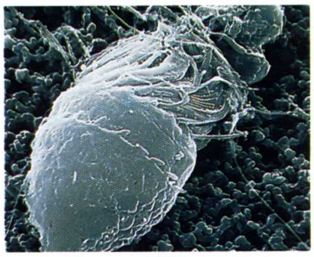


Scanning electron micrograph (SEM) of Strombidium, *a common species off the West Coast* (Photo: Hoe Chang, NIWA)

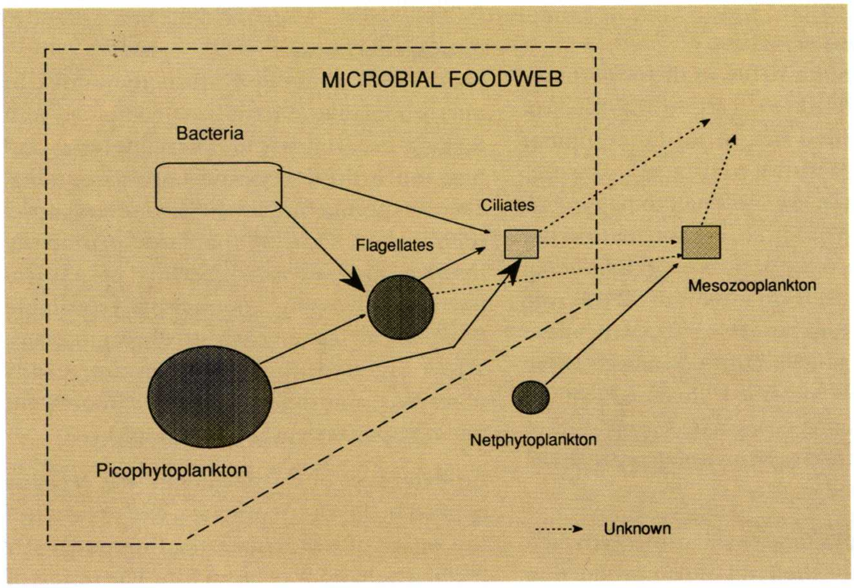
experiments off the west coast of the South Island showed that many microzooplankton taxa seemed able to discriminate not only on the basis of size but also on "palatability" (taste). They fed on labelled natural particles at higher rates than on artificial ones. Only small microzooplankton taxa (<30 µm) were able to feed on bacteria-sized particles, but they preferred larger picophytoplankton-sized particles. Microzooplankton >30 µm were generally not capable of feeding on these very small cells and relied on larger phytoplankton. Some larger ciliates are carnivorous, feeding on other ciliates. Clearly, even within each group there is a complex trophic structure. The diverse array of resource utilisation by these groups has no doubt led to their success and ubiquitous presence in aquatic environments.

Realistic complexity for modelling

Clearly pelagic food webs are very complex and we need to be careful not to simplify them too much when applying models. An example of the major pathways in the pelagic ecosystem off the west coast of the South Island is shown in the diagram. The size of each energy pool is indicated by the size of the boxes or arrows. The data on which this diagram was based was collected as part of the NIWA multi-disciplinary programme, Marine Environment of the West Coast (a project funded by the Foundation for Research, Science and Technology).

The diagram shows that microzooplankton appear to be an important potential link to higher trophic levels in that ecosystem, without which a large component of primary production would not be available to higher trophic levels and fish.

Revised food web for the marine environment off the West Coast in winter, showing major carbon pathways. Pool sizes are shown by the size of the boxes.



A further improved understanding of the structure and functioning of aquatic food webs, particularly the micro-organisms, is required if we are to answer questions such as: why can some toxic algae bloom with little "top-down" control? and, why is secondary production low relative to the nutrient levels and primary producers in some of our freshwater and marine ecosystems? Continuing NIWA research is addressing these issues. ■

Mark James is a scientist with NIWA in Christchurch.

Microbial food webs: the importance of algae that graze

Julie Hall

THE STRUCTURE and dynamics of the food web in the open ocean are extremely complex. In studies which aim to enhance our understanding of the processes involved, it is often easiest to focus on just a small section. One such section is the microbial food web which involves organisms less than 200 µm in size. The main food sources are bacteria and picophytoplankton. *Bacteria* are generally in the size range 0.2-1.0 µm. They gain energy from organic compounds such as glycolate which are released from larger organisms. *Picophytoplankton* are algae in the size range 0.2-2.0 µm. They gain energy from photosynthesis.

