

Role of Nanoplanktons in Marine food-webs

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ABSTRACT. Nanoplanktons are ubiquitous protozoan zooplankton in a size range of 2 to 20 µm, play key ecological roles in aquatic ecosystems. Heterotrophic nanoflagellates are distributed through the continental shelf and margin area of the oceans as well as deep-sea. These organisms contribute significantly to the total living biomass within these systems, serve as the major top–down control on bacterial assemblages, and are an important source of mortality for microalgae and other heterotrophic nanoflagellates. From many recent studies, it is generally accepted that HNF is one of the most important bacterial consumers. They also function as important remineralizers of organic matter and nutrients in aquatic systems. In accordance with these important ecological roles, heterotrophic nanoflagellates have been the subject of considerable study both in the field and laboratory.

1. MARINE FOOD WEBS AND THE ‘MICROBIAL LOOP’

Aquatic ecosystems cover about 70% of the surface of our globe and marine environment makes up ~ 97% of the aquatic ecosystem. Marine eco-niches are characterized by diverse and contrasting physical, chemical and biological characteristics - from the shallow coastal to extreme deep-sea habitats. Diverse organisms are inhabitants of the marine ecosystem. From the smallest viruses (<0.2 microns) and bacteria (<2 microns) to single-cell marine plants called phytoplanktons (2 – 200 microns) to the biggest of mammals – the blue whales (25meter), all play a role in the sustainability as these marine organisms remain interdependent on each other through “marine food-webs”. Thus marine food-webs represents a ‘network of food chains’ or feeding relationships by which energy and nutrients are passed on from one species of living organisms to another for growth and reproduction (Fig.1) .

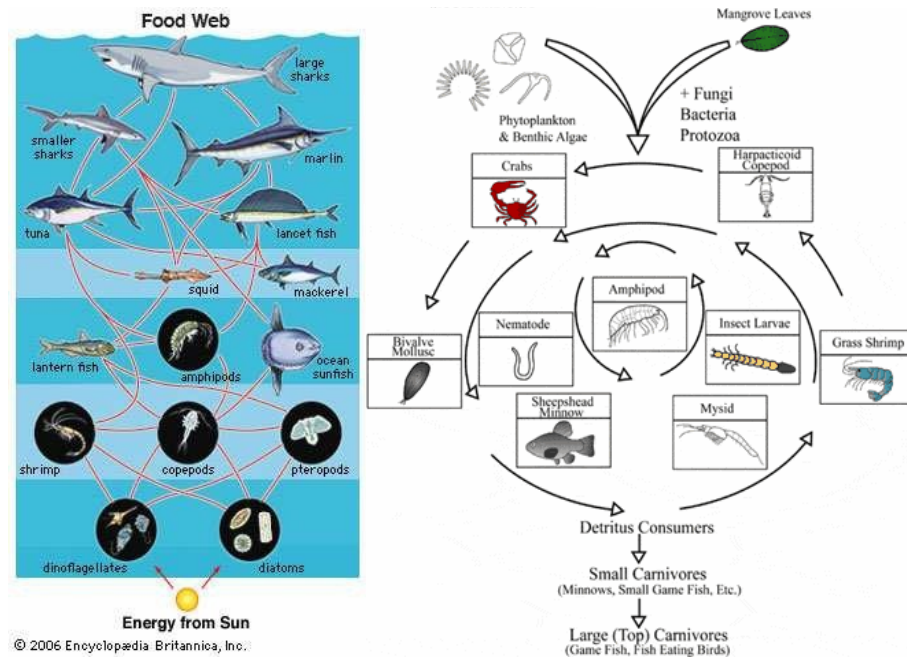


Fig. 1 Marine food-webs

2. STRUCTURE AND FUNCTIONING OF MARINE FOOD-CHAINS

The marine food chains are described in more quantitative terms of the 'ecological pyramids' or the 'trophic prisms' which describes the various stages within the ecological food chain based on numbers, biomass or energy. At the individual trophic levels of the prism, marine organisms can be broadly classified as the producers, consumers and decomposers, wherein matter is cycled among organisms and passed on from producers to consumers at the second trophic level and subsequently remineralized by the decomposers to be again brought back to the system for the producers (Fig. 2) and shapes the biogeochemical cycling of carbon and nutrients on our planet.

