Standard station locations for repeat sampling in the Laurentian Great Lakes (LGL) - Superior, Huron, Erie from 2004 tp 2013 (SINC project, IRONMAN project, NILSS project, CARGO project)

Website: https://www.bco-dmo.org/dataset/3614
Version: 03 August 2012
Version Date: 2012-08-03

Project
» Sources and Sinks of Stoichiometrically Imbalanced Nitrate in the Laurentian Great Lakes (SINC)
» Trace Metal Limitation of Phytoplankton Productivity: Combined Immunological, Geochemical and Growth Assay Approaches in Lake Superior (IRONMAN)
» The Nitrifying of Lake Superior and Its Intersections with the P and Fe Cycles (NILS)
» Primary Production and Grazing Dynamics In the Ultra-Oligotrophic Waters of Lake Superior (CARGO)

Programs
» Laurentian Great Lakes Ecosystem Studies (Laurentian Great Lakes Ecosystem Studies)
» Laurentian Great Lakes Ecosystem Studies (Laurentian Great Lakes Ecosystem Studies)
» Laurentian Great Lakes Ecosystem Studies (Laurentian Great Lakes Ecosystem Studies)
» Laurentian Great Lakes Ecosystem Studies (Laurentian Great Lakes Ecosystem Studies)

Contributors	Affiliation	Role
Sterner, Robert W.	University of Minnesota Twin Cities (UMTC)	Principal Investigator, Contact
Brown, Erik T.	University of Minnesota Duluth	Co-Principal Investigator
Bullerjahn, George S.	Bowling Green State University (BGSU)	Co-Principal Investigator
Finlay, Jacques C.	University of Minnesota Twin Cities (UMTC)	Co-Principal Investigator
McKay, Robert Michael	Bowling Green State University (BGSU)	Co-Principal Investigator
Sherrell, Robert M.	Rutgers University	Co-Principal Investigator
Brovold, Sandra	University of Minnesota Twin Cities (UMTC)	Technician
Gegg, Stephen R.	Woods Hole Oceanographic Institution (WHOI BCO-DMO)	BCO-DMO Data Manager

Table of Contents

Dataset Description

The project research team identified named sampling locations to facilitate repeat occupation of those locations and develop time-series data sets.

This is the complete list of the standard stations for all the projects asscociated with the Laurentian Great Lakes Ecosystem Studies Program - IRONMAN, NILSS, CARGO and SINC. See project specific standard stations for those stations asoociated with that particular project.

Methods & Sampling

Complied by Sterner, et al

Data Processing Description

The list of repeat sampling locations was contributed originally as an Excel spreadsheet. Some information was moved to the notes field, and negative signs prepended to longitudes to make them compatible with BCO-DMO database conventions.

BCO-DMO Edit History:

- Added station CH3 (occupied on CARGO2). Using lat/lon from Sterner e-mail - 03August2012/srg
- Added "Project" column identifying on which project(s) the station was occupied - 27July2012/srg
- Added station CB. Using Lat/Lon from CTD profile data - 25July2012/srg
- Added stations Grab 01 - Grab 10 and UMW from Sterner e-mail - 14June2012/srg
- Corrected Latitude position(degs) for WM7 (48 -> 46) - 07June2012/srg
- Changed stations Sterner A thru G to STE-A thru STE-G - 07June2012/srg
- Added stations UW1 - UW15, GRAB #9, GRAB #10 - 06June2012/srg
- Added station GRAB5 - 06March2012/srg

[table of contents | back to top]

Data Files

File
Standard_Stations_All.csv (Comma Separated Values (.csv), 5.75 KB) MD5:0a70cc358daffd6dbf0cda0133faae2f Primary data file for dataset ID 3614

[table of contents | back to top]

Parameters

Parameter	Description	Units
Lake_location	name of the lake	dimensionless
Station	Name of the standard station location.	dimensionless
lat	latitude in decimal degrees (positive is North)	decimal degrees
lon	longitude in decimal degrees (negative is West)	decimal degrees
water_col_depth	estimated depth of the water column at location	meters
dist_to_land	distance to land from location; estimated using Google Earth	kilometers
notes_and_comments	notes and comments	dimensionless
Project	Project or Projects on which the standard station was occupied for sampling	dimensionless

