UNIVERSITY of TORONTO SCARBOROUGH
December 2013
Department of Physical & Environmental Sciences

Environmental Science EES C18

The Great Lakes: An Introduction to Limnology

North America is endowed with eight of the twelve largest fresh-water lakes in the world. The origin and geological history, 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 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)
Office: SY 346 (Maria Dittrich)

The course consists of a 2-hour lecture each week; **and** student seminars; and designated readings. Each lecture will be accompanied by either a handout or the lectures will be posted on the web.

Lectures: Tuesday 2 pm – 4 pm **Room:** BV 264
Office hours: Tuesdays 11 – 1 pm Room: SY 346

Course Grade:	**Assignment 1**	**15 %**
	Midterm Exam (in-class)	**30%**
	Report	**15%**
	Final Examination	**40 %**

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 Access*Ability* Services Office as soon as possible. The UTSC Access*Ability* 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
Jan-7	1	• Introduction: Structure and Productivity of Aquatic Ecosystems	MD
Jan-14	2	• Structure and Productivity of Aquatic Ecosystems/Carbon and Nitrogen Cycles	MD
Jan-21	3	• Phosphorus Cycle	MD
Jan-28	4	• Food Web, Planktonic Communities/ Demonstration: Field equipment for lake studies	MD
Feb-4	5	• Climatology/Dynamics /**Assignment**	MD/BG
Feb-11	6	• Thermal structure of the Great Lakes	MD/BG
Feb-25	7	• Circulation /**Midterm in Class**	MD/BG
Mar-4	8	• Eutrophication in Great Lakes/ Demonstration: sediment sampling	MD
Mar-11	9	• Water-Land-Interfaces	MD
Mar-18	10	• Invasive species	MD
Mar-25	11	• Pollutants in Great Lakes	MD
Apr-1	12	• Course Overview/Demonstration	MD

Week 1 – Jan 7th **ORIENTATION/GREAT LAKES IN A GLOBAL CONTEXT/** STRUCTURE AND PRODUCTIVITY OF GREAT LAKES/CARBON AND NITROGEN CYCLES
Course Outline; Lecture Schedule
Lake Ecological Concept Ecosystem Interrelationships, Productivity.

Week 2 - Jan 14th STRUCTURE AND PRODUCTIVITY OF GREAT LAKES/CARBON AND NITROGEN 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
Nitrogen Loading and Algal Productivity

Week 3 – Jan 21st PHOSPHORUS CYCLES
Phosphorus in freshwater systems
Phosphorus and the sediments, internal loading, sediment demonstration
Phosphorus Loading and Algal Productivity

Week 4 – Jan 28th FOOD WEB, PLANKTONIC COMMUNITIES/DEMONSTRATION: FIELD EQUIPMENT
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 5 –Feb 4th CLIMATOLOGY/DYMANICS/THERMAL STRUCTURE OF THE GREAT LAKES
Climatology, Thermal Layering & Lake Overturning
Thermocline Development
Thermal Classification of Lakes; Vertical Stability
Examples from the North American Great Lakes ***Assignment 1 (due: March 11th)***

Week 6 – Feb 11th THERMAL STRUCTURE OF THE GREAT LAKES
Thermal Classification of Lakes; Vertical Stability
Examples from the North American Great Lakes, Dynamic Forcing of the Lakes
Week 7 - Feb 25th CIRCULATIONS **Midterm in class**
Coastal upwelling; Thermal bar revisited
Great Lakes Circulation
Week 8 - March 4th EUTROPHICATION PROBLEMS IN THE GREAT LAKES
Basic Concepts of Eutrophication
Natural and Cultural Processes of Eutrophication
Relationships among Nutrients, Water Clarity, and Phytoplankton
Eutrophication Problems in: (i) Lake Erie; (ii) Lake Superior; (iii) Lake Michigan, (iv) Lake Huron; (v) Lake Ontario.
Week 9 – March 11th 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 – March 18th INVASIVE SPECIES
Stressors and Induced Ecological Changes
Invasive exotic Species: Definition and Mechanisms of Introduction
Week 11 – March 25th 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,
Week 12 – April 1st Course Overview/Demonstration: sediment sampling

The report will be worth 15% of the total course grade.

Last Day of Classes April 1st, the deadline for the reports

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.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.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