Limnology

limno-, limn-

(Greek: lake, marshy lake, pool, marsh)

lentic systems = lakes lotic systems = flowing water

History in North America

Development of the Science of Limnology in North America really started in 1875, the young E.A. Birge became an instructor at the University of Wisconsin. In the early 1900s Chancey Juday joined Birge at the UW. The accomplishments of these two scientists are staggering. They collaborated on over 400 publications and established a legacy in limnological study at the UW that continues to this day. One of their major contributions was to recognize the multidisciplinary nature of limnology, which led them to collaborate with chemists, physicists, bacteriologists, algologists, plant physiologists, geologists, etc.

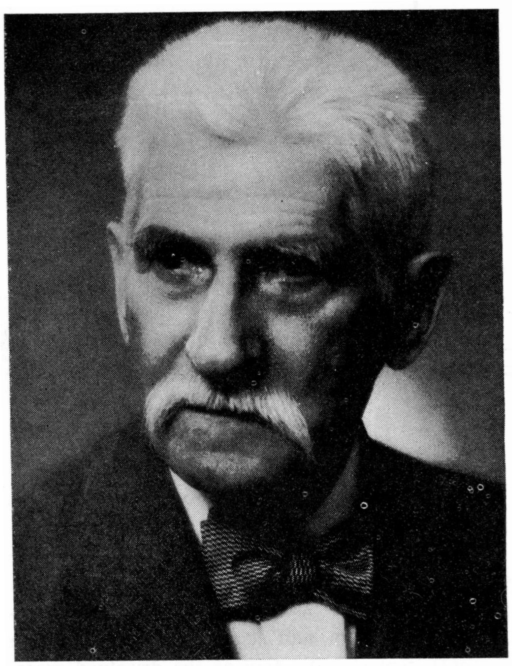


Fig. 1.1.—E. A. Birge. Portrait by Harold Hone.

Fig. 1.2.—Chancey Juday. Portrait by Harold Hone.

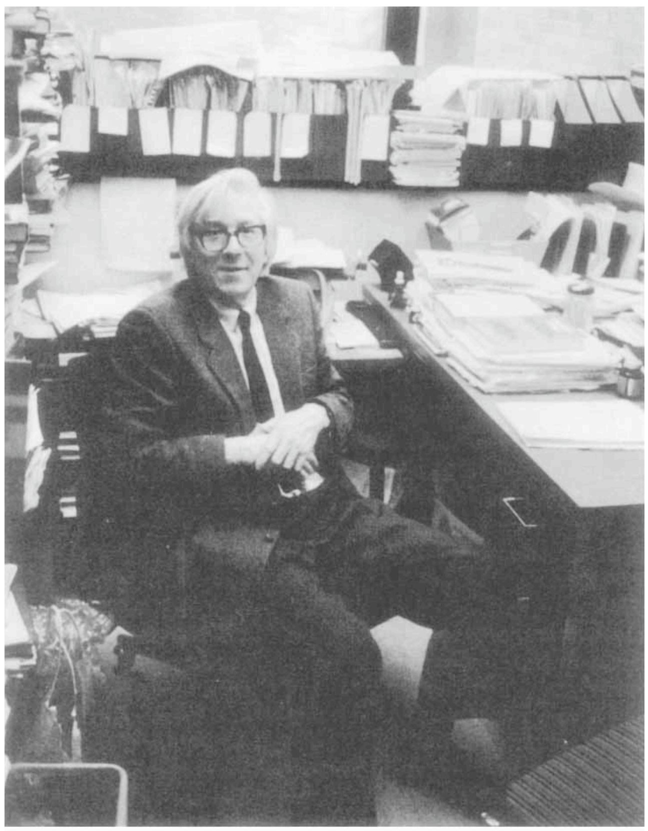
On the west coast, major programs in limnology were established by W.T. (Tommy) Edmundson on Lake Washington. He worked for 40 years on lakes in Washington, from the hypersaline Soap Lake in central Washington to Lake Washington. It was in Lake Washington that Tommy Edmundson made a significant contribution to applied limnology and lake restoration. He received numerous awards and honors during his career (he published his first paper on rotifers while still in high school), including dedication of a special issue of the journal Limnology and Oceanography (Volume 33, No.6). He is one of the few limnologists that even had a song composed in his honor (sung to the tune of *Good King Wenceslaus*:

Good Professor Edmondson walked outside one nooning,
Looked out on Lake Washington, noticed it was blooming.
All the other scientists asked what was polluting.
Some said it was CO,; he said it was soo-00-age.