[table of contents | back to top]

Deployments

LGL_All

Website	https://www.bco-dmo.org/deployment/58839
Platform	Unknown Vessel
Start Date	2004-04-01
End Date	2013-09-01
Description	Faux deployment to cover the standard stations for all the projects associated with the Laurentian Great Lakes Ecosystem Studies program. Projects: IRONMAN, NILSS, CARGO, SINC See individual projects for standard stations asscociated with just that project. Platform "Unknown" is assigned as there are multiple vessels involved in the four different projects. Cruise track generated from station locations and plotted as unconnected points.

[table of contents | back to top]

Project Information

Sources and Sinks of Stoichiometrically Imbalanced Nitrate in the Laurentian Great Lakes (SINC)

Website: http://www.tc.umn.edu/~stern007/

Coverage: Lake Superior; Great Lakes

This award is funded under the American Recovery and Reinvestment Act of 2009 (Public Law 111-5).

Over large scales encompassing heterogeneous conditions, biogeochemical mechanisms act to achieve a stoichiometric balance between nitrogen and phosphorus. Locally, however, imbalances can develop. The Laurentian Great Lakes are a vast freshwater system where nitrate has been steadily accumulating for decades. Previous work has shown that in Lake Superior, the headwaters of the system, nitrate enters the lake water primarily due to in-lake biogeochemical processes, not due to passive accumulation of nitrate as a conservative substance as previously believed. An extreme stoichiometric imbalance of nitrate/phosphate ratios (~ 10,000 by moles) is present and is apparently growing. This set of prior findings opens up two major questions. First, what are the principal biogeochemical control points that tip the N cycle toward buildup of excess nitrate? And second, how does the extreme stoichiometric imbalance affect the ecology and evolution of Lake Superior's biota?

In this project, researchers at the University of Minnesota - Twin Cities and the Bowling Green State University, who previously documented the nitrate buildup in Lake Superior, will continue their research program and address these two questions. The project is organized around making comparative measurements of N assimilation, nitrification, denitrification, anammox, and microbial community structure in Lake Superior and in the central basin of Lake Erie. These two environments differ greatly in many ways including redox state and organic carbon production rates. From the standpoint of N balancing mechanisms, they can be considered end members within the Laurentian Great Lakes. Additional data will be collected across a larger region of the Upper Great Lakes including Lake Huron. Up-to-date mass balance budgets of nitrogen of the most of the Great Lakes (Lake Superior is already done) will be constructed and linked with hydrologic fluxes to gain insights into the dynamics of N across the entire Laurentian Great Lakes System. Observations of water chemistry will be made with ship-board sampling together with field-deployed nitrate sensors in shallow and deep waters. Process studies will be performed in the water column and at the sediment-water interface and will involve sensitive stable isotope techniques. These will include measurements of NO3 and NH4+ uptake into different size fractions, exchanges of different forms of N and C between the water column and sediments, nitrification, denitrification, and anammox. The diversity and abundance of ammonia oxidizing Archea (AOA) and bacteria (AOB) will be studied using quantitative real time PCR and DGGE. Similarly, the genetic composition of denitrifyers and anammox bacteria will be studied to see if they too are represented by novel clades in Lake Superior. Cultured nitrifyers will be characterized in terms of growth under different conditions typically encountered across the Great Lakes. The project will yield valuable information and insight into the operation of the nitrogen cycle under conditions that promote stoichiometric imbalances.

Previous work (2004-2007) by this team of investigators and others investigated the intersection of the nitrogen cycle with the phosphorus and iron cycles in Lake Superior and included studying the responses of plankton communities to differing nutrient supply regimes. Prior to 2004, many of the same investigators conducted research on the existence, mechanisms, spatial-temporal extent, and significance of trace metal limitation to primary production in Lake Superior. This early research was designed to quantify and characterize total and bioactive trace metal concentrations of Al, Fe, Mn, Zn, Cu, Cd, and Co in Lake Superior. The project included immunological and fluorescence assays to assess metal deficiency in algae in the natural environment and trace metal enrichment experiments in the laboratory to assess limitation experimentally.

