



MULTIPLE STRESSORS AND CUMULATIVE EFFECTS IN GREAT LAKES ECOSYSTEMS

Halfway through the CREATE Training Program: Looking Back and Forward

As of April 2016, our CREATE program will be three years old, and thus halfway through its six-year duration. 2015 was an exciting year for the program, more than doubling the number of students, and rounding out the range of Great Lakes topics being addressed by the program. Additionally, we are pleased to announce the recent addition of two new members to the CREATE training team, Dr. Sapna Sharma (York University) and Dr. Adam Yates (Western University).

The goal of this CREATE program is to train and prepare students as the next generation of scientists and policy-makers who understand and can address the many environmental problems affecting the Great Lakes

ecosystems. In addition to financing student stipends, we accomplish this by direct teaching (via the CREATE course, offered every September at the University of Guelph), CREATE-sponsored webinars, and support the establishment and financing of internships which are designed to be complementary to student research interests. In return, we encourage students to think of their specific research topics in the context of multiple stressors and cumulative effects in the Great Lakes, and to utilize the program infrastructure as a starting point for fruitful interactions and knowledge-sharing between institutions and research groups. In this edition of CREATE Waves, we update the activities in the CREATE program in 2015/16 and profile research dealing with

invasive species, one of the many stressor classes affecting the Great Lakes.

New Co-Investigators Dr. Sapna Sharma and Dr. Adam Yates

We are pleased to welcome Dr. Sapna Sharma from York University, and Dr. Adam Yates from Western University to the cadre of CREATE investigators! Dr. Sharma's research focuses on the effects of climate change, and ice coverage in particular, on multiple stressors in the Great Lakes and their surrounding basins. Dr. Yates focuses on ecological assessments and water quality issues related to cumulative effects in populated landscapes.

CREATE Waves



Summer, 2016

CREATE Student News

In the past year, the CREATE program has grown by nine students. We welcome the following recent additions to the CREATE program:

Brett Allen (MSc) under the supervision of Dr. Nicholas Mandrak. Brett is examining how multiple stressors are impacting fish assemblages in the Credit River watershed.

Omar El-Ansari (PhD) under the supervision of Dr. Charles Trick. Omar is working on the ecophysiology and toxin production of benthic cyanobacteria in Lake Erie.

Tej Heer (PhD) under the supervision of Dr. Nicholas Mandrak. Tej is focusing on the potential of Asian carp to spawn in the tributaries and near-shore zones of the Great Lakes.

Meagan Kindree (PhD) under the supervision of Dr. Nicholas Mandrak. Meagan is working on the modelling of fish assemblages vs. multiple stressors in the Grand River watershed.

Lianna Lopez (MSc) under the supervision of Dr. Sapna Sharma. Lianna is working on the effects of changing ice phenology and surface water temperatures and primary productivity.

Orro Omni (PhD) under the supervision of Dr. Gail Krantzberg.

Dmitri Perlov (MSc) under the supervision of Dr. Roberto Quinlan.

Dmitri is using a paleolimnological approach to infer the history of hypoxic/anoxic events in Lake Erie.

Melanie Raby (PhD) under the supervision of Dr. Paul Sibley. Melanie is examining the toxicity of neonicotinoids in aquatic invertebrates of the Great Lakes watershed.

René Shahmohamadloo (PhD) under the supervision of Dr. Paul Sibley. René's work focuses on microcystin bioaccumulation in Lake Erie fishes.

Keara Stanislawczyk (MSc) under the supervision of Dr. Hugh MacIsaac. Keara's work focuses on early detection methodologies of invasive species, and zooplankton in particular, in the Great Lakes.

Khafi Weekes (PhD) under the supervision of Dr. Gail Krantzberg. Khafi is examining the transboundary governance of groundwater in the Great Lakes basin.

Yiminxue Zheng (MSc) under the supervision of Dr. Nicholas Mandrak. Yiminxue is examining the effects of multiple stressors on brook trout populations in the Greater Toronto Area.