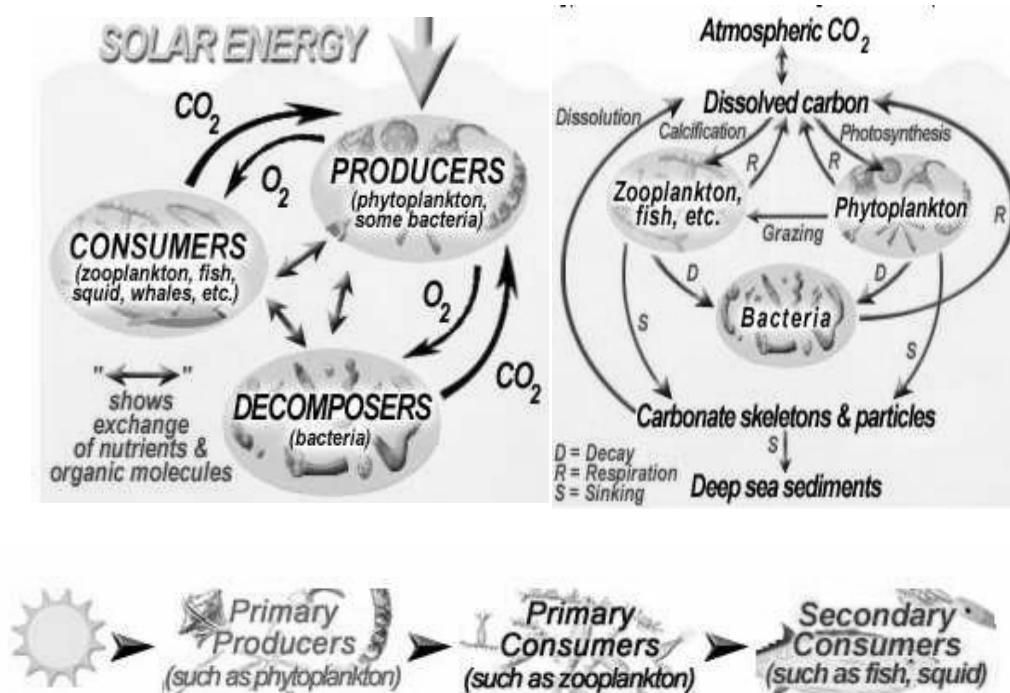


Fig. 2 Cycling of matter and energy flow through marine food chains

Thus, at the base of ecological pyramids (Fig. 3) we have the Primary Producers of “marine food-webs” which can be single-cell marine plants called “**Phytoplanktons**” in the sunlit upper layers of the ocean called the euphotic zone, or even “**chemo- autotrophic bacteria**” in deep-sea environments of hydrothermal vents.