The Laurentian Great Lakes are a valuable regional resource and an immense reservoir of planetary fresh water. Lake Superior is often considered to be relatively pristine but the ultimate source of the N converted to nitrate in the lake is as yet unknown and may involve past changes to the watershed or other anthropogenic factors.

Trace Metal Limitation of Phytoplankton Productivity: Combined Immunological, Geochemical and Growth Assay Approaches in Lake Superior (IRONMAN)

Website: http://www.tc.umn.edu/~stern007/

Coverage: Lake Superior

ABSTRACT FROM NSF AWARDS: OCE-9819324 / OCE-9902660 / OCE- 9902658

Although a number of recent studies have verified that primary production in various marine environments may be limited by trace metal availability, there has not yet been a similar body of research for freshwater systems, even the inland sea system of the North American Great Lakes. In this project researchers from the University of Minnesota, Rutgers University, and Bowling Green State University will investigate the existence,

mechanisms, spatial-temporal extent, and significance of trace metal limitation to primary production in Lake Superior. They will take a three-pronged approach. First, to quantify and characterize total and bioactive trace metal concentrations, Al, Fe, Mn, Zn, Cu, Cd, and Co would be determined in solution, in suspended particles, and in plankton in the field. Secondly, immunological and fluorescence assays would be used to assess metal deficiency in algae in the field. Third, trace metal enrichment experiments would be used to assess limitation experimentally in the laboratory. The three field sites would be chosen to take advantage of existing data available from the NSF-sponsored KITES program.

The Nitrifying of Lake Superior and Its Intersections with the P and Fe Cycles (NILS)

Website: http://www.tc.umn.edu/~stern007/

Coverage: Lake Superior

ABSTRACT FROM NSF AWARDS: OCE- 0352291 / OCE- 0352274 / OCE 0352208

Collaborative Research: The Nitrifying of Lake Superior and Its Intersections with the P and Fe Cycles

The concentration of nitrate in Lake Superior waters has increased steadily during the past century by six-fold from ca. 5 to ca. 30 umol L-1. Today, nitrate remains in excess of biotic demand at the end of the growing season. Though the increase in nitrogen concentration is not surprising, the magnitude and rate of increase in Lake Superior are, considering the long, fifty-year N turnover rate of the lake, and the absence of significant local sources of N to the mainly forested watershed.

To elucidate the causes of this impressive nitrate build up, researchers from the University of Minnesota, Bowling Green State University, and Rutgers University will undertake studies of the Lake Superior nitrogen cycle, combined with studies of limiting nutrients and the responses of plankton communities to differing nutrient supply regimes. Nitrification and denitrification rates, previously assumed to be zero, will be measured with stable isotope tracers and with other methods. Sources and transformations of the lakes nitrate will be traced using natural abundances of stable isotopes of nitrogen and oxygen in the lake, in streams and rivers, and in atmospheric sources. In addition to testing the limitation on nitrate uptake, the team of scientists will also explore the N cycle and its intersection with the P and Fe cycles in this large lake. Shortages of P, along with cold and dark physical conditions, are likely important factors in understanding lack of ecosystem assimilation of added nitrate. Iron too may play an important role because of its critical role in nitrate utilization by plankton. Indeed, it may be that absence of iron limits the ability of the plankton to utilize nitrate such that the plankton are N deficient even in the presence of nitrate surplus. In addition to developing a new water column nitrogen model and data sets for several geochemically distinct pools of dissolved P and Fe (with both spatial and temporal coverage of large portions of the lake) this research will also yield a dramatically improved knowledge of the nitrogen cycle in the worlds' largest lake.

PUBLICATIONS PRODUCED AS A RESULT OF THIS RESEARCH

Finlay, J.C., R.W. Sterner, & S. Kumar.. "Isotopic evidence for in-lake production of accumulating nitrate in Lake Superior.," *Ecological Applications.*, v.17, 2007, p. 2.

Sterner, R. W., E. Anagnostou, S. Brovold, G. S. Bullerjahn, J. C. Finlay, S. Kumar, R. M. L. McKay, and R. M. Sherrell.. "Increasing Stoichiometric Imbalance in Earth?s Largest Lake.," *Geophysical Research Letters*, v.34, 2007.