Stressor Spotlight: Invasive Species

Invasive species is one of the most significant stressor classes contributing to cumulative effects in the Great Lakes. Eight CREATE trainees, representing one fifth of the program, consider invasive species to be a direct

component of their research. The importance of the issue is reflected in the breadth of the research, including studies on ballast control, species composition and interactions (zooplankton, zebra mussels and fish), development of novel detection and prediction techniques, and factors regulating colonizing potential.

As Keara Stanislawczyk, an MSc candidate with Dr. Hugh MacIsaac at the University of Windsor, explains, “the introduction of invasive species in the Great Lakes is generally from ships’ ballast tanks. These invaders can also bring in novel diseases that can affect native species which haven’t evolved to survive with these diseases.” Stanislawczyk’s research aims to develop early detection techniques for invasive species to “help prevent another zebra mussel-like problem”. As she notes, the negative effects of invasive species on ecosystems can go beyond diseases: “An invader may be a superior hunter compared to similar native species, and therefore it can eat all the food and ‘starve out’ native species. Once one invasive species arrives in the area, it can facilitate the survival of another species.” This link between invasive species and broader ecosystem components is something that Omar El-Ansari, a PhD candidate studying invasive cyanobacteria with Dr. Charles Trick at Western, understands as well. El-Ansari notes that “harmful filamentous cyanobacteria can directly and indirectly affect a number of stressors in the Great Lakes that include zebra/quagga mussels, invasive aquatic plants (underwater), hypoxia, biological

stressors such as macroinvertebrates, zooplankton, fish, aquatic birds and humans.” Furthermore, it is possible that the effects of climate change may enhance the ability of invasive species establishing themselves in the Great Lakes. Stanislawczyk says that “higher water levels and reduced ice cover in the Great Lakes are expected in the future, which could allow for new invaders (such as Asian carp) to enter, and for invaders who aren’t cold-tolerant to survive the winter and establish year round populations, rather than being reintroduced each spring.”

While Stanislawczyk’s work looks forward to prevent future invasions, another MSc candidate with Dr. MacIsaac, Sharon Yong, is focusing on an invasive species that has long been established in the Great Lakes: the zebra mussel. Perhaps little can be done to remove zebra mussels from the Great Lakes, yet there is still much to learn regarding their dispersion techniques. The development of a zebra mussel dispersion model, one of the goals of Yong’s research, would not only aid in predicting the future spread of zebra mussels to other Canadian water bodies, but it could also be adapted and applied to the dispersion of new invasive species which are not yet established in the Great Lakes. As Yong notes, there remains much to discover regarding how zebra mussels interact with aquatic ecosystems, and this could be of great relevance to other researchers in the CREATE program whose

research focuses on eutrophication: “The effect of zebra mussels on nutrients in lakes depends on the lake. In some cases, phosphorus concentrations increase after the invasion of zebra mussels, while other research finds a decrease in total phosphorus in lakes with zebra mussels.” Dr. Soren Brothers, a post-doctoral fellow and CREATE program manager working with Dr. Paul Sibley at the University of Guelph, has also been focusing on the interaction between changes in water clarity in the Great Lakes across the past 40 years (which are linked to the filtering effects of zebra mussels and to changes in watershed nutrient loading) and total changes in areal algal production, taking into account a trade-off between declining off-shore phytoplankton production and increasing near-shore benthic algal production.