The lake had turned a muddy brown from Oscillatoria.
Reminded of Lake Zurich, then, he was in euphoria.
All of the Seattleites looked on with aversion.
They believed their lake was dead; he called for diver-er-sion.

Voters took a public stand to make their lake look pretty.
Their task began in '63; it ended with Lake City.
They harkened to his learned words; pollution dropped to zero.
Good Professor Edmondson had become a he-ee-ro.

Lyrics by John T. Lehman



dmondson in his office in Kincaid Hall, University of Washington. Hasti
by A. Litt.)

Dr. Edmundson, who died in 2000, was an engaging personality and teacher. He once remarked that he sampled one particular lake in Massachusetts just so that he could fill an entire line of his Ph.D. dissertation with the lake’s name:
Lake Chaugogagogmanchaugagogchaubunagungamaug.

Dr. Charles Goldman at the University of California, Davis, established another major limnology research group centered on studies of Lake Tahoe. Dr. Goldman established the Tahoe Research Group that over the last 45-years has documented the early onset of eutrophication and the progressive change from a classically nitrogen-limited lake to a phosphorus-sensitive one, largely due to loading of atmospheric nitrogen compounds to the lake. The Tahoe work showed the essential importance of physical forcing to interannual variation in primary productivity, which was driven by storm-induced deep mixing events. He also demonstrated the dominant effects of El Nino years on Castle Lake and Lake Tahoe. A number of studies in New Guinea, Africa, Central America and South America were instrumental in preventing inadvisable or reckless dam projects.

Overall, perhaps the most important aspect of Prof. Goldman's research is the long-term Lake Tahoe ecosystem study on the early stages of eutrophication that has made it possible for governmental regulatory agencies to utilize science-based decision-making for the conservation of Lake Tahoe as well as other threatened lakes.

Why study lakes?

Freshwater lakes comprise a large percentage of the readily accessible, “drinkable and fishable” water on the planet.

TABLE 1-1 Water in the Biosphere*

	VOLUME (THOUSANDS OF KM^3)	PER CENT OF TOTAL	RENEWAL TIME
Oceans	1,370,000	97.61	3100 years†
Polar ice, glaciers	29,000	2.08	16,000 years
Groundwater (actively exchanged)‡	4000	0.29	300 years
Freshwater lakes	125	0.009	1–100 years§
Saline lakes	104	0.008	10–1000 years§
Soil and subsoil moisture	67	0.005	280 days
Rivers	1.2	0.00009	12–20 days¶
Atmospheric water vapor	14	0.0009	9 days

*Modified from Vallentyne, J. R., after Kalinin and Bykov. *In:* The Environmental Future. London, Macmillan Publishers, Ltd. Reprinted by permission of Macmillan London and Basingstoke.

†Based on net evaporation from the oceans.

‡Kalinin and Bykov (1969) estimated that the total groundwater to a depth of 5 km in the earth's crust amounts to $60 \times 10^6 km^3$. This is much greater than the estimate by the U.S. Geological Survey of 8.3×10^6 km^3 to a depth of 4 km. Only the volume of the upper, actively exchanged groundwater is included here.

§Renewal times for lakes vary directly with volume and mean depth, and inversely with rate of discharge. The absolute range for saline lakes is from days to thousands of years.

¶Twelve days for rivers with relatively small catchment areas of less than 100,000 km^2; 20 days for major rivers that drain directly to the sea.

From Wetzel

Freshwater resources are increasingly stressed and are likely to become a limiting resource in the future. Already, in more arid parts of the world, access to freshwater is prompting political crises.

