BIOE 155, Freshwater Ecology

Phytoplankton and Zooplankton (AKA; Small freshwater organisms) (read pp 65-78; 85-106 in Dodson)

"There is probably no almost complete list of species of animals and plants available for any lake, but it would seem likely from the several hundred species of diatoms and insects known from certain lakes that a species list of the order of a thousand entries may be not unusual." G.E. Hutchinson 1965.

Background

Plankton—organisms that live up in the water column, and are subjected to the control of the movement of water.

There are several key consequences of being small:

- Movement is dominated by viscous forces (Reynolds number)
- Surface to volume ratio is a function of size.
    - Smaller size → increased surface:volume ratio
    - Therefore, smaller cells can do better in low nutrient conditions

Feeding type:

Autotrophic—organisms that get their energy from the sun using photosynthesis (for example, plants, phytoplankton).

Heterotrophic—organisms that extract their energy from organic substances (for example; fish, zooplankton, fungi).

"BACTERIA" ***Smallest (<2 micron)***

Prokaryotes

Energy consumption:
This group includes organisms that photosynthesize (such as Cyanobacteria (blue-green bacteria/algae)), as well as other bacteria that utilize organic molecules and are heterotrophs.

Heterotrophs—consume organic matter

Photoheterotrophs—use light energy to help uptake/metabolize dissolved organic matter.

Chemoheterotrophs—metabolize organic matter without the help of light.

Photoautotrophs (e.g., cyanobacteria such as Aphanizomenon)—can photosynthesize.

Prokaryotes are:

Single-celled organisms
Lack intracellular organelles (such as a nucleus)
Are often heterotrophic (break down energy-rich compounds).

Found as:

- Individuals
- Colonies (e.g., Nostoc)
- Filaments (e.g., cyanobacteria such as Aphanizomenon)

Movement—bacteria move with flagella
Reproduction—generally asexual, reproduce every 20 minutes. Some species can also form resistant spores that can withstand drought.

Archae

Not technically bacteria, but similar in structure.
Found more often in extreme habitats. This group includes methane bacteria, salt-loving species, and sulfur bacteria. Often capable of anaerobic life

PROTISTA; *small, generally 1-50 microns long.*
One-celled organisms alone or in colonies.
Protists are eukaryotes (have organelles such as nucleus).
These include important primary producers (phytoplankton), important consumers (heterotrophs), and important diseases.

Includes:

Protozoa—animal-like protists
Algae—photosynthetic protists

Major groups. There are numerous groups within this classification, some of which are heterotrophic while others are autotrophic. Here are a couple of the important groups:

- **Ciliophora**—covered with cilia, used to move organisms or water flows.
- Includes *Paramecium*. Free-living and sedentary, solitary and colonial.

- **Rhizopoda**—amoebas. Not colonial. Are free-living, parasitic, benthic, and planktonic.

- **Zoomastigophora**—flagelated protests. Often heterotrophic and can be parasitic or free-living. These include *Giardia*.

- **Chlorophyta**—Green algae. Are solitary and colonial. Small and often palatable, so good eatin' size for zooplankton.

- **Cryptophyta**—Also generally photoautotrophic, but with a mix of green, yellow, red and brown pigments. Small, so good eatin' size for zooplankton.

- **Chrysophyta**—golden-brown algae. These are the planktonic diatoms that are such an important part of the phytoplankton. They are also often palatable so are an important base of the food chain. Use silica to form shells. These silica

skeletons are used by limnologists to reconstruct past changes in lakes using *paleolimnology*—sediment cores of lakes.

Habitats
Planktonic.—protists are important parts of the plankton community. The phytoplankton species (the photosynthetic protists and cyanobacteria) are found living in the euphotic zone.

Benthic.—Aufwuchs—community of bacteria, protests and fungi attached to surfaces underwater.

FUNGI
Fungi are heterotrophic, feeding off of other matter. Thus, they often compete with bacteria. They are generally poorly studied/understood.

LARGER ORGANISMS
There are a diverse set of larger (but still small) animals that live in lakes in streams. This lecture focuses on the zooplankton.

ROTIFERS (phylum Rotifera)
Mutlicellular organisms that have cilia patches on "head". These are among the smallest multicellular animals, but have a large size range, depending on species. There are several groups of freshwater rotifers. Some of them are benthic, while other are pelagic. Because rotifers are small, they generally feed on small things, like bacteria. Rotifers need relatively high levels of O2 (but their eggs don't, see below).

Characteristics:
Cilia, Transparent
No body segmentation

Mobility:
Generally, rotifers cruise around slowly using their cilia.

Reproduction:
Rotifers can reproduce both sexually and asexually (cloning via parthenogenesis—see below). Sexual reproduction generally under poor and crowded conditions. This flexible life-history allows rotifers to reproduce rapidly when conditions are good but then introduce added genetic variability when conditions are poor.

Parthenogenesis—asexual reproduction where females produce eggs without fertilization.

