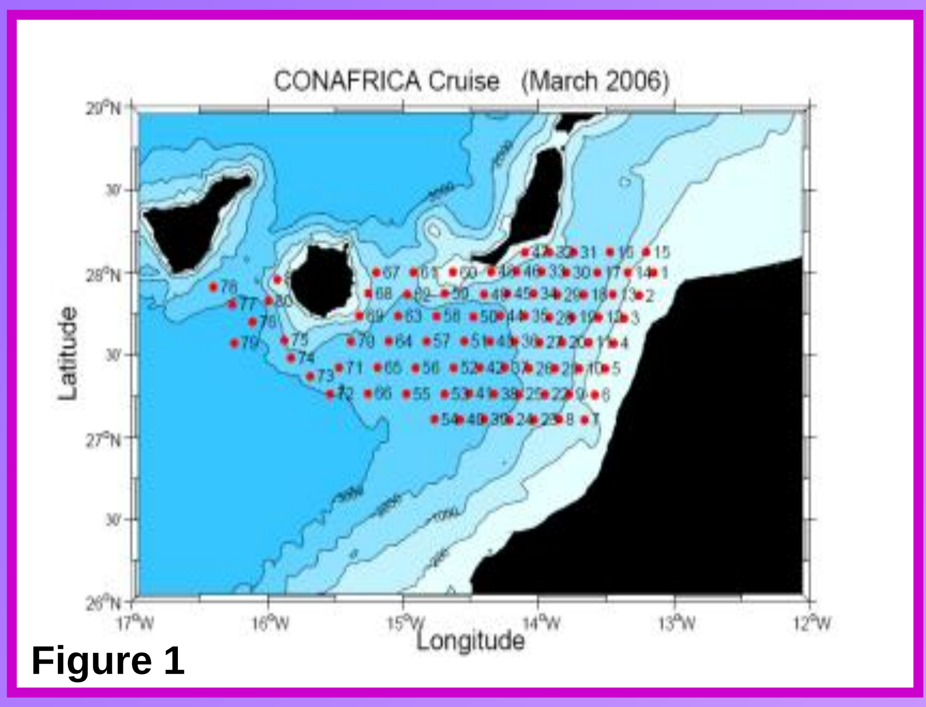


Figure 1

DAY		NIGHT	
Coastal St.	Offshore St.	Coastal St.	Offshore St.
y = 0.755x + 0.064 (R^2 = 0.578) N = 44	y = 0.544x – 0.006 (R^2 = 0.281) N = 143	y = 0.754x – 0.229 (R^2 = 0.667) N = 20	y = 0.823x – 0.094 (R^2 = 0.553) N = 77

Table 1

In stations with high values of chlorophyll "a" (figure 2), (upwelling area and stations related with the cyclonic eddy, figure 3) zooplankton grow with high metabolic rates. In these areas ETS activity correlates well with biomass (figures 4 and 5). In coastal stations this relationship diminishes and is closer to Kleiber's Law (figure 6). Offshore the ratio, ETS/Biomass, decreases to low values (figure 7). In general, regardless of depth, the upwelling zone has higher ETS/Biomass ratios than either the offshore or inshore.

Between day and night, (table 1), there were no significant differences in the ETS/Biomass ratio in the coastal stations. 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.

Depth seems to have very little impact on the ETS/Biomass ratio in the upwelling area. However, offshore the ratio at 100-200 m is much lower than in the surface layer. This can be seen in two typical offshore transect (G and H) see Table II.

After analysing 672 samples, we find a slope of ETS to Biomass = 1, meaning that logarithmic transformations are unnecessary (figure 8) 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. ETS activity detects biomass well.