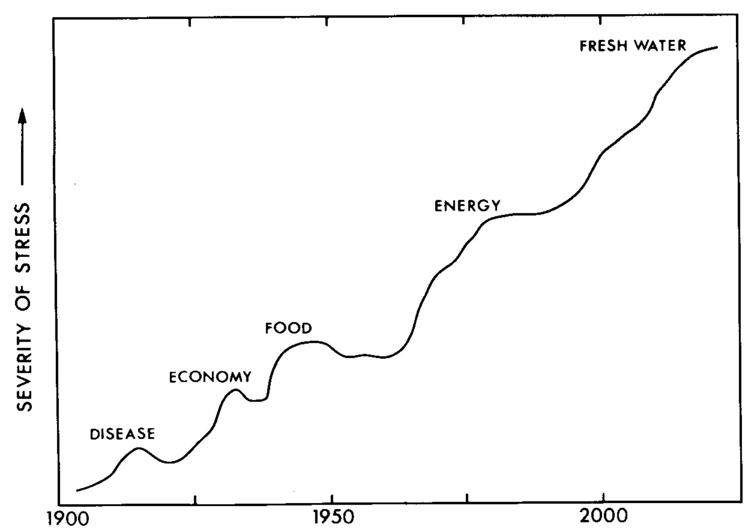


Figure 1-1. Stresses of increasing severity imposed upon the populations of developed countries resulting largely from excessive demophoric growth. (Modified from Wetzel, 1978.)

From Wetzel

Freshwater Politics

Along the Tigris and Euphrates Rivers, Turkey and Syria are currently approaching a massive confrontation over water resources. Relations between the two countries, strained at best, have been exacerbated since the 1980s by growing tensions over water, which have brought them to the brink of war several times.

Despite the signing of a protocol ensuring Syrian access to Euphrates water in 1987, Turkish development efforts have increasingly threatened to marginalize and even eliminate Syrian access to water. Most notably, the Southeast Anatolia (GAP) Project has provided Turkey, situated at the headwaters of the Tigris and Euphrates River system, extensive control over the flow of Euphrates water.5 Turkish disruption of the flow of the Euphrates in January 1990 to fill water reservoirs in front of the Attaturk dam highlighted Syrian vulnerability to Turkish control over upstream water resources. Further complicating the issue is Syria's continued support for the extremist PKK (Kurdish Workers' Party) in its insurgency against Turkey, a move that has prompted Turkey to threaten a blockade of water.

The historically troubled relations between Israel and the Palestinians have also been magnified by water. Mutual reliance on the West Bank Mountain Aquifer, which rests atop the demarcating border of the disputed West Bank territory (and currently provides 1/3rd of Israel's water supply and 80% of Palestinian consumption), has created friction between the State of Israel and the Palestinian Authority. Despite being the most important source of long-term water for Israel, use of the Aquifer – as a result of its uncertain status – has not been implemented to the fullest extent possible. Israeli officials, while cognizant of the growing water crisis, fear Israeli dependency on potentially Palestinian-controlled water sources. (see Berman and Wihbey, 1999. *Strategic Review* article for additional information

Lake water resources of the World

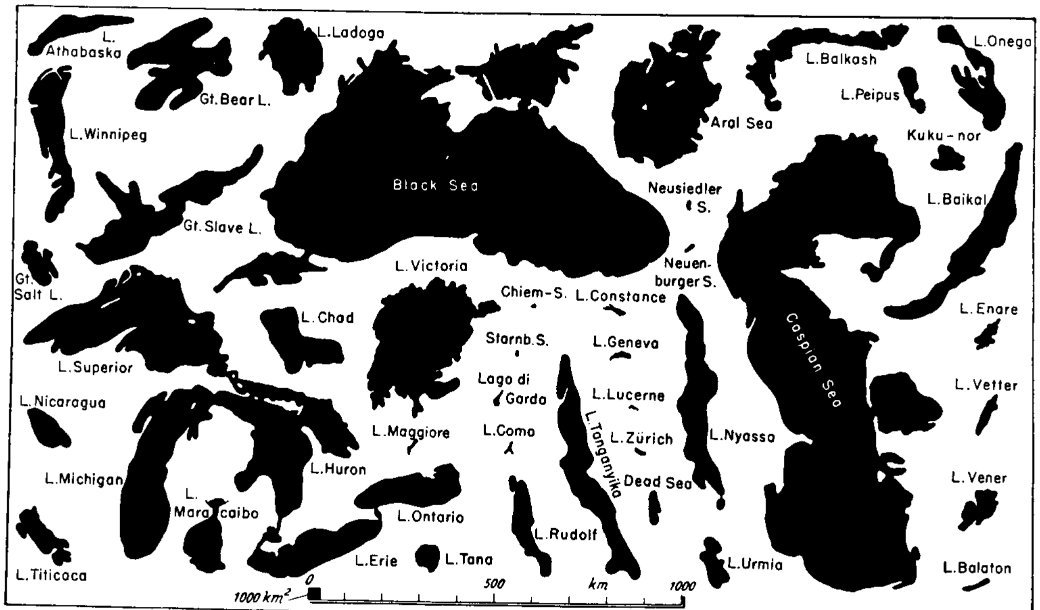


Figure 3-1 An approximate comparison of the surface areas of many of the larger inland waters of the world, all drawn to the same scale. (After Ruttner, F.: Fundamentals of Limnology. Toronto, University of Toronto Press, 1963.)

