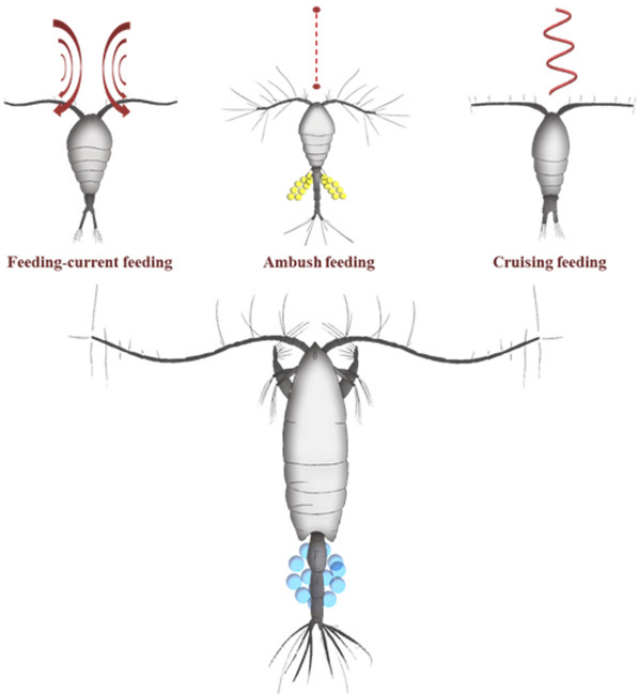
Insight into the structure and function of marine pelagic food webs: traits and trade-offs in zooplankton feeding behaviour

Summary Report-Rodrigo Almeda

Most biological processes in the ocean are due to planktonic organisms. Zooplankton, which comprise the most abundant group of marine animals on Earth (copepods), play key roles in pelagic food webs, biogeochemical cycling, and recruitment of fish populations. Traditionally, models of plankton food webs quantify interactions between species or functional types, but attempts to embrace the inherent complexity of marine food webs make these models very complex. An emerging alternative approach, the *trait based approach*, proposes to replace the thousands of species with organisms that are characterized by a few key traits (i.e. those characteristics that are essential to the success – fitness - of an organism) and their associated trade-offs (the costs and benefits of a particular trait). In this project, we identified *feeding behaviour as a key trait* in zooplankton and we *experimentally quantified the trade-offs* (i.e., feeding efficiency vs. metabolic cost and mortality risk) associated with the three main foraging strategies in zooplankton (i.e. ambush feeding, feeding-current feeding and cruising feeding). I summarise here specific results and conclusions organized through the two main questions raised in the project:

1) What is the cost in terms of predation risk and metabolic expenses of the main foraging strategies in zooplankton?



Zooplankton exhibit different small-scale motile behaviours related to feeding and mating activities. Copepods with "active" feeding behaviours (feeding-current and cruising feeders) showed significantly higher mortality from predation (~2–8 times) than similarly sized copepods with low motility feeding behaviour (ambush feeders). Copepod males, which have a more active motile behaviour than females (mate-seeking behaviour), suffered a higher predation mortality than females. However, the predation risk for mate-searching behaviour in copepods varied depending on feeding behaviour with ambush feeders consistently having the greatest difference in predation mortality between genders (~4 times higher for males than for females. Differences in C-specific respiration rates among copepods with different feeding behaviours were relatively small.

Conclusions: motile behaviour is a key trait in zooplankton that significantly affects predation risk and therefore is a main determinant of distribution and composition of zooplankton communities.

2) *What feeding behaviour is most efficient in plankton food webs?* We determined the feeding efficiency of ambush and active feeders to evaluate the trade-off between efficiency vs. predation risk associated with foraging strategies in zooplankton. We show that efficiency is similar among feeding behaviours for motile prey but one order of magnitude lower for ambush than for active feeders towards non-motile prey. The prey size spectrum is narrower and towards relatively larger

prey in ambushers compared to active feeders. Prey detection in ambushers relies on the hydrodynamic disturbances and is inefficient towards non-motile prey but most efficient for large motile prey. This compensates for the lower prey encounter velocity in ambushers compared to active feeders. Thus, the less risky ambushing strategy is more restricted in target prey than active feeders and prey perception mechanism determines the efficiency of zooplankton foraging strategies. The conflict between mate searching and feeding can cause significant difference in feeding efficiency between copepod genders in ambush feeders but not in feeding-current and cruising feeders. *Conclusions:* feeding efficiency is similar among zooplankton foraging strategies towards motile prey but one order of magnitude lower for ambush than for active feeders towards non-motile prey. Feeding efficiency and predation risk are correlated allowing the co-existence of different foraging strategies and promoting the trait diversity in marine plankton food webs.