Ivanikova, N. V., R. M. L. McKay, G. S. Bullerjahn, and R. W. Sterner. 2007. Nitrate utilization in Lake Superior is impaired by low nutrient (P, Fe) availability and seasonal light limitation - a cyanobacterial bioreporter study. Journal of Phycology 43:475-484.

Kumar, S., J. C. Finlay, and R. W. Sterner. 2010. Isotopic composition of nitrogen in suspended particular matter of Lake Superior: implications for nutrient cycling and organic matter transformation. Biogeochemistry 103:1-14.

Kumar, S., R. W. Sterner, B. J. Finlay, and S. Brovold. 2007. Spatial and temporal variation of ammonium in Lake Superior. Journal of Great Lakes Research 33:581-591.

Kumar, S., R. W. Sterner, and J. Finlay. 2008. Nitrogen and carbon uptake dynamics in Lake Superior. Journal of Geophysical Research - Biogeosciences 113:G04003.

Sterner, R. W., T. Andersen, J. J. Elser, D. O. Hessen, J. M. Hood, E. McCauley, and J. Urabe. 2008. Scale-dependent carbon:nitrogen:phosphorus seston stoichiometry in marine and freshwaters. Limnology and Oceanography 53:1169-1180.

Primary Production and Grazing Dynamics In the Ultra-Oligotrophic Waters of Lake Superior (CARGO)

Website: http://www.tc.umn.edu/~stern007/

Coverage: Lake Superior

PRIMARY PRODUCTION AND GRAZING DYNAMICS IN THE ULTRA-OLIGOTROPHIC WATERS OF LAKE SUPERIOR ("CARGO" which stands for CArbon Gain and lOss)

All higher organisms including fish ultimately rely on carbon fixed by primary production for their growth. A major gap in our understanding of Lake Superior lies in a highly incomplete knowledge of the rates primary production and grazing in the lake's waters. This data gap impedes the progress of scientific understanding of the lake on many fronts. Primary production is the foundation for all food webs and is a large, perhaps the largest, term in the lake's carbon cycle. Over the years, there have been but a small handful of investigators who have measured primary production in this, Earth's largest lake by area. Attempts to construct comprehensive carbon budgets using literature values for major terms such as DOC import, sedimentation, etc. indicate a large imbalance in the C cycle in the lake. According to current best estimates, organic carbon disappears at much faster rate (14-40, Cotner et al. 2005) or (13-81, Urban et al. 2005) than its rate of input (5.3 Tg/y, Cotner et al. 2004) or (3-8 Tg/y, Urban et al. 2005) (all values in Tg/y). The budget is out of balance by a factor of about 2 to 27. Unless the lake is metabolizing vast quantities of old, "fossilized" carbon (implausible), current out-of-balance budgets must be wrong, meaning we do not have good estimates for one or more of these fundamental processes in the lake.

Of the possible terms in the carbon budget of the lake, a focus on primary production is appropriate because of the large magnitude of this term plus the dearth of actual measurements that have been performed and the many untested assumptions that lurk behind those few measurements. At the same time, a major loss of particulate organic carbon has been almost entirely ignored until now. That loss is the grazing rate, the rate of consumption of lake particles (including bacteria and algae) by living organisms in the water column. As Banse (2002) has described for the oceans, though physical mixing and sinking contribute to the dynamics of phytoplankton and other small planktonic organisms, it is principally production and grazing which determine dynamics. To a first approximation, the rate of change of phytoplankton is equal to the difference between production and grazing.

This project comprises a two-year study that will focus on primary production and grazing in the world's largest lake by area. Primary production will be measured using 14C additions to shipboard incubations using a photosynthetron device. P-I curves plus other data will be used as input for numerical models of areal production. Production numbers so obtained will be compared to in situ incubations. Grazing assays will be based on the dilution series methods developed by Landry and Hassett (1982) and since employed by many others, including myself and my students; this method provides an overall measure of in situ particle turnover.

