

UNIVERSITY of TORONTO at SCARBOROUGH
September 2011
Department of Physical & Environmental Sciences

Environmental Science EES C18

The Great Lakes: An Introduction to Physical and Chemical Limnology

North America is endowed with eight of the twelve largest fresh-water lakes in the world. The origin and geological history, the hydrodynamics and hydraulics, cycles of carbon, nitrogen and phosphorus, and structures of ecosystems of the North American Great Lakes will be used as examples of *large* lacustrine systems.

Fundamental concepts in physical and chemical limnology will be related to features found in the Great Lakes. Topics include: lake origins, lake classification, lake temperature structure and heat budgets, seasonal water circulations, productivity, plankton ecology, food-web dynamics, exotic species invasions, eutrophication-related phenomena and water quality/fisheries management. Specific anthropogenic influences will be illustrated using case studies from the local environment, and students will be allowed to pursue their own interests through a series of short seminars.

Instructors: Maria Dittrich (MD), George Arhondtsis (GA), William Gough (BG)
Office: SY 346 (Maria Dittrich)

The course consists of: (a) a 2-hour lecture each week; (b) a 2-hour tutorial/practical class each week, where the assignments are given out and discussed; (c) student seminars; and (d) designated readings. Each lecture will be accompanied by either a handout or the lectures will be posted on the web.

Lectures: Tuesday 1300-1500 h **Tutorial/Practical/Seminar:** Tuesday 1600-1800 h
Room: BV 361 **Room:** MW 160

Course Grade:	Assignment 1	10 %
	Assignment 2	10 %
	Report and presentation	35 % (20% written and 15% oral)
	Final Examination	45 %

Prerequisite: EESB03F **Recommended:** EESB02S

N.B. Students with diverse learning styles and needs are welcome in this course. In particular, if you have a disability/health consideration that may require accommodations, please feel free to approach me and/or the AccessAbility Services Office as soon as possible. The UTSC AccessAbility Services staff (located in S302) are available by appointment to assess specific needs, provide referrals and arrange appropriate accommodations (416) 287-7560 or ability@utsc.utoronto.ca. The sooner you let us know your needs the quicker we can assist you in achieving your learning goals in this course.

TENTATIVE COURSE OUTLINE

Date		Lecture Topic	Lecturer
Sept-13	1	• Introduction, Climatology	GA, BG, MD
Sep-20	2	• Dynamics	BG
Sep-27	3	• Circulation	BG
Oct-4	4	• Structure and Productivity of Aquatic Ecosystems	MD
Oct-11	5	• Carbon, Nitrogen and Phosphorus Cycles	MD
Oct-18	6	• Food Web, Planktonic Communities: Algae and Cyanobacteria	MD
Oct-25	7	• Eutrophication	GA
Nov-1	8	• Water Quality	GA
Nov-8	9	• Water-Land-Interfaces	MD
Nov-15	10	• Invasive species	MD
Nov-22	11	• Pollutants in Great Lakes	MD
Nov-29	12	• Students presentations	GA, BG, MD

Week 1 – September 13

ORIENTATION

Course Outline; Lecture Schedule

Practical Schedule; Seminar Schedule

CLIMATOLOGY

Great Lakes in a global context

Week 2 – September 20- Dynamics

THERMAL STRUCTURE OF THE GREAT LAKES

Thermal Layering & Lake Overturning

Thermocline Development

Thermal Classification of Lakes; Vertical Stability

Examples from the North American Great Lakes

Potential impacts of climate change

Week 3 - September 27

CIRCULATIONS

Dynamic Forcing of the Lakes

Coastal upwelling; Thermal bar revisited

Great Lakes Circulation

Assignment I

Week 4 - October 4

STRUCTURE AND PRODUCTIVITY OF GREAT LAKES

Lake Ecological Concept,

Population growth and Regulation

Community Structure and Interrelationships

Ecosystem Interrelationships, Productivity

Week 5 – October 11

CARBON, NITROGEN AND PHOSPHORUS CYCLES

The Oxygen content of inland waters, distribution of oxygen in Lakes

The occurrence of inorganic carbon in freshwater systems, utilization of carbon by algae

Sources and transformation of nitrogen in water

Phosphorus in freshwater systems

Phosphorus and the sediments, internal loading

Phosphorus and Nitrogen Loading and Algal Productivity

Week 6 – October 18

FOOD WEB, PLANKTONIC COMMUNITIES: ALGAE AND CYANOBACTERIA

Composition of the Algae of Phytoplankton, Importance of size

Phytoplanktonic Communities, Growth Characteristics and Mortality of Phytoplankton

Heterotrophy of organic carbon by algae and cyanobacteria

Seasonal succession of Phytoplankton

Zooplankton, Food, Feeding and Food selectivity, Food-web Dynamics in Great Lakes

Week 7 –October 25

WATER POLLUTION EUTROPHICATION

Basic Concepts of Eutrophication

Food Web Structure

Natural and Cultural Processes of Eutrophication

Relationships among Nutrients, Water Clarity, and Phytoplankton

Response Models for Trophic State – Eutrophication Models

Other Pollutants and Mitigation of Water Pollution

Assignment II

Week 8 – November 1

EUTROPHICATION PROBLEMS IN THE GREAT LAKES

Great Lakes Water Quality Agreement

Eutrophication Problems in: (i) Lake Erie; (ii) Lake Superior; (iii) Lake Michigan, (iv) Lake Huron; (v) Lake Ontario.