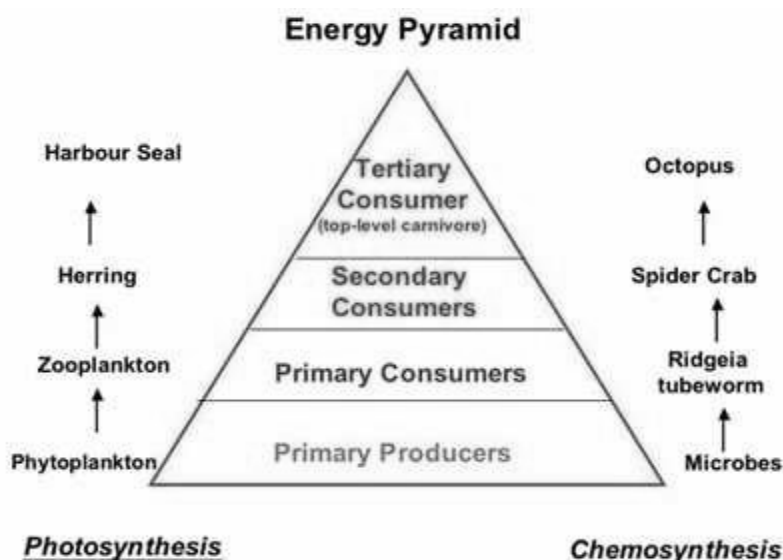


Fig. 3 Trophic prism comparing a sunlit phytoplankton based community with a deep sea microbe based Hot Vent community

The vast area of the pelagic ocean and euphotic zone, however makes “**Phytoplanktons**” the most important primary producers of our planet. They form the basis of an intricately linked “food web”. Through process of photosynthesis and respiration “Phytoplanktons” are responsible for gaseous exchanges of carbon-dioxide and oxygen with the atmosphere.

Until a few decades ago, marine pelagic food webs were depicted as containing only three major groups of organisms: algal cells were the primary producers at the bottom of the food chain, they were grazed by mesozooplankton (0.2 mm – 20 mm in size), which in turn were grazed by fish. This is called the classic food chain or the grazing food chain and results in high productivity that supports the fisheries of the world.

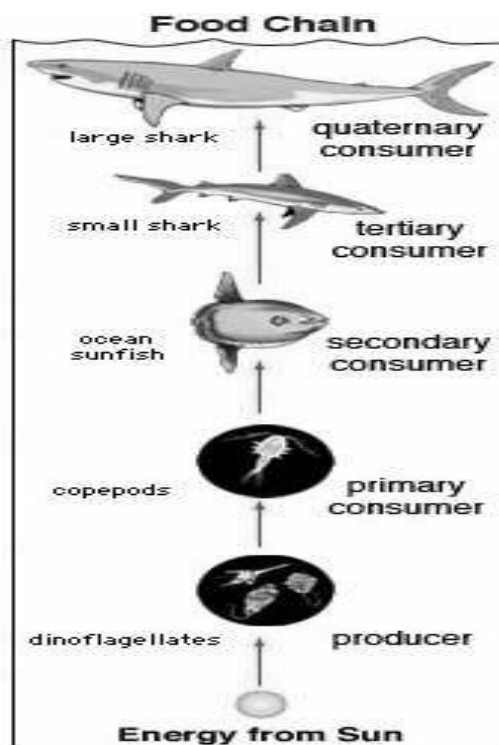


Fig. 4 Classical marine food-chains

This view of a marine pelagic food chain was challenged during the 1970s and 1980s by scientists such as Pomeroy and Azam who showed that there was an alternative pathway of carbon flow that led from bacteria to protozoans (nanoflagellates and ciliates) to metazoa, with dissolved organic matter (DOM) being utilized as substrate by the bacteria. DOM can enter the pelagic environment from a variety of sources: excretion of dissolved organic carbon (DOC) by algal cells, algal cell lysis, 'sloppy grazing' by mesozooplankton or diffusion from fecal pellets. This food web paradigm was called the microbial loop (Fig. 5). This food web is thus driven by recycled carbon.