From Wetzel

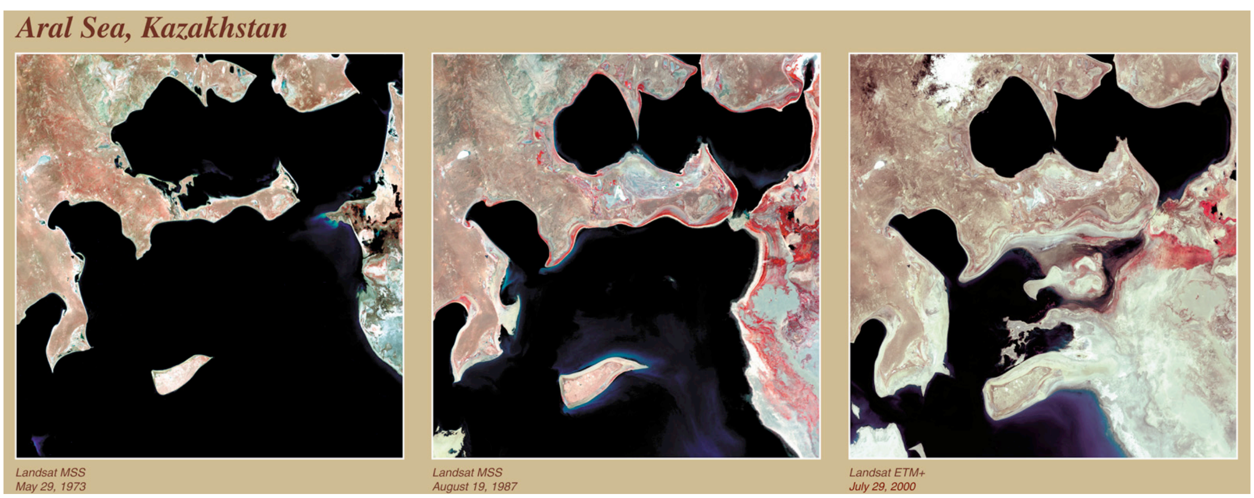
Lake Como

Lake Baikal is the world's largest freshwater lake in terms of volume. It contains about 5521 cubic miles of water (23,600 cubic kilometers), or approximately 20% of Earth's fresh surface water. This is a volume of water approximately equivalent to all five of the North American Great Lakes combined.

Lake	**Location**	**Volume (km^3)**
Caspian Sea	Azerbaijan, Iran, Kazakhstan, Russian Federation, Turkmenistan	78,200
Baikal (Ozero Baykal)	Russian Federation	23,600
Tanganyika	Burundi, Congo (Democratic Republic), Tanzania, Zambia	19,000
Superior	Canada, United States of America	12,100
Malawi (Nyasa, Niassa)	Malawi, Mozambique, Tanzania	7,775
Michigan	United States of America	4,920
Huron	Canada, United States of America	3,540
Victoria	Kenya, Tanzania, Uganda	2,760
Great Bear Lake	Canada	2,292
Great Slave	Canada	2,088
Issyk-Kul (Isyk-Kul)	Kyrgyzstan	1,738
Ontario	Canada, United States of America	1,640
Titicaca (Lago Titicaca)	Bolivia, Peru	932
Ladoga	Russian Federation	908
Hamoun i Helmand	Afghanistan, Iran	510
Erie	Canada, United States of America	484
Hovsgol (Khuvsgul)	Mongolia	380
Winnipeg	Canada	371
Kivu	Congo (Democratic Republic), Rwanda	333
Nipigon	Canada	320

The Caspian Sea lies in an endorheic basin. Salinity varies from freshwater in the north to saline in the south.

The nearby Aral Sea is slowly diasappearing due to diversion of the Ama Dariya and the Syrdariya Rivers for irrigation. Soil salination and pollution of drinking water by salt, metals, and agricultural chemicals have caused human health problems



May 29, 1973 August 19, 1987 July 29, 2000