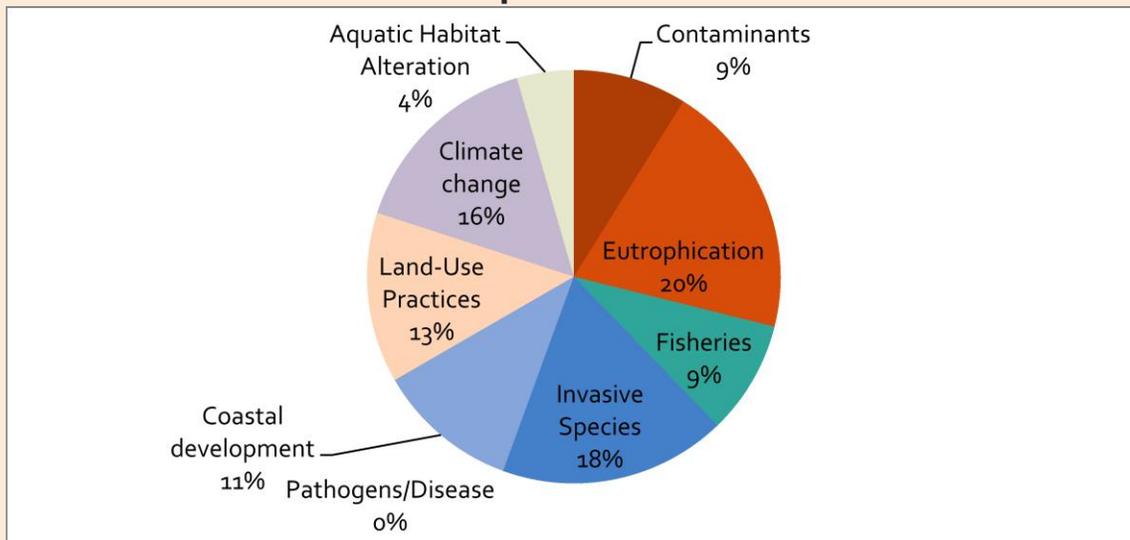
It is often stated that preventing invasive species from entering the Great Lakes is the best form of control but history clearly shows that this has met with limited success. Understanding how a new invasive species might utilize habitat and interact with other species, through predictive modeling and environmental assessment, could provide a strong

basis for managing the problem once invasion occurs. This approach forms the basis of the research of Dr. Nicholas Mandrak (University of Toronto), training two MSc (Yiminxue Zheng, Allen Brett) and two PhD candidates (Meagan Kindree, Tej Heer), who are focusing on the role of the Great Lakes’ watersheds and tributaries in the establishment, and potential impacts on food webs, of invasive fish species. Kindree notes that “invasive species drive habitat alteration, while influencing food web dynamics and interspecific competition.” Kindree’s work on mapping the temporal distribution and movement of invasive species throughout a Great Lakes river watershed will provide another key component to understanding, and ultimately preventing or mitigating the future introduction and establishment of invasive species, such as Asian carp, in the Great Lakes ecosystems.

The high proportion of CREATE trainees focusing on invasive species in the Great Lakes reflects the pervasive and complex nature of this important issue. Understanding the ecological implications of invasive species is an important prerequisite for developing appropriate policies aimed at prevention and management strategies directed to combatting new arrivals. Collectively, the research produced by CREATE trainees will contribute significantly to this effort.



Program Insights: Cohesion in the Student Research Matrix Experiments



CREATE trainees were recently asked to complete a research matrix, identifying the stressors, topics, and geographical extent of their research projects. Based on the stressor categories developed by Allan et al. (PNAS 110: 372-377; 2013), which includes a number of CREATE collaborators, the goal of this initiative was to provide the CREATE management team with an idea of the breadth of topics covered in the training program to ensure that it is meeting its goal of understanding multiple stressors and cumulative effects in the Great Lakes basin and to inform the planning process.

Of 22 CREATE trainees (January 2016), eutrophication (20%) and invasive species (18%) are the most common research topics, followed by climate change (16%), land-use practices (13%), coastal development (11%), and fisheries and contaminants (9% each). Of the biological groups being examined, CREATE trainees cover an impressive range, from microbes to humans (excluding only aquatic birds and reptiles/amphibians). Geographically, the entire Great Lakes Basin is covered; not only are each of the lakes represented (Lake Ontario and Lake Erie [36% each], Lake Huron [23%], and Lake Michigan and Superior [14% each]) but a high proportion of students are also focusing on direct or indirect aspects of the watershed (36%), recognizing the importance of an integrative approach for understanding multiple stressors in the Great Lakes basin.