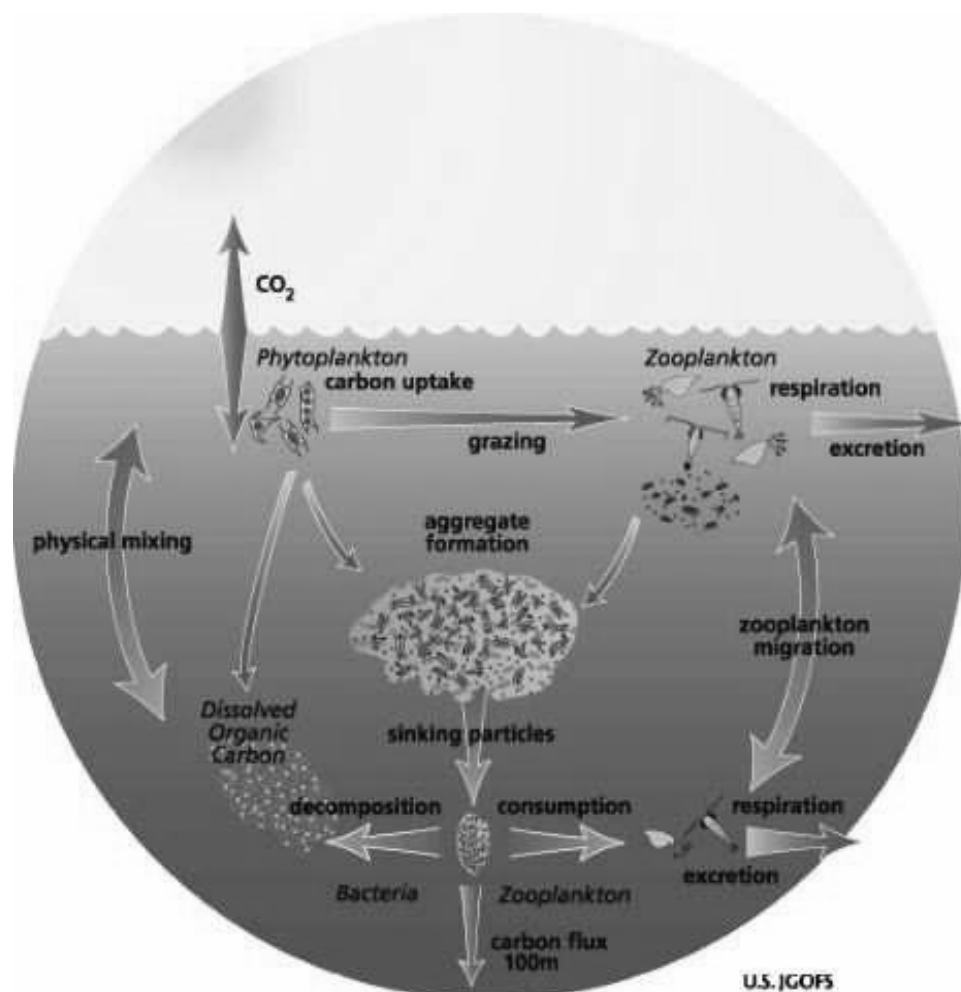


Fig. 5 Role of Microbes in the marine environment

3. MICROBIAL FOOD WEB MODEL

The microbial food web refers to the combined trophic interactions among microbes in aquatic environments. An important pathway sustaining the marine microbial food-web is the “microbial loop”. It describes the process by which bacteria can uptake dissolved organic material (DOM) that cannot be directly ingested by larger organisms. DOM includes phytoplankton photosynthates, zooplankton wastes and cytoplasm that leaks out of phytoplankton cells. Nanoflagellates and ciliates eat these marine bacteria, helping to recycle organic matter back into the marine food web. Bacteria also help to facilitate phytoplankton growth by releasing nutrients.

