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ARTICLE

Plankton food-webs: to what extent can they be simplified?

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ABSTRACT

Plankton is a hugely diverse community including both unicellular and multicellular organisms, whose individual dimensions span over seven orders of magnitude. Plankton is a fundamental part of biogeochemical cycles and food-webs in aquatic systems. While knowledge has progressively accumulated at the level of single species and single trophic processes, the overwhelming biological diversity of plankton interactions is insufficiently known and a coherent and unifying trophic framework is virtually lacking. We performed an extensive review of the plankton literature to provide a compilation of data suitable for implementing food-web models including plankton trophic processes at high taxonomic resolution. We identified the components of the plankton community at the Long Term Ecological Research Station MareChiara in the Gulf of Naples. These components represented the sixty-three nodes of a plankton food-web. To each node we attributed biomass and vital rates, *i.e.* production, consumption, assimilation rates and ratio between autotrophy and heterotrophy in mixotrophic protists. Biomasses and rates values were defined for two opposite system's conditions; relatively eutrophic and oligotrophic states. We finally identified 817 possible trophic links within the web and provided each of them with a relative weight, in order to define a diet-matrix, valid for both trophic states, which included all consumers, from nanoflagellates to carnivorous plankton. Vital rates for plankton resulted, as expected, very wide; this strongly contrasts with the narrow ranges considered in plankton system models implemented so far. Moreover, the amount and variety of trophic links highlighted by our review is largely excluded by state-of-the-art biogeochemical and food-web models for aquatic systems. Plankton models could potentially benefit from the integration of the trophic diversity outlined in this paper: first, by using more realistic rates; second, by better defining trophic roles of consumers in the planktonic web. We suggest that most trophic habits present in planktonic organisms must be contemplated in new generation plankton models.

Key words: Food-webs; grazing; plankton vital rates.

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INTRODUCTION

Plankton is a morphologically, genetically and trophically diverse ensemble of both unicellular and multicellular organisms, whose individual dimensions span over seven orders of magnitude (Boyce *et al.*, 2015). Their phylogenetic differences are larger than those of terrestrial organisms covering the same size range. The only reason why they are grouped together is that they live suspended in the water, without relying on any substrate which is not produced by them. Nevertheless, plankton is a fundamental player in the biogeochemical cycles in aquatic systems and constitutes the essential source of carbon ultimately feeding the larger metazoans living in the ocean (Behrenfeld and Boss, 2014).

The general perception is that plankton is undergoing important modifications in the oceans due to global change (Chen *et al.*, 2012; Chust *et al.*, 2014). Yet, those modifications are often elusive, probably because the knowledge on the cascading processes which regulate the plankton food-web is still scarce. Indeed, while a deeper and deeper knowledge is accumulating at the level of single species and single trophic processes, the overwhelming biological diversity of plankton interactions is insufficiently known and only rarely, and partially, integrated within a coherent and unifying trophic framework (Boit *et al.*, 2012). Yet, advisable studies on plankton communities should move towards holistic/system ecological approaches considering several, if not all, components of the food-webs and possibly highlighting the emergent properties which hint at the regulating mechanisms of a complex system as plankton. For emergent properties we refer to those relying on interactions among system's components that are not predictable by analysing the response of individual components in isolation. These properties revealed to be crucial in regulating pelagic communities at the level of macroscopic organisms via mechanisms driven by food-web organization (Link *et al.*, 2015).

Food-web models should be seen at as networks including functional nodes (FNs), which, in turn, must be connected by trophic links. They should be based on a minimum number of nodes, thus impeding gross aggregations among taxa (Abarca-Arenas and Ulanowicz, 2002). For each node, a somewhat precise biomass value and vital rates, such as production, consumption and as-