The CREATE program features a full spectrum of topics and stressors, providing trainees with a valuable resource for exchanging ideas and communicating research through the CREATE course, webinars, conference sessions, and professional relationships. The program thus represents a cohesive set of interests, towards which we are able to address the science and policies surrounding the Great Lakes. In addition to this cohesion within the program, nearly half of the trainees identified “multiple stressors” as a research topic in itself. Our program thus also works at improving our understanding of multiple stressors and cumulative effects in the Great Lakes through the innovations and ideas of individual trainees. Regardless of their research topic, we encourage all trainees to consider the wider implications of their research, whether it be of importance to governance, policy formation, or seemingly unrelated scientific research topics. Not only will this approach help your work reach a broader audience when it comes time to publish, but it also improves the impact of your research on the Great Lakes community in general.

CREATE KNOWLEDGE

Recent publications from CREATE researchers

- Brothers, S., Y. Vadeboncoeur, and P. Sibley, 2016. Benthic algae compensate for phytoplankton losses in large aquatic ecosystems. *Global Change Biology*. doi: 10.1111/gcb.13306
- Jetoo, S., V.I. Grover, and G. Krantzberg, 2015. The Toledo drinking water advisory: suggested application of the water safety planning approach. *Sustainability* 7:9787-9808.
- Jetoo, S., A. Thorn, K. Friedman, S. Gosman, and G. Krantzberg, 2015. Governance and geopolitics as drivers of change in the Great Lakes-St. Lawrence basin. *Journal of Great Lakes Research* 41:108-118.
- Jetoo, S. and G. Krantzberg, 2014. Donning our thinking hats for the development of the Great Lakes nearshore governance framework. *Journal of Great Lakes Research* 40:463-465.

Internship News

A key goal of the CREATE Great Lakes program is to provide students with opportunities to enhance their research experience by interacting directly with industry and government partners. The mechanism by which this will be achieved is through internships and placements. Internships can be up to four months in duration and funding is available through the CREATE program to students to help offset placement-related living expenses.

To date, CREATE students have taken advantage of a wide range of internship options, working with groups as diverse as the Saugeen Ojibway First Nations, Ontario Ministry of the Environment and Climate Change, an environmental

consulting company (NovaTox Inc.), and several non-governmental organizations including Trout Unlimited, Credit Valley Conservation Authority, and the Grand River Conservation Authority. Upcoming planned internships will be undertaken at the Inter-American Development Bank (in Washington, D.C.), Wildlife Preservation Canada, and the Ohio State Stone Lab, in Lake Erie.

The CREATE team is always interested in hearing about your ideas for internship opportunities. Note, however, that internships are NOT restricted to just the CREATE training team. If you are aware of an industry or government agency that sponsors an internship program, or could benefit from a CREATE-sponsored internship, we would be delighted to hear from you.

Conference Recap: Guelph IAGLR 2016



The University of Guelph was a proud host of the 2016 conference of the International Association of Great Lakes Research (June 6-10), which ended up having 746 attendees, making it the largest in IAGLR history. The CREATE Great Lakes team played a major role throughout the conference, in organizational roles, through volunteering, and by presenting original, exciting scientific research. We would like to thank all of you who participated in this event, and congratulate you on a job well done!

UPCOMING EVENTS

**Association for the Sciences of Limnology
and Oceanography (ASLO)**

Aquatic Sciences Meeting

Honolulu, Hawaii Feb. 26th to Mar. 3rd, 2017<http://aslo.org/meetings/>**International Association for Great Lakes
Research (IAGLR)**60th Conference on Great Lakes ResearchDetroit, Michigan May 15th to 19th, 2017<http://iaglr.org/>**Keep Current!**www.creategreatlakes.org<https://twitter.com/creategreatlake>