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The size-trophic relationship in plankton foodwebs in the East China Sea

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Aquatic food webs are strongly size-based, and most predators are larger than their prey. As such, body size provides a useful surrogate measure of trophic position. Size-based food web analyses may provide insights to understand the dynamics of aquatic ecosystems.

Why is the size-trophic relationship important?

In aquatic ecosystems, a substantial number of studies suggested a positive linear relationship between log-body size and trophic level. Nevertheless, most empirical studies in aquatic systems have been restricted to only larger organisms and have typically neglected plankton. In the present study, we used stable isotope to study size-specific trophic level and predator-prey interactions in marine food webs. Plankton were collected from the East China Sea (ECS). Plankton samples were sieved through filters to obtain 8 size fractions. For each size fraction, $\delta^{15}N$ was estimated, and trophic level spectra (TL-S) were computed as follows:

$$TL_i = \frac{\delta^{15}N_i - \delta^{15}N_1}{3.4} + 1$$

where the $\delta^{15}N$ content in each size fraction is standardized by the $\delta^{15}N$ content in the particulate organic matters (trophic level 1), and 3.4 ‰ corresponds to the average trophic enrichment of a predator with its prey (1 trophic level). The nominal size representing each size fraction was converted from ESD to volume as an estimate of body biomass.

Overall, the $\log_2$ (ESD biovolume) and trophic levels were significantly linearly correlated ($r=0.34$; $p<0.0001$; $n=279$, Fig. 1). However, the slopes of the TL-S (TL versus $\log_2$ (biovolume) relationship) were very variable among stations. We correlated the TL-S slope of each station with the environmental factors. A positive significant relationship was found between significant slopes of TL-S and phosphate and silicate concentrations at surface.

Results & Discussion

We find a trend of increasing slope of TL-S with increasing resource availability. This entails that in enriched environments the PPMR would decrease and thus the transfer efficiency from one end to the other of the size spectrum would decrease due to enhanced number of intermediaries. Our results contradict theoretical assumptions of shallower TL-S when nutrient availability increases. It seems that, in areas with higher nutrient input in the ECS, organisms may have more availability of large individuals in their array of possible preys and thus they may select those larger preys instead of the more abundant smaller preys. This may indicate that individual feeding selection (largest preys) to optimize foraging is a key factor to determine trophodynamics in marine plankton foodwebs.

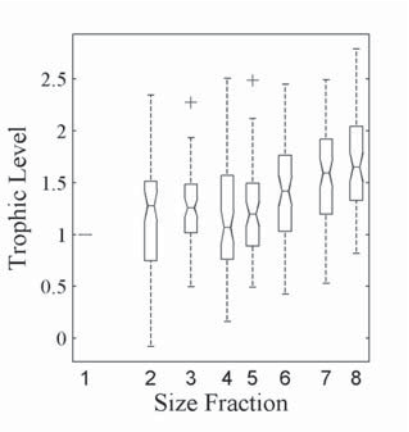

Figure 1. Boxplot of the size-specific trophic level (horizontal bars within the boxplot indicate the median of each distribution, whiskers are 1.5 times of the interquartile range, and outliers are indicated by the crosses). Boxplots are notched to represent a robust estimate of the uncertainty about the medians for box to box comparison.