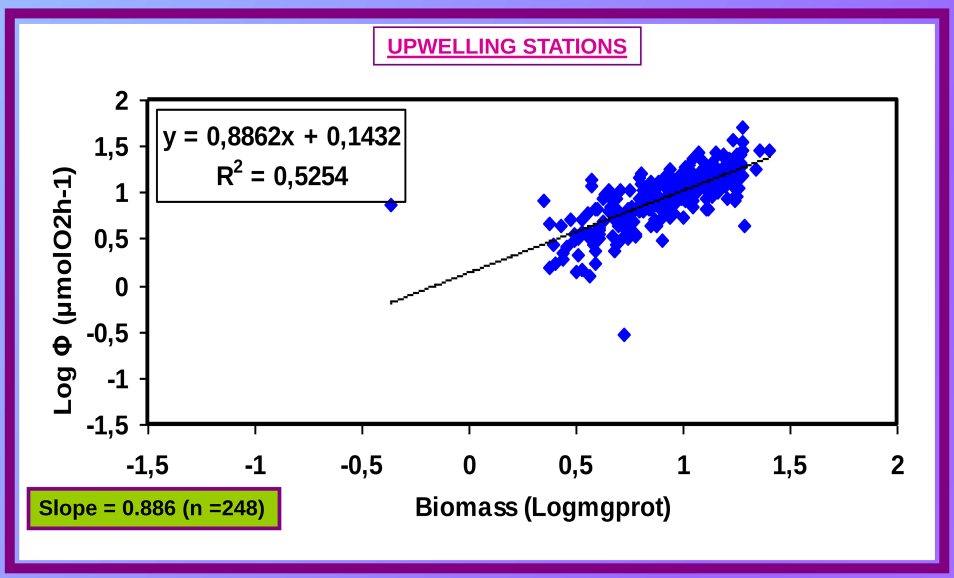


Figure 4

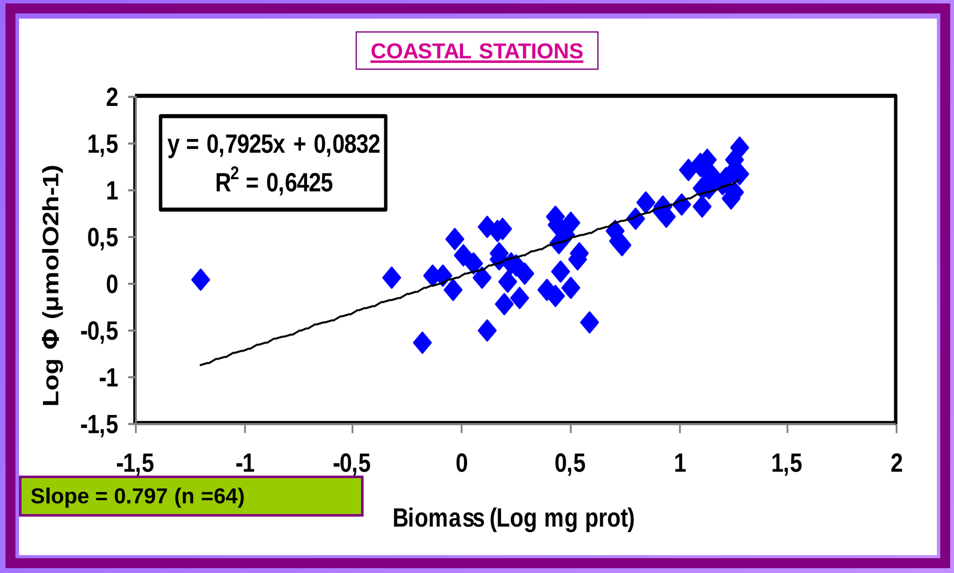


Figure 6

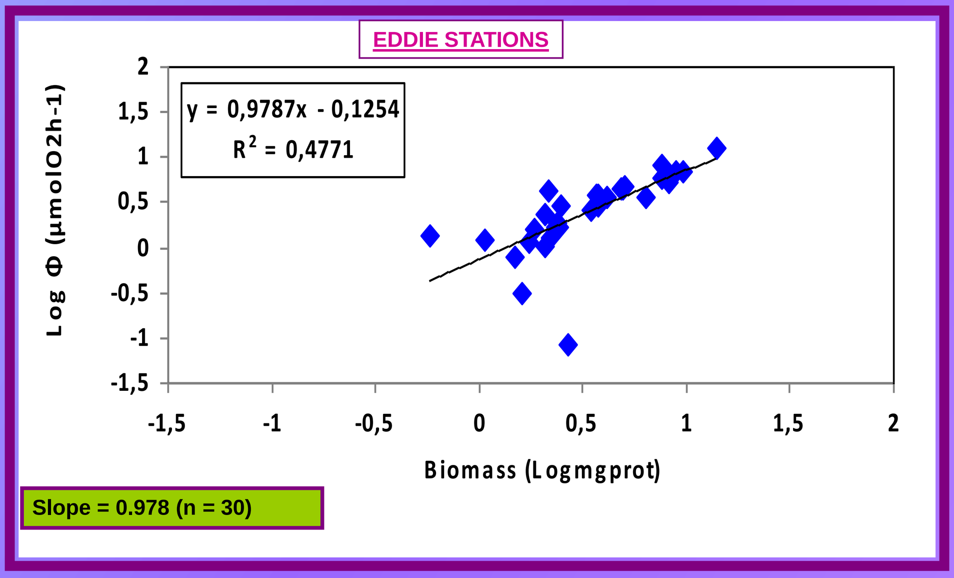


Figure 5

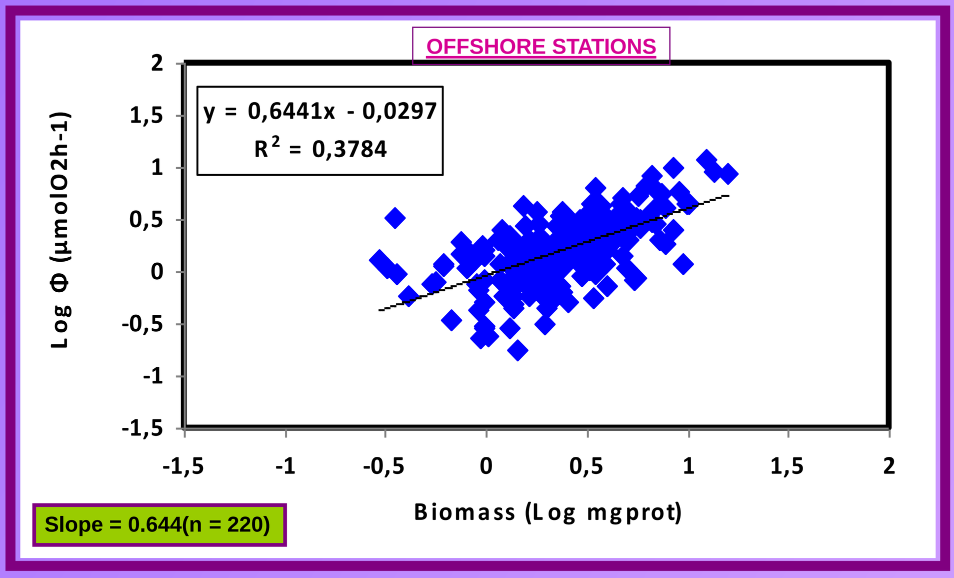


Figure 7

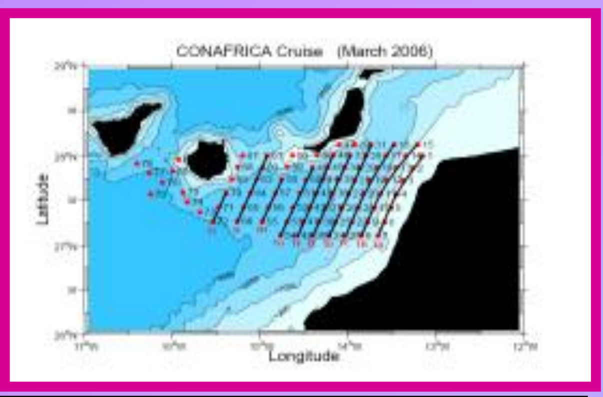
From our results and the literature we conclude that:

1.- In well-nourished organisms (Upwelling and cyclonic eddy areas) the slope of the log-log plots of ETS-biomass is near 1, indicating a direct relationship. This is in accordance with the result observed in cultures (Packard et al, 1983).

2.- In coastal stations and in fresh zooplankton samples (Packard and Gómez, 2008), the slope is lower and closer to Kleiber's law, indicating less than well-nourished conditions.