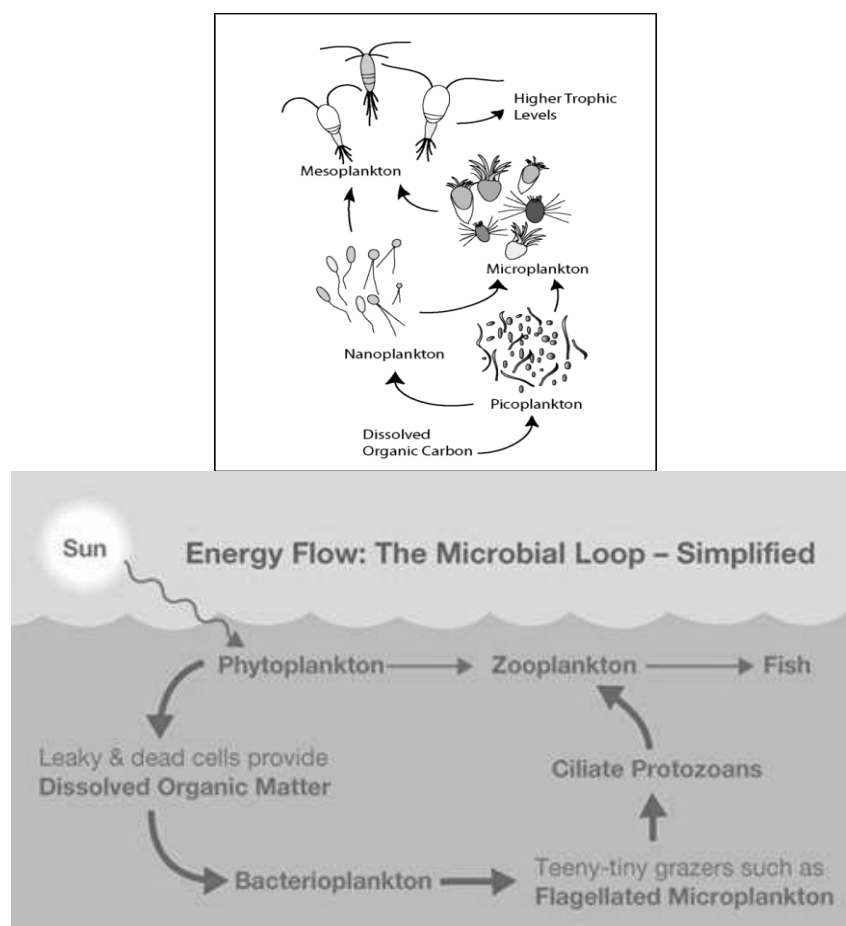


Fig. 6 The Microbial food-web model

A large degree of complexity exists in the interactions that can take place between the micro-organisms in pelagic food webs which includes:

- a) **Preferential Grazing** - For example, young copepod life stages and ciliates may compete for the same food sources, but adult copepods have been observed to graze preferentially on ciliates and so may give their offspring a competitive advantage.
- b) **Omnivory** - It has been discovered that omnivory is very common. For example, both copepods and ciliates can be primary and secondary consumers, with ciliates preying on autotrophic and heterotrophic flagellates as well as cyanobacteria and bacteria, and copepods grazing on phytoplankton and ciliates.

The Microbial Food web components

The microbial components of webs can be divided into two main size classes-

1. **Picoplankton** ($<2\mu\text{m}$) including autotrophic prokaryotic and eukaryotic phytoplankton cells and heterotrophic microbes (bacteria and small flagellates).
2. **Nanoplankton** ($2\text{--}20\mu\text{m}$) with nanophytoplankton, large flagellates and small ciliates. Flagellates and ciliates are the most important picoplanktivorous protozoa in most aquatic Environments (McManus & Fuhrman, 1988, Sander et al; 1992).

