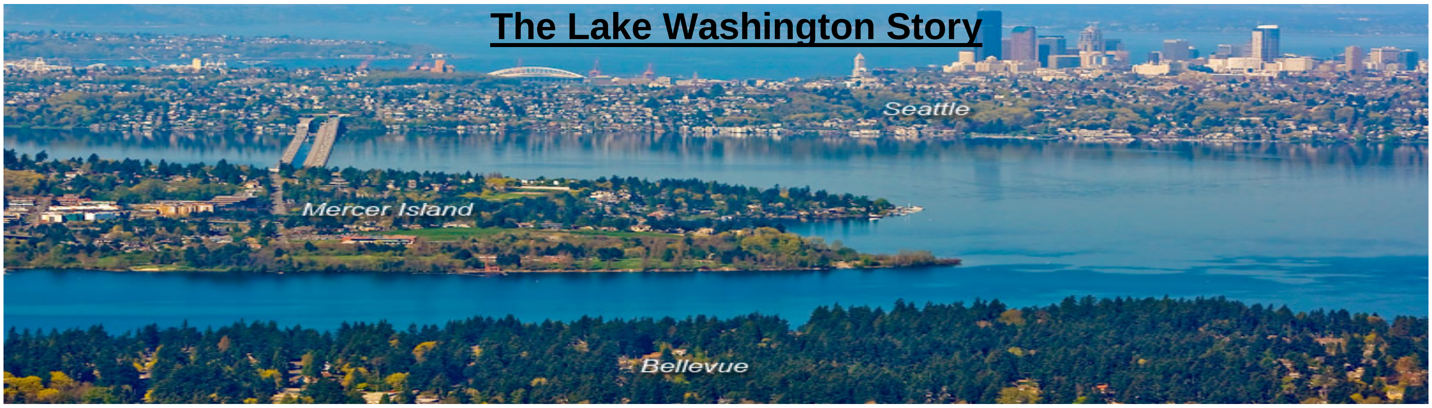
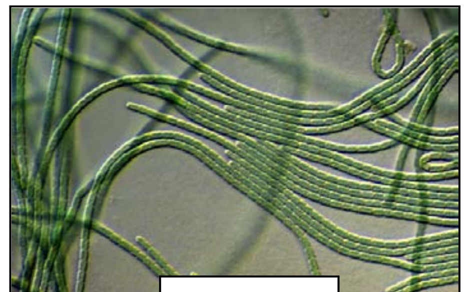
The Lake Washington Story



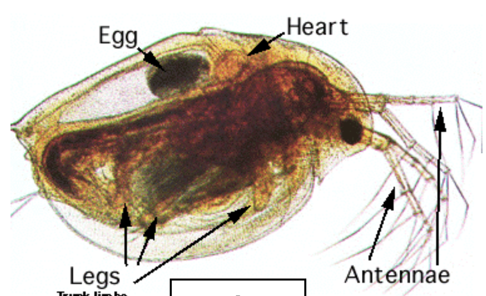
Water quality is greatly influenced by human activities, but other seemingly subtle biological activities are also of great significance. Lake Washington is an interesting example of how human influences and biological processes can alter water quality. The late Dr. W.T. Edmondson, former professor of zoology at the University of Washington, studied the biology and chemistry of Lake Washington for many decades. The 1955 discovery of the **cyanobacteria** *Oscillatoria rubescens* (formerly called a blue-green alga) in the lake, by oceanographer George Anderson, led to further research and predictions that nutrient conditions would soon be stimulating nuisance algal conditions, as had been documented in Lake Zurich in Switzerland. Dr. Edmondson's studies implicated phosphorus from sewage as being the nutrient causing the major bloom of algae, which would occur in the 1960s. This finding had major implications for industry, and great political discussion ensued. He also predicted increased water clarity following the diversions of sewage from Lake Washington; however, the transparency after 1976 increased to a point beyond what was expected for the measured amount of phosphorus. This increase came about with changes in the composition and relative abundances of the algae, **zooplankton**, and fish.



Oscillatoria

During Lake Washington's period of **eutrophication** in the 1960s, the cyanobacteria *Oscillatoria rubescens* was a prominent nuisance, forming thick masses near the water's surface. This species is relatively long and filamentous, generally unsuitable food for grazing zooplankton. *Oscillatoria* has inhibitory effects on other algae through the physical impact of shading and also through biochemical means. Since phosphorus is necessary nutrient for *Oscillatoria*, it was able to thrive in the phosphate-rich lake water. With the sewage diversion from the lake and subsequent decrease in available phosphorus, conditions were no longer ideal for *Oscillatoria* and it diminished entirely in 1976.