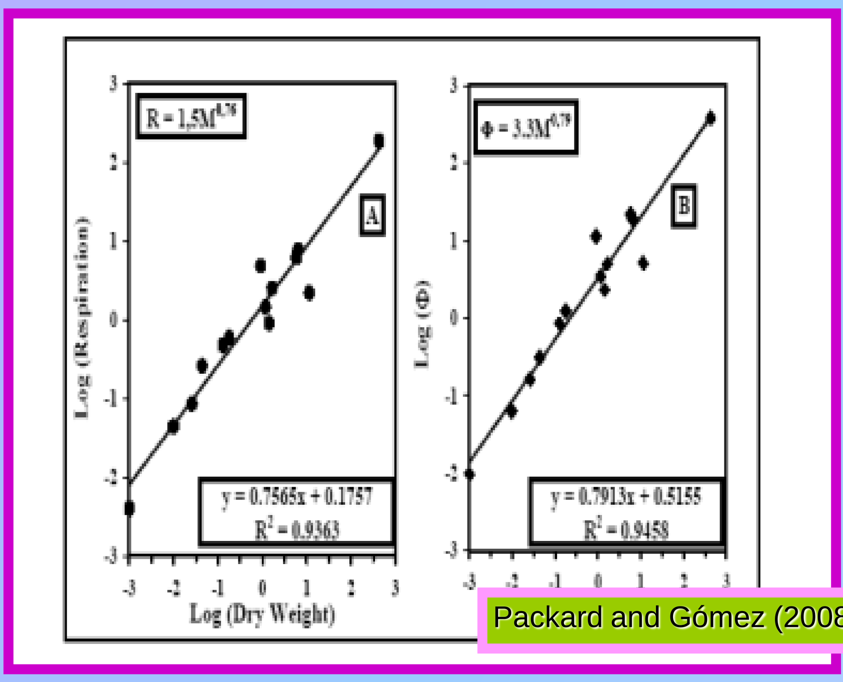
3.- In low food conditions, as in the offshore stations, the slope is lower than Kleiber's Law.

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.

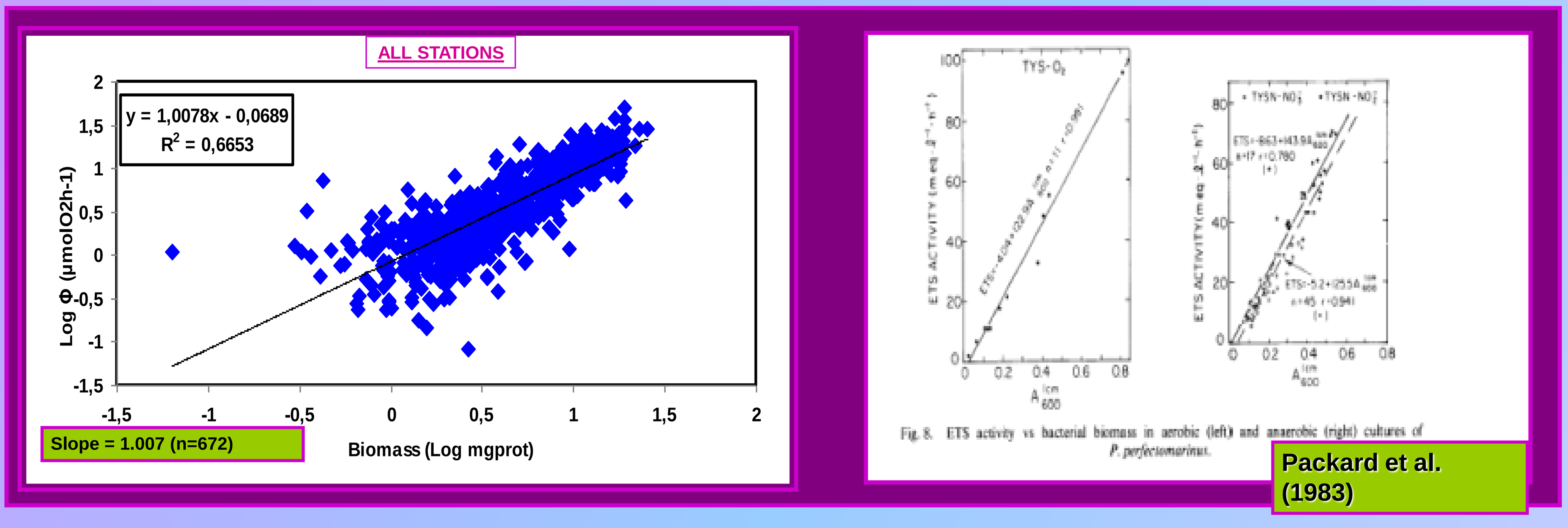


TRANSECT	DEPTH (M)	
TB	0-100	y = 1.153x – 0.115 (R^2=0.68, N= 30)
	100-200	y = 1.201x – 0.232 (R^2=0.823, N= 40)
TC	0-100	y = 0.728x + 0.390 (R^2=0.503, N=39)
	100-200	y = 0.687x + 0.114 (R^2=0.601, N= 41)
TD	0-100	y = 1.052x + 0.150 (R^2=0.573, N= 39)
	100-200	y = 1.112x – 0.102 (R^2=0.565, N= 40)
TE	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)

Table 2



Packard and Gómez (2008)



Packard et al. (1983)

Figure 8