In the open ocean off the West Coast of the South Island, the microbial food web is a very important part of the overall food web. In fact, picophytoplankton account for 40-80% of plant production. They may be small but there are lots of them - up to 60 million cells per litre of water. These organisms are generally too small to be grazed by the larger zooplankton. So, if their production is to contribute to that of the region as a whole, they must be "packaged" into larger parcels that can be grazed on by the microzooplankton.

Such "packaging" is done by intermediate organisms which are small enough to be able to graze on the bacteria and picophytoplankton. The main group to gain energy from this source comprises the heterotrophic flagellates, which have a size range of 2-20 µm.

Experiments on plankton grazing

In the past, only heterotrophic flagellates were thought to be capable of grazing on bacteria and picophytoplankton. However, recent laboratory studies have shown that *phytoflagellates* - a type of plant plankton, generally considered to gain energy only through photosynthesis - may also be able to graze on these tiny cells.

In a recent study of the structure and function of the microbial food web in the open sea off the west coast of the South Island, experiments were conducted to investigate whether grazing by phytoflagellates formed a significant part of the energy transfer within the microbial food web. The experiments involved adding fluorescent beads, similar in size to bacteria (0.5 µm) and picophytoplankton (1.0 µm), to water samples collected from different sites. After 30 minutes the samples were preserved in glutaraldehyde and filtered onto 3 µm filters. These filters let the uneaten beads pass through but catch the larger flagellate cells.

The filters were then examined using fluorescent microscopy which allowed the identification of heterotrophic flagellates and phytoflagellates and also enabled each cell to be examined to ascertain if it contained any fluorescently-labelled beads that had been eaten. These beads were counted and the results used to calculate the grazing rates of both heterotrophic flagellates and phytoflagellate cells (see cover photograph).

We found that the phytoflagellates grazed 80% as many 0.5 µm fluorescently-labelled beads as the heterotrophic flagellates and 60% as many 1.0 µm fluorescently-labelled beads. The results also showed that only some species of phytoflagellates were grazing.

These data were the first in the world to show that natural populations of phytoflagellates are capable of grazing a significant proportion of the bacteria and picophytoplankton population.

Why do phytoflagellates graze?

The reason for phytoflagellate grazing is unclear. There are several theories.

- Phytoflagellate cells are unable to obtain enough nitrogen and/or phosphorus from the water to support growth. Grazing on bacteria and picophytoplankton allows access to the necessary additional nitrogen and phosphorus.
- Because of low light levels, phytoflagellate cells are unable to gain enough energy from photosynthesis to support growth. Grazing is used as a supplementary energy source.
- Phytoflagellate cells are unable to obtain from the water organic compounds which are essential for growth (e.g. vitamins). They graze to obtain these compounds.

An alternative theory altogether is that phytoflagellate cells which graze are not primarily photosynthetic cells that supplement growth through grazing, but primarily heterotrophic flagellates that use photosynthesis as a supplementary energy source when the bacteria and picophytoplankton populations are too low to support growth.

Whatever the reasons for the dual mode of nutrition, the phytoflagellate cells are likely to have a competitive advantage over cells with only one mode of nutrition.

Revised view of food web structure

How does this new information change the way we think about and view food web structure?

In the past, organisms were considered to be either producers (bacteria, picophytoplankton) or grazers (heterotrophic flagellates). Now that line is blurred as we know that some organisms fit into both categories, adding to the complexity of our understanding of the structure and dynamics of the microbial food web in the ocean.

The information also raises important questions about how we define food web structure and stability in the open ocean and other aquatic habitats. ■

Julie Hall is a scientist with NIWA in Hamilton.

Hoki and the MOCNESS

Mike Page and Rob Murdoch

IN 1992, NIWA and MAF Fisheries jointly purchased a Multiple Opening/Closing Net Sensing System (MOCNESS) for sampling plankton from oceanographic vessels. Designed and manufactured by Biological Environmental Sampling Systems (USA), the system has nine rectangular nets (each 1 m^2) which are opened and closed sequentially by commands from the surface through an armoured, conducting, tow-cable. Sensors to measure conductivity, temperature, fluorescence/turbidity and pressure are attached to the net frame. Additional sensors monitor flow past the net, angle of the net from vertical and the sequential opening and closing of nets. All data is transmitted, via cable, to a surface deck unit interfaced to an on-board computer. Software (modified by