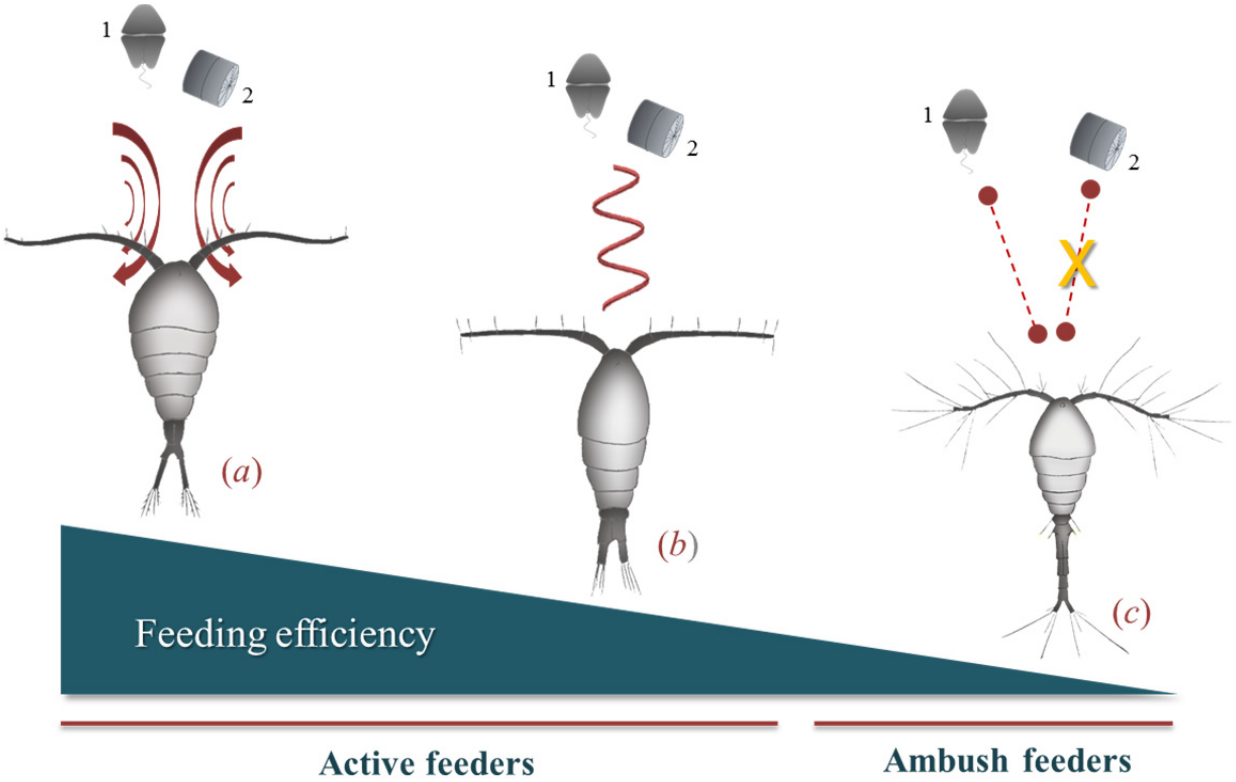


Figure: Graphic abstract showing two main hypotheses of this project: i) ambush feeders are less efficient than active feeders (feeding-current and cruising feeders) in acquiring resources, and (ii) that ambushers are particularly poor in collecting non-motile prey. (a): feeding-current feeder, (b): cruising feeder, (c): ambush feeder, 1: motile prey, 2: non-motile prey. We found that, in contrast to model predictions, the efficiency of the three studied behaviours was similar for motile prey with a size range of 7-40 µm and therefore our first hypothesis was rejected. Our second hypothesis was confirmed since ambush feeding was clearly an inefficient foraging strategy for non-motile prey like diatoms.

Overall, our results represent valuable contributions for (i) a better understanding of the factors that govern the structure and function of plankton food webs, (ii) explaining the spatio-temporal coexistence of the different zooplankton foraging strategies in marine environments and (iii) implementing trait-based models to predict zooplankton trait distributions and seasonal succession of plankton communities in the ocean.