Multiple Stressors and Cumulative Effects in the Great Lakes:

An NSERC CREATE Program to Develop Innovative Solutions through International Training Partnerships

Project Title	Tracing the effects of oligotrophication on contaminant dynamics in Great Lakes benthic food webs
Position	PhD
Institution	University of Guelph
Department	School of Environmental Sciences
Primary Advisor(s)	Dr. Paul Sibley/Dr. Soren Brothers
Term	3 years/9 semesters
Start	May 2016
Stipend	$21,000 /annum

Project Description

Successful reductions in anthropogenic nutrient loading in the Great Lakes, coupled with the effects of the accidental introduction of invasive zebra and quagga mussels, have produced a dramatic rise in water clarity in the Great Lakes over the past forty years. Resulting from a decline in phytoplankton (suspended algae) production, this increase in water clarity is predicted to have a substantial positive effect on benthic algae productivity, which models suggest could significantly compensate for phytoplankton losses in several of the Great Lakes. Some support for this proposed autotrophic shift from pelagic to benthic food-web dominance has come from recent stable isotope analyses which have identified an increased reliance of fish upon benthic resources in some areas of the Great Lakes in recent years.

A shift towards a greater role of benthic resources in Great Lakes food webs could change the dynamics of interactions between emerging and persistent legacy chemical contaminants and food web components. Although the uptake and integration of recalcitrant sediment contaminants into Great Lakes food webs has been reasonably well studied, the nature and extent of such changes, if any, in the context of the recent shifts in trophic state and food web structure have not been documented. Historically, under more eutrophic conditions, higher phytoplankton production rates produced greater particle sedimentation rates and low light conditions at the benthic surface, likely resulting in high burial rates that enhanced the entrainment of many contaminants and reduced uptake into lake food webs. However, recent evidence indicates that a structural shift in Great Lakes algal communities, characterized by greater water clarity and greater contribution of benthic algae to total lake primary production (PP) may be occurring. This shift toward increased benthic PP appears to be accompanied with a corresponding increase in the importance of the benthic environment as the base energy channel for nearshore food webs. How might this shift influence the dynamics of legacy and emerging contaminant transfer between sediments, which may serve as both a sink and a source, and food webs? Does increased benthic production mitigate (e.g., a capping effect) or propagate (e.g., increase biological activity leading to increase sediment disturbance via bioturbation) the flux of contaminants to/from Great Lakes sediments and therefore into or out of food webs? Can the “near-shore shunt” concept, which suggests that oligotrophication in the Great Lakes results in an enhanced channeling of nutrients within the nearshore littoral lake zones at the expense of off-shore zones, be applied to contaminant distributions in the Great Lakes as well?

We seek a highly motivated PhD student who is interested in exploring the role that shifts in benthic primary production may be playing in the dynamics of sediment contaminants in large aquatic systems

such as the Great Lakes. This research project would thus involve direct *in-situ* and modeled measurements of benthic primary production, as well as investigations into benthic resource utilization by higher trophic level organisms (via stable isotope analyses), novel assessments of contemporary sediment burial rates (by sediment traps and dated sediment cores), and contaminant profiles in invertebrate and fish tissue samples to assess the effect, if any, of the apparent shift in food web structure through increased benthic production on contaminant distribution in the Great Lakes.

Student Responsibilities
The successful candidate will undertake a PhD program at the University of Guelph which will include: • Required course work as directed by the advisory committee • Develop field sampling and/or experiment designs, execution of experiments, data analysis, and publication of results • Complete all requirements of a PhD degree as outlined by the University of Guelph and the NSERC CREATE program (www.creategreatlakes.org)

Qualifications (recommended)
The following qualifications are desired but not necessary required for the position (required qualifications are indicated in brackets): • Undergraduate or MSc degree in Biology or related discipline (e.g., aquatic ecology, limnology, ecotoxicology) (REQUIRED) • Minimum 80% average (University of Guelph minimum standard) in an M.Sc. and the final 2 years of a four year Honours degree or equivalent (REQUIRED) • SCUBA diving certification • Valid driver's license

Apply to	
Contact	**Dr. Paul Sibley** University of Guelph School of Environmental Sciences Bovey Building, Gordon Street Guelph, Ontario Canada N1G 2W1 519.824.4120 x52707 psibley@uoguelph.ca
Pre-Screening Application Material	Please provide • Short cover letter (<1-page) • Transcripts (unofficial are suitable for initial screening) • Statement of research interests (i.e., why do you want to undertake a PhD? *Note: the statement of research interest will also be used as a gauge of written communication proficiency*
Formal Application to the University	Successful candidates will be required to submit a formal application to the University of Guelph, including: • Two academic reference letters (due upon formal submission of application to the University) • Proof of English proficiency (if English is not the candidates first language) For further details, see: http://www.creategreatlakes.org/how-to-apply.html For a full break down of general requirements for a PhD at the University of Guelph please

	visit: https://www.uoguelph.ca/graduatestudies/future/apply/requirements