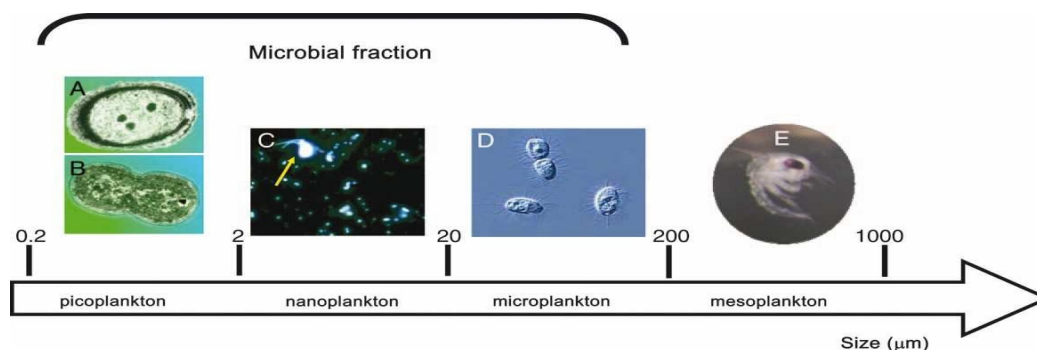


Fig. 7 Size classes of the microbial food web components

4. Position of Nanoflagellates in Trophic Prism

The position of nanoflagellates in trophic prism is based on its nutritional status as either autotrophs or heterotrophs. Thus nanoflagellates are residing under either in the producer or primary consumer. So their numbers also vary for their different type of grazing strategy and energy utilization. Like this way autotrophic nanoflagellates are coming under the producer rather heterotrophic nanoflagellates are grouped as the primary consumer.

5. Role of Nanoflagellates and ciliates in the Microbial Food web

Heterotrophic Bacteria remains at the base of the Microbial food-web. The extent of role of bacteria in an ecosystem to act as only "remineralizers" of nutrients or as direct nutritional source for higher trophic levels depends on several factors controlling their production and abundance. Nanoflagellates are reported bacteriovores and hence control their abundance and production. Nanoflagellates can also graze on the phototrophic picoplanktons and Ciliates can graze on both bacteria and small flagellates. Thus, the role of Nanoplanktons (Nanoflagellates and ciliates) is important to understand the pattern of the energy flow through microbial loop to higher zooplanktons and fisheries. Due to the scarcity of diagnostic morphological features, the destruction of delicate forms by fixation and the selectivity of culturing efforts we have little knowledge about the diversity, autecology and biogeography of heterotrophic nanoflagellates (Lim *et al.* 1999). Chrysomonads or chrysophyceans (class Chrysophyceae) are phototrophic and/or heterotrophic nanoflagellates that comprise a major component of the aquatic food web in both marine and freshwater systems e.g. colorless chrysomonads together with bicosoecids constitute between 20 - 50% of the annual average biomass of pelagic HNF (Arndt *et al.* 2000).

6. Current Status and Significance:

The population genetics study revealed that the importance of heterotrophic nanoflagellates related to climate change, therefore in Polar Regions, heterotrophic nanoflagellates are major consumers of bacteria and contribute significantly to the carbon flux from DOC via bacteria to larger organisms such as ciliates and metazoans. New research explored that the growth rates of *P. imperforate*, a heterotrophic nanoflagellate increased significantly with increasing temperature in Polar Regions (Lee and Fenchel 1972). It has been examined that growth rates of cultured heterotrophic nanoflagellates from permanently cold environments (Lee and Fenchel, 1972; Choi and Peters, 1992; Mayes *et al.*, 1997). Now a days culture of the heterotrophic nanoflagellate species have been examined to determine the effects of a wide range of physical and chemical parameters on growth rate and other physiological and biogeochemical processes.

5. CONCLUSION

Several studies have shown that Heterotrophic bacteria consume dissolved organic material (DOM) originating from phytoplankton photosynthetic activity, converting it to particulate organic material (POC) (Azam *et al.*, 1983). Studies have shown that heterotrophic bacteria can consume

10–40% of primary production in the eastern subarctic Pacific (Kirchman *et al.*, 1993) and North Atlantic (Ducklow *et al.*, 1993; Li *et al.*, 1993). Heterotrophic bacteria are known to be fed primarily by heterotrophic nano- flagellates (HNF), which in turn are cropped mainly by microzooplankton (Sherr and Sherr, 1988; Weisse and Scheffell-Möser, 1991). Thus, in addition to micro-zooplankton herbivory, HNF bacterivory can be regarded as a fundamental process in controlling carbon flow through microbial food webs in the ocean.

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