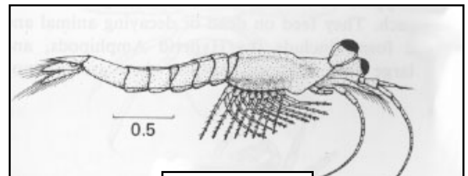
Daphnia, commonly called a water flea, is a filter feeding planktonic **crustacean** about 2 mm long. It suddenly became an important member of the zooplankton in Lake Washington in 1976, although it had been present in small numbers previously. Daphnia is an efficient filter feeder and can reduce algae populations quickly, thus increasing water transparency. While Daphnia can consume some kinds of filamentous plankton, *Oscillatoria* clogs its filtering apparatus so it is unable to feed. Thus, the increase in Daphnia coincided with the demise of *Oscillatoria* in the lake. Since Daphnia can quickly reproduce quickly to exploit favorable conditions, its numbers can fluctuate dramatically through the year, although peak abundances occur in May and June when temperature and sunlight trigger increased activity.



Daphnia

http://dnr.metrokc.gov/wlr/waterres/lakes/biolake.htm

In addition to the decrease of *Oscillatoria* and the increase in Daphnia, there was a reduction in the population of possum shrimp. *Neomysis mercedis*, the possum shrimp, is a planktonic crustacean that can reach a total length of about 14 mm (0.5 inch). It has been shown to have a strong feeding preference for Daphnia and is the main predator on Daphnia. In the late 1970s, Paul Murtaugh of the University of Washington studied the gut contents of *Neomysis* and concluded that it is an especially potent predator on Daphnia, capable of strongly influencing Daphnia abundances. *Neomysis* is a native species that has been present in Lake Washington for many decades, but has been scarce since 1968. Coinciding with its decline has been a rise in the number of long-fin smelt, which were first discovered in the lake in 1960 by Robert Dryfoos, a UW student at the time.



Neomysis

Longfin smelt

Lake Washington's longfin smelt are one of two landlocked populations of this small **anadromous** fish; the other population is in Harrison Lake, British Columbia. The species is distributed on the Pacific coast from northern California to northern British Columbia. Studies from the UW and Washington Department of Fisheries have shown the longfin smelt to be highly selective in feeding on *Neomysis*, with some two-year olds having a diet comprised of 96% Neomysis. Younger longfin smelt are less specialized, eating *Neomysis*, Daphnia, and other crustacean zooplankton. Reasons for the increase in these smelt are not obvious, but may be linked to inadvertent improvements in breeding habitat in the Cedar River; where the vast majority of spawning takes place. Government agencies have been working to sustain salmon habitat and to control flood damage in the area, and the smelt may have benefited from these habitat improvements.

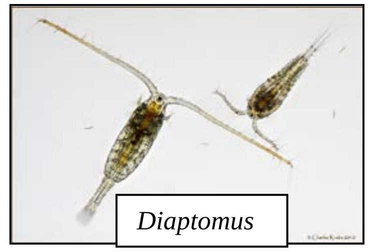
Now we can see how changes in the amount of phosphorus, mainly from sewage outfalls into the lake, affected the species composition of the lake. The cyanobacteria *Oscillatoria* were not able to thrive in the lake after sewage diversions decreased the level of phosphorus input, so the numbers of Daphnia increased. The Daphnia populations also increased because its main predator, *Neomysis*, was reduced by the longfin smelt. Filter feeding by Daphnia helped reduce the green algae populations, so water clarity and quality increased.

Sockeye smolt

Sockeye salmon are another species whose numbers increased during the lake's period of eutrophication, although the increase was probably not directly related to the level of phosphorus in the lake. Sockeye salmon are unique among salmon in that the **smolts** have a year-long phase in freshwater lakes prior to their migration to the sea. Sockeye had been planted in the Cedar River in 1953, but were in relatively low numbers until the mid 1960s. In 1970 the fish were numerous enough for the state to permit commercial fishing in the lake. The increase in sockeye may be due to inadvertent benefits reaped to the spawning beds, when flood control measures and a halt to channel dredging (due to equipment failure) just happened to reduce the silt accumulation on the gravel spawning beds. The smolts from Lake Washington are the largest of their species, but numbers have been down in recent years. Research into the cause of the decline is underway by a number of agencies, and includes research on food supply, predation, and physical damage from the government locks during outmigration.

http://dnr.metrokc.gov/wlr/waterres/lakes/biolake.htm

Contrary to common notion, recent UW research has not shown northern squawfish to be preying substantially on sockeye in Lake Washington, but cutthroat and rainbow trout have actually been implicated as being predators on the sockeye. Northern squawfish, however, are certainly adaptable in their diet, readily able to shift to different prey items. Largemouth and smallmouth bass are potential predators on sockeye, and one theory is that an increase in the number of boat docks has resulted in an increase in habitat for the bass. However, the spatial overlap between them and the sockeye may not be sufficient for there to be much of an impact. The major food supply for sockeye **fry** in winter is unknown. They do feed on Daphnia, but the sockeye fry appear in the lake about March or April, a month or two before Daphnia becomes abundant.