Eutrophication Risk Assessment and Adaptive Management Implementation in the Hamilton Harbour.

Week 9 – November 8

WATER-LAND-INTERFACES

The littoral zone: aquatic macrophytes, their metabolism and primary production

Productivity of littoral algae

Periphyton, littoral zooplankton communities

Importance of wetlands and estuaries

Sediments: general composition, re-suspension, aerobic and anaerobic decomposition

Week 10 – November 17

INVASIVE SPECIES

Stressors and Induced Ecological Changes

Invasive exotic Species: Definition and Mechanisms of Introduction

Week 11 – November 24

POLLUTANTS IN THE GREAT LAKES

Toxic Substances, Sources of Contaminants, The Fate of Contaminants, The Sediment Record Physical and Chemical Characteristics of Contaminants and Their Distribution in Nature, Toxicity and Its Prediction, Bioaccumulation and Biomagnification, Mercury and the Mercury Cycle, Toxic Chemicals, Environmental Health,

STUDENT SEMINARS during tutorial hours

Week 12 – December 1

STUDENT SEMINARS and COURSE REVIEW

In the 11th (tutorial hours) and 12th weeks of class student will make a presentation. This presentation will be worth 15% and the report 20% of the total course grade.

Last Day of Classes December 2, final examination between December 7 and 18.

READINGS

There is **no required text** for this course, since there is no book that covers all the course material, while several books cover much more material than is required. Thus, specific readings will be given out during each lecture and/or practical sessions; however, a number of texts cover the course material in part and there is one journal devoted specifically to research on large lakes of the world, but with a dominance of papers on North American Great Lakes research:

Journal of Great Lakes Research, International Association for Great Lakes Research.

<http://www.iaglr.org/jglr/journal.php>

This journal and the reference sources below will be used for course readings and as starting points for student seminars.

Books:

Kalff, J., 2002. *Limnology*, Prentice-Hall, NJ, 592 pp.

Wetzel, R.G., 2001. *Limnology: Lake and River Ecosystems*. Third Edition, Academic Press, NY.

Lampert, W., Sommer, U., 2007, *Limnoecology*, Oxford ; New York : Oxford University Press Inc., 2007. 2nd ed.

A few Web Reference Sources:

<http://www.epa.gov/glnpo/atlas/> The Great lakes Atlas

<http://www.great-lakes.net/index.html> Great Lakes Information Network (GLIN)

<http://www.epa.gov/glnpo/index.html> U.S. Environmental Protection Agency (EPA)

<http://www.cciw.ca/nwri-e.html> Environment Canada, National Water Research Institute (NWRI)

<http://www.ilec.or.jp/database/index/idx-lakes.html> Basic Data on World Lakes

<http://www.eolss.net> Encyclopedia of Life Support Systems (EOLSS), Developed under the Auspices of the UNESCO, EOLSS Publishers, Oxford ,UK

<http://ri.ijc.org/> Great Lakes-St. Lawrence Research Inventory, The International Joint Commission's Council of Great Lakes Research Managers (CGLRM)

<http://www.glc.org/> Great Lakes Commission (GLC)

<http://www.ndbc.noaa.gov/index.shtml> National Oceanic and Atmospheric Administration's (NOAA) National Data Buoy Center

<http://www.crh.noaa.gov/ifps/ifps.php?site=dtx&config=marine> NOAA's National Weather Service, Weather Forecast Office

<http://coastwatch.glerl.noaa.gov/> NOAA Coastwatch, Great Lakes Node

<http://www.glerl.noaa.gov/> National Oceanic and Atmospheric Administration (NOAA) Great Lakes Environmental Research laboratory (GLERL)

<http://www.glerl.noaa.gov/res/Programs/ncrais/> National Oceanic and Atmospheric Administration (NOAA) National Center for Research on Aquatic Invasive Species

<http://www.glfc.org/home.php> Great Lakes Fisheries Commission (GLFC)

<http://www.dfo-mpo.gc.ca/regions/central/pub/bayfield/01-eng.htm> Fisheries and Oceans Canada (DFO), Bayfield Institute - Great Lakes Research

<http://www.glsc.usgs.gov/> United States Geological Survey (USGS), Great lakes Science Center