Resting eggs—products of sexual reproduction of rotifers. These eggs can enter diapause and withstand drying, freezing, etc.

ARTHROPODS (phylum arthropoda)

BRANCHIOPODS (0.2 – 5mm)—small crustaceans, aka., microcrustacea.
Branchiopods are segmented with a chitinous exoskeleton. They have compound eyes, a head, thorax, and abdomen. They are very important in lake food webs, both as grazers of algae but also as food for fishes, as we have learned about *Daphnia* in Lake Washington. They feed through filter feeding generally.

Notable types of branchiopods:

- Fairy shrimp (Anostraca)
- Tadpole shrimp (Notostraca)
- *Water fleas (Cladocerans)—key components of the zooplankton community
  - *Daphnia*
  - *Leptodora* (predaceous water flea)
  - *Bythotrephes* (spiny water flea)

Reproduction: Like rotifers, branchiopods are generally asexual but can reproduce sexually given the conditions.

COPEPODS
Shrimp-like crustaceans that are also very important component of the zooplankton community. They have a jointed, chitinous exoskeleton and long first antennae. These animals are more mobile than the cladocerans, so are harder for fish to catch and eat. They move around in bursts. They feed by filter feeding and grasping.

Reproduction: Sexual. The young stages of the life cycle are called nauplia.

PREDATION AND ZOOPLANKTON
Predation pressure (by fishes and other zooplankton) can exert strong pressure on zooplankton.

Predation often size-selective.

Fish eat the biggest zooplankton and are visual predators
Big zooplankton eat the smallest zooplankton

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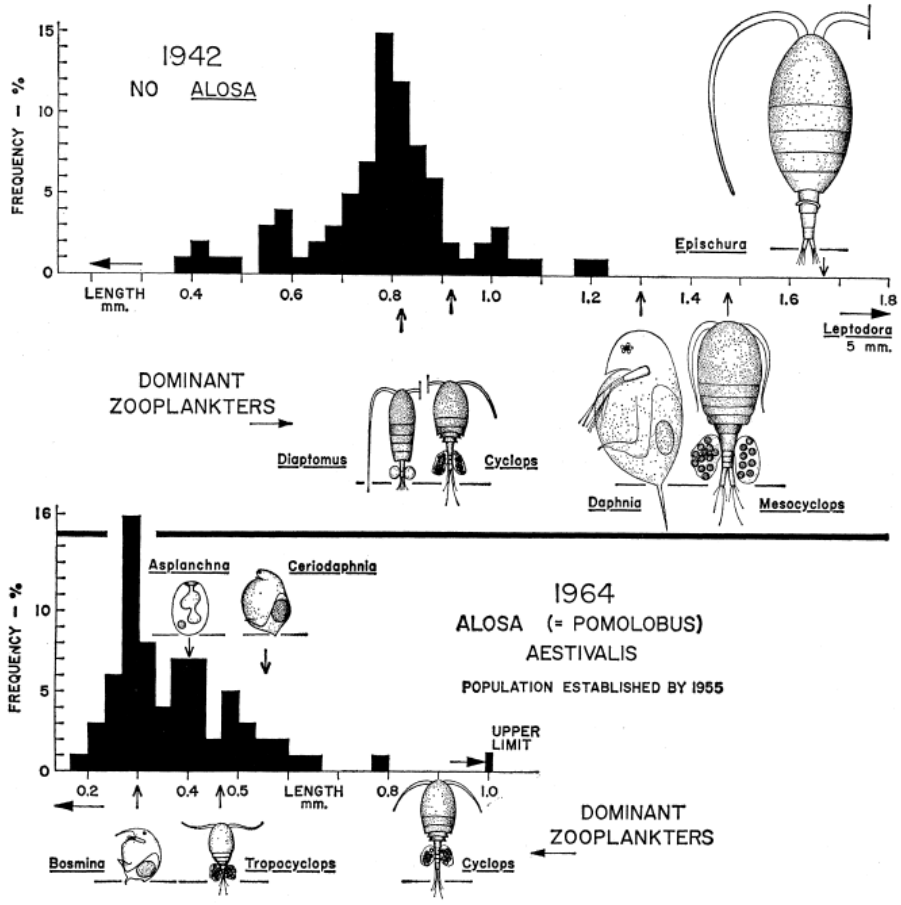
A classic study by Brooks and Dodson (Science 1965) showed that the introduction of a zooplanktivorous fish (Alewife) dramatically changes the size structure of lakes. See figure below.



Source: Brooks and Dodson 1965

Zooplankton have evolved many mechanisms to deal with predation. Some of these adaptations are fixed, while others are induced by the chemical signals of predators, also called *kairomones*.

Adaptations include:

- Behavioral responses. For example: *Diel vertical migration*
- Morphology. Tail spins, helmets, thick exoskeletons, clear bodies, etc.
    - *Cyclomorphosis*. Changes in morphology within a species, in response to predation pressure.
- Life-history