Diaptomus

Diaptomus and *Epischura* are genera of **calanoid** **copepods**, present in the lake year round. The population peaks occur in early spring (March and April) and again in late summer (August and September). In contrast, Daphnia peak abundances are generally in May and June. The role of the copepods in the food chain of Lake Washington is currently being investigated, especially in the light of recent declines in sockeye fry and smolts. Before the increase of Daphnia in the mid 1970s, *Epischura* and a summer cladoceran, *Diaphanosoma*, had been the preferred prey of planktivorous fish in the lake.

Numerous fish species have been introduced into lakes of the United States, in part by the deliberate actions of the U.S. Bureau of Fisheries in the late 1800s. Some introductions in Lake Washington occurred just after the 1909 Alaska-Yukon Expedition, when fish dumped in Drumheller Fountain on the UW campus somehow found their way into the lake. Such introductions have often resulted in the reduction of native species through predation, competition, or other interactions. Lake Washington is known to have a total of at least 28 fish species. Examples of introduced species in Lake Washington are: large mouth bass, small mouth bass, black crappie, yellow perch, sunfish, brown bullhead (a type of catfish), goldfish, carp, and Atlantic salmon. While a native species such as the northern squawfish often takes the blame for being a voracious fish predator (the state has a bounty program for squawfish in certain areas), it may often be the introduced species that are causing the greatest impacts.

Rainbow trout are native to this area, but only two lakes (Ross Lake and Chester Morse Reservoir) in the state have self-sustaining populations; others are supplemented by hatcheries. The level of stocking in Lake Washington could have significant impact, due to the trout predation on smelt, Daphnia, and sockeye fry. Crayfish and sculpins are very abundant in many parts of the lake, and comprise a significant portion of the diet of a number of fish predators. Their abundance plays a big role in the lake ecology by acting as a buffer to predation on other species.

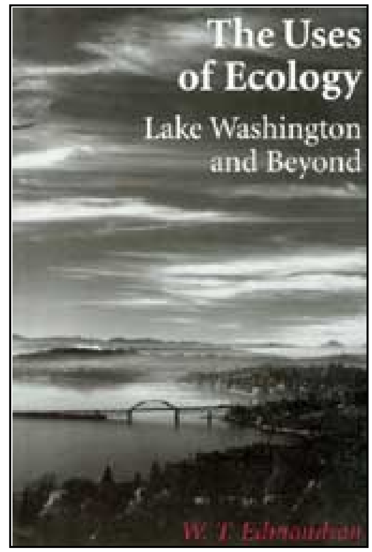
The Lake Washington story is an epic amongst the scientific literature, thanks to Dr. Edmondson and his contingent of students and researchers. His research goes well beyond Lake Washington, and his stature as a scientist, educator, and citizen is outstanding. The literature generated through his UW lab covers five decades, and the influences in science and lake management are enormous. Well known for his work in the Pacific NW, he also is an expert on **rotifers** (a group of invertebrates, primarily fresh water, with nearly 2000 species), with publications going back to 1934. Much of the information in this section is garnered from Dr. Edmondson's work. Supposedly he retired in 1986. For more information, see the following publication.

Rotifers

Edmondson, W.T. 1991. The uses of Ecology: Lake Washington and Beyond. University of Washington Press.

Sally Abella and Arni Litt kindly reviewed a draft of this section, as they and others carry on with lake research in the UW Zoology Department.

Text written by Kevin Li
Back to Lake Washington
Updated: 10/28/98



For questions about the
Water and Land Resources Web Site,
please contact Fred Bentler,
Visual Communication & GIS Unit.

Updated: October 28, 1998

Glossary

Anadromous: swimming from the sea to fresh water in order to spawn
Calanoids: a type of copepod with a pair of long antennae
Copepods: a type of microcrustacean that feed on other plankton
Crustacean: a group of animals including crabs, lobsters, shrimp, etc.
Cyanobacteria: "blue-green" photosynthetic bacteria
Eutrophication: the addition of nutrients, such as nitrates and phosphates, to a body of water
Fry: young salmon stage just after the egg sac of the alevin stage has been absorbed
Rotifers: a microscopic multi-celled animal that is common in fresh water
Smolt: juvenile salmon that have begun to migrate to the ocean
Zooplankton: *plankton* are tiny organisms that float near the surface of lakes and oceans; *zoo*plankton are animals whereas *phyto*plankton are photosynthetic