[table of contents | back to top]

Program Information

Laurentian Great Lakes Ecosystem Studies (Laurentian Great Lakes Ecosystem Studies)

Website: http://www.tc.umn.edu/~stern007/

Coverage: Laurentian Great Lakes

A series of studies concerned with the chemistry and biology of the Laurentian Great Lakes. These different studies share a focus on the dynamics of organic pools of carbon, nitrogen and phosphorus, and the stoichiometric linkages among these elements. At different times, work also has focused on trace metal dynamics and interactions with biota, the rates of primary production and herbivory, rates and patterns of primary productivity, and the century-long, steady trend of increasing nitrate in Earth's largest lake by area. Microbial populations have been investigated and linked to these chemical properties.

This Program was created by BCO-DMO staff to bring various Laurentian Great Lakes Research projects under one umbrella for improved discovery and access.

Dates: 1998 - 2014
Funding: NSF/OCE and Minnesota Sea Grant

Laurentian Great Lakes Ecosystem Studies (Laurentian Great Lakes Ecosystem Studies)

Website: http://www.tc.umn.edu/~stern007/

Coverage: Laurentian Great Lakes

A series of studies concerned with the chemistry and biology of the Laurentian Great Lakes. These different studies share a focus on the dynamics of organic pools of carbon, nitrogen and phosphorus, and the stoichiometric linkages among these elements. At different times, work also has focused on trace metal dynamics and interactions with biota, the rates of primary production and herbivory, rates and patterns of primary productivity, and the century-long, steady trend of increasing nitrate in Earth's largest lake by area. Microbial populations have been investigated and linked to these chemical properties.

This Program was created by BCO-DMO staff to bring various Laurentian Great Lakes Research projects under one umbrella for improved discovery and access.

Dates: 1998 - 2014
Funding: NSF/OCE and Minnesota Sea Grant

Laurentian Great Lakes Ecosystem Studies (Laurentian Great Lakes Ecosystem Studies)

Website: http://www.tc.umn.edu/~stern007/

Coverage: Laurentian Great Lakes

A series of studies concerned with the chemistry and biology of the Laurentian Great Lakes. These different studies share a focus on the dynamics of organic pools of carbon, nitrogen and phosphorus, and the stoichiometric linkages among these elements. At different times, work also has focused on trace metal dynamics and interactions with biota, the rates of primary production and herbivory, rates and patterns of primary productivity, and the century-long, steady trend of increasing nitrate in Earth's largest lake by area. Microbial populations have been investigated and linked to these chemical properties.

This Program was created by BCO-DMO staff to bring various Laurentian Great Lakes Research projects under one umbrella for improved discovery and access.

Dates: 1998 - 2014
Funding: NSF/OCE and Minnesota Sea Grant

Laurentian Great Lakes Ecosystem Studies (Laurentian Great Lakes Ecosystem Studies)

Website: http://www.tc.umn.edu/~stern007/

Coverage: Laurentian Great Lakes

A series of studies concerned with the chemistry and biology of the Laurentian Great Lakes. These different studies share a focus on the dynamics of organic pools of carbon, nitrogen and phosphorus, and the stoichiometric linkages among these elements. At different times, work also has focused on trace metal dynamics and interactions with biota, the rates of primary production and herbivory, rates and patterns of primary productivity, and the century-long, steady trend of increasing nitrate in Earth's largest lake by area. Microbial populations have been investigated and linked to these chemical properties.

This Program was created by BCO-DMO staff to bring various Laurentian Great Lakes Research projects under one umbrella for improved discovery and access.

Dates: 1998 - 2014
Funding: NSF/OCE and Minnesota Sea Grant

[table of contents | back to top]

Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-0927512
NSF Division of Ocean Sciences (NSF OCE)	OCE-0927277
NSF Division of Ocean Sciences (NSF OCE)	OCE-9819324
NSF Division of Ocean Sciences (NSF OCE)	OCE-9902660
NSF Division of Ocean Sciences (NSF OCE)	OCE-9902658
NSF Division of Ocean Sciences (NSF OCE)	OCE-0352291
NSF Division of Ocean Sciences (NSF OCE)	OCE-0352208
Minnesota Sea Grant (MN Sea Grant)	unknown LGL Ecosystem Studies MN Sea Grant

